Chinese incidence on the Chilean solar power sector

WORKING GROUP ON DEVELOPMENT AND ENVIRONMENT IN THE AMERICAS

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Over the last decade, China has become an important ally in Chile's goal of diversifying its energy matrix away from fossil fuels. China's over-production of solar PV panels came at just the right time for Chile, which was looking for new sources of low-emissions electricity after Argentina drastically reduced its gas exports. The resulting relationship between Chile and China is very promising for both parties. Solar power is still nascent in Chile, but growing quickly: as of this writing, over half of new power projects with approved environmental permits are solar.

Chile can maximize the local benefit from this new relationship by encouraging linkages, establishing norms, and investing in education. Encouraging linkages can include training local companies to perform related services like equipment maintenance, which only a few Chilean firms currently provide. Establishing quality norms for imported PV panels can protect the grid from defective or unsafe equipment, and would not be prohibitively complicated: Chile could require certification from one of the international bodies or adopt international norms. Finally, the Chilean state should consider investing in education for residential and business consumers of PV panels as well as potential workers in the industry.

1. Introduction

Chile's power sector is characterized by mainly relying on large power plants based on hydropower and fossil fuels and by long distribution lines. By 2013 installed capacity in Chile was just over 18,000 MW. A key structural change in the Chilean electricity mix occurred in 1998 when low cost natural gas from Argentina was introduced. However, in 2004 drastic export restrictions from Argentina implied an end to this natural gas based expansion and in 2008 the gas valve to Chile was finally completely closed.

This Chilean energy crisis, together with high international oil prices and an unprecedented drought that continues through this writing have triggered a complex situation in the Chilean power sector. The lack of natural gas has been remediated by introducing other imported inputs, of more polluting and/or more expensive sources of energy, such as coal and oil. The carbonization of the electricity mix, together with new investment projects of large hydropower dams located in pristine Southern areas of the country, have been the source of criticisms from different sectors of the society. Citizens' concerns have been reflected in increasing legal actions that have even paralyzed the construction of new power projects.

Under this tense scenario, renewable energies could play a vital role in achieving the huge challenge faced by the Chilean power sector: a cleaner, lower cost and more socially legitimate energy portfolio. At present there are 1,117 MW of Non-Conventional Renewable Energy (NCRE) in operation, from which only a small fraction are solar projects. However, it is foreseen that solar power will increase its relevance in the near future. In fact, it is expected that solar PV will reach 200 MW in operation by the end of 2014, and will continue growing, considering that more than 50% of the 10,000 MW of new projects with environmental permits approved in the country are currently solar projects.

On the other hand, the growth of China`s large scale export-oriented solar industry, fuelled by favorable policies in many industrialized governments, together with important Chinese support policies to encourage its overseas trade and investment, rapidly catapulted China to the top of global solar cell manufacturing capacity. This significant supply capacity, together with recent efficiency improvements in modules manufacturing, have led to a dramatic fall in global PV prices in recent years, leading to important changes in the global solar industry.

Chilean access to low cost PV cells and modules from China may open a window of opportunity in terms of contributing to solve the current energy crisis, providing lower cost solutions, curbing carbon emissions and other environmental impacts, and reducing social conflicts around energy investments. On the other hand, the existence of significant policy support to China´s solar industry is a major issue for Chile to consider if the country decides to promote the development of a national solar industry.

As solar energy has become a crucial element for the future of energy strategies in Chile and a potentially interesting sector for economic development, Chile has to confront the question of the potential medium to long-term effects of the Chinese involvement in its domestic industrial development.

This document is a first attempt to identify key emerging issues involved with the development of the solar PV industry in Chile and solar PV imports and investment from China. It provides an overview of trade between Chile and China and key insights about the trends in the Chilean electricity generation sector and determinant policies and regulatory measures. Section 4 examines the emerging solar energy sector in Chile identifying the Chinese influence. Section 5 analyses Chinese policy towards its solar energy sector. Finally, section 6 draws and analysis of the previous sections and provides key emerging issues and policy implications for Chile.

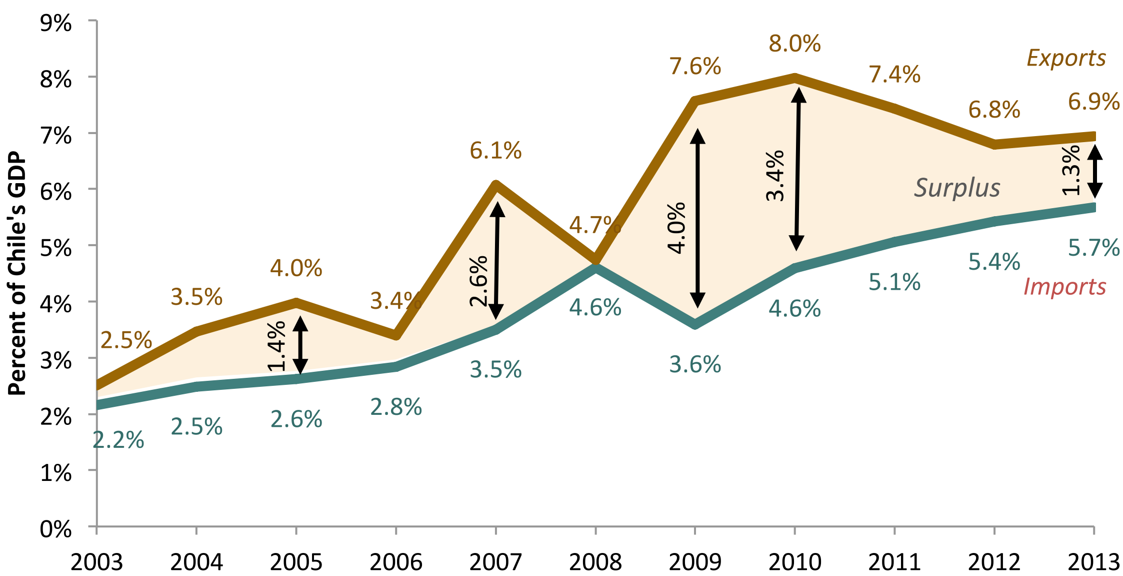
2. Overview of trade between Chile and China

2.1 Trade between Chile and China

2.1.1 Imports and exports between Chile and China

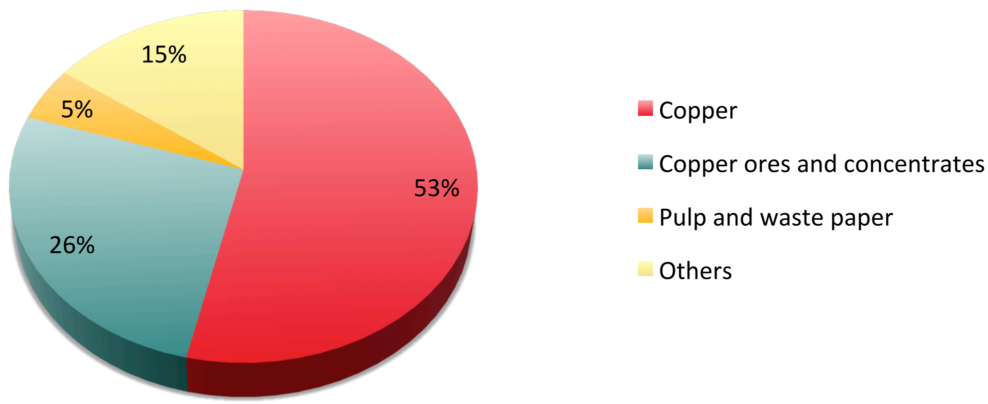
Trade relations between Chile and China have been overall positive, wherein China has become one of the 4 major trade partners for Chile, increasing its trade in the last 10 years. China became the main export destination for Chile in 2009, and increased its position since 2010.

Figure 1: Chilean Total Exports/Imports with Mainland China (Percent of GDP)



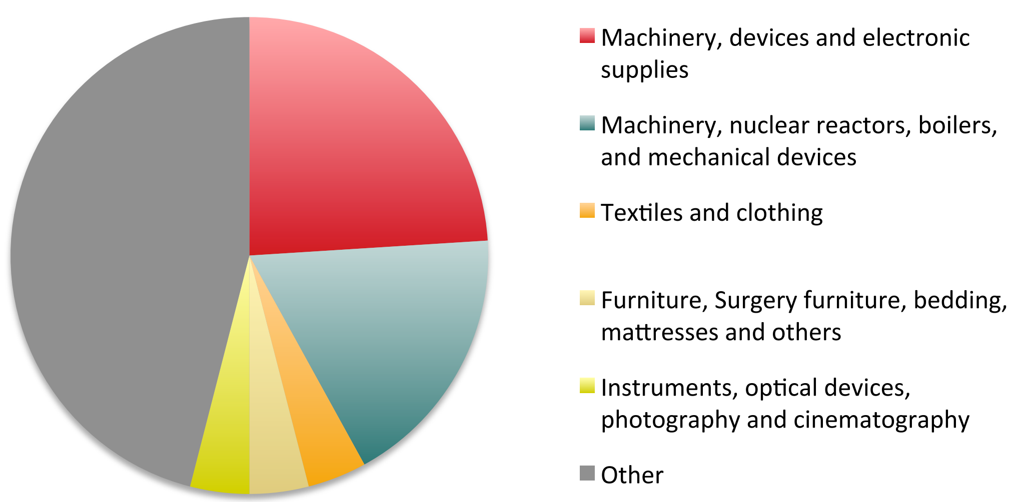
Source: Author´s work based on Banco Central Chile (2013), IMF WEO.

Figure 2: Chilean main export products to China 1994-2013



Source: Author´s work based on UN Comtrade (2014).

Figure 3: Chilean main import products from China in 2012



Source: Dirección General de Relaciones Económicas Internacionales, DIRECON (2014).

2.1.2 Trade Agreement between Chile and China

In October 2006 Chile and China's trade relations reached another stage, as the free trade agreement (FTA) between these nations came into force. This agreement was the first Chinese negotiation of its type with a non ASEAN country (DIRECON, 2014).

Table 1: The China-Chile free trade agreement progressive negotiation phases

Phase	Trade Agreement	Date
I	Free trade agreement for goods	October 2006
II	Supplementary trade agreement for services	August 2010
III	Supplementary trade agreement for investment	February 2014

Source: Dirección General de Relaciones Económicas Internacionales, DIRECON (2014).

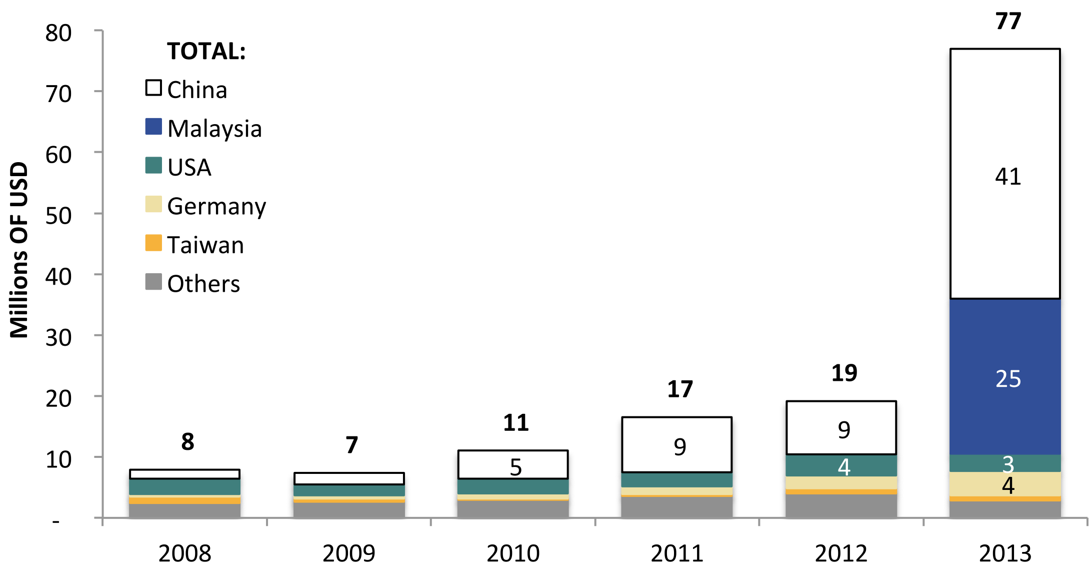
The first results were the reduction of barriers and increment of incentives for the entry of products in both directions. Tariff reductions in January 2013, implied that 1,610 products from Chile and 811 products from China that belong to the "10 year" category had a 10% reduction in their tariffs. Up to this date Chilean and Chinese products included in the agreement have had an 80% reduction in their tariffs, and it is expected that by 2015 100% of these products will have zero tariffs, excluding an exception list [1] (DIRECON, 2014).

[1]Solar panels and direct accessories are not considered in the exception list.

2.2 Trends in Chile's solar panels trade

Chile`s imports of PV panels reached USD 76.9 million by 2013, while there are no registered exports of this product. Imports of PV panels have increased largely between 2008 and 2013. China has dramatically increased its participation over Chilean PV imports, growing from 18% of the total in 2008 to 53% by 2013, becoming the main supplier.

Figure 4: Chilean Solar PV Imports 2008-2013



Source: Author´s work based on Servicio Nacional de Aduanas Chile, 2013

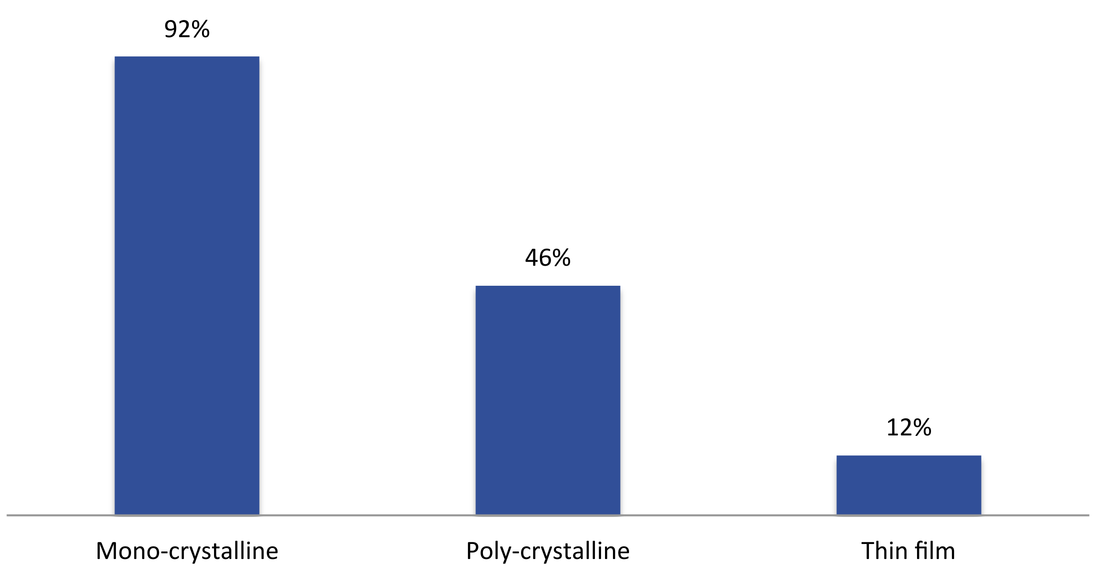
Table 2: Main Origins of Chilean Solar PV Imports 2008-2013

	2008	2009	2010	2011	2012	2013
China	**18%**	**26%**	**42%**	**54%**	**45%**	**53%**
USA	33%	23%	22%	15%	18%	4%
Malaysia	0%	0%	0%	0%	0%	33%
Germany	5%	8%	7%	8%	11%	5%
Taiwan	12%	7%	2%	1%	4%	1%
Others	31%	36%	27%	22%	21%	4%
TOTAL:	100%	100%	100%	100%	100%	100%

Source: Author´s work based on Servicio Nacional de Aduanas Chile, 2013

The bulk of the PV panels in the Chilean market have either mono or poly crystalline silicon technology. Crystalline silicon PV panels are widely manufactured and exported by Chinese companies.

Figure 5: Commercialized solar PV Technology in Chile



Source: CDT, 2012

3. The Chilean energy-power sector

3.1 Trends in the power sector

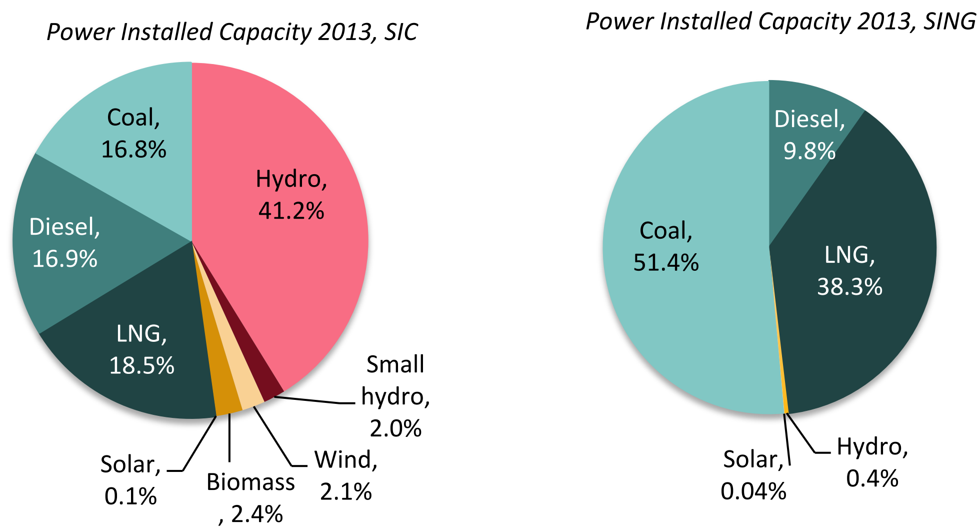
3.1.1 Trends in the power grid

The Chilean electricity grid is divided into 3 subsectors: generation, transmission and distribution. In total, the electricity sector generated 68,000 GWh in 2013 (CNE, 2013), supplying a demand that has been growing at a rate of 4.4% over the last 10 years (CNE, 2013).

The Chilean electricity market is composed of 4 subsystems. There are 2 main interconnected systems: The Central Interconnected Grid (SIC) provides 75% of the country's electricity demand and supplies over 90% of its population, and the Norte Grande Interconnected Grid (SING), which provides 24% of the country's electricity demand and mainly supplies the copper mining industry. The remaining 1% is shared between small subsystems in more isolated areas. Currently, the government is endorsing a project for the interconnection between the SIC and SING subsystems by 2018, arguing that it would provide more security and sustenance to the national electricity grid (EE2030, 2013).

By 2013 the Chilean electricity grid had a total installed capacity of 18,653 MW. The SIC has a combination of different technologies, clearly predominated by hydroelectricity; although it has fallen considerably since 2008. NCRE accounts for 5% of the total installed capacity in the SIC. The SING, however, relies almost exclusively on thermal power generation, and only 1%is supplied by NCRE.

Figure 6: The Chilean Electric Portfolio 2013

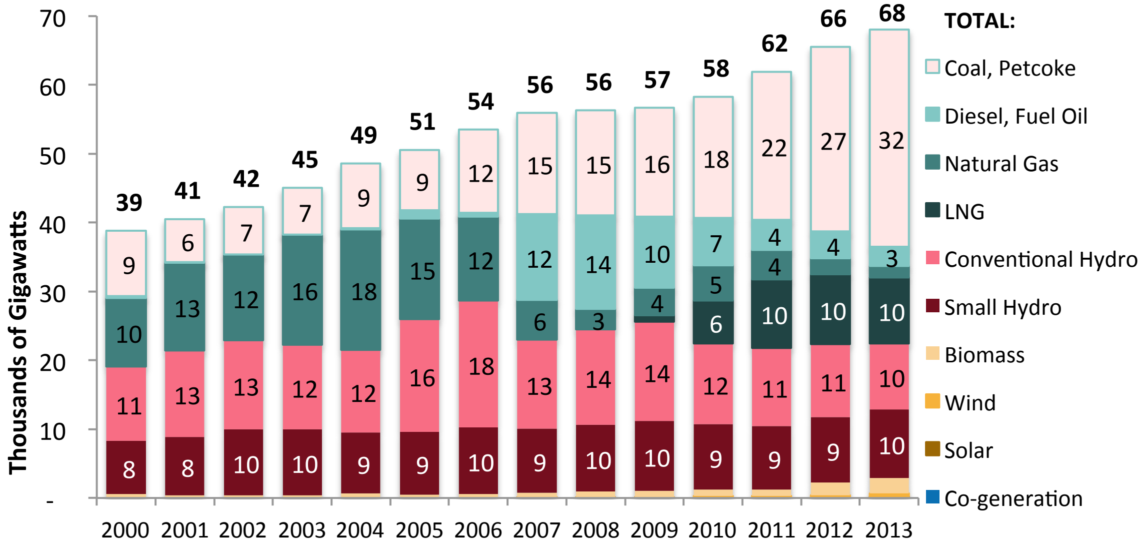


Source: Authors work based on CNE, 2013

Most of the inputs used to generate electricity are currently being imported (coal and diesel), with the notable exception of hydroelectricity and biomass. Chile currently imports 72% of its energy needs, while in 1990 it only imported 48% (FCH, 2008).

The Chilean energy crisis produced by Argentina's cut of natural gas over the past decade, together with an unprecedented drought that continues until this writing and that has drastically reduced the traditional hydroelectric capacity of the country, have triggered an extremely complex scenario.

Figure 7: Trends of the Power Generated in the SIC-SING subsystems (GWh)



Source: Author´s work based on CNE (2013) and Ministerio de Energía (2010).
Note: The SIC-SING subsystems generated a total power of 68.049 GWh in 2013.

The lack of natural gas has been compensated by the introduction of other imported sources of energy such as coal and oil, which are more polluting and more expensive than natural gas. The carbonization and higher cost of the electric portfolio, together with the push by large hydropower dams located in southern pristine areas to fill the future energy gap, have been subject to strong criticisms from different sectors of the society. Likewise, the current Chilean electric model, which relies almost exclusively on private initiative to define the power portfolio with no real long-term planning, has also been criticized (EE2030, 2013).

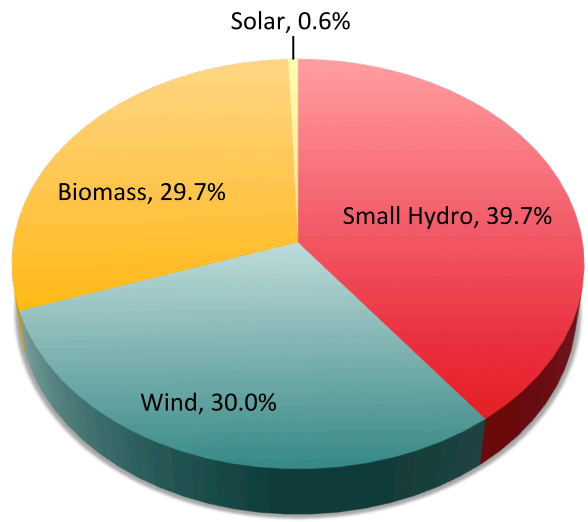
Citizens' concern and unrest related to the electric sector is reflected in increasing legal actions or, litigation procedures that have led to the halting of the construction of new power projects. At present, more than 75% of the megawatts from new projects with their construction permit approved by the environmental authority (SEIA) are paralyzed due to legal or administrative claims against them. They mostly involve large hydroelectric dams or coal-fuelled thermo electrical plants located far away from the main consumption centers (EE2030, 2013). At the moment, this phenomenon is the most important factor preventing the development of new power projects, which together with the absence of appropriate measures to address policy bottlenecks, have led to a critical situation in terms of the lack of implementation of new projects for the period 2013-2018. Altogether, it has resulted in a difficult challenge for the Chilean power sector; the need for a cleaner, lower-cost and more socially acceptable energy portfolio.

Under this scenario, NCRE could become a crucial factor to unlock the current energy crossroads. NCRE involve important attributes, including low local and global emissions, the later being a key tool for advancing with GHG mitigation; enjoy greater social acceptability; have nearly-null operational costs, and therefore lowering marginal costs or spot prices of the system and, in the case of solar and wind projects, they also are of very rapid implementation.

3.1.2 Trends for Non-Conventional Renewable Energies in the Power Grid

NCRE total installed capacity reached 1,117MW in 2013, which represents 6% of the total, and was mainly composed by small hydro, wind and biomass, while solar energy only represented 0.6%. This indicates that the NCRE quota, established by the Law N° 20,257 and recently modified by the Law 20/25 was achieved.

Figure 8: Non-Conventional Renewable Energy Installed Capacity, 2013



Source: Author´s work based on CER, 2013

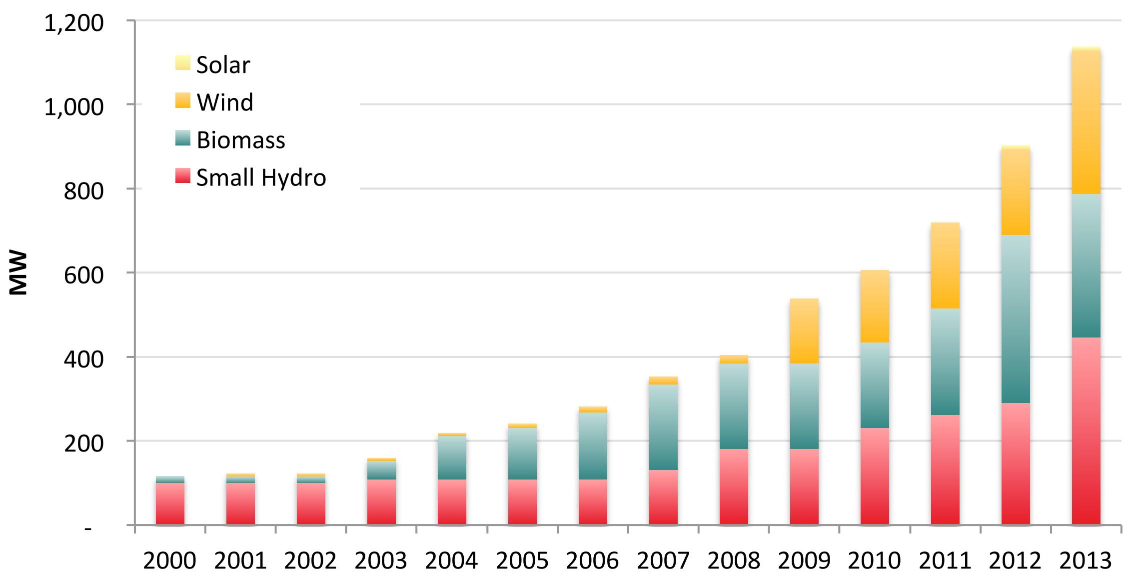
Table 3: Conventional versus NCRE Sources in 2013 by System (MW)

Source	SIC	SING	Total
Hydro > 20 MW	5,681.3	-	5,681.3
LNG	2,776.9	2,111.7	4,888.6
Coal	2,394.3	2,099.7	4,494.0
Diesel	2,263.6	378.0	2,641.6
Total Conventional:	*13,116.1*	*4,589.4*	*17,705.5*
Hydro < 20 MW	433.8	10.2	444.0
Biomass	332.0		332.0
Wind	335.0		335.0
Solar	2.9	3.8	6.7
Total NCRE:	*1,103.7*	*14.0*	*1,117.7*
Total	**14,052.8**	**4,601.0**	**18,653.8**

Source: Author´s work based on CDEC SIC and CDEC SING (2013) and CER (2013).
Note: Rows may not add to totals due to rounding.

NCRE is a new but emerging market in Chile and it shows significant growth prospects. Projects submitted to the Environmental Impact Assessment System (SEIA) in 2013, had a record of a total supply capacity of 17,000 MW of new renewable energy projects, either approved or in progress. These projects corresponded to solar (59%), wind (36%), and small hydro, geothermic, and biomass projects (5%). Nearly all the country's electricity generation companies are developing or considering projects of this nature; new companies have already been set up with the sole purpose of starting such initiatives and a further significant number hope to follow this path in the near future (CER, 2013). This solar trend responds to the incentive of Law 20/25, the reduction of investment costs in solar PV, and a deeper knowledge and technological adaptation from developers and citizens.

Figure 9: NCRE Installed Capacity in the Electricity Grid



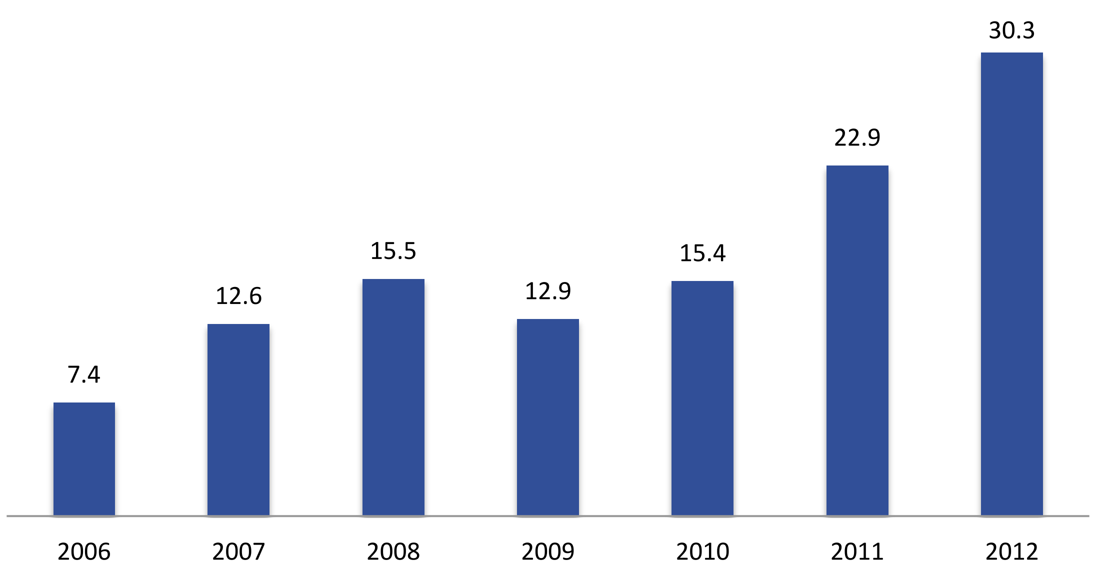
Source: CER and CNE (2013).

3.2 Trends in investments and FDI in the energy sector

3.2.1 Investments and FDI in Chile

The privatization of the Chilean electricity companies initiated in the 1980s was the main incentive to attract private investment into the national electricity sector, which had been completely state-owned and controlled until then. Up until the mid-1990s, private investment was mainly domestic but by the end of the 1990s it was largely controlled by foreign companies (Pollitt, 2004).

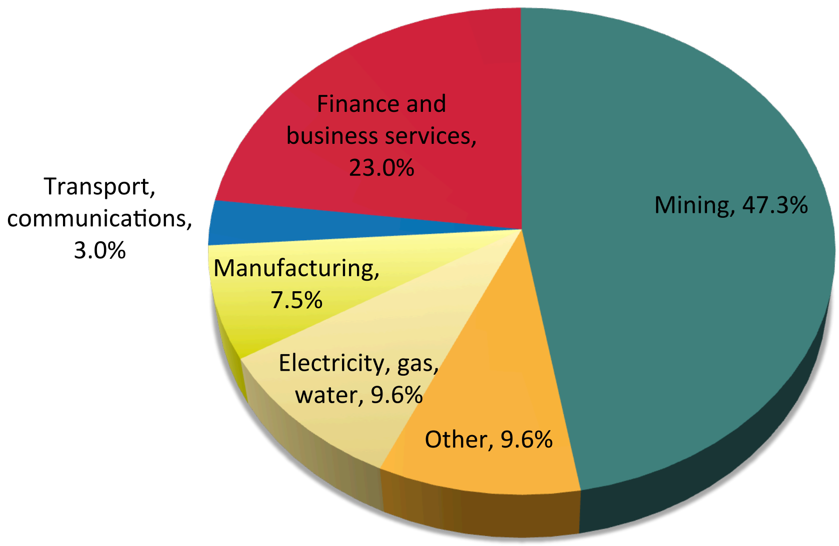
Figure 10: Total Foreign Direct Investment (FDI) Flow 2006-2012, Billions of USD



Source: Foreign Investment Committee (CIE, 2010).

Total Foreign Direct Investment (FDI) in Chile, through law D.L.600[2], reached US$ 81.5 billion between 2009 and 2012 (CIE, 2010).

Figure 11: FDI in Chile 2009-2012 by Sector



Source: Central Bank of Chile (www.bcentral.cl).

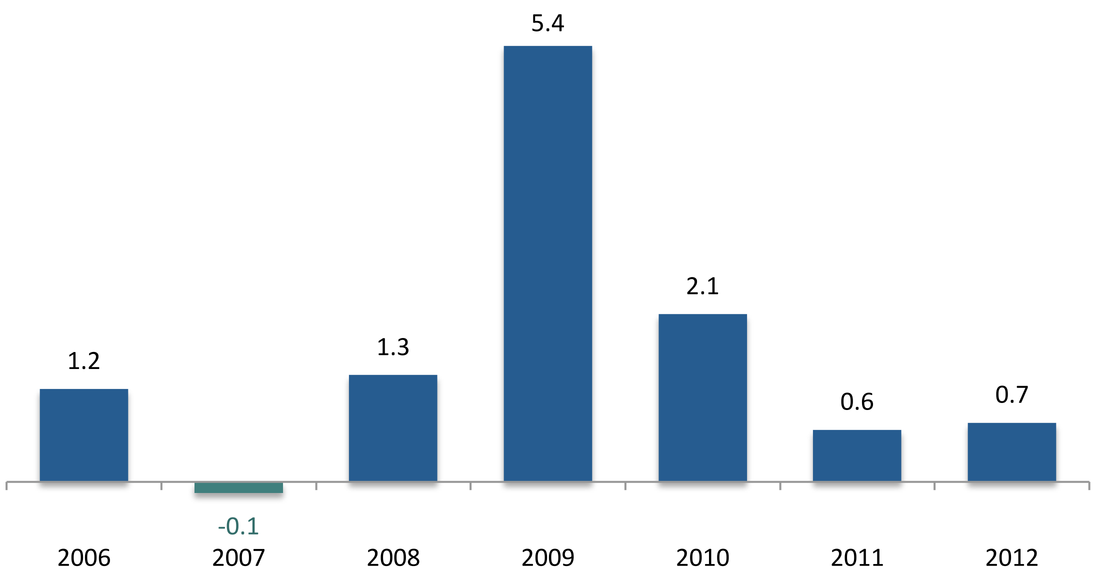
3.2.2 Investment and FDI in the Energy Sector

Foreign and particularly European investments dominate the electricity generation and transmission network today. Spain has been the main source of FDI in the energy sector in Chile, accounting for over half of the inflow through DL 600 between 1974 and 2010. It was followed by the USA (20.4%) and Canada (16.1%). 82.7% of FDI in the energy, gas and water sector corresponded to multi-region projects, due to its nature (CIE, 2010).

[2] Law No. 600 of 1974 is the instrument by which direct foreign investment enters Chile.

FDI in the sector has had great fluctuation during the period 2006-2012, even reaching negative figures in 2007, due to disinvestment in the energy sector possibly as a reaction to the strict restrictions towards natural gas imports in that period. However, FDI began to recover, reaching a peak in 2009 when it accounted for over 40%, partly explained by investment in the Mejillones and Quinteros natural gas storage plants.

Figure 12: FDI in Electricity, Gas, and water, 2006-2012 (Billions of USD)



Source: Author´s work based on Central Bank of Chile (www.bcentral.cl)

Box 1: Examples of FDI in NCRE in Chile

- **Endesa Eco:** wind farms Parque Eólico Canela in 2007 (18 MW) and Canela II in 2009 (60 MW), and small-scale hydroelectric project Ojos Aguan in 2008 (9 MW).
- The Spanish Group **Enhol**, wind-power project: Parque Eólico Hualpén (38 MW).
- **Iberdrola**, small-scale hydroelectric plant, Ruca Cura, in the Bio Bio region (4.7 MW).
- In 2004, joint venture between Australian company **Pacific Hydro** and Norwegian company **SN Power (Tinguiririca Energy)**. Two hydropower projects, La Higuera and La Confluencia. The Run-of-Hydro project La Confluencia (158 MW) was registered under the Clean Development Mechanism (CDM) of the Kyoto Protocol.
- **SN Power** subsidiary Norwind, built the wind farm Parque Eólico El Totoral(46 MW) in 2010.
- **Pacific Hydro** also operates the run-of-river hydropower plants Coya and Pangal (76 MW), and is currently building the Chacaves project (111 MW) in the Alto Cachapoal Valley and Pacific Hydro's first wind farm in Chile, the Punta Sierra Wind Farm, in the Coquimbo Region.
- In 2009, the Irish group **Mainstream Renewable Power** announced a joint venture with the Chilean company **Andes Energy** involving a series of projects for US$1 billion to generate 481 MW of NCRE. Currently, there are 33 MW operating in Negrete wind far and 266 MW approved and beginning construction for solar PV projects and 2,680 MW in development, from which 731 MW are solar PV energy.
- In July 2009 **GTN LA**, the Latin American subsidiary of the German geothermal company GTN, began operations in association with Fundación Chile and Manvitt (Iceland) for the exploration of geothermal resources in Chile.
- Italian enterprise **Enel**, in conjunction with Chilean state enterprises **ENAP** and **CODELCO**, are developing geothermal explorations and projects for a geothermal plant with a capacity of 50 MW that would produce 375 GWh annually for the SING. Besides, the Chilean generating company Colbún has an alliance with the US company Geoglobal Energy (GGE) to develop geothermal projects.

Solar energy foreign investment in Chile:

- **Solar Pack** (Spain) currently has different undergoing solar PV projects in the I and II regions of Chile with an investment of US$253.3 million. Of these projects 62 MW are in development and 1 MW operational.
- **Saferay** (Germany) has created a joint venture with Seltec Chile, developing projects under the name SelRay. These projects with an estimated investment of US$370 million are located in the I and III regions with 186 MW in development and 1.4 MW operationa.
- **Juwi** (Germany) through Kaltemp Chile has an operational 1.08 MW solar PV project in the IV Region, with an investment of US$3 million.
- **Sun Edison** (USA) has different solar PV proejcts in the I, II, and III regions of Chile, with a total investment of US$1,148.5 million, which implies 499 MW in development and 2 MW operational.
- **Kraftwerk** (Germany) through Subsole Chile has an operational solar PV project of 0.3 MW with a total investment of US$1 million.
- **First Solar** (USA) in 2013 acquired the Chilean project developer Solar Chile and is developing projects of 192 MW in the I and III regions of Chile with a total investment of US$ 460 million.
- **Andes Mainstream** (Ireland) is developing two solar PV projects: Parque Pedernales with an investment of US$420 million and an installed capacity of 162 MW in the III Region; and Parque Solar Azapa with an investmetn of US$210 million and in installed capacity of 104 MW in the XV Region. Both these plants have received permit approval and will begin construction soon.

Chinese investment in solar PV in Chile:

- **ReneSola**: SelRaywill acquired 29.1 MW of multicrystalline solar modules from the Chinese company REnesola for the La Huayca II plant. The project will expand the existing 1.4 MW La Hayca I solar PV power plant to a total capacity of 30.5 MW and would be the first large-scale solar project in Chile's SING.
- **Jinko Solar**: The Chinese company supplied the solar PV modules for the operating Andacollo plant. The project in the IV Region of Chile is operational since June 2013, with a capacity of 1.2 MW, providing energy to both the mining company *Dayton Mining* and the Chilean spot energy market through the SIC grid.
- **Sky Solar**: Developers Sky Solar and *Ingenieria y Construccion Sigdo Koppers Chile* (ICSK) with the financial support of the China Development Bank is in an early stage of construction of the Planta Solar FV Arica I. The project has a planned installed capacity of 18 MW. Sky Solar is a Chinese renewable energy asset developer and IPP (Independent Power Producer) with close relations with the Chinese solar PV manufacturers.
- **Powerway**: The Chinese company is participating in the *Esperanza* project of 3 MW ground mounted project in El Salvador, III Region of Chile, with a commercial partnership with the Chilean solar developer RTS Energía Ltda. This project of 23,040 panels will inject electricity to the SIC grid and is equipped with 6,300 PV Powerway high quality ground screws. The group's core business includes electrical design, structural design, product supply, construction services, installation and operation and maintenance.

Although there are no official figures about FDI in the NCRE segment, it has also become a pole of attraction for foreign investors. As Box 1 suggests, this has been especially true for wind power and small-scale hydroelectric projects, and increasingly for solar energy.

3.3 Policy Framework: Regulations and Incentives

Chile was the first country in the world to implement comprehensive reforms to its electricity grid (Pollitt, 2004). The first modifications to the Chilean Electricity Law were made in the early 1980s with the 1982 General Electricity Services Law (also known as DFL1), which is still the main regulatory instrument for the sector. Key modifications to the law resolved the vertical integration problems of the market, separating the electricity generation, transmission and distribution segments, which also allowed the private sector to participate in an area that had been until then

100% state-controlled (Pollitt, 2004). Large-scale privatization of the electricity companies began in 1986 and the grid is now 100% privately owned.

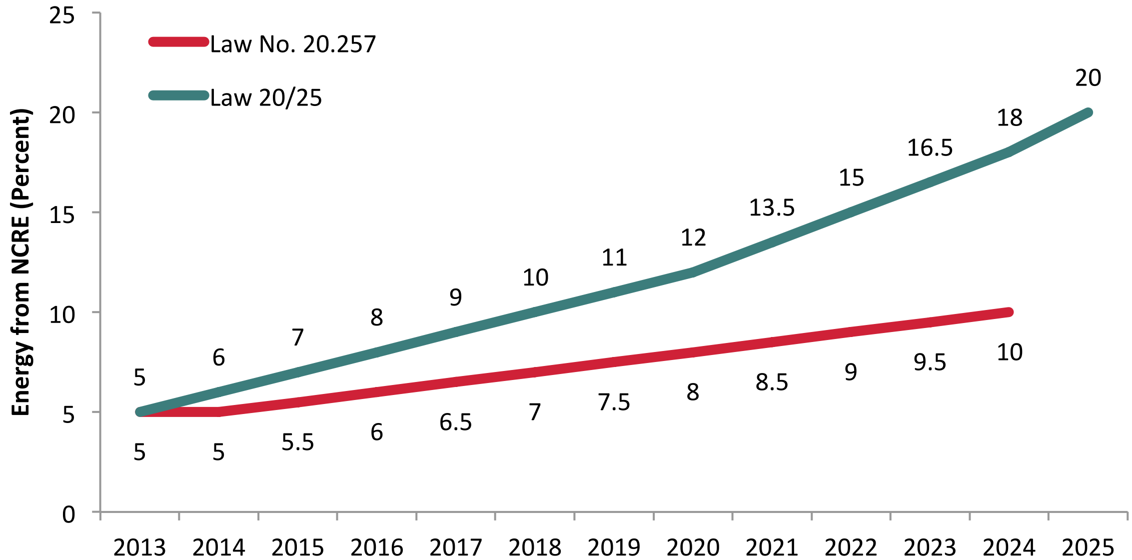
One of the fundamental principles of the Electricity Law is that resources from investment are administered by the national electricity market based on economic efficiency, with a guarantee of equal treatment for all energy sources. The law establishes two kinds of clients: regulated and unregulated consumers. Generating companies not participating in the above participate in a spot market, where prices correspond to the short-term marginal cost, which results from the fluctuating in-the-moment balance between supply and demand.

Table 4: Key policy changes relevant for NCRE

Key Policies	Detail
Law Nº. 19.940 (2004)	Improves the electricity transmission payment system. It opens the spot market, guaranteeing small-scale plants the right to connect to distribution networks and exempting them from main transmission tolls (full exemption for plants producing less than 9 MW and partial exemption for plants producing 9-20 MW).
Law Nº. 20.018 (2005)	Establshes that contracts beteween regulated consumer and the distributing and generating segment must be through a process of open tendering.
Law Nº. 20.257 (2008)	Defines NCRE and seeks to create favorable conditions for investment projects of NCRE. From 2010, all electricity companies of SIC and SING that operate over 200MW intalled capacity must obtain 5% of their annual electricity sales from NCRE, or pay a surcharge (this percentage will gradually increase to 10% in 2024).
Law 20/25 (2013)	Increases the target for NCRE from 10% in 2024 to 20% by 2025.
Law Nº. 20.571, Net-Metering Law (2012)	Establishes rights for generators with an installed capacity below 100 kWp, to inject their surplus power to the distribution grid and receive copmensation. Key points of dispute so far involve: differences between the price that the generators will receive per kWh and the price they will pay to the distributor per kWh.
Promotion and Financing Instruments for NCRE from CORFO and the CNE	Pre-investment program for preliminary NCRE research: supports projects with amounts above US$ 400,000 subsidizing pre-investment studies or consultations.
	Pre-investment program for advanced NCRE level: fund from banks and CNE to co-finance part of the costs for basic and specific engineering, electircal connection research, and environmental evaluation research.
	CORFO credit for NCRE: soft loans for investments in NCRE through financing lines of CORFO operating through local banks. The loans are under fixed fee deadlines from 3 to 12 years, and can reach up to US$ 5 million per project. There is also another financing line for energy efficiency and NCRE with a maximum amount of US$ 15 million, with a deadline of 13 years. A project could apply for both instruments.

Source: Author´s work based on Ministerio de Energía (2012); Laws: N° 19.940, N°20.018 and N°20.257; and draft laws: N° 20.571 & 20/25. Note: CORFO: Productive Development Corporation; CNE: National Energy Commission of Chile.

Figure 13: NCRE Annual Energy Requirement Modification Law 20/25



Source: Author´s work based on ACERA (2013). Note: Law 20/25 increases the target for NCRE from 10% in 2024 to 20% in 2025.

Box 2: National Energy Strategy 2012-2030 (ENE):

The National Energy Strategy 2012-2030 (ENE) proposes a long-term view for the future national energy grid that requires advancing towards generating the right conditions for an energy grid that is cleaner, more diverse, and secure, with more players and a robust distribution networks with sufficient space. In order to do this, the ENE establishes 6 main pillars: growth with energy efficiency; enhancing NCRE development; the role of conventional energy and greater domestic hydro and less external dependency; greater focus on transmission toward a public energy highway; a more competitive electrical market; and improvement in the regional electric interconnection options. In this sense, it is more about a primary road map for the energy sector than a strategy. Regarding NCRE the strategy involves a series of measures to accelerate their inclusion into the national grid (Ministerio de Energía 2012), including:

Tendering Mechanism to Foster NCRE Development: Open tendering in which the participating generating company can adjudicate a subsidy from the state to improve the power sale conditions (later integrated into Law 20/25).

Geo-Referenced Platform – Economic Potential for NCRE Projects: A public information instrument that will assist in private NCRE investment decisions. This platform will be integrated with those of other governmental institutions that administer national territories, such as the Minister of National Assets, with the aim of supplying certainty to the development of NCRE projects and strengthen the use of fiscal lands for the development of energy installations.

Promotion and Financing: This measure will focus on the design of promotion mechanisms in conjunction with other public institutions, such as instruments of insurance, new credit with international financing, and feasibility studies, among other economic incentive measures (instruments managed by the Renewable Energies Center).

Technology Strategy: Since every NCRE technology has different obstacles for its development, it emphasizes the need to establish a different long-term strategy for each NCRE technology. For instance, recognizing the great potential and high load factor of geothermal energy in Chile, a new regulatory framework is being prepared to foster investment in this resource.

Pilot Project Subsidizing Plan: This proposes a new subsidizing and incentive plan for NCRE pilot projects that allow advancing in the development of these technologies nationally. These pilot projects allow new knowledge in the practical aspects of economic and technical capital that Chile must develop to deal with its renewable resources. Furthermore, it is expected that these projects will help integrate the experience and know-how of international enterprises with the development of local technology and services, driving innovation in the national NCRE industry.

Net Metering: The design of a regulation, approved by the National Congress, to consolidates net metering will be implemented with the perspective that distributed generation could be an effective solution in improving the electric system through greater supply and efficiency. This initiative suggests that the residences or small companies could connect NCRE generating technologies from their homes or installations to the national grid, receiving compensation for any injection.

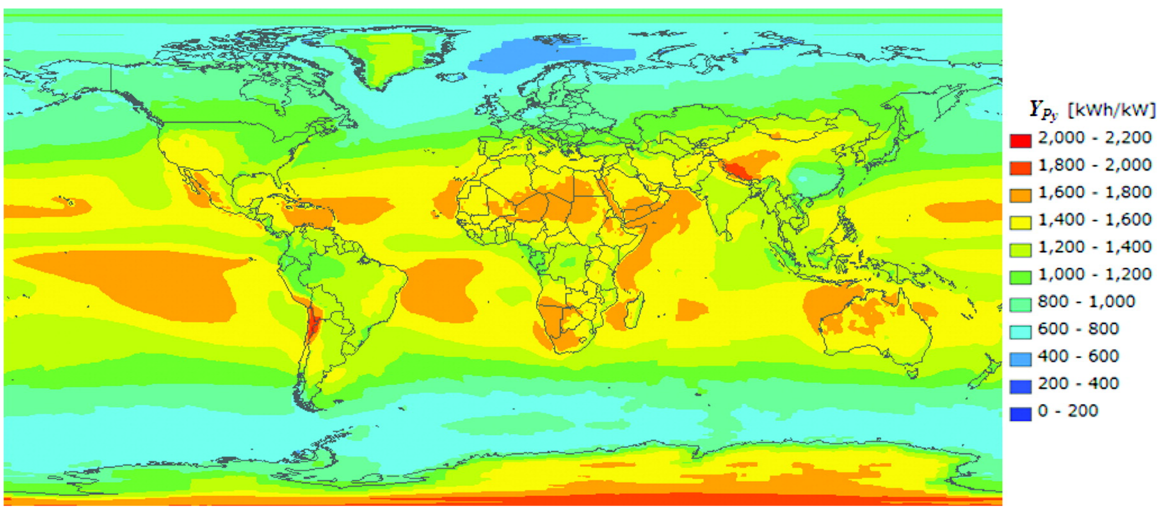
Source: Ministerio de Energía (2012).

4. The emerging Solar Energy Sector in Chile

4.1 Trends in the Solar PV Sector Structure

Chile has exceptional conditions for solar power generation, with among the highest radiation rates in the world, reaching a capacity factor of 31% for solar PV technology (NRDC, 2012). Apart from excellent radiation levels, Chile has wide land areas available for future solar PV installations in the North of the country (desert), mainly belonging to the Ministry of National Assets (91%).

Figure 14: Global Solar Radiation



Source: Kawajari et al., 2011.

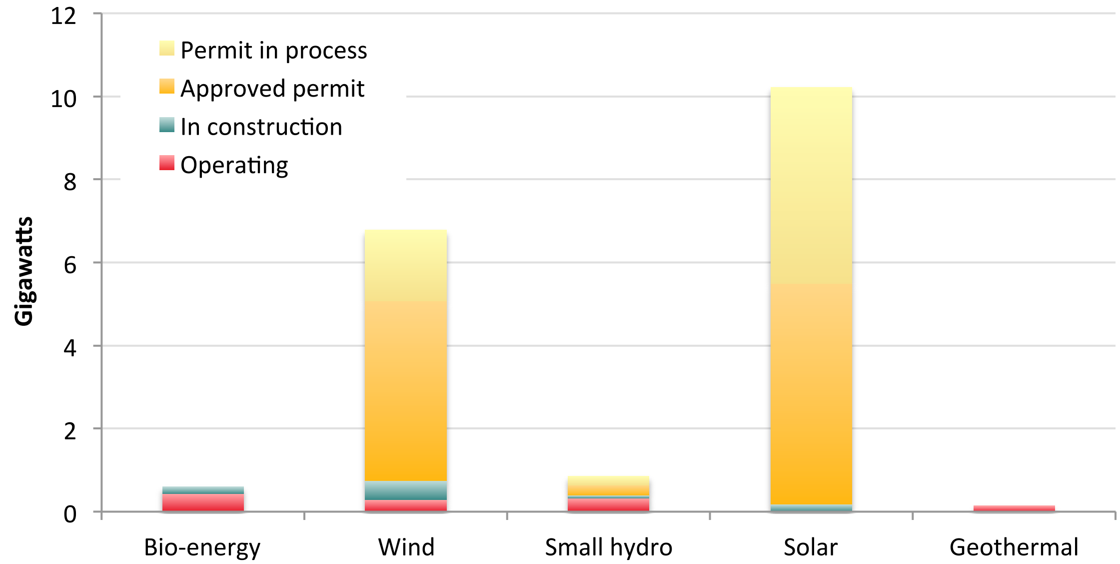
Additionally, PV Grid Parity has already been reached in the residential segment, although to different extents in diverse locations of the country (Eclareon, 2013). For instance, in Santiago, Grid Parity is only partial since PV LCOE is only competitive with the rate applicable to excess consumption in winter. However, in Northern Chile, PV LCOE is not only significantly lower than the rate applicable to excess consumption in winter but, for the most competitive quotations, it is also lower than the standard (non-TOU) electric rates. Moreover, considering that the small-scale PV market in Chile is still relatively immature, there are plenty of margins for further price reductions, which could push full grid parity proximity closer.

At present there are 1,117 MW of NCRE in operation, from which only a small fraction (7.5 MW) are solar projects. However, the pipeline of solar projects shows that this proportion is dramatically changing. Figure 15 shows that there are 128 MW of solar PV projects in construction (of a total of 686 MW of NCRE in construction), and by the beginning of 2014 it is expected that solar PV will reach approximately 200 MW in operation. These projects do not only involve small projects of 1 to 2 MW as it has been the case till today, but also large projects of more than 100 MW.

In the long run, solar prominence in the Chilean power grid will continue growing, considering that more than 50% of the 10,000 MW in new projects that have their environmental permit approved already correspond to solar initiatives. This figure is likely to grow even further considering that there are another 5,000 MW of solar projects that have their environmental permits under review.

Key driving forces behind the solar phenomenon are Law 20/25 (which increases the target for NCRE from 10% in 2024 to 20% in 2025), lower solar PV modules prices, a better understanding and technological acceptability by developers and citizens and a more consolidated foreign market looking for new market opportunities.

Figure 15: State of NCRE Projects, 2013 (MW)



Source: Reporte CER (2014).

4.2 Ownership of the Projects, Providers and Developers

4.2.1 Large Scale Solar PV Projects

According to SEIA and the Renewable Energy Center (CER), there are a number of operational solar projects in place throughout the Northern regions of Chile, and several projects under construction that would be operational in the coming years (CER, 2014). These projects are aimed at generating electric power at a larger scale for both the SING and the northern part of the SIC systems, and should be seen as "first initiatives" of larger plants and have linked projects aiming to expand their capacity in the near future.

Table 5: Current Large PV Electric Generating Projects

Project Name	Cap. (MW)	Investment (US$ million)	Developer	Off-taker	Location (Region)	State
El Águila PV Plant	2.4	7.0	E-CL / SunEdison	Quiborax	XV	Operational
La Huayca I	1.4	2.5	SelRay	Spot SNG	I	Operational
Andacollo	1.3	2.0	Solaire Direct	Dayton Mining	IV	Operational
Tambo Real	1.2	3.0	Kaltemp / Juwi	Spot SIC	IV	Operational
Calama Solar 3	1.0	3.5	Solarpack	Codelco	II	Operational
Subsole	0.3	1.0	Subsole / Kraftwerk	Spot SIC	III	Operational
Amanecer Soar CAP PV Park	100.6	241.0	Sunedison	CAP	III	Construction
Provincia del Tamarugal PV Plant	30.5	-	SelRay	Spot SING	I	Construction
FV Arica I PV PLant	18.0	70.0	Sky Solar	Spot SING	XV	Construction
Pozo Almonte Solar 3	16.0	71.0	Solarpack	Collahuas i	I	Construction
Pozo Almonte Solar 2	9.0	40.0	Solarpack	Collahuas i	I	Construction
El Salvador PV Plant	2.9	-	RTS Energy / Powerway	Spot SIC	III	Construction
Diego de Almagro PV Park	36.0		Enel	Spot SIC	III	Construction
PSF Lomas Coloradas	2.4	-	Coener	-	IV	Construction
PSF Pama	2.4	-	Coener	-	IV	Construction

Source: Author´s work based on RedSoLAC (2013). Note: FV: Fotovoltaico

The developers are generally international enterprises and in many cases they work together with Chilean companies through joint ventures or collaborations. PV projects under construction involve 197 MW, with more than 50% of them corresponding to one project: Amanecer Solar CAP, developed by the US company SunEdison to provide energy to the national mining company CAP.

Regarding the current role of the Chinese solar PV industry in these projects, they act mostly as manufacturers and suppliers of PV modules and less commonly as project developers or EPC companies. Examples of Chinese participation in PV operating projects include the 1.3 MW "Andacollo" plant with Jinko Solar´s PV modules, the 1.2 MW "Tambo Real" plant with Kaltemp as developer and the Canadian Solar (through its Chinese subsidiary) supplying PV modules, and the 1 MW Calama Solar project developed by Solarpack, which involve Chinese and German PV panels.

Considering the projects that are under construction, Chinese presence in the form of PV panel suppliers include Yingli Solar, which supplies 100% of the PV panels involved in Pozo Almonte (23 MW), and ReneSola, which will supply 7.5 MW of solar PV modules to SelRay´s first expansion project to La Huayca and will later provide 21.5 MW once the second stage of this expansion project is approved. Furthermore, the Chinese company ET Solar would also be providing 4.8 MW of solar PV modules to Chilean developers Coener SpA, for the projects "PSF Lomas Coloradas" and "PSF Pama". Lastly, Chinese solar PV project developer Sky Solar, together with the Chilean company Sigdo Koppers, have "Arica I", an 18 MW solar PV plant under construction. The involvement of Chinese companies in the Arica I project is projected to be threefold: a Chinese project developer (Sky Solar), possible Chinese PV panel supplier (unidentified) and project´s financial support from the China Development Bank (CDB).

Financial support from CDB is a common practice facilitating Chinese investment abroad. CDB provides credit lines to corporate entities and supports project financing, specifically to acquire and to develop overseas power plants. CDB also provides credit to overseas buyers of Chinese solar products and to EPC companies building projects overseas, which can catalyze Chinese investments in the host country. In Chile, in addition to the Arica I project, financial support from CDB has been involved in the wind farm Estancia Negrete, developed by the Irish company

Mainstream with technology from the Chinese Goldwind. Moreover, Mainstream is about to start the construction of the 162 MW Parque Pedernales solar plant. The company is currently in process of selecting the EPC who will be later in charge of selecting the PV panel supplier. According to the company, the fact that Chinese technology comes with access to financial resources through the CDB gives it a competitive advantage. Indeed, according to the WRI (2013), it is the access to this capital that has enabled Chinese companies to expand their businesses overseas, without the need for project financing. This makes their investment returns more attractive compared to other developers who have to rely on relatively higher-cost project financing.

More broadly, many solar projects that have been approved or are in the process of obtaining their environmental permits, would have some sort of Chinese involvement, either as suppliers of PV modules or, less commonly, as project developers.

Table 6: Approved Solar PV Projects with Chinese Involvement

Project Name	Capacity (MW)	Investment (US$ million)	Developer	Location (Region)	Status
Diego de Almagro PV Park (Parque Pedernales)	162	420.0	Andes Mainstream	III	Approved
Azapa PV Park	104	210.0	Andes Mainstream	XV	Approved
Solar Sky I	26	78.0	Sky Solar	II	Approved
Solar Sky II	26	78.0	Sky Solar	II	Approved
La Huayca II	21	46.0	SelRay	I	Approved
Planta SF Arica II	15	45.0	Sky Solar	XV	Approved
Planta SF Arica I (expansion)	9	15.4	Sky Solar	XV	Approved

Source: Author´s work based on RedSoLAC (2013).

According to Table 6, the main projects with permits to start construction, and with Chinese involvement, include:

- La Huayca II from SelRay Energias Ltda. will acquire 21.5 MW of multicrystalline solar modules from the Chinese company ReneSola for the second stage of expansion.

- Chinese solar PV project developers Sky Solar plan to install 300 MW of solar PV plants in a period of 3 years with a total investment of US$ 1.3 million. This Chinese company has several approved projects, but there is no further information about the construction plans or about the origins of their supplies.

- Andes Mainstream is working with the CDB for financial support of the Parque Pedernales project; this could lead to further involvement of Chinese solar PV companies. The environmental resolution documents (RCA) of Andes Mainstream´s "Parque Solar Azapa" provide information about the possible use of Chinese PV solar modules for this project.

Summing up, China has become a key supplier of solar PV modules to Chile for large scale projects. However, Chinese incidence in the Chilean PV solar sector goes beyond being a technology supplier; it also plays a role as a contractor (ECP), project developer and as a source of funds for project development.

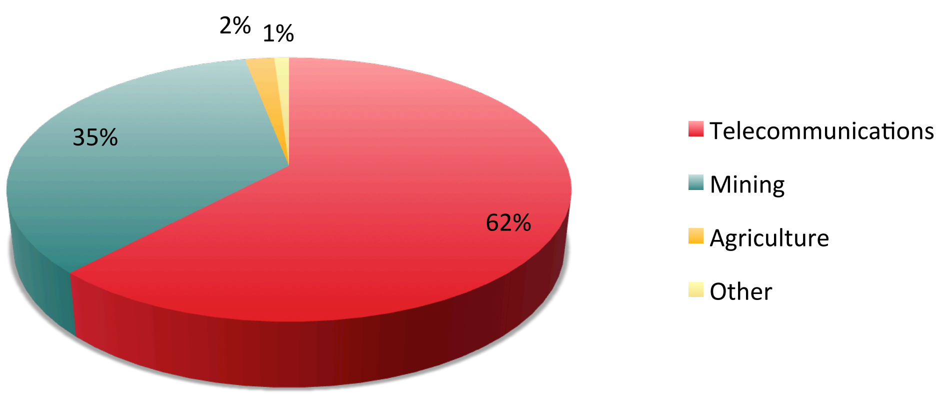
4.2.2 Commercial-Residential Scale Solar PV Sector

The PV market for commercial and residential scale in Chile is still in a very early development stage. Up until 2011 there was a total installed capacity of 904 kilowatts-peak (kWp) for off grid PV systems, and according to the Technological

Development Corporation (CDT, 2012), it will approximately reach2 MW during 2014.

A recent study on the solar PV market in Chile carried out by CDT provides an overview and characterizes the market of commercial and residential scale solar PV in Chile. The main buyers of solar PV equipment for small scale systems in Chile are businesses that focus on NCRE system development, services and commercialization; these include solar PV equipment for residential and commercial scale PV systems. Among the major importing businesses in the small scale solar PV market in Chile are Solener and Heliplast, which have 30% and 22% of total installed small scale solar PV systems in Chile, respectively (CDT, 2012). These businesses develop and commercialize modules mainly for sectors such as telecommunication and mining. There is also a growing demand for smaller systems in the agricultural sector, universities and residences, generally located in the northern regions of the country, which are mostly off-grid systems that do not inject power directly into a grid.

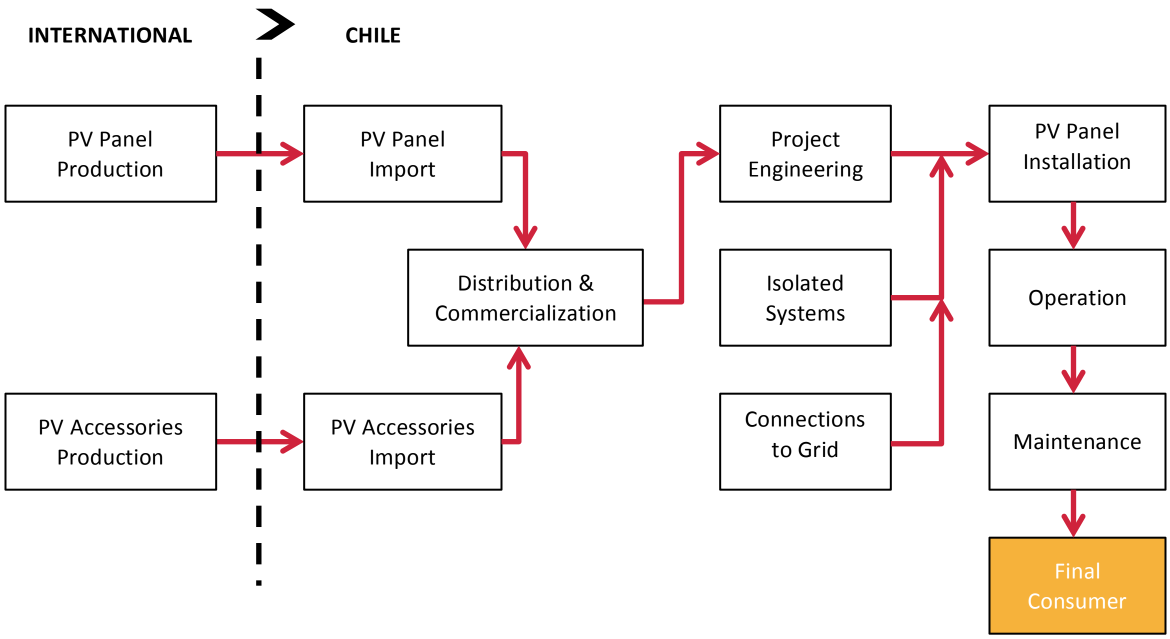
Figure 16: Solar PV Sector Demand



Source: CDT, 2012.

In general, businesses that develop small-scale solar PV module systems in Chile cover the whole value chain, including the supply of cabling and mounting frames. The only exception is the manufacturing of panels, and other equipments such as inverters, which come from foreign companies, such as Kyocera (Japan), Yingli (China), Komaes (China), Sun Tech (China) and Solar Word (Germany). Only few Chilean companies carry out maintenance and other auxiliary services so far.

Figure 17: Small scale solar PV value chain in Chile



Source: CDT, 2012.

The primary imported appliances for the commercial-residential scale solar PV systems in Chile are solar PV panels with mono crystalline modules. Currently there are no local PV module manufacturing companies, and the main importing companies to Chile in 2012 were Kyocera, Suntech, Solarworld and Yingli Energy, representing 72% of total solar PV module imports. By 2013, the Chinese presence has reached53% for PV modules.

Table 7: Importing Solar PV Panel Companies to Chile in 2012

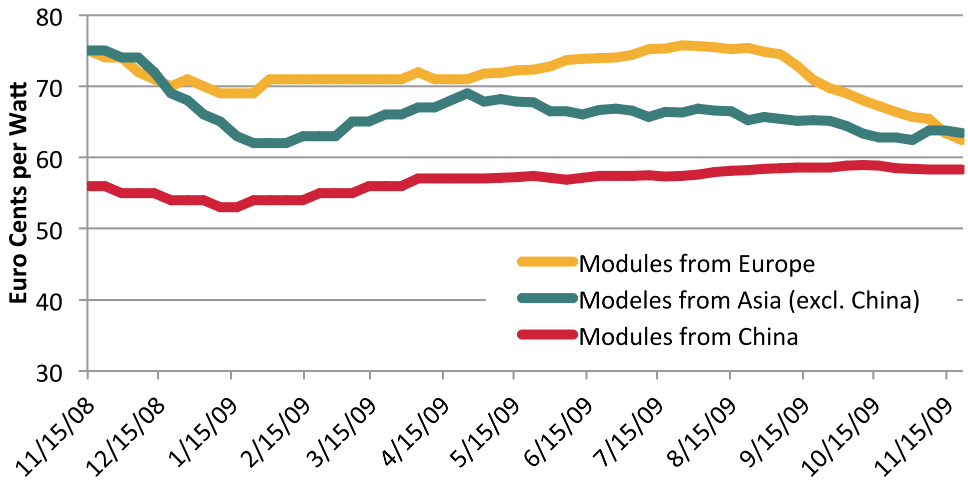
Solar PV Panel Manufacturers	Country	Import Percent
Kyocera	Japan	35.1%
Suntech	China	16.4%
SolarWorld	Germany	12.6%
Yingli Energy	China	8.4%
Sun Wize	USA	2.9%
Beijing	China	2.7%
Solisto	USA	2.4%
Ningbo Komaes Solar	China	2.2%
Other	Various	17.3%

Source: CDT, 2012.

4.3 Costs of PV Solar Panels

A key matter regarding Chinese PV solar panels relates to their lower cost in relation to panels from other countries. Market prices in the German spot market of silicon PV modules show that China has a persistently lower price compared to those from other origins.

Figure 18: German spot market prices for solar PV modules



Source: Author´s work based on Photon module Price index from Photon International Magazine (2013).

The costs depicted in Table 7 (most common modules available, between 100-250 Wp) are the market average of the main brands found in Chile for a smaller scale commercial-residential client.

Table 8: Cost of solar PV in Chile

		Average Cost per Wp		
Company	**Country**	**CLP/Wp**	**€/Wp**	**USD/Wp**
Komaes	China	858	1.08	1.51
Hareon	China	664	0.84	1.17
SolarWorld	Germany	939	1.18	1.65
Kyocera	Japan	1435	1.81	2.52
Ja Solar	China	788	0.99	1.38
Bosch	Germany	1247	1.57	2.19
Schott	Germany	1159	1.46	2.04
Tianwei	China	695	0.88	1.22
OEM	China	603	0.76	1.06

Source: Author´s work based on market costs information from local solar PV commercial distributors (2014).

The first noticeable matter is the significant amount of PV module alternatives from Chinese origins. In terms of the costs of solar PV modules in the Chilean market, there is a significant difference between Chinese PV modules and those from

Germany or Japan. The analysis shows that Chinese modules' prices are between €0,76 and €1,08 per watt, while those from Germany rank between €1,18 - €1,57 per watt and Japanese between €1,69 and €1,99 per watt.

4.4 Technology and Quality Standards

There are several relevant international standards for PV technology that support longevity, safety, and related market guarantees of solar PV panels worldwide, from certification laboratories such as TÜV Rheinland PTL or Intertek among others. Among key conditions to make a large scale PV solar project bankable is that the selected technology complies with specific quality standards and technical guarantees, and that these modules come from Tier 1 manufacturers. Generally, in the case of project finance this is reflected is a reduction in the revenue return risk borne by equity investors and, debt servicing risk borne by lenders. Common conditions for long-term energy guarantees from EPC contractors are up to 5 years. Longer-term guarantees are not commonly available from EPC contractors; however, insurance products that offer longer-term guarantees are available (WSGR, 2012). In terms of module manufacturers, 5+ year term product warranties are quite common. Furthermore, a non-compliance of these standards and guarantees is a key barrier to attain project finance for solar PV projects.

Cases of non-compliance to international standards and guarantees by some Chinese solar PV companies have created controversy so far. The certification laboratory TÜV Rheinland has followed up and publicly listed different solar PV products and companies that make use of unauthorized TÜV labels (see table 10)[3]. Even though large global Chinese PV technology companies comply with the main

[3]Complete TÜV Rheinland blacklist (available at: www.tuv.com/en/corporate/business_customers/product_testing_3/blacklist.html)

standards, noncompliance is still an issue among many smaller Chinese PV manufacturers, many of which target the Chilean residential and commercial segment. The problem is exacerbated by the fact that there are only a few distributing and NCRE institutions intervening in the selection of the technology, leaving clients unprotected. Although in Chile there is no evidence of activities or products from companies on the TÜV Rheinland blacklist, such as Sungold Solar and G&P New Energy, this is still an issue that need to be followed.

Table 9: Unauthorized labeling of Chinese solar PV panels

Product/Type/Brand	Importer/Manufacturer	Type of Misuse
Solar Products	Dongguan Changan Hengpu Hardware Products Factory No. 1, West First Street, Xingfa South Road Wusha Liwu Sixth Industrial Zone Chang'an, Dongguan, Guangdong, China	Unauthorized labelling, TÜV Rheinland trademark
Solar Panel SGM-200W	Shenzhen Sungold Solar Co., Ltd. Weentao Industry Park Yingrenshi, Shiyan Town Shenzhen, Guangdong, China	Unauthorized labelling, TÜV Rheinland trademark
Solar Panel GPM-xxx	Zhejiang G&P New Energy Technology Co., Ltd. West Industrial Zone Yongkang, Zhejiang, China	Unauthorized labelling, TÜV Rheinland trademark
Silicon Solar module	Bol Photovoltaic Technology Co., Ltd. Building 4, No. 18 Songshan Road Huimin Street, Jiashan County Jiaxing, Zhejiang, China	Unauthorized labelling, TÜV Rheinland trademark
Solar Panel HPSM-200W	Shenzhen Hopesun Tech. Co., Ltd. C1626, 16/F, Niulanqian Building Minzhi Road, Minzhi Street Bao'an District, Shenzhen, Guangdong, China	Unauthorized labelling, TÜV Rheinland trademark
Solar Panel CNCBxxx, CNCCxxx, CNCK-xxx	Ningbo Zhenhai Geebo Electronics Tech. Co., Ltd. Zhongguang West Road 777# Ningbo City, China	Unauthorized labelling, TÜV Rheinland trademark

Source: Author´s work based on TÜV Rheinland blacklist (www.tuv.com/en/corporate/business_customers/product_testing_3/blacklist.html)

Currently, there are no national regulations that require certifications or standards for solar PV modules in Chile. Requirements of existing international standards are only regulated by the market. Due to the absence of national regulations, financial institutions play a key role especially regarding large PV power plants. All major large-scale solar PV projects in Chile have been supported, until this writing, through multilateral financing institutions, which can take on greater risk in terms of guarantees than local Chilean financing institutions can afford to take at present. Due to the fact that solar PV projects are still in an early stage in Chile, there are questions about the actual role of local financing institutions on how to minimize solar PV project risks regarding financial guarantees. Local banks are developing some ideas to support future solar PV plants, possibly firstly through pilot projects with a capacity equal or above 3MW (a lower MW capacity is not iable under the project finance system used by private banks). These solar PV pilot projects would assist local institutions in understanding more about the guarantees and standards of this sector, and could lead to opening up more support to develop future projects. There is also the possibility of a bank association able to finance future large solar projects.

Therefore, there are at least three elements of risk for relying on Chinese manufacturers:

- The bulk of the segment - especially the residential sector- has no information regarding the existence of international standards and guarantees, and thus they do not enforce compliance by the supplier.

- There have been cases where Chinese PV panels and related products have entered markets with unauthorized labels and certifications.[4] As mentioned, above there are many cases of solar PV panels with unauthorized labels in the TÜV Rheinland blacklist. This list shows many solar PV products from different Chinese companies[5].

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[4]Information gathered from the interviews.

[5]Complete TÜV Rheinland blacklist (available at: www.tuv.com/en/corporate/business_customers/product_testing_3/blacklist.html)

- The current restructuring process of the Chinese solar PV industry (see section 5.3) has led many Chinese producers to struggle for survival with many of them going into bankruptcy, leaving project developers using that technology under uncertainty about who will be accountable for the respective quality standards and guarantees.

4.5 Environmental Impacts of Solar Plants

Although it is generally considered that solar PV technology has mostly beneficial impacts on the environment, research also points out several potential impacts that must be taken into account when referring to this technology. The main environmental impacts considered from solar PV technologies are detailed below.

4.5.1 Extensive Land Use of Large Scale Solar PV Plants

Larger scale solar plants are raising concerns about land degradation, habitat loss and/or archaeological value. Total land area requirements vary depending on the technology, geography of the site, and the intensity of the solar resource. Estimates for solar PV systems need approximately one square kilometer for every 20-30 MW of generated electricity, and the land could have a secondary alternative use (EPA, 2011). A study comparing a solar PV installation to a coal power plant concludes that a 30-year old PV plant is seen to occupy approximately 15% less land than a coal power plant of the same age, mainly due to the disposal of solid residues of coal power plants. As the age of the power plant increases, the land use intensity of PV power becomes considerably smaller than that for coal power (Turney & Fthenaki, 2011). Land use impacts from large-scale solar systems can be minimized by setting them at lower-quality locations such as brownfields, abandoned mining land, or existing transportation and transmission corridors. Smaller-scale solar PV modules, at homes or commercial buildings, which in most cases can be built on rooftops, have minimal land use impact.

According to the inventory of operating solar PV plants in Chile, the land use for these types of installations reached 0.03 km^2 in 2013 with a total capacity of 3.7 MW, and is expected to reach 1.62 km^2 assuming a total capacity of 200 MW during 2014. Under an scenario where solar PV installations reach 2,033 MW in Chile by 2030, the land use involved would be 28.5 km^2, representing around 5% of the total land used by both SIC-SING grids (EE2030, 2013).

Most of the PV plants are and will be located in desert, brownfields and unused areas in the North of the country, having a minimal land use impact. However, the danger of an archeological loss or damage has gained increasing attention recently. This risk has been rising, given the planned growth in this sector -increasingly linked to technology and development from Chinese companies. This creates a need to carry out proper due diligence in solar PV projects in order to avoid or minimize this potential impact.

4.5.2 Life Cycle Greenhouse Gas and Other Air Emissions

Even though there are no global GHG emissions involved in the power generation from solar PV technology, there are GHG emissions related to the life cycle of solar PV panels, specifically in the processes of raw material extraction, manufacturing, materials transportation, installation, maintenance, and decommissioning and dismantlement (IPCC, 2012). The stage where more emissions are generated is in the upstream processes, such as raw material extraction and module manufacturing, reaching between 60-70% of the total emissions of solar PV technology (NREL, 2012). Among the solar PV cells with higher GHG emissions are the widely used Mono-Crystalline and Poly-Crystalline Silicon technology (IPCC, 2012). According to an analysis comparing life cycle air emissions of different solar PV technologies, thin-film CdTe technology has the lowest air emissions (CO2eq, NOx and SOx) of the main solar PV technologies (Environment Canada, 2010).

Table 10: Estimated Life Cycle GHG and Air Pollutant Emissions

Region	GHG Emissions Associated w/ Fuel Mix (CO2 eq, g/kW h)	Technology	GHG Emissions (CO2 eq, g/kW h)	NO_X (mg/kW h)	SO_X (mg/kW h)
Western Europe	484	Multicrystalline	40-50	75-85	125-150
		Multicrystalline	40-50	80-85	140-160
		CdTe	15-25	35-45	50-90
United States	678	Multicrystalline	50-60	157-185	350-375
		Multicrystalline	50-60	180-200	360-390
		CdTe	20-30	75-85	150-175

Source: Environment Canada (2010).

The total life cycle emissions of GHG (CO_2eq) have been reported to be between 28 and 72.4 g/kWh for crystalline silicon, and 18 to 20 g/kWh for thin-film CdTe (Environment Canada, 2010). This is mainly due to the amount of energy required to manufacture the crystalline silicon panels. The GHG emissions related to the life cycle of the panels would also vary according to the utilized source of energy, as it is different depending on the country and the power grid. However, research indicates a trend towards declining GHG emissions for three types of silicon technologies (mono-crystalline, ribbon and poly-crystalline) (Alsema, 2006). Alsema (2006) predicts that life-cycle GHG emissions could drop to 20 g/kWh for crystalline silicon technologies.

As for Chile, it is estimated that the emission factor related to solar PV technology is 48 tCO_2eq/GWh. These emission levels are lower than those of natural gas-fitted power plants (IPCC, 2012). Furthermore, PV insider (2014) research shows that solar PV plants operating in Chile reduced the national GHG emissions by 2.2 million $tCO_2eq$for 2013 and it is expected to reduce it by at least an additional 4.4MM tCO_2eq for 2014 (PV Insider, 2014).

In terms of life cycle emissions from solar PV panels, Chile might need to start considering the indirect emissions from the shipment and manufacturing processes of Chinese PV panels. Currently, theses PV panels could have a significant carbon footprint due to China´s highly carbonized energy grid and large distances transported. Even though this impact is arguable, considering that the benefit of clean energy produced by these panels could be greater than the energy needed to produce them, the PV panel´s footprint itself can still be improved with local participation like storage and assembly.

4.5.3 Hazardous Materials in Solar PV Technology:

The PV industry uses some toxic and explosive gases, as well as corrosive liquids in its production lines. The presence, amount and type of chemicals used depend on the type of PV cell. In general, many hazardous materials used are applied to clean and to purify the semiconductor surface such as hydrochloric acid and sulfuric acid (NREL, 2012).

Thin-film PV cells contain many more toxic materials than silicon PV cells, such as gallium arsenide and cadmium-telluride. If not handled and disposed of properly, these materials could pose serious environmental and public health threats (IPCC, 2012).

However, even though hazardous chemicals can be found in solar PV technology, these are in significantly smaller proportions than other energy sources; for instance, activities for solar PV technology emit 30 times less mercury and 150 times less cadmium than those generated by coal plants (Turney & Fthenaki, 2011). Furthermore, the PV industry has a strong financial incentive to recycle these highly valuable but hazardous components, forcing the use of rigorous control methods that minimize the emission of potentially hazardous elements (IPCC, 2012).

In Chile, most solar panels installed today are silicon crystalline cells, while only a small amount of the PV modules being used are thin film cells (CDT, 2012). Moreover China´s PV industry manufactures mainly silicon technology cells (REN21, 2013). In terms of the environmental impacts of hazardous materials from PV products, the larger use of silicon PV technology in Chile –with most of them coming from China- can be considered a positive aspect as this technology utilizes less hazardous materials in its activities or components.

5. Chinese Global Prominence and Its Solar Energy Policies

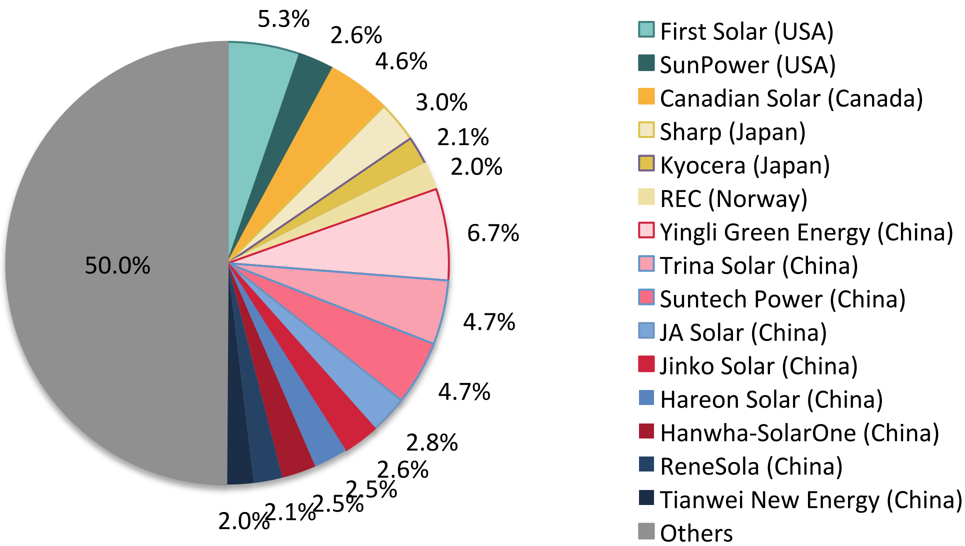
Like in other renewable energy sector worldwide, the solar market in China has been developed thanks to ambitious national policies with strong domestic support. China, like many other countries, has sought to promote their renewable energy sector in order to achieve several strategic policy goals, including energy security, a low-emissions development path, and an industrial pole that generates high-quality jobs. By its very nature, these policies have important feedback effects on employment and international trade.

5.1 Chinese PV Production in a Global Context

The development of the PV industry in China started at the beginning of the new millennium, growing quickly from 8% of the global PV market in 2005 (Zhao et al., 2006) to more than 30% in 2012 (REN21, 2013).

In contrast to other NCRE, China's PV industry has predominantly been oriented to the export market, with cell and module manufacturers exporting more than 95% of their products (Zhao et al., 2006). This export growth has also been fuelled by favorable energy policies among wealthy countries, in particular from countries like Germany, Spain, Italy, and the USA and, more recently, also from some emerging markets. In order to support their exports of solar modules and cells, competitive Chinese companies have embraced practically the whole of the solar value chain in these countries, providing manufacturing, engineering, procurement and construction (EPC) services and even developing solar PV plants(Tan, Zhao et al., 2013). China has rapidly vaulted to the top of global solar cell manufacturing capacity, as reflected in the fact that that 9 Chinese manufacturers rank among the top 15 global solar PV module manufacturers.

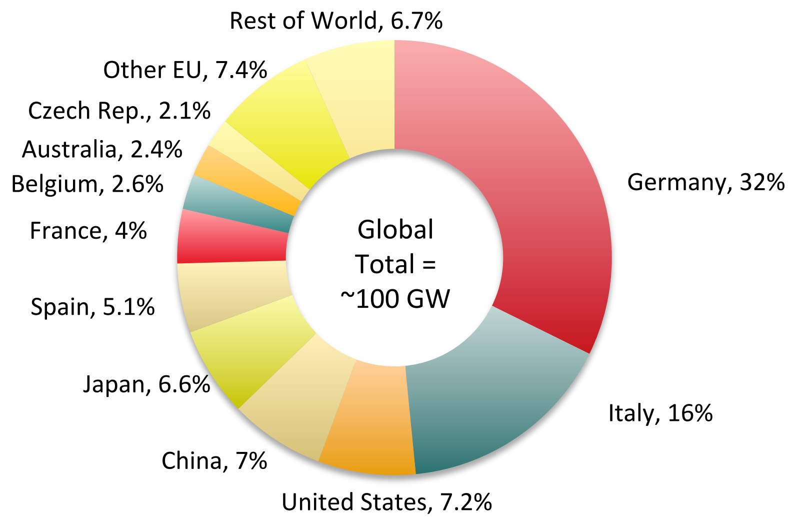
Figure 19: Solar PV, Top 15 Global PV Module Manufacturers 2012



Source: REN21 (2013)

The strong export orientation of the Chinese solar industry is also reflected by its relatively small solar installed capacity: about 7 GW, or 7% of global installed capacity.

Figure 20: Solar PV Global Installed Capacity, Top 10 Countries 2012



Source: REN21 (2013).

However, according to forecasts from REN21 (2013) this global picture is changing, as installed capacity in China is expected to accellerate (REN21, 2013). China plans to add 10 GW of solar capacity each year from 2013 to 15, with a goal of 35 GW of installed solar power capacity by 2015.

REN21 (2013) states that China's aggressive PV sector growth in 2010 and 2011 resulted in an excess production capacity and supply. Combined with extreme competition, this drove prices down in 2012, yielding smaller margins for manufacturers and spurring continued industry consolidation. The average price of crystalline silicon solar modules fell by 30% or more in 2012, contributing to an 80% fall between 2008-2013 (Bloomberg New Energy Finance, 2013), while thin film prices dropped about 20% in 2012 (REN21, 2013). This situation, together with the global economic crisis, meant that many competitors, especially from Europe and the USA have started to struggle and even to close down their operations. As a result, main solar PV associations from both the USA and the EU have raised accusations against Chinese manufacturers for unfair trade practices, and brought cases to the WTO, resulting in antidumping measures (see section 5.4).

The economic crisis that lead to declining subsidies to the European solar market, the fall in prices of PV modules, driven by the Chinese oversupply, together with trade measures, have caused domestic Chinese solar manufacturers to scale back production, lay off workers, and some even to stop operations completely (Stones & Associates, 2011)[6].

This entire situation has prompted China to change its policies with respect to the solar industry, from one oriented solely toward incentivizing exports, to one with two main goals: to stimulate its domestic demand, and to push companies to invest and to develop markets overseas.

Even though main global solar associations from the EU and US complained against the Chinese production, downstream national producers from these countries have seen important benefits from the fall in global prices driven by the Chinese production, as many of them use Chinese cells as part of their overall manufacturing processes, especially those in the commercial and residential rooftop segment (Bridges, 2013a)

The recent global crisis, the over-production of PV panels by China, and the associated fall in PV prices have led to changes in the solar industry. Indeed, while during the past 5 years the focus of the industry has been on module cost reduction, it is now about reductions in the balance of systems costs. This includes the cost of inverters, hardware, customer acquisition and financing costs. At the same time, this has been leading to the consolidation of the global industry, with no clarity yet about which enterprises will survive. Under this scenario, many Chinese

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[6]For example, Suntech Power has recently announced its bankruptcy (Bradsher, 2013).

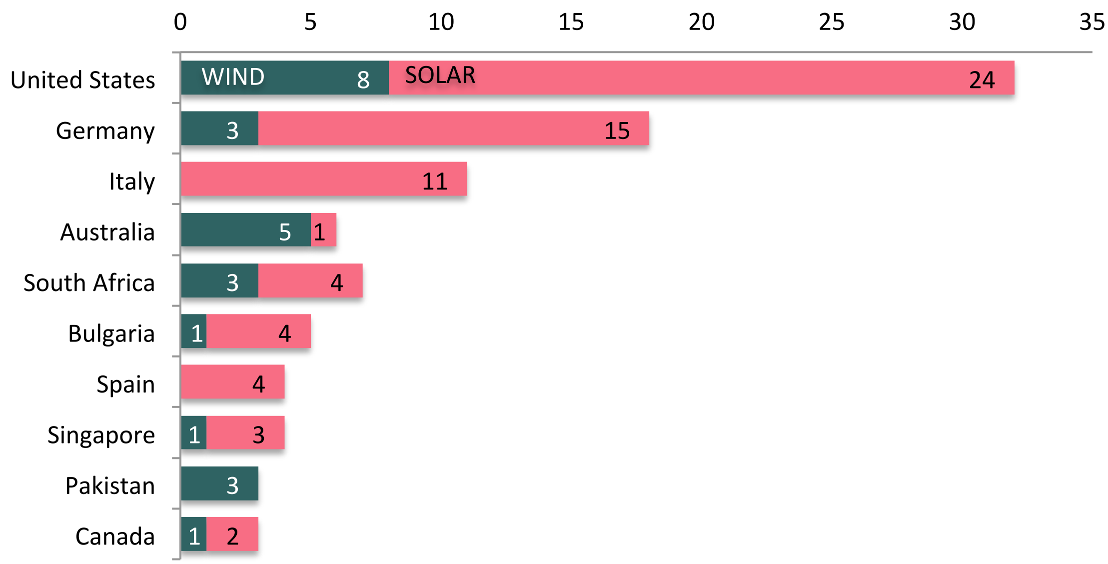
manufacturers who were facing debt and overcapacity have been struggling. The Chinese government, who supported the creation of several manufacturing giants, such as LDK Solar Co. (LDK) and Snitch Power Holdings Co. (STP), is now pushing for the consolidation of the Chinese market, to just 10 or 20 major international players.

Forecasts for the industry are optimistics. Bloomberg (2013) argues that after several years of painfully low pricing for manufacturers, prices across the value chain are stabilizing. Deutsche Bank outlooks state that surging domestic demand in China, Japan and the USA may underpin a "second solar gold rush" (Deutsche Bank, 2014). By 2014, annual global solar installed capacity is expected to increase by 46 GW, and by an additional 56GW in 2015. A key point behind this outlook is the spread of grid parity. As of 2014, solar power is competitive without subsidies in at least 19 markets globally, and Deutsche Bank expects more markets to reach grid parity by 2014, as solar system prices decline further.

5.2 Chinese solar FDI in the world

Declining subsidies in the European solar market, together with trade sanctions, have decreased demand for Chinese solar products. As a result, direct investments overseas are seen as a way of retaining and expanding market share, typically through creating demand for the export of products. As such, China is also increasingly becoming a global force in international clean energy investment. The country has provided at least 124 investments to other countries' solar and wind industries, summing up at least US$40 billion over the past decade.

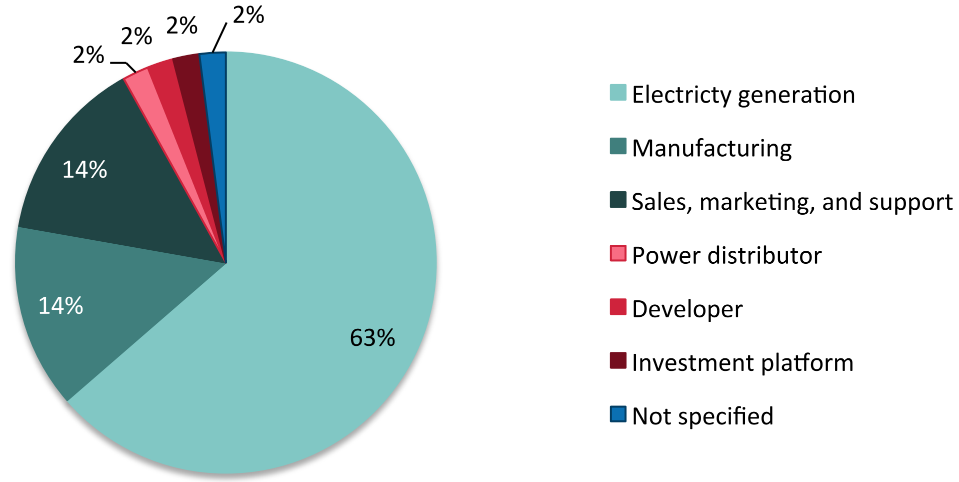
Figure 18: Number of China´s Overseas Investment in Solar and Wind Industries in Top 10 Destination Countries, 2002-2012



Source: Tan et al. (2013).

More than 90% of China's investments in the solar industry were made by companies performing three functions: electricity generation; sales, marketing and support; and manufacturing. Nearly half of the 83 investments were made in new photovoltaic (PV)-based electricity generation plants, either as greenfield investments or through joint ventures.

Figure 22: Percentage of Solar Investment by function



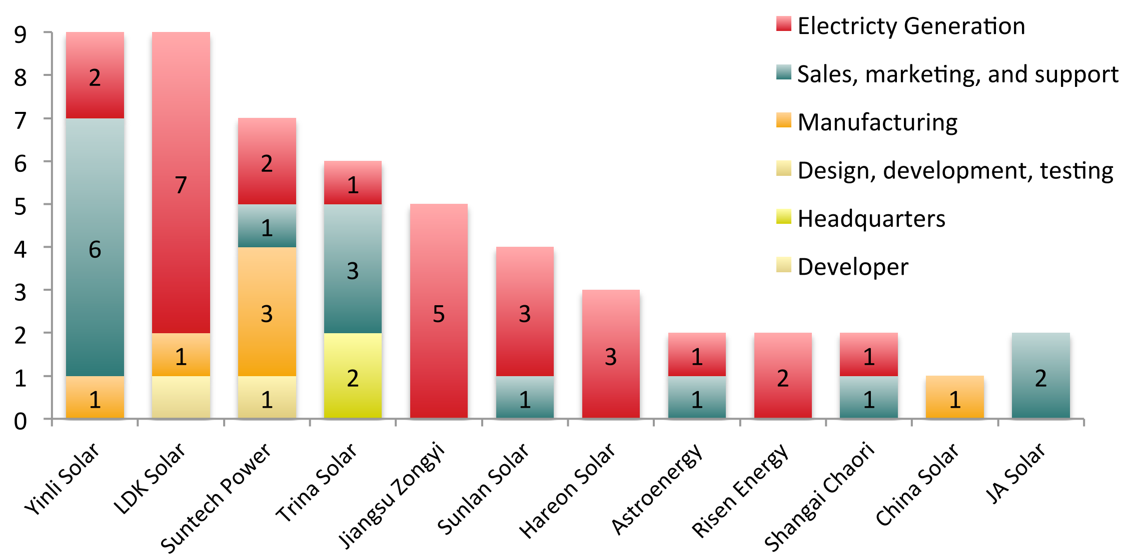
Source: Tan et al. (2013).

In a few cases, Chinese solar companies have also invested in ancillary industries in the supply chain. In 2008, Suntech Power partially acquired KSL Kuttler in Germany to gain new production technologies and localize production. In 2011, China National Bluestar Company acquired the silicon operations of Norway's Elkem to enhance competitiveness in the industry. Also notably, while most Chinese companies have been using first-generation crystalline silicon PV cell technology, a few of them acquired USA companies to access second-generation thin-film PV cell technologies. China Solar Energy Holdings Ltd. has acquired stakes in two companies: 100% in Thin Silicon Inc. and 51% in Terra Solar Global Inc.

In December 2013, JA Solar opened a sales office in Chile, with the view to supply the South American market. In contrast, relatively smaller companies like LDK Solar, Jiangsu Zongyi, Sunlan Solar, and Hareon Solar put most of their overseas investments into building solar power plants worldwide. Thus, it appears that the top solar exporters set up foreign subsidiaries mainly to support the export of their Chinese manufactured products.

Many would see this strategy as a good way to keep the Chinese industry competitive in the current round of global consolidation. Forbes (2013) argues that Chinese solar manufacturers that are focused on silicon technologies or newer thin-film entrants can significantly improve their existing technology through acquisitions of innovative or even disruptive technologies from Western countries. Forbes sustains that Chinese manufacturers are also well positioned to bring down production and research costs and accelerate a move towards an era expected in 5-7 years, when solar energy will not require any subsidies to be profitable.

Figure 19: Functions of Investments by Chinese Companies with Multiple Investments



Source: Source: Tan et al (2013).

5.3 Chinese Policies towards the Solar Industry

Key factors behind the growing global prominence of China's solar industry include domestic policy incentives in host countries that attract Chinese companies, and Chinese financing from Chinese banks.

China's solar industry relies largely on the international market. This has been enabled by a "push" from the Chinese government to develop these strategically emerging industries and address the problem of excess capacity, enabling support from China's financial sector through access to abundant and relatively low-cost capital, and measures by host country governments to "pull" (attract) investments.

The Chinese government has taken several steps to "push" its renewable industry overseas, with a clear objective to combat domestic oversupply, in the recognition of the fact that this industry offers an opportunity for them to compete internationally.

The first direct major policy "push" for the industry to invest overseas came in September 2009 when the government issued a circular to "curb excess capacity and redundant construction in several industries and promote the healthy development of industries" (State Council, 2009). This, coupled with declining subsidies in Germany, Spain, Italy, and other major markets, hit their domestic solar industries, providing an opportunity for Chinese companies to invest in these markets since they were known to accept lower returns. In October 2010, the State Council gave the strategic emerging industries a further impetus to go overseas, targeting seven priority industries including new energy – nuclear, solar thermal, solar PV, wind, smart grid, and biomass (State Council, 2010). A year later, the Ministry of Commerce of the People's Republic of China (MOFCOM) provided guidelines to the solar industry, to acquire key technologies to enhance international cooperation and to build power plants overseas to restructure its exports (MOFCOM, 2011a). Further guidance was expected from the "New Energy Industry Development Plan" that was approved in 2012 (Xie, 2010)

Box 3: Chinese Government incentive programs to incentivize overseas solar investment

2012:

- 12th Five-Year Plan for the Solar Photovoltaic Industry
- Draft 12th Five-Year Plan for Renewable Energy Development
- 12th Five-Year Plan for Strategic Emerging Industries Development

2011: Guidelines on Enabling Strategic Emerging Industries to Go Overseas, encouraging renewable energy industries to acquire key technology overseas.

2010:

- Decision of the State Council on Accelerating the Fostering and Development of Strategic Emerging Industries, including solar PV and wind.
- Opinions on Promoting Healthy Development of the Wind Equipment Industry, called for internationalization.
- National Law for Renewable Energy amended, guaranteed electricity generated from renewable sources to be purchased in full amount.

2009:

- Curbing Excess Capacity and Redundant Constrution of Several Industries and Promoting Healthy Development of Industries, including winde equipment and polysilicon.
- Notice on Policy to Improve Grid-Connected Power Pricing for Wind Power, set feed-in tariff for wind.

2008: Renewable Energy Development under the 11th Five-Year Plan published; National Renewable Energy Development Fund established.

Source: Yan et al. 2013.

During the last few years, China has been prompted to foster market development. A key policy promoting development of its domestic market is the setting of a national target of sourcing 15% of its energy mix from renewables by 2020 and 30–45% by 2050.

Box 4: Chinese Government Incentive Programs for Developing its Domestic Solar Market

Program	Structure
Concession for grid-connected solar PV plants	Before setting fixed feed-in tariff, reverse bidding for PV concession was implemented. About 130 MW of projects were approved in 2009; 280 MW in 2010; 500 MW in 2011.
"Golden Sun" demonstration projects	The program is designed to subsidize 50-70% of the initial costs of connected solar PV power plants. First tranche of the program supported 294 projects with total capacity exceeding 632 MW.

Source: Tan et al. 2013.

An additional but interrelated factor enabling the mainstreaming of the solar industry abroad has been access to abundant and relatively low-cost capital provided by Chinese financial institutions, especially the CDB, which has enabled Chinese state owned enterprises (SOEs), and to a lesser extent privately-held solar and wind companies, to invest overseas. Financing has been available through lines of credit to corporate entities and as project financing, specifically to acquire and to develop overseas power plants. It has also been available as credit support to overseas buyers who import Chinese wind and solar products and to EPC companies building projects overseas, which can catalyze overseas investments. Access to other available capital allowed Chinese companies to expand their businesses overseas on their balance sheets, without the need for project financing, which makes their returns on investments more attractive than European and USA market developers. These include the US$46 billion "green stimulus" package announced in 2009, US$ 5.9 billion from the capital markets in 2009 through initial public offerings (IPOs), and Chinese government loan guarantees worth US$36 billion in 2010.

5.4 Solar PV Domestic Policies and Trade conflicts

Chinese support policies to its national solar industry have been the source of trade conflicts. The most relevant trade disputes against the Chinese solar industry relate to dumping and receiving unfair policy support from the government. Both cases were raised almost in parallel during the last few years, led by the respective main solar association industries of the EU and the USA. While main solar associations seek to protect larger domestic manufacturers, downstream producers are against imposing duties on foreign-made cells, as they will raise costs for national producers that use these cells as part of their overall manufacturing processes.

Trade conflicts involving PV panels from China are inserted in an old discussion about the impacts of domestic policy support to renewable energy industry and how countries should best foster the development of renewable energy. Many countries devote policy incentives to their renewable energy industries with the aim of creating new markets and high-quality jobs. Most of these incentives contain measures related to local content requirements or restrictions, which are increasingly used as policy tools to achieve green growth (Kuntze et al. 2013). They are controversial due to their protectionist nature and discrimination against foreign producers, which have important consequences on employment and international trade. A crucial element behind current discussion is the cost-effectiveness of local content requirements, the context where they are useful and legality under the trade regimes (Kuntze et al., 2013).

6. Key Emerging Issues and Policy Implications for Chile

The Chilean energy crisis has triggered a complex situation for the Chilean power sector. The lack of natural gas has been remediated by introducing other imported inputs: more polluting and/or more expensive sources of energy, such as coal and oil. The carbonization of the electricity mix, together with the push of new investment projects of large hydropower dams located in Southern areas of the country, have been the source of criticisms from different sectors of the society, resulting in legal actions that have contributed to paralyzing the construction of new power projects.

Under this scenario, renewable energies could play a vital role in achieving the challenge faced by the Chilean power sector: a cleaner, lower-cost and more socially legitimate energy portfolio.

Besides the exceptional high solar radiation conditions and land availability in the desert areas, there are key features behind the recent development of solar power in Chile. From a regulatory angle, Law 20/25 represents a key factor in the development of NCRE. Likewise, the implementation of the Law of Net-metering will play a key role in driving solar power, at a residential and commercial scale in Chile. Likewise, the dramatic reduction in the costs of PV technology worldwide implies that in certain areas in northern Chile and under certain conditions of transmission costs, solar energy generation has already reached grid parity.

Solar power may have an important impact on the way energy is generated and used, making it a catalyst for the transformation of the whole of the power industry. Solar energy is not only suitable for large-scale utility projects, but new developments in solar technology at the commercial-residential scale appear increasingly likely to give consumers the option of generating their own power. Moreover, the eminent characteristic of solar power, being its intermittency, constitutes a potential catalyzer for investments in new types of storage technology, smart grids, electric vehicles, and other innovations.

Under this positive scenario, Chile might develop its national solar sector to achieve strategic policy goals, including energy security, sustainable development, a low-emissions development path, higher quality of life in rural and urban areas, and industrial development based on high-quality jobs. In pursuit of these goals, national policies and regulations involving some selective domestic support will have to be developed and implemented, and existing practices and regulations will have to be analyzed with regard to their effect towards this goal. It is in this context that Chinese involvement in the Chilean solar industry acquires its relevance.

The analyzed evidence suggests that the presence of China in Chile has been threefold so far. First, Chinese companies are relevant players in the pipeline to become project developers. Second, Chinese companies are PV panel suppliers. Third a significant number of projects receive project financing through the CDB.

The first may imply more international presence in the country, and a real contribution to comply with the Law 20/25. The second has helped to increase the range of suppliers, and to have access to cheaper PV panels. The third element has contributed to financing NCRE projects in Chile, as local financial institutions are still not well-developed to support and to finance these types of initiatives. This is a window of opportunity for Chile, but the short-run benefits have to be weighed against the dependence on imported supply, the lost opportunity for industrial development, and quality risk and environmental impacts.

All in all, the Chilean model to maximize benefits related to developing its solar industry should embrace the following pillars:

- Selective industrial policy
- Standards for the Solar Sector
- Education and capacity building among all stakeholders involved in the solar industry.
- Reduction of existing barriers to solar projects

6.1 Selective Industrial Policy

Given that Chile is not a solar manufacturer, and given its market-oriented energy policies, it encounters the Chinese policy impacts in a very different way than other countries with established PV manufacturing bases. In particular, access to low-cost PV cells and modules for the development of solar power plants may open a window of opportunity for Chile and could help solving the current energy crisis, providing lower-cost solutions, curbing carbon emissions and other environmental impacts, and reducing social conflicts around energy investments.

On the other hand, as solar energy becomes a crucial element for the future of energy strategies in Chile and a potentially interesting sector for industrial development, Chile has to confront the question of the potential long-term effects of the Chinese involvement in its domestic industrial development. This development will be influenced by Chile´s ability to compete against Chinese solar industry products, which have been subject to significant and highly volatile subsidies. It also involves questions of quality, guarantee and environmental issues around solar technology imported from China, which has to be considered when aiming to create a solid, growing and long lasting solar market and industry in the country.

Despite the potential for the development of the solar industry, as of this writing Chile has not established a clear and solid solar industrial policy, and still lacks a national vision with concrete goals and a strategic action plan to foster solar industry development.

So far, Chile has not proved to be competitive in the manufacturing of solar panels or cells. The maturity reached by the technology at the global level, together with the high costs involved in local production, suggests this is not a viable path. However, an industrial development for the solar industry in Chile goes beyond panel or cells production. It involves a wide range of goods and services for which Chile may present development opportunities. In the short term, experts agree that there are immediate opportunities in the production of several goods and services for grid-connected PV projects including: resource measurement; construction of control houses; maintenance of PV panels and the provision of copper wires needed by grid-connected solar projects both for the national and other Latin-American markets. In the longer term, as utility-scale solar projects and the industry itself develop, Chile may become a pole of solar energy exports to neighboring countries. In the residential-rooftop segment main opportunities lie in marketing, installation, and maintenance of solar systems.

In this scenario, policy makers could play an important role in creating the enabling environment, technical capabilities and education across the value chain to foster solar development. This should not only involve capabilities along the value chain but also within the public sector, so as to create adequate counterparts in this process. There have been some positive signs with the government taking some steps, however still rather hesitantly and sporadically, towards initiating a more systematic approach, including:

- The creation of the Research Centre for Solar Energy (SERC-Chile) in 2013 with public funding by CONICYT.[7] Its main objectives were to further scientific knowledge and training; to educate, inform and interact with citizens and with those responsible for public policies, regarding the use, importance and potential of solar energy; and to facilitate technological transfer programs through private-public projects, among others.

[7] National Commission for Scientific and Technological Research.

- Creation of a company-driven International Center of Excellence on Solar Energy and Energy Efficiency, by the French/Belgian group GDF SUEZ-LABORELEC, with the support of Chilean government funds, through CORFO. The main objective is to become a center for research and development for renewable energies that could be a reference for Latin America.

- The Fraunhofer Institute for Solar Energy (ISE) established in 2013, and partially financed by CORFO and the Ministry of Energy. Its main objective is to develop market-oriented solutions in sustainable energies, with a main focus on solar energy.

- Initial studies started in 2014 to foster a cluster of solar energy in northern part of the country promoted by the Ministry of Energy. The studies, to be carried out by the Energy Centre of Universidad de Chile, aim to create a system of collaboration and synergies among various Chilean solar PV industry stakeholders; to assist project developers, financial institutions, and consumers in obtaining a deep comprehension of the resource; and to identify the solar technology barriers and opportunities. The cluster should also promote coordination and engagement in agreements for the transmission and distribution of solar energy, and it should permit the development of local expertise in maintenance and complementary services in the solar PV sector.

- Moreover, the new government just released its “Energy Agenda 2014-2017”. A key focus of the agenda is to promote a “I&D Program on Solar Energy,” which looks to stimulate innovation and selective industrial-based solar developments, including the development of a solar technological road map, a closer collaboration among key stakeholders (government institutions, the above-mentioned Centers and the private sector), as well as new tools and financial resources.

In this scenario, Chile could eventually become a platform for the solar market oriented towards both local and in Latin American markets in the near future. Chile could thus seize the opportunity of rapidly developing its solar industry, and enjoying second-mover advantages in the industry with respect to the rest of the region.

6.2 Standard setting for the Solar Sector

Solar industrial development should go hand-in-hand with the expansion of a national solar market. In this sense, a key issue that Chile has to confront in order to develop a national solar market is the lack of compulsory quality standards for solar panel manufacturing or any formal monitoring of the quality of the PV imports into the country. However, for large scale projects, where financial private/multilateral institutions/ national development banks are involved, due diligence is playing an important role as an indirect form of regulation. In contrast, commercial and residential-scale projects are naturally less regulated, partially due to their lack of knowledge regarding the international quality standards and certifications that are in force in more consolidated markets, and the lack of technical capacity to process and to monitor such information.

Even though there are still no signs of the development of a Chilean standard for the solar industry at the moment, the regulator should particularly focus on commercial and residential-scale consumers, who could be more susceptible of being trapped in this market. Therefore, policy makers could start by implementing an information disclosure program, to present information on the international standards in place, the certification processes available, and the reliability of certain firms, in order to empower Chilean solar PV consumers and consolidate a long-lasting solar market in the country. The energy policy plan could eventually consider the adoption of international norms and standards for the domestic market, requesting certification with an international agency, and/or developing norms, and standards and promoting the development of Chilean certification agencies, which could provide the necessary guarantees for the consolidation of the solar market in the country.

6.3 Education and Capacity Building Programs for consumers

Education and empowerment must also reach consumers of solar PV energy. Not only do they need to be aware of the international certification programs, but they also need to be trained about the use and maintenance of the technology. Brand building of solar technology among consumers, would improve its acceptability, particularly among those that would like to be differentiated as green consumers. This education process would require a strategic and coordinated approach, such as Foundation, Deployment and Public Exit: Foundation (including a vision set by the national government with stakeholder buy-in and participation), Deployment (including education and capacity building) and Public Exit (including transferring responsibility from public/private to private) (UC Berkeley Haas IBD Team, 2013).

6.4 Reduction of existing barriers to solar projects

According to Escenarios Energéticos,[8] one of the most important barriers facing solar projects in Chile is the access to finance. The role of the public sector is fundamental in order to reduce such a barrier and to be able to encourage the proliferation of both small and large scale projects. Examples of such policies are: grants or special rates for pilot projects, access to loan guarantees through multi-

[8] "Electricity Generation Projects: preliminary identification of key issues affecting their development" Comité Técnico, Plataforma Escenarios Energéticos Chile 2030, 31st August 2012.

lateral banks or government funds,[9] cash incentives to earlier adopters, mitigation of soft costs, decoupling, net metering, encouraging of utility cooperation,[10] etc. Moreover, the public sector could contribute to reduce the upfront costs of solar projects for residents and small business owners by promoting Third Party Ownership (TPO) models that promote solar leases or Solar Power Purchase Agreement (PPA). The regulator could promote the bundle of individual projects and the aggregation of community demand (group-purchase programs, crowd funding platform for solar projects) to drive down cost and to achieve scale, and so to induce financing from banks and other multilateral-institutions. Regulators could also introduce mechanisms to reduce financing risk (e.g. loan guarantees) and thus make the solar projects more appealing for banks.

Another important barrier is the economic viability of connecting the solar plants to the grid using the transmission system. Given that solar plants are more efficient in areas of high radiation, this limits their mobility and increases the cost of transmission required to connect solar plants with the national grid. However, the law currently exempts generators of less than 9MW and NCRE generators of up to 20MW from transmission fees of using the national grid. Regulators could also encourage the association of solar plants to share a transmission line towards the national grid.

The third main identified barrier is access to terrains for the location of solar plants, due to the ownership of land. If lands are not privately owned, they will very often require legal permits from the regulator. In the northern part of the country, the regulator owns about 91% of the land, and the Ministry of National Assets has given away, as concessions, 8,300 hectares for NCRE projects so far.

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[9]Private loans so far could only be available for projects or 3MW or more, so small scale projects are definitely out of scope so far.

[10]Data sharing to improve grid management and to ensure grid reliability and safety.

Finally, the issue of environmental impacts of the projects can create barriers to project development. Although solar plants have a low environmental impact over the land compared to other energy sources, and imply a non-exclusive use of the land, there may be some archeological concerns to be considered. Therefore, the role of the regulator in trying to disclose information regarding the legal status of the terrains and in improving the efficiency of permit applications would be essential. Given the high demand for terrains for these types of initiatives, the Ministry of National Assets has introduced a mechanism of allocation of rights in two stages that guarantees that these projects will finally take place.

All in all, solar energy represents an opportunity for a cleaner and more secure source of energy, which could help to insulate from price volatility in the sector, create exports and diversify economic growth. It could also democratize and diversify energy generation even contributing to reduce income inequality. Indeed, it currently also represents a market opportunity for solar energy leadership in the Latin American region (UC Berkeley Haas IBD Team, 2013).

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