PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE

ESCUELA DE INGENIERIA

CUTTING DOWN RESIDENTIAL PV SOLAR SYSTEMS PRICES THROUGH DIFFERENT BUSINESS MODELS: A REVIEW OF PV SOLAR SYSTEMS COST TO DISCOVER THE REAL COST THAT RESIDENTIAL CUSTOMERS FACE

FRANCIS HELENA MARTÍNEZ FIRGAU

Thesis submitted to the Office of Research and Graduate Studies in partial fulfillment of the requirements for the Degree of Master of Science in Engineering

Advisor:
DAVID EDUARDO WATTS CASIMIS

Santiago de Chile, (June, 2020)

PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
ESCUELA DE INGENIERIA

CUTTING DOWN RESIDENTIAL PV SOLAR SYSTEMS PRICES THROUGH DIFFERENT BUSINESS MODELS: A REVIEW OF PV SOLAR SYSTEMS COST TO DISCOVER THE REAL COST THAT RESIDENTIAL CUSTOMERS FACE

FRANCIS HELENA MARTÍNEZ FIRGAU

Members of the Committee:

DAVID EDUARDO WATTS CASIMIS

ÁLVARO HUGO LORCA GÁLVEZ

DANILO ANDRÉS JARA AGUILERA

LUCIANO EDUARDO CHIANG SÁNCHEZ

Thesis submitted to the Office of Research and Graduate Studies in partial fulfillment of the requirements for the Degree of Master of Science in Engineering

Santiago de Chile, (June, 2020)

To my wonderful family, who has always been supportive.

ACKOWLEDGMENTS

This Master of Science in Engineering was not just a degree, it was a journey full of experiences, emotions and lessons. Finishing this work sometimes seemed very far away but, after seeing the results, I think that the effort was definitely worth it. I would first like to thank to my amazing advisor David Eduardo Watts Casimis who always supported, guided and taught me, not only about energy stuff but also skills to be a better professional. I also thank to my family for their unconditional support in this in this new academic and professional challenge. I also thank the support provided by Conicyt - Fondecyt project 118113, Pontificia Universidad Católica de Chile, projects CORFO 13CEI2-21803 (CSET) and Conicyt FONDAP 15110019 (SERC).

TABLE OF CONTENTS

Pág.

LIST OF TABLES

Pág.

LIST OF FIGURES

Pág.

RESUMEN

Los sistemas solares fotovoltaicos de pequeña escala usualmente no son rentables para los propietarios de viviendas debido a los altos precios, influenciados por la limitación o falta de información, altos costos blandos ineficientes, poca transparencia de precios y la presencia competencia monopolística en el mercado. La reputación de las empresas, el volumen de ventas y el dominio de los servicios públicos locales, promueven la competencia monopolística.

A través del modelo econométrico de costos de sistemas solar fotovoltaicos desarrollado en esta investigación, se puede confirmar que los costos blandos representan hasta 60% del costo total de un sistema de pequeña escala y alrededor del 30% de estos son evitables. Además, se demuestra que es posible evitar hasta 1500 USD/kW si se aprovechan las economías de escala. Con este trabajo se busca dimensionar el costo real de sistemas de pequeña escala y aclarar la estructura de costo real que enfrentan sus clientes. Adicionalmente, se demuestra que a través de modelos de negocio es posible reducir las barreras a las que se enfrentan dichos clientes, como las económicas, financieras, regulatorias, técnicas, geográficas y socioculturales como el modelo *Third Party Owned* o *Community Share* que pueden mitigar las barreras económicas, financieras y geográficas y *Cross Selling* adicionalmente puede reducir las barreras técnicas y socioculturales.

Para reducir los precios de sistemas solares fotovoltaicos a pequeña escala e incentivar su desarrollo, se propone recopilar y analizar información de costos para proporcionar transparencia de precios al sector público y permitir la competencia en el mercado; desarrollar modelos de negocio basados en la compra agregada para reducir hasta un 300% el costo inicial y aprovechar las bajas tasas de interés como las tasas hipotecarias para disminuir las barreras financieras.

Palabras Claves: PV solar systems; cost breakdown; Distributed Generation (DG); PV business models; price transparency; PV solar market; economies of scale; aggregate purchase; collective purchase.

ABSTRACT

Small-scale PV solar systems are often not cost effective for homeowners because of their very high purchasing prices, influenced by lack of or limited information, high inefficient soft costs, poor price-transparency and the monopolistic competition in the market. Companies' reputation, sales volume, information privileges and dominance of local utilities, provide space for market power under the figure of monopolistic competition.

Through our PVSS cost model developed in this article, we confirmed that soft cost represents up to 60% of the total cost of a small-PV system and about 30% of these are avoidable. It also shows that can be avoided up to1500 USD/kW if economies of scale are exploited. This article seeks to size the real cost of small systems and clarify the real cost structure that customers face.

Business models can reduce barriers that small-scale PV systems face such as economic, financial, policy-regulation, technical, geographic and sociocultural. While Third-party, Community and Shared solar can potentially mitigate economic, financial and geographic barriers, business models like Cross-selling can also reduce technical and sociocultural barriers. Even when the traditional Host-owned model does not reduce any of those barriers, in some markets it has potential.

In order to lower small-scale PV solar system prices and incentivize its deployment we propose collecting and analyzing cost information to provide price-transparency to the public sector and allow market competition; develop business models based on aggregate purchase to reduce up to 300% the upfront cost and taking advantage of low interest rates like mortgage rates to decrease financial barriers.

Keywords PV solar systems; cost breakdown; Distributed Generation (DG); PV business models; price transparency; PV solar market; economies of scale; aggregate purchase; collective purchase.

ABBREVIATIONS

In this document we use the following abbreviations:

PV: Photovoltaic

PVSS: Photovoltaic Solar Systems

DG: Distributed Generation

EoS: Economies of Scale

EoSF: Economies of Scale Factor

BoS: Balance of Systems

Co: Company

TC: Total cost

$C_{inefficient}$: Inefficient cost

$C_{inevitable}$: Inevitable cost

1 INTRODUCTION: SEIZING THE OPPORTUNITY OF HIGH SOLAR POTENTIAL TO TURN EMERGENT NATIONS INTO DISTRIBUTED PV SOLAR COUNTRIES

The end of fossil fuel era is now, there are no more new coal power plants in Chile and with the decarbonization plan taught in 2019, eight coal power plants will be closed between 2020 and 2024 and by 2040 it will be a coal-free country (Ministerio de Energia, 2019). Suddenly, imported coal cannot compete against abundant renewable resources, especially solar Photovoltaic (PV). Renewable projects are developing faster than ever.

Chile, a developing country, has been recognized as the country with highest irradiance on Earth (above 7 kWh/m2 per day) (Escobar et al., 2015; Rondanelli, Molina, & Falvey, 2015) and high electricity rates in Latin America (Osinergmin, 2018; Watts, Valdés, Jara, & Watson, 2015). Since 2014, the country is seizing its high solar potential with several large-scale PV projects development without subsidies, which allowed to reach very low-cost PVSS but mainly for large-scale.

The role of “well-though” regulation is to transfer this low-cost deployment to medium and small-scale distributed generation (DG) so that, residential clients also take advantage of the technology, high irradiance resource and access to cheap financing to migrate to distributed PV solar country by 2025.

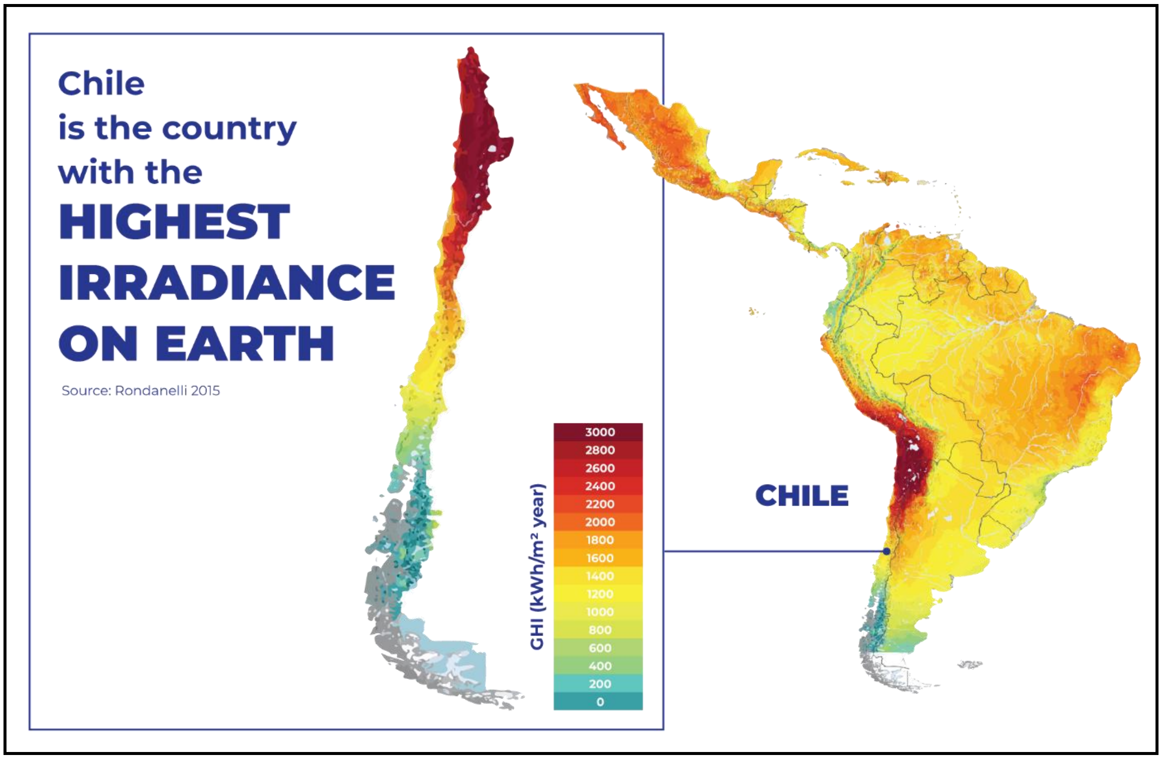

Figure 1-1: Global Horizontal Radiation in Chile contrasted with the Latin America and Caribbean (Solargis, 2018; Watts et al., 2015)

1.1 Poor price transparency as a barrier for PV solar systems in the residential sector

Poor price transparency and lack of information about costs of PV solar systems (PVSS) in the literature (Barbose, Darghouth, Lacommare, Millstein, & Rand, 2018; Camilo, Castro, Almeida, & Pires, 2017; Fu, Feldman, & Margolis, 2018b; IRENA, 2016), quotes and web pages (In, Energysage, Calculator, Loans, & Upgrades, 2020; Solar Choice, 2020; Ulrich, 2016) generates mistrust and discourages to potential customers (Horváth & Szabó, 2018; Strupeit & Palm, 2016) impeding massive residential PV solar deployment. There are some efforts to reach low prices for PVSS (Ardani et al., 2013; Ulrich, 2016) such as the 1 USD/W initiative from two decades ago, but they are close to 3 USD/W for small-scale (Fu et al., 2018b) which is a very high cost, especially for low and medium-income families. Achieving 0.5 USD/W as in large scale, remains as dream target.

The aspiration is that all residential consumers can benefit from solar energy and this article points in that direction.

The absence of accurate cost studies leads to high cost-variability which makes potential clients feel like this is a market with cost overruns. An example of this, is the price of 1 kW PVSS in the USA which cost 4.5 USD/W (Barbose et al., 2018) and in Chile 1.65 USD/W (both before taxes), this means a 173% more expensive system of the same capacity with no apparent reason for normal customers. Several articles target cost differences among developed and large industrial countries (De Boeck, Van Asch, De Bruecker, & Audenaert, 2016; Seel, Barbose, & Wiser, 2014), but no one is targeting smaller developing countries.

Revealing the real cost structure of small scale PVSS and the real cost structure, sizing its cost components and their potential to be reduced, can promote appropriate policies and innovative regulation which should reduce economic, financial, socio-cultural, policy and regulatory barriers that prevent residential PVSS to take off . For this reason, this article seeks to clarify the real cost structure that customers face providing a review of research targeting PV cost components along with a process of local quotations and engineering analysis to contrast with.

1.2 Cutting down inefficient soft cost to massive deployment of PV solar rooftop.

There is a large price gap between two or more PV solar rooftop of the same capacity. A 6 kW PV solar system in the USA could cost around 3 USD/W, while in other countries, like Australia and China, prices are around 1.5 USD/W. It is half of the price of expensive countries like USA, Brazil, Argentina, Japan, Canada among others. This is supported by several articles taking part of this review (Barbose et al., 2018; Energy Sage, 2019; Fu et al., 2018b; Molavi & Bydén, 2018).

Nowadays, countries like China and India are offering PVSS kits at a very low price due to their massive production of components such as inverters, PV modules and other hardware equipment (De La Tour, Glachant, & Ménière, 2011; Green, 2019). They are offering a variety of qualities and prices, from the lowest to the highest cost/quality market segments. The key question is, why are PVSS so expensive?

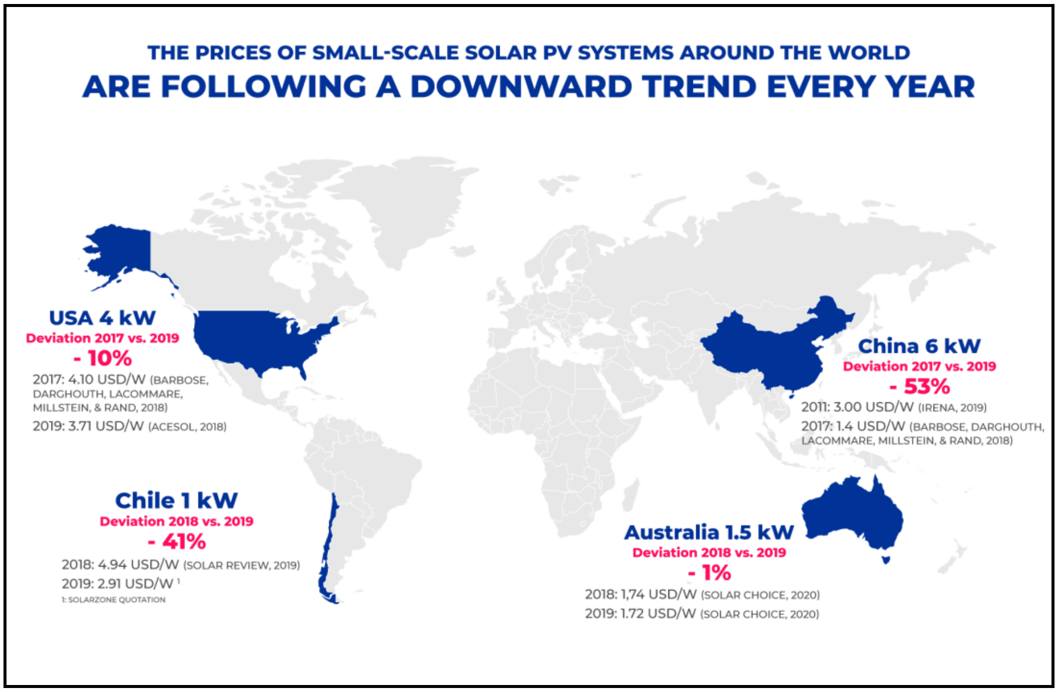

Figure 1-2: Downward trend of PVSS in USA, Chile, China and Australia.

Even when prices of hardware are going down (more than 60% (Ulrich, 2016) in 10 years), the cost of investing in these projects at residential scale is still very high, mainly due to the inefficient soft cost (Mundada, Nilsiam, & Pearce, 2016; Ulrich, 2016) components, some of which can be avoided or reduced considerably.

Soft costs can represent up to 60% of the total cost (Fu et al., 2018b; Speer, 2012) of a residential PV system, including cost components such as, sales and marketing, installation labor, design of the system, permits, interconnection, supply chain, inspection, taxes and overhead cost (Chung, Davidson, Fu, Ardani, & Margolis, 2015; IRENA, 2019). In the interest to cut down these prices, the main cost breakdown is studied, including fixed and variable costs and the most relevant factors that influence in rising prices.

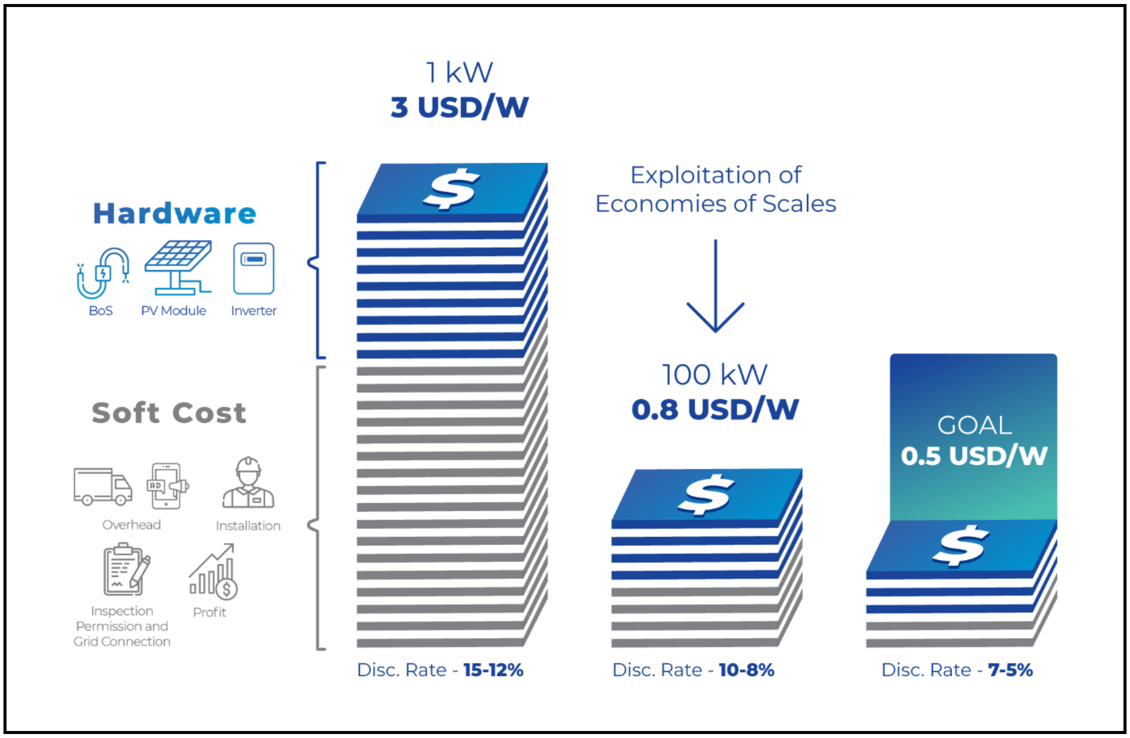

Figure 1-3: Small and big scale hardware and soft cost of PVSS.

More than half of soft cost can be avoided with adequate regulation and different business models which have the ability to mitigate economic, financial, political, regulatory and social barriers (Drury et al., 2012; Gabriel & Kirkwood, 2016; Horváth & Szabó, 2018; Strupeit & Palm, 2016) that impede massive develop of residential PVSS, burdening and slowing down the transition to a green economy.

The key business models under review are, host-owned (Burger & Luke, 2017; He, Pang, Li, & Zhang, 2018; Karakaya, Nuur, & Hidalgo, 2016; Strupeit & Palm, 2016) also known as customer owned (Horváth & Szabó, 2018; Huijben & G.P.J., 2013), host owned feed in, user owned (Horváth & Szabó, 2018) and traditional self-financing (Speer, 2012); third party owned (Augustine & Mcgavisk, 2016; Burger & Luke, 2017; Coughlin, Cory, Coughlin, & Cory, 2009; Davidson, Steinberg, & Margolis, 2014; Drury et al., 2012; Hobbs, Pierpont, & Varadarajan, 2013; Huijben & G.P.J., 2013; Speer, 2012; Wijeratne, Yang, Too, & Wakefield, 2019; F. Zhang, Deng, Margolis, & Su, 2015) or third party owns (Horváth & Szabó, 2018; Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015); community shared (He et al., 2018; Horváth & Szabó, 2018) also known as community solar providers (Burger & Luke, 2017), community solar (purchasing panels, leasing panels and investing in system), community shares (Horváth & Szabó, 2018; Huijben & G.P.J., 2013), community shared solar (Augustine & Mcgavisk, 2016; Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015), community owned model (Horváth & Szabó, 2018); shared solar (Horváth & Szabó, 2018; Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015); cross-selling (Strupeit & Palm, 2016), cooperatives, solar leasing, roof rental and crowded leasing (Dunlop & Roesch, 2016).

1.3 Solar rooftop trend in developing countries: Enabling low cost microscale PVSS

Energy consumption in developing countries is lower than in developed ones, so the size of residential PVSS in emergent nations is smaller. In 2015 the energy consumption in the U.S. was 12071 kWh a year per capita while in Chile is 3739 kWh, which means only 31% of the U.S. energy consumption. Similarly, consumption per capita (kWh/cap) is very low in other developing countries such as China (4475), India (1181), Brazil (2516) and small countries such as Peru (1268), Bolivia (683), and Jamaica (943) among others (CIA, 2020).

In the U.S, the dominant solar rooftop size trend is 6 kW (Fu et al., 2018b; In et al., 2020). Based on the 30% relationship of the energy consumption of Chile compared with US consumption, PVSS in more likely to be scaled down to 1.8 kW. Moreover, lack of subsidies would reduce the optimal size further down (Brown, Hall, & Davis, 2019; Cucchiella, D'Adamo, & Gastaldi, 2015; Watts et al., 2015). In fact, from 2016 to 2019, in Chile, 49% of the small-scale PV projects (up to 6kW) where smaller than 1 kW (Comisión Nacional de Energía. Energía Abierta, 2019b) which corroborates the preference for the microscale (See **Figure 1-4**.).

Sizing PV for self-consumption is the dominant strategy, not only in Chile, but also in several other developing countries. This is reviewed in several references targeting Net billing (Dufo-López & Bernal-Agustín, 2015; Watts et al., 2015) instead of Net metering (Astriani, Shafiullah, Anda, & Hilal, 2019; Camilo et al., 2017; Campoccia, Dusonchet, Telaretti, & Zizzo, 2020), penalizing energy injections at lower selling prices and encouraging self-consumption.

Nevertheless, these microscale systems are very expensive (per kW) because they do not take advantage of economies of scale, facing a high cost burdened by inefficiency associated mainly to high soft costs. Moreover, there is a poor access to very cheap loans for residential clients, which interferes in their possibility to develop cost-effective projects. Green finance initiatives are massive for large-scale but quite limited for residential scale (Global Environment Facility, 2011; United Nations Environment Programme, 2017).

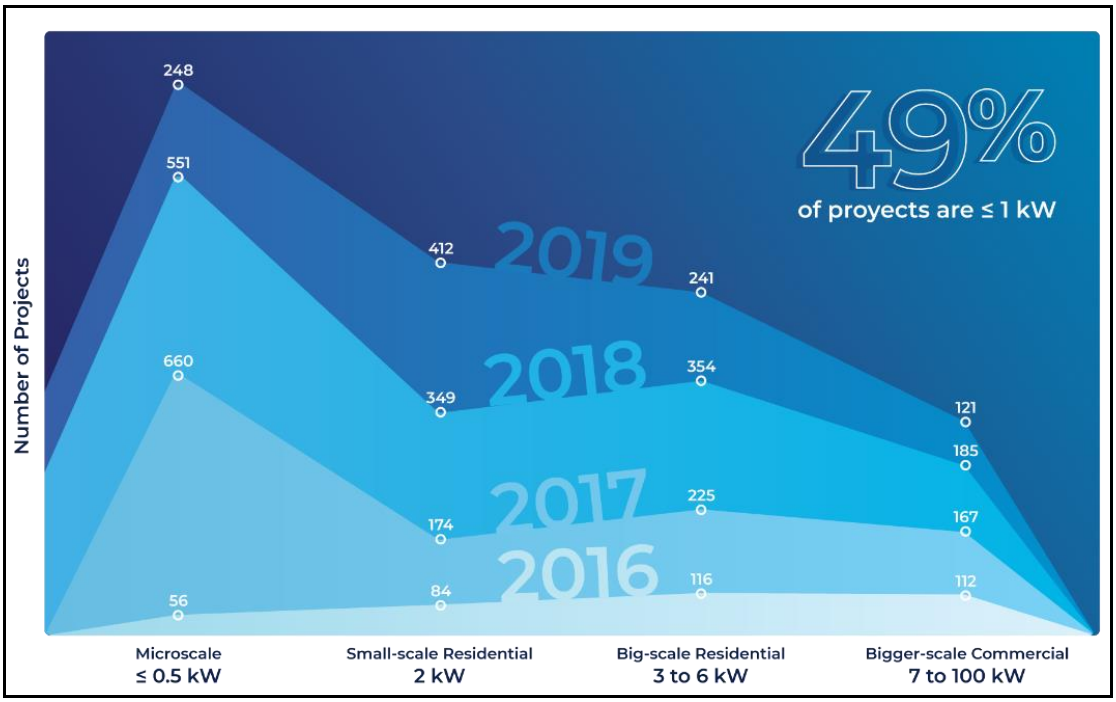

Figure 1-4: Solar PV distributed projects in Chile 2016 to 2019.

In Chile, the distributed solar generation at residential scale it is not as massive as expected due to its high solar potential. From 2016 to 2019, 1515 small-scale projects (Comisión Nacional de Energía. Energía Abierta, 2019b) where installed, right after the small DG regulation was approved. These projects add up to 28.2 MW, which means about 1.06% of Chile's PV solar matrix (2.7 GW) (Comisión Nacional de Energía. Energía Abierta, 2019a) and 1.35% of the 2095 MW (Energia abierta Comisión Nacional de Energía, 2019) solar generation deployed those years. This is still a very low participation of PVSS in a country that has one of the highest radiations in the world, so actions must be taken to exploit this advantage.

In order to allow developing countries with high solar potential to go solar, different business models and innovative regulation must be designed and developed. These tools should not interfere but rather promote the deployment of PV solar energy.

1.4 Finding the true cost structure to deploy massive residential low-cost PVSS

Information about PVSS costs in developed and developing countries was collected, including their successful and failed experiences in transferring the true cost of a PV rooftop to their consumers.

Also, to find the important local component in the cost, quotes from the main residential PV suppliers in Chile were made, iterating with them to find out more details on their project’s components and costs. This cost review is contrasted with an engineering analysis of cost components of real projects we design.

The analysis of all the information presented in this thesis allow gaining insight about real costs, and cost structure of each project, revealing information is hardly ever presented in the literature. The economic definition of cost entails the use of the minimum possible cost to develop a project or activity, that is, the efficient costs of developing a residential PV project. This definition motivates this paper.

This work seeks to find the true cost structure of residential PV projects. The cost at which policy should aim to have a competitive and healthy development of the sector. The search for such low cost pointed us to an aggregation business model which has the potential to achieve extremely low-cost and massive development of PV rooftop.

Also, a review of the barriers that potential consumers of small-scale PV solar systems face and different business models to reduce those barriers are presented. As a result, from the review, business models like Host owned, Third part owned, Community share, Shared solar and Cross Selling are categorized according to their benefit, location, owner, financing schemes and application sector to detect which are the most suitable clients for each model in order to make suggestions to readers and policy makers. A list of barriers that each business model mentioned can reduce is also presented.

The investigation is organized as follows: Section 2 provides a critical review of PVSS cost of the literature and an analysis of cost breakdown of all-scale PV systems highlighting their poor cost efficiency. Section 3 presents the barriers imposed to massive deployment of PV systems and how business models reduce and even eliminate these barriers. Finally, section 4 presents recommendations of how to take advantage of economies of scale through aggregated purchases, cheap loans and an innovative and accurate regulation that mitigates cost inefficiency.

2 PRICE-TRANSPARENCY FOR SMALL-SCALE PVSS: INEFFICIENT SOFT COSTS THAT ARE TACKED-ON TO THE PRICES THAT CUSTOMERS FACE

2.1 Scarce cost information and cost breakdown of residential PV solar systems is causing slow deployment of solar self-consumption

The scarce cost breakdown information for residential PVSS shows that is not being well studied and disseminated causing a slow deployment of PV solar self-consumption. Poor cost information and price-transparency of residential PVSS allow firms to exercise market power by increasing their prices (O'Shaughnessy & Margolis, 2018) which prevents the transfer of efficient costs to customers.

There are levels of market power between monopoly and perfect competition. As the market power is distributed the closest to equitable is considered perfect competition. Companies that have high market power is because they operate in a monopolistic competition regime with company and product differentiation, which allows them to have this power (Dhingra & Morrow, 2019).

A very valuable source to achieve a well-studied price is through local quotes because they offer real and, in some cases, detailed cost information on what is offered in the residential PVSS market. Depending on the variability of the costs obtained from quotes, an exercise of high market power can be detected, which needs an intervention of regulation and policies that guarantee a healthy and competitive residential PVSS market (Engelken, Römer, Drescher, Welpe, & Picot, 2016; Strupeit & Palm, 2016). The main purpose of this article is to analyze ad explore how customers could access to lower and fair prices through a well-studied residential PVSS cost and alternative business models .

This article takes advantage of the valuable local information by doing quotes of different small-scale PVSS, as in some reports (Chung et al., 2015; In et al., 2020; IRENA, 2019; Solar Choice, 2020), but, in this review in the city of Santiago. The aim of comparing it with an engineering analysis and cost review allows getting closer to the real costs that customers face, including offered components, services, financing schemes and communication channels with the future client (web page, e-mails, phone calls etc.).

Table 2-1 Review of PV solar systems costs in the literature.

Co / Org	Size and countries	Description	Source
NREL	**2015 - 5.2 kWp:** USA **2016 - 5.6 kWp:** USA **2017 - 6.2 kWp:** USA **2018 – 6.2 kWp:** USA	In NREL's reports there are cost breakdowns of the most common size of residential PV solar system in the US per year. Lack of cost for systems under 5 kWp.	(Chung et al., 2015) (Fu et al., 2016) (Fu, Feldman, Margolis, Woodhouse, & Ardani, 2017) (Fu et al., 2018b)
LBNL	**2 - 12 kW:** USA **6.3 kW:** Brazil, Switzerland, Japan, South Africa, Thailand, Malaysia, France, Korea, Australia, UK, Germany, Spain, China, India	LBNL presents total cost for a 6.3 kW PVSS from many countries but they do not make a cost breakdown.	(Barbose et al., 2018)
IRENA	**Utility scale - 1MW:** Canada, Russian Federation, Japan, South Africa, USA, Australia, Brazil, Mexico, Argentina, UK, Korea, Saudi Arabia, Turkey, Indonesia, Germany, France, China, Italy, India	IRENA presents a PVSS cost breakdown in several countries but, only for utility scale.	(IRENA, 2019)
Solar Choice	**From 2018** **1.5, 2, 3, 4, 5, 7 10 kWp:** Australia **From 2019** **1.5, 2, 3, 4, 5, 6, 7 10, 30, 50, 70, 100 kWp:** Australia	Solar Choice presents Australia PVSS costs. They use incentives that allow sellers and customers to reach very low costs for a system up to 100 kW.	(Solar Choice, 2020)
Acesol	**2.5, 5, 30, 100, 500, 3000 kWp:** Chile	Acesol presents PVSS cost for residential, commercial and utility scale. Prices are taken from developed projects.	(Acesol, 2018)
Solar Reviews	**4, 5, 6, 8, 10, 12, 20 kWp:** USA	Solar review presents cost based on quotes. They do not make a cost breakdown.	(Solar review, 2019)

GIZ	**<u>1, 5 10, 30, 100, 500, 1500 kWp:</u>** Chile	One of the few sources that presents the cost of a residential solar PV systems in Chile. They use ranges of PVSS scales to present costs, so their data is not too representative.	(Gesellschaft für Internationale Zusammenarbeit, 2018)
SEIA	**<u>6, 1000 kWp:</u>** USA	SEIA has a lot of information about PVSS but in order to access it you must pay for the reports.	(Perea et al., 2019)
Solar Action Alliance	**<u>5, 10, 15 kWp:</u>** USA	Solar action alliance presents closer costs that consumers really face	(Solar Action Alliance, 2018)
Journal Solar energy	**<u>0.5, 1, 1.5, 4 kWp:</u>** Portugal	"Economic assessment of residential PV systems with self-consumption and storage in Portugal" Presents the total cost for few solar PV systems in Portugal.	(Camilo et al., 2017)

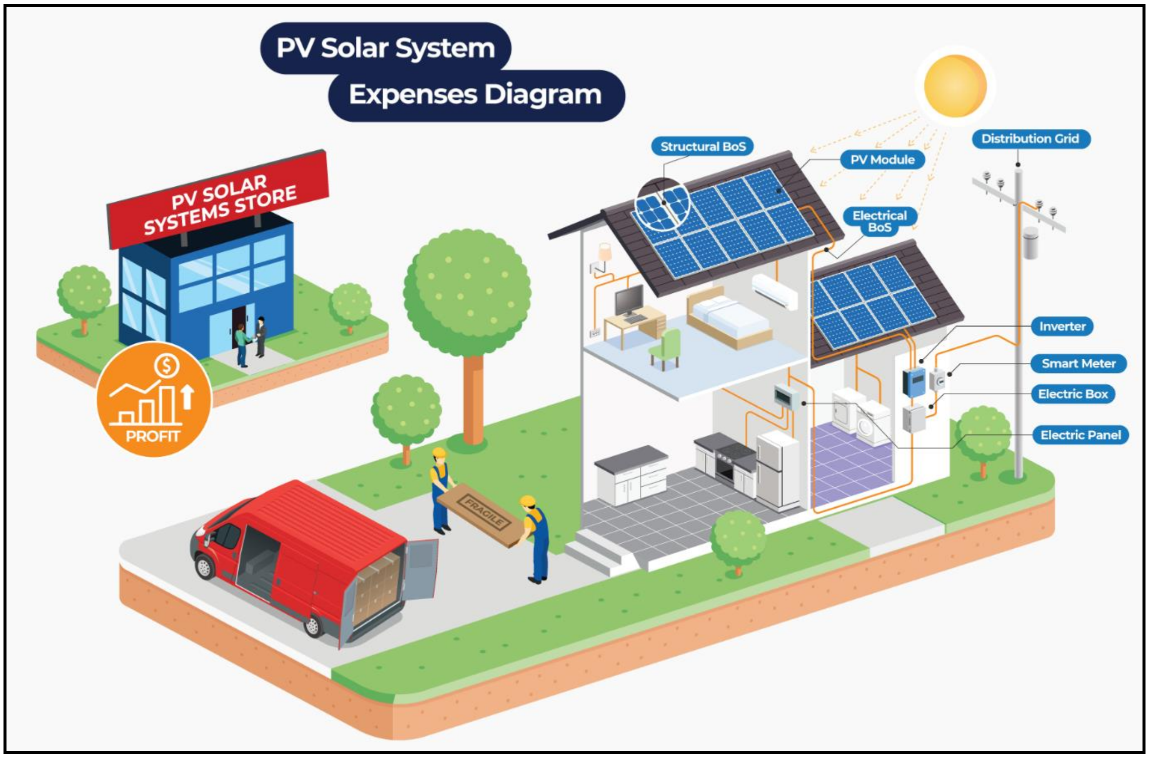

Figure 2-1: PV rooftop components/equipment and deployment process.

In the interest of obtaining a well-studied residential PVSS cost, first, a cost breakdown categories are developed based on the analyzed information about cost structure (Chung et al., 2015; In et al., 2020; IRENA, 2019). By categorizing the cost of residential PVSS it would be possible to transparent the nature of each cost category in terms of unavoidable and avoidable cost (Murat Cekirge, 2019) that can be potentially reduced through more efficient practices, regulation and business models (Rai, Reeves, & Margolis, 2016; Strupeit & Palm, 2016).

The two macro cost categories are hardware cost, together with Balance of System (BoS), and soft costs of multiple nature. Here Hardware cost, includes PV modules, inverter(s), electrical BoS (cables, connectors, protections, etc.), structural BoS (mounting structures), while soft cost, includes installation, permissions, grid connection, overhead (supply network, advertising, office rent etc.) and company profits (See **Table 2-2**).

Table 2-2 Description of a cost breakdown of PV solar systems

Category	Definition	Source
Hardware **(PV Module, Inverter and BoS)**	The hardware cost is the sum of all costs related to necessary equipment, PV module, inverter, electrical and structural BoS.	(Efficiency, Energy, & Office, 2020; In et al., 2020)
PV Module	PV Module is one of the main components of a PV solar system. There are different technologies like monocrystalline, polycrystalline and thin film (Horváth & Szabó, 2018). Module efficiency averages about 15% (e.g. Polycrystalline 250W Yingli Solar) to 20.2% (e.g. Monocrystalline 300W Trina Solar). Monocrystalline modules are more efficient (Markvart & Castañer, 2003) and expensive than polycrystalline.	(Horváth & Szabó, 2018; Markvart & Castañer, 2003; Notton, Lazarov, & Stoyanov, 2010)
Inverter	The inverter is the component that converts DC power to AC from PV module so the system can interact with the grid. It could be centralized for larger scales, string or microinverter for medium and small scale PVSS.	(Hasan & Mekhilef, 2017; Hasan, Mekhilef, Seyedmahmoudian, & Horan, 2017)

Electrical BoS	Electrical BoS are all electrical components such as conductors, combiner box, switches, protections among others that allow the connection between equipment such as electrical meter, inverter and PV modules.	(Efficiency et al., 2020; Fu, Feldman, & Margolis, 2018a; Markvart & Castañer, 2003)
Structural BoS	Structural BoS are components related to the structure that fixes and shapes such as aluminum frames, frames to allow inclination.	(Efficiency et al., 2020; In et al., 2020; Markvart & Castañer, 2003)
Soft cost (Installation I,P&GC, Overhead and Cpo. Net income)	Soft costs are those that are not considered in the hardware, which means, all costs that are not associated with the materials to make a PVSS. This cost includes installation, buying permits and financing, company profit, supply chain, marketing and advertising, etc.	(Ardani et al., 2013; Ulrich, 2016)
Installation	Installation cost is the labor of installing the PV solar system, structure, cables, inverter, PV modules and other components. It also includes equipment configuration and tests.	(Fu et al., 2016; IRENA, 2019)
Inspection, Permissions and grid connection (I,P&GC)	Inspection, Permissions and grid connection cost is the cost of the specialists who ensure the proper functioning of the PV system and thus avoid damage to the customer's internal and distribution grid. Also, it involves the cost of the connection to the distribution network studies, design and additional facilities if required.	(Fu et al., 2016; IRENA, 2019)
Overhead	Overhead cost is the business expenses not directly attributed to creating a product or service. The overhead represents about 10 to 30 percent of the sum of hardware and installation labor (Assaf, Bubshait, Atiyah, & Al-Shahri, 2001). This cost does not include profit. Some examples of overhead costs are: Costs and fees associated with shipping and handling of equipment, office supplies, marketing and advertising, sales calls, site visits, salaries and wages etc. (cost of doing business) (Tuovila, 2019).	(Assaf et al., 2001; Tuovila, 2019)
Company net income	Company net income or profit is the revenue remaining after all costs are paid. These costs include labor,	(Pendlebury, Maurice Edward, Groves, & Groves, 2004)

	materials, interest on debt, and taxes.

2.1.1 Local cost methodology: Taking advantage of the local cost information of residential PVSS Through quotes

A house (**Figure 2-2**), with a specific address in Santiago, Chile was chosen in the interest of transparent real residential PVSS price through quotes. This typical house has two floors, colonial roof tiles and a roof inclination around 30°. Using a real location to quote, it is possible to access to real local residential PVSS costs that firms could offer.

PVSS seller companies of different sizes in the market were selected. A big size company selected was Enel X which is associated with the utility in Santiago, Chile, also, Heliplast and Mirosolar which have more than 20 years in the PVSS. Small and medium business companies like Sol de Clima, Solartek were selected. Thirty-six quotes of different systems size (between 0.5 and 6 kW) were made from fourteen different companies. This variety of selected companies and size of the system allows to study widely the circumstance of the market.

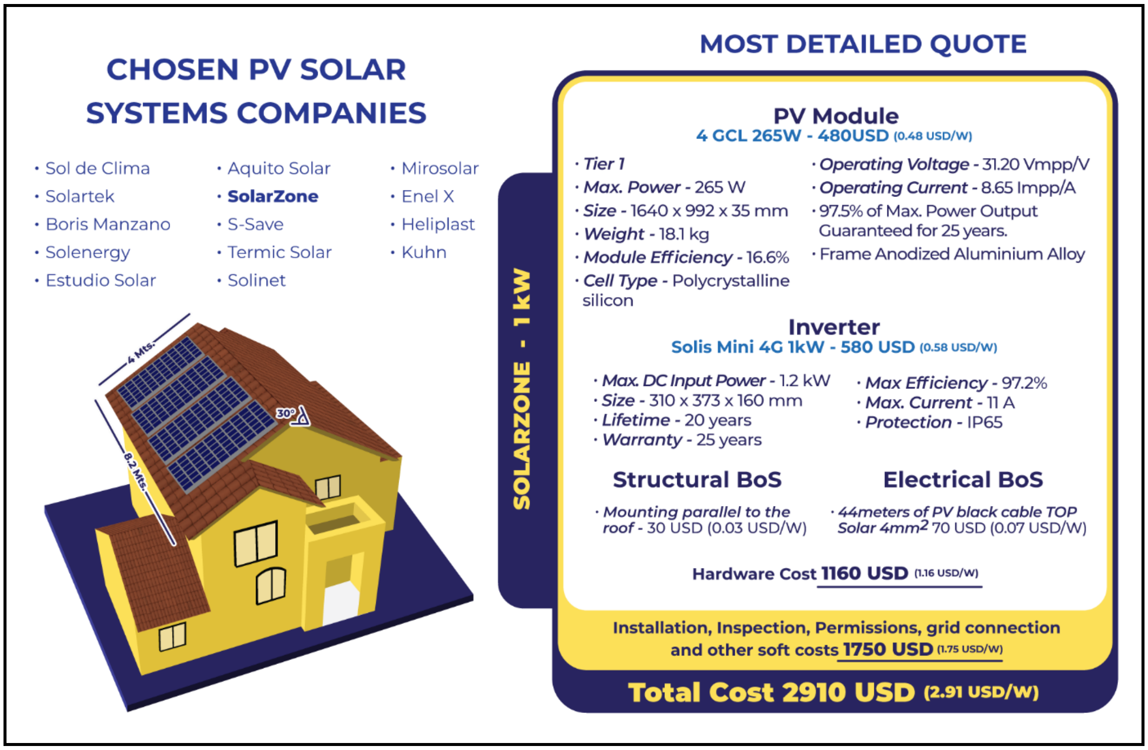

Figure 2-2: Chosen PV solar systems companies to quote a system for a medium-high income house in Santiago, Chile.

The most common size offered by the companies were around 300W polycrystalline PV module from different brands such as GCL, Amerisolar, Ulica, DAH, Canadian Solar, Yingli solar and DAH with an average efficiency of 16.5%. Almost all quotes included a string inverter of the brand Omnik or Mini Solis with an average efficiency of 97.5%.

The poor price-transparency in the residential PVSS market in Chile was corroborated. Only seven quotes were detailed in terms of components and cost and thirty were detailed only in terms of components. There was no quote that itemizes soft cost therefore, it is suspected that it is spread out among the cost of the hardware, installation, inspection and permissions, hiding the real cost of each component.

A great inconsistency in the prices offered by various companies for systems of the same size was observed, triggering a qualitative analysis of the characteristics of the quotes and a quantitative one to size the price differentials and study their causes. The results of the quotation process are summarized in the following table (See **Table 2-3**), where in addition to presenting the costs and characterization of the systems, some commercial conditions are presented.

Table 2-3: Quotations of residential PV solar systems in Santiago, Chile

kW	Company	Total (Untaxed) USD/W	Total (Untaxed) MMCLP	Cost break down		Cost info.			Payments options offered by the company				Hardware Quality	
				Yes	No	Price list	Web page	Quotes	Leasing	Finance	Interest free	Cash	Tier 1	Inverter Efficiency
0.5	Sol de Clima	1.77	0.63		•		•					•	•	95.5%
	EnelX	3.51	1.25		•		•				up to 12 months	•		
1	Sol de Clima	1.65	1.18		•		•					•		97.2%
	Solar Zone	2.91	2.07	•				•				•	•	97.2%
2	Sol de Clima	1.44	2.06		•		•					•		97.2%
	Kuhn	1.66	2.37		•		•					•		97.5%
	EnelX	1.88	2.68		•		•				up to 12 months	•		
	Solar Zone	2.11	3.01	•				•				•	•	97.7%
3	Sol de Clima	1.34	2.88		•		•					•		98.1%
	Solartek	1.52	3.26		•		•					•		97.5%
	S-Save	1.52	3.25		•			•	•	•		•		97.5%
	EnelX	1.53	3.27		•		•				up to 12 months	•		
	Boris Manzano	1.55	3.31		•			•				•		
	Est. Solar	1.55	3.31		•			•				•		
	Aquito Solar	1.62	3.47	•				•				•	•	98.0%
	Heliplast	1.67	3.58	•		•						•	•	98.1%
	Conf. Cpo.	1.69	3.62		•			•				•		
	Solar Zone	1.92	4.11	•				•				•	•	98.1%
4	Conf. Cpo.	1.11	3.18		•			•				•		97.6%
	Solartek	1.16	3.32		•		•					•	•	97.5%
	Mirosolar	1.60	4.58		•	•						•		97.5%
	Solar Zone	1.82	5.2	•				•				•	•	

5	**Sol de Clima**	1.26	4.50		•		•	•		97.5%
	Heliplast	1.41	5.04	•		•		•	•	98.0%
	Mirosolar	1.55	5.52		•	•		•		97.5%

2.1.2 Key findings on product differentiation and pricing

Companies **that offer residential PVSS at low costs** tend to protect their cost effectiveness by **avoiding showing their cost breakdown to client**, showing only a total cost. An example of this can be seen in the 4 kW PVSS from Solartek and Solar Zone (**Table 2-3**) with a price gap of 56%. Both projects offer **Tier 1**[1] PV module but, the cost information from Solar Zone is through a personal quote (prepared specifically to a client) with a detailed cost structure.

The business model applied by each company influences its high or low costs offered to clients. **The cost of a 0.5 kW PVSS could range from 1.77 USD/W to 3.51 USD/W**, a price gap of 98%, even when the **cheapest one offers a** Tier 1 PV module and **both** costs are published in their **web pages**. **The differences between these quotes is a signal of high market power of the company selling the PVSS**, the company that offers the highest price is associated to the utility (distributor) in Santiago, which has more years of experience and privileged information of client's energy consumption. High market power allows a company to set higher prices and still sell its systems (O'Shaughnessy & Margolis, 2018; Seel et al., 2014).

The **key factors** that influence in the variation of the final price are the availability/use of price lists, market power of the supplier, the development of personalized quotes, availability of multiple payment options and hardware quality. Those factors are summarized as follows: first, **the price list**, when companies show their prices through this channel they are usually more expensive (up to 37%); second, **market power**, some companies have more experience and insider

[1] Tier 1 is "*module manufacturers are those which have provided own-brand, own-manufacture products to six different projects, which have been financed non-recourse by six different (non-development) banks, in the past two years.*" https://review.solar/wp-content/uploads/2018/09/bnef_2012-12-03_PVModuleTiering.pdf

information so they offer higher costs and set prices as in monopolistic competition (up to 100%); third, **personal quotes with cost structure**, not every company that transparent their offers lowers costs (up to 20%); fourth, **payment options**, companies like Enel X and S-save, offer a financial option such as interest free fees, leasing and cheap finance giving higher prices; and fifth, **hardware quality,** clients usually think that a very good quality component (efficiency, lifetime, warranty etc.) costs a lot more but, the review shows that this factor does not influence in price increase as much as the others.

2.2 Exposing the cost breakdown of all-scale PVSS: Inefficient high soft costs are tacked-on to the prices that customers face

Consumers should understand why some systems are more expensive than others and how to estimate how much a PVSS can cost them without the need of a deep research (O'Shaughnessy & Margolis, 2018). This review exposes the real cost breakdown (See **Table 2-1**) for all-scale PVSS that customers should perceive. It presents how much each category of cost structure influences in the total cost through an analysis of cost trend and linear regressions, as a method of data prediction. Both methods allow to discover the true cost of residential PVSS hidden behind the inconsistent and scattered information.

Figure 2-3: Quotation of a 1 kW PVSS in Santiago, Chile.

Despite the price gap in quotes between systems of the same capacity, they have a negotiation and a reality component of the country where they were made. An example of this, is the quote of Solar Zone, which offers a 1 kW system as well as Sol de Clima but at 76% more expensive price (See **Figure 2-3**), the same goes for the 3 kW PVSS quotes, where EnelX is 14% more expensive than Sol de Clima because of their market power (a company associated with the electricity distributor in Chile) (See **Figure 2-4**). These cases accredit a type of imperfect competition referred as monopolistic competition (Dhingra & Morrow, 2019) for the residential PVSS market in Chile.

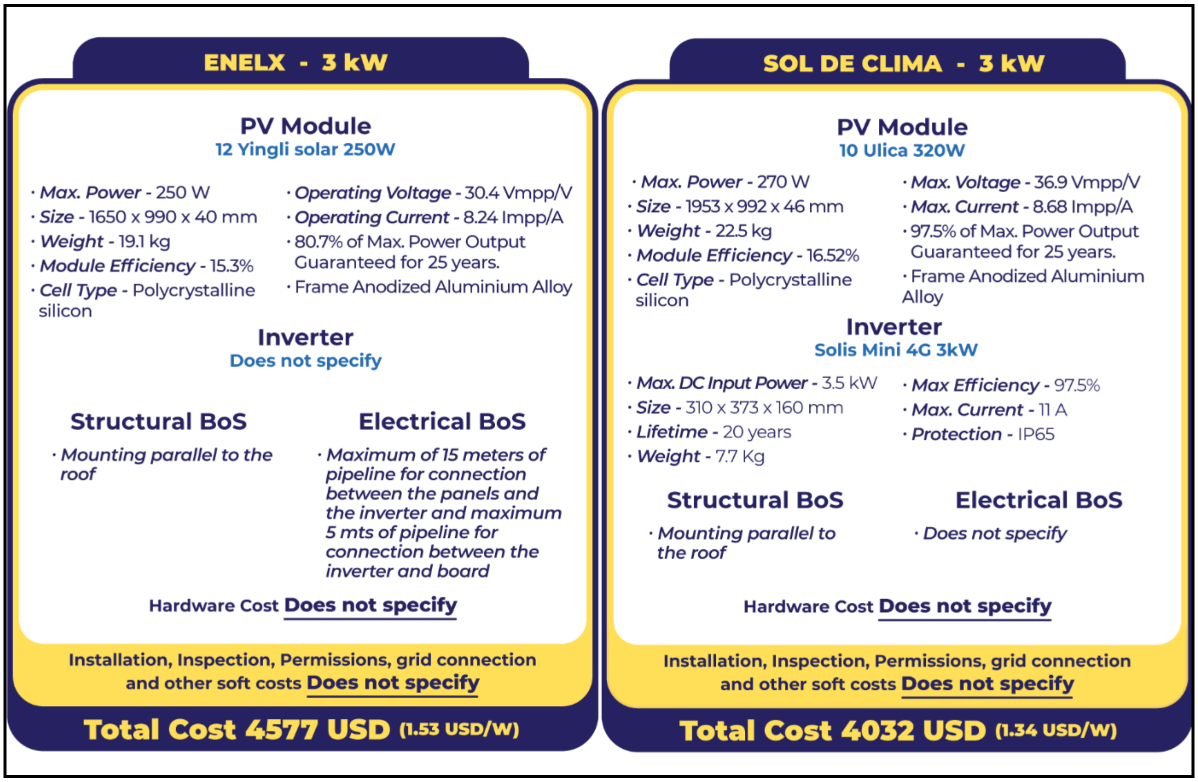

Figure 2-4: Quotation of a 3 kW PVSS in Santiago, Chile.

The cost structure of any business implies a functional form that can be often expressed as linear or logarithmic (Genesove & Mullin, 1998) expression. Typically, the total cost (TC) of the system can be conceptualized as the sum of two components, one that varies with the scale ($C_{inevitable}$ MUSD/KW) of the project, which is considered unavoidable, and another that can be significantly reduced or avoidable ($C_{inefficient}$ MUSD) increasing sales and production. This is similar to "variable" and "fixed" costs structures (e.g. Formula 2.1). Each of these cost components ($C_{variable}$ and C_{fixed}) are composed of various items such as profit, overhead, costs associated with product creation and value among others.

$$TC = C_{variable} \cdot kW + C_{fixed} = 1.1 \frac{MUSD}{kW} \cdot kW + 1.4\, MUSD \qquad (2.1)$$

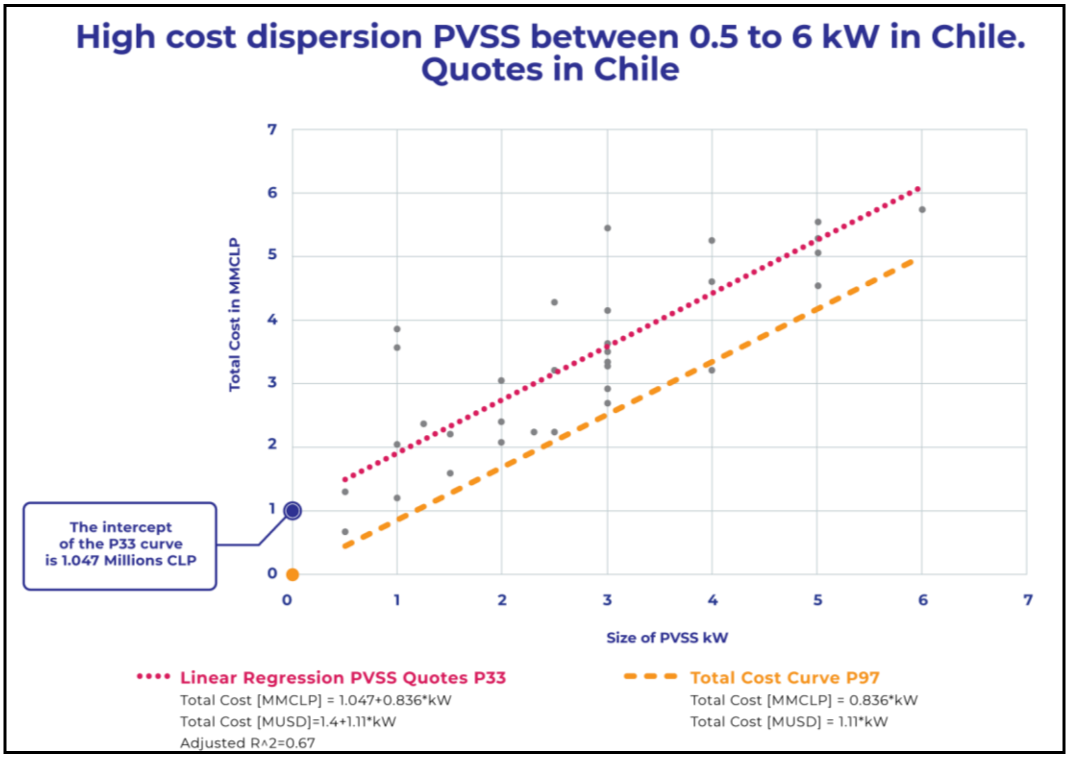

Figure 2-5: High dispersion between quotes of PVSS in Chile.

The total costs of PVSS tends to the logarithmic logic form. However, when applying different functional forms such as linear, logarithmic and power regression curves in soft cost and total costs, there is a great similarity between them since there are no variations greater than 4% for systems larger than 2 kW (See **Figure 2-6** and **Figure 2-7**).

Even though logarithmic regressions in econometrics are highly used due to their varied advantages, such as no variation in the slope when there are different units and the easy identification of elasticities, linear regressions allow revealing cost structure information and the role of fixed and variable costs of each item in the result of the total cost (Jann, 2019; Montgomery, Peck, & Vining, 2012; Seber & Lee, 2003). The linear cost structure model allows almost any reader to understand how each component influences in the total cost and in what measure.

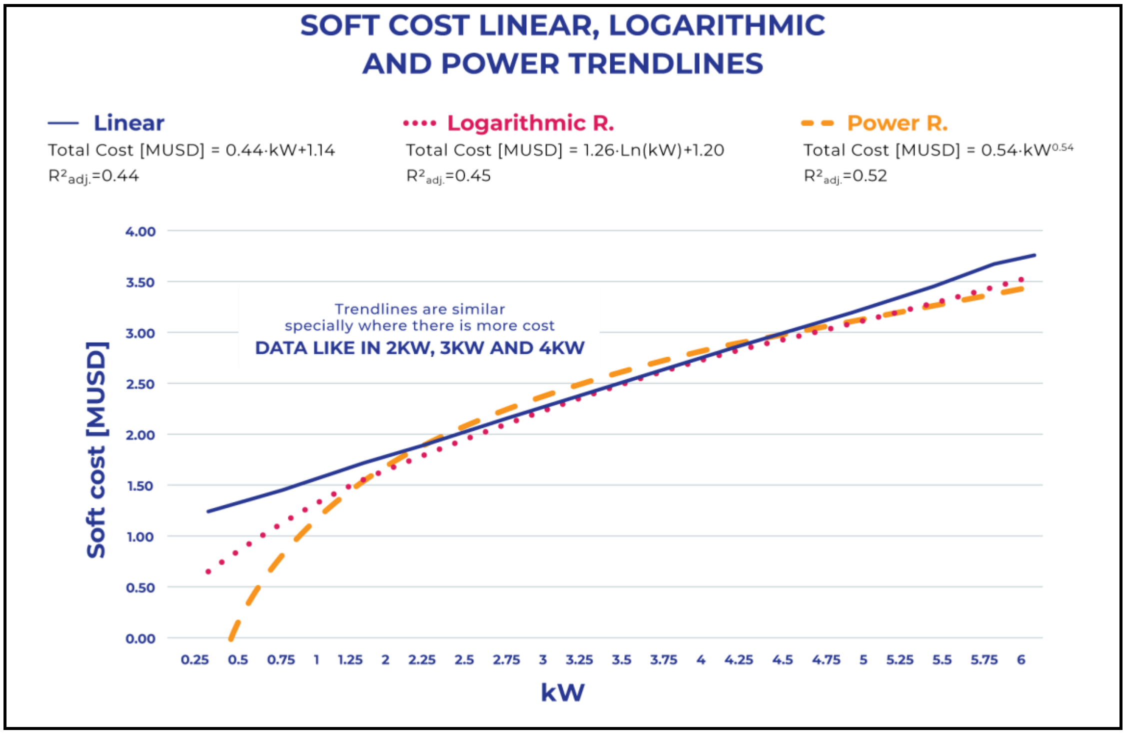

Figure 2-6: Soft cost trend lines for a small-scale PVSS.

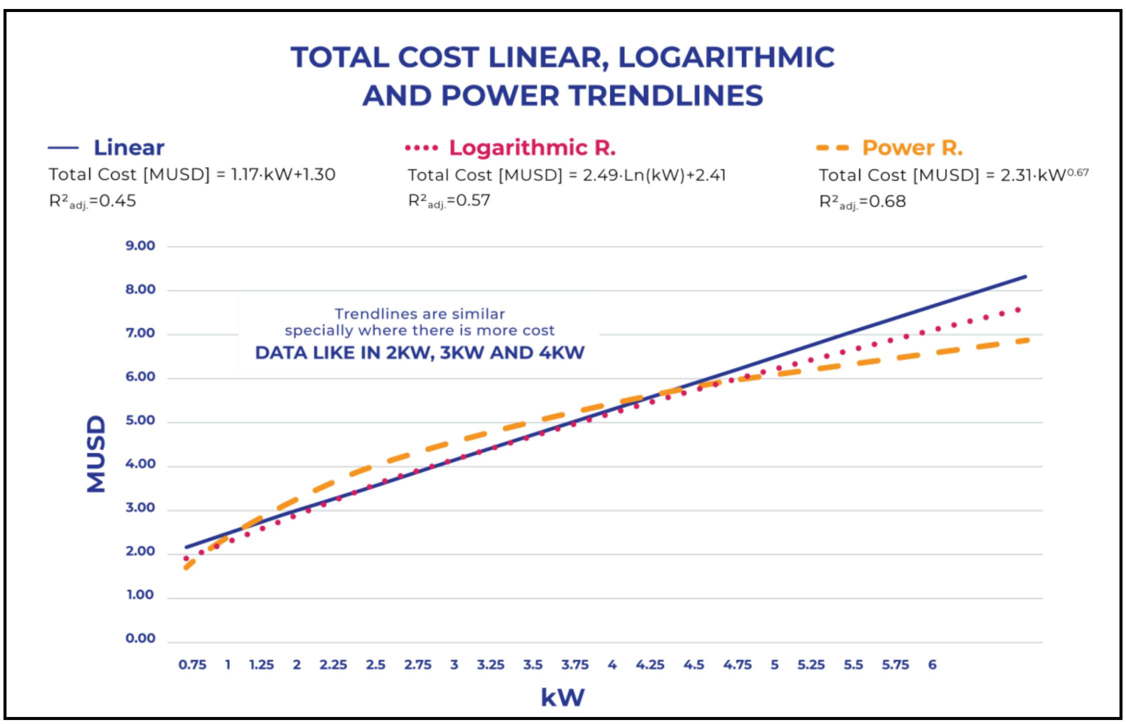

Figure 2-7: Total cost trend lines for a small-scale PVSS.

The quantitative effect of factors that influence in price variability such as the market power, communication channel with the client, financing schemes and the quality of the hardware are determined with dummies variables in the regression models. They take value one when they meet each factor and zero when they do not. The coefficient obtained from the regressions will be associated with each factor and it has a probability that will indicate its representativeness in the mathematical model.

More than 90% of the cost data used in the regressions for small-scale PVSS are not broken down. It includes 36 different costs from Chile (32 from quotes and 4 from reports) (Acesol, 2018; Gesellschaft für Internationale Zusammenarbeit, 2018) and 45 are from other countries including Australia, USA, Portugal, Spain, Brazil , India China, United Kingdom, France, Malaysia, Korea, Japan, Thailand and Germany (Camilo et al., 2017; Fu et al., 2018a; IRENA, 2019; Solar Choice, 2020) (See **Table 2-4**).

Table 2-4: Descriptive statistic of small-scale PV solar systems cost from 0.5kW to 6kW.

Category	**PV Module**	**Inverter**	**Electrical BoS**	**Structural BoS**	**Hardware**	**Installation**	**Inspection, permissions and grid connection**	**Customer acquisition**	**Overhead**	**Co. net income**	**Total cost (Untaxed)**
Min	0.35	0.23	0.10	0.10	**0.53**	0.23	0.05	0.34	0.31	**0.38**	**0.80**
Median	**0.52**	**0.39**	**0.12**	**0.27**	**0.85**	**0.66**	**0.16**	**0.36**	**0.32**	**0.39**	**1.82**
Max	0.70	0.52	0.12	0.35	**1.54**	1.43	0.32	0.62	0.62	**0.62**	**5.35**
Range	0.35	0.29	0.02	0.25	**1.01**	1.20	0.27	0.28	0.31	**0.24**	**4.55**
Samples	**6**	**6**	**5**	**5**	**26**	**27**	**26**	**5**	**5**	**5**	**81**

Unlike small-scale systems, half of large-scale cost data presents a cost breakdown (55% of the total) which allows to know the minimum cost of each category (See **Table 2-5**). The ranges observed between maximum and minimum costs for all-scales are quite wide (1.2USD/W to 0.2 USD/W) due to the variability of information between countries, companies and organizations especially in the case of small-scale.

Table 2-5: Descriptive statistic of large-scale PV solar systems cost from 30 kW to 3000 kW

Category	PV Module	Inverter	Electrical BoS	Structural BoS	Hardware	Installation	Inspection, permissions and grid connection	Overhead	Co. net income	Total cost (Untaxed)
Min	0.27	0.04	0.06	0.01	**0.47**	0.03	0.01	0.01	0.03	**0.64**
Median	**0.41**	**0.08**	**0.19**	**0.10**	**0.80**	**0.16**	**0.05**	**0.15**	**0.13**	**1.17**
Max	0.79	0.34	0.33	0.23	**1.46**	0.68	0.22	0.37	0.40	**2.48**
Range	0.52	0.30	0.27	0.22	**0.99**	0.65	0.21	0.36	0.37	**1.84**
Samples	**21**	**21**	**21**	**21**	**22**	**22**	**22**	**21**	**19**	**38**

Regardless the few cost data, the compiled information of small and large-scale PVSS cost can contribute to create an additive model as successful as possible so that all readers can understand the cost that consumers could really access.

2.2.1 Large scale PVSS cost define the inevitable cost and small scale PVSS define inefficient costs of all scales systems

PV solar systems cost can be defined or understood as compound of two types of cost, one that is truly unavoidable named as “inevitable” and other that can be potentially reduced or avoidable named as “inefficient”. An example of inevitable cost is the manufacturing cost of a component such as a PV module or inverter and of inefficient cost are those that can be removed from a business operation such as high equipment expenses because the company does not take advantage of wholesale purchase.

Large-scale systems have quite similar and even equal unit costs, so it can be said that this represents the **minimum or inevitable** cost of a PVSS regardless of its capacity. In the case of small-scale systems, these have an inevitable cost and additionally a set of inefficient costs. In the interest of constructing a single logical-mathematical expression for PVSS cost structure, the results of large and small-scale models are combined. The large-scale will represent the inevitable costs and from the small-scale, inefficient costs will be extracted.

Statistical significance: Regression indicators analysis allows identifying how representative is the mathematical model obtained according to the variables and data used. In the case of this study, all regressions are made with 95% confidence level, which indicates the degree of certainty with which the total cost model will be estimated. Among the indicators obtained, the first to look is the adjusted squared error, this represents in percentage how well the chosen variables represent the model. Then, the probability or significance of each variable indicates the significance of every variable used in the model, the smaller it is, the more it adjusts to the model. The probabilities are represented as 5% (*), 2.5% (**) and 1% (***). Finally, the significance F is the value that allows to determine whether to reject the null hypothesis, which means the model is in the chosen confidence interval (Jann, 2019) (More detail about linear regressions (Montgomery et al., 2012)).

High prices offered in PV systems are usually more related to market power (for small-scale systems) and expensive countries characteristic such as high taxes for hardware, expensive labor or higher allocation of inefficient costs (IRENA, 2016; Jana, Saha, & Das Bhattacharya, 2017; Mundada et al., 2016; Ulrich, 2016) (for large-scale systems). These variables are indispensable in the regression models to demonstrate the behavior of monopolistic competition that exists in this market[2].

Table 2-6: Results of large-scale PV solar system econometric analysis

Cost	**Details**	**Variables**	**Intercept** MUSD	**Size – kW** USD/W	**Expensive** Dummy - MUSD	**Adjusted R Square**	**Significance F**	**Standard error**
Quotes and reports all countries	**PVSS 30 - 3000kW**	**Size and Expensive countries**	-21.80 (0.47)	0.87 **(9.6E-25)*****	92.09 (0.011)**	0.97	1.8E-24	90.70
	PVSS 70 - 1000kW	**Size and Expensive countries**	-18.78 (0.58)	0.87 (7.4E-21)	111.13 (0.007)***	0.97	2.2E-20	95.16
	PVSS 70 - 3000kW	**Size and Expensive countries**	-264.38 (0.21)	0.64 (5.9E-08)***	36.27 **(0.19)**	0.96	2.4E-10	107.73
	PVSS 100 - 3000kW	**Size**	46.70 (0.11)	0.87 (1.7E-19)***		0.96	1.7E-19	109.77
	PVSS 70 - 3000kW	**Size and Expensive countries (Intercept =0)**	0.00 (-)	0.81 (5.7E-25)***	96.21 (0.001)***	0.95	4.4E-24	93.92

LARGE-SCALE PVSS REGRESSIONS

$$R1_{Q\&R}: Total\ cost = -21.8 + 0.87^{***} \cdot Power + 92.09^{**} \cdot Expensive[MUSD]$$

$$R2_{Q\&R}: Total\ cost = -18.78 + 0.87^{***} \cdot Power + 111.13^{***} \cdot Expensive\ [MUSD]$$

$$R3_{Q\&R}: Total\ cost = -264.38 + 0.64^{***} \cdot Power + 36.27 \cdot Expensive\ [MUSD]$$

$$R4_{Q\&R}: Total\ cost = 46.7 + 0.87^{***} \cdot Power[MUSD]$$

$$\boldsymbol{R5_{Q\&R}: Total\ cost = 0.81^{***} \cdot Power + 96.21^{***} \cdot Expensive[MUSD]}$$

[2] Monopolistic competition refers to a market with various vendors, where the product offered (the PVSS) is not homogeneous (they are not all the same) and companies are free to enter and exit from it. In this imperfect competition, there is a small percentage of companies that set prices due to their high market power (Dhingra & Morrow, 2019; Peoples, 2019))

Figure 2-8: Results of large-scale PVSS cost model.

Under the t-statistics, with 95% of confidence level, no large-scale regression that have been made can be rejected in favor of another (Genesove & Mullin, 1998) (See **Table 2-6**). However, the regression chosen to represent the large-scale model is the one with all variable significant at 1% subject to size and expensive countries with the zero-intercepted (See in **Figure 2-8** 12 R5) where the total variable costs are 810 USD/kW related to the power of the PVSS and the variable expensive countries that increase cost by 96,210 USD (for an average system of 100kW). Because large-scale takes advantage of economies of scale, fixed cost spread out, that is why the intercept is set to zero.

Once again, no regression can be rejected in favor of another for small-scale results (See **Table 2-7**), especially because there are several models with all their significant coefficients (regressions of small-scale PVSS are focus on the review in Chile). However, the fifth regression made with the variables size and market power is chosen to highlight the fact that the small-scale market has monopolistic competition (See **Figure 2-9**). The regression indicates that the fixed cost of a small-scale PV system is USD 660, the variable cost associated with the power is 1190 USD/ kW and if it is a company with market power or, alternatively, in an expensive country the price increases by 920USD. When evaluating this regression, very similar costs are observed to those of the literature and the quotes, which indicates that the predictors are quite accurate.

Table 2-7: Results of large-scale PVSS cost model.

Cost	Details	Variables	Intercept MUSD	Size – kW USD/W	Market power	Cost breakdown	Price List	Quotes	Web page	Adjusted R2	Significance F	Standard error
Only quotes in 0.5 -5 kW		**Size, cost breakdown and market power**	0.61 (0.024)**	1.19 **(5.9E-13)***	0.68 (0.005)***	0.52 (0.05)*	- (-)	- (-)	- (-)	0.92	2.9E-12	0.35
		Size, cost	0.57	1.20	0.72	0.52	-	-	-	0.92	2.9E-	0.35

breakdown, market power and price list	(0.06)	(2.2E-11)***	(0.009)***	(0.05)	0.1 (0.73)	(-)	(-)		11	
Size, cost breakdown, market power and quotation	0.50 (0.06)	1.19 (7.1E-13)***	0.75 **(0.002)*****	0.33 (0.22)	- (-)	0.2 (0.13)	- (-)	0.92	9.5E-12	0.33
Size, cost breakdown, market power and web page	1.02 (0.009)***	1.14 (7.54E-12)	0.63 (0.007)***	0.31 (0.27)	- (-)	- (-)	-0.3 (0.13)	0.92	9.5E-12	0.35
Size and market power	**0.66** (0.021)**	**1.19** (6.1E-13)***	**0.92** (1E-4)***	**-** (-)	**-** (-)	**-** (-)	**-** (-)	**0.92**	**1.0E-12**	**0.36**

SMALL-SCALE PVSS REGRESSIONS

$$R1_Q: CTT = 0.61^{**} + 1.19^{***} \cdot Power + 0.68^{***} \cdot Market\ Power + 0.52^{*} \cdot \text{CostBreakdown}\ [MUSD]$$

$$R2_Q: CTT = 0.57 + 1.20^{***} \cdot Power + 0.72^{***} \cdot Market\ Power + 0.52 \cdot \text{CostBreakdown} - 0.1 \cdot PriceList\ [\text{MUSD}]$$

$$R3_Q: CTT = 0.50 + 1.19^{***} \cdot Power + 0.75^{***} \cdot Market\ Power + 0.33 \cdot \text{CostBreakdown} + 0.2 \cdot Quote\ [\text{MUSD}]$$

$$R4_Q: CTT = 1.02^{***} + 1.14^{***} \cdot Power + 0.63^{***} \cdot Market\ Power + 0.31 \cdot \text{CostBreakdow} - 0.3 \cdot Web\ page\ [\text{MUSD}]$$

$$R5: CTT = 0.66^{**} + 1.19^{***} \cdot Power + 0.92^{***} \cdot Market\ Power\ [\text{MUSD}]$$

Figure 2-9: Results of small-scale PVSS cost model.

The single logical-mathematical expression for the total cost of a PVSS (TC) is integrated (See **Figure 2-9**) by an “inevitable” cost ($C_{inevitable}$) of 810 USD/kW, this is the costs associated with the power of a large-scale system which is the minimum or inevitable cost of a PVSS. Then, by an “inefficient” cost ($C_{inefficient}$) of 660 USD, this is the small-scale fixed cost or inefficient cost for all-scales. The effect of this variable in large-scale PVSS is almost imperceptible (an additional of 0.5% in the total cost and non in the average cost). And finally, by the coefficient of the discrete variable related to an expensive country or company

$(Expensive_{country\ or\ company})$ is 920 USD/kW, this component is also considered as an inefficient cost. This is from the value of market power in small-scale regression. By evaluating the variable in the integrated model, it can be affirmed that the factor represents the effect on the cost increase by expensive countries and companies (See **Figure 2-10**).

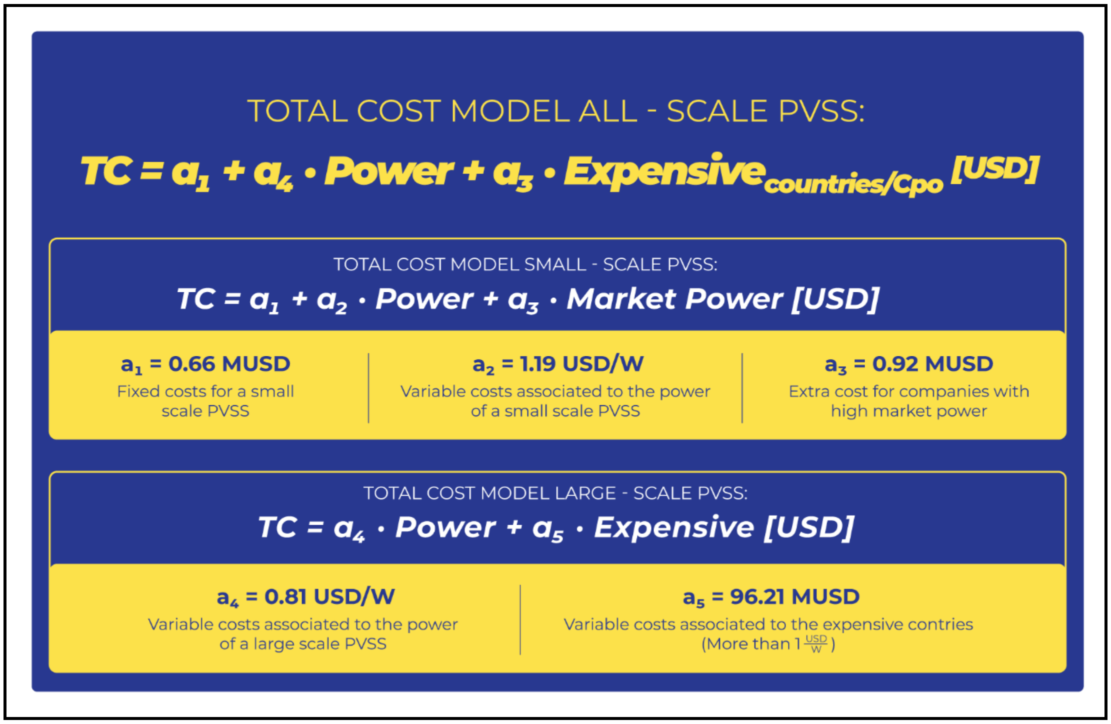

Figure 2-10: Small and large-scale PVSS total cost model integration.

2.2.2 The combination of large- and small-scale costs breakdown translates into a single cost structure for PV solar systems

The most suitable regressions to obtain the total cost are those that are based on total costs of literature and quotes and those based on cost breakdown are more accurate for cost structure. Therefore, simple regressions are performed for each component of the cost structure and then, they are combined to obtain a single cost structure. (See **Table 2-8**, **Table 2-9** and **Table 2-10** highlighted values were the ones chosen)

Table 2-8: Cost breakdown econometric analysis of small-scale PV solar systems. From 0.5kW to 6 kW in Chile.

	Category	Total cost functional forms by component $C_{category}$ MUSD		
		Linear	Logarithmic	Power
PV solar systems 0.5kW to 6 kW (Small scale) Chile	**PV Module**	$0.43 \cdot kW + 0.6$ $Radj.2=0.97$	$0.89 \cdot \ln(kW) + 0.41$ $Radj.2=0.93$	$0.48 \cdot kW^{0.94}$ $R^2_{adj.} = 0.98$
	Inverter	$0.05 \cdot kW + 0.45$ $R^2_{adj.} = 0.12$	$0.07 \cdot \ln(kW) + 0.53$ $R^2_{adj.} = 0.05$	$0.53 \cdot kW^{0.07}$ $R^2_{adj.} = 0.01$
	Electrical BoS	$0.04 \cdot kW + 0.08$ $R^2_{adj.} = 0.14$	$0.10 \cdot \ln(kW) + 0.10$ $R^2_{adj.} = 0.16$	$0.10 \cdot kW^{0.53}$ $R^2_{adj.} = 0.19$
	Structural BoS	$0.13 \cdot kW + 0.09$ $R^2_{adj.} = 0.70$	$0.30 \cdot \ln(kW) + 0.01$ $R^2_{adj.} = 0.57$	$0.09 \cdot kW^{1.11}$ $R^2_{adj.} = 0.76$
	Hardware **(PV Module, Inverter and BoS)**	$0.52 \cdot kW + 0.87$ $R^2_{adj.} = 0.77$	$1.4 \cdot \ln(kW) + 1.02$ $R^2_{adj.} = 0.68$	$1.31 \cdot kW^{0.57}$ $R^2_{adj.} = 0.76$
	Installation	$0.37 \cdot kW + 0.89$ $R^2_{adj.} = 0.76$	$1.5 \cdot \ln(kW) + 0.94$ $R^2_{adj.} = 0.45$	$1.07 \cdot kW^{0.56}$ $R^2_{adj.} = 0.50$
	Inspection, Permissions and grid connection	$0.07 \cdot kW + 0.25$ $R^2_{adj.} = 0.37$	$0.22 \cdot \ln(kW) + 0.25$ $R^2_{adj.} = 0.39$	$0.28 \cdot kW^{0.49}$ $R^2_{adj.} = 0.49$
	Overhead	Poor data available to make a regression		
	Company net income			
	Soft cost	$0.44 \cdot kW + 1.14$ $R^2_{adj.} = 0.44$	$1.26 \cdot \ln(kW) + 1.20$ $R^2_{adj.} = 0.45$	$0.54 \cdot kW^{0.54}$ $R^2_{adj.} = 0.52$
	Total cost (Untaxed)	$1.17 \cdot kW + 1.30$ $R^2_{adj.} = 0.45$	$2.49 \cdot \ln(kW) + 2.41$ $R^2_{adj.} = 0.57$	$2.31 \cdot kW^{0.67}$ $R^2_{adj.} = 0.68$

Table 2-9: Cost breakdown econometric analysis of all-scale PV solar systems. From 0.5kW to 1000 kW in Australia, USA, Portugal, Spain, Brazil, India, China, United Kingdom France, Malaysia, Korea, Japan, Thailand, Germany and Chile.

	Category	Total cost functional forms by component $C_{category}$ MUSD		
		Linear	Logarithmic	Power
PV solar systems 0.5kW to 1000kW All countries*	**PV Module**	$0.45 \cdot kW - 0.68$ $R^2_{adj.} = 0.79$	$76.9 \cdot \ln(kW) - 109$ $R^2_{adj.} = 0.69$	$0.3 \cdot kW^{1.04}$ $R^2_{adj.} = 0.98$
	Inverter	$\mathbf{0.08} \cdot kW + 0.16$ $R^2_{adj.} = 0.74$	$14.5 \cdot \ln(kW) + 20.1$ $R^2_{adj.} = 0.65$	$0.32 \cdot kW^{0.79}$ $R^2_{adj.} = 0.96$
	Electrical BoS	$0.18 \cdot kW - 38.5$ $R^2_{adj.} = 0.67$	$30.4 \cdot \ln(kW) - 35$ $R^2_{adj.} = 0.61$	$0.06 \cdot kW^{1.14}$ $R^2_{adj.} = 0.97$
	Structural BoS	$0.11 \cdot kW - 1.67$ $R^2_{adj.} = 0.52$	$-27 \cdot \ln(kW) + 0.46$ $R^2_{adj.} = 0.46$	$0.12 \cdot kW^{0.96}$ $R^2_{adj.} = 0.93$
	Hardware **(PV Module, Inverter and BoS)**	$0.83 \cdot kW - 3.48$ $R^2_{adj.} = 0.87$	$139 \cdot \ln(kW) - 156$ $R^2_{adj.} = 0.83$	$0.87 \cdot kW^{0-98}$ $R^2_{adj.} = 0.99$

	Installation	$\mathbf{0.10} \cdot kW + 1.67$ $R^2_{adj.} = 0.76$	$16.1 \cdot \ln(kW) - 16$ $R^2_{adj.} = 0.74$	$0.9 \cdot kW^{0.65}$ $R^2_{adj.} = 0.95$
	Inspection, Permissions and grid connection	$\mathbf{0.03} \cdot kW + 0.39$ $R^2_{adj.} = 0.81$	$5.16 \cdot \ln(kW) - 5.36$ $R^2_{adj.} = 0.76$	$0.21 \cdot kW^{0.70}$ $R^2_{adj.} = 0.96$
	Overhead	$\mathbf{0.09} \cdot kW + 3.82$ $R^2_{adj.} = 0.64$	$18.3 \cdot \ln(kW) - 28$ $R^2_{adj.} = 0.64$	$1.52 \cdot kW^{0.59}$ $R^2_{adj.} = 0.93$
	Company net income	$\mathbf{0.10} \cdot kW + 2.14$ $R^2_{adj.} = 0.75$	$19.4 \cdot \ln(kW) - 32$ $R^2_{adj.} = 0.76$	$0.9 \cdot kW^{0.69}$ $R^2_{adj.} = 0.95$
	Soft cost	$\mathbf{0.30} \cdot kW + 1.59$ $R^2_{adj.} = 0.88$	$50.9 \cdot \ln(kW) - 51$ $R^2_{adj.} = 0.87$	$1.02 \cdot kW^{0.81}$ $R^2_{adj.} = 0.98$
	Total cost (Untaxed)	$0.69 \cdot kW + 2.05$ $R^2_{adj.} = 0.97$	$85.8 \cdot \ln(kW) - 94.8$ $R^2_{adj.} = 0.69$	$2.06 \cdot kW^{0.81}$ $R^2_{adj.} = 0.95$

Table 2-10: Cost breakdown econometric analysis of large-scale PV solar systems. From 30 kW to 3000 kW in Chile.

	Category	**Total cost functional forms by component $C_{category}$ MUSD**		
		Linear	**Logarithmic**	**Power**
Large scale PVSS in Chile	**PV Module**	$\mathbf{0.28} \cdot kW - 3.61$ $R^2_{adj.} = 1$	$46 \cdot \ln(kW) - 176$ $R^2_{adj.} = 0.95$	$0.17 \cdot kW^{1.08}$ $R^2_{adj.} = 0.99$
	Inverter	$0.07 \cdot kW + 0.90$ $R^2_{adj.} = 0.99$	$19 \cdot \ln(kW) - 40$ $R^2_{adj.} = 0.97$	$0.11 \cdot kW^{0.93}$ $R^2_{adj.} = 0.99$
	Electrical BoS	Poor data available to make a regression		
	Structural BoS	$\mathbf{0.07} \cdot kW + 0.90$ $R^2_{adj.} = 0.99$	$7.66 \cdot \ln(kW) - 28$ $R^2_{adj.} = 0.97$	$0.09 \cdot kW^{0.90}$ $R^2_{adj.} = 0.99$
	Hardware (PV Module, Inverter and BoS)	Poor data available to make a regression		
	Installation			
	Inspection, Permissions and grid connection			
	Overhead			
	Company net income			
	Soft cost			
	Total cost (Untaxed)	$\mathbf{0.57} \cdot kW + 6.04$ $R^2_{adj.} = 1$	$215 \cdot \ln(kW) - 766$ $R^2_{adj.} = 0.63$	$1.01 \cdot kW^{0.91}$ $R^2_{adj.} = 0.98$

Total cost and cost breakdown models are integrated in order to get the cost structure model for all-scale PVSS. A bottom up adjustment by percentage was made, which means the final cost structure model is made based on the application of percentage that represents each item of the cost breakdown in the total cost model for all scales (See **Figure 2-11**).

PROCESS TO OBTAIN THE COST STRUCTURE MODEL OF ALL SCALES PVSS

Initial PVSS cost structure Based only on cost breakdown

COST BREAKDOWN MODEL AND PERCENTAGE OF PARTICIPATION RELATED TO THE TOTAL

Item	Inevitable cost USD/kW	Inefficient costs USD	Inevitable %	Inefficient %
PV Module	280	150	34%	7%
Inverter	80	450	10%	20%
Electrical BoS	80	50	10%	2%
Structural BoS	70	30	9%	1%
Hardware	510	680	63%	30%
Installation	95	560	12%	25%
Inspection, Permissions and grid connection	31	140	4%	6%
Overhead	95	730	12%	32%
Co. net income	100	159	12%	7%
Soft cost	304	1587	37%	70%
TOTAL COST (UNTAXED)	814	2267	100%	100%

Adjusted PVSS cost structure

BOTTOM UP ADJUSTMENT

Item	Inevitable Adjusted USD/W	Inefficient Adjusted USD
PV Module	279	105
Inverter	80	314
Electrical BoS	80	35
Structural BoS	70	21
Hardware	508	474
Installation	95	390
Inspection, Permissions and grid connection	30	98
Overhead	94	509
Co. net income	100	111
Soft cost	302	1106
TOTAL COST (UNTAXED)	810	1580

Final PVSS cost structure

Item	Inevitable Adjusted USD/kW	INEFFICIENT COST BREAKDOWN: Inefficient Adjusted Others USD	Inefficient Adjusted Exp. USD	Total Inefficient Adjusted USD
PV Module	279	50	54	105
Inverter	80	150	163	314
Electrical BoS	80	17	18	35
Structural BoS	70	10	11	21
Hardware	508	227	247	474
Installation	95	187	203	390
Inspection, Permissions and grid connection	30	47	51	98
Overhead	94	244	265	509
Co. net income	100	53	58	111
Soft cost	302	530	576	1106
TOTAL COST (UNTAXED)	810	757	823	1580

Figure 2-11: Cost structure econometric model stage and results for all scale PVSS.

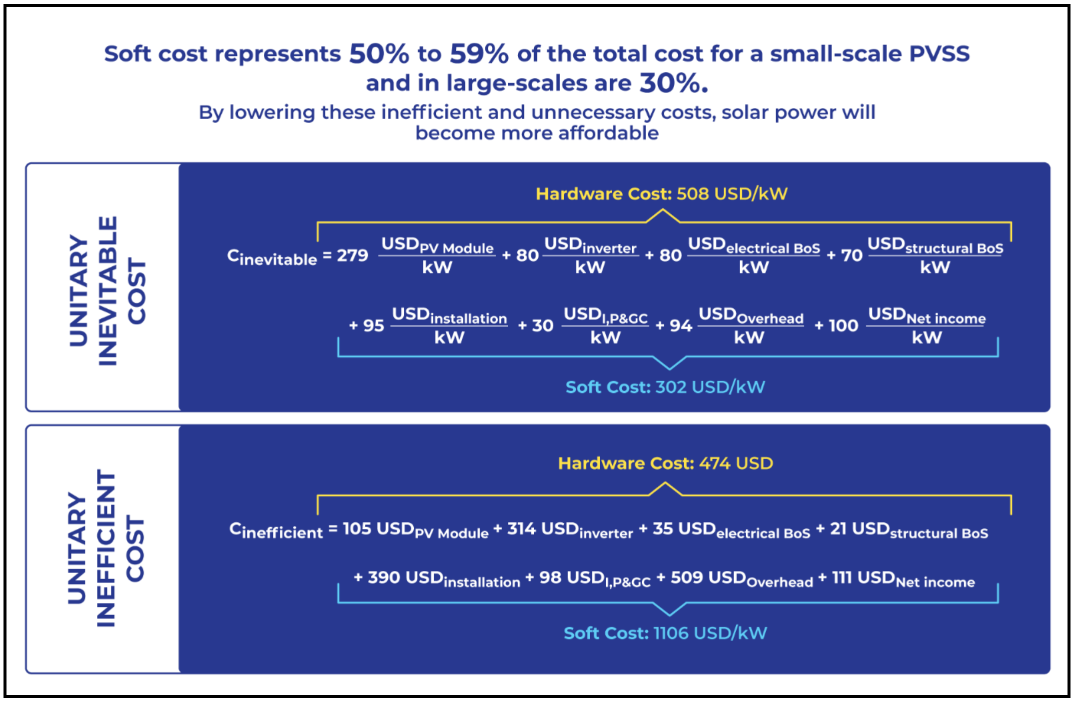

Figure 2-12: Final cost breakdown model for all scale PVSS.

This analysis confirm that the soft costs represent between 50% and 59% of the total costs for a small-scale PVSS in the cost structure model for all-scales (See **Figure 2-12**). The lower value is assigned to cheap small-scale systems and the higher one to expensive small-scale ones. This means that an expensive country or company could rise its prices up to 1 USD/W for microscale PVSS.

Overhead cost is not directly attributed to creating the PVSS [38] neither profits nor installations which means it is an internal cost that the company set. The need to charge high margin may be due to low sales since the PVSS are not yet a technology of mass use or may also be associated with companies with great market power that seek to maximize their profits and set high prices. By lowering these inefficient and unnecessary costs, solar power will become more affordable spreading out faster.

The higher inefficient cost in hardware category, is associated with inverters which have had to adapt over time to the needs of customers, from the centralized inverter to systems to microinverters for very small-scale PVSS. This is and external component of cost so it is harder to cut down these prices (Shiao & S. Moskowitz, 2015).

2.3 Exploiting economies of scale in order to significantly reduce the total cost of small-scale PVSS

Economies of scale (EoS) represent the cost-saving due to more efficient processes and services, which means, producing and offering more at lower cost. EoS could be internal and external, in the case of PVSS the internal ones refer to the services offered by the company-seller, which is reflected in the soft cost, and the external ones refer to the hardware, which is related to the manufacturers of PV modules, inverters (Humphrey, 1983; Nerlove, 1963; SCL Econometrics, 2009),

Economic of scale factor (EoSF) allows identifying, the variation in the total cost by varying the size of the system (Budnevich, Franken, & Paredes, 2001; Ferro & Lentini, 2010; Humphrey, 1983; Jara & Cortés, 1996; Nerlove, 1963) which was calculated by the ratio of unitary and marginal costs, this is the inverse of the cost elasticity (Díaz & Romero, 2007; SCL Econometrics, 2009). This factor is a way to illustrate effect of EoS in PVSS. Another way to present the effect of EoS is through the average cost (See **Figure 2-13**). If the average cost of a small PVSS is higher than larger one, it can be stated that there are **EoS. For example, based on our analysis and cost structure model, the soft cost for a 1 kW PVSS is 1408 USD/kW and for a 100kW one is 313 USD/kW, this is 4.5 times cheaper. This is enough to ensure that there are economies of scale for PV**

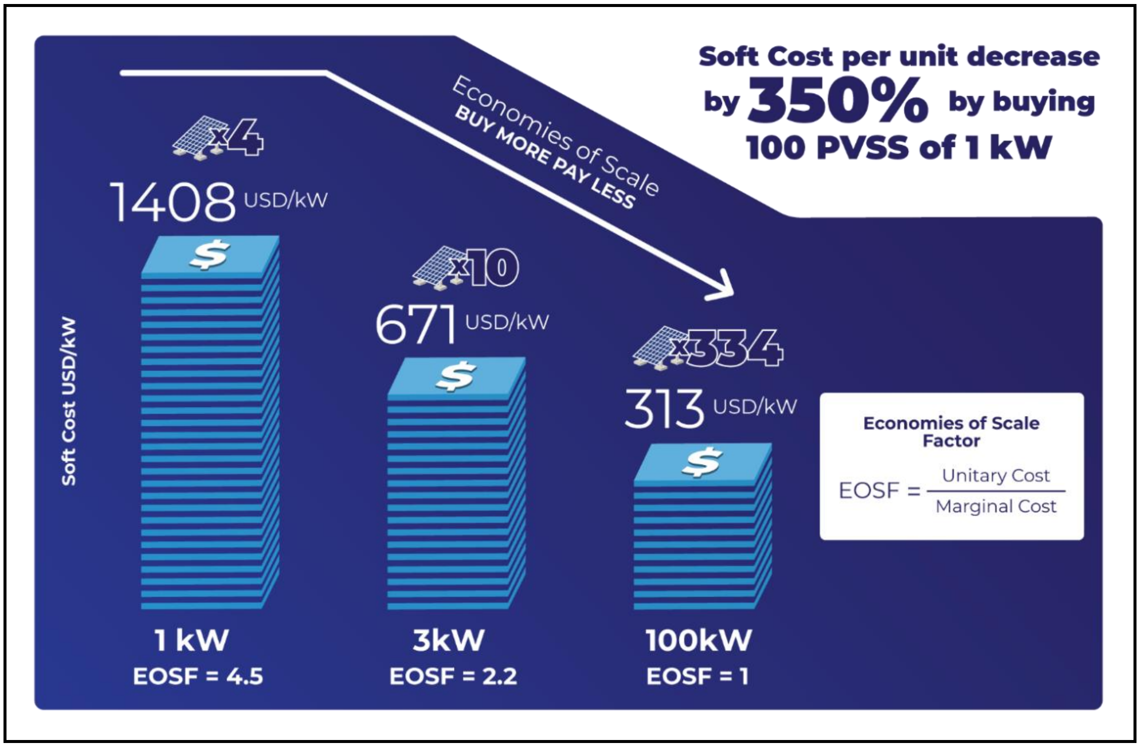

Figure 2-13: Economies of scale factor and the effect in the price for large and small-scale PV solar systems based on the cost review.

Taking advantage of economies of scale allows spreading out, fixed cost through **large purchases,** therefore the unitary **cost decreases** (Feldman, Brockway, Ulrich, Margolis, & National Renewable Energy Laboratory, 2015; Jara & Cortés, 1996)**. Lower prices in h**ardware can be exploited by making large purchases of PV modules, inverters and BoS for example, the hardware of a 1kW PVSS costs around 100% more per unit than a 100 kW (1106 USD/kW vs 508 USD/kW respectively).

For soft costs, **high economies of scale are not entirely justifiable**. As the size of the PVSS increases there is no need for more marketing or even a lot more staff for the installation, but it is evident that as the PVSS is larger, the lower the soft cost will be.

A business model based on aggregate purchase is an opportunity to cut down cost inefficiency through the exploitation of EOS. For example, a community could buy 100 PVSS of 1 kW for 0.81 USD/W each and they can save 195%.

3 BREAKING THROUGH INTO LOW COST SMALL-SCALE PVSS MARKET: SOLAR DISTRIBUTED GENERATION BUSINESS MODELS FOR ALL

3.1 Overcoming economics, financial, policy, social, regulatory and geographic barriers through business models for small scale PVSS and green finance

Small-scale PVSS requires high levels of investments that most of the residential customers cannot afford, building an economic and financial barrier between customer and the residential PV systems development. Not only high prices build a barrier, but also the unstable public policies, poor price-transparency, lack of awareness and knowledge of the benefits, and process of PV solar self-consumption (Herbes, Brummer, Rognli, Blazejewski, & Gericke, 2017a; Strupeit & Palm, 2016).

PVSS business models and financing mechanisms emerged in order to reduce or even eliminate these multiples barriers (Dunlop & Roesch, 2016; Strupeit & Palm, 2016). Barriers can be classified into five categories: political and regulatory (Engelken et al., 2016; Hobbs et al., 2013; Horváth & Szabó, 2018; Karakaya et al., 2016; Luthra, Kumar, Garg, & Haleem, 2015; Prasad & Kim, 2018; Sen & Ganguly, 2017), social and cultural (Engelken et al., 2016; Hobbs et al., 2013; Horváth & Szabó, 2018; Prasad & Kim, 2018; Rai et al., 2016; Richter, 2013; Sen & Ganguly, 2017), geographical (Engelken et al., 2016; Prasad & Kim, 2018), technical (Engelken et al., 2016; Hobbs et al., 2013; Horváth & Szabó, 2018; Karakaya et al., 2016; Luthra et al., 2015; Richter, 2013) (from the client) and economic and financial (Augustine & Mcgavisk, 2016; Coughlin et al., 2009; Engelken et al., 2016; Hall & Roelich, 2016; Hobbs et al., 2013; Horváth & Szabó, 2018; Luthra et al., 2015; Prasad & Kim, 2018; Rai et al., 2016; Richter, 2013; Speer, 2012) (See **Figure 3-1**). Residential PVSS barriers impede that many potential consumers take advantage of the benefits of distributed PV solar generation.

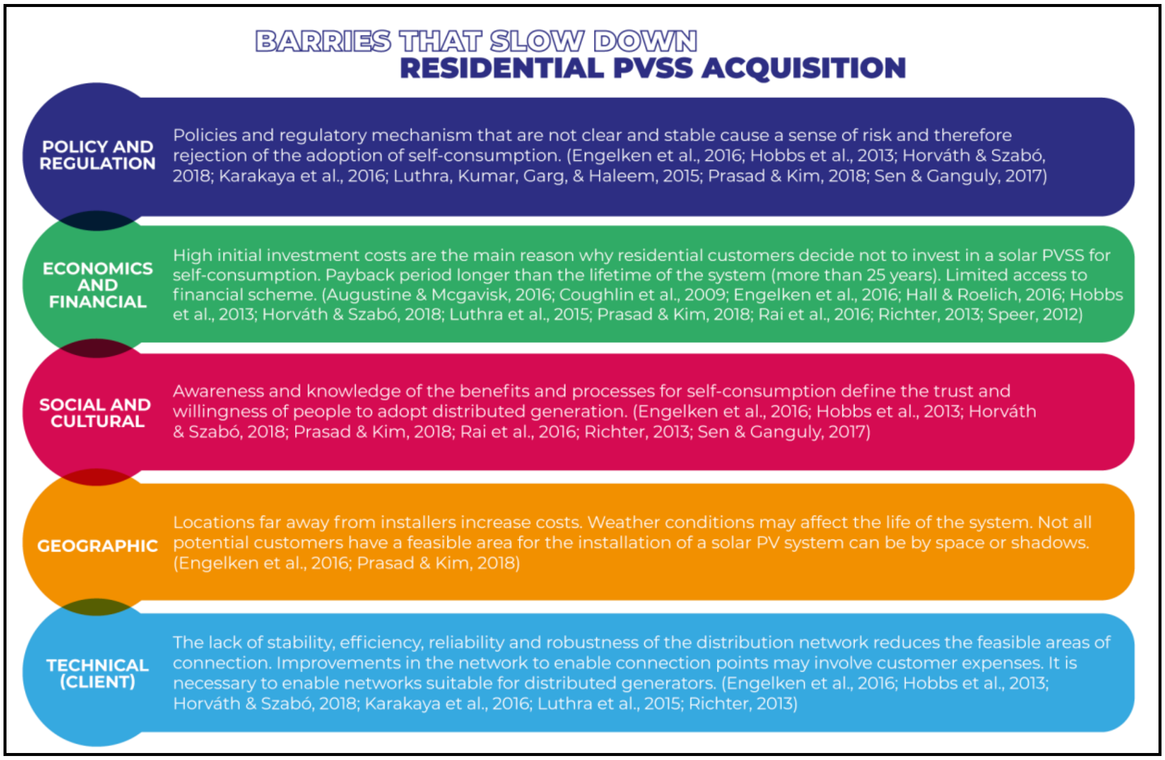

Figure 3-1: Description of the dimensions of the barriers for PVSS.

The biggest barrier that business models have to mitigate is the financial and economic one (Drury et al., 2012). Usually, this barrier is faced through subsides and financing schemes such as loans, crowdfunding, green credits among others (Dunlop & Roesch, 2016).

Green financing refers to financial investments with low interest rates that allow the sustainable development of projects. This financing focuses on supporting a proposal that improves current environmental conditions such as renewable energy projects, energy efficiency or waste management (Lindenberg, 2014).

Consumer credits are the most common financing scheme (S. Zhang, 2016) but the interest rates of these credits for low and medium income houses are high, usually between 14% to 30% (Bovarnick & Johnson, 2017). To achieve cost-effective residential PVSS more green credits must be offered (Haas, 2003; Mir-artigues, 2014). All rates in this article are annualized real rates as opposed to nominal ones whose difference is only expected inflation (money value losses of 2-3% annually in Chile) (Banco Central de Chile, 2018).

The Levelized cost of Energy (LCOE) is calculated for different interest rates and investment (See **Figure 3-2**) to illustrate the effect of low and high interest rates. The LCOE allows to describe approximately the cost of the power produced by the PVSS during its lifetime (Watts et al., 2015). In order to the PV solar project be cost-effective the LCOE must be lower than the residential tariff (Watts et al., 2015).

If LCOE is lower than the energy tariff that customers access it can be suggested that the project is cost-effective. The residential regulated tariff in Santiago, Chile, is 0.16 USD/kWh (Enel, 2019), any residential PVSS project in Santiago with a LCOE significantly lower than this will make the client perceive savings from the PV system. The interest rate at which the LCOE matches the tariff is known as break-even point (Harb, Kedia, Zhang, & Balog, 2013). This means indifference, the client does not save or lose money.

LCOE is a simple and transparent indicator of cost effectiveness, however limitations of LCOE are well known (lack of representation of dispatchability, financing and leverage, cash flow, etc.) (Watts et al., 2015). By analyzing this indicator, it is easier to make choices of development of a PVSS.

For a 1 kW PVSS in Santiago, Chile, that generates 1494 kWh per year and costs 1.65USD/W (price from local quotes), thus, the annual interest rate must be lower than 12% to become cost-effective (See **Figure 3-2**). Nowadays, rates of a consumer credit for general purposes are between 14% to 30% yearly, so even the cheapest small-scale PVSS found (1.65 USD/W) could not be cost effective for a potential customer if these rates remain high. Based on this, we can show the importance of lower green rates and low cost PVSS if we want to go solar. Similarly, using home mortgages can provide very low interest rates (2%) to enable cost effective residential PV deployment.

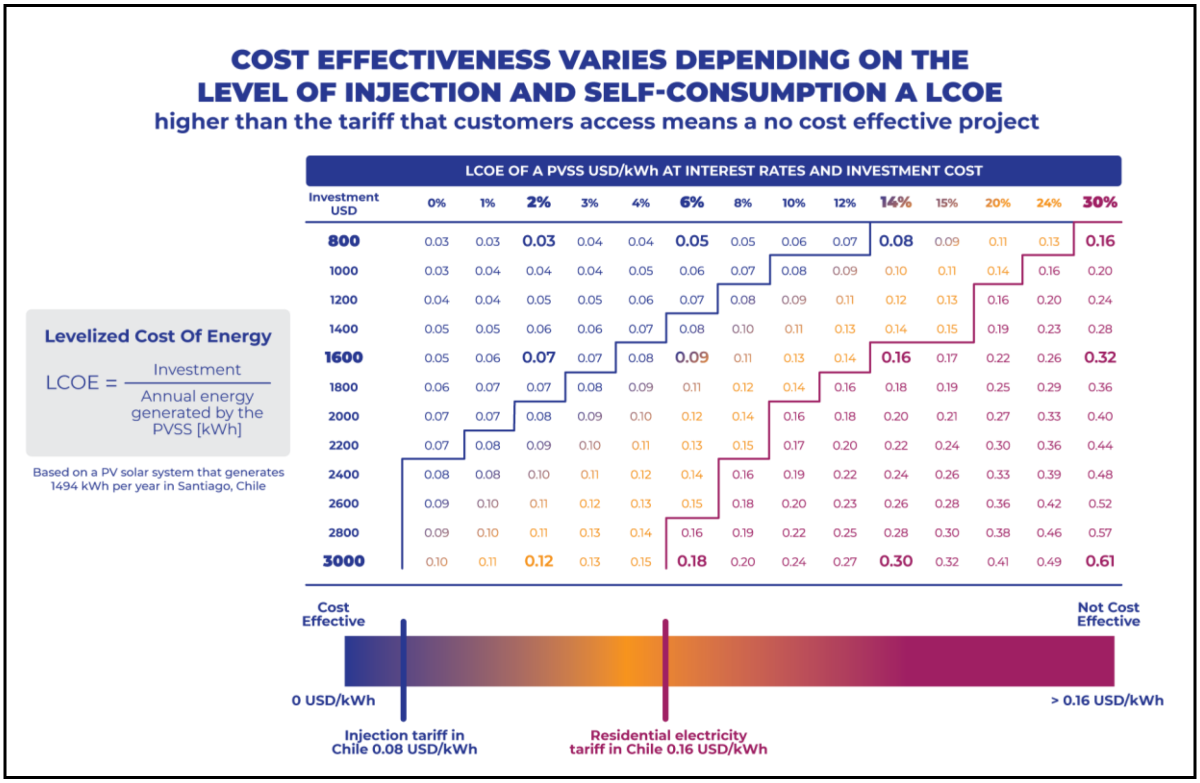

Figure 3-2: Levelized cost of energy by rates.

3.2 Most suitable business model for every type of client: The behavior and customs of society influence the effectiveness of business models

A business model is not only the story of how a company makes money, it is also how it creates, delivers and captures value to their customer segments. In order for a business model to succeed, as Magretta said (Magretta, 2002), companies have to know the needs of their clients and how they will cover them to achieve upselling and customer acquisition and retention. (Brown et al., 2019; Horváth & Szabó, 2018; Osterwalder & Pigneur, 2009; Zott, Amit, & Massa, 2011)

Residential PV business models have been improving through the years in order to offer more suitable solutions to different types of client and boost even more the development of residential PVSS (Chesbrough, 2010). To develop new solutions, it should be understood how business models of today overcome different barriers and what are the causes of the low acquisition and deployment of small-scale PVSS. For this reason, a literature business model review (Augustine & Mcgavisk, 2016; Engelken et al., 2016; Hall & Roelich, 2016; Hobbs et al., 2013; Horváth & Szabó, 2018; Karakaya et al., 2016; Luthra et al., 2015; Sen & Ganguly, 2017; Verbruggen et al., 2010) had been made.

Business models can only work if the application segment and their needs are recognized (Fisk, 2015). For example, even when a client has high radiation and a suitable roof, it does not necessarily mean that the consumer has the possibility to self-finance a 3000 USD project, so it is important to create solutions for multiple types of clients.

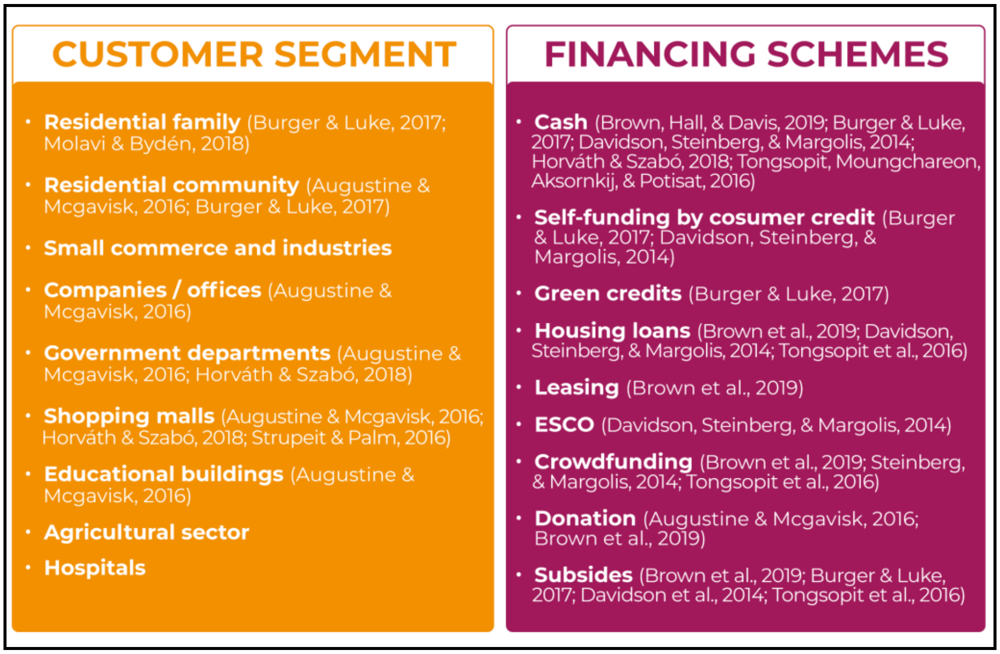

Figure 3-3: Most common customer segment and financing schemes for different business models.

The variety of business models allow more people of different economic income (Bovarnick & Johnson, 2017) and local conditions to take advantage of the benefits of solar energy (**Table 3-1**) (Hobbs et al., 2013; Prasad & Kim, 2018). The most frequent business models presented in the literature are host owned (Burger & Luke, 2017; Horváth & Szabó, 2018; Huijben & G.P.J., 2013; Karakaya et al., 2016; Speer, 2012; Strupeit & Palm, 2016; S. Zhang, 2016), third party owned (Augustine & Mcgavisk, 2016; Coughlin et al., 2009; Davidson et al., 2014; Drury et al., 2012; Hobbs et al., 2013; Horváth & Szabó, 2018; Huijben & G.P.J., 2013;

Speer, 2012; Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015; Wijeratne et al., 2019; S. Zhang, 2016) and community solar (Augustine & Mcgavisk, 2016; Burger & Luke, 2017; Horváth & Szabó, 2018; Huijben & G.P.J., 2013; Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015; S. Zhang, 2016).

Table 3-1: Business models for small-scale PV solar systems classification.

Business model	Financing scheme	Owner	Location	Scale	Application segment	Source
Host owned	Own capital or debt	Consumer	Consumer's property	Residential	Property owner with access to high amount of capital and/or low interest rates	(Burger & Luke, 2017; Horváth & Szabó, 2018; Huijben & G.P.J., 2013; Karakaya et al., 2016; Speer, 2012; Strupeit & Palm, 2016; S. Zhang, 2016)
Third party owned	Third party	Third party. Right to purchase at the end of the contract	Consumer's property	Residential	Owner or lessee of property with low access to capital	(Augustine & Mcgavisk, 2016; Coughlin et al., 2009; Davidson et al., 2014; Drury et al., 2012; Hobbs et al., 2013; Horváth & Szabó, 2018; Huijben & G.P.J., 2013; Speer, 2012; Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015; Wijeratne et al., 2019; S. Zhang, 2016)
Community share	Own capital or debt/ third party/ donation	Consumer and/or investor	Virtual plants	SMB/ Residential	Community	(Augustine & Mcgavisk, 2016; Burger & Luke, 2017; Horváth & Szabó, 2018; Huijben & G.P.J., 2013; Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015; S. Zhang, 2016)
Shared solar	Third party	Third party	Virtual plants or some	SMB/ Residential	Residential, community,	(Horváth & Szabó, 2018; Tongsopit, Sopitsuda, Moungchareon,

			consumer's property			Sunee, Aksornkij, Apinya, Potisat, 2015)
Cross selling	House's owner	House's owner	Consumer's property	SMB/ Residential	Owner of the property	(Strupeit & Palm, 2016)
Cooperatives	Third party/ donation	Third party	Virtual plants or consumer's property	SMB/ Residential	Public consumption such as educational and public buildings, agriculture sector	(Dunlop & Roesch, 2016)
Solar leasing	Third party	Third party. Right to purchase at the end of the contract	Consumer's property	Residential	Owner or lessee of property	(Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015)
Roof rental	Third party	Third party	Rooftop of the house´s owner (not the consumer)	Residential	The electricity generated by the system is consumed by a third party. The owner of the property rents the rooftop	(Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015)

Residential PVSS business models are created for customers to take advantage of low energy cost and environmental benefits that residential solar system offers. Due to the high investment cost of a residential PVSS, any of the PV solar business models are useful for those countries or areas with a high energy tariff (Murat Cekirge, 2019; Watts et al., 2015), but the goal is that every type client seize the benefits of PV solar self-consumption by applying the most suitable business model for each one (Horváth & Szabó, 2018; Strupeit & Palm, 2016). A review of most common PVSS business models were made in order to identify the most suitable model for different types of clients.

3.2.1 Host owned is the force model for today's developed countries

Clients that has access to credits with low interest rates, usually in developed countries, are the most likely to use the traditional host owned model. The consumer is the owner of the PVSS who is responsible of the maintenance of the project (Burger & Luke, 2017; Horváth & Szabó, 2018; Karakaya et al., 2016; Speer, 2012). This not a solution for the vast majority of the population as they are exposed to high amounts of investment and expensive financing (Strupeit & Palm, 2016). In addition, the fact that saving is not perceived once the system has been installed, discourages its adoption (savings come long into the future).

This model is the force in developed European countries because they have the advantage of accessing low transaction costs such as permits and connections to the network and client acquisition thanks to the fact that PVSS manufacturers instructed installers in the technical and sales area (Horváth & Szabó, 2018).

3.2.2 Third party owned is the dominant model in countries with low savings rates, low access to financing at low interest rates for individuals, but with access to low-cost business capital

A company that follows Third Party Owned (TPO) business model, plan, install, own and maintain a PVSS and the project financing comes from a third party (Hobbs et al., 2013; Horváth & Szabó, 2018). This model emerged in the U.S. (Strupeit & Palm, 2016).

The purchase and sales of clean energy from a TPO model is based on PPA contracts which have terms of 15 to 20 years because the price is predictable and does not vary greatly. At the end of the PPA contract, the customer can buy the photovoltaic system, withdraw it by the supplier or make a new agreement (Coughlin et al., 2009).

The TPO model has the advantage of allowing the client to perceive the savings from the beginning because a third party is financing the project. The net savings in electricity bills are said to be between 10 and 20% (Hobbs et al., 2013).

Companies under the TPO model shorten their processing time and costs because of their experience which also enables the transfer of risks of the project to the company (Coughlin et al., 2009). This model allows to reduce the financing barrier for a project that has high interest rates and long return periods (Strupeit & Palm, 2016). TPO reduces the difficulty in obtaining home equity loans in the wake of the financial crisis which restricted the ability of many consumers to incur high investments with extended return periods (Coughlin et al., 2009; Esipova, Pugliese, & Ray, 2014; Strupeit & Palm, 2016).

3.2.3 Community solar and shared solar are the innovative models that fit homes with low solar potential, limited spaces or low investment capacity

Community solar and shared solar models allow removing the barrier of those customers who do not have the space for an electrical installation or a favorable location for solar generation (low solar potential) through the installation of the system in a suitable area (Horváth & Szabó, 2018; Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015; S. Zhang, 2016).

Community solar take advantage of economies of scale because it involves multiple investors. It could be a community or group of people, that buys a large scale PVSS for the same interest of benefit from solar energy self-consumption (Augustine & Mcgavisk, 2016).

Shared solar models aggregate energy purchase, so consumers can access to low energy rates because of the economies of scale. Also, clients do not have to make a high investment and can take advantage of the low energy costs offered by renewable energy (Huijben & G.P.J., 2013).

In some countries like Chile, PVSS must be a property of the consumer in order to make discounts on the electricity bill, that is why community solar and shared solar do not reduce the policy and regulation barrier. In order to take advantage of these business models some countries have to develop new regulations.

3.2.4 Cross selling is the ideal model to promote the early adoption of PV solar systems in the residential sector at low interest rates from the purchase of homes

Cross-selling, which is a less mentioned PVSS business model, is a solution for the high costs of acquiring solar systems. Despite not having the same popularity as those mentioned above, this model is presented mainly in Japan. This model involves a house, apartment, condominium, commercial premises etc. with a PVSS already installed and its price is unified in the cost of the property (Strupeit & Palm, 2016).

This model allows access to PV systems at lower costs because the expenses of the cost are included in the mortgage of the property, which allows to reduce transaction costs and interest rates. This model could work very well in Chile as we have one of the lowest interest rates for mortgage loans, around 2% (CNN Chile, 2019)

Usually, this business model makes a PVSS 10% cheaper for the buyer by selling it with the house. In addition, the solar resource is used and is more aesthetic because the design of the system is done in conjunction with that of the property (Strupeit & Palm, 2016).

Another business models but less study in the literature are solar leasing and roof rental. Solar leasing allows lower initial investment (usually 30% of the total cost) because consumers can rent a PVSS up to 36 month (S-save, 2019) and take advantage of this solar systems. This model free the consumer to be fully familiar with the residential PV regulation and it processes (Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, 2015).

About Roof rental, this is a business model that works as the host owned, but the PVSS is in a different rooftop than the consumer, so this only reduces the geographic barrier since it can be placed in a rooftop that receives more irradiation.

Almost every business model can reduce economical and financial barrier, and, in some cases, technical and geographic barriers but now is the time for policies and regulation to potential this PV business model and finally residential PV solar market take-off.

Each business model has the potential to reduce or even eliminate one or several barriers defined as integrative solutions. The fact of reducing more barriers does not make the model better, this represents a solution for different circumstances and customers.

The main purpose of this review is to clarify the different options of business model that have been developed in order to reduce the most common barriers hindering the deployment of small scale PVSS (Horváth & Szabó, 2018) (**Table 3-2**).

Table 3-2: Reduction of small-scale PVSS' barriers by business models.

Business Model	**Barriers**				
	Economic and financial	**Policy and regulation**	**Technical (Client)**	**Geographic**	**Social and cultural**
Host owned					
Third party owned	✔(Horváth & Szabó, 2018)	✔	✔(Horváth & Szabó, 2018)		✔(Horváth & Szabó, 2018)
Community share	✔(Horváth & Szabó, 2018)		✔	✔	✔(Horváth & Szabó, 2018)
Shared solar	✔		✔	✔	✔
Cross selling	✔		✔		✔
Solar Leasing	✔	✔	✔		
Roof rental			✔	✔	

4 CONCLUSIONS: IMPROVEMENTS TO PREVENT REGULATION FROM BEING A BARRIER TO THE TAKEOFF OF DISTRIBUTED GENERATION SOLAR

4.1 The influence of business model in the variability and inconsistency in costs for residential PVSS: The total price could oscillate between 40% to 100% for companies with different business models

Poor price-transparency and inconsistent costs are one of the main characteristics of residential PVSS market. Nowadays, clients of these sector must make complex choices of adopting PV distributed generation based on limited and very variable cost information, delaying adoption and limiting deployment

Researchers and policy makers are seeking to expose the reason why small-scale PVSS are so expensive (Ardani et al., 2013; Horváth & Szabó, 2018). Inefficient soft costs, along with search and comparison costs, add up a list of barriers which result in very high costs. This study also suggests that the business models applied by each company, and local regulation, influence considerably on their high or low costs offered to clients.

There are several business models in place, such as host owned, third party owned, community solar, shared solar, among others, that can be classified according to the property/ownership of the system, financing scheme, application segment /market, system location and scale of the system. Each dimension has an impact on the profitability of the project and its potential adoption.

From simple host owned, to virtual multisite plants and crowdfunding, regulation must enable all these business/financing models due to the high potential to succeed in some specific conditions by overcoming or even eliminating one or several barriers. In the Latin America, Brazil (Paulo, Paiva, & Galelli, 2017)was the first to implement virtual multisite plants followed by Chile in 2018 [3].

[3] Biblioteca del Congreso Nacional. Modifica la ley general de servicios eléctricos, con el fin de incentivar el desarrollo de las generadoras residenciales. Art 143. https://www.leychile.cl/Navegar?idNorma=1125560 (accessed December 7, 2019).

Innovative regulation and policy makers must focus not only on enabling great access to economic financing schemes, such as green credits and mortgages, they must also seek for a free competition in a market that has a lot of potential for local consumers. Free and healthy competition is a key tool to transfer low costs to consumers, so is very important to follow up new markets and be sure that they are operating under a scheme close to a competitive market through prices, services offered, prevention of accessing to privilege information among others

Also, it is important to develop very detailed standards and regulations in order to limit the PVSS installers' flexibility in countries where residential PVSS are wanted to take off, like in Chile. This is to ensure that installations are as convenient and safe for consumers and the lack of experience does not affect the result (Aderhold, 2018; Tsui, Chapman, Schnirer, & Stewart, 2006).

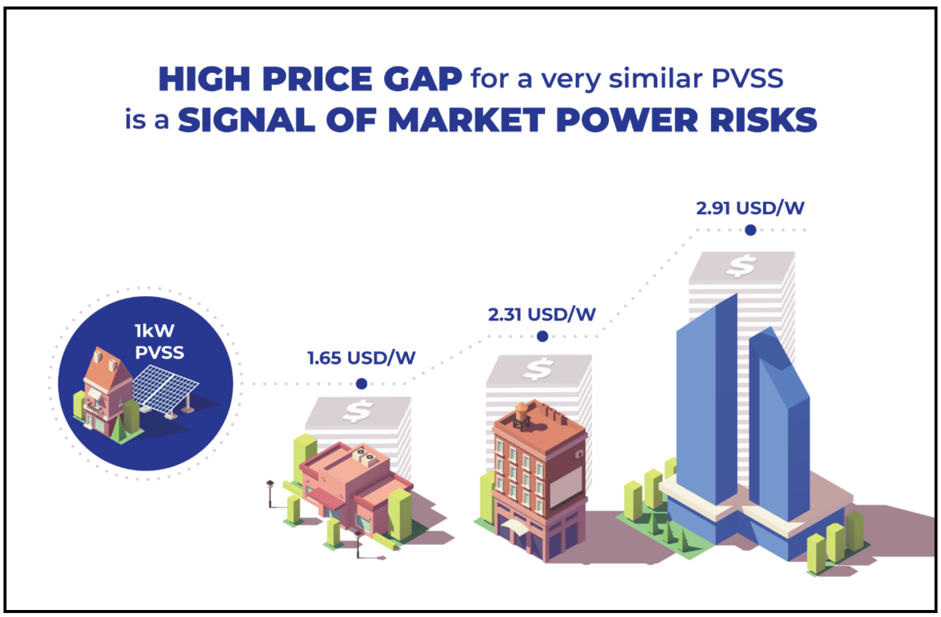

Figure 4-1: Business models and market power as indicators of high and low prices.

4.2 Monopolistic competition, market power, product differentiation and the role of governments gathering and publishing transparent ad real cost information

Companies **that offer low-cost residential PVSS** tend to protect their cost effectiveness by **avoiding showing their cost breakdown. Indeed, personal quotes with cost structure** were usually 20% more expensive than those showing only a total cost. **Market power can also increase the price up to 920 USD/kW** while **payment options**, and **hardware quality** influence the system prices but to a lesser extent (See **Figure 4-1**).

The most powerful PVSS companies are usually the electric utilities ones and those that have been in the market for more years making larger-scale projects and now they joined to distributed generation projects. With several stores across the cities and using their names they can quasi monopolize a part of the potential PV rooftop demand. The experience has a price, but the access to insider information, like the one that distribution companies have, does not allow healthy competition in the residential PVSS market. Information asymmetry is a barrier.

Governments and public institutions have a fundamental role in collecting cost information to provide to the public sector price-transparency(Haas, 2003; O'Shaughnessy & Margolis, 2018). Perfect, real and transparent information is a fundamental requirement to know how much a PV system really costs. This is also necessary to take advantage of market competition as an efficiency instrument and achieve low (cost-effective) prices in the market. Various governments, institutions and programs have been very active to achieve low prices through collecting information such as NREL in the U.S.A, IRENA, in Europe, Solar Choice in Australia and *Techos Solares Públicos* in Chile.

4.3 The ideal cost structure for a residential PVSS: Mitigating the soft cost and reducing inefficiencies through "massive aggregate purchases"

Households that are interested in or have potential to self-consumption should understand why some system are more expensive than others and how to estimate how much a PVSS can cost to them without the need of deep research. Appropriate policy must be developed to facilitate consumer choices and decisions. In a competitive market it is expected that systems price differences obey to cost differences. This review exposes the real cost breakdown for all-scale PVSS and how each category influences in the total cost in terms of value and percentage.

The review about PVSS cost was made to highlight the possibility of achieving very low prices for small-scale systems as low as large-scale, by taking advantage of economies of scales through innovative business model that involve aggregate purchase. In the cost structure obtained, it can be recognized that by increasing the size of the systems, price per unit can cost much lower.

This model backed up with success stories such as Groupon and some online travel agencies, are slowly being adopted by some municipalities and government institutions to easy PV deployment.

The main purpose of business models based on aggregate purchase is through bulk ordering clients who can buy small-scale PV solar systems at very low prices. The aggregate purchase scheme, also known as Group Buying, Collective Solar Purchasing, Solar Group Buy, can significantly reduce the economical barrier by lowering upfront costs of a PV solar system, especially soft costs. Also, lower upfront costs of small-scale PV solar systems make self-consumption more attractive for the residential sector. This scheme has been offered with the intention to significantly reduce investment cost of small-scale PV solar systems by non-profit companies such as Ecooo(Triodos Bank, 2019) in Madrid, organization like OCU (Organización de Consumidores y Usuarios) (OCU, 2020), partnership initiatives like Grow Solar of Midwest Renewable Energy Association in the US (MREA, 2019) also programs of companies like Avalancha Solar of EndeF (ENDEF, 2019) from Zaragoza or Solar Together of iChoosr from England (iChoosr, 2019).

The most common way to participate in aggregate purchase is through subscription; then the customers select the PV solar hardware kit that they want (modules and inverters) or they can ask for help to choose their right size and hardware and after, they have to pay a deposit to request the installation (Solar Together, Grown Solar, SOM Energía, EndeF, Ecooo). Some programs like Oleada Solar (Triodos Bank, 2019) and Avalancha Solar and the social movement, Collectiu Solar (Collectiu Solar, 2019), all three from Spain, affirmed that buyers can get prices 30 to 40% cheaper.

Two examples of aggregate purchase in Chile are two different projects that the company Sunbelt developed. The first one was for a social housing complex financed by the municipality after a public call for tender. It consisted on 323 individual PV solar systems of 1.36 kW. The second project was for a private complex. It included 20 individual PV solar systems of 960 W and it was developed during the construction time. Both projects saved around 30% of the individual cost of PV solar systems because the company took advantage of aggregate purchase.

The private project is a very good example to follow up, this project applied a combination of aggregate purchase and cross selling business model, because it was developed during construction, so customers could access to lower prices and finance their PV solar system through their mortgage loan which has very low interest rates [4]. Also, the public project has a component that also allowed to get the most competitive price through a public call for tender.

Aggregate purchases are widely used in multiples markets, but the small-scale PVSS market has not been boosted enough to take full advantage of them. The local experience (Sunbelt) and international (Spain and the United States) of companies and non-profit organizations that have applied the aggregate purchase scheme declare that they have reduced the price by around 30% from the consumer's point of view (ENDEF, 2019; MREA, 2019). However, it has not been popularized enough or fully exploited to even achieve greater demand that means

[4] Sunbelt. Proyectos destacados. https://sunbelt.cl/category/proyecto-destacados/ (accessed May 8, 2020)

greater savings for each client. That is why in this study encourage to take advantage of this business model with the support of different representatives, both private and public.

The economic barrier is not the only one slowing down the development of PVSS in the low energy consumption sector, but business models (Herbes, Brummer, Rognli, Blazejewski, & Gericke, 2017b; Strupeit & Palm, 2016) such as aggregate purchasing open a door for those consumers by allowing them to explore and take advantage of the benefits of self-consumption with the support of those who has access to capital as government entities, which can finance projects at low rates or by subsidies or real estate that could offer properties with the system already installed and the cost of financing the system is absorbed in the mortgage loans (Dunlop & Roesch, 2016; Matisoff & Johnson, 2017).

Transferring experiences between consumers also facilitates education without the need to directly use resources in this objective. However, it is recommended to continue to use efforts in education tools as it speeds adoption.

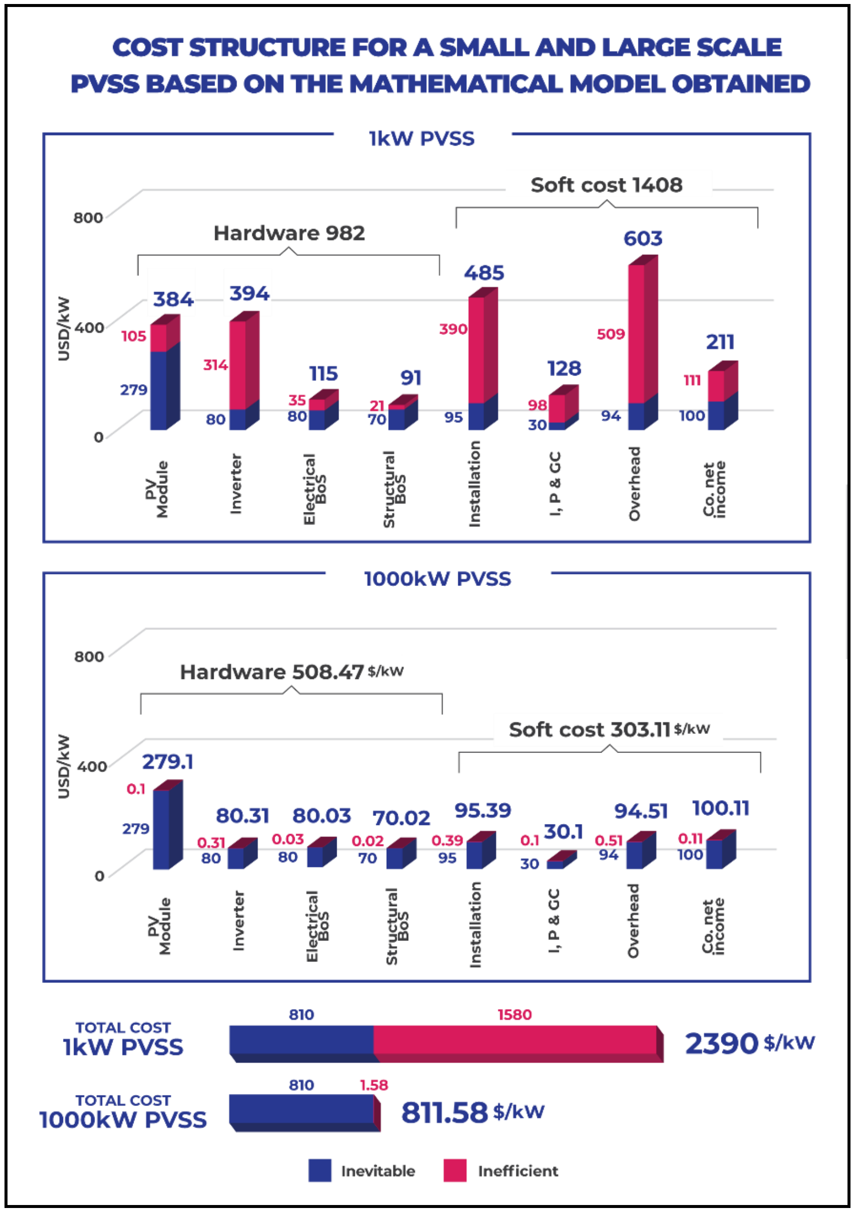

Figure 4-2: Cost structure based on the mathematical model developed by the econometric analysis made in this article.

Buying in bulk of small-scale PVSS is very similar to buy a large-scale PVSS allowing fixed costs to spread in the quantities. If a business model, based on aggregate purchase, is applied in a community, buying simultaneously 1000 or even 100 PVSS of 1 kW, average cost can go down up to 300%, which means saving of 2.2USD/W (dropping from 3 USD/W to 0.8 USD/W). The economies of scale of this model can also mitigate inefficient cost (up to 1.7 USD/W), by spreading out fixed costs, and at the same time reduce hardware costs (up to 0.5 USD/W) by wholesale purchasing.

By having access to transparent cost information, it is possible to identify cost overruns by the government and individuals through tools such as comparators. Knowing the cost structure allows to identify which items are having cost overruns, also makes harder to companies to transfer inefficient cost to customers (Dhingra & Morrow, 2019). Even if society in general does not have large knowledge in technical specs of PVSS, similar options can be offered and the client can choose depending on their energy consumption, available space and purchasing capacity.

The information about the cost breakdown of PVSS can be used by end users and by intermediaries who advise buyers like in some companies that use the aggregate purchasing scheme like Solar Together (Manchester) or Grown Solar (Wisconsin), where according to certain characteristics given by consumers, such as energy consumption and roof space, an expert can offer suitable options of systems of different quality and price. The ability to compare various offers and options in the market provides greater competitiveness in the markets (O'Shaughnessy & Margolis, 2018). Being able to access disaggregated cost information will also make it easier for regulators to identify who is responsible for cost overruns and, in some cases, to be able to do something about it.

Small-scale PVSS cost comparators will be a great tool for providing insight and guide for consumers to join this beneficial technology, having government support is essential. In addition, there is a need for well-though regulation that ensures consumers and everyone interested to access transparent cost information and it also will encourage a more competitive market.

Figure 4-3: Massive aggregate purchase business model.

Business model can only work if the application segment and their needs are clearly recognized (Fisk, 2015). Real estate developers, which are natural aggregators of housing demand, as well as Municipalities and government offices/departments can be used to serve as organicists of the aggregation demand process, an example of this in Chile is the Energy Ministry that is aggregating demand through the program *Techos Solares Públicos*. The solar city of Diego de Almagro in Chile has large deployment of microscale PV thanks to this model (Fraunhofer Chile, 2017).

4.4 The transition to a green economy requires commitment from the government through regulation and incentives and support from the financial sector to develop sustainable investments

The transition to a **coal-free** country **requires a commitment from the government through regulation and incentives, as well as financial sector support** to develop sustainable investments. Customers mostly affected by the limited options to invest in cost effective green projects are in **residential** and commercial sectors, who often only have easy **access** to consumer **credits at high**

interest rates (between 14% and 30%). Financing schemes with high interest rates build an important barrier that prevents the client from perceiving the benefits of solar self-consumption project like lower energy tariffs and avoid utilities transmission fixed costs.

Academic literature has not paid enough attention to the role of banking in the green transition (United Nations Environment Programme, 2017) of the residential sector, which is an extremely important tool to reduce or even eliminate the economic and financial barrier of acquiring a distributed generator. Transiting from "consumer" credits (interest rates around 30%) to mortgage or green credit rates (e.g. 2%) could reduce levelized cost of energy, from 0.32 USD/kWh to 0.05 USD/kWh allowing the system to be paid by its savings. Such huge interest gap is only present in the residential and SMBs sector.

For the first time in Chile, in 2019 the bank, Banco Estado, along with the Ministry of Energy, as technical advisor, launched a green credit for consumer with low interest rates. The green consumer credit *"Crédito Verde del Banco Estado"* offers a special preferential rate near 6 % (the rate will depend on the amount, term and credit evaluation, and is also subject to variation according to commercial conditions in force at the time of granting the credit), 100% financing of the value of the project, up to 90 days for the payment of the first installment and up to two months in the year, not consecutive, of non-payment of these (La Tercera. El Pulso, 2019). Mortgages instead, have credits ranging from 1.4 to 4.2 SBS credit, but limited to first mortgage and with high operational costs.

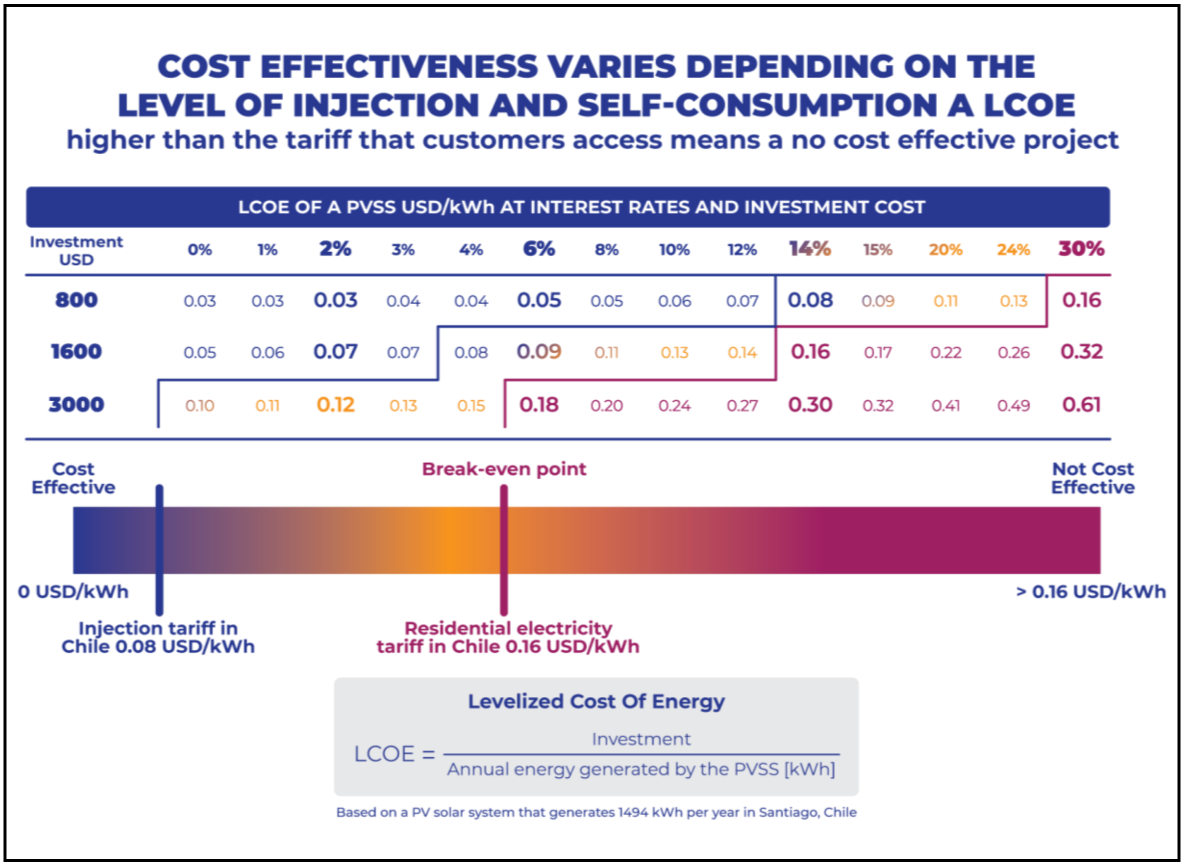

Figure 4-4: Break-even point in the levelized cost of energy.

The effect of low rates is very remarkable in cost-effective projects. For an 800 USD (0.8 USD/W) PVSS, even if the discount rate is 29%, the project is still cost-effective but for a 3000 USD project rates must be lower than 5% which can be found in mortgages or green credits. The work to achieve low interest rates not only lies in regulation, but also in the financial sector.

Local cost component allowed to discover the price variability and the true cost-structure model that identifies the relevance of market power.

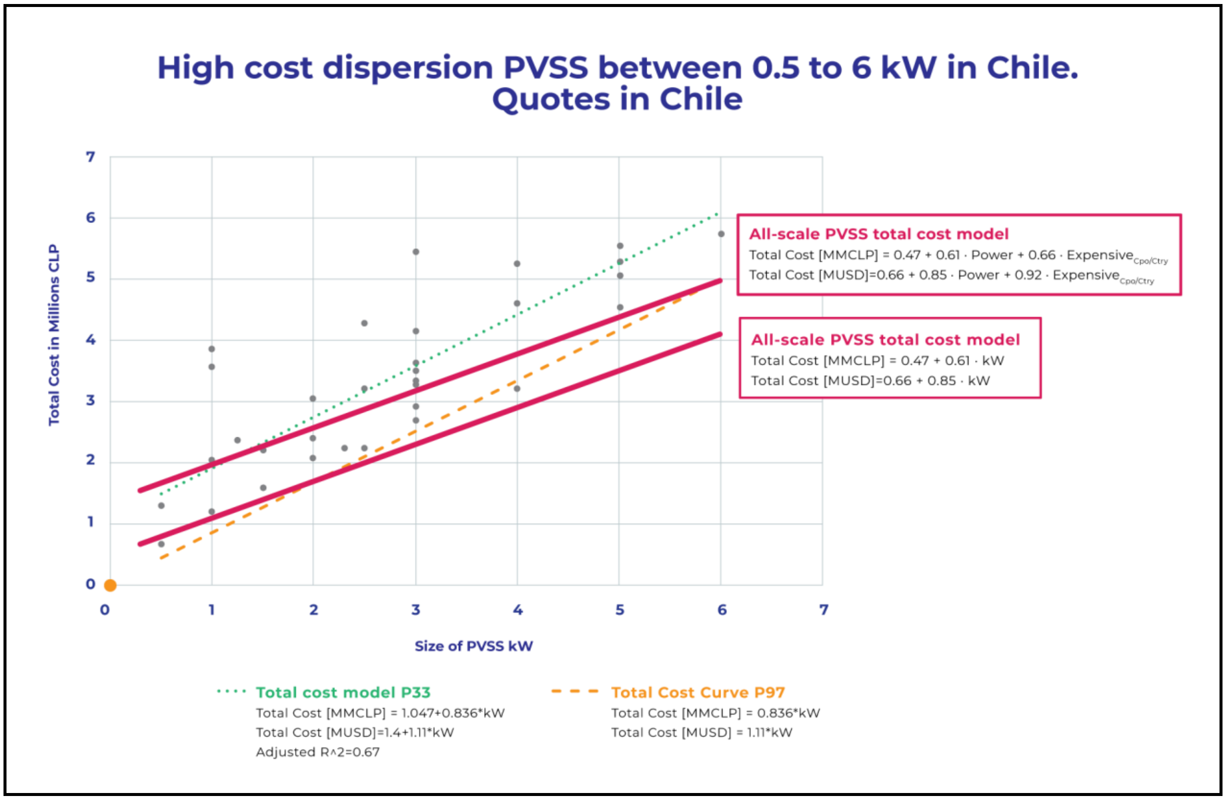

Figure 4-5**:** All-scale PVSS model, linear functional form.

Nowadays, there are researches that try to reveal the real cost that a PV solar project involves (O'Shaughnessy & Margolis, 2018; Seel et al., 2014; Ulrich, 2016) and also more innovative business models proposes. If further review focus on revealing real cost-structure of small-scale PVSS and its components, along with developing of innovative business models, as has been done in this review, policy maker will have the necessary tools to insurance a free competition market, and the dreamed 0.5 USD/W will not be as far as it is believed and developers will be able to transfer cost efficiency to their clients.

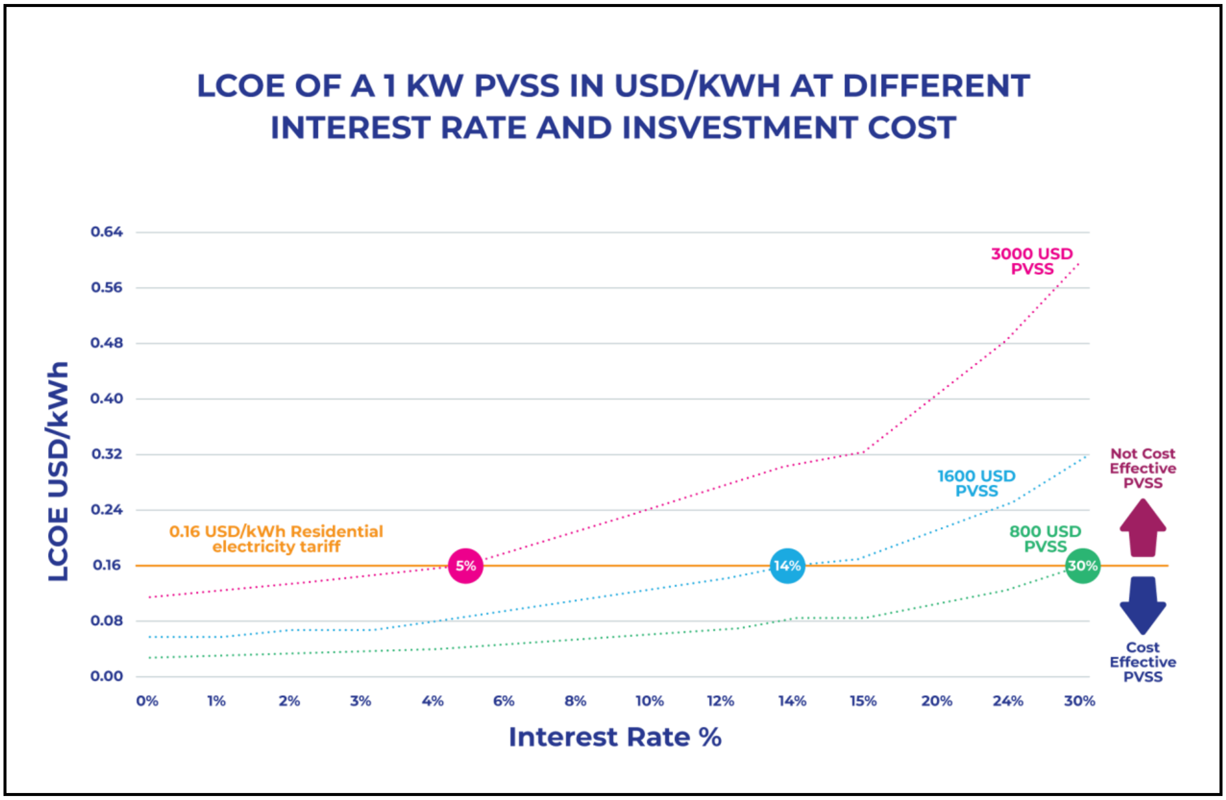

Figure 4-6: Investment price and interest rates can define cost-effectiveness.

Some of the recommendation for policy makers to reduce the price gap, based on the econometric analysis developed in this article are the follow ones:

- Apply business models based on aggregate purchase to take advantage of economies of scale.

- Exploit and benefit from business models that are already implemented based on communities' behavior.

- Developed a comparing tool to educate about PVSS' costs and components. Also, to reduce social-cultural barriers that impede residential sector to take advantage of self-consumption.

- Monitoring market power of small-scale PVSS' market. An alternative to monitor this market could be to request to the installation firm, on the permission form, a price breakdown of the PVSS.

- Avoid subsides that cover the total cost of any small-scale PVSS. Design a subside based on a unitary average and transparent price of a small-scale PVSS.

Different tools such as low interest credits, aggregated purchase and price-transparency will help new business models to develop, which will allow overcoming barriers for residential PVSS. It is true that financing is one of the great barriers that prevents the exploitation of residential PV solar systems, but solutions that reduce multiple barriers are also needed. Green financing and aggregate purchasing can effectively reduce economic and financial barriers and if, in addition, policies are developed to enable virtual plant consumption for communities, house construction with PVSS (solar ready) by 2050 in developing countries can go solar.

REFERENCES

Acesol. (2018). Valores referenciales de sistemas fotovoltaicos, generación y retorno de inversión (Santiago). Retrieved March 3, 2019, from https://acesol.cl/

Aderhold, E. D. (2018). *Renewable energy Policy recommendations*. *Architectural Digest* (Vol. 68). France. https://doi.org/10.1109/iccep.2011.6036306

Ardani, K., Seif, D., Davidson, C., Morris, J., Truitt, S., Torbert, R., & Margolis, R. (2013). Preliminary non-hardware ('soft') cost-reduction Roadmap for residential and small commercial solar photovoltaics, 2013-2020. *Conference Record of the IEEE Photovoltaic Specialists Conference*, (August 2013), 3463–3468. https://doi.org/10.1109/PVSC.2013.6745192

Assaf, S. A., Bubshait, A. A., Atiyah, S., & Al-Shahri, M. (2001). The management of construction company overhead costs. *International Journal of Project Management*, *19*(5), 295–303. https://doi.org/10.1016/S0263-7863(00)00011-9

Astriani, Y., Shafiullah, G. M., Anda, M., & Hilal, H. (2019). Techno-economic evaluation of utilizing a small-scale microgrid. *Energy Procedia*, *158*, 3131–3137. https://doi.org/10.1016/j.egypro.2019.01.1013

Augustine, P., & Mcgavisk, E. (2016). The next big thing in renewable energy: Shared solar. *Electricity Journal*, *29*(4), 36–42. https://doi.org/10.1016/j.tej.2016.04.006

Banco Central de Chile. (2018). Funciones del Banco Central de Chile. Retrieved January 23, 2020, from https://www.bcentral.cl/web/banco-central/el-banco/gobierno-corporativo/funciones-del-banco

Barbose, G., Darghouth, N., Lacommare, K., Millstein, D., & Rand, J. (2018). *Tracking the Sun Installed Price Trends for Distributed Photovoltaic Systems in the United States - 2018 Edition*. Retrieved from https://emp.lbl.gov/sites/default/files/tracking_the_sun_2018_edition_final_0.pdf

Bovarnick, B., & Johnson, L. (2017). *Research Review on Residential Solar Access: Barriers and Solutions for Low and Moderate Income Communities*. Connecticut. Retrieved from http://cbey.yale.edu/sites/default/files/Barriers and Solutions LMI Solar_FINAL.pdf

Brown, D., Hall, S., & Davis, M. (2019). Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK. *Unpublished*, *135*(August), 110984. https://doi.org/10.1016/j.enpol.2019.110984

Budnevich, C., Franken, H., & Paredes, R. (2001). Economías de Escala y Economías de Ámbito en el Sistema Bancario Chileno. *Economía Chilena*, *4*(2), 59–74. Retrieved from https://www.econ-jobs.com/research/13045-Economas-de-Escala-y-Economas-de-mbito-en-el-Sistema-Bancario-Chileno.pdf

Burger, S. P., & Luke, M. (2017). Business models for distributed energy resources : A review and empirical analysis. *Energy Policy*, *109*(June), 230–248. https://doi.org/10.1016/j.enpol.2017.07.007

Camilo, F. M., Castro, R., Almeida, M. E., & Pires, V. F. (2017). Economic assessment of residential PV systems with self-consumption and storage in Portugal. *Solar Energy*, *150*, 353–362. https://doi.org/10.1016/j.solener.2017.04.062

Campoccia, A., Dusonchet, L., Telaretti, E., & Zizzo, G. (2020). ScienceDirect An analysis of feed ' in tariffs for solar PV in six representative countries of the European Union. *Solar Energy*, *107*(2014), 530–542. https://doi.org/10.1016/j.solener.2014.05.047

Chesbrough, H. (2010). Business model innovation: Opportunities and barriers. *Long Range Planning*, *43*(2–3), 354–363. https://doi.org/10.1016/j.lrp.2009.07.010

Chung, D., Davidson, C., Fu, R., Ardani, K., & Margolis, R. (2015). *U.S. Photovoltaic Prices and Cost Breakdowns : Q1 2015 Benchmarks for Residential , Commercial , and Utility-Scale Systems*. *National Renewable Energy Laboratory*. https://doi.org/NREL/TP-6A20-64746

CIA. (2020). Electricity - consumption compares total electricity generated annually plus imports and minus exports, expressed in kilowatt-hours. Retrieved November 12, 2019, from https://www.cia.gov/library/publications/the-world-factbook/rankorder/2233rank.html

CNN Chile. (2019, September 30). Nueva baja : Tasas de crédito hipotecario registran mínima histórica por octava vez, pp. 1–5. Retrieved from https://www.cnnchile.com/pais/baja-tasa-credito-hipotecario_20190930/

Collectiu Solar. (2019). Colectivo Solar. Retrieved April 18, 2020, from https://www.collectiu-solar.cat/es/como-funciona

Comisión Nacional de Energía. Energía Abierta. (2019a). Capacidad total instalada. Retrieved January 8, 2020, from http://energiaabierta.cl/visualizaciones/capacidad-instalada/

Comisión Nacional de Energía. Energía Abierta. (2019b). Generación Distribuida - Instalaciones Inscritas. Retrieved January 10, 2020, from http://datos.energiaabierta.cl/dataviews/235587/generacion-distribuida-instalaciones-inscritas/

Coughlin, J., Cory, K., Coughlin, J., & Cory, K. (2009). *Solar Photovoltaic Financing : Residential Sector Deployment*. Colorado. Retrieved from https://www.researchgate.net/publication/255206480_Solar_Photovoltaic_Financing_Residential_Sector_Deployment

Cucchiella, F., D'Adamo, I., & Gastaldi, M. (2015). Financial analysis for investment and policy decisions in the renewable energy sector. *Clean Technologies and Environmental Policy, 17*(4), 887–904. https://doi.org/10.1007/s10098-014-0839-z

Davidson, C., Steinberg, D., & Margolis, R. (2014). Exploring the market for third-party-owned residential photovoltaic systems : insights from lease and power-purchase agreement contract structures and costs in California. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/10/2/024006

De Boeck, L., Van Asch, S., De Bruecker, P., & Audenaert, A. (2016). Comparison of support policies for residential photovoltaic systems in the major EU markets through investment profitability. *Renewable Energy*, *87*, 42–53. https://doi.org/10.1016/j.renene.2015.09.063

De La Tour, A., Glachant, M., & Ménière, Y. (2011). Innovation and international technology transfer: The case of the Chinese photovoltaic industry. *Energy Policy*, *39*(2), 761–770. https://doi.org/10.1016/j.enpol.2010.10.050

Dhingra, S., & Morrow, J. (2019). Monopolistic competition and optimum product diversity under firm heterogeneity. *Journal of Political Economy*, *127*(1), 196–232. https://doi.org/10.1086/700732

Díaz, A., & Romero, A. (2007, September). Economías de escala en el sector eléctrico mexicano. *Comercio Exterior, 57*. Retrieved from http://revistas.bancomext.gob.mx/rce/magazines/107/3/DiazBautista-Romero.pdf

Drury, E., Miller, M., Macal, C. M., Graziano, D. J., Heimiller, D., Ozik, J., & Perry IV, T. D. (2012). The transformation of southern California's residential photovoltaics market through third-party ownership. *Energy Policy*. https://doi.org/10.1016/j.enpol.2011.12.047

Dufo-López, R., & Bernal-Agustín, J. L. (2015). A comparative assessment of net metering and net billing policies. Study cases for Spain. *Energy*, *84*, 684–694. https://doi.org/10.1016/j.energy.2015.03.031

Dunlop, S., & Roesch, A. (2016). *EU-Wide solar PV Business models guidlines for implementation*. Belgium. Retrieved from http://resource-platform.eu/files/knowledge/reports/EU-wide-solar-PV-business-models-PV-Financing.pdf

Efficiency, E., Energy, S., & Office, T. (2020). Power Electronics and Balance of System Hardware Technologies, 1–4. Retrieved from https://www.energy.gov/eere/solar/power-electronics-and-balance-system-hardware-technologies

ENDEF. (2019). Avalancha Solar. Retrieved April 18, 2020, from https://endef.com/avalancha-solar-by-endef/

Enel. (2019). Tarifa de suministro eléctrico BT1. Retrieved October 23, 2019, from https://www.enel.cl/content/dam/enel-cl/personas/tarifas-y-reglamentos/tarifas/tarifas-históricas/tarifas-de-suministros-clientes-regulados/Tarifas Suministros Clientes Regulados - Septiembre 2019.pdf

Energia abierta Comisión Nacional de Energía. (2019). Capacidad instalada generación - SEN. Retrieved January 10, 2020, from http://datos.energiaabierta.cl/dataviews/245691/capacidad-instalada-de-generacion-sen/

Energy matters. (2011). A better deal on solar - Buyers groups. Retrieved April 18, 2020, from https://www.energymatters.com.au/residential-solar/solar-buyers-group/

Energy Sage. (2019). *Solar marketplace Intel Report*. Boston. Retrieved from https://www.energysage.com/data/#intel-9

Engelken, M., Römer, B., Drescher, M., Welpe, I. M., & Picot, A. (2016, July 1). Comparing drivers, barriers, and opportunities of business models for renewable energies: A review. *Renewable and Sustainable Energy Reviews*. Elsevier Ltd. https://doi.org/10.1016/j.rser.2015.12.163

Escobar, R. A., Cortés, C., Pino, A., Salgado, M., Pereira, E. B., Martins, F. R., … Cardemil, J. M. (2015). Estimating the potential for solar energy utilization in Chile by satellite-derived data and ground station measurements. *Solar Energy*, *121*, 139–151. https://doi.org/10.1016/j.solener.2015.08.034

Esipova, N., Pugliese, A., & Ray, J. (2014). International Organization for Migration The demographics of global internal migration, 1–6.

Feldman, D., Brockway, A. M., Ulrich, E., Margolis, R., & National Renewable Energy Laboratory. (2015). Shared Solar: Current Landscape, Market Potential, and the Impact of Federal Securities Regulation. *National Renewable Energy Laboratory*, (April), 70.

Ferro, G., & Lentini, E. (2010). *Economías de escala en los servicios de agua potable y alcantarillado*. Santiago. Retrieved from https://repositorio.cepal.org/bitstream/handle/11362/3831/1/lcw369e.pdf

Fisk, P. (2015). *Identifying Your Most Profitable Customers: An introduction to Customer Segmentation*. *Magento*. California. Retrieved from https://magento.com/sites/default/files8/2019-01/introduction-to-customer-segmentation-v2.pdf

Fraunhofer Chile. (2017). *Estrategia local informe final Comuna Diego de Almagro*. Santiago. Retrieved from http://www.minenergia.cl/comunaenergetica/wp-content/uploads/2016/06/INFORME-DIEGO-DE-ALMAGRO_27112017.pdf

Fu, R., Chung, D., Lowder, T., Feldman, D., Ardani, K., & Margolis, R. (2016). *U.S. Photovoltaic Prices and Cost Breakdowns : Q1 2016 Benchmarks for Residential , Commercial , and Utility-Scale Systems*. *National Renewable Energy Laboratory*. https://doi.org/10.7799/1325002

Fu, R., Feldman, D. J., & Margolis, R. M. (2018a). U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018, (November). https://doi.org/10.2172/1483475

Fu, R., Feldman, D., & Margolis, R. (2018b). *U.S. Photovoltaic Prices and Cost Breakdowns : Q1 2018 Benchmarks for Residential , Commercial , and Utility-Scale Systems*. *National Renewable Energy Laboratory*. https://doi.org/10.7799/1325002

Fu, R., Feldman, D., Margolis, R., Woodhouse, M., & Ardani, K. (2017). U.S. Photovoltaic Prices and Cost Breakdowns : Q1 2017 Benchmarks for Residential , Commercial , and Utility-Scale Systems. *National Renewable Energy Laboratory*, (September), 73.

Gabriel, C. A., & Kirkwood, J. (2016). Business models for model businesses: Lessons from renewable energy entrepreneurs in developing countries. *Energy Policy*, *95*, 336–349. https://doi.org/10.1016/j.enpol.2016.05.006

Genesove, D., & Mullin, W. (1998). Testing Static Oligopoly Models : Conduct and Cost in the Sugar Industry , 1890-1914. *The RAND Journal of Economies*, *29*(2), 355–377. Retrieved from https://www.jstor.org/stable/pdf/2555893.pdf?refreqid=excelsior%3A34fbf355e01c0e1742d882e6e6902925

Gesellschaft für Internationale Zusammenarbeit. (2018). Índice de Precios de Sistemas Fotovoltaicos (FV) conectados a la red de distribución comercializados en Chile, 1–5. Retrieved from http://4echile.cl/4echile/wp-content/uploads/2018/12/GIZ-Indice-de-precio-FV-2018-1.pdf

Global Environment Facility. (2011). Introduction to green finance. Retrieved October 23, 2019, from https://www.thegef.org/sites/default/files/events/Intro to Green Finance.pdf

Green, M. A. (2019). How Did Solar Cells Get So Cheap? *Joule*, *3*(3), 631–633. https://doi.org/10.1016/j.joule.2019.02.010

Haas, R. (2003). Market deployment strategies for photovoltaics: An international review. *Renewable and Sustainable Energy Reviews*, *7*(4), 271–315. https://doi.org/10.1016/S1364-0321(03)00062-5

Hall, S., & Roelich, K. (2016). Business model innovation in electricity supply markets : The role of complex value in the United Kingdom. *Energy Policy*, *92*, 286–298. https://doi.org/10.1016/j.enpol.2016.02.019

Harb, S., Kedia, M., Zhang, H., & Balog, R. S. (2013). Microinverter and string inverter grid-connected photovoltaic system - A comprehensive study. *Conference Record of the IEEE Photovoltaic Specialists Conference*, 2885–2890. https://doi.org/10.1109/PVSC.2013.6745072

Hasan, R., & Mekhilef, S. (2017). Highly efficient flyback microinverter for grid-connected rooftop PV system. *Solar Energy*, *146*, 511–522. https://doi.org/10.1016/j.solener.2017.03.015

Hasan, R., Mekhilef, S., Seyedmahmoudian, M., & Horan, B. (2017). Grid-connected isolated PV microinverters: A review. *Renewable and Sustainable Energy Reviews*, *67*, 1065–1080. https://doi.org/10.1016/j.rser.2016.09.082

He, Y., Pang, Y., Li, X., & Zhang, M. (2018). Dynamic subsidy model of photovoltaic distributed generation in China. *Renewable Energy*, *118*, 555–564. https://doi.org/https://doi.org/10.1016/j.renene.2017.11.042

Herbes, C., Brummer, V., Rognli, J., Blazejewski, S., & Gericke, N. (2017a). Responding to policy change: New business models for renewable energy cooperatives – Barriers perceived by cooperatives' members. *Energy Policy*, *109*, 82–95. https://doi.org/10.1016/j.enpol.2017.06.051

Herbes, C., Brummer, V., Rognli, J., Blazejewski, S., & Gericke, N. (2017b). *Responding to policy change: New business models for renewable energy cooperatives – Barriers perceived by cooperatives' members*. *Energy Policy* (Vol. 109). Elsevier Ltd. https://doi.org/10.1016/j.enpol.2017.06.051

Hobbs, A., Pierpont, B., & Varadarajan, U. (2013). *Improving Solar Policy : Lessons from the solar leasing boom in California Climate Policy Initiative*. California. Retrieved from https://climatepolicyinitiative.org/publication/improving-solar-policy-lessons-from-the-solar-leasing-boom-in-california/

Horváth, D., & Szabó, R. Z. (2018). Evolution of photovoltaic business models: Overcoming the main barriers of distributed energy deployment. *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2018.03.101

Huijben, J. C. C. M. V., & G.P.J. (2013). Breakthrough without subsidies? PV business model experiments in the Netherlands. *Energy Policy*, *56*(January 2012), 362–370. https://doi.org/10.1016/j.enpol.2012.12.073

Humphrey, D. (1983). *Costos y economías de escala en la intermediación financiera*. La Paz: XX Reunión de técnicos de Bancos Centrales del continente Americano. Retrieved from https://books.googleusercontent.com/books/content?req=AKW5QacEmIsJmY9nGOCYMbO4Mk2R4kEvnoYHX_Af3D6B8Ksn9PPMbMx5c9R7qcutB4eiKVBcvB6UnGiNE7xtzknQHBROFiB3arNox1udFIo0U_j5FRYkHYKpfoyzGxWOUcXg4C_mKCMXIXzSRJCVonkXrrYhqTzV6O7wpKBE8pGzeFmkDO8q7hievQF8Q7gr1GVcerMqO

iChoosr. (2019). Solar group buying scheme. Retrieved April 18, 2020, from https://www.solartogether.co.uk/gmca/home

In, S., Energysage, W., Calculator, S., Loans, S., & Upgrades, E. (2020). Why are solar panels so expensive ? Understanding the cost of a solar panel system. Retrieved December 12, 2019, from https://news.energysage.com/understanding-the-cost-of-a-solar-panel-system/

IRENA. (2016). *The Power to Change: Solar and Wind Cost Reduction Potential to 2025*. *Inernational Renewable Energy Agency*.

IRENA. (2019). *Renewable Power Generation Costs in 2018*.

Jana, J., Saha, H., & Das Bhattacharya, K. (2017). A review of inverter topologies for single-phase grid-connected photovoltaic systems Grid-connected inverter Efficiency Transformer-less inverter Multilevel inverter Soft-switching inverter, *72*(April 2015), 1256–1270. https://doi.org/10.1016/j.rser.2016.10.049

Jann, B. (2019). Influence functions for linear regression (with an application to regression adjustment). *University of Bern Social Sciences Working Paper*, *41*(32), 0–26. Retrieved from http://econpapers.repec.org/paper/bsswpaper/32.htm

Jara, S., & Cortés, C. (1996). On the Calculation of Scale Economies from Transport Cost Functions. *Journal of Transport Economics and Policy*, *30*(3), 157–170. Retrieved from https://www.jstor.org/stable/20053107

Karakaya, E., Nuur, C., & Hidalgo, A. (2016). Business model challenge : Lessons from a local solar company. *Renewable Energy*, *85*, 1026–1035. https://doi.org/10.1016/j.renene.2015.07.069

La Tercera. El Pulso. (2019, October 1). Autoridades junto a BancoEstado lanzan primer crédito de consumo verde. Retrieved from https://www.latercera.com/pulso/noticia/autoridades-junto-bancoestado-lanzan-primer-credito-consumo-verde/842442/

Lindenberg, N. (2014). *Definition of Green Finance*. *German Development Institute*. Bonn. Retrieved from https://www.die-gdi.de/uploads/media/Lindenberg_Definition_green_finance.pdf

Local Energy Scotland. (2019). What is Local Energy ? Funding Resources Projects and Case Studies. Retrieved April 18, 2020, from https://www.localenergy.scot/resources/solar-pv-collective-purchase/

Luthra, S., Kumar, S., Garg, D., & Haleem, A. (2015). Barriers to renewable/sustainable energy technologies adoption: Indian perspective. *Renewable and Sustainable Energy Reviews*, *41*, 762–776. https://doi.org/10.1016/j.rser.2014.08.077

Magretta, J. (2002). Why business models matter. *Harvard Business Review*, *133*(May), 86–92. Retrieved from https://www.academia.edu/1131170/Why_business_models_matter

Markvart, T., & Castañer, L. (2003). *Practical Handbook of Photovoltaics: Fundamentals and Applications*. (T. Markvart & L. Castañer, Eds.). Oxford: Elsevier Advanced Technology. Retrieved from https://books.google.cl/books?hl=es&lr=&id=E2BAosEwDfQC&oi=fnd&pg=PP1&dq=%22Balance+of+system%22&ots=HNyTlDRAQk&sig=rk_wnhAvQ4PSMDEZHSMjaNTgzpk&redir_esc=y#v=onepage&q=%22Balance of system%22&f=false

Matisoff, D. C., & Johnson, E. P. (2017). The comparative effectiveness of residential solar incentives, *108*(June 2016), 44–54.

Ministerio de Energia. (2019). Plan de Descarbonización proceso histórico para Chile. Retrieved January 7, 2020, from http://www.energia.gob.cl/tema-de-interes/plan-de-descarbonizacion-proceso

Mir-artigues, P. (2014). Combining tariffs , investment subsidies and soft loans in a renewable electricity deployment policy. *Energy Policy*, *69*, 430–442. https://doi.org/10.1016/j.enpol.2014.01.040

Molavi, S., & Bydén, W. (2018). *Solar Prosumer Business Models in Sweden*. KTH School of Industrial Engineering and Management. Retrieved from https://pdfs.semanticscholar.org/ddf9/5bb834b1735de2722283c3c7dcffed4605be.pdf

Montgomery, D., Peck, E., & Vining, G. (2012). *Introduction to Linear Regression Analysis*. New Jersey: John Wiley & Sons. Retrieved from https://books.google.cl/books?hl=es&lr=&id=0yR4KUL4VDkC&oi=fnd&pg=PP13&dq=linear+regression&ots=p5rxBfdXCk&sig=qP8Hbqbc6qneKZprlN_0hmA5mB8&redir_esc=y#v=onepage&q=linear regression&f=false

MREA. (2019). Midwest “ Grow Solar ” Group Purchase Programs. Retrieved April 18, 2020, from https://www.midwestrenew.org/wp-content/uploads/2019/09/Solarize-Overview-2019-compressed-1.pdf

Mundada, A. S., Nilsiam, Y., & Pearce, J. M. (2016). A review of technical requirements for plug-and-play solar photovoltaic microinverter systems in the United States. *Solar Energy*, *135*, 455–470. https://doi.org/10.1016/j.solener.2016.06.002

Murat Cekirge, H. (2019). Modified Levelized Cost of Electricity or Energy, MLOCE and Modified Levelized Avoidable Cost of Electricity or Energy, MLACE and Decision Making. *American Journal of Modern Energy*, *5*(1), 1. https://doi.org/10.11648/j.ajme.20190501.11

Nerlove, M. (1963). Returns to Scale in Electricity Supply. In *Measurement in Economics: Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld* (First Edit, pp. 167–197). Stanford: Stanford University Press.

Notton, G., Lazarov, V., & Stoyanov, L. (2010). Optimal sizing of a grid-connected PV system for various PV module technologies and inclinations, inverter efficiency characteristics and locations. *Renewable Energy*, *35*(2), 541–554.

https://doi.org/http://dx.doi.org/10.1016/j.renene.2009.07.013

O'Shaughnessy, E., & Margolis, R. (2018). The value of price transparency in residential solar photovoltaic markets. *Energy Policy*, *117*(April), 406–412. https://doi.org/10.1016/j.enpol.2018.03.025

OCU. (2020). Energías renovables Ya está aqui la III Compra Colectiva de Kits Fotovoltaicos. Retrieved April 18, 2020, from https://www.ocu.org/comunidad/energias-renovables/produccion-de-electricidad/conversacion/2672/ya-esta-aqui-la-iii-compra-colectiva-de-kits-fotovoltaicos-para-autoconsumo-de-ocu-renovamos#

Osinergmin. (2018). Tarifas eléctricas residenciales en Latinoamérica - 4to trimestre 2018. Retrieved January 16, 2020, from http://observatorio.osinergmin.gob.pe/tarifas-electricas-residenciales-latinoamerica

Osterwalder, A., & Pigneur, Y. (2009). *Business Model Canvas*. (T. Clark, Ed.). Portland. Retrieved from http://radio.shabanali.com/business-model-generation-osterwalder.pdf

Paulo, A., Paiva, D., & Galelli, B. (2017). Photovoltaic electricity production in Brazil : A stochastic economic viability analysis for small systems in the face of net metering and tax incentives, *168*, 1448–1462.

Pendlebury, Maurice Edward, R., Groves, V., & Groves, R. (2004). *Company Accounts: Analysis, Interpretation and Understanding* (Sixth). London: Thomson Learning 2004. Retrieved from https://books.google.cl/books?id=dY6txuHY3b8C&pg=PA23&dq=what+are+company+profit&hl=es&sa=X&ved=0ahUKEwiKvMuZhprmAhVoK7kGHSrSA9AQ6AEIKDAA#v=onepage&q=what are company profit&f=false

Peoples, J. (2019). Monopolistic Market Structure , Unionization , and Racial Wage Differentials James Peoples , Jr . Source : The MIT Press Stable. *The Review of Economics and Statistics*, *76*(1), 207–211. https://doi.org/10.2307/2109841

Perea, A., Smith, C., Davis, M., Mond, A., Gallagher, B., Rumery, S., … Baca, J. (2019).

U . S . Solar Market Insight Executive Summary. Retrieved from https://www.seia.org/research-resources/solar-market-insight-report-2019-q2

Prasad, L., & Kim, Y. (2018). An analysis on barriers to renewable energy development in the context of Nepal using AHP. *Renewable Energy*, *129*, 446–456. https://doi.org/10.1016/j.renene.2018.06.011

Rai, V., Reeves, D. C., & Margolis, R. (2016). Overcoming barriers and uncertainties in the adoption of residential solar PV. *Renewable Energy*, *89*, 498–505. https://doi.org/10.1016/j.renene.2015.11.080

Richter, M. (2013). German utilities and distributed PV: How to overcome barriers to business model innovation. *Renewable Energy*, *55*, 456–466. https://doi.org/10.1016/j.renene.2012.12.052

Rondanelli, R., Molina, A., & Falvey, M. (2015). The Atacama surface solar maximum. *Bulletin of the American Meteorological Society*, *96*(3), 405–418. https://doi.org/10.1175/BAMS-D-13-00175.1

S-save. (2019). Financiamos tu proyecto de ahorro. Retrieved January 4, 2020, from https://www.s-save.cl/financiamiento.html

SCL Econometrics. (2009). *Cuantificación de las economías de escala en el sector sanitario*. Santiago. Retrieved from https://www.economia.gob.cl/1540/articles-190023_recurso_1.pdf

Seber, G., & Lee, A. (2003). *Linear Regression Analysis*. New Jersey: John Wiley & Sons. Retrieved from https://books.google.cl/books?hl=es&lr=&id=X2Y6OkXl8ysC&oi=fnd&pg=PR5&dq=linear+regression&ots=sdoWC-iVnw&sig=oXXpvwQgQcWme9vj_WSw9T5CRec&redir_esc=y#v=onepage&q=linear regression&f=false

Seel, J., Barbose, G. L., & Wiser, R. H. (2014). An analysis of residential PV system price differences between the United States and Germany. *Energy Policy*, *69*, 216–226. https://doi.org/10.1016/j.enpol.2014.02.022

Sen, S., & Ganguly, S. (2017). Opportunities, barriers and issues with renewable energy development – A discussion. *Renewable and Sustainable Energy Reviews*, *69*(September 2016), 1170–1181. https://doi.org/10.1016/j.rser.2016.09.137

Shiao, M. J., & S. Moskowitz. (2015). *The global PV inverter landscape 2013: Technologies, Markets and Survivors*. Edindburgh. Retrieved from http://www.greentechmedia.com/research/report/the-global-pv-inverter-landscape-2015

Solar Action Alliance. (2018). Residential Solar Panels Cost Analysis: Full Breakdown. Retrieved July 23, 2019, from https://solaractionalliance.org/residential-solar-panel-cost/

Solar Choice. (2020). Solar panel costs based on live database | Jan 2020 How much do Solar Panels cost ? (January 2020) Compare quotes from up to 7 installers in your area See individual graphs by city and system size in our Residential Solar PV Price Index blog articles Co. Retrieved June 12, 2019, from https://www.solarchoice.net.au/blog/solar-power-system-prices

Solar review. (2019). How much does a solar power system cost in 2019. Retrieved June 17, 2019, from https://www.solarreviews.com/solar-panels/solar-panel-cost/

Solargis. (2018). Solar resource maps of Latin America and Caribbean GHI. Retrieved January 28, 2020, from https://solargis.com/maps-and-gis-data/download/

Solcoa isntalaciones fotovoltaicas. (2019). Compra Conjunta de Equipos de Energía Solar Granada. Retrieved April 18, 2020, from https://www.eseficiencia.es/2019/06/25/primera-compra-colectiva-cien-instalaciones-fotovoltaicas-dirigida-personas-negocios-tejado-propio

Speer, B. (2012). *Residential Solar Photovoltaics : Comparison of Financing Benefits , Innovations , and Options Residential Solar Photovoltaics : Comparison of Financing Benefits , Innovations , and Options*. Retrieved from http://solarplusnw.org/wp-content/uploads/2013/06/NRELPVFinancing.pdf

Strupeit, L., & Palm, A. (2016). Overcoming barriers to renewable energy diffusion: Business models for customer-sited solar photovoltaics in Japan, Germany and the United States. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2015.06.120

Tongsopit, Sopitsuda, Moungchareon, Sunee, Aksornkij, Apinya, Potisat, T. (2015). Business Models and Financing Options for a Rapid Scale-up of Rooftop Solar Power Systems in Thailand. *Energy Policy*, (April), 79–136. https://doi.org/10.1016/j.enpol.2016.01.023

Triodos Bank. (2019). Cómo instalar paneles fotovoltaicos en casa y participar en una Oleada Solar. Retrieved April 18, 2020, from https://www.triodos.es/es/articulos/2018/como-instalar-paneles-fotovoltaicos-en-casa-y-participar-en-una-oleada-solar

Tsui, L., Chapman, S. A., Schnirer, L., & Stewart, S. (2006). *A Handbook on Knowledge Sharing : Strategies and Recommendations for Researchers , Policymakers , and Service Providers*. *Community-University Partnership for the Study of Children, Youth, and Families*. Edmonton. Retrieved from https://www.westernsydney.edu.au/__data/assets/pdf_file/0018/405252/Knowledge_Sharing_Handbook.pdf

Tuovila, A. (2019). Overhead cost. Retrieved January 8, 2020, from https://www.investopedia.com/terms/o/overhead.asp

Ulrich, E. (2016). Soft Costs 101: The Key to Achieving Cheaper Solar Energy. Retrieved September 20, 2019, from http://energy.gov/eere/articles/soft-costs-101-key-achieving-cheaper-solar-energy

United Nations Environment Programme. (2017). *On the role of Central Banks in enhancing green finance*. *United Nations Environment Programme*. Retrieved from http://unepinquiry.org/wp-content/uploads/2017/02/On_the_Role_of_Central_Banks_in_Enhancing_Green_Finance.

pdf

Verbruggen, A., Fischedick, M., Moomaw, W., Weir, T., Nadaï, A., Nilsson, L. J., … Sathaye, J. (2010). Renewable energy costs, potentials, barriers: Conceptual issues. *Energy Policy*, *38*(2), 850–861. https://doi.org/10.1016/j.enpol.2009.10.036

Watts, D., Valdés, M. F., Jara, D., & Watson, A. (2015). Potential residential PV development in Chile: The effect of Net Metering and Net Billing schemes for grid-connected PV systems. *Renewable and Sustainable Energy Reviews*, *41*, 1037–1051. https://doi.org/http://dx.doi.org/10.1016/j.rser.2014.07.201

Wijeratne, W. M. P. U., Yang, R. J., Too, E., & Wakefield, R. (2019). Design and development of distributed solar PV systems : Do the current tools work ? *Sustainable Cities and Society*, *45*(November 2018), 553–578. https://doi.org/10.1016/j.scs.2018.11.035

Zhang, F., Deng, H., Margolis, R., & Su, J. (2015). Analysis of distributed-generation photovoltaic deployment, installation time and cost, market barriers and policies in China. *Energy Policy*, *81*, 43–55. https://doi.org/https://doi.org/10.1016/j.enpol.2015.02.010

Zhang, S. (2016). Innovative business models and financing mechanisms for distributed solar PV (DSPV) deployment in China. *Energy Policy*, *95*, 458–467. https://doi.org/10.1016/j.enpol.2016.01.022

Zott, C., Amit, R., & Massa, L. (2011). The business model: Recent developments and future research. *Journal of Management*, *37*(4), 1019–1042. https://doi.org/10.1177/0149206311406265

APPENDIX

A. Appendix A : International experience of aggregate purchase

Table A-1: International experience of aggregate purchase scheme application in Spain, USA, England and Edinburgh.

Name	Country / City	Main target audience	Details
GROW SOLAR	Illinois, Wisconsin and Iowa, USA.	Individuals, local municipality, club, employer etc.	Partnership initiative of Midwest Renewable Energy Association.
solar together	Manchester.	Residential.	Program of the energy company iChoosr.
ocu La fuerza de tus decisiones	Spain.	n/a.	Compra Colectiva de Equipos de Placas Solares. OCU is an organization.
oleada solar	Madrid, Spain.	Residential.	Program of Ecoo, a nonprofit company.
LOCAL ENERGY SCOTLAND	Edinburgh.	Farmer.	Program of an energy company.
paleBLUEdot	Southwest Virginia, USA.	Individuals, business, or municipal agencies.	Environmental services company.
#Avalancha Solar	Madrid, Aragon and Málaga, Spain.	Communities, companies, individuals etc.	Program of an energy company.
solcoa instalaciones fotovoltaicas	Granada, Spain.	n/a	Program of a company.
col·lectiusolar sobiraniaenergètica	Spain.	n/a	Social movement.
som energia	Madrid, Spain.	Houses and business.	Cooperative.

ENERGY MATTERS	Australia.	Residential.	Program of an energy company

B. Appendix B: Small-scale PV solar systems description of the quotations made in Santiago, Chile

Table B-1 Characteristics of the quotation made in Santiago, Chile for different scales of PVSS

Empresa	Size kW	Módulo FV	Inversor	Cableado	Montaje	Medidor bidireccional	Batería	Instalación	Tramitación	Costo USD/W
Heliplast	**1.25**	5 Komaes modelo KM250 Monocrystalline	5 microinverter Enphase M250 250W							**2.61**
	2.5	9 Talesun Hipro II TP660M 300 W Monocrystalline	Ingeteam Ingecon Sun 1 Play 2.5TL M 2.5kW							**1.77**
	3	11 Talesun Hipro II TP660M 300 W Monocrystalline	Ingeteam Ingecon Sun 1 Play 3TL M 3kW				No	Sí		**1.67**
	5	18 Talesun Hipro II TP660M 300 W Monocrystalline	Ingeteam Ingecon Sun 1 Play 5TL M 5kW							**1.41**
	6	21 Talesun Hipro II TP660M 300 W Monocrystalline	Ingeteam Ingecon Sun 1 Play 6TL M de 6kW							**1.41**
Aquito solar	**3**	9 unidades Policrystalline 300W	Inverter-charger 28V 6 kVA con controlador de carga solar MPPT 60A	Cables	3 montajes paneles coplanar a techo		Sí	Si	Si	**1.62**
Solar Zone	**1**	4 GCL 265W	Solis Mini 4G 1kW	44 de cable fotovoltaico TOP Solar 4mm2 negro						**2.91**
	2	8 GCL 265W	Moso SF3600 Wifi	44 de cable fotovoltaico TOP Solar 4mm2 negro	Estructura básica para paneles paralelos al techo			Si	Si	**2.11**
	3	12 GCL 265W	Moso SF3600 Wifi	44 de cable fotovoltaico TOP Solar 4mm2 negro						**1.92**
	4	15 GCL 265W	Moso SF4200 Wifi	56 de cable fotovoltaico TOP Solar 4mm2 negro		Monofásico	No			**1.82**
Solenergy	**1**	5 unidades Konig Sonne 250 W	1 unidad Inversor string Omnksol 1 K RL2 de 1300W	10 metros entre panel e inversor	Estructura porta panel techo acostado	Elster modelo A150	No	No	No	**1.75**
Miro solar	**4**	16 unidades Amerisolar 250 Wp	Inversor string 4 kW	Si	Estructura aluminio anodizado	No	No	Si	Si	**1.60**

	5	20 unidades Amerisolar 250 Wp	Inversor string 5 kW	Si	Estructura aluminio anodizado	No				**1.55**
Conf. Cpo	**3**	GCK/Amerisolar 10 paneles de 330 Wp 2,17 m2 por panel 22m2 en total	Inversor string OMNIK/Solis/Solax 3kVA	Cableado CC y CA hasta 20 metros	Estructura de aluminio para techos y fierro para suelos	No	No	Si	Si	**1.69**
	4	GCK/Amerisolar 12 paneles de 330 Wp 2,17 m2 por panel 26m2 en total	Inversor string OMNIK/Solis/Solax 4kVA	Cableado CC y CA hasta 20 metros	Estructura de aluminio para techos y fierro para suelos	No	No	Si	Si	**1.11**
EnelX	**1.5**	6 Yingli solar 250W	No especifica	15 metros de canalización máxima para conexión entre los paneles y el inversor y 5 metros de canalización máxima para conexión entre el inversor y tablero	Paralelo al techo	No especifica	No	Si	Si	**2.92**
	2	8 Yingli solar 250W								**1.88**
	3	12 Yingli solar 250W								**1.53**
Termic solar	**3**	8 unidades Phono solar 375 W	Microinversor Hoymiles MI700. Hasta 900 MW	Conector hembra para corriente AC para microinversor. Conector terminal para corriente AC para microinversor	Base de apoyo L para perfiles estructura panel FV Perfil riel estructura panel FV 3.1 metros	Elster modelo A150	No	No	No	**1.61**
Kuhn	**2**	8 Paneles policristalinos 260Wp	On Grid Omnik, Inc. Switch DC Wi-fi	24mts cable solar 4 mm2 (7mts rojo+17 mt negro) 1 par de conectores MC4(1 macho+1 hembra)	Estructura de aluminio para soporte (paralela a techumbre)	No	No	0.45	0.21	**1.66**
Sol de clima	**0.5**	2 Canadian 320W	Microinverter Nep 600W	No especifica	Estructura de aluminio para soporte (paralela a techumbre)	No	No	Si	Si	**1.77**
	1	4 DAH Solar 270W Polycrystaline	Mini solis 1 kW		Estructura de aluminio para soporte (paralela a techumbre)	No	No			**1.65**
	1.5	5 Ulica 320W Policrystalline	Mini solis 1.5 kW		Estructura de aluminio para soporte (paralela a techumbre)	No	No			**1.65**
	2	7 Ulica 320W Policrystalline	Mini solis 2 kW		Estructura de aluminio para soporte (paralela a techumbre)	No	No			**1.44**

	2.31	7 Ulica 330W Polycrystalline	Mini solis 4G 2 kW	Fusible 12-10amp diferencial tipo A 2x25 para inversor, interruptor automático 2x6 o 2x10, 1 par de llaves para mc4, 1 par conector mc4, 20 metros cable solar 4mm2	2 riel aluminio 4200mm, 10 unión placa, 8 terminal placa, 16 soporte L o 12 soportes para tejas,	No	No	0.513	0.117	**1.40**
	2.5	8 Ulica 320W Polycrystalline	Omnik 2.5 kW	No especifica	2 riel aluminio 4200mm, 10 unión placa, 8 terminal placa, 16 soporte L o 12 soportes para tejas,	No	No	Si	Si	**1.46**
	3	10 Ulica 320W Polycrystalline	Mini solis 3 kW		Estructura de aluminio para soporte (paralela a techumbre)	No	No			**1.34**
	5	10 Ulica 320W Polycrystalline	Mini solis 5 kW		Estructura de aluminio para soporte (paralela a techumbre)	No	No			**1.26**
Solartek	**3**	10 Kuhn 310W KYL-310P	On Grid Omnik, Inc. 3.0K-TL2-S Switch DC	Switch DC, 7mts de cable solar 4 mm2 color rojo, 17 mts cable solar 4 mm2 color negro, 1 par de conectores mc4	Estructura aluminio para soporte de paneles (2x4+1x2 tipo L)	No	No	Si	Si	**1.52**
	4	12 Canadian Solar 330W	Solis 400W	Switch DC, 7mts de cable solar 4 mm2 color rojo, 17 mts cable solar 4 mm2 color negro, 1 par de conectores mc5	Estructura aluminio para soporte de paneles (2x4+1x2 tipo L). Ducto metálico EMT	No	No			**1.16**

C. Appendix C: PV solar systems quotes in Chile: Total cost trendline by company

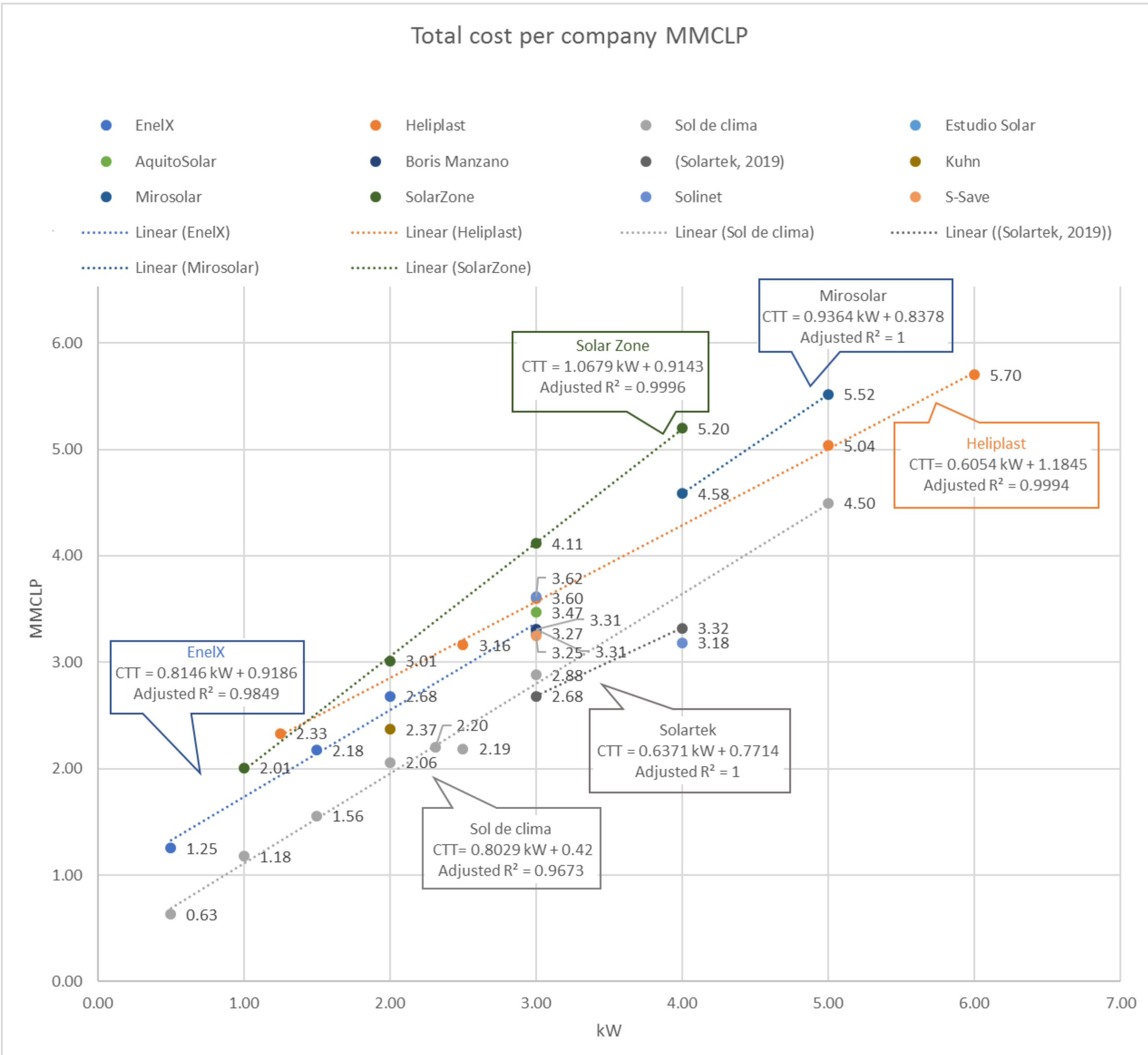

Figure C-1: Total cost trendline per company quoted in Santiago, Chile. Those companies that has higher slope tend to be the ones that has more market power.

D. Appendix D: International and multi-size database of PV solar systems cost

Table D-I: Cost breakdown database of large-scale PV solar systems. International and national sources.

Cost breakdown data Large scale PVSS USD/W															
Country	**Size kW**	**Year**	**PV Module**	**Inverter**	**Electrical BoS**	**Structural BoS**	**Hardware**	**Supply network**	**Installation**	**Inspection, Permissions and**	**Overhead**	**Co. net income**	**Total cost (Untaxed)**	**Sales Taxes**	**Source**
CL	30	2018											**0.76**		(GIZ, 2018)
AU	30	2019											**1.16**		(Solar Choice, 2019)
CL	30	2016											**1.32**		(GIZ, 2017)
CL	30	2017											**1.40**		(Acesol, 2018)
AU	50	2019											**1.17**		(Solar Choice, 2019)
AU	70	2019											**1.15**		(Solar Choice, 2019)
CL	100	2018											**0.64**		(GIZ, 2018)
CL	100	2017											**1.00**		(Acesol, 2018)
CL	100	2018					**0.60**		0.34	0.08			**1.02**		(Heliplast, 2019)
AU	100	2019											**1.04**		(Solar Choice, 2019)
CL	100	2016											**1.22**		(GIZ, 2017)
CL	500	2018											**0.84**		(GIZ, 2018)
CL	500	2017											**0.90**		(Acesol, 2018)
CN	1000	2016	0.40	0.10	0.06	0.07	**0.63**	0.03	0.06	0.02	0.01		**0.75**		(Fang, Honghua & Sicheng, 2016)
IN	1000	2018	0.32	0.06	0.12	0.05	**0.54**		0.07	0.03	0.14	0.03	**0.81**		(IRENA, 2019)
IT	1000	2018	0.37	0.05	0.11	0.07	**0.60**		0.07	0.03	0.08	0.11	**0.89**		(IRENA, 2019)
CN	1000	2018	0.29	0.05	0.12	0.01	**0.47**		0.13	0.04	0.15	0.10	**0.90**		(IRENA, 2019)
US	1000	2019											**0.90**		(SEIA, 2019)
US	1000	2018											**0.95**		(SEIA, 2019)
FR	1000	2018	0.27	0.09	0.23	0.12	**0.70**		0.17	0.04	0.05	0.13	**1.10**		(IRENA, 2019)
DE	1000	2018	0.48	0.07	0.15	0.10	**0.81**		0.13	0.01	0.06	0.13	**1.14**		(IRENA, 2019)
ID	1000	2018	0.60	0.04	0.16	0.10	**0.90**		0.03	0.05	0.12	0.11	**1.22**		(IRENA, 2019)
TR	1000	2018	0.38	0.07	0.14	0.07	**0.65**		0.12	0.11	0.18	0.16	**1.23**		(IRENA, 2019)
SA	1000	2018	0.33	0.08	0.10	0.07	**0.58**		0.14	0.03	0.22	0.32	**1.29**		(IRENA, 2019)
KR	1000	2018	0.41	0.08	0.19	0.10	**0.78**		0.12	0.09	0.18	0.18	**1.35**		(IRENA, 2019)
UK	1000	2018	0.48	0.06	0.18	0.07	**0.79**		0.23	0.12	0.17	0.08	**1.39**		(IRENA, 2019)
AR	1000	2018	0.48	0.14	0.19	0.08	**0.89**		0.18	0.13	0.15	0.12	**1.46**		(IRENA, 2019)
MX	1000	2018	0.34	0.07	0.23	0.16	**0.79**		0.19	0.04	0.20	0.29	**1.51**		(IRENA, 2019)

BR	1000	2018	0.39	0.10	0.22	0.21	**0.93**		0.32	0.06	0.15	0.09	**1.55**		(IRENA, 2019)
US	1000	2018	0.41	0.08	0.20	0.17	**0.86**		0.36	0.04	0.12	0.19	**1.58**		(IRENA, 2019)
AU	1000	2018	0.32	0.09	0.26	0.23	**0.90**		0.36	0.06	0.17	0.10	**1.58**		(IRENA, 2019)
ZA	1000	2018	0.66	0.11	0.19	0.17	**1.13**		0.11	0.09	0.24	0.14	**1.70**		(IRENA, 2019)
TR	1000	2018	0.59	0.1	0.09	0.03	**0.81**		0.08	0.01	0.05		**1.96**		(Gürtürk, 2019)
JP	1000	2018	0.54	0.34	0.21	0.10	**1.18**		0.68	0.08	0.09	0.10	**2.14**		(IRENA, 2019)
RU	1000	2018	0.46	0.13	0.33	0.12	**1.04**		0.49	0.22	0.37	0.22	**2.35**		(IRENA, 2019)
CA	1000	2018	0.79	0.12	0.31	0.23	**1.46**		0.33	0.03	0.26	0.40	**2.48**		(IRENA, 2019)
CL	1500	2018											**0.80**		(GIZ, 2018)
CL	3000	2017											**0.80**		(Acesol, 2018)

Table D-II: Cost breakdown database of small-scale PV solar systems. International and national sources

Cost breakdown data Small-scale PVSS USD/W																		
Country	**Size kW**	**Year**	**PV Module**	**Inverter**	**Electrical BoS**	**Structural BoS**	**Hardware**	**Supply network**	**Installation**	**Inspection, Permissions and grid connection**	**Customer acquisition**	**Overhead**	**Co. net income**	**Soft costs**	**Total cost (Untaxed)**	**Sales Taxes**	**Total cost MUSD**	**Source**
CL	0.5	2019													**2.10**		**1.1**	(Sol de clima, 2019)
PT	0.5	2017													**3.01**		**1.5**	(Camilo et al. 2017)
CL	1	2019													**1.96**		**2.0**	(Sol de clima, 2019)
PT	1	2017													**2.36**		**2.4**	(Camilo et al. 2017)
CL	1	2019					**1.16**		1.43	0.32				1.75	**2.91**	0.53	**3.9**	(Solar Zone, 2019)
CL	1	2016													**4.94**		**4.9**	(GIZ, 2017)
CL	1	2018													**5.35**		**5.3**	(GIZ, 2018)
CL	1.25	2019					**1.44**		0.95	0.22				1.17	**2.61**	0.50	**3.3**	(Heliplast, 2019)
AU	1.5	2019													**1.72**		**2.6**	(Solar Choice, 2019)
CL	1.5	2019													**1.65**		**2.5**	Sol de clima, 2019
AU	1.5	2018													**1.74**		**2.6**	(Solar Choice, 2018)
CL	1.5	2019													**2.92**	0.48	**3.4**	(EnelX , 2019)
PT	1.5	2017													**2.15**		**3.2**	(Camilo et al. 2017)
AU	2	2018													**1.46**		**2.9**	(Solar Choice, 2018)
CL	2	2019					**1.00**		0.45	0.21				0.66	**1.66**	0.31	**3.3**	(Kuhn, 2019)
CL	2	2019													**1.72**		**3.4**	(Sol de clima, 2019)
CL	2	2019					**0.82**		1.05	0.24				1.29	**2.11**	0.40	**4.2**	(SolarZone, 2019)
US	2	2017													**4.50**		**9.0**	(Barbose et al. 2018)
CL	2.31	2019													**1.59**		**3.7**	(Sol de clima, 2019)
CL	2.5	2019													**1.46**		**3.6**	(Sol de clima, 2019)

CL	2.5	2019					**0.90**		0.71	0.16				0.87	**1.77**	0.34	**4.4**	(Heliplast, 2019)
CL	2.5	2017													**2.38**		**6.0**	(Acesol, 2018)
AU	3	2018													**1.07**		**3.2**	(Solar Choice, 2018)
AU	3	2019													**1.11**		**3.3**	(Solar Choice, 2019)
CL	3	2019													**1.52**		**4.6**	(Solartek, 2019
CL	3	2019					**0.91**		0.50	0.11				0.61	**1.52**	0.29	**4.6**	(S-Save, 2019)
CL	3	2019					**0.74**		0.66	0.15				0.81	**1.55**	0.29	**4.6**	(Boris Manzano, 2019)
CL	3	2019					**0.74**		0.66	0.15				0.81	**1.55**	0.29	**4.6**	(Estudio Solar, 2019)
CL	3	2019													**1.34**		**4.0**	(Sol de clima, 2019)
CL	3	2019					**0.77**		0.69	0.16				0.85	**1.62**	0.31	**4.9**	(AquitoSolar, 2019)
CL	3	2019					**0.88**		0.65	0.15				0.80	**1.67**	0.32	**5.0**	(Heliplast, 2019)
CL	3	2019					**0.81**		0.72	0.16				0.88	**1.69**	0.32	**5.1**	(Solinet, 2019)
CL	3	2019					**0.70**		0.99	0.22				1.21	**1.92**	0.36	**5.7**	(SolarZone, 2019)
CL	3	2019	0.47	0.46	0.12	0.10	**1.15**		1.10	0.28				1.38	**2.53**	0.65	**7.6**	(Termic Solar, 2019)
US	3	2017													**4.20**		**12.6**	(Barbose et al. 2018)
AU	4	2018													**0.91**		**3.6**	(Solar Choice, 2018)
AU	4	2019													**0.99**		**4.0**	(Solar Choice, 2019)
CL	4	2019					**0.53**		0.47	0.11				0.58	**1.11**	0.21	**4.4**	(Solinet, 2019)
CL	4	2019													**1.16**	0.17	**1.3**	(Solartek, 2019
CL	4	2019					**0.77**		0.68	0.16				0.84	**1.60**	0.30	**6.4**	(Mirosolar, 2019)
CL	4	2019					**0.70**		0.91	0.21				1.12	**1.82**	0.35	**7.3**	(SolarZone, 2019)
PT	4	2017													**1.82**		**7.3**	(Camilo et al. 2017)
US	4	2019													**3.71**		**14.8**	(Solar Reviews, 2019)
US	4	2017													**4.10**		**16.4**	(Barbose et al. 2018)
AU	5	2018													**0.80**		**4.0**	(Solar Choice, 2018)
AU	5	2019													**0.86**		**4.3**	(Solar Choice, 2019)
CL	5	2019					**0.76**		0.54	0.12				0.66	**1.41**	0.27	**7.1**	(Heliplast, 2019)
CL	5	2016													**1.47**		**7.4**	(GIZ, 2017)
CL	5	2018													**1.47**		**7.4**	(GIZ, 2018)
CL	5	2019													**1.26**		**6,3**	Sol de clima, 2019
CL	5	2019					**0.74**		0.66	0.15				0.81	**1.55**	0.29	**7.7**	(Mirosolar, 2019)
CL	5	2017													**2.14**		**10.7**	(Acesol, 2018)
US	5	2017	0.57	0.23			**1.03**		0.23					1.25	**2.28**		**11.4**	(Solar Action Alliance, 2018)
US	5	2019													**3.53**		**17.7**	(Solar Reviews, 2019)
US	5	2017													**4.00**		**20.0**	(Barbose et al. 2018)
US	5.2	2015	0.7	0.52	0.12	0.2	**1.54**	0.2	0.33	0.11	0.36	0.32	0.38	1.70	**3.24**	0.08	**16.8**	(Chung et al. 2015)
US	5.6	2016	0.64	0.39	0.12	0.35	**1.5**	0.23	0.26	0.1	0.37	0.33	0.4	1.69	**3.19**	0.10	**17.9**	(Fu et al., 2016,)
US	5.7	2017	0.35	0.34	0.11	0.33	**1.13**	0.48	0.26	0.10	0.34	0.31	0.39	1.88	**3.01**	0.11	**17.2**	(Fu et al. 2017)
US	5.7	2017					**0.78**		0.31	0.16	0.62	0.62	0.62	2.34	**3.12**		**17.8**	(Aggarwal, 2018)
AU	6	2019													**0.81**		**4.9**	(Solar Choice, 2019)
CL	6	2019					**0.73**		0.49	0.11				0.60	**1.41**	0.21	**8.5**	Heliplast, 2019)
US	6	2018													**2.80**		**16.8**	(SEIA, 2019)

US	6	2019													**2.80**		**16.8**	(SEIA, 2019)
US	6	2019													**3.38**		**20.3**	(Solar Reviews, 2019)
US	6	2017													**3.80**		**22.8**	(Barbose et al. 2018)
US	6.2	2018	0.47	0.39	0.1	0.27	**1.23**	0.37	0.24	0.05	0.35	0.32	0.39	1.72	**2.95**	0.11	**18.3**	(Fu et al. 2018)
IN	6.3	2017													**1.00**		**6.3**	(Barbose et al. 2018)
CN	6.3	2017													**1.40**		**8.8**	(Barbose et al. 2018)
ES	6.3	2017													**1.40**		**8.8**	(Barbose et al. 2018)
DE	6.3	2017													**1.50**		**9.5**	(Barbose et al. 2018)
UK	6.3	2017													**1.70**		**10.7**	(Barbose et al. 2018)
AU	6.3	2017													**1.80**		**11.3**	(Barbose et al. 2018)
KR	6.3	2017													**1.80**		**11.3**	(Barbose et al. 2018)
FR	6.3	2017													**1.90**		**12.0**	(Barbose et al. 2018)
MY	6.3	2017													**2.30**		**14.5**	(Barbose et al. 2018)
TH	6.3	2017													**2.30**		**14.5**	(Barbose et al. 2018)
ZA	6.3	2017													**2.50**		**15.8**	(Barbose et al. 2018)
JP	6.3	2017													**2.60**		**16.4**	(Barbose et al. 2018)
CH	6.3	2017													**2.70**		**17.0**	(Barbose et al. 2018)
BR	6.3	2017													**2.80**		**17.6**	(Barbose et al. 2018)
US	6.3	2017													**3.60**		**22.7**	(Barbose et al. 2018)

E. Appendix E Economies of scale factor by size of PV solar systems

Table E-I: Cost elasticity of a PV solar system between 0.25 kW and 1000 kW.

Size kW	Elasticity E = CMg/CMe (Ferro & Lentini, 2010)										
	Total cost	**PV Module**	**Inverter**	**Electrical BoS**	**Structural BoS**	**Hardware**	**Installation**	**Inspection, Permissions and grid connection**	**Overhead**	**Co. net income**	**Soft Cost**
0.25	**0.11**	0.40	0.06	0.36	0.45	**0.21**	0.06	0.07	0.04	0.18	**0.06**
0.5	**0.20**	0.57	0.11	0.53	0.62	**0.35**	0.11	0.13	0.08	0.31	**0.12**
0.75	**0.28**	0.67	0.16	0.63	0.71	**0.45**	0.15	0.19	0.12	0.40	**0.17**
1	**0.34**	0.73	0.20	0.70	0.77	**0.52**	0.20	0.24	0.16	0.47	**0.21**
1.25	**0.39**	0.77	0.24	0.74	0.81	**0.57**	0.23	0.28	0.19	0.53	**0.25**
1.5	**0.43**	0.80	0.28	0.77	0.83	**0.62**	0.27	0.32	0.22	0.57	**0.29**
1.75	**0.47**	0.82	0.31	0.80	0.85	**0.65**	0.30	0.35	0.24	0.61	**0.32**
2	**0.51**	0.84	0.34	0.82	0.87	**0.68**	0.33	0.38	0.27	0.64	**0.35**
2.25	**0.54**	0.86	0.36	0.84	0.88	**0.71**	0.35	0.41	0.29	0.67	**0.38**
2.5	**0.56**	0.87	0.39	0.85	0.89	**0.73**	0.38	0.44	0.32	0.69	**0.41**
2.75	**0.59**	0.88	0.41	0.86	0.90	**0.75**	0.40	0.46	0.34	0.71	**0.43**
3	**0.61**	0.89	0.43	0.87	0.91	**0.76**	0.42	0.48	0.36	0.73	**0.45**
3.25	**0.62**	0.90	0.45	0.88	0.92	**0.78**	0.44	0.50	0.38	0.75	**0.47**
3.5	**0.64**	0.90	0.47	0.89	0.92	**0.79**	0.46	0.52	0.39	0.76	**0.49**
3.75	**0.66**	0.91	0.49	0.90	0.93	**0.80**	0.48	0.54	0.41	0.77	**0.51**
4	**0.67**	0.91	0.50	0.90	0.93	**0.81**	0.49	0.55	0.43	0.78	**0.52**
4.25	**0.69**	0.92	0.52	0.91	0.93	**0.82**	0.51	0.57	0.44	0.79	**0.54**
4.5	**0.70**	0.92	0.53	0.91	0.94	**0.83**	0.52	0.58	0.45	0.80	**0.55**
4.75	**0.71**	0.93	0.55	0.92	0.94	**0.84**	0.54	0.60	0.47	0.81	**0.56**
5	**0.72**	0.93	0.56	0.92	0.94	**0.84**	0.55	0.61	0.48	0.82	**0.58**
5.25	**0.73**	0.93	0.57	0.92	0.95	**0.85**	0.56	0.62	0.49	0.83	**0.59**
5.5	**0.74**	0.94	0.58	0.93	0.95	**0.85**	0.57	0.63	0.50	0.83	**0.60**
5.75	**0.75**	0.94	0.59	0.93	0.95	**0.86**	0.58	0.64	0.52	0.84	**0.61**
6	**0.75**	0.94	0.60	0.93	0.95	**0.87**	0.59	0.65	0.53	0.84	**0.62**
6.25	**0.76**	0.94	0.61	0.93	0.95	**0.87**	0.60	0.66	0.54	0.85	**0.63**

6.5	**0.77**	0.95	0.62	0.94	0.96	**0.87**	0.61	0.67	0.55	0.85	**0.64**
6.75	**0.78**	0.95	0.63	0.94	0.96	**0.88**	0.62	0.68	0.56	0.86	**0.65**
7	**0.78**	0.95	0.64	0.94	0.96	**0.88**	0.63	0.69	0.56	0.86	**0.66**
7.25	**0.79**	0.95	0.65	0.94	0.96	**0.89**	0.64	0.69	0.57	0.87	**0.66**
7.5	**0.79**	0.95	0.66	0.94	0.96	**0.89**	0.65	0.70	0.58	0.87	**0.67**
7.75	**0.80**	0.95	0.66	0.95	0.96	**0.89**	0.65	0.71	0.59	0.87	**0.68**
8	**0.80**	0.96	0.67	0.95	0.96	**0.90**	0.66	0.71	0.60	0.88	**0.69**
8.25	**0.81**	0.96	0.68	0.95	0.96	**0.90**	0.67	0.72	0.60	0.88	**0.69**
8.5	**0.81**	0.96	0.68	0.95	0.97	**0.90**	0.67	0.73	0.61	0.88	**0.70**
8.75	**0.82**	0.96	0.69	0.95	0.97	**0.90**	0.68	0.73	0.62	0.89	**0.71**
9	**0.82**	0.96	0.70	0.95	0.97	**0.91**	0.69	0.74	0.63	0.89	**0.71**
9.25	**0.83**	0.96	0.70	0.95	0.97	**0.91**	0.69	0.74	0.63	0.89	**0.72**
9.5	**0.83**	0.96	0.71	0.96	0.97	**0.91**	0.70	0.75	0.64	0.90	**0.72**
9.75	**0.83**	0.96	0.71	0.96	0.97	**0.91**	0.70	0.75	0.64	0.90	**0.73**
10	**0.84**	0.96	0.72	0.96	0.97	**0.91**	0.71	0.76	0.65	0.90	**0.73**
10.25	**0.84**	0.96	0.72	0.96	0.97	**0.92**	0.71	0.76	0.66	0.90	**0.74**
10.5	**0.84**	0.97	0.73	0.96	0.97	**0.92**	0.72	0.77	0.66	0.90	**0.74**
10.75	**0.85**	0.97	0.73	0.96	0.97	**0.92**	0.72	0.77	0.67	0.91	**0.75**
11	**0.85**	0.97	0.74	0.96	0.97	**0.92**	0.73	0.77	0.67	0.91	**0.75**
11.25	**0.85**	0.97	0.74	0.96	0.97	**0.92**	0.73	0.78	0.68	0.91	**0.75**
11.5	**0.85**	0.97	0.74	0.96	0.97	**0.92**	0.74	0.78	0.68	0.91	**0.76**
11.75	**0.86**	0.97	0.75	0.96	0.98	**0.93**	0.74	0.79	0.69	0.91	**0.76**
12	**0.86**	0.97	0.75	0.96	0.98	**0.93**	0.74	0.79	0.69	0.92	**0.77**
12.25	**0.86**	0.97	0.76	0.97	0.98	**0.93**	0.75	0.79	0.69	0.92	**0.77**
12.5	**0.87**	0.97	0.76	0.97	0.98	**0.93**	0.75	0.80	0.70	0.92	**0.77**
12.75	**0.87**	0.97	0.76	0.97	0.98	**0.93**	0.76	0.80	0.70	0.92	**0.78**
13	**0.87**	0.97	0.77	0.97	0.98	**0.93**	0.76	0.80	0.71	0.92	**0.78**
13.25	**0.87**	0.97	0.77	0.97	0.98	**0.93**	0.76	0.80	0.71	0.92	**0.78**
13.5	**0.87**	0.97	0.77	0.97	0.98	**0.94**	0.77	0.81	0.71	0.92	**0.79**
13.75	**0.88**	0.97	0.78	0.97	0.98	**0.94**	0.77	0.81	0.72	0.93	**0.79**
14	**0.88**	0.97	0.78	0.97	0.98	**0.94**	0.77	0.81	0.72	0.93	**0.79**
14.25	**0.88**	0.97	0.78	0.97	0.98	**0.94**	0.78	0.82	0.73	0.93	**0.80**
14.5	**0.88**	0.97	0.79	0.97	0.98	**0.94**	0.78	0.82	0.73	0.93	**0.80**
14.75	**0.88**	0.98	0.79	0.97	0.98	**0.94**	0.78	0.82	0.73	0.93	**0.80**
15	**0.88**	0.98	0.79	0.97	0.98	**0.94**	0.78	0.82	0.74	0.93	**0.80**
15.25	**0.89**	0.98	0.79	0.97	0.98	**0.94**	0.79	0.83	0.74	0.93	**0.81**

15.5	**0.89**	0.98	0.80	0.97	0.98	**0.94**	0.79	0.83	0.74	0.93	**0.81**
15.75	**0.89**	0.98	0.80	0.97	0.98	**0.94**	0.79	0.83	0.74	0.93	**0.81**
16	**0.89**	0.98	0.80	0.97	0.98	**0.94**	0.80	0.83	0.75	0.94	**0.81**
16.25	**0.89**	0.98	0.80	0.97	0.98	**0.95**	0.80	0.83	0.75	0.94	**0.82**
16.5	**0.89**	0.98	0.81	0.97	0.98	**0.95**	0.80	0.84	0.75	0.94	**0.82**
16.75	**0.90**	0.98	0.81	0.97	0.98	**0.95**	0.80	0.84	0.76	0.94	**0.82**
17	**0.90**	0.98	0.81	0.97	0.98	**0.95**	0.80	0.84	0.76	0.94	**0.82**
17.25	**0.90**	0.98	0.81	0.98	0.98	**0.95**	0.81	0.84	0.76	0.94	**0.83**
17.5	**0.90**	0.98	0.82	0.98	0.98	**0.95**	0.81	0.84	0.76	0.94	**0.83**
17.75	**0.90**	0.98	0.82	0.98	0.98	**0.95**	0.81	0.85	0.77	0.94	**0.83**
18	**0.90**	0.98	0.82	0.98	0.98	**0.95**	0.81	0.85	0.77	0.94	**0.83**
18.25	**0.90**	0.98	0.82	0.98	0.98	**0.95**	0.82	0.85	0.77	0.94	**0.83**
18.5	**0.90**	0.98	0.82	0.98	0.98	**0.95**	0.82	0.85	0.77	0.94	**0.83**
18.75	**0.91**	0.98	0.83	0.98	0.98	**0.95**	0.82	0.85	0.78	0.94	**0.84**
19	**0.91**	0.98	0.83	0.98	0.98	**0.95**	0.82	0.86	0.78	0.94	**0.84**
19.25	**0.91**	0.98	0.83	0.98	0.98	**0.95**	0.82	0.86	0.78	0.95	**0.84**
19.5	**0.91**	0.98	0.83	0.98	0.98	**0.95**	0.83	0.86	0.78	0.95	**0.84**
19.75	**0.91**	0.98	0.83	0.98	0.99	**0.95**	0.83	0.86	0.79	0.95	**0.84**
20	**0.91**	0.98	0.84	0.98	0.99	**0.96**	0.83	0.86	0.79	0.95	**0.85**
25	**0.93**	0.99	0.86	0.98	0.99	**0.96**	0.86	0.89	0.82	0.96	**0.87**
30	**0.94**	0.99	0.88	0.99	0.99	**0.97**	0.88	0.90	0.85	0.96	**0.89**
35	**0.95**	0.99	0.90	0.99	0.99	**0.97**	0.89	0.92	0.87	0.97	**0.91**
40	**0.95**	0.99	0.91	0.99	0.99	**0.98**	0.91	0.93	0.88	0.97	**0.92**
45	**0.96**	0.99	0.92	0.99	0.99	**0.98**	0.92	0.93	0.89	0.98	**0.92**
50	**0.96**	0.99	0.93	0.99	0.99	**0.98**	0.92	0.94	0.90	0.98	**0.93**
55	**0.97**	0.99	0.93	0.99	0.99	**0.98**	0.93	0.94	0.91	0.98	**0.94**
60	**0.97**	0.99	0.94	0.99	1.00	**0.98**	0.94	0.95	0.92	0.98	**0.94**
65	**0.97**	0.99	0.94	0.99	1.00	**0.99**	0.94	0.95	0.92	0.98	**0.95**
70	**0.97**	0.99	0.95	0.99	1.00	**0.99**	0.94	0.96	0.93	0.98	**0.95**
75	**0.97**	1.00	0.95	0.99	1.00	**0.99**	0.95	0.96	0.93	0.99	**0.95**
80	**0.98**	1.00	0.95	0.99	1.00	**0.99**	0.95	0.96	0.94	0.99	**0.96**
85	**0.98**	1.00	0.96	0.99	1.00	**0.99**	0.95	0.96	0.94	0.99	**0.96**
90	**0.98**	1.00	0.96	1.00	1.00	**0.99**	0.96	0.97	0.94	0.99	**0.96**
95	**0.98**	1.00	0.96	1.00	1.00	**0.99**	0.96	0.97	0.95	0.99	**0.96**
100	**0.98**	1.00	0.96	1.00	1.00	**0.99**	0.96	0.97	0.95	0.99	**0.96**

105	**0.98**	1.00	0.96	1.00	1.00	**0.99**	0.96	0.97	0.95	0.99	**0.97**
110	**0.98**	1.00	0.97	1.00	1.00	**0.99**	0.96	0.97	0.95	0.99	**0.97**
120	**0.98**	1.00	0.97	1.00	1.00	**0.99**	0.97	0.97	0.96	0.99	**0.97**
150	**0.99**	1.00	0.97	1.00	1.00	**0.99**	0.97	0.98	0.97	0.99	**0.98**
200	**0.99**	1.00	0.98	1.00	1.00	**1.00**	0.98	0.98	0.97	0.99	**0.98**
250	**0.99**	1.00	0.98	1.00	1.00	**1.00**	0.98	0.99	0.98	1.00	**0.99**
500	**1.00**	1.00	0.99	1.00	1.00	**1.00**	0.99	0.99	0.99	1.00	**0.99**
1000	**1.00**	1.00	1.00	1.00	1.00	**1.00**	1.00	1.00	0.99	1.00	**1.00**

Table E-II: Economies of scale factor for PV solar system between 0.25 kW and 1000 kW.

Note: Factors equals to 1.0 indicates non-economies of scale nether diseconomies of scale (Ferrero & Lentini, 2010).

Size kW	**Economies of scale (SCE) SCE=1/|E| (Ferro & Lentini, 2010)**										
	Total cost	**PV Module**	**Inverter**	**Electrical BoS**	**Structural BoS**	**Hardware**	**Installation**	**Inspection, Permissions and grid connection**	**Overhead**	**Co. net income**	**Soft Cost**
0.25	8.80	2.50	16.75	2.75	2.20	**4.73**	17.47	13.85	22.59	5.44	**15.64**
0.5	4.90	1.75	8.88	1.88	1.60	**2.87**	9.24	7.43	11.79	3.22	**3.22**
0.75	3.60	1.50	6.25	1.58	1.40	**2.24**	6.49	5.28	8.20	2.48	**2.48**
1	2.95	1.38	4.94	1.44	1.30	**1.93**	5.12	4.21	6.40	2.11	**2.11**
1.25	2.56	1.30	4.15	1.35	1.24	**1.75**	4.29	3.57	5.32	1.89	**1.89**
1.5	2.30	1.25	3.63	1.29	1.20	**1.62**	3.75	3.14	4.60	1.74	**1.74**
1.75	2.11	1.21	3.25	1.25	1.17	**1.53**	3.35	2.84	4.08	1.63	**1.63**
2	1.98	1.19	2.97	1.22	1.15	**1.47**	3.06	2.61	3.70	1.56	**1.56**
2.25	1.87	1.17	2.75	1.19	1.13	**1.41**	2.83	2.43	3.40	1.49	**1.49**
2.5	1.78	1.15	2.58	1.18	1.12	**1.37**	2.65	2.29	3.16	1.44	**1.44**
2.75	1.71	1.14	2.43	1.16	1.11	**1.34**	2.50	2.17	2.96	1.40	**1.40**
3	1.65	1.13	2.31	1.15	1.10	**1.31**	2.37	2.07	2.80	1.37	**1.37**
3.25	1.60	1.12	2.21	1.13	1.09	**1.29**	2.27	1.99	2.66	1.34	**1.34**
3.5	1.56	1.11	2.13	1.13	1.09	**1.27**	2.18	1.92	2.54	1.32	**1.32**
3.75	1.52	1.10	2.05	1.12	1.08	**1.25**	2.10	1.86	2.44	1.30	**1.30**
4	1.49	1.09	1.98	1.11	1.08	**1.23**	2.03	1.80	2.35	1.28	**1.28**

4.25	1.46	1.09	1.93	1.10	1.07	**1.22**	1.97	1.76	2.27	1.26	**1.26**
4.5	1.43	1.08	1.88	1.10	1.07	**1.21**	1.92	1.71	2.20	1.25	**1.25**
4.75	1.41	1.08	1.83	1.09	1.06	**1.20**	1.87	1.68	2.14	1.23	**1.23**
5	1.39	1.08	1.79	1.09	1.06	**1.19**	1.82	1.64	2.08	1.22	**1.22**
5.25	1.37	1.07	1.75	1.08	1.06	**1.18**	1.78	1.61	2.03	1.21	**1.21**
5.5	1.35	1.07	1.72	1.08	1.05	**1.17**	1.75	1.58	1.98	1.20	**1.20**
5.75	1.34	1.07	1.68	1.08	1.05	**1.16**	1.72	1.56	1.94	1.19	**1.19**
6	1.33	1.06	1.66	1.07	1.05	**1.16**	1.69	1.54	1.90	1.19	**1.19**
6.25	1.31	1.06	1.63	1.07	1.05	**1.15**	1.66	1.51	1.86	1.18	**1.18**
6.5	1.30	1.06	1.61	1.07	1.05	**1.14**	1.63	1.49	1.83	1.17	**1.17**
6.75	1.29	1.06	1.58	1.06	1.04	**1.14**	1.61	1.48	1.80	1.16	**1.16**
7	1.28	1.05	1.56	1.06	1.04	**1.13**	1.59	1.46	1.77	1.16	**1.16**
7.25	1.27	1.05	1.54	1.06	1.04	**1.13**	1.57	1.44	1.74	1.15	**1.15**
7.5	1.26	1.05	1.53	1.06	1.04	**1.12**	1.55	1.43	1.72	1.15	**1.15**
7.75	1.25	1.05	1.51	1.06	1.04	**1.12**	1.53	1.41	1.70	1.14	**1.14**
8	1.24	1.05	1.49	1.05	1.04	**1.12**	1.51	1.40	1.67	1.14	**1.14**
8.25	1.24	1.05	1.48	1.05	1.04	**1.11**	1.50	1.39	1.65	1.13	**1.13**
8.5	1.23	1.04	1.46	1.05	1.04	**1.11**	1.48	1.38	1.63	1.13	**1.13**
8.75	1.22	1.04	1.45	1.05	1.03	**1.11**	1.47	1.37	1.62	1.13	**1.13**
9	1.22	1.04	1.44	1.05	1.03	**1.10**	1.46	1.36	1.60	1.12	**1.12**
9.25	1.21	1.04	1.43	1.05	1.03	**1.10**	1.45	1.35	1.58	1.12	**1.12**
9.5	1.21	1.04	1.41	1.05	1.03	**1.10**	1.43	1.34	1.57	1.12	**1.12**
9.75	1.20	1.04	1.40	1.04	1.03	**1.10**	1.42	1.33	1.55	1.11	**1.11**
10	1.20	1.04	1.39	1.04	1.03	**1.09**	1.41	1.32	1.54	1.11	**1.11**
10.3	1.19	1.04	1.38	1.04	1.03	**1.09**	1.40	1.31	1.53	1.11	**1.11**
10.5	1.19	1.04	1.38	1.04	1.03	**1.09**	1.39	1.31	1.51	1.11	**1.11**
10.8	1.18	1.03	1.37	1.04	1.03	**1.09**	1.38	1.30	1.50	1.10	**1.10**
11	1.18	1.03	1.36	1.04	1.03	**1.08**	1.37	1.29	1.49	1.10	**1.10**
11.3	1.17	1.03	1.35	1.04	1.03	**1.08**	1.37	1.29	1.48	1.10	**1.10**
11.5	1.17	1.03	1.34	1.04	1.03	**1.08**	1.36	1.28	1.47	1.10	**1.10**
11.8	1.17	1.03	1.34	1.04	1.03	**1.08**	1.35	1.27	1.46	1.09	**1.09**
12	1.16	1.03	1.33	1.04	1.03	**1.08**	1.34	1.27	1.45	1.09	**1.09**
12.3	1.16	1.03	1.32	1.04	1.02	**1.08**	1.34	1.26	1.44	1.09	**1.09**
12.5	1.16	1.03	1.32	1.04	1.02	**1.07**	1.33	1.26	1.43	1.09	**1.09**
12.8	1.15	1.03	1.31	1.03	1.02	**1.07**	1.32	1.25	1.42	1.09	**1.09**

13	1.15	1.03	1.30	1.03	1.02	**1.07**	1.32	1.25	1.42	1.09	**1.09**
13.3	1.15	1.03	1.30	1.03	1.02	**1.07**	1.31	1.24	1.41	1.08	**1.08**
13.5	1.14	1.03	1.29	1.03	1.02	**1.07**	1.31	1.24	1.40	1.08	**1.08**
13.8	1.14	1.03	1.29	1.03	1.02	**1.07**	1.30	1.23	1.39	1.08	**1.08**
14	1.14	1.03	1.28	1.03	1.02	**1.07**	1.29	1.23	1.39	1.08	**1.08**
14.3	1.14	1.03	1.28	1.03	1.02	**1.07**	1.29	1.23	1.38	1.08	**1.08**
14.5	1.13	1.03	1.27	1.03	1.02	**1.06**	1.28	1.22	1.37	1.08	**1.08**
14.8	1.13	1.03	1.27	1.03	1.02	**1.06**	1.28	1.22	1.37	1.08	**1.08**
15	1.13	1.03	1.26	1.03	1.02	**1.06**	1.27	1.21	1.36	1.07	**1.07**
15.3	1.13	1.02	1.26	1.03	1.02	**1.06**	1.27	1.21	1.35	1.07	**1.07**
15.5	1.13	1.02	1.25	1.03	1.02	**1.06**	1.27	1.21	1.35	1.07	**1.07**
15.8	1.12	1.02	1.25	1.03	1.02	**1.06**	1.26	1.20	1.34	1.07	**1.07**
16	1.12	1.02	1.25	1.03	1.02	**1.06**	1.26	1.20	1.34	1.07	**1.07**
16.3	1.12	1.02	1.24	1.03	1.02	**1.06**	1.25	1.20	1.33	1.07	**1.07**
16.5	1.12	1.02	1.24	1.03	1.02	**1.06**	1.25	1.19	1.33	1.07	**1.07**
16.8	1.12	1.02	1.24	1.03	1.02	**1.06**	1.25	1.19	1.32	1.07	**1.07**
17	1.11	1.02	1.23	1.03	1.02	**1.05**	1.24	1.19	1.32	1.07	**1.07**
17.3	1.11	1.02	1.23	1.03	1.02	**1.05**	1.24	1.19	1.31	1.06	**1.06**
17.5	1.11	1.02	1.23	1.03	1.02	**1.05**	1.24	1.18	1.31	1.06	**1.06**
17.8	1.11	1.02	1.22	1.02	1.02	**1.05**	1.23	1.18	1.30	1.06	**1.06**
18	1.11	1.02	1.22	1.02	1.02	**1.05**	1.23	1.18	1.30	1.06	**1.06**
18.3	1.11	1.02	1.22	1.02	1.02	**1.05**	1.23	1.18	1.30	1.06	**1.06**
18.5	1.11	1.02	1.21	1.02	1.02	**1.05**	1.22	1.17	1.29	1.06	**1.06**
18.8	1.10	1.02	1.21	1.02	1.02	**1.05**	1.22	1.17	1.29	1.06	**1.06**
19	1.10	1.02	1.21	1.02	1.02	**1.05**	1.22	1.17	1.28	1.06	**1.06**
19.3	1.10	1.02	1.20	1.02	1.02	**1.05**	1.21	1.17	1.28	1.06	**1.06**
19.5	1.10	1.02	1.20	1.02	1.02	**1.05**	1.21	1.16	1.28	1.06	**1.06**
19.8	1.10	1.02	1.20	1.02	1.02	**1.05**	1.21	1.16	1.27	1.06	**1.06**
20	1.10	1.02	1.20	1.02	1.02	**1.05**	1.21	1.16	1.27	1.06	**1.06**
25	1.08	1.02	1.16	1.02	1.01	**1.04**	1.16	1.13	1.22	1.04	**1.04**
30	1.07	1.01	1.13	1.01	1.01	**1.03**	1.14	1.11	1.18	1.04	**1.04**
35	1.06	1.01	1.11	1.01	1.01	**1.03**	1.12	1.09	1.15	1.03	**1.03**
40	1.05	1.01	1.10	1.01	1.01	**1.02**	1.10	1.08	1.13	1.03	**1.03**
45	1.04	1.01	1.09	1.01	1.01	**1.02**	1.09	1.07	1.12	1.02	**1.02**
50	1.04	1.01	1.08	1.01	1.01	**1.02**	1.08	1.06	1.11	1.02	**1.02**
55	1.04	1.01	1.07	1.01	1.01	**1.02**	1.07	1.06	1.10	1.02	**1.02**

60	1.03	1.01	1.07	1.01	1.01	**1.02**	1.07	1.05	1.09	1.02	**1.02**
65	**1.03**	**1.01**	**1.06**	**1.01**	**1.00**	**1.01**	1.06	1.05	1.08	1.02	**1.02**
70	**1.03**	**1.01**	**1.06**	**1.01**	**1.00**	**1.01**	1.06	1.05	1.08	1.02	**1.02**
75	**1.03**	**1.01**	**1.05**	**1.01**	**1.00**	**1.01**	1.05	1.04	1.07	1.01	**1.01**
80	**1.02**	**1.00**	**1.05**	**1.01**	**1.00**	**1.01**	1.05	1.04	1.07	1.01	**1.01**
85	**1.02**	**1.00**	**1.05**	**1.01**	**1.00**	**1.01**	1.05	1.04	1.06	1.01	**1.01**
90	**1.02**	**1.00**	**1.04**	**1.00**	**1.00**	**1.01**	1.05	1.04	1.06	1.01	**1.01**
95	**1.02**	**1.00**	**1.04**	**1.00**	**1.00**	**1.01**	1.04	1.03	1.06	1.01	**1.01**
100	**1.02**	**1.00**	**1.04**	**1.00**	**1.00**	**1.01**	1.04	1.03	1.05	1.01	**1.01**
105	**1.02**	**1.00**	**1.04**	**1.00**	**1.00**	**1.01**	1.04	1.03	1.05	1.01	**1.01**
110	**1.02**	**1.00**	**1.04**	**1.00**	**1.00**	**1.01**	1.04	1.03	1.05	1.01	**1.01**
120	**1.02**	**1.00**	**1.03**	**1.00**	**1.00**	**1.01**	1.03	1.03	1.04	1.01	**1.01**
150	**1.01**	**1.00**	**1.03**	**1.00**	**1.00**	**1.01**	1.03	1.02	1.04	1.01	**1.01**
200	**1.01**	**1.00**	**1.02**	**1.00**	**1.00**	**1.00**	1.02	1.02	1.03	1.01	**1.01**
250	**1.01**	**1.00**	**1.02**	**1.00**	**1.00**	**1.00**	1.02	1.01	1.02	1.00	**1.00**
500	**1.00**	**1.00**	**1.01**	**1.00**	**1.00**	**1.00**	1.01	1.01	1.01	1.00	**1.00**
1000	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	1.00	1.00	1.01	1.00	**1.00**