# BARRIERS AFFECTING DISTRIBUTED SOLAR PV GENERATION IN CHILE: A DEVELOPERS' PERSPECTIVE

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# Motivation

- Over the last few years, the role of Non-Conventional Renewable Energies (NCRE) in the Chilean matrix has increased significantly.
- The participation of NCRE in the total installed energy capacity grew from only 5% in 2014 to 30% in August 2021 (Energía Abierta, 2021).
- Solar PV technology is the most developed technology, corresponding to 16% of the energy matrix.
- However, unlike other countries where small-scale distributed generation plays an important role, most of this capacity comes from large-scale projects (utility scale).
- Currently, the small-scale distributed solar PV segment has a capacity of 1.14 GW, which is very limited despite its high potential of more than 6,000 GW

# Motivation

- Despite the large resource potential of distributed solar PV generation in the country and all their benefits -emission reductions, cost reductions in electricity supply, decrease in electrical losses, improvement in service quality, and lessening transmission congestions- to date, the progress of these technologies in the country has been low
- Therefore, considering the benefits of distributed generation, its potential and high availability of solar resources in Chile, having the highest solar radiation in the world, it is relevant to identify and mitigate the main barriers that hinder the advancement of this segment to allow its successful deployment.
- In this context, this research seeks to establish and analyze the main barriers that affect the implementation of distributed PV projects from the perspective of developers in Chile

# Literature Review

- In the academic literature, there are several studies identifying the main barriers to the development of distributed photovoltaic generation, most of them based on case studies of a particular country or region where greater development is observed.
- In fact, most of the works are related to the US, Germany and China, which are precisely the places where the development of distributed photovoltaic solar energy is most advanced in the world (Shen et al, 2021).
- In particular, China and the US represent 10% and 7% of the distributed photovoltaic installed capacity in the world, respectively

# Literature Review

- In general, the evidence presented in the different existing case studies allows us to classify the main barriers to greater penetration of distributed generation from the developer's perspectives into five categories: financial and profitability barriers; awareness and behavior; regulatory and institutional; technological and market; and company resources
- Regarding the South American region, the few existing studies focus on Brazil, probably because it is the country with the greatest development of distributed photovoltaic energy with 4.4 GW of capacity

# Literature Review

- One of the most complete studies for the case of Brazil is that of Bisognin et al. (2018), who investigate the main obstacles faced by distributed photovoltaic development in the southern region of Brazil through a systematic review of the literature and semi-structured interviews with professionals in the sector.
- Their results show that the most relevant barriers include the durability and quality of photovoltaic systems; the high initial cost and access to financing; consumer culture and lack of adequate knowledge about photovoltaic technology; inefficient after-sales services and negative publicity; and, finally, the dependence on imports and the lack of attractive mechanisms and incentives for consumer

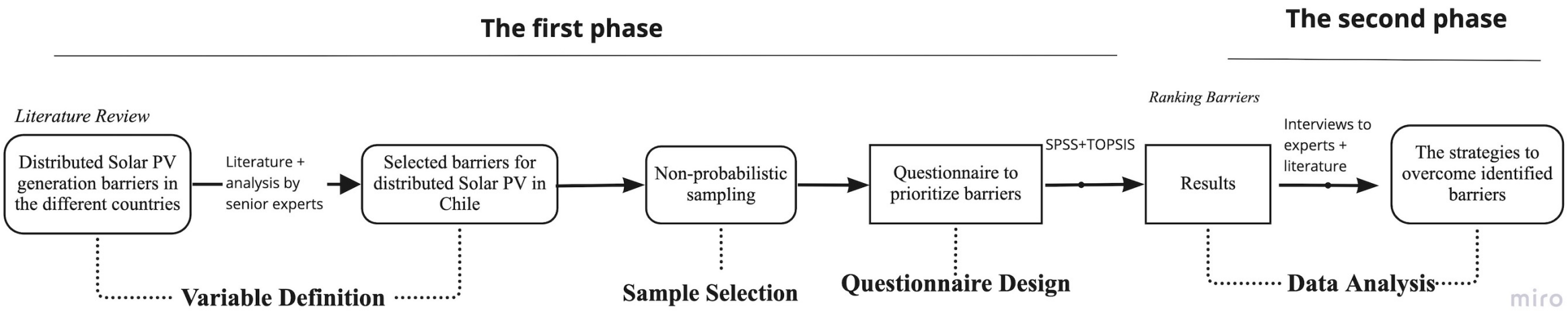
# Methodology

- The methodology of the study is composed of two main phases. In the first phase, quantitative information is generated on the different most relevant barriers for the implementation of projects in the sector.
- For these purposes, a survey is carried out on developers of distributed Solar PV projects in Chile, which are selected through a non-probabilistic sampling technique by quotas.
- This research technique has been widely used in the literature and allows data to be obtained and processed quickly and efficiently (Anguita et al, 2003).
- In the second phase, semi-structured qualitative interviews are conducted with experts (Mah et al, 2018; Zhang, 2016) in order to further analyze each of the most critical barriers in depth

# Methodology

- This approach, which considers surveys and interviews, has many advantages.
- On the one hand, surveys require less time and cost less, so their scope can be greater, and additionally they allow greater objectivity and easy comparison and generalization.
- On the other hand, interviews allow to obtain detailed answers, so using them in a second stage provides more information regarding the most relevant barriers.

# Methodology



# Methodology

- In order to identify the most relevant barriers in Chile, the largely common barriers found in the international literature were initially considered and a preliminary list of barriers was defined, including those that could be important in the context of the Chilean photovoltaic electricity market
- The preliminary list was tested in a pilot study, made up of several expert professionals with more than 10 years of experience in the industry in order to validate the potentially applicable barriers in Chile. In this way, a definitive list was established with the 12 potentially most critical barriers that could affect the development of distributed photovoltaic generation in Chile

# Methodology: Barriers

| Dimension | Code | Barriers |
|---|---|---|
| **Economic and Financial** | A1 | PV LCOE Compared to Stabilized Price or Power Price |
| | A2 | Difficulty accessing financing |
| | A3 | Financial structuring and financing costs |
| **Technological and Market** | B1 | Lack of skilled labor and specialist companies |
| | B2 | Network structure, its capacity and regulation for expansion |
| | B3 | Market adaptability in the face of pressure |
| **Regulatory Policies** | C1 | Uncertainty prices stabilized by blocks and other regulatory requirements |
| | C2 | Long administrative process and connection costs to the network |
| | C3 | Lack of incentives for new models with storage and flexibility |
| **Social and Environmental** | D1 | Lack of capacity, channels and tools to link the community |
| | D2 | Long evaluation times and demands in the SEIA[1] |
| | D3 | Lack of information to understand and share social benefits and costs |

# Methodology

- The target population for the survey was defined as: expert professionals who work in the development of distributed solar PV generation projects, considering a representative for each company in the market
- All the companies that were registered under the same code and subcode of economic activity in the database of the Internal Revenue Service (SII) were considered. As a result, 59 companies developing distributed solar PV projects were identified.
- A questionnaire was designed based on the data collected in the pilot study and considered the institutional and regulatory context of the distributed photovoltaic electricity sector in Chile
- To identify the most important barriers for the implementation of distributed solar PV projects, the respondents had to evaluate the relevance of each of the different barriers using a 5-point Likert scale

# Methodology: main characteristics of the respondents

| **Years of relevant professional experience in the sector:** | **Distributed PV solar energy companies** |
|---|---|
| 6-10 | 31% |
| +15 | 28% |
| 1-5 | 18% |
| **Academic training:** | |
| University Graduate | 33% |
| Master's Degree | 49% |
| Diploma | 10% |
| **Position in the Organization:** | |
| Manager | 38% |
| Others (consultant, specialist) | 47% |
| Director | 15% |
| **Organization size:** | |
| Medium (25-100 employees) | 38% |
| Micro company (0-9 employees) | 15% |
| Small (10-25 employees) | 21% |

# Results

- In order to perform a statistical analysis based on the data collected from the survey, the reliability of the classifications is first verified using the Cronbach alpha value,where a value of 0.7 or higher indicates reliable group classifications
- Then, a multi-criteria decision analysis method known as the Order of Preference for Similarity with the Ideal Solution Technique (TOPSIS) was implemented. TOPSIS is one of the multi-criteria decision-making (MCDM) approach methods based on the fact that the chosen alternative must be the closest to the positive ideal solution and the furthest from the negative ideal solution
- In this way, it is possible to rank and prioritize each of the alternatives by comparing the relative distances

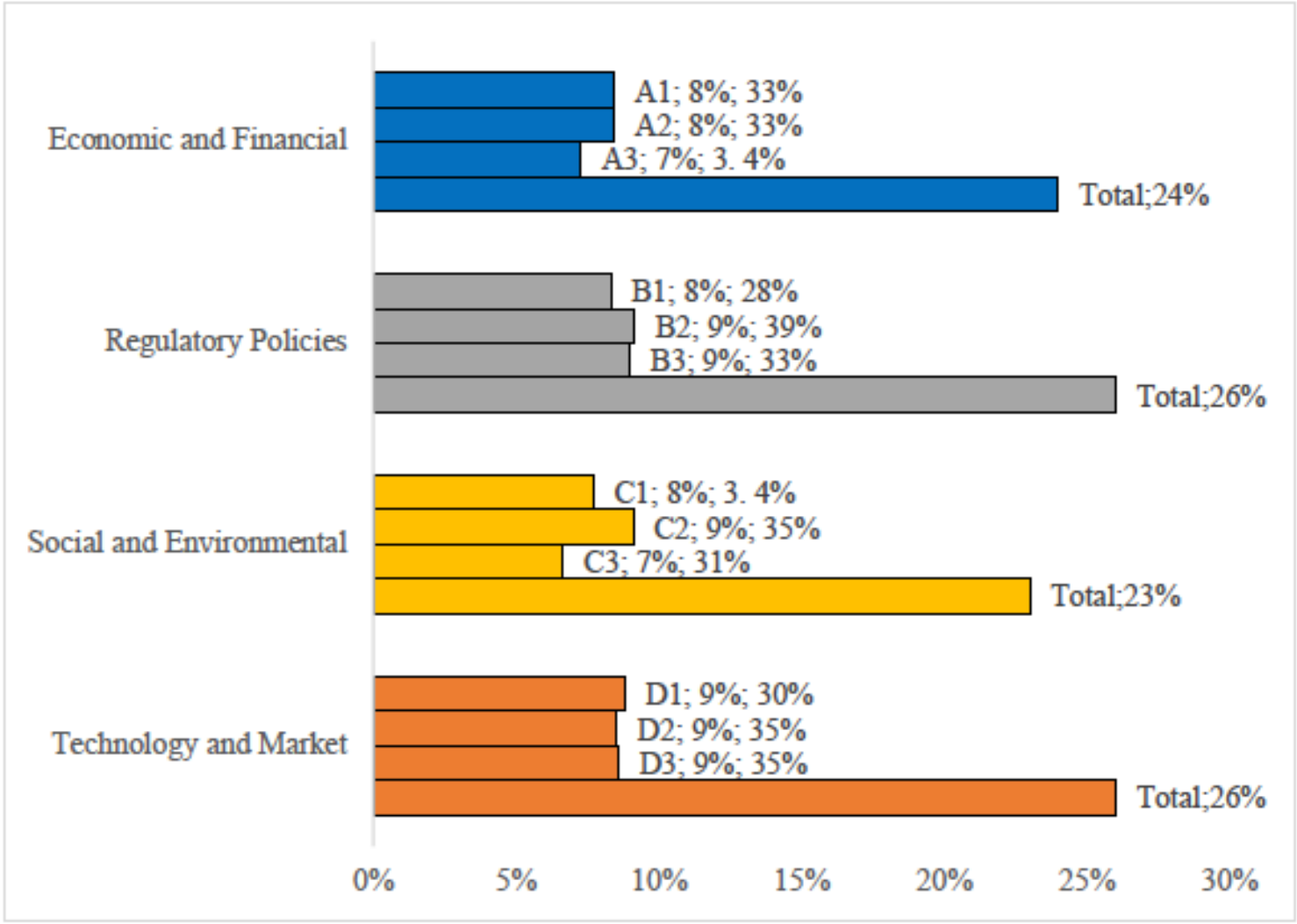
# Results

| Barriers | TOPSIS | Order |
|---|---|---|
| A1: PV LCOE compared to stabilized price or power price | 0.46 | 6 |
| A2: Difficulty accessing financing | 0.47 | 5 |
| **A3: Financial structure and financing costs** | **0.48** | **4** |
| B1: Lack of skilled labor and specialist companies | 0.38 | 12 |
| **B2: Structure of the network, its capacity and regulation for expansion** | **0.51** | **1** |
| B3: Market adaptability in the face of pressure | 0.39 | 10 |
| **C1: Uncertainty of prices stabilized by blocks and other regulatory requirements** | **0.51** | **3** |
| **C2: Long administrative process and connection costs to the network** | **0.51** | **2** |
| C3: Lack of incentives for new models with storage and flexibility | 0.44 | 9 |
| D1: Lack of capacity, channels and tools to link the community | 0.38 | 11 |
| D2: Long evaluation times and demands in the SEIA | 0.46 | 7 |
| D3: Lack of information to understand and share social benefits and costs | 0.46 | 8 |
| Cronbach's Alpha | | 0.877 |

# Results

- The results show that the most important barriers that affect the implementation of distributed photovoltaic projects are "The structure of the network, its capacity and regulation for expansion" (B2), followed by "The long administrative process and the costs of connection to the network" (C2), followed by "Uncertainty due to prices stabilized by blocks and other regulatory requirements" (C1) and "Financial structuring and financing costs" (A3).
- Cronbach's alpha coefficient is 0.796 greater than 0.7, which confirms that the Likert scale of 5 used is reliable.

# Results: relative percentage of each barrier and each category



# Results

- The most critical barrier for the development of Distributed solar PV projects in Chile is related to the network structure, its current capacity and the regulation to allow its expansion
- The main obstacle for generation purposes is that they were not designed to connect this type of distributed energy resource.
- However, today it is possible to change the type of distribution network operation from a radial to a ring type, thus allowing the addition of other lines for the injection of small-scale distributed PV, which would reduce potential congestion and saturation of the distribution networks
- Likewise, this possible solution can reduce costs for small-scale distributed PV, given that, with a better distribution of consumption and injections, investments in new infrastructures can be avoided, or reinforcement costs can be lower

# Results

- The administrative processes required to connect to the network are the second most critical obstacle according to the results of the study.
- This process is often affected by serious delays, which have a significant impact on the economic benefits of PV systems
- One solution is to use a pool cost allocation, where initial interconnection costs are distributed among a group of projects being evaluated at the same time, based on their relative contributions.
- Another alternative, consists of the subsequent assignment of all the necessary investments. Under this scheme, a single entity pays all the initial costs and then, as new generators enter and use the investments made, they reimburse the entity that incurred the cost

# Conclusions

- The greater expansion of photovoltaic distributed generation in Chile can play a key role in the achievement of main energy objectives of the country established by the National Energy Policy plan, which contemplates fully decarbonizing its energy matrix and reaching 80% of electricity generation from renewable energy sources by 2050.
- This study identifies and analyzes the main barriers that affect the implementation of distributed photovoltaic solar generation projects from the perspective of developers through data collection from surveys

# Conclusions

- The analysis of the data is carried out with the TOPSIS methodology to prioritize the barriers, and then carry out face-to-face interviews with experts in the sector. The results of the analysis indicate that "The structure of the network, its capacity and regulation for expansion", followed by "The long administrative process and the costs of connecting to the network", followed by "The uncertainty due to prices stabilized by blocks and other regulatory requirements" and "Financial structuring and financing costs" are the most critical barriers for the implementation of small-scale distributed PV projects, in the distributed generation segment