



# Strategic Market Report Large-Scale PV Power Plants 2023

*Open Market and Regulated Market*

 Greener



- **42.4 GW of new solar PV projects were authorized** between March/2022 and February/2023, reaching a total capacity of 86 GW, a growth of 97% compared to the period between March/2021 and February/2022. Out of this total, **4.9 GW** are **under construction** and **7.5 GW** are **already in operation**.
- **Manufacturers of tracking systems** closed more than **7.0 GWp** of contracts between March/2022 and February/2023, an increase of 56% compared to the period between March/2021 and February/2022.
- The BNB and BNDES development banks continue to be the principal source of financing for large-scale PV plants, providing **R\$6.3 billion in financing** in 2022.
- The volume of mapped **solar PPAs** reached **11.9 GWp** while broadening the range of consumers to a number of new business segments, such as the healthcare, food production, and technology sectors.

## HIGHLIGHTS

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CHAPTER 1

# **Solar in the Open and Regulated Energy Markets**





# Introduction

## Overview

This report provides an overview of the market for large-scale solar photovoltaic ventures in both the open market and regulated contracting environments, also creating references for current and future projects according to market dynamics and their impacts on attractiveness, as well as demonstrating how the centralized generation photovoltaic sector has evolved in recent years.

## Highlights of the Report:



Status and profile of PV Solar projects



**Market Forecasts** for Centralized Generation



**Supplier Rankings:** Modules, Inverters, Trackers, Financing, EPC, O&M and Project Owners



**Solar PPAs** in the Open Energy Market



**Financial Institutions** and Amounts Financed



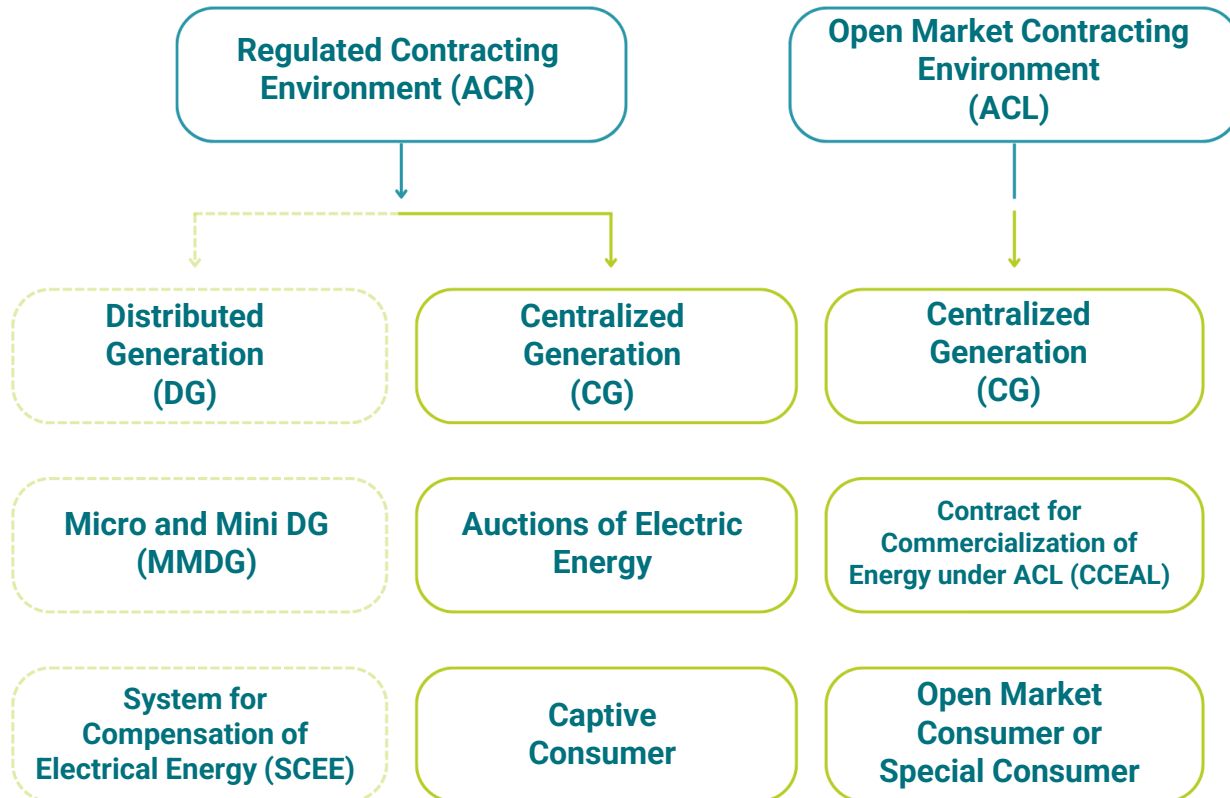
Consumer Profiles and **Business Models** in the Open Energy Market



**Financial Modeling** and specific Risks in the Open Market

# Centralized Generation Ecosystem

Open Energy Market and Regulated Market



- **Centralized Generation (CG)** is characterized by large-scale power plants with large installed capacities.
- The energy can be **contracted** either through **energy auctions** organized by the energy regulator ANEEL (Brazilian Electricity Regulatory Agency), or through **bilateral contracts** negotiated between the parties, called “Energy Commercialization Contracts in the Open Contracting Environment” (CCEAL), alternatively known as Power Purchase Agreements (PPAs).

# Contracting Environments for Electrical Energy

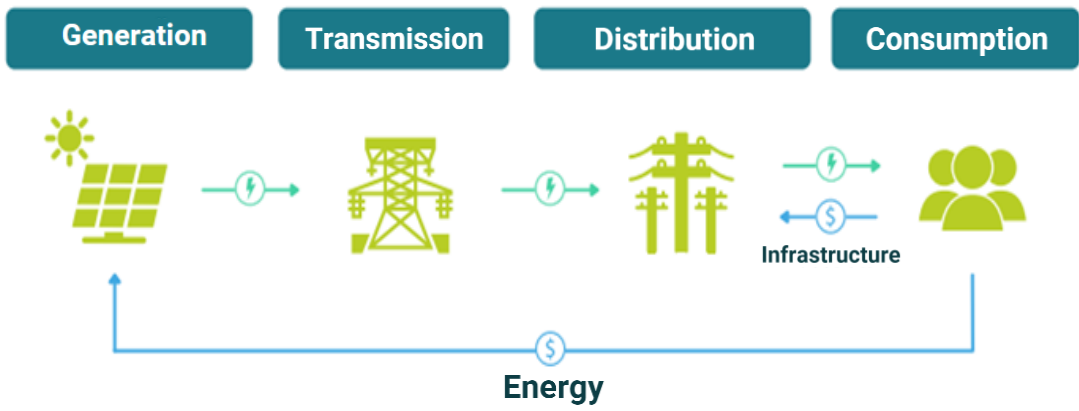
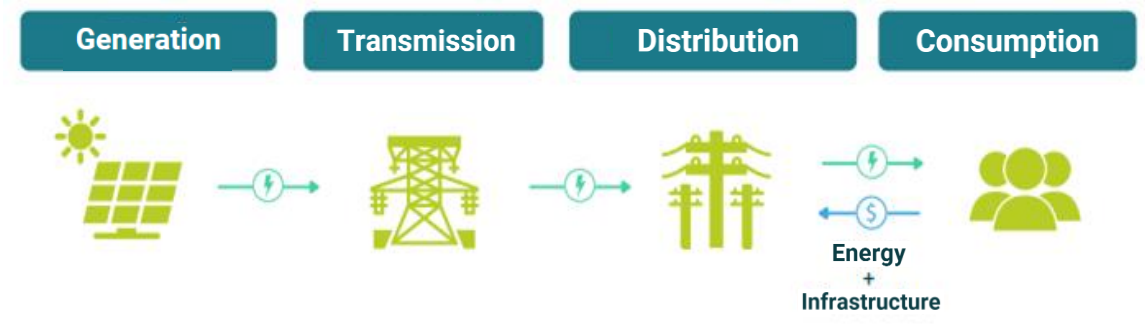
Regulated Market and Open Market

## Regulated Contracting Environment (ACR)

- **Purchasers:** electrical energy distributors which supply 100% of the regulated market (captive);
- **Sellers:** autoproducers, independent producers, energy traders and public energy providers / generators.

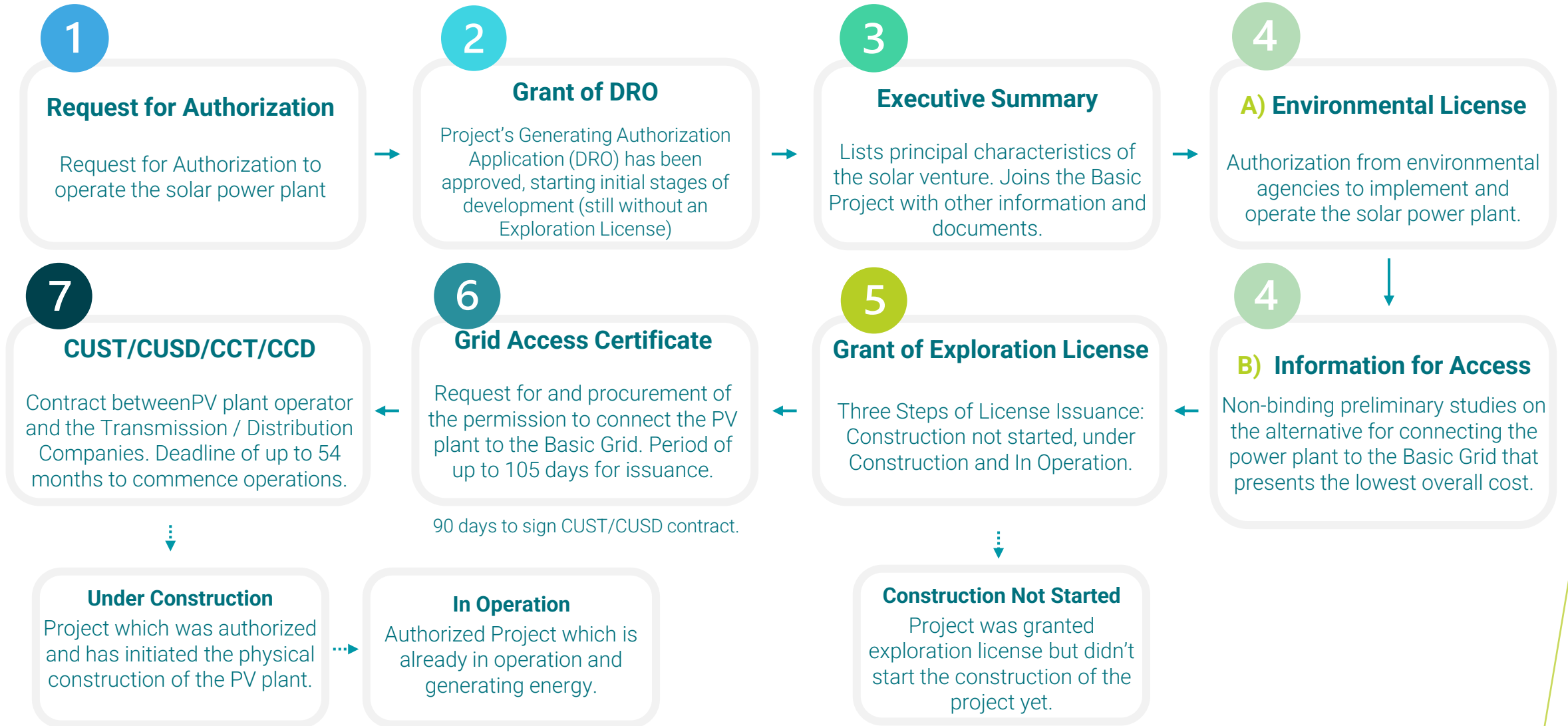
## Open Market Contracting Environment (ACL)

- **Purchasers:** open market customers and special rate customers with a minimum contracted demand of 500 kW with voltage needs equal to or above 2.3 kV;
- **Sellers:** autoproducers, independent producers, energy traders, public energy providers / generators and retailers.



# Regulatory Steps for Grid Connection of PV plant

Regulatory Steps for Grid Connection – Open Market and Regulated Market

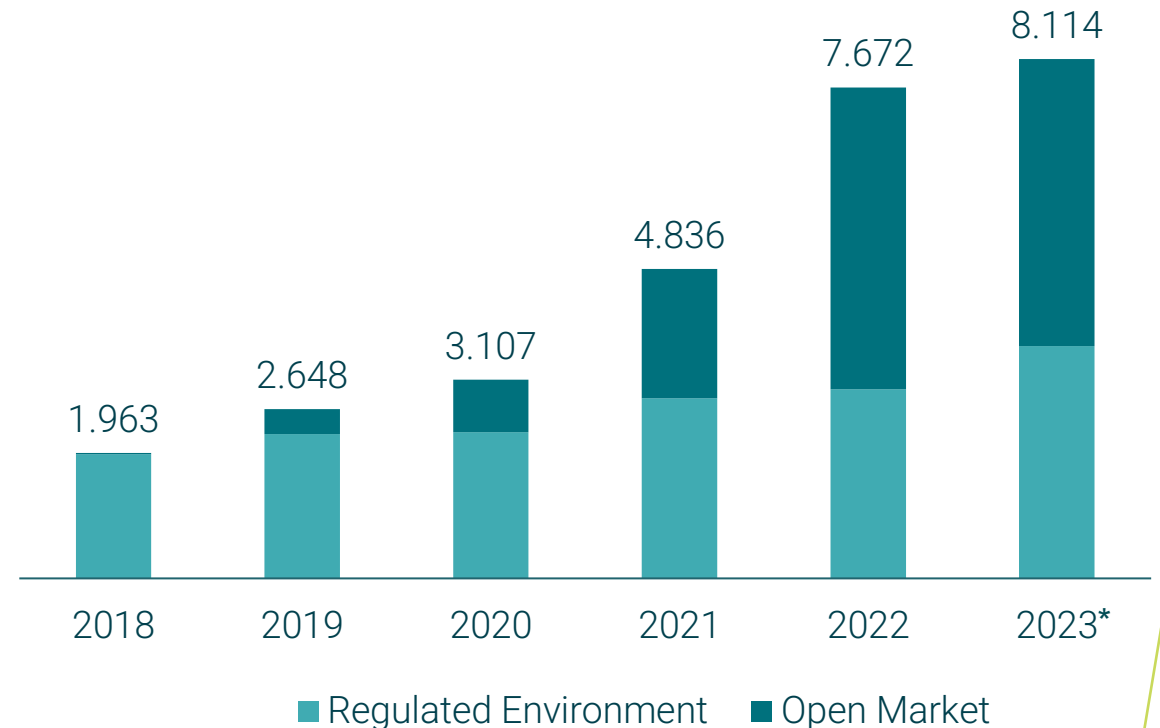


# Installed Capacity of Solar PV Plants

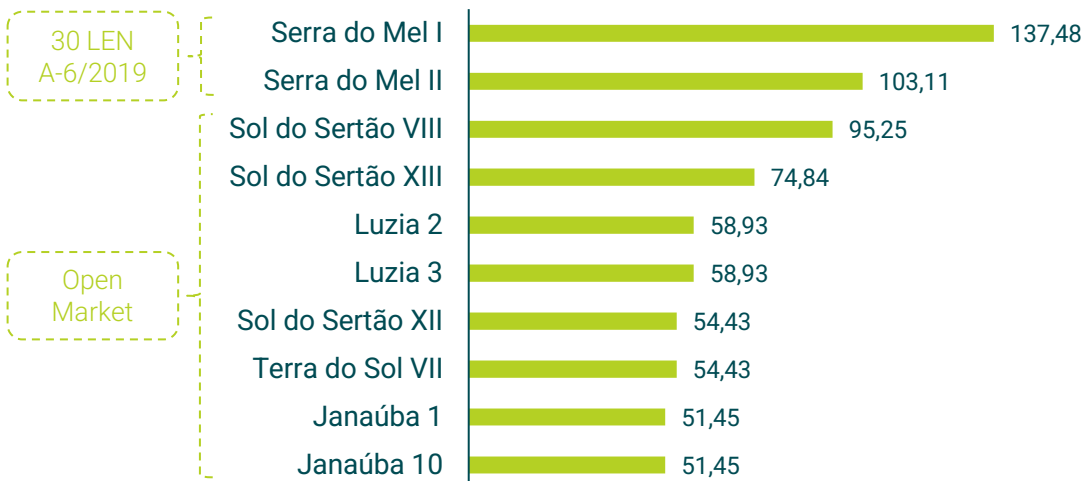
Open Market and Regulated Market : Installed Capacity [MW]

- Growth of **58.6% (2,835MW)** in the year **2022** compared to prior year, driven by the **Open Energy Market**, which represents 61% of the installed capacity up to February 2023.

**Annual Cumulative Installed Capacity (MW)**



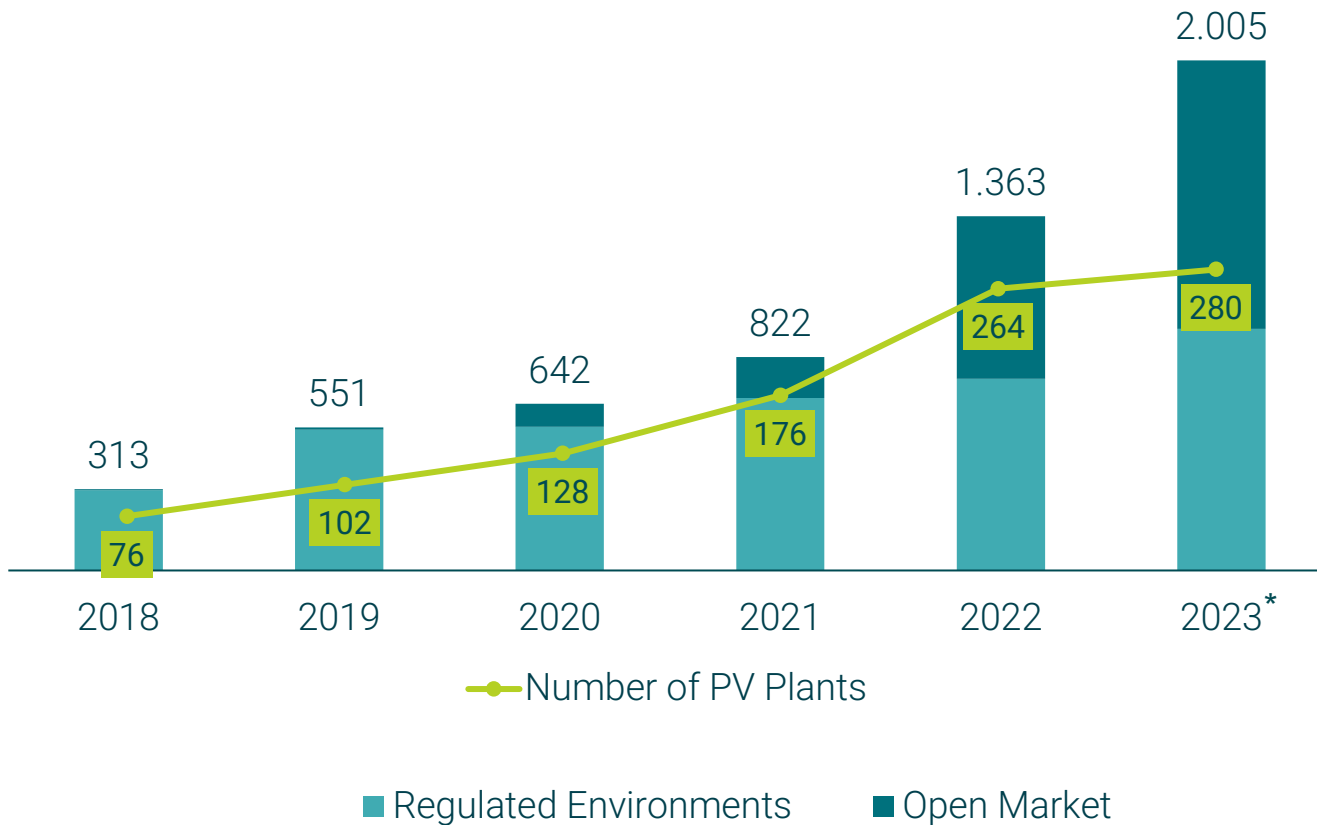
**Installed Capacity (MW) per solar PV venture**



# Solar PV Plants in Operation

Open Market and Regulated Market : Average Generation [MWm] and Cumulative Number of PV Plants

**Average Generation per Year (MWm)**



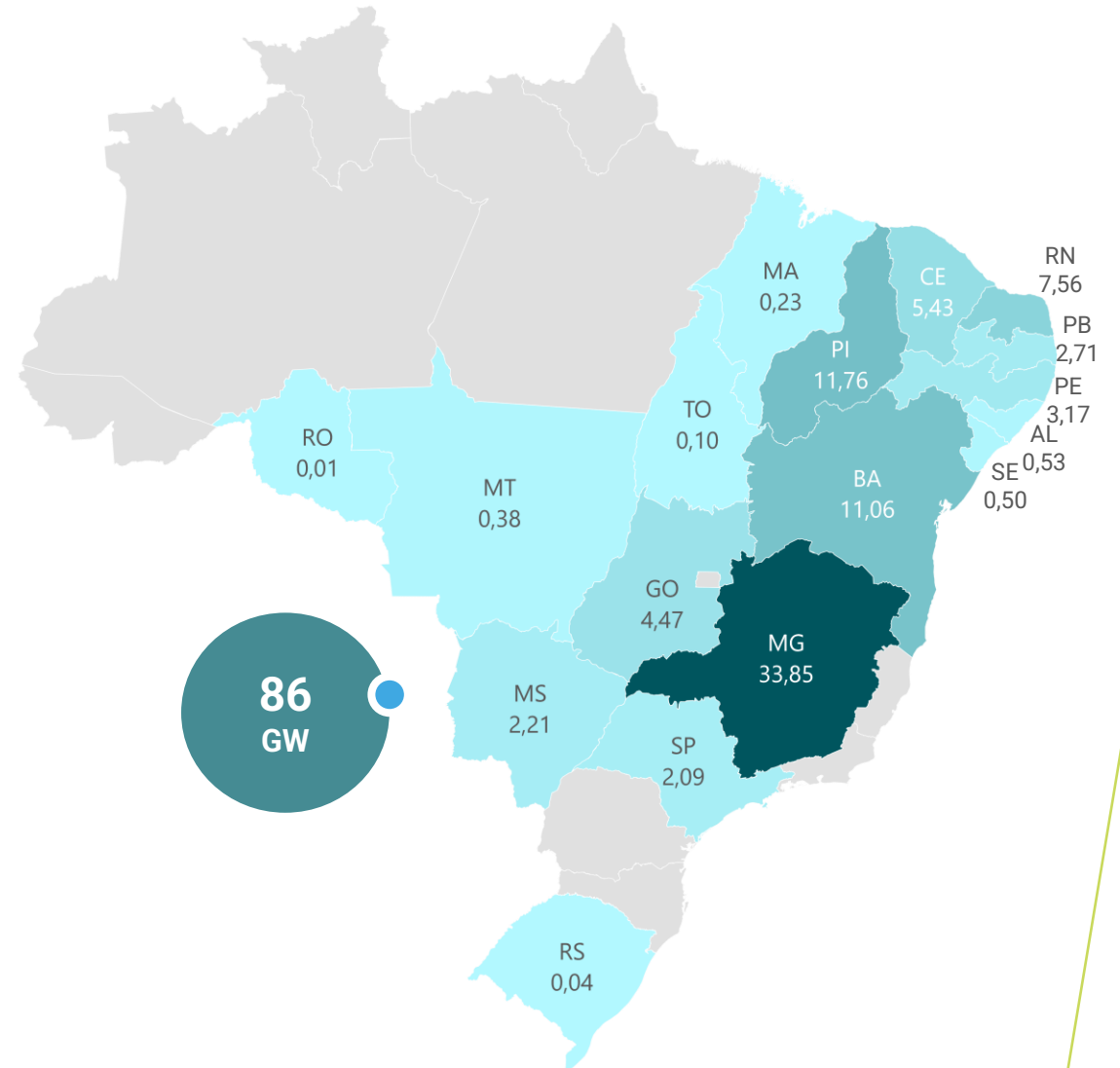
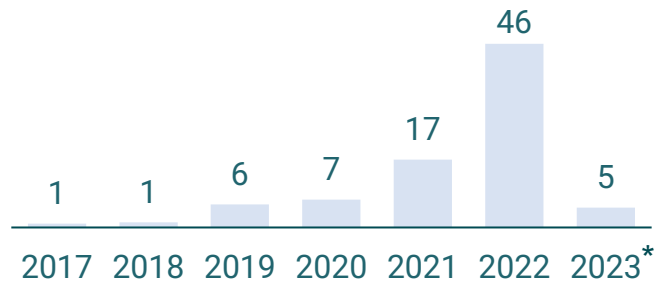
- In **February 2023, 2.1 GWm of solar energy was generated, the highest value ever registered** for this source on the SIN grid, representing an **increase of 74.7%** about the same period of the previous year.
- The solar PV energy generation in February 2023 represented **2.9% of the electricity generated in the country.**

# Authorized Projects [GW]

Open Market and Regulated Market: Cumulative Capacity per State

- **Acceleration** in the granting of **authorizations in 2022** due to the end of discount on TUSD/TUST transmission charges.
- **Acceleration in implementing and constructing** solar ventures **in the coming 2 to 3 years.**

Authorized Capacity per year (GW)

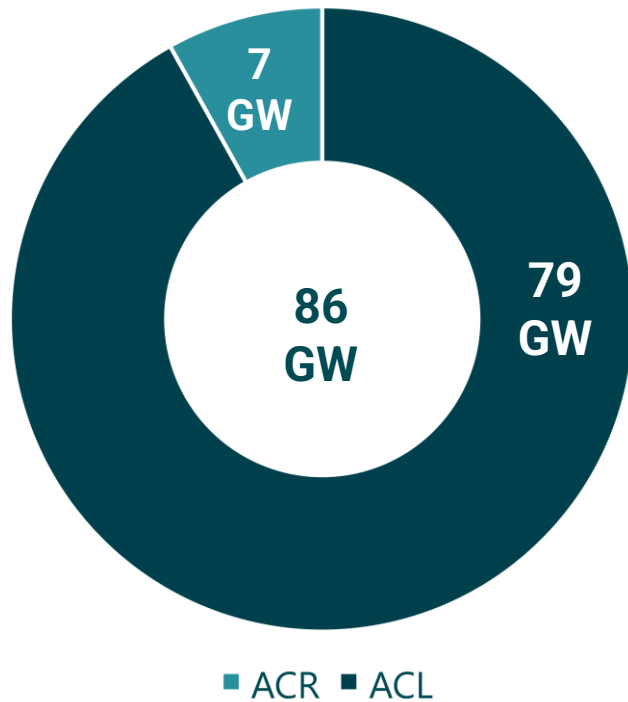




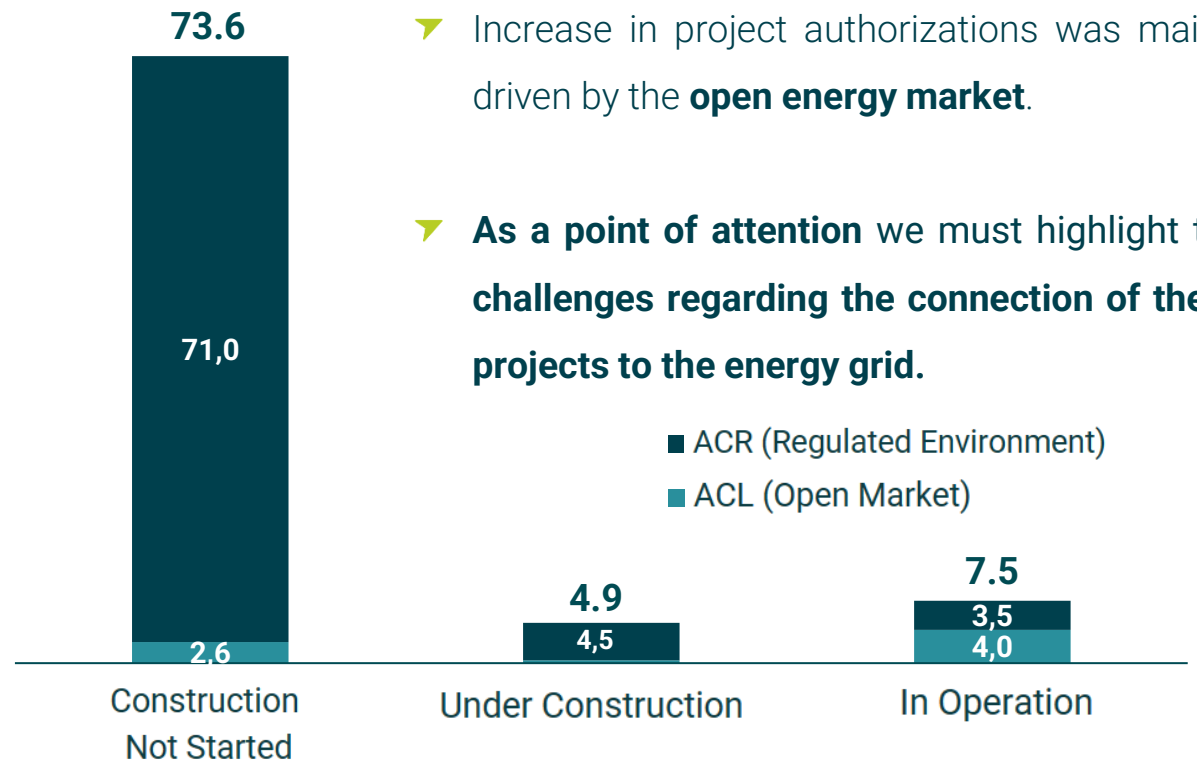
# Authorized Capacity of Projects

Open Market and Regulated Market

## Contracting Environment



## Status (GW)



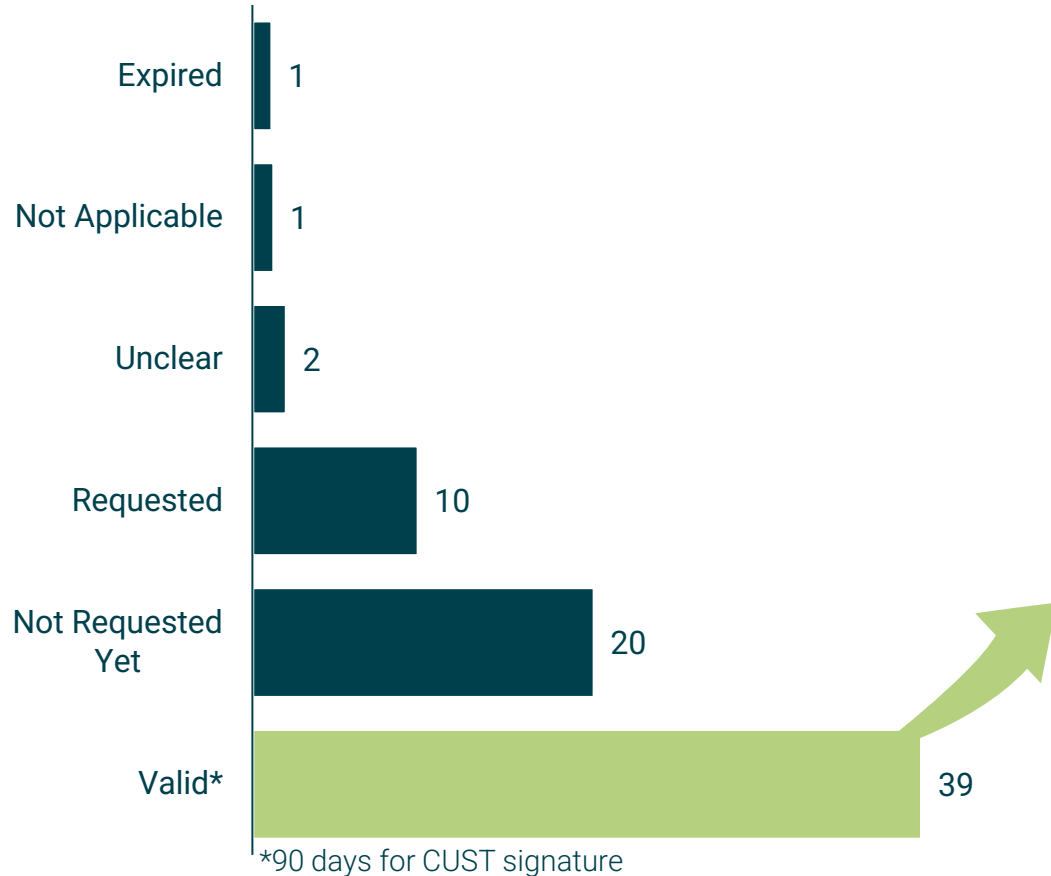
- Increase in project authorizations was mainly driven by the **open energy market**.
- **As a point of attention** we must highlight the **challenges regarding the connection of these projects to the energy grid**.

■ ACR (Regulated Environment)  
■ ACL (Open Market)

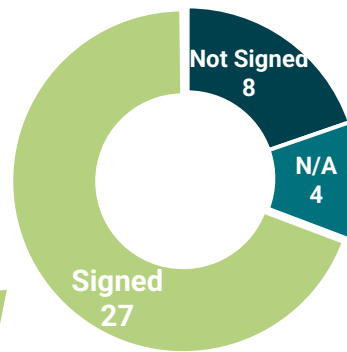
# Projects in Pre-Construction Phase

Grid Access Certificate and Cost of Use of Transmission System (CUST)

### Status of Exploration License (GW)



### Status of CUST (GW)

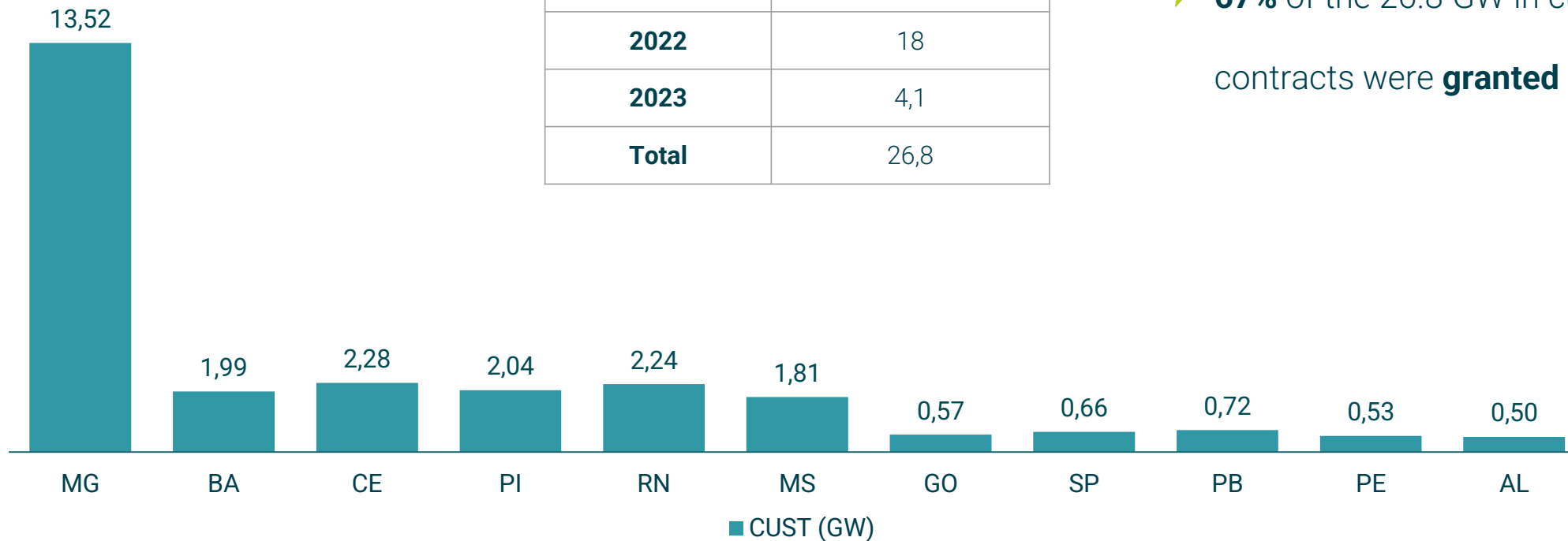


- **39 GW** of exploration licenses for PV plants have been granted, some of which are conditional upon the **availability of future margin** (a change in the rules by grid operator ONS), creating **uncertainty** for investors and the electrical system.
- **27 GW** of projects have signed **CUST contracts, many of which** came with **operating restrictions** (some more and some less severe, possibly impacting the financial viability of the ventures).

# Projects in Pre-Construction Phase

Contracts for Use of the Transmission System (CUST) per State

Year	CUST (GW)
2020	0,9
2021	3,8
2022	18
2023	4,1
<b>Total</b>	<b>26,8</b>



- **50.4%** of projects **with signed CUST** contracts are located **in MG**.
- **67%** of the 26.8 GW in cumulative CUST contracts were **granted in 2022**.

# Evaluation of Grid Access Viability

Operator of the National Electrical System (ONS)

- **Concern** from the competent agencies regarding the **discrepancy between the expressive demand** for generation access and the planned **transmission expansion**.
- To **avoid structural and systemic problems** (increased risk), **ONS changes the conditions for issuing information and exploration licenses**, discontinuing the flexibilities related to the application of operational measures (Special Protection Systems - SEPs).

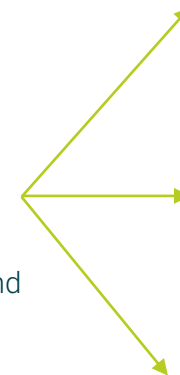
If there is **no problem** with load/voltage



**Exploration License viable**

If there is **some problem** with load/voltage

Depends on type of problem and the structural solution for it.



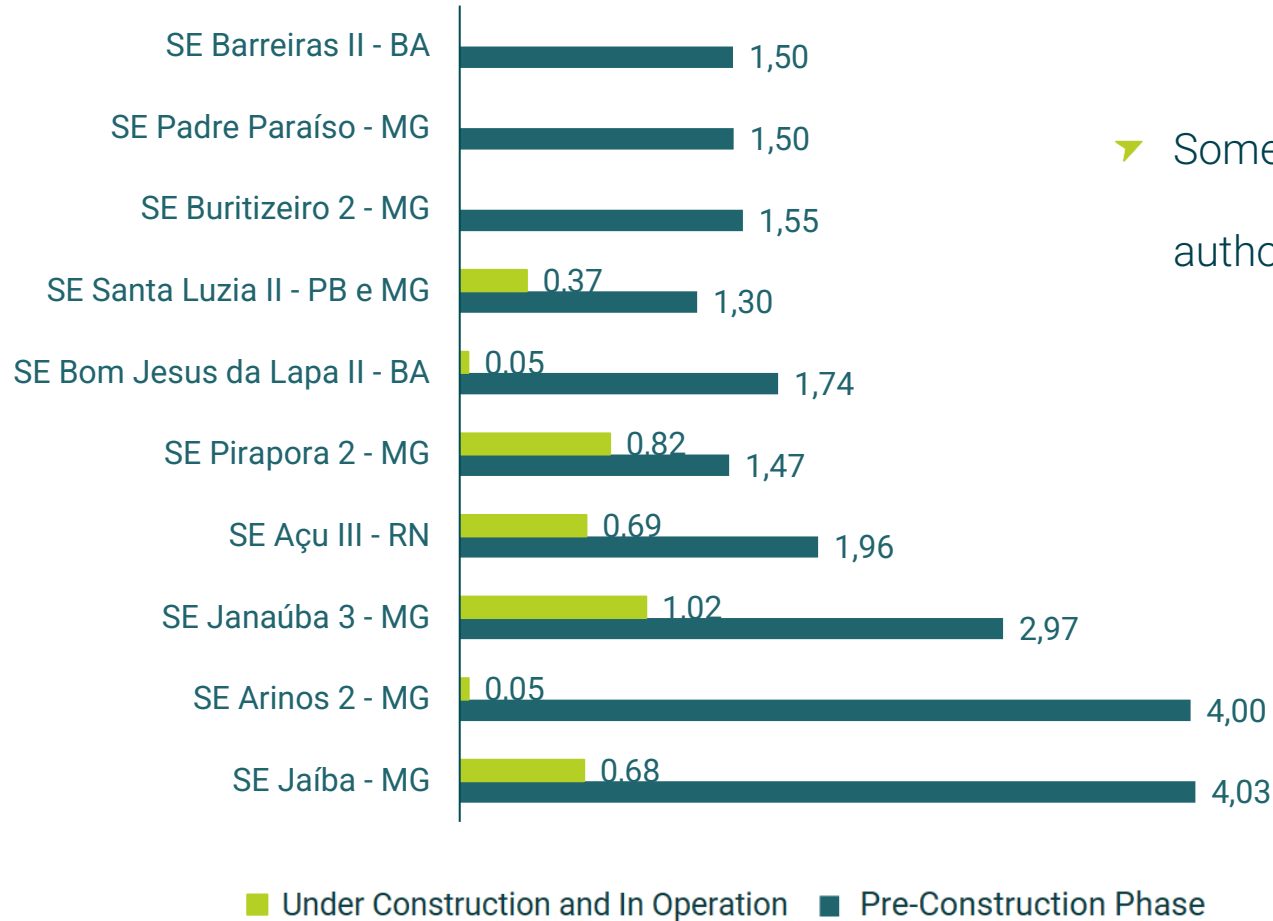
**Exploration License viable with Generating Restrictions**

**Exploration License conditionally viable**

**Exploration License unviable**

# Grid Connections

Authorized Projects per Substation (GW)



➤ Some substations with **high volumes** of authorized projects, exceeding 4GW.

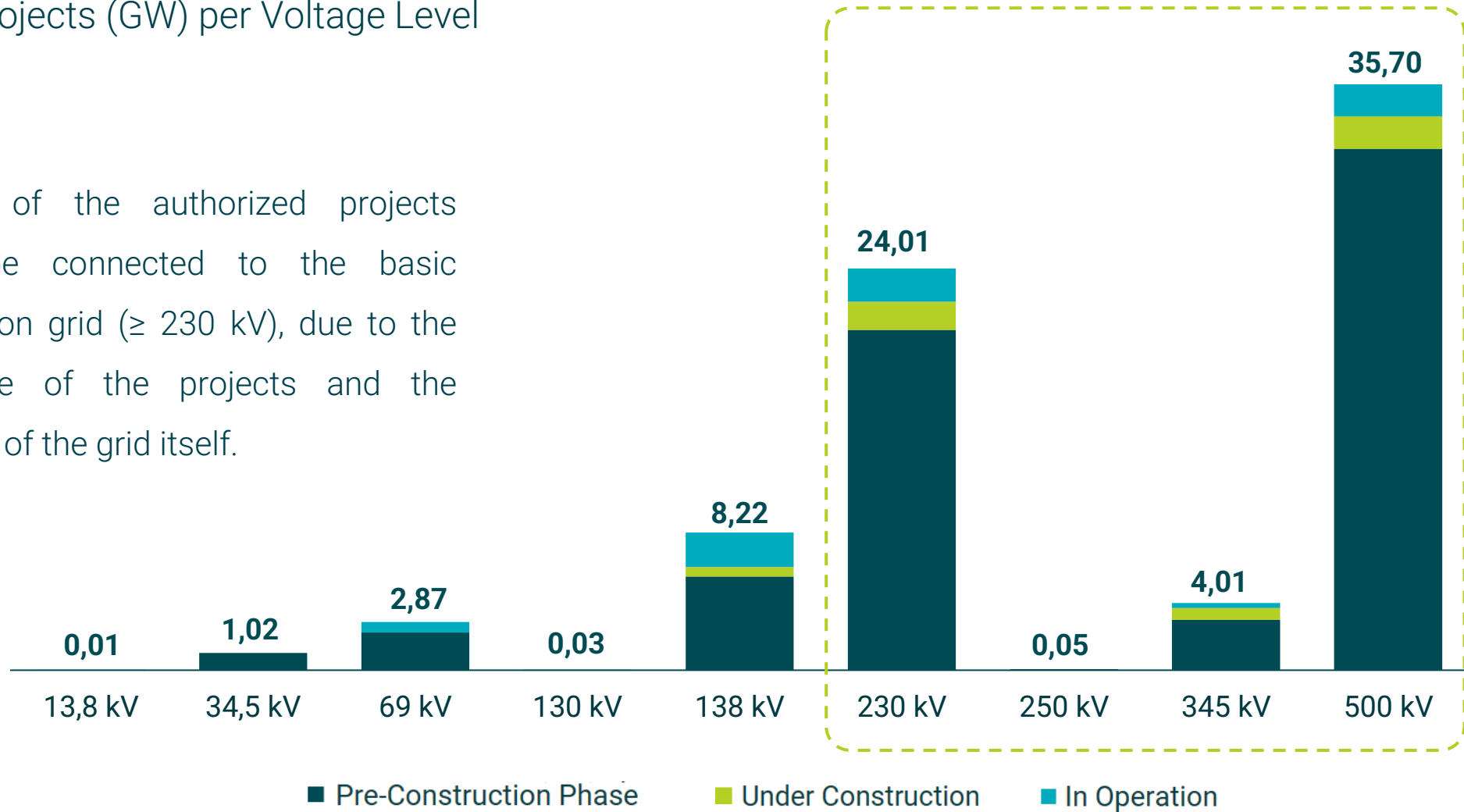
Note: According to ANEEL, 7.47 GW are associated with a substation called "SE Other".

Source: ANEEL. Updated: 02/2023.

# Grid Connections

Authorized Projects (GW) per Voltage Level

➤ **84%** of the authorized projects are/will be connected to the basic transmission grid ( $\geq 230$  kV), due to the larger size of the projects and the availability of the grid itself.

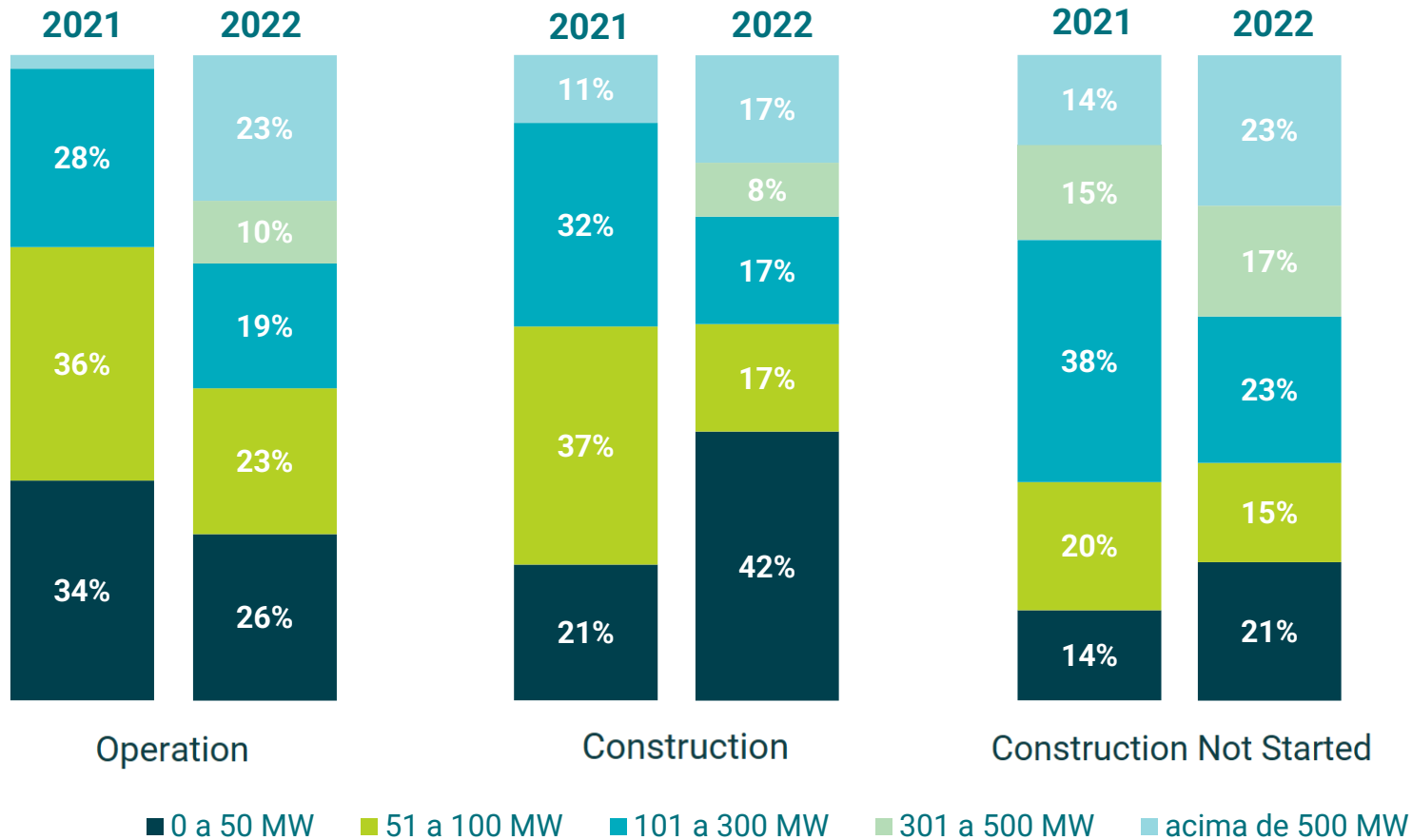


Note: Out of the total volume of authorized PV projects, 10.16 GW are categorized by ANEEL as not having started construction and with a voltage equivalent to 0 kV.

Source: ANEEL, Greener. Updated: 02/2023.

# Size of Solar PV Complexes (MW)

Open Market and Regulated Market

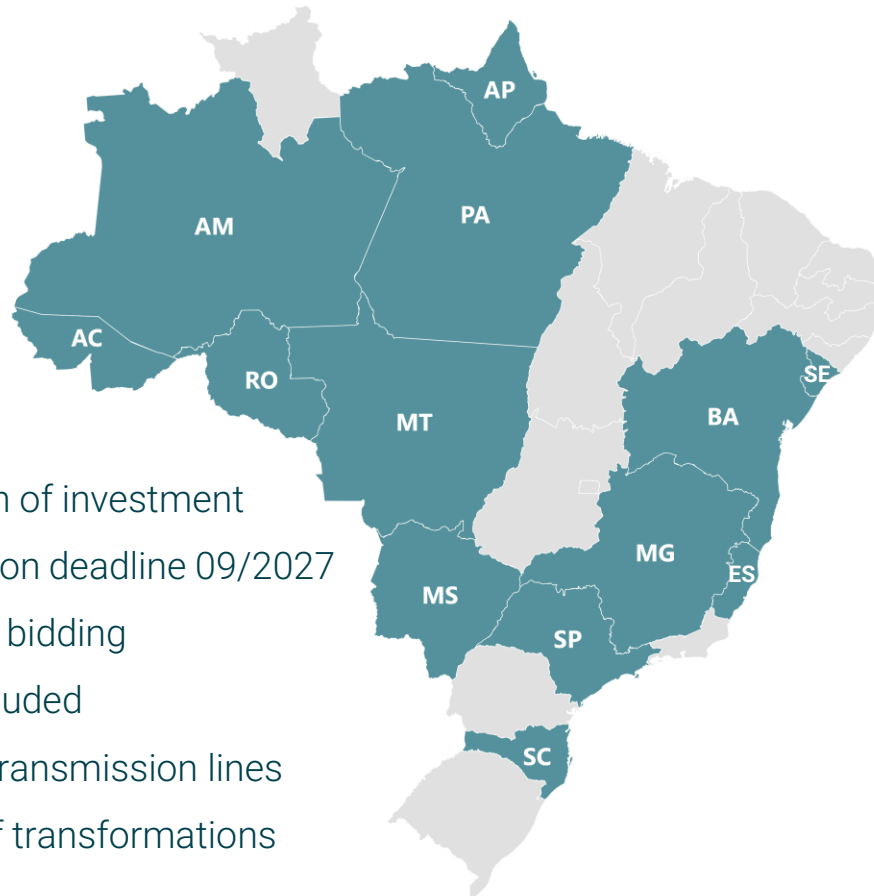


- A **solar photovoltaic complex** consists of a set of photovoltaic plants divided into different Special Purpose Vehicles (SPVs) **sharing the same grid connection** infrastructure.
- The **average size of the new ventures has increased** in relation to the plants already in operation. The efficiency gain with the increase in scale has encouraged entrepreneurs to develop larger projects, which optimizes investment and operating costs.

# Expansion of the Transmission System

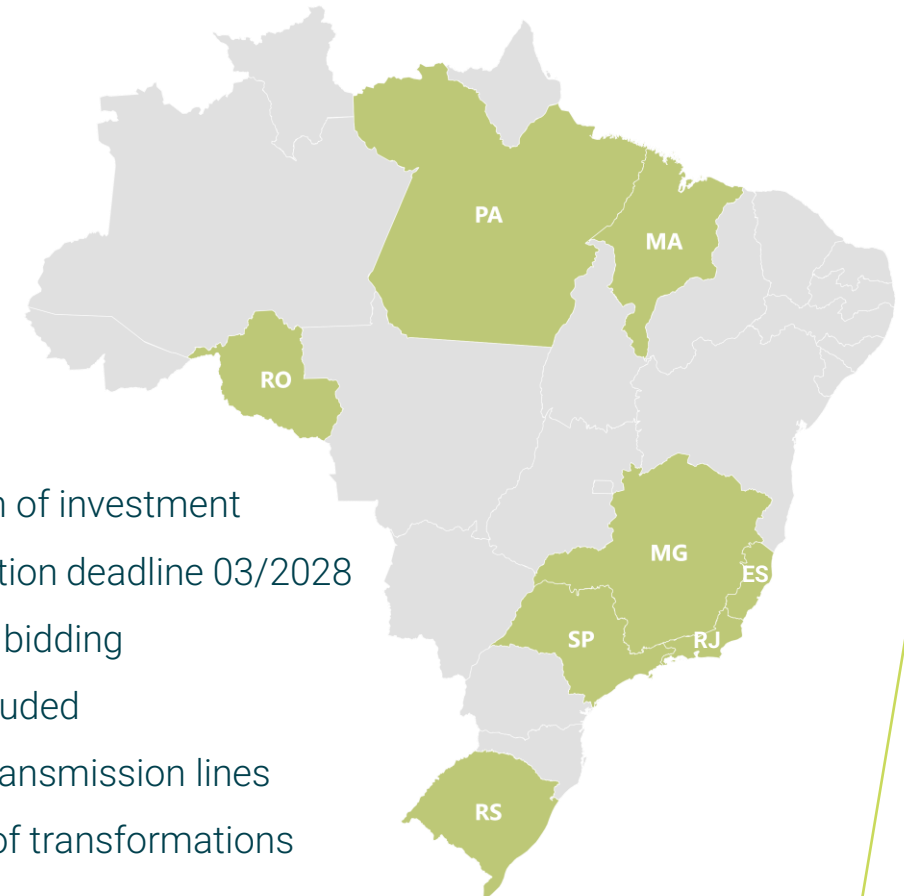
Auctions for Transmission Capacity held in 2022

### Transmission Auction N° 01/2022



- R\$ 15.3 billion of investment
- Implementation deadline 09/2027
- 13 lots up for bidding
- 13 States included
- 5.425 km of transmission lines
- 6.180 MVA of transformations

### Transmission Auction N° 02/2022



- R\$ 3.5 billion of investment
- Implementation deadline 03/2028
- 6 lots up for bidding
- 8 States included
- 710 km of transmission lines
- 3.650 MVA of transformations



# Article: The Dilemma Generation *Versus* Transmission

## Part 1



Alécio Barreto  
Ceo Carpe Vie

A few years ago, not even the most optimistic and devoted renewable energy enthusiasts could have foreseen the growth that has taken place in recent years, especially of solar energy in Brazil.

In the recent past, talking about solar PV projects with an installed capacity of 1.0 GW sounded like a daydream.

What we have seen recently shows the strength of renewables, as well as the attractiveness of these sources for investments.

Until recently, the contracting of solar PV generation projects took place exclusively in the ACR (Regulated Contracting Environment), through energy auctions, in their various formats (new, reserve and alternative sources). In this scenario, the institutions of the SEB (Brazilian Electricity Sector) controlled the expansion of generation, by matching the demand declared by distributors with the contracting volume in the auctions.

Thus ANEEL, ONS and EPE had a centralized and updated view of the expansion in generating capacity.

Until each following energy auction, the new generation of PV plants to be integrated to the Basic Grid of the SIN (National Interconnected System) was well known, both in terms of power and connection points, making it possible to make it directly compatible with the transmission expansion.

By enabling the execution of bilateral contracts between buyers (load) and sellers (generation), without the need to participate in an ACR auction, the expansion in the ACL has reached an unusual and unexpected dimension, removing any kind of control or entry barrier for those who can directly negotiate their generation capacity with the energy trading companies, or end customers.

In this new context, we have observed an exponential growth in requests for Grid Access Information to ONS and for authorizations to ANEEL, which resulted in a high number of requests for Grid Access Certificates.

Currently, in April, there are **almost 100 GW of solar projects licensed as PIE** (Independent Power Producer), as well as **more than 39 GW of solar projects with a valid Access Certificate** - with and without operational restrictions, or conditional upon

the start of transmission line construction work. If we also count wind projects under development, the numbers are impressive.

Faced with this picture, several questions arise:

- Is there demand for all this electricity generation?
- Considering the current scenario of CAPEX (Capital Expenditure), OPEX (Operational Expenditure) and tariffs, are these projects feasible from a financial point of view?
- Should grid planners take all this new capacity into account for the expansion of transmission?
- Will the integration of this forecasted generation exhaust the transmission grid, causing problems for the operation, with overloads and voltage control?
- Will equipment suppliers be able to provide this volume of hardware for power plant, substation and transmission line projects?
- Would an auction of "margin" (remaining capacity) be a solution?
- Is there even any "margin" to be auctioned?

Faced with this range of questions and uncertainties, there is one central observation: **The power flow studies reveal that the transmission grid is exhausted and overloaded.**

# Article: The Dilemma Generation *Versus* Transmission

## Part 2

When dispatching the already contracted generation (signed CUST) with a valid Grid Access Certificate, overloads and problems for voltage control are already being observed at several points of the SIN's Basic Grid.

In the power flow studies, **breaches of the operational limits of the grid are being detected** even before adding the additional generating capacity the studies envisage.

Some of these problems have already been taken into account in the EPE research, so that a structural planning solution has already been recommended, but only for future scenarios beyond 2027.

Other problems arise frequently, and still do not have a structural solution. However, several licenses set a deadline of 48 months from their publication until commercial operation (COD - Commercial Operational Date) to ensure the 50% discount on the TUST/TUSD (Tariff for Use of Transmission / Distribution System).

Thus, there is a regulatory deadline that may expire well before the transmission expansion is effectively integrated. Additionally, in view of the perceived difficulties and concerns about its operations, ONS has adopted a less flexible position regarding the criteria for issuing Authorizations and Grid Access Certificates.

On 12/30/2022, in a reply letter to ABEEólica and ABSOLAR (CTA-ONS DGL 2333/2023), ONS explained the "decision tree" applied to the access viability assessment, in the form of a flow chart.

This flowchart classifies the access into:

- Viable
- Viable with operating restrictions (partial or total)
- Conditionally viable
- Not viable

Based on the criteria adopted, and explained in the flowchart, many solar projects received a 'not viable' response for their Access Certificates.

A further group of projects received an Access Certificate conditional on the integration of future transmission works, not yet tendered, without a defined horizon for the beginning of commercial operations.

The regulatory "novelties" are a further unexpected chapter, sure to elicit strong emotions. The recent regulation regarding the Substation Development Area (ADS), is one of these unexpected episodes, with important repercussions for many projects.

All these elements create a scenario that reminds us of a popular saying, well known and often repeated in the Northeast of Brazil: "Little flour, my stew first". Faced with the scarcity of transmission, whoever "arrives first" can guarantee their "place in the sun", turning the subsequent projects unviable. The mismatch between the expansion of transmission and generating capacity has transformed the connection process into something similar to a "chess game", in which the next move needs to be connected to the following ones.

**How to mitigate the risks, map the threats and opportunities**, in order to enable the connection and operation of solar projects, **without compromising their financial performance** and the resulting return on investment?

With almost 30 years of experience and performance in the electricity sector, 13 years as an ONS specialist engineer, working with renewable energy for more than 15 years, I recommend the following:

- Surround yourself with information and rely on strategic advice, if possible on an ongoing basis.



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# Article: The Dilemma Generation *Versus* Transmission

## Part 3

- Plan each movement, with a systemic (broad) vision;
- Perform studies, not only to fulfill procedural obligations, but to have an updated view of the connection;
- Add common sense, balancing caution and audacity;
- Be aware of the "windows of opportunity";
- Seek possibilities to mitigate risks, whenever possible.

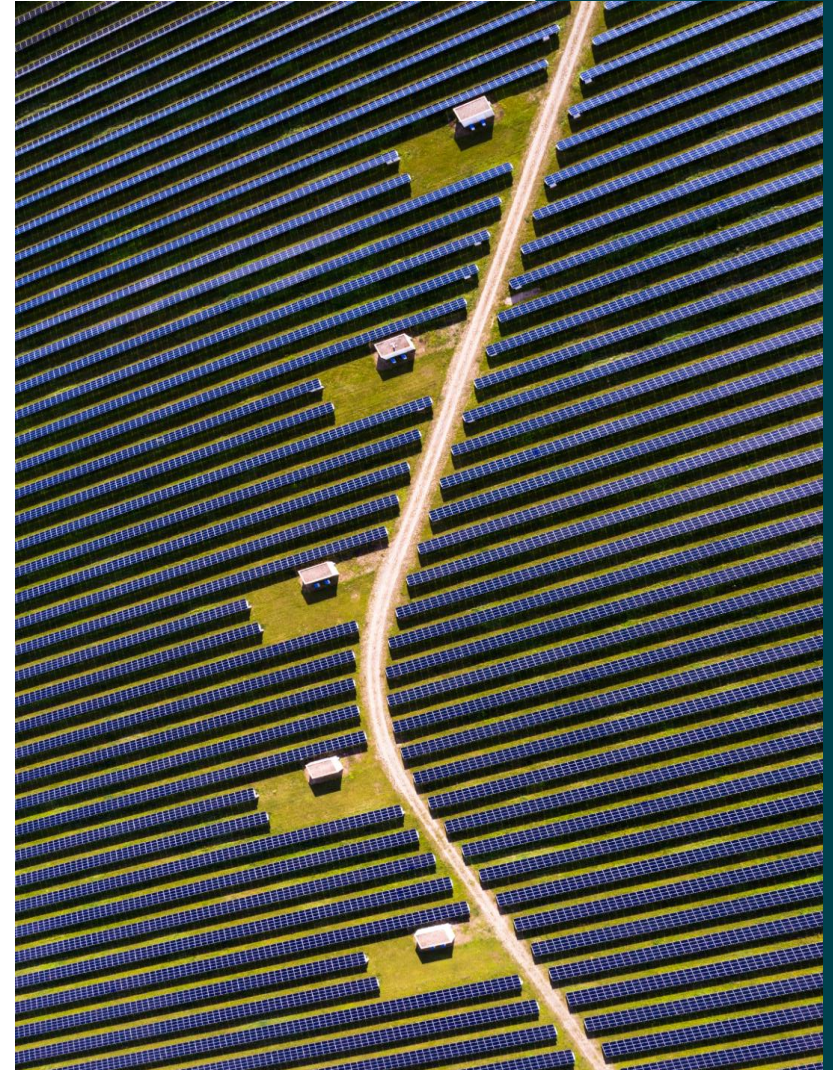
In fact, we are living in a VUCA (Volatility, Uncertainty, Complexity and Ambiguity) environment.

If we cannot change the environment, we must adapt, not only to survive, but to thrive in the face of the new and challenging reality.

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### *About the author:*

*Alécio has a PhD in electrical engineering, with twenty-nine (29) years of professional experience in the field of electrical studies and thirteen (13) years of experience as a specialist engineer at ONS (National Electric System Operator), working in the operation of the National Interconnected System (SIN). Since 2003 he is CEO/Founding Partner of Carpe Vie Engenharia Ltda and currently is Director/Founding Partner of Nexiall Consultoria em Energia Ltda.*



CHAPTER 2

# Forecasts for the CG Solar Market

CHAPTER 3

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CHAPTER 4

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- SUMMARY OF THE RESULTS: AVERAGE PRICE AND CONTRACTED CAPACITY
- PROJECTS CONTRACTED THROUGH AUCTIONS
- SUPPLIER MAP: PV PLANTS IN OPERATION
- CAPACITY FACTOR: FORECAST VS REALITY

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CHAPTER 5

# Solar in the Open Market

# CONTENTS OF CHAPTER 5

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- PROJECTS IN THE OPEN MARKET: SIZE AND LARGEST COMPLEXES
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- PROFILE OF THE OFFTAKER/CONSUMER – SOLAR PPAS
- STATUS OF PROJECTS IN THE OPEN MARKET: COMPARISON OF PPAS
- MAPPING OF SOLAR PPAS/AUTO-PRODUCTION IN THE OPEN MARKET

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CHAPTER 6

# Prices

# CONTEÚDO DO CAPÍTULO 6

- PRICE OF ENERGY PER CONTRACTING ENVIRONMENT: ACR AND ACL
- PRICE OF POLYSILICON
- PRICE OF STEEL
- PRICE OF PV MODULES IN BRAZIL

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CHAPTER 7

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CHAPTER 8

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- TECHNICAL AND ECONOMIC-FINANCIAL CONDITIONS
- STRUCTURING OF THE PPA
- RESULTS AND SENSITIVITY ANALYSES
- CONCLUSIONS OF THE CASE

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- A very low energy price in the short-term market combined with high interest rates and higher CAPEX in 2022 were factors that contributed to the drop in long-term solar contracting (PPAs). Even with a possible fall in CAPEX in 2023, the **low spot price** combined with the prospect of **high-interest rates throughout 2023** should be a point of attention in **pricing long-term contracts (PPAs)**, possibly giving rise to alternatives such as dollar-denominated PPAs.
- A considerable number of projects for the **regulated market** were financed by the **development banks BNB and BNDES**. But new financing instruments such as **debentures** are on the radar of entrepreneurs.
- (Draft) **Bill 414/2021**, which proposes the **gradual opening of the electricity market**, and the **new rules for Distributed Generation** are factors that should contribute to accelerating the traction of business models based on **Auto-Production** with Leasing of the Generation Asset, as well as arrangements based on Independent Energy Producer (PIE) Equivalent to Auto-Production in the coming years.

## INSIGHTS

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- In line with previous years, a significant **part (65%) of CG solar projects exhibited a capacity factor that was lower** than expected. This can be related to the abnormal insolation conditions in the analyzed period, but indicates an important point of attention for projects under development and construction regarding the robustness of their predicted operating assumptions.

## INSIGHTS

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JA Solar is among the 3 largest manufacturers of photovoltaic modules in the world according to Bloomberg rankings and is also one of the sector's sales leaders, with the 2nd largest number of shipments of solar equipment worldwide in 2021. Founded in 2005, JA Solar's main differentials are its R&D team with more than 1,000 patents in the PV cell and module segment, its highly verticalized internal production, as well as its enormous production capacity of +50 GW/year.

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