

Project Iracema

AEA technical session



28 November 2023



About Proton Ventures

EMPOWERING AMMONIA SOLUTIONS

Chemicals, green energy and beyond

- 22 years pioneers and developers in (green) ammonia
- Technology agnostic engineering & system integrator
- Entire green ammonia value chain knowhow
- International team of specialists
- Expertise on cracking
- In house engineering disciplines & certifications

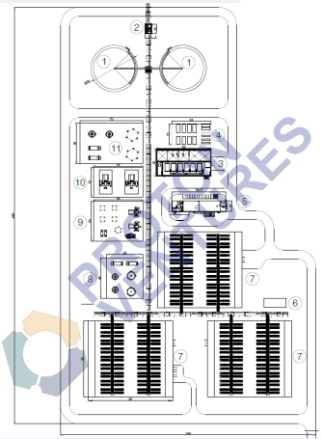
Your trusted partner for the green ammonia value chain

Your Trusted Partner for the **Green Ammonia Value Chain**



Proton Ventures – Pioneering the green ammonia industry

Green H₂ / NH₃ Production



(Green) ammonia production references

- EPC 4 MTPD green ammonia pilot plant (including 2x 2 MW PEM/AWE electrolysers and H₂ storage) in Jorf Lasfar, Morocco
- Multiple FEED studies for ammonia plant's ranging from 3 MTD to 60 MTPD (green) ammonia.
- > 25 Class III/IV Feasibility studies for (green) ammonia production plants.
- > 5 Scoping studies (pre-feasibility) studies for large scale (green) ammonia production plants.

NH₃ & Energy Storage



Developing green ammonia

- EPC-(M) of 2x30.000 Metric ton Estonia
- 2nd EPC (M) of 2x30.000 Metric ton in Estonia
- EPC-(M) of 10.000 Metric ton Bulgaria
- EPC-(M) of 12.000 Metric ton Bulgaria
- FEED of 2x30.000 Metric ton UAE
- EPC-(M) of Ammonia Jorf Lasfar

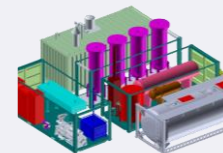
Project development



Building green ammonia export hubs

- Founding member of the TransHydrogen Alliance
- **Project Iracema: 400kT/y in the port of Pecem by 2027 and 2,2MT/y by 2031.**
- Other locations under investigation

Other applications



Conventional applications

- Engineering & EPC for De-Nox/N₂O removal
- Engineering & services for Urea & Nitric Acid facilities
- Engineering & EPC-(M) services for UAN

Innovative applications

- Feasibility studies for Ammonia to Power & combustion solutions
- Feasibility studies for ammonia decomposition, cracking and purification.



01

Consortium

The CCT Consortium

Partners with Complementary Know-how



CDV is a leading player in Brazil's renewables market

4.2 GW energy generation projects in operation or under construction

50.9 GW of solar and wind energy projects developed or under development

Integrated platform, acting in project development, building, operating and commercialization

TotalEnergies, owns a 34% stake in CDV to exclusively develop, build and operate its renewable portfolio in Brazil, including green hydrogen and green ammonia projects



Leading energy trader in Brazil

20+ years of experience, structured in four main business verticals: centralized renewable generation, distributed generation, energy trading, and energy solutions

0.9 GW operational renewable energy generation projects, with aim to reach 2.2 GW by 2024

2.8 GW avg energy traded (1Q'23 LTM)

50% owned by **Vibra Energia**, leading fuels distributor in Brazil



Pioneers in the green ammonia industry, designing the largest ammonia terminals of Europe and sustainable ammonia plants

Extensive project experience and engineering capabilities along the entire green ammonia value-chain

Develops solutions within the entire chain of production, storage and applications such as cracking

Provides innovative engineering and turn-key solutions for world-scale storage terminals, modular ammonia production units and other related applications



Leading international physical commodity trader. Engaged in the marketing, trading and distribution of raw materials critical to the fertilizer, petrochemical and mining industries

Holds **24% of global** ammonia seaborne trade, operating the **largest ammonia fleet in the world**

Largest ammonia buyer in the world, being the only global ammonia trader purchasing through long-term or spot agreements in 25 countries

Electrons

Molecules

The consortium is made up of value chain specialists and holds expertise in **the whole value chain** of Green Ammonia: Brazilian Renewable Energy, Engineering, Production, Storage, Shipping and Marketing



02

Iracema Project

Why Pecem?

Dedicated Green H2 Hub with developed infrastructure



Green Hydrogen Corridor between the Port of Pecém and the Port of Rotterdam:

Port of Rotterdam Authority is a 30% shareholder in the Pecém Industrial Port Complex.

More than 1,000 ha. allocated for green H₂ production:

ZPE (Duty Free Zone)

Other Tax benefits (Corporate Tax, ICMS)

Project to implement common port infrastructure & storage pool for green NH₃ with target 2027:

Bids underway for NH₃ storage pool and transfer pipeline with international storage operators

Utilities:

Favorable position for connection to the extra-high voltage electrical system (500kV).

Shared water supply with reuse of wastewater from Fortaleza city

Potential synergy with the industries in the port's vicinity:

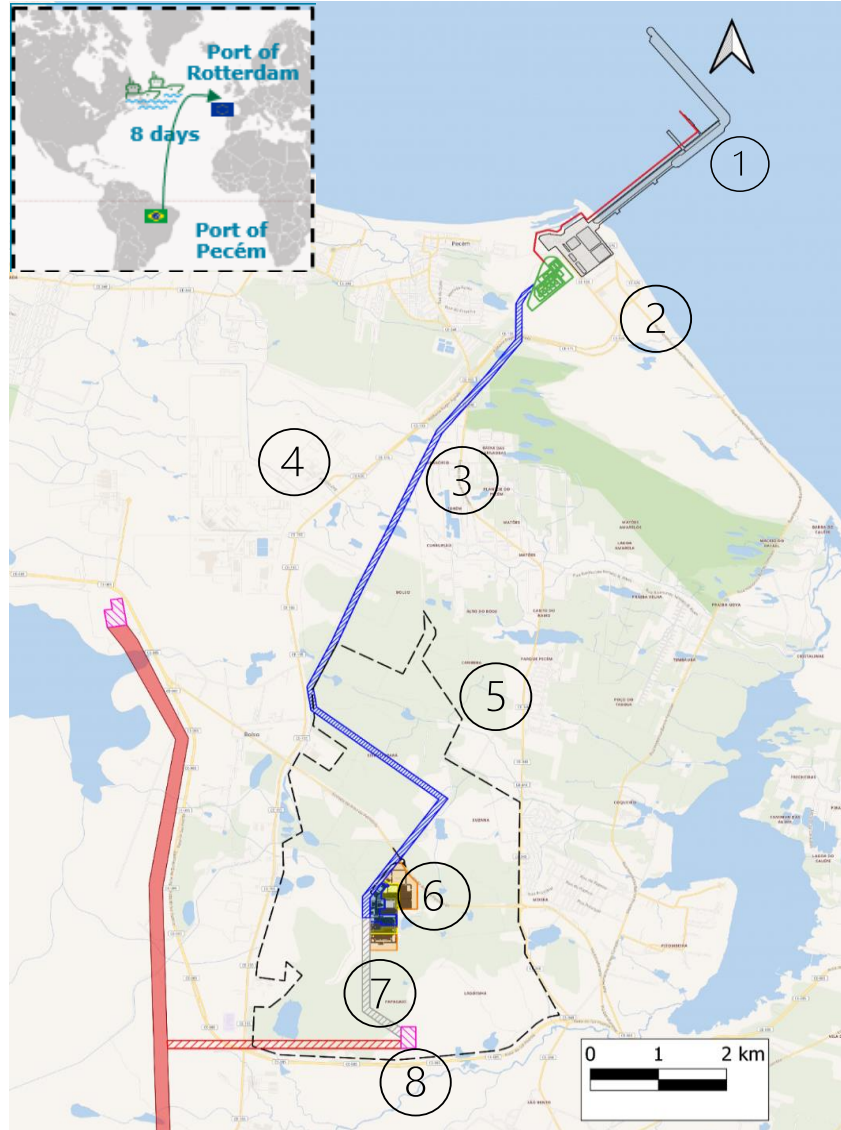
Steel industry, cement and power plants

Future expansion plans for a refinery, offshore wind marshalling area as well as potential for fertilizers

Project Iracema

Project Overview

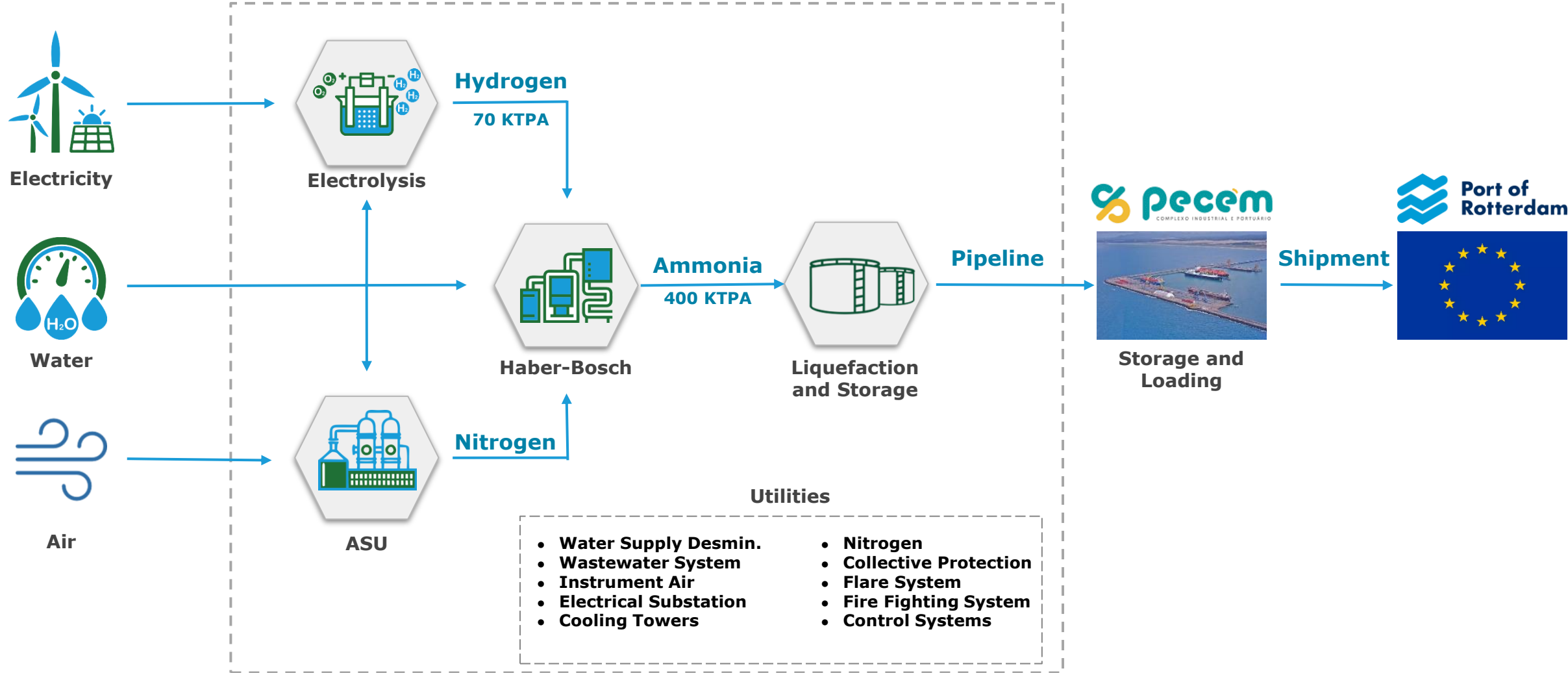
Objectives	Green ammonia production to the European market, exported through the Port of Pecém and the Rotterdam Green Corridor
Location	Port of Pecém - Ceará - Brazil
Ammonia Capacity	Phase 1: 400 KTPA Final Capacity: 2,200 KTPA
Renewable Energy	Grid connected project , able to source PPAs from Brazil's clean grid and the possibility of 24x7 plant operation



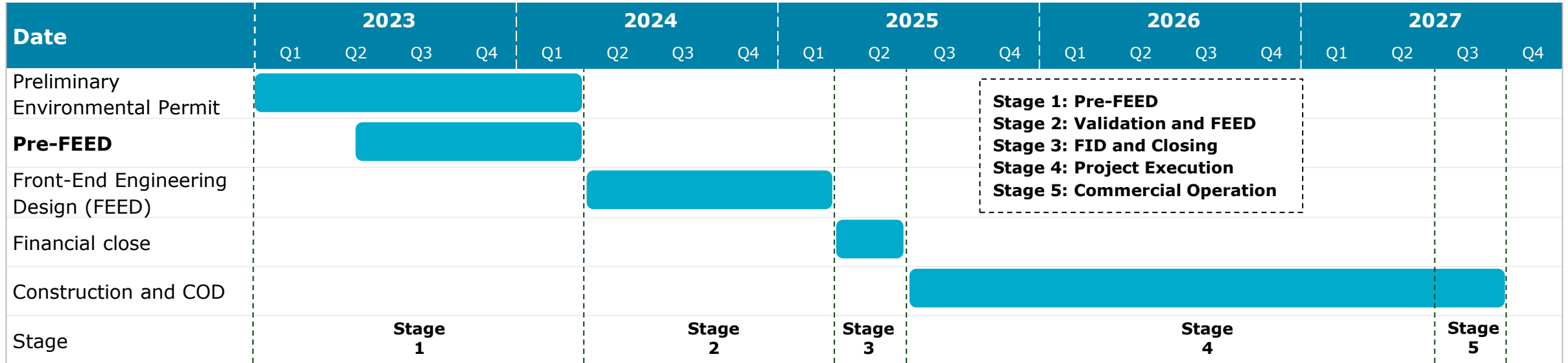
- ① Future ammonia berth, currently handling LNG
 - ② Future common storage infrastructure
 - ③ Future ammonia pipeline
 - ④ Steel factory from Arcelor Mittal,
 - ⑤ Future refinery
 - ⑥ Project Iracema plant plot of 60ha
 - ⑦ HV connection line
 - ⑧ 500/33kV substation
- H₂ Hub in the industrial and port complex and the Free Trade Zone (ZPE Ceará)




Project Iracema

First Phase Conceptual Design



Project timeline



		2027	2029	2031	Total
POWER GENERATION		540 MWavg	+540 MWavg	+1,890 MWavg	2,970 MWavg
ELECTROLYSIS GH2 Capacity		450 MW Electrolysis 70 KTPA	+450 MW Electrolysis +70 KTPA	+1,575 MW Electrolysis +245 KTPA	2,280 MW Electrolysis 385 KTPA
AMMONIA SYNTHESIS GNH3 Capacity		1,140 tpd Capacity 400 KTPA	+1,140 tpd Capacity +400 KTPA	+3,990 tpd Capacity +1,400 KTPA	+6,270 tpd Capacity 2,200 KTPA

Media and politics attention



**Pre-FEED MoU signing procedure
Dutch embassy in Brasilia
February 2023**



**World Hydrogen Summit
Green Ports Partnership signing ceremony
May 2023**



03

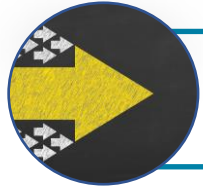
Offtake

Unique selling points for offtake



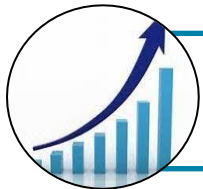
Certification

- RFNBO compliant green ammonia to meet the mandates



Early provider

- First volumes shipped in 2027



Scale-up timeline

- First phase by 2027, ramping-up to 2,2MT/y by 2031



Volume guarantees

- High guaranteed offtake because no dependence on intermittent production
- Low technical risk and downtime due to continuous production



Flexible point of transfer

- From FOB to DDP, logistics and incoterms are flexible

Key markets for Offtake



Green ammonia for petrochemical feedstock and industry: Mandated to consume 42% of RFNBOs by 2030. Ammonia is a smaller part of the costs build-up of industrial clients, with more ability to absorb premiums.



Green Steel and Refineries: offer mature business cases, since these sectors already use “grey hydrogen”, the offtake picture is clear, but tied to the roll-out of cracking & pipelines. Will also be mandated to consume 42% of RFNBOs by 2030.



Mobility: such as commercial road transport, hydrogen-powered bus and train networks with centralised refuelling stations/depots, also dependent on the roll-out of cracking & pipelines. Highest green premiums achievable in this sector.



Power: Likely an early-adopter for co-firing, but only short-medium term. Short-term partial decarbonization of coal power plants. Large presence of German utilities on offtake. Significant programs in Japan and Korea.



Fertilizers: Large market, but unlikely to pay a premium for green ammonia over other low-carbon ammonia as agricultural usage is very price sensitive.



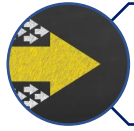
Shipping: Largest market after 2035, but not a first-mover. Technology and safety procedures being established. Infrastructure and ships are not ready yet to allow ammonia to replace fuel oil. Regulations are not in place for bunkering of ammonia in ships.

Mandated and early-adopters are targeted for offtake

Opportunities highlights



STRATEGIC LOCATION



FRONT RUNNERS



DEVELOPMENT PIPELINE



ABUNDANT LOW COST RENEWABLES



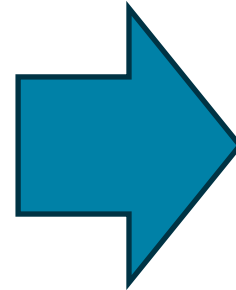
LEADING UPSTREAM DEVELOPERS



DOWNSTREAM INTEGRATION



DEVELOPED INFRASTRUCTURE & INCENTIVES



Providing large amounts of competitive green ammonia to Europe

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Ammonia Project Features

Renewable ammonia exports from Brazil: Project Iracema



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Project Manager Green
Hydrogen, Casa dos Ventos



Ricardo Gedra

Market Analysis and
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**Tues 28 Nov,
9AM BRT**

hosted by:
Kevin Rouwenhorst
Technology Manager, AEA

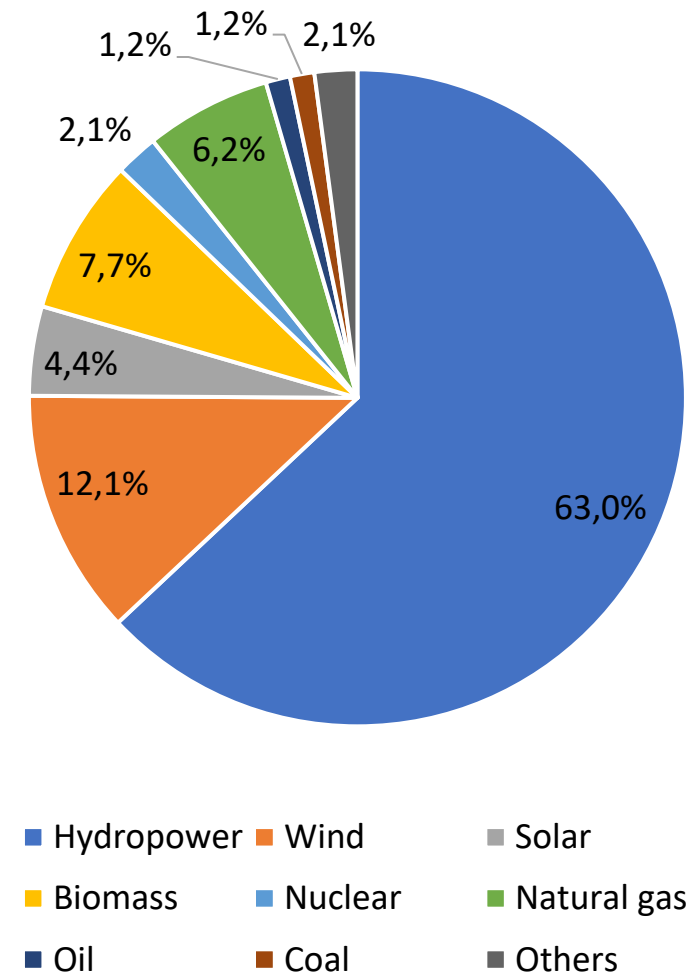


**AMMONIA ENERGY
ASSOCIATION**



Electricity generation in Brazil

- Brazil has a high renewable penetration in the grid, with nearly 90% of electricity generation from renewables (hydro, wind, solar), biomass, and nuclear
- Allows for grid-connected electrolyzers, similar to historical electrolysis-based ammonia plants





Ammonia production in Brazil

- Brazil produces about 1.5 million tonnes of ammonia per annum, accounting for less than 1% of global production
- Unigel announced a 60 MW alkaline electrolysis system (ThyssenKrupp Nucera) for its Camaçari plant, set to produce 60 kilotonnes of ammonia per annum





Ammonia production in Pecem

- Various project consortia are developing renewable ammonia projects in Pecem, in the northern state of Ceara. This includes the project of Casa dos Ventos, Comerc, and the TransHydrogen Alliance, and the project of Fortescue
- Casa dos Ventos, Comerc, and the TransHydrogen Alliance are developing 2.2 million tonnes of grid-connected ammonia production capacity; The first phase amounts to 0.4 million tonnes in 2027





Ammonia Project Features

Renewable ammonia exports from Brazil: Project Iracema



Jonas Rechreche

Business Analyst, Proton
Ventures



Matheus Kleming

Project Manager Green
Hydrogen, Casa dos Ventos



Ricardo Gedra

Market Analysis and
Information Manager, CCEE



**Tues 28 Nov,
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hosted by:

Kevin Rouwenhorst
Technology Manager, AEA



**AMMONIA ENERGY
ASSOCIATION**

Webinar AEA

Brazilian Power Market

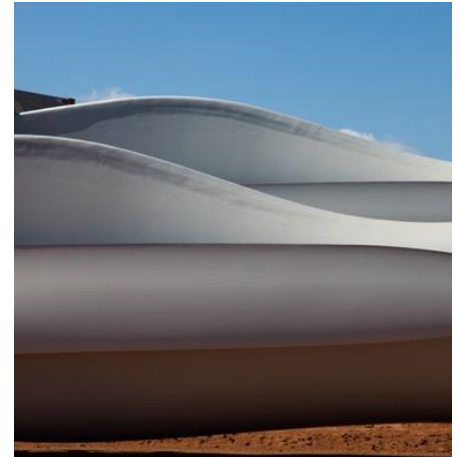
November 2023



uso conf

Agenda

1. Institutional Presentation
2. Brazilian Electrical Market





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01

Institutional
Presentation

From project developer to corporate PPA leadership

Casa dos Ventos



Casa dos Ventos started the largest wind exploration campaign in the world, with a vision ahead of the market

First direct investments by Casa dos Ventos as a **power generator**

Solutions dedicated to corporate clients and consolidation of the **self-production** model

Expansion of the **energy trading** division, based on data and proprietary technology

JV with **TotalEnergies**, the largest transaction in the Brazilian renewable sector

2007

2013

2018

2020

2022

2009

2015

2019

2021

Sale of the first **wind projects**, starting the successful trajectory that took it to the position of largest renewable developer in Brazil

Development of **solar and solar hybrid** projects

Development of **proprietary tools with data science, cloud and digital**

Green molecules solutions: **hydrogen and ammonia**



Brazilian renewable energy leader with unique capabilities

Casa dos Ventos



50.9 GW

of projects developed & under development



4.2 GW

of projects built or under construction by CDV



100%

of projects delivered on time or ahead of schedule



1 out of 4

of all operational wind projects in Brazil by CDV¹



Unrivaled expertise

- **+15 years** of experience in renewable energy
- **Deep understanding of the regulatory framework** resulting in proven value creation



Distinguished track record in development & execution

- **Vertically integrated structure**, acting in all links of the value chain
- **Area equivalent to 50% of Belgium's territory** in land owned or leased since 2007



Assets with higher capacity factors and reliability

- **Richest wind and solar measurement database** in Latin America
- **Higher density of measurements** which leads to more reliable energy production



Leadership as partner of choice in energy transition

- **Largest Corporate PPA² origination volume**, making CDV a key player in Brazil
- **Pure wind and solar player**, with most efficient projects and highest competitiveness

1. Developed by CDV, constructed by CDV or its Clients

2. Corporate Power Purchase Agreement (PPA)



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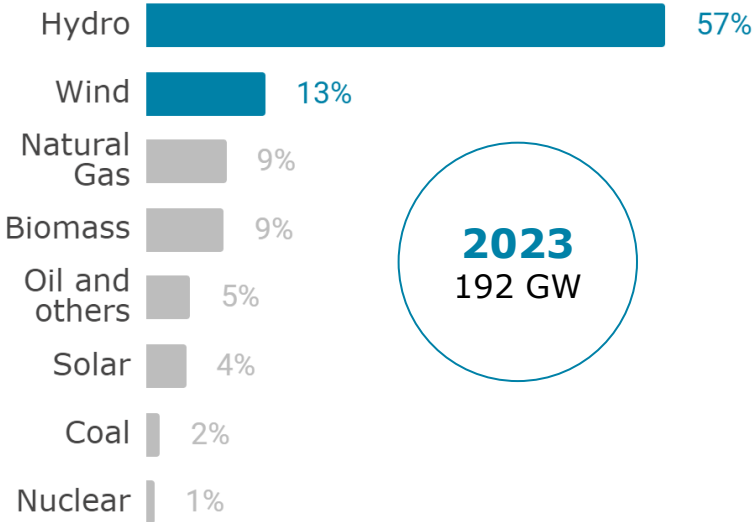
02

Brazilian
Electrical Market

Brazilian Electricity Grid - 84% renewable

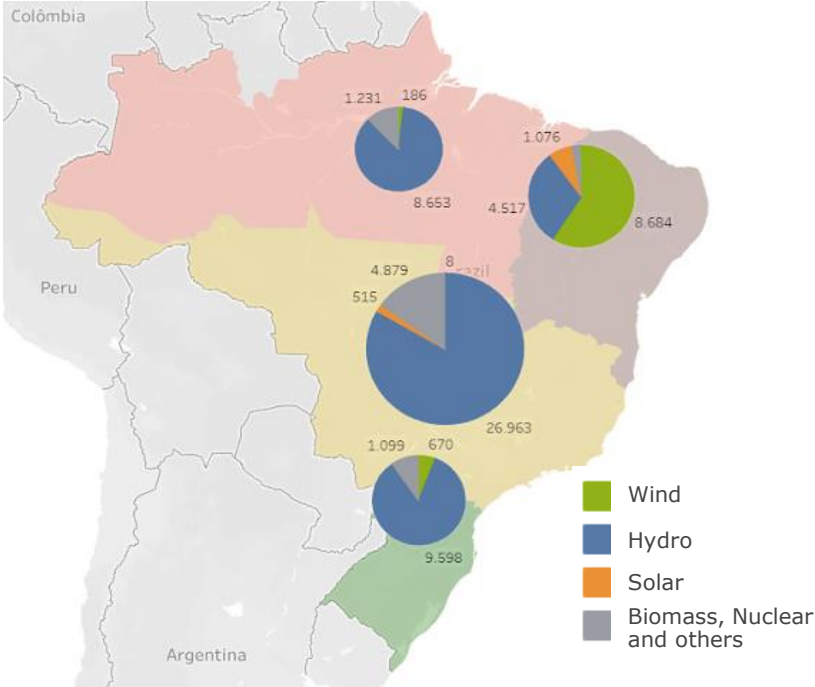
Reliable and natural energy sources

Electrical Mix



83.5% of renewable sources

Electrical Mix Distribution



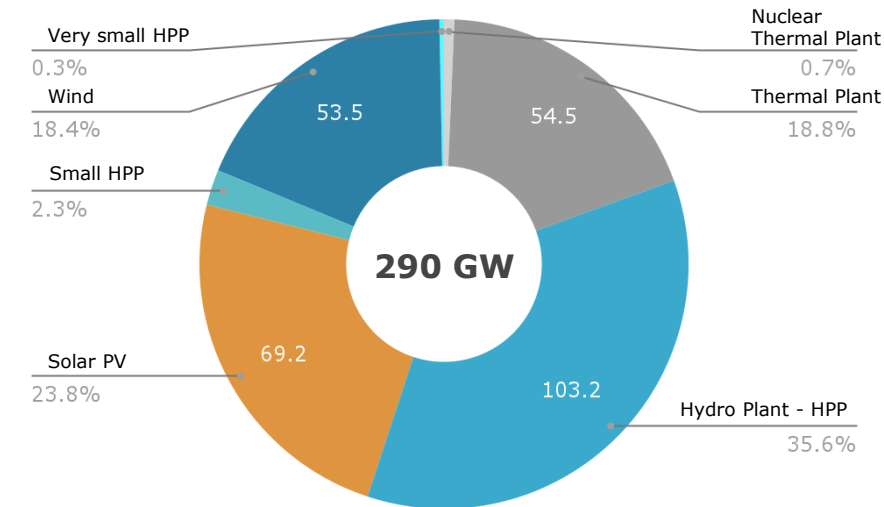
Source: CCEE, SIGA - ANEEL

Electricity Offer Expansion Forecasting

Installed Capacity - GW (may/2023)



Installed Capacity - GW (2029)



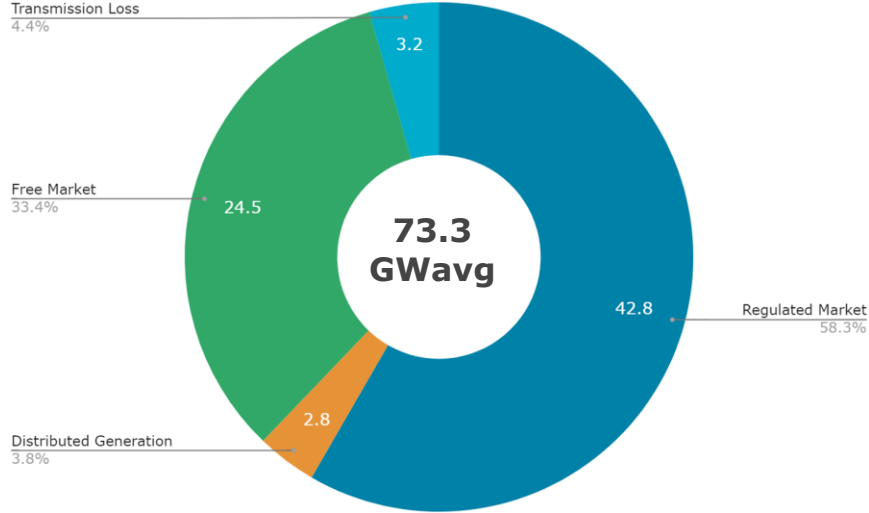
For wind and solar expansion we considered:

- Plants that are likely to start operating (those that are already under construction or that already have a *transmission contract* signed or a *grid connection permission* issued)
- Release of 24GW with the transmission lines auction in 2023 and 2024, of which 70% will be wind and 30% solar

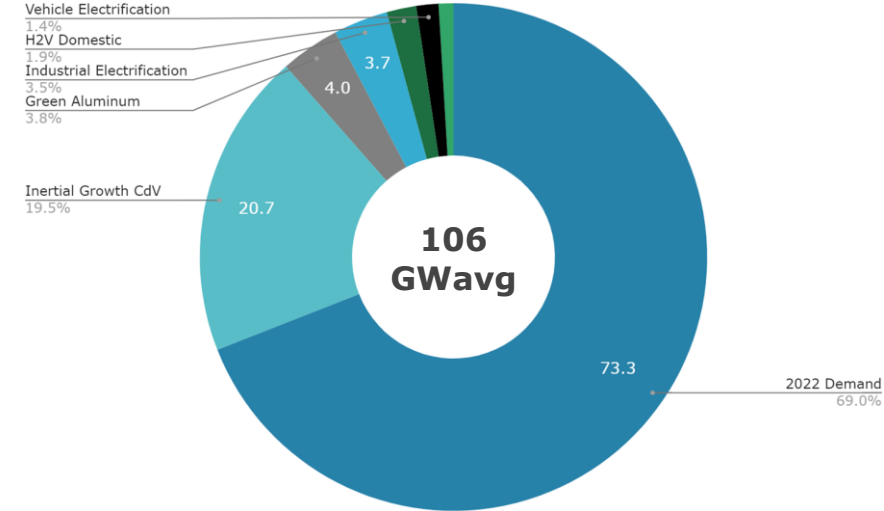
Source: SIGA - ANEEL, RALIE - ANEEL

Demand in Brazil: the expectation of energy transition

Demand - GWavg (2022)



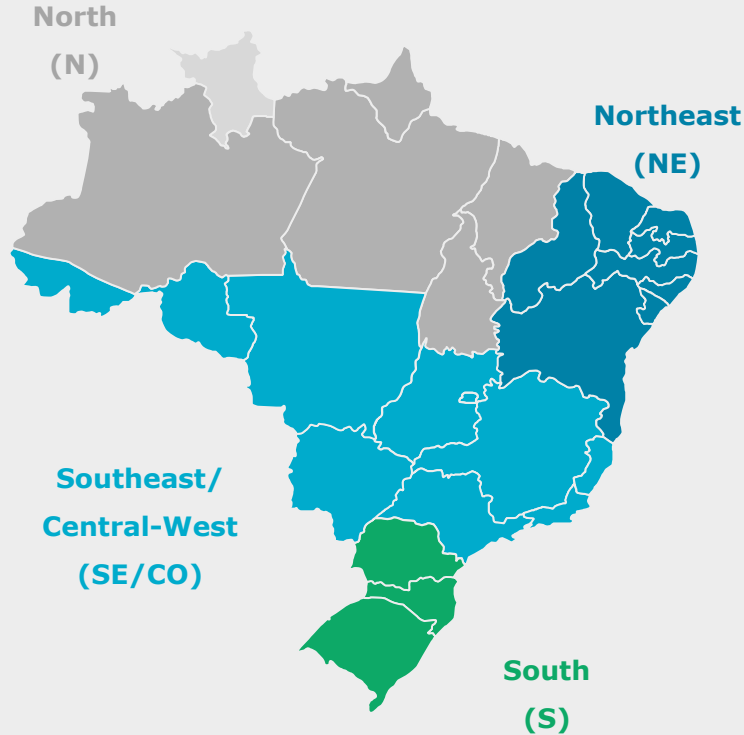
Demand Forecasting - GWavg (2023 - 2030)



- Inertial Growth: Energy Demand x GDP Correlation 2014-2022. GDP projection 2023-2030.
- Green Aluminum, Industrial Electrification, H2V Domestic and Vehicle Electrification: McKinsey Projections.

Source: CdV, Mck

Electrical Submarkets



- Brazil has an **interconnected transmission system** and is **divided into submarkets**
- The submarkets are **divisions of the NIS** whose boundaries are defined due to relevant physical constraints of transmission grid between the regions

Main characteristics of the submarkets

- SE/CO: largest consumption and reservoir storage capacity
- S: hydrothermal system. Dependent on energy exchange with the Southeast/Central-West
- NE: Predominance of renewable energy sources
- N: Large hydroelectric power plants. Exports energy.

Main variables - Energy prices

Load

Hydro inflows

Renewable
sources
generation
'Net load'

Transmission
capacity /
availability



Power Plants
operational
restrictions

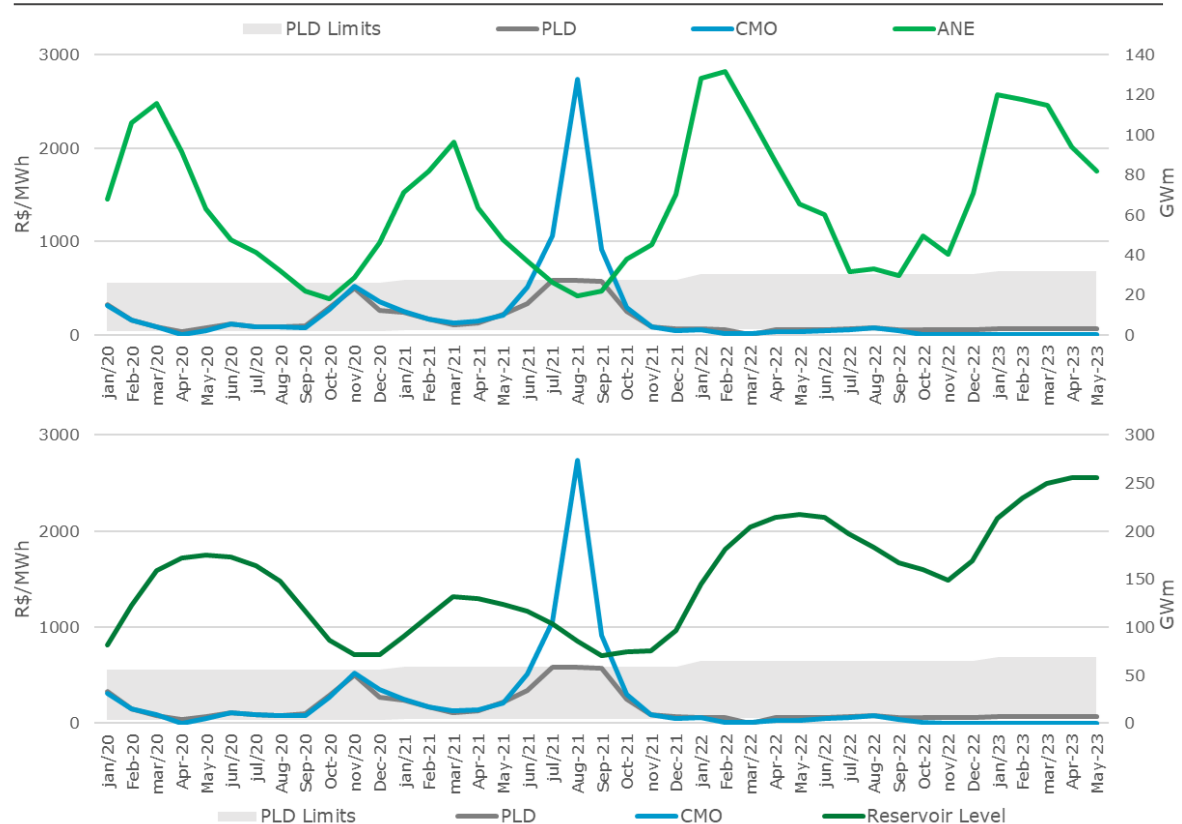
Reservoir Level

Generation
availability /
expansion

Price Formation

- In the Brazilian electricity industry, the **spot price** is called the '**Settlement Price for Differences**' (PLD)
- The spot price is calculated by computational models. First the ISO and the Settlement agent uses these models to calculate the Operating Marginal Cost (CMO). After the CMO is limited by a floor and cap value, for daily and hourly prices.
- High volatility:
 - Increase of 484% in the CMO in two months, reaching the marginal cost of R\$2,700/MWh
 - Reduction of 3.136% in cost, from R\$2,760/MWh to R\$88/MWh in three months
- Favorable hydrological and system structural condition since 2022: prices at the minimum regulatory value

Operation Marginal Cost vs Spot Prices vs Affluent Natural Energy (ANE)



PLD: Brazilian electricity spot price calculated by model

ANA: affluent natural energy

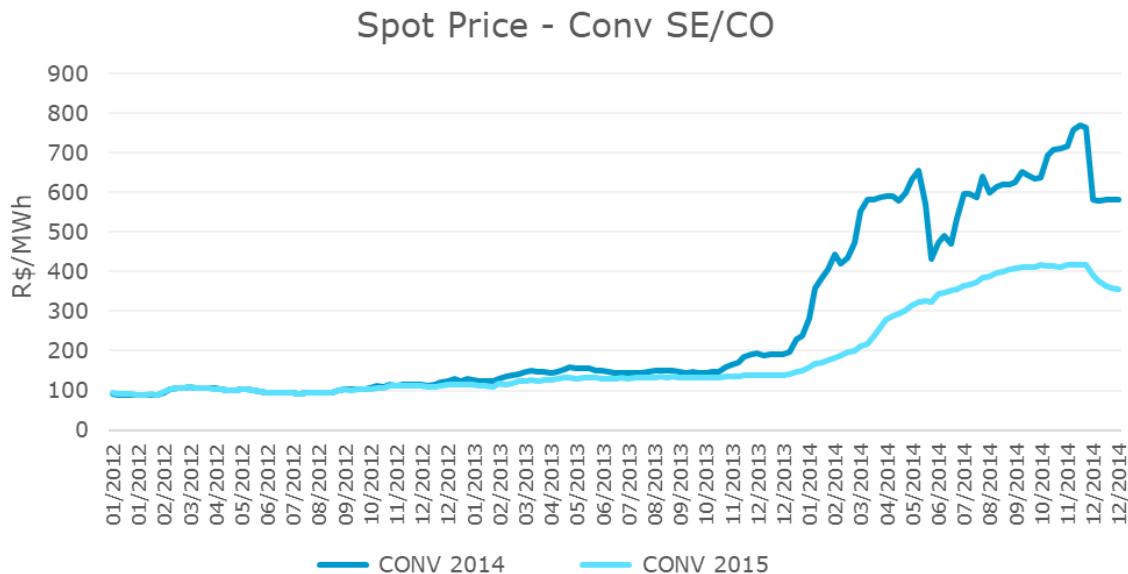
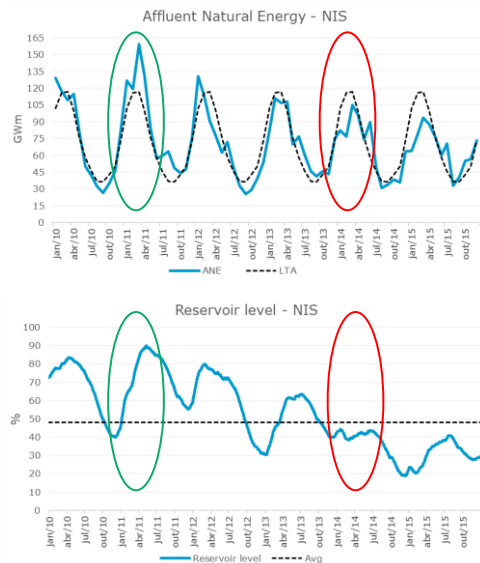
CMO: marginal operating costs

Forward Curve

Impact of hydrological condition on market price

- Historical evolution of SE/CO Conventional market prices related to 2014 and 2015 products.

In 2012, year with good hydrologic conditions, the market projected low forward prices for the coming years. However, as the delivery of the power got closer and hydrological conditions become worse, there was a disruptive price increase converging to the spot price.



Power supply strategy

100% Renewable

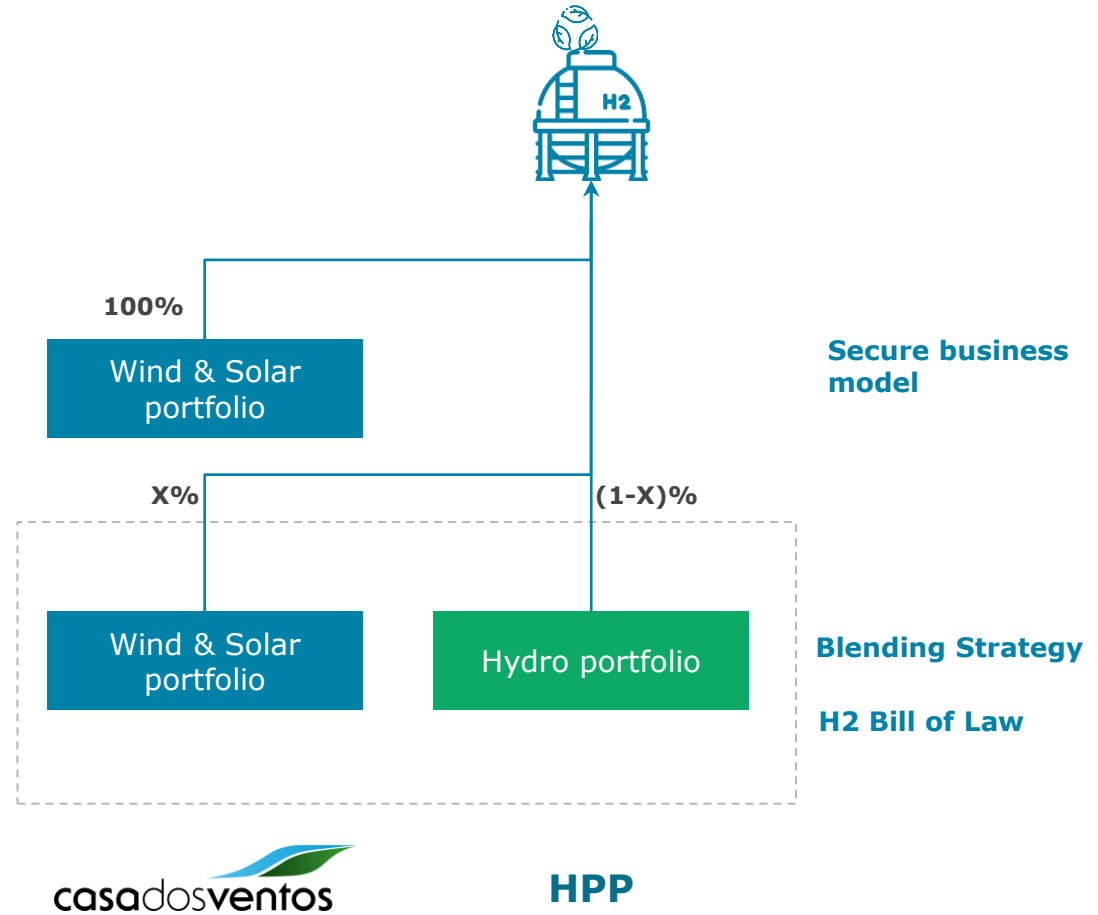
- **Self-production by equivalence**
- Capex stability or reduction, falling interest rate, transmission tariff discount, consolidated equivalence self production mode

Blending Renewable & Existing hydro

- Current bearish market price for uncontracted hydro subject to volatility according to hydrological conditions

H2 Bill of Law

- In discussion at the Congress



Power supply alternatives

Decarbonizing with competitive renewable energy

PPA

- Budget predictability
- Competitive prices

Transmission Tariff

- 50% discount in the wire costs
- Estimated Benefits **15 - 40 R\$/MWh**

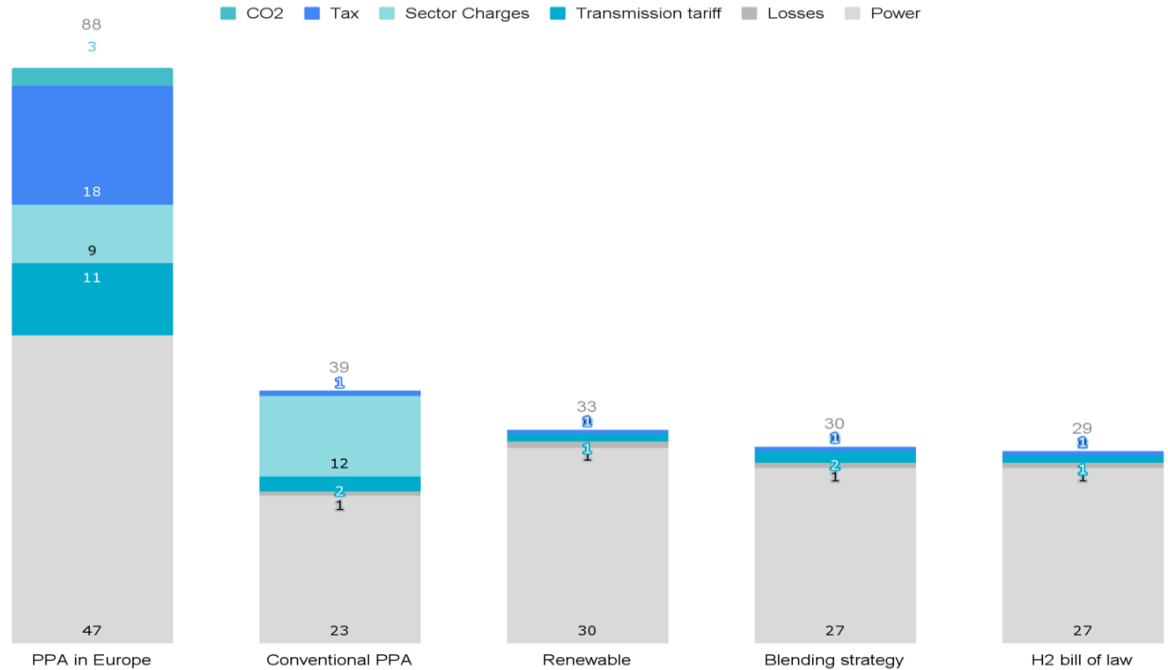
Sector Charges

- Exemption from sector charges (CDE, PROINFA, ERCAP, ESS and EER)
- Estimated Benefits **50 - 75 R\$/MWh**

Environmental Attributes

- Carbon Credits
- I-RECs

Comparative breakdown of electricity costs (indicative prices for conservative cases):




Self-production provide some sector charges exemption for consumers who become partners in the renewable generation project (by consortium or by equivalence structure) or enter into a lease agreement with the generator.

Hydrogen bill of law: 50% discount in the wire costs, exemption from sector charges and tax benefit, without equity investment as required in self-production agreement.



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Hydrogen certification

Ammonia Energy Association

Ricardo Gedra

November, 28

ccee





launched the initial version of the certification

Reference: RED II and delegated acts –
version set/2022



Cigre working group

**Participation of the Advisory Committee from
Green Hydrogen Organisation**

**World bank partnership – Hydrogen for
Development – H4D**

**CCEE is developing the second version of the
certification based on RED III, including ammonia**



Steps for certification

1 – > 90% renewable generation

2 – Emission < 18gCO₂eq/MJ

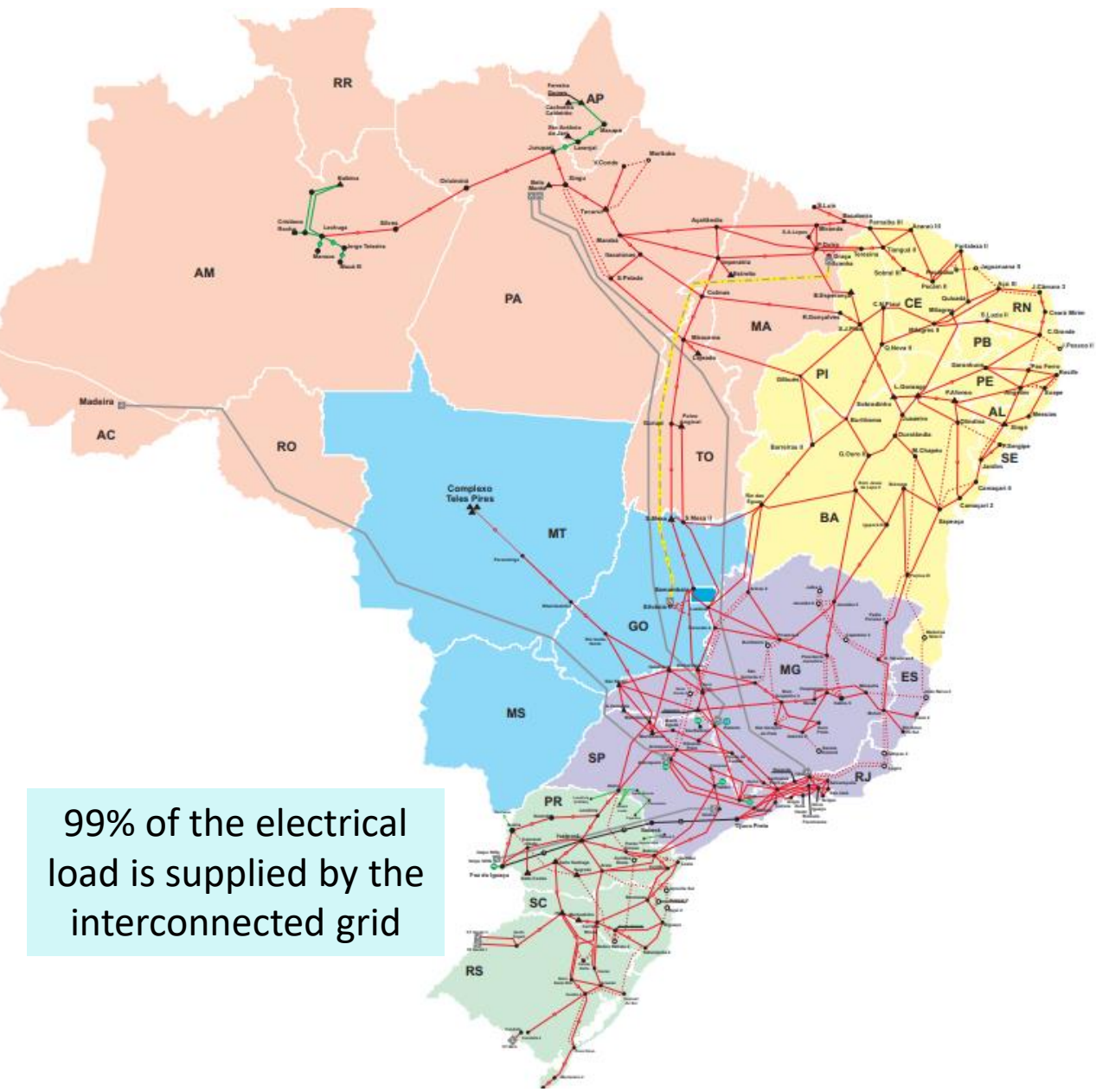
3 – Constrain off

4 – PPA with additionality, Temporal correlation and Geographical correlation

If 90% is met - not necessary to check PPA for certification – Valid for 5 years

Percentage calculated by bidding zone. What is bidding zone in Brazil?

National interconnected grid



99% of the electrical load is supplied by the interconnected grid

Electrical submarket



There is no official definition for each country outside Europe. Interpreting the regulation.....

- (3) The rules set out in this Regulation should apply regardless of whether the liquid and gaseous transport fuel of non-biological origin is produced inside or outside the territory of the Union. Where reference is made to bidding zone and imbalance settlement period, concepts that exist in the Union but not in all other countries, it is appropriate to allow fuel producers in third countries to rely on equivalent concepts provided the objective of this Regulation is maintained and the provision is implemented based on the most similar concept existing in the third country concerned. In case of bidding zones such concept could be similar market regulations, the physical characteristics of the electricity grid, notably the level of interconnection or as a last resort the country.

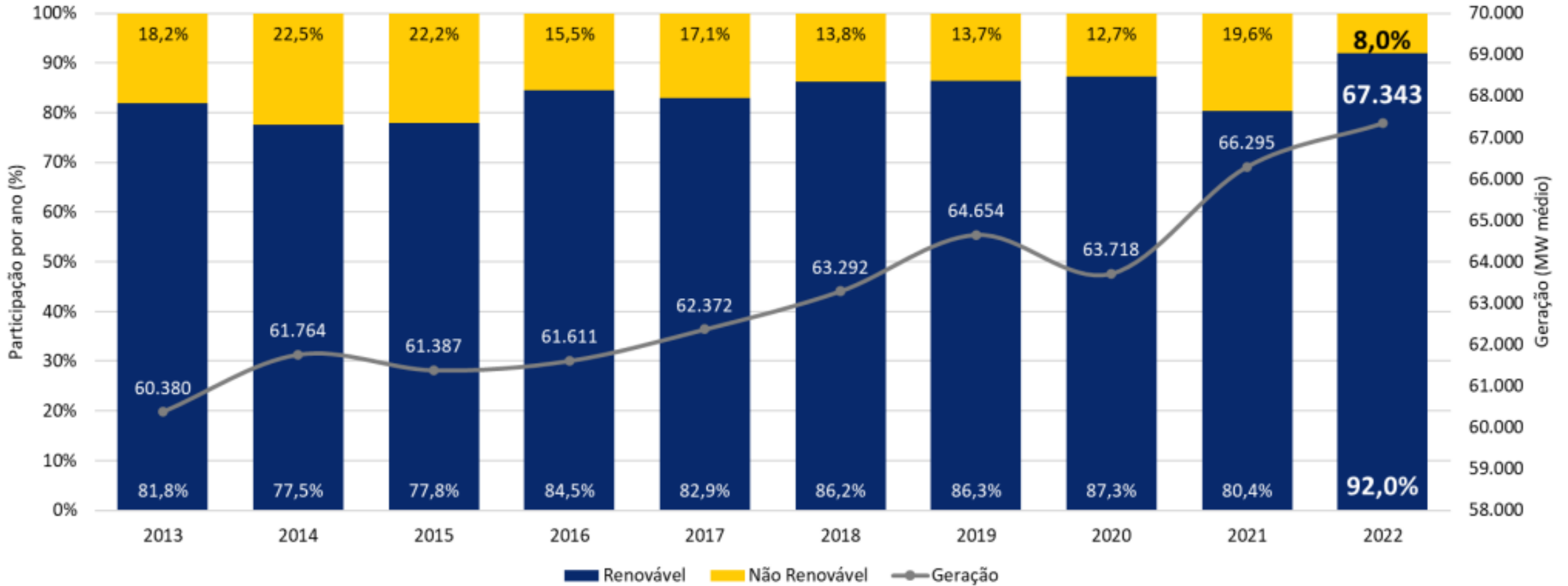
Delegated Act 1184 / 2023

Accordingly, the following approach should be applied:

- Certifiers should assess whether at the location of the electrolyser, market regulations applied are similar to the rules set out for bidding zones in Regulation (EU) 2019/943. In this context “similar” means that there are rules requiring establishing hourly prices for electricity in a geographical area. If such rules are in place, the geographical area for which the prices are established should be considered as a bidding zone for the purpose of the implementation of the methodology.

Considering the whole country

Share of renewable considering only each year Generation without import and export



2023 should reach more than 92%

This analysis doesn't consider import and export, but it isn't very relevant for national point of view

Considering by submarket

Share of renewable considering only each year generation without import and export



Impor and export between submarkets is very relevant for this point of view

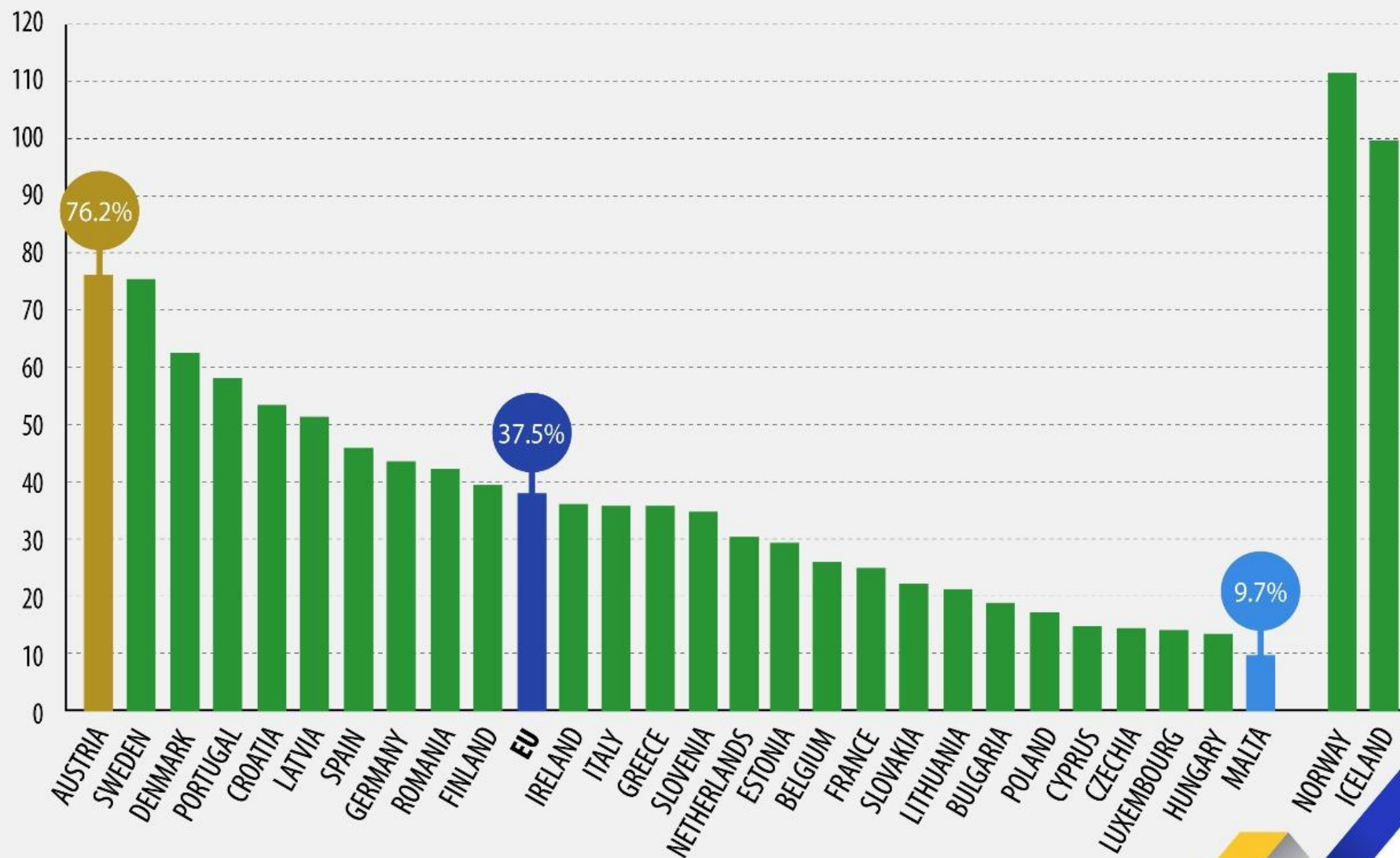
This maximum number of hours shall be calculated by multiplying the total number of hours in each calendar year by the share of renewable electricity reported for the bidding zone where the renewable liquid and gaseous transport fuel of non-biological origin is produced. The average share of renewable electricity shall be determined by dividing the gross final consumption of electricity from renewable sources in the bidding zone calculated by analogy to the rules set out in Article 7(2) of Directive (EU) 2018/2001 by the gross electricity production from all energy sources as defined in Annex B to Regulation (EC) No 1099/2008 of the European Parliament and of the Council ⁽⁵⁾, except from water previously pumped uphill, plus imports minus exports of electricity to the bidding zone. Once the average share of renewable electricity exceeds 90 % in a calendar year, it shall be continued to be considered to be higher than 90 % for the subsequent five calendar years.

Delegated Act - jun/2023

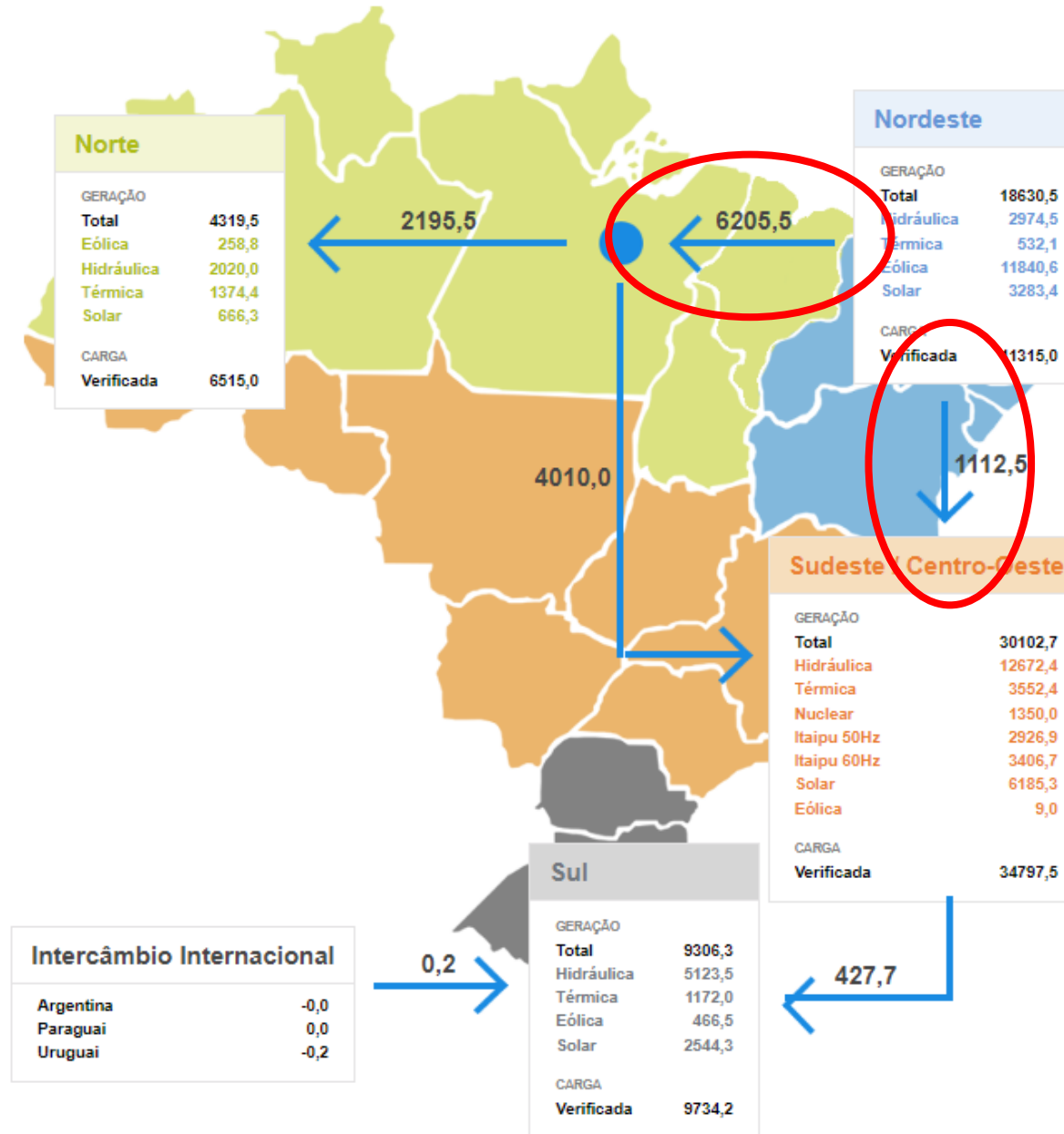
$$\text{Share of renewable} = \frac{\text{Renewable generation}}{\text{Total generation} + \text{import} - \text{export}}$$

Share of energy from renewable sources in gross electricity consumption, EU, 2021

(% by country)



Typical day – North east exporter



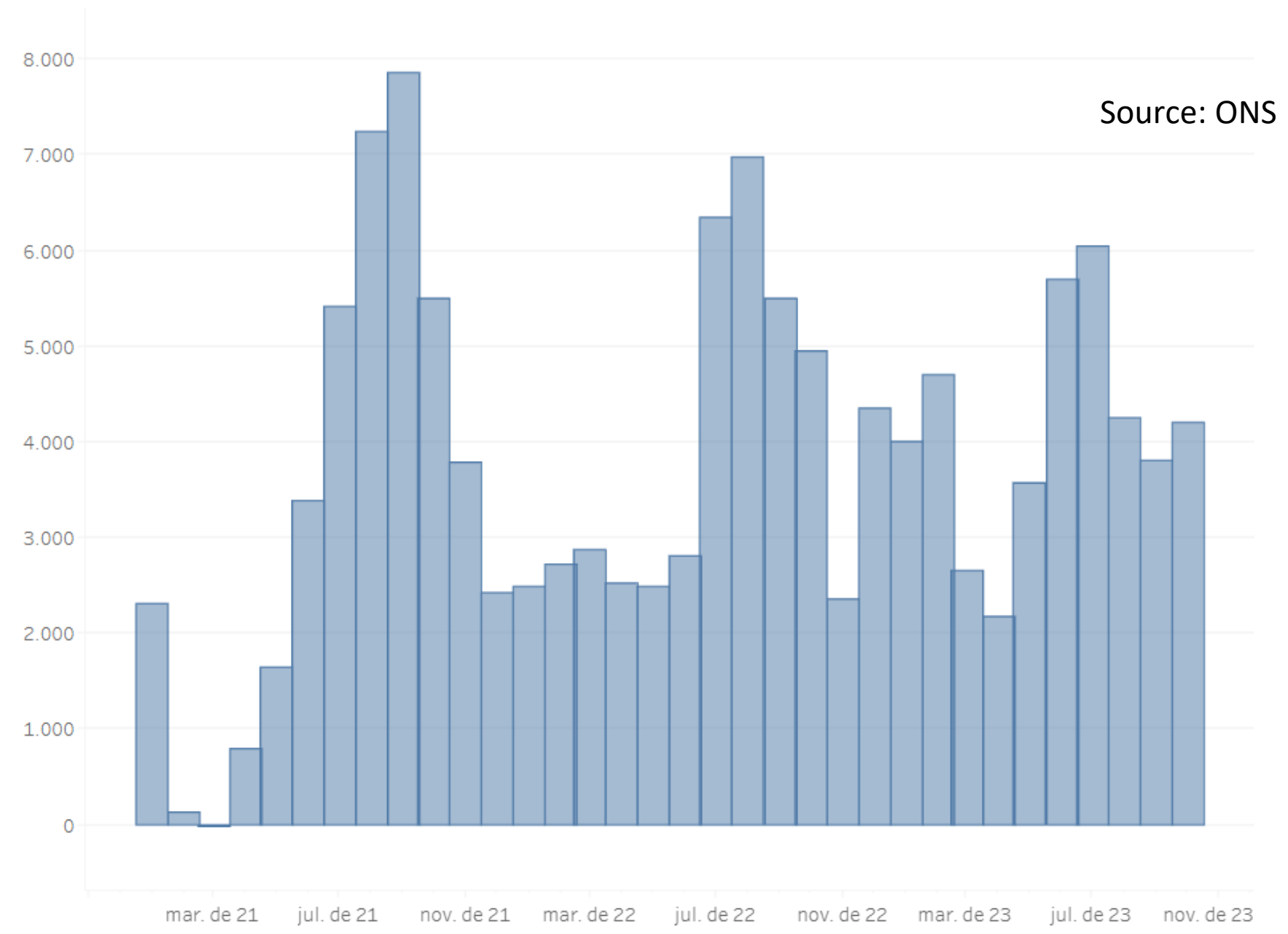
Source: ONS

Monthly net export from northeast to southeast/central-west from 2021 to 2023

Total Generation in northeast is around 16.000 MWm currently

As Northeast is typical exporter, the share of renewable should be above 100% (EU rules)

Important: This behavior depends on unmanageable weather conditions such as rain and wind



- All the rules for hydrogen and ammonia production outside Europe are not very clear
- Interpreting the rules, submarket in Brazil appears to be more adherent, but is not yet officially defined.
- Considering submarket, the north and northeast regions should present percentages above 100%, as they are typical exporters.
- It is important to submit a first project for recognition to obtain this official definition from the European Commission

Thank you

Hydrogen certification

Ricardo Gedra

11/28/2023



ccee.org.br



[ccee_oficial](https://www.instagram.com/ccee_oficial)



[CCEE Oficial](https://www.youtube.com/CCEE_Oficial)



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<https://www.linkedin.com/company/cc-ee>



<https://www.facebook.com/cceeoficial>

The logo for CCEE, consisting of the lowercase letters 'ccee' in a white, rounded, sans-serif font.