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ENERGY RESEARCH

Brazil Power Market Key Trends and Challenges

New Market Service

Aurora provides market leading forecasts & data-driven intelligence for the global energy transition

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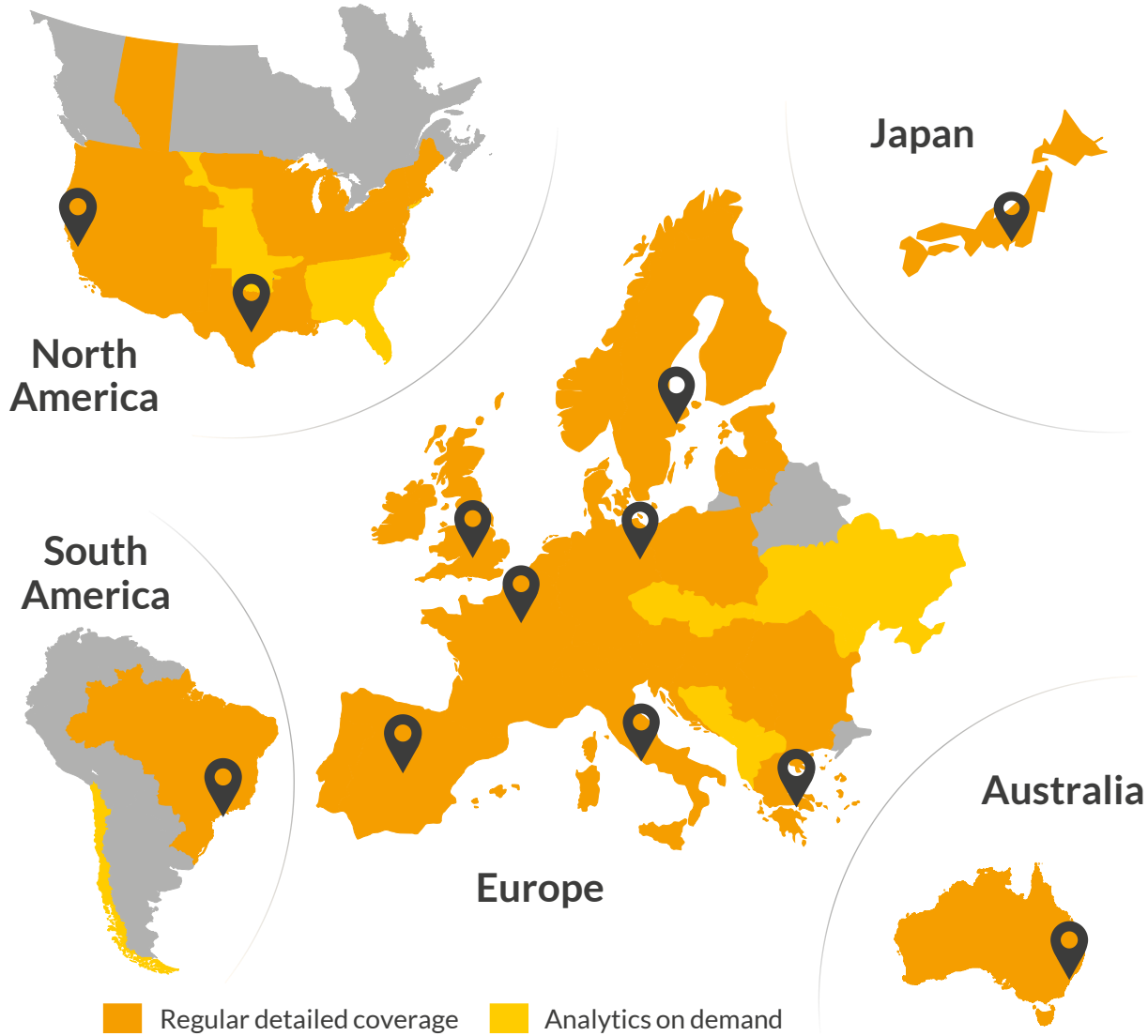
- Power markets
- Renewables
- Storage
- Electric vehicles
- Hydrogen H_2
- Carbon CO_2
- Natural gas



12 Offices

Oxford | Berlin | Madrid | Athens
Paris | Sydney | Austin | Oakland
Rome | Stockholm | Tokyo
São Paulo

500+

market experts

750+

subscribing companies

150+

transactions supported in 2022

Source: Aurora Energy Research

Our market leading models underpin a comprehensive range of seamlessly integrated services to best suit your needs

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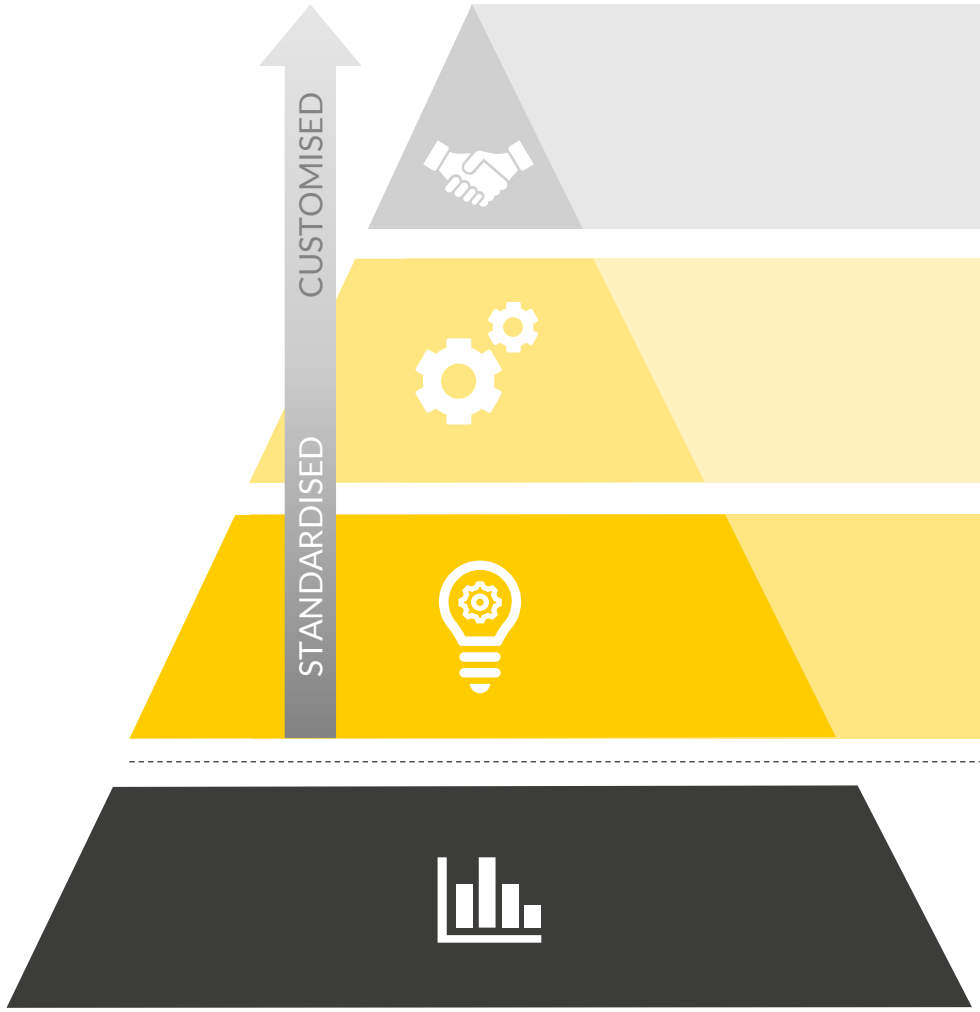


Advisory

Access tailored expert advice and analytics for your crucial projects

Trusted advice and dedicated support for strategy, investments, transactions and policy engagement

1,400+ projects globally

Software Solutions

Make standard analysis bespoke through direct access to our models

Unique SaaS subscriptions to create your own scenarios and asset-specific investment cases

100+ company licenses

Subscription Analytics

Receive regularly updated forecasts, sample investment cases and timely deep-dives

Industry-standard outlook reports, bankable price forecasts and strategic insights for power and commodities

700+ subscribing companies

Models & Data

Market-leading models for power, gas, hydrogen, carbon, oil & coal markets

Proprietary and continuously updated cutting-edge models populated with highest quality curated datasets

Developed over 10 years, 70+ dedicated modellers

Source: Aurora Energy Research

Brazilian market players have raised a lot of concerns about the future of power, and we identified the biggest painpoints

Hydrology	How will different weather years and climate change impact power prices and asset economics?
Liberalisation	How will the speed of market liberalisation affect risks and opportunities for new asset development?
Energy demand	Current demand is lower than expected. Will energy demand rebound? What is the impact of lower demand on suppliers in the regulated market?
Distributed generation	What will be the impact of the continued growth of distributed solar on electricity demand and the need for new centralised assets?
Grid constraints	What if the transmission grid is not expanded as needed? Where do we expect to see emerging congestion issues and what would be the impact on asset economics?
Messy transition	Will supply chain challenges slow down new build generation?
Flexible generation	What is the role of distributed and centralised flexible generation in the Brazilian power market? Will the market have room for storage given the high share of hydro flexibility?
Green hydrogen	What is the internal Brazilian demand? Can we export to Europe and other markets? What will be the impact on the Brazilian power market?
Market advisors	Are the current forecast providers sufficiently independent?

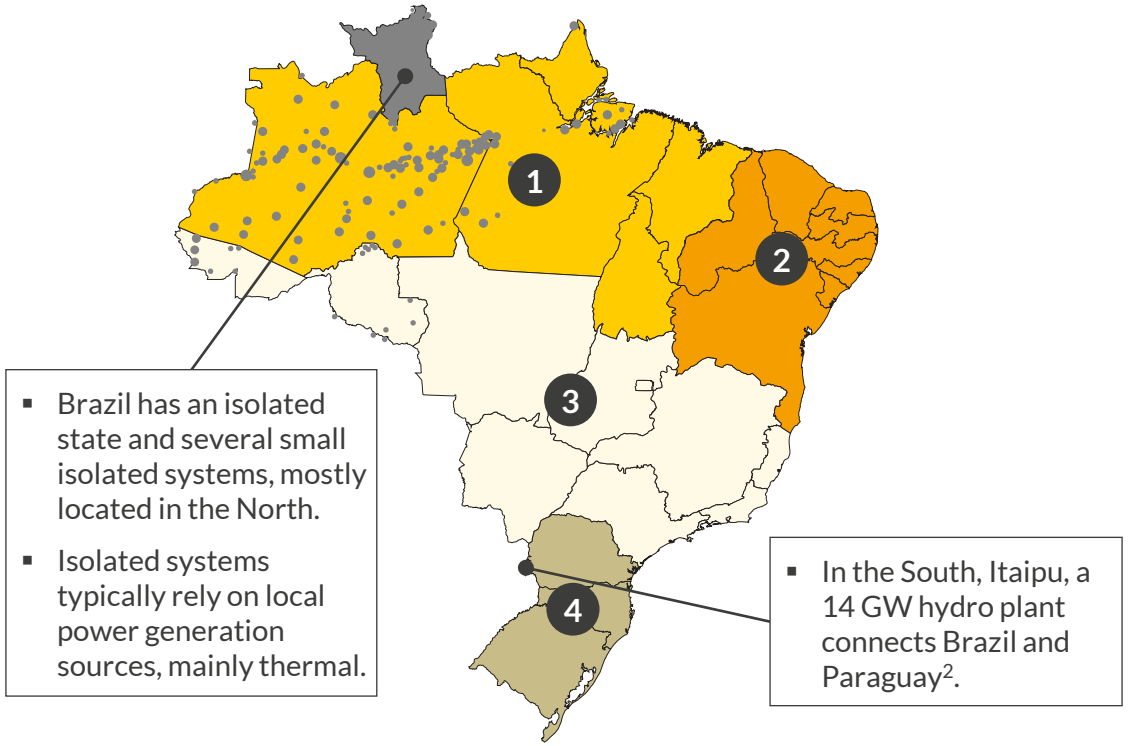
To learn more about how we can help your business face the challenges and seize the opportunities in the Brazilian power market do not hesitate to contact **Priscila Vellano, Commercial Manager** priscila.vellano@auroraer.com

Source: Aurora Energy Research

The Brazilian interconnected power system supplies over 99% of the country's demand and is divided in four submarkets

The Brazilian interconnected power system[1] supplies over 99% of the country's electricity demand. Although Boa Vista (Roraima) is the only state capital that is not connected, there are still 212 isolated systems across seven states. Brazil's most relevant international interconnection is with Paraguay via a 14 GW binational hydro plant[2].

Map of the Brazilian interconnected power system[3]



- Brazil has an isolated state and several small isolated systems, mostly located in the North.
- Isolated systems typically rely on local power generation sources, mainly thermal.

- In the South, Itaipu, a 14 GW hydro plant connects Brazil and Paraguay[2].

Market snapshot by 2022

Regions	Installed capacity GW	Share %	Annual demand TWh	Share %
1 North	27	15%	54	9%
2 Northeast	45	25%	98	16%
3 Southeast /Midwest	86	47%	348	57%
4 South	24	13%	103	17%
Isolated systems	1.2	1%	3.9	1%

1) "Sistema Interligado Nacional", or SIN. 2) Brazil is also interconnected with Argentina and Uruguay via 2.2 GW and 0.57 GW of transmission lines, respectively. Brazil operates at 60 Hz and Paraguay, Argentina and Uruguay at 50 Hz thus converters are required. There is also an interconnection with Venezuela and the Roraima grid, which is not part of the interconnected power system. 3) Grey areas are not connected to the power system.

Sources: Aurora Energy Research, ONS, EPE, ANEEL

Hydro dominates the market's generation mix; dispatch of the system revolves around optimising short and long-term hydro opportunity costs

Key features of the Brazilian power market

1 Hydro dominated market, representing 63-78% of the generation mix over the last 10-years

- ONS optimises hydro operations based on water values[1] over five years. The system operation is updated on a rolling-horizon resulting in day-ahead hourly prices.
- Hydro is the fundamental driver for low or high power market prices, depending on abundant or scarce water periods.

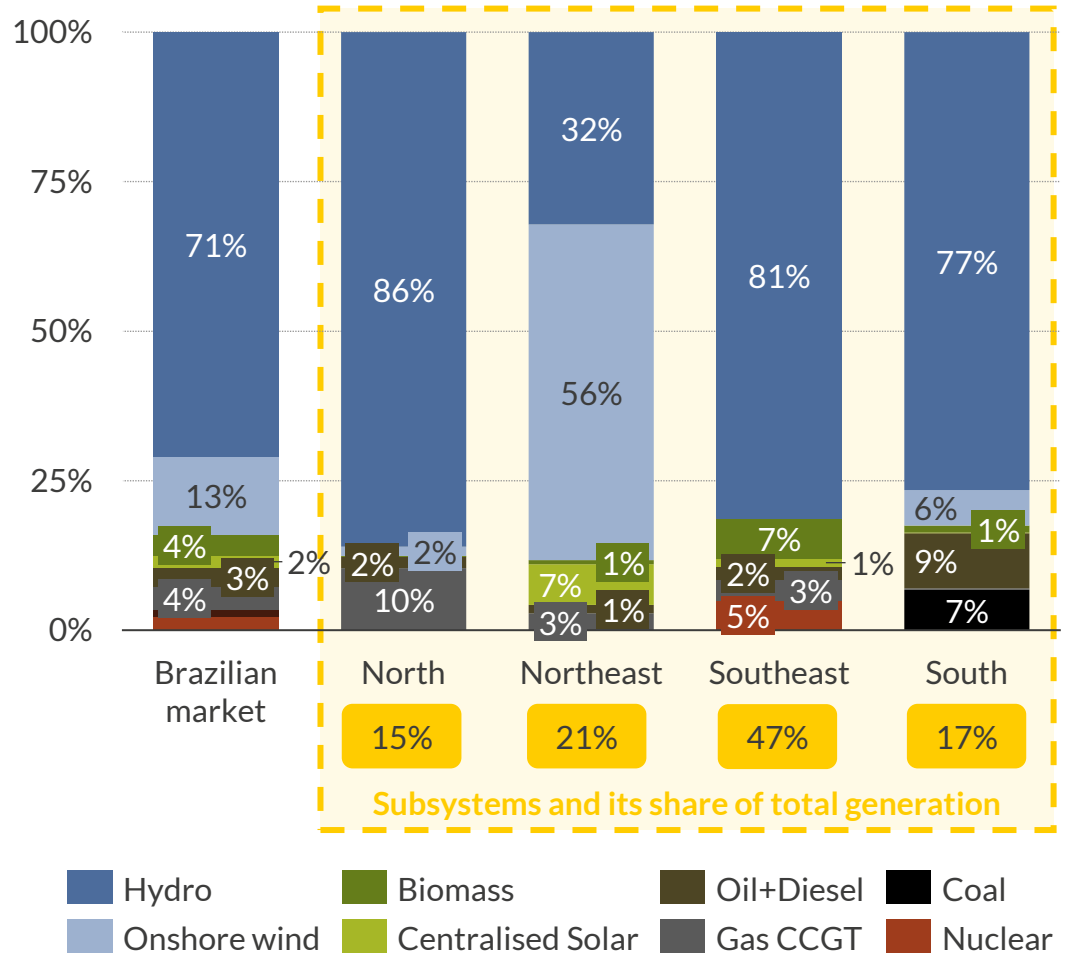
2 Split into four subsystems with different hydrological conditions and renewable resources

- The Southeast/Midwest represented 47% of the total generation by 2022, mostly hydro. Given Brazil's large territory, there are hydrological differences across subsystems.
- When operating the market, plants are treated as a common pool exploiting the subsystems' complementarity; but there is also a central hedging approach that shares hydrological risks evenly among individual plants[2].

3 Energy-only day-ahead market with a capacity reserve

- ONS controls day-ahead and real-time dispatch. The current market design still relies heavily on auctions and long-term contracts[3].
- There are no balancing or reserve markets, but there are availability auctions, ensuring plants are available. Dispatch is done on a merit order basis, unless out of merit operations are required to enhance reliability and security of supply.

Technology share in the generation mix by 2022: market and subsystems



1) Hydro opportunity costs. 2) Energy relocation mechanism (or mecanismo de realocação de energia, MRE). Details can be found in slide 69. 3) Under the regulated market, all demand must be backed by long-term contracts.

Sources: Aurora Energy Research, CCEE, ONS

The federal government is responsible for the energy sector and is supported by key institutions that define its regulatory and policy framework

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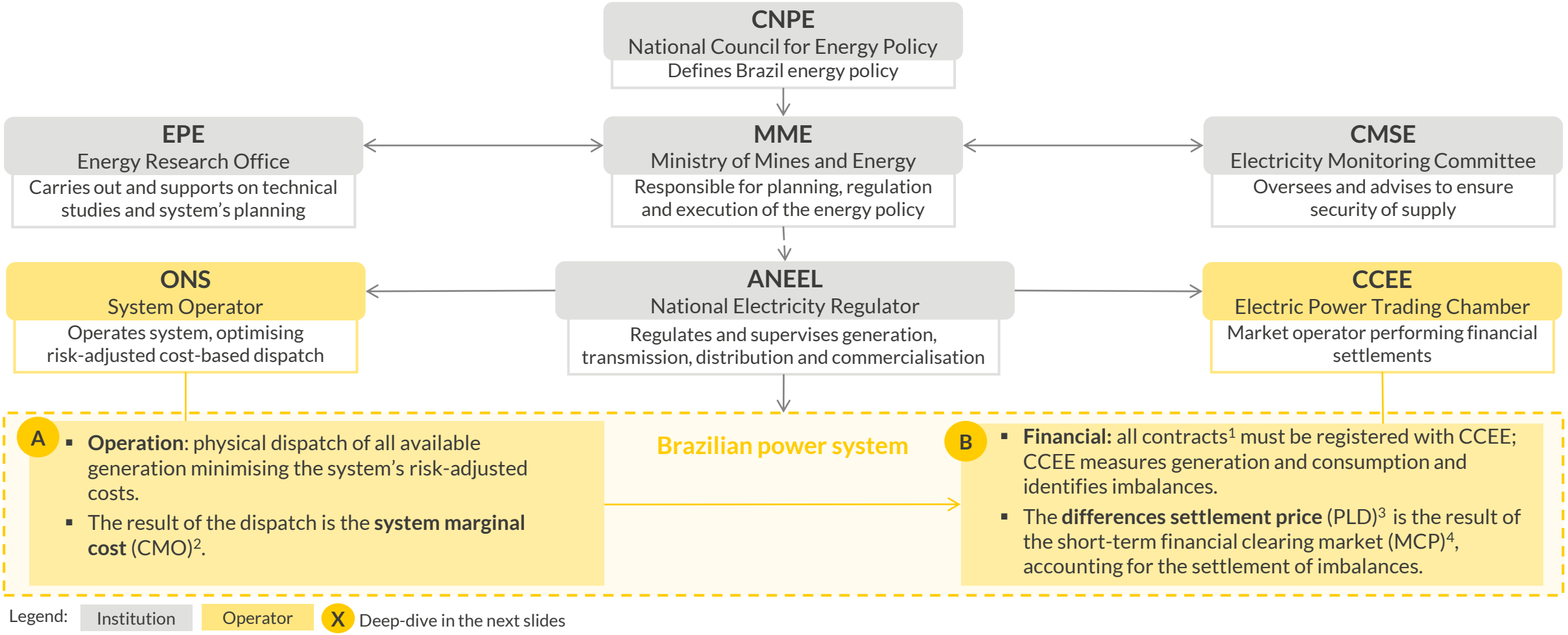
The operation of the Brazilian power system is centralised and cost-based. The System Operator (ONS) is responsible for the programming and dispatch of available resources to minimise the power system's total risk-adjusted costs, while the Electric Power Trading Chamber (CCEE) performs all financial settlements.

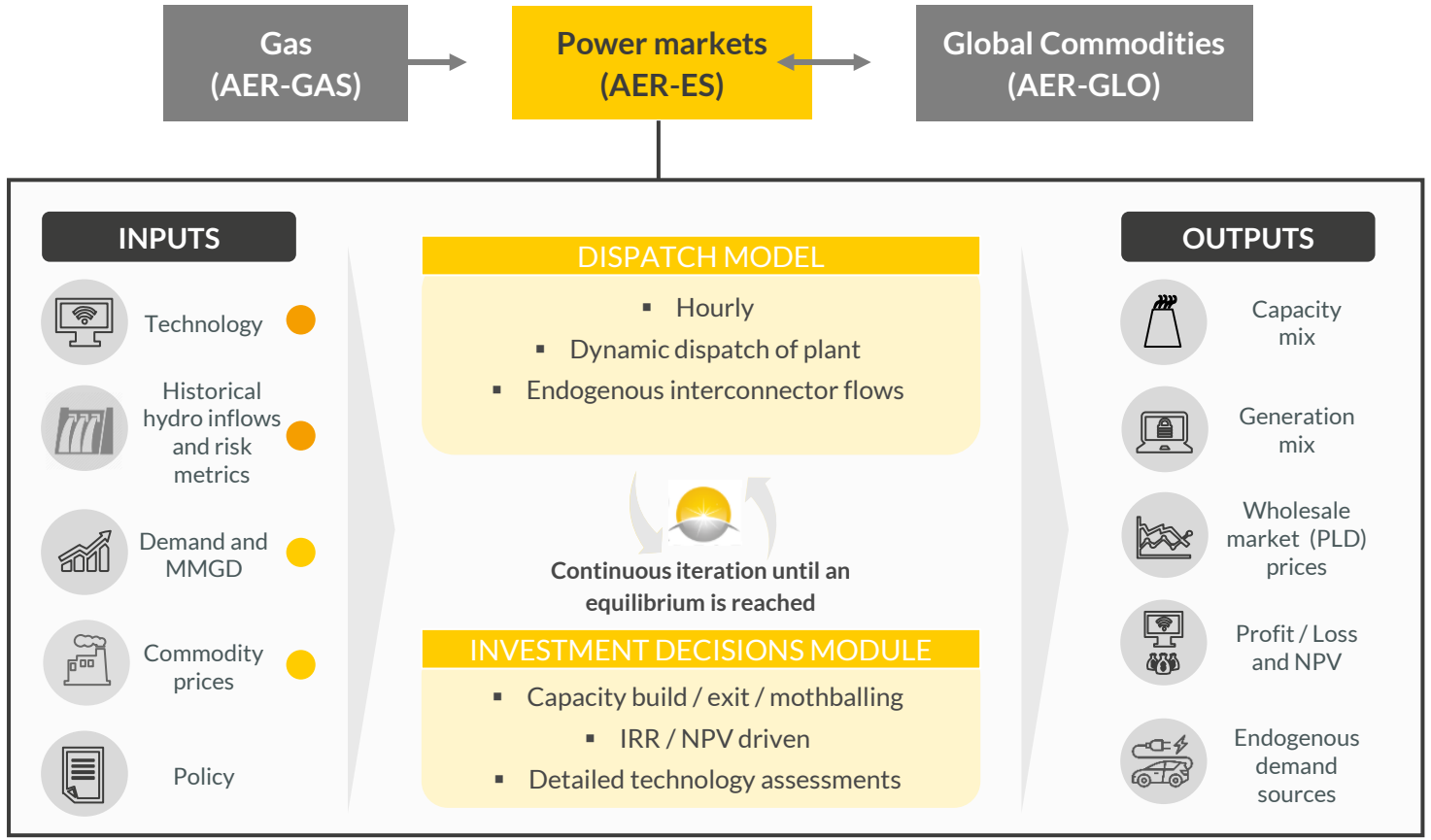


Legend: Institution | Operator | X Deep-dive in the next slides

1) All contracts from both regulated contracting environment "(Ambiente de Contratação Regulada" or"ACR") and from free contracting environment ("Ambiente de Contratação Livre" or ACL). 2) "Custo marginal de operação". 3) "Preço de liquidação das diferenças". 4) "Mercado de curto prazo".

Sources: Aurora Energy Research, MME, CCEE

Our analysis of the Brazilian power market uses our proprietary, in-house modelling capabilities with data from official sources



Official assumptions[1] Modelled in-house

Up to 70	c. 55k	10k	70+
specifications modelled for each plant	investment hours on modelling capabilities	model runs per week	strength of modelling team globally

1) Assumptions from National System Operator (ONS) and other key institutions (see slide 7).

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Advantages of our Approach

- Flexible and nimble because we own the code
- Transparent results
- State-of-the-art infrastructure
- Zero dependence on black-box third-party software (e.g. Plexos)
- Constantly up to date through subscription research
- Ability to model complex policy changes very quickly
- Ability to model new technologies (e.g. storage) and demand sources (e.g. green hydrogen)

Find out more:

priscila.vellano@auroraer.com

We combine official data sources with our global expertise in defining the assumptions that are likely to shape long-term prices

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INPUTS

+5 years

+35 years

1 **In the short-term, we aim to match our assumptions with those from official sources.**

- The current state of the system and its growth for the next five years is closely benchmarked to the Monthly Operation Plan (PMO), provided by ONS/CCEE as a NEWAVE run.
- Further plant-level details are also obtained from more granular operation plans such as the Weekly and Day-ahead operation plans, which are published as DECOMP and DESSEM databases.

Reference Data

- Monthly Operation Plan (NEWAVE)
- Weekly Operation Plan (DECOMP)
- Daily-ahead Operation Plan (DESSEM)

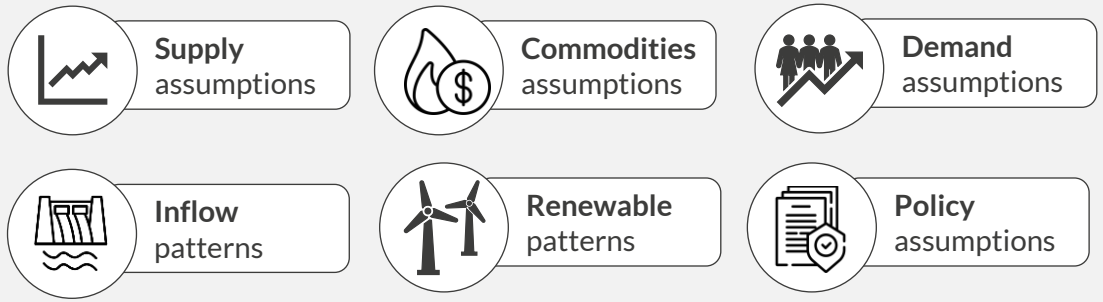
Official Assumptions

- Detailed plant-level data
- Equivalent hydro reservoirs
- Thermal and hydro capacity expansion
- Interconnection expansion
- Operational constraints
- Policy/regulatory assumptions

2 **For the longer horizon, Aurora's global commodities and research teams provide long-term assumptions for the key model inputs.**

- Aurora's global commodities team provides evolution of commodity prices and their impact on international and national fuel prices (e.g., gas, coal, biomass).
- Our demand assumptions consider the evolution of new and flexible sources of demand.
- We have a global and local view on the costs and the technical progress of different technologies (e.g., solar panels, wind turbines). We consider availability of natural resources such as hydro inflows, wind speed and solar irradiation.
- Our local team monitors and assesses the latest regulatory and policy announcements ensuring appropriate implementation into our models.

Aurora Assumptions



Our model accurately simulates real market outcomes across subsystems and historical years, handling extreme wet and dry hydro years

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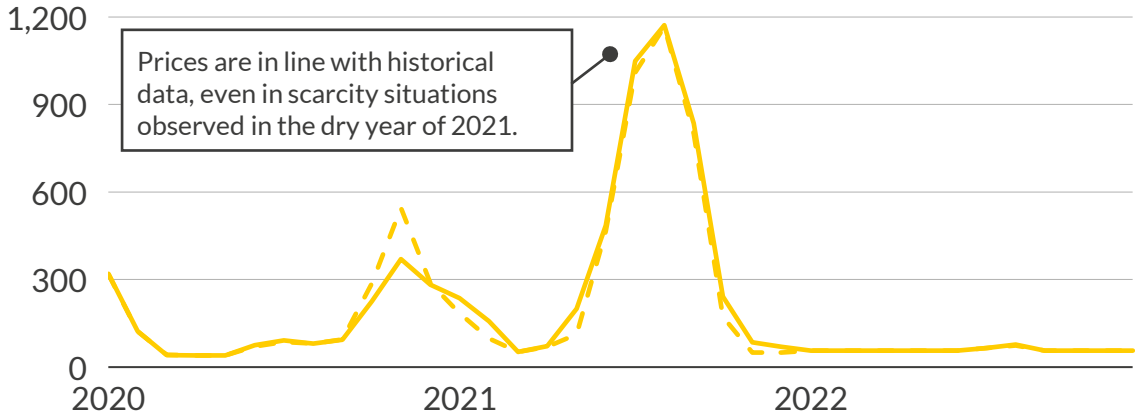
OUTPUTS

North subsystem: wholesale market (PLD) prices[1]

R$/MWh (nominal)

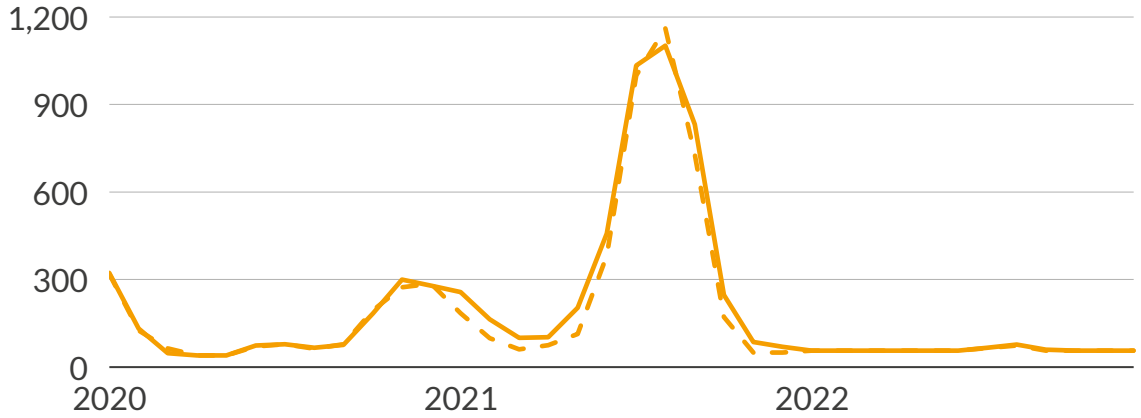
North



Northeast subsystem: wholesale market (PLD) prices

R$/MWh (nominal)

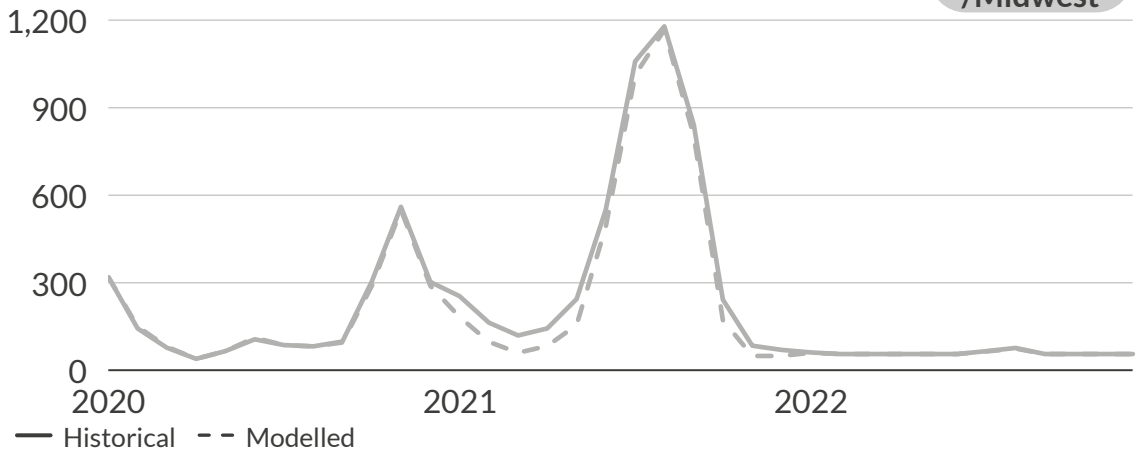
Northeast



Southeast/Midwest subsystem: wholesale market (PLD) prices

R$/MWh (nominal)

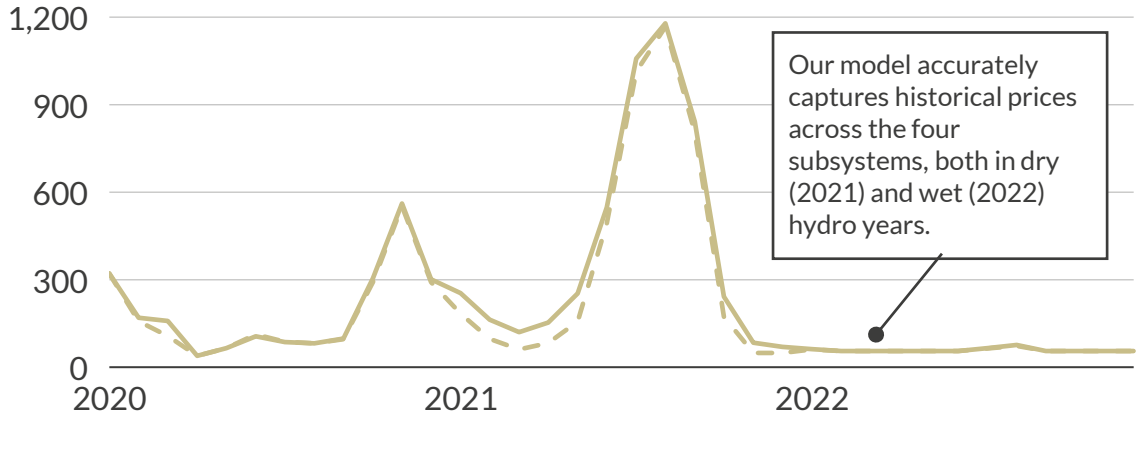
Southeast /Midwest



South subsystem: wholesale market (PLD) prices

R$/MWh (nominal)

South



1) Considering maximum hourly PLD and minimum PLD announced by CCEE for each year.

Sources: Aurora Energy Research, ONS, CCEE

Brazilian Power & Renewables Service:

Dive into key market analysis and forecasts for the Brazil power and renewables markets

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Power & Renewables Service

Forecast Reports & Data

Market Summary Reports

Take an in-depth look back at the past month's technology and market updates

Forecast Reports & Data

Forecast reports and data in interactive formats and market long-term price projections with scenarios to match your business needs

Interactive EOS Platform

Comprehensive data and content provided on a web-based, interactive platform with company-wide access; Explore scenarios through EOS, our dynamic online platform featuring a full library of reports and datasets

Strategic Insights

Strategic Insight Reports

In-depth, thematic reports on topical and timely issues in your market

Policy Updates

Timely research notes on recent changes to policy and regulation, demonstrating the impacts and opportunities for market participants

3 Group Meetings

Bringing the subscriber community together, in-person, to hear and discuss our latest strategic insight

Analyst Support

Biannual workshops and support from our bank of analysts, including native speakers and on-the-ground experts

We work with a very broad range of clients … their constant challenge keeps us up on our toes and ensures our independence

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> *"With its capabilities, intellect and with its credibility Aurora plays an essential role bringing the dialogue [in the global energy transition] to a different plane"*
>
> **Ben van Beurden, CEO, Shell**

> *"Aurora analysis and the provision of reliance was crucial for our debt funding. Their ability to explain market logics and revenue streams was vital for this successful financing."*
>
> **Jeremy Taylor, Director, Green Frog Power**

Power & utilities

fortum, FORSA ENERGY, edp, e·on, IBERDROLA, Tesla, Urenco, centrica, CALPINE, 50hertz, RWE, Ørsted, drax, enel, InterGen, uniper, EDF, UK Power Networks, ESB, Enea, Viridor, EnBW, axpo, sorgenia, Energa, Eneco, SSE, nationalgrid, ukpowerreserve, ENGIE, Terna, VATTENFALL, Statkraft, enviva

Energy consumers

BASF We create chemistry, Port of Rotterdam, GLENCORE, Heineken, BOC Member of The Linde Group, MITSUBISHI POWER, umicore, SIEMENS, EVONIK, Google, ITM POWER Energy Storage | Clean Fuel, INEOS, UPM, SALZGITTER AG, Unilever, SNCF, SIMEC, AlzChem, DB, wieland, orange

Financial sector & investors

GREENCOAT CAPITAL, Close Brothers Asset Finance, 北京控股有限公司, CIP, JLEN, equitix, Allianz Global Investors, SOCIETE GENERALE, CaixaBank, Commonwealth Bank, Foresight, BARCLAYS, LLOYDS BANK, NatWest, MUFG, Partners Group, InfraRed, CPP INVESTMENT BOARD, ENERGY INFRASTRUCTURE PARTNERS, Marubeni, OCTOPUS INVESTMENTS, ONTARIO TEACHERS' PENSION PLAN, Legal & General, RBC, 中国投资有限责任公司, bluefield Partners LLP, NTR, mirova, UniCredit, COMMERZBANK, Moody's, DALMORE CAPITAL, Downing, RIVER STONE, National Australia Bank, HSBC, MACQUARIE

Oil & gas

ORLEN, Vitol, GASAG, equinor, eustream, OGE, SW//M Stadtwerke München, snam, bp, centrica, nationalgrid, Thyssengas, Naturgy, fluxys, Shell

Project developers

BELECTRIC, CanadianSolar, POLENERGIA, GreenFrog Power, solarcentury, brockwell energy, NEOEN, enlight, PACIFICO, tagenergy, BORALEX, British Solar Renewables, BayWa r.e., Good Energy, low carbon, BANKS Group, greentech, Invenergy, res power for good, bnrg, powercapital renewable energy, Anesco, HIVE ENERGY, TECHNIQUE SOLAIRE, EnergieKontor, lightsource bp, bp

Policy & regulation

Bundesnetzagentur, Bundesministerium für Wirtschaft und Klimaschutz, Ministerie van Economische Zaken en Klimaat, seai, Climate Change Committee, DRC Development Research Center of the State Council of the People's Republic of China, Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil Department of Communications, Climate Action & Environment, European Climate Foundation, European Commission, HM Treasury, Energy Regulatory Office, JETRO Japan External Trade Organization, National Audit Office, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, NATIONAL INFRASTRUCTURE COMMISSION, AEMO, LOW CARBON CONTRACTS COMPANY, Electricity Settlements Company, Department for Business, Energy & Industrial Strategy

Source: Aurora Energy Research


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