AURORA
ENERGY RESEARCH

Assumptions Shaping the Future of Chile's Power Market

Public Report

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Agenda

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I. About us

II. Chile Market Overview

III. Key Market Drivers in Chile
   a. Demand
   b. Renewables and storage
   c. Transmission

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

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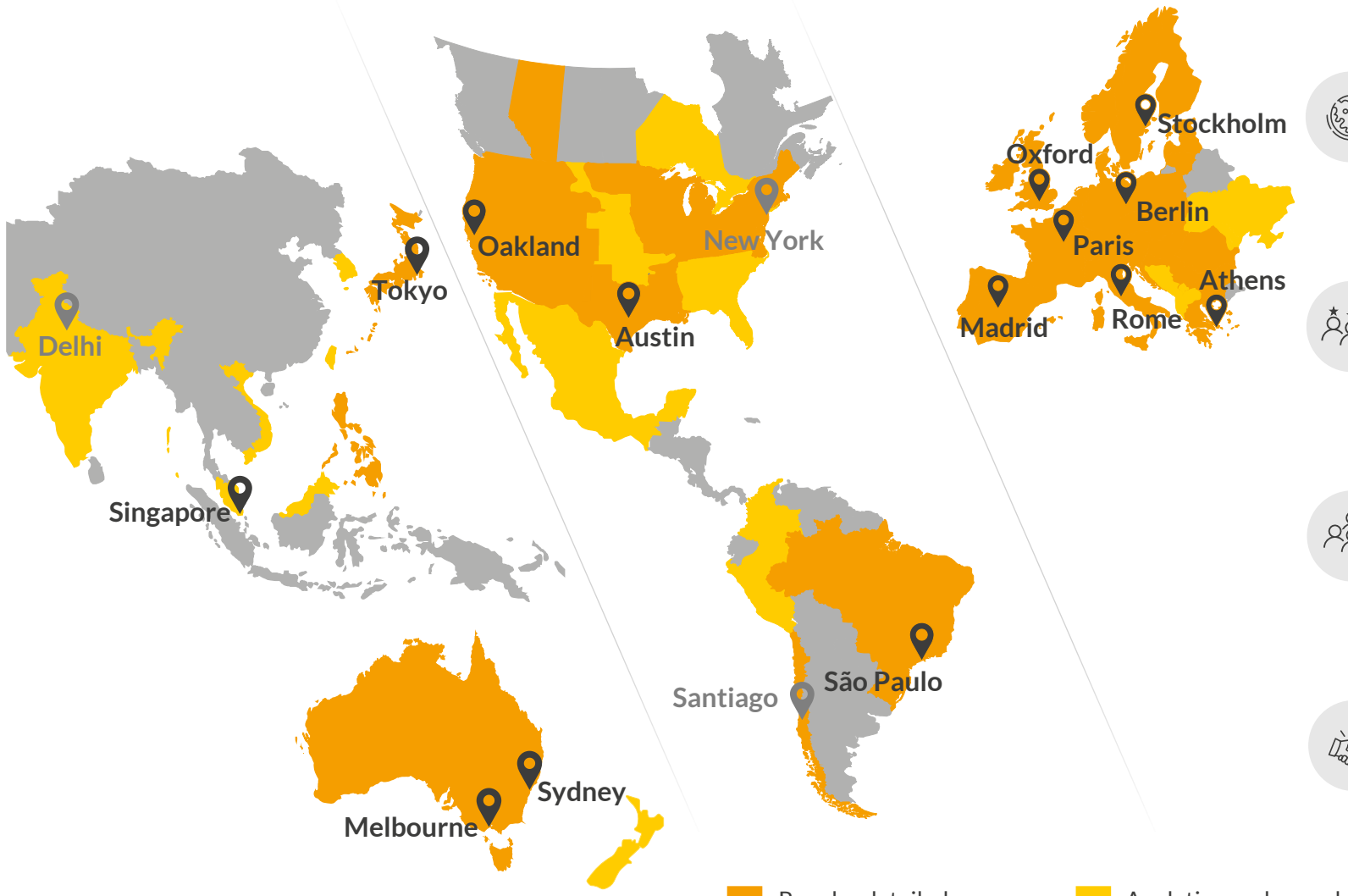
- Power markets
- Renewables & PPAs
- Storage
- Grid & Congestion
- Electric vehicles
- Hydrogen H_2
- Carbon CO_2
- Natural gas



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and three more coming soon

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market experts

850+
subscribing companies

150+
transactions supported in 2023

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

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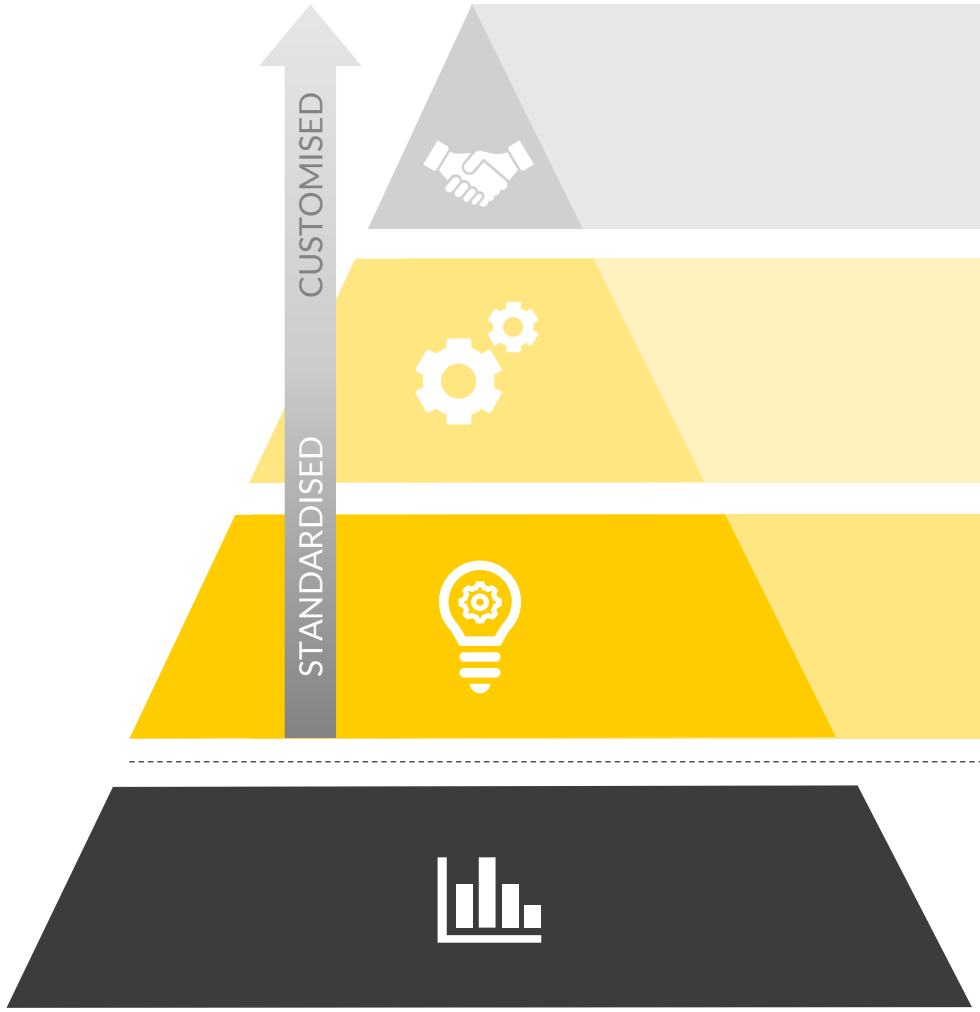

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Access tailored expert advice and analytics for your crucial projects

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1,400+ projects globally

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Make standard analysis bespoke through direct access to our models

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

150+ company licenses

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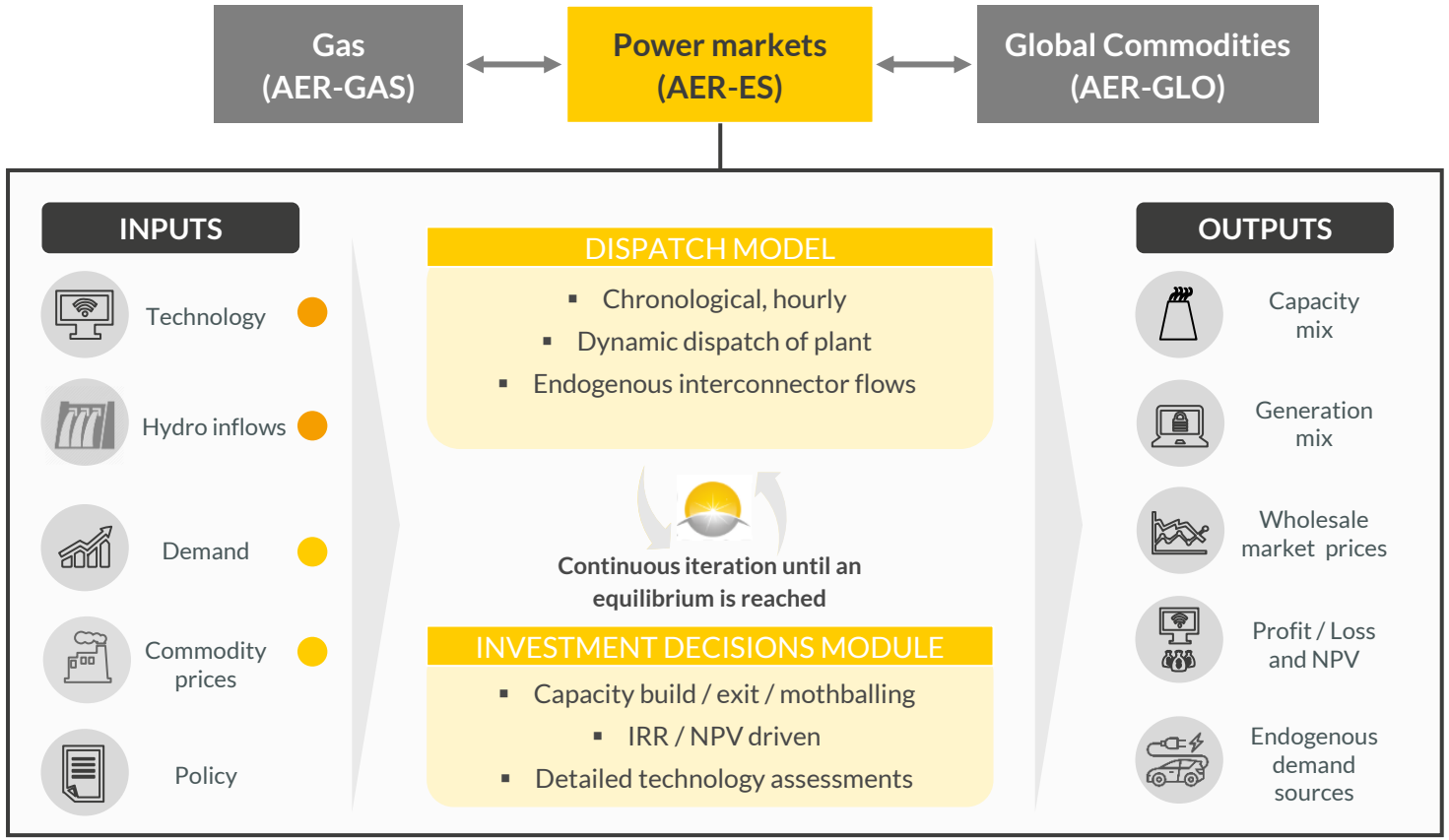
Market-leading models for power, gas, hydrogen, carbon, oil & coal markets

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

Developed over 10 years, 70+ dedicated modellers

Source: Aurora Energy Research

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



Official assumptions[1] Modeled in-house

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

1) Assumptions from CEN and Ministerio de Energía.

Source: Aurora Energy Research

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Advantages of Aurora's Approach

- Flexible and nimble because we own the code
- Transparent results
- State-of-the-art infrastructure
- Zero dependence on black-box third-party software
- 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 and EVs)

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In 2023, renewables made up 63% of Chile's generation mix, with solar contributing nearly half of the hourly generation during peak hours

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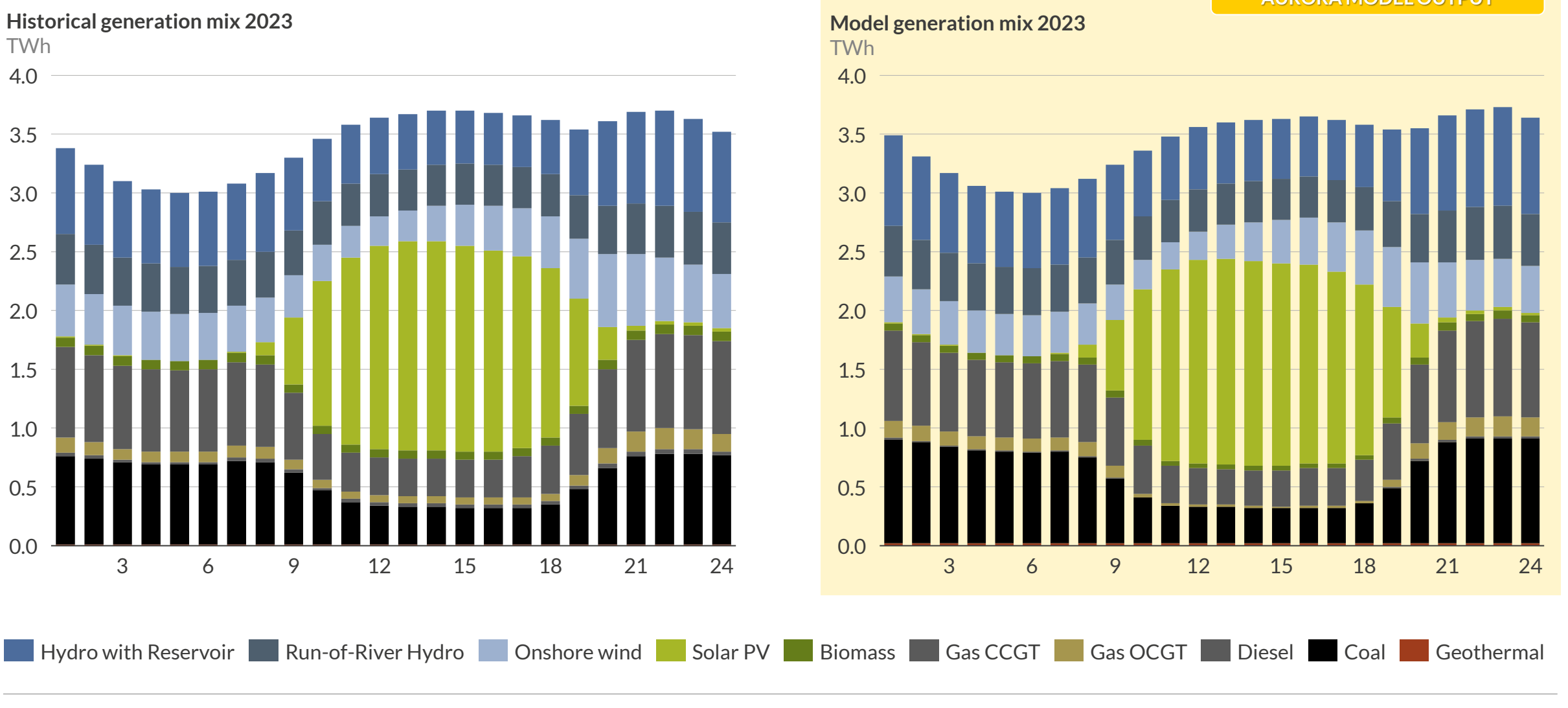
AURORA MODEL OUTPUT

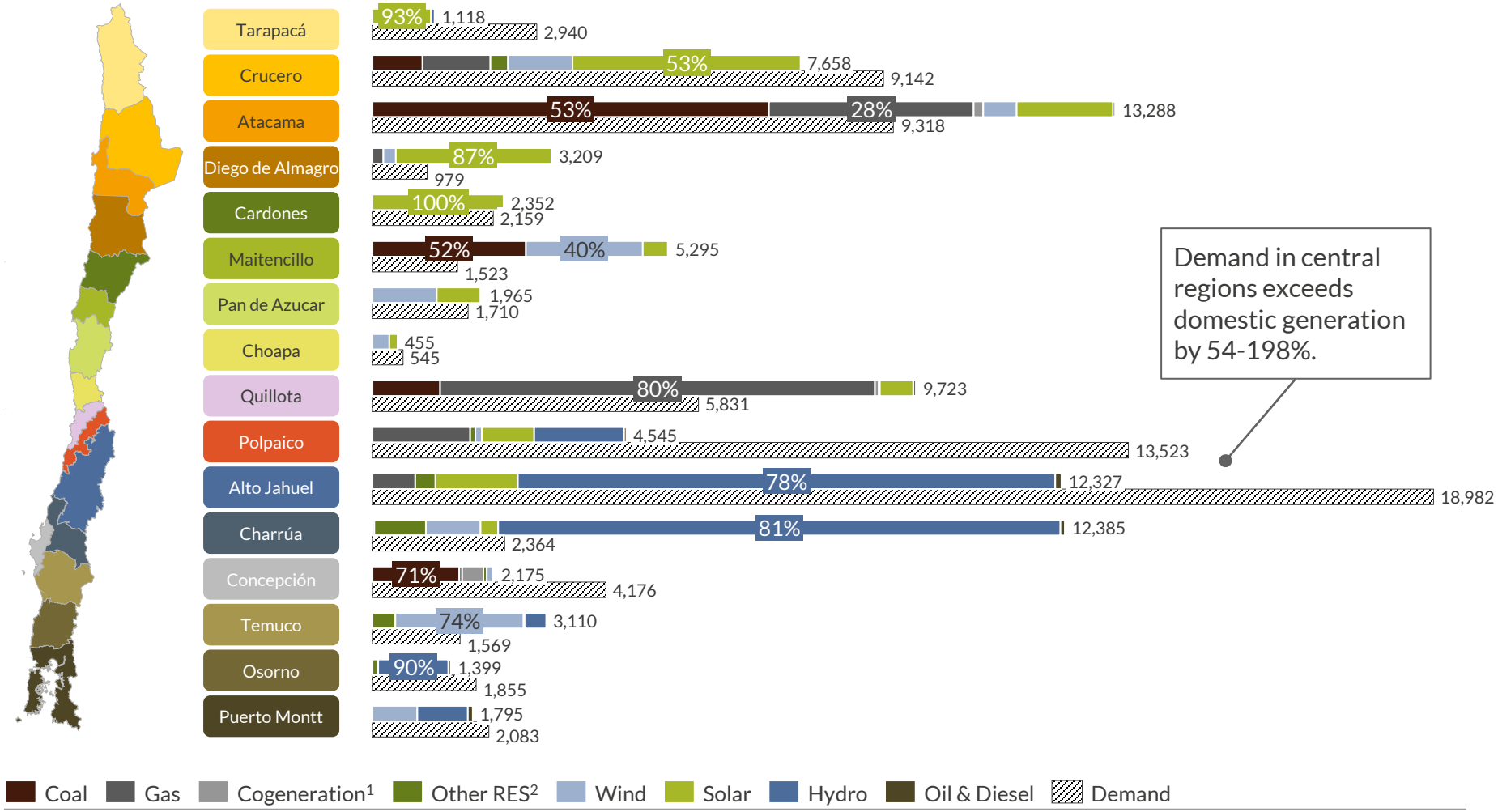


Sources: Aurora Energy Research, CEN

Chile sees an unequal distribution of demand and generation; solar generation is concentrated in the north, hydro in the central regions

Generation vs demand in 2023 per Aurora nodal hub

GWh

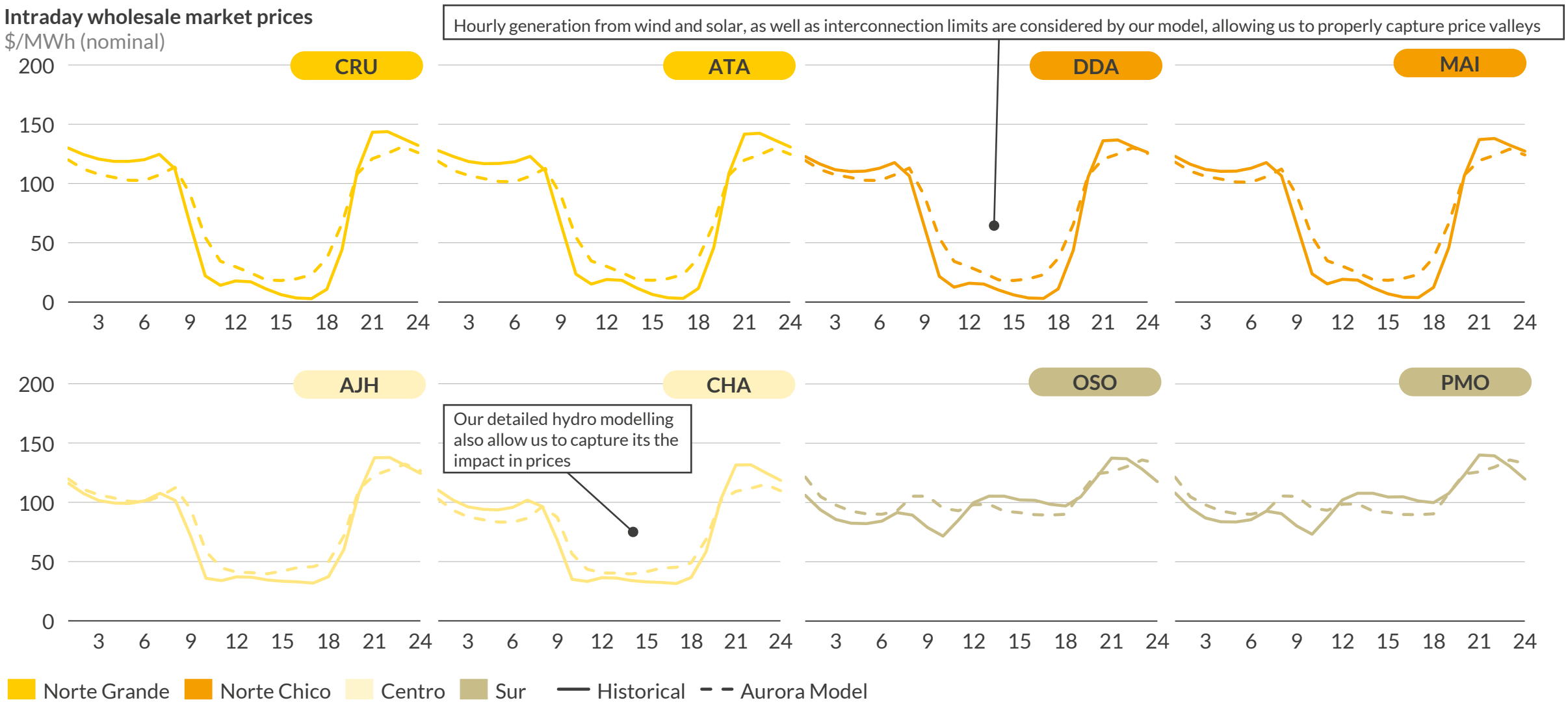


1) Cogeneration includes petcoke. 2) Other renewables include biogas, biomass and geothermal.

Source: CEN

- In 2023, 72% of solar generation came from the northern regions between Tarapacá and Cardones, which benefit from high irradiance levels.
- Coal and gas are most relevant in Atacama and Quillota. Both regions generate over 80% of their hubs total generation using thermal sources.
- Wind generation is spread across the country with the largest hubs in Maintencillo and in the South of SEN (Temuco and Puerto Montt).
- 82% of SEN's total hydro generation in 2023 is in the center (Alto Jahuel and Charrúa), making up around 80% of the domestic hubs' generation. Osorno and Puerto Montt are also dominated by hydro.

Intraday wholesale market prices across Chile are significantly influenced by regional generation mix and interconnection limits



Sources: Aurora Energy Research, CEN

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We have analyzed current demand sectors, identified its key drivers, and explored future demand trends

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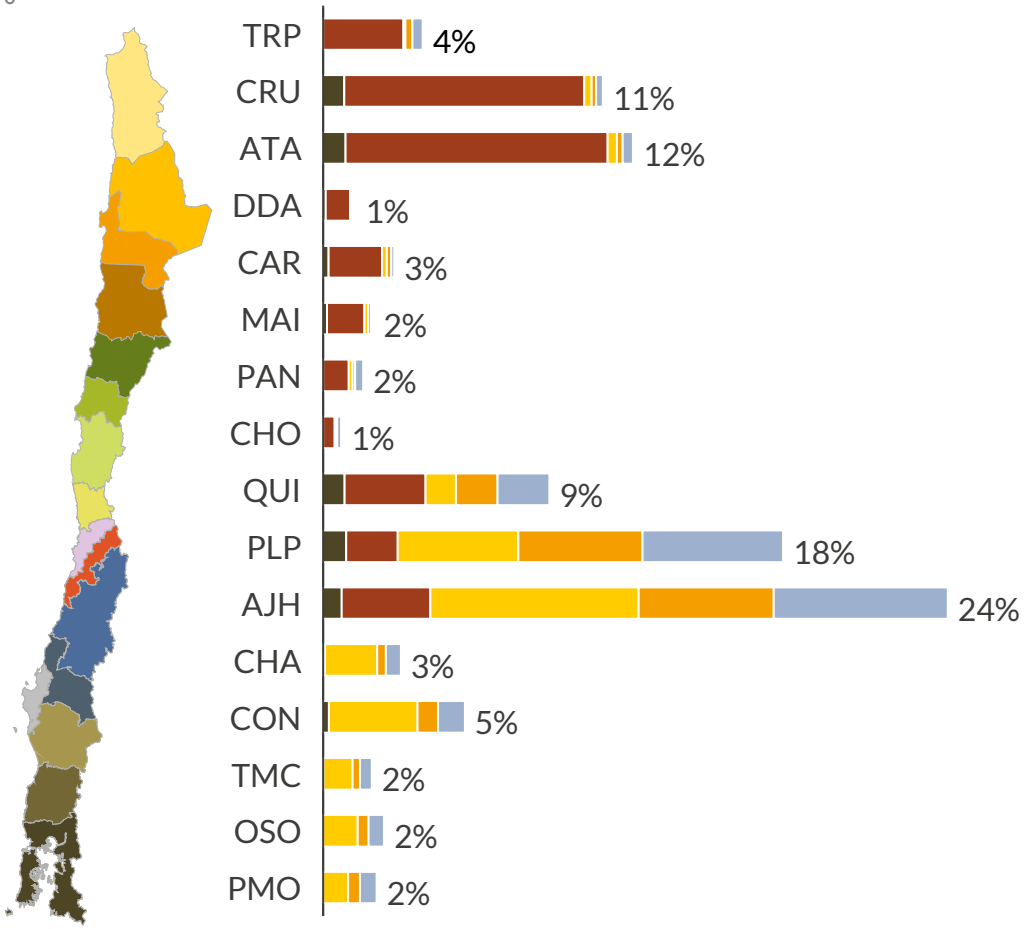
Historic split of power demand[1]

%



Aurora's drivers for base demand forecast

Residential demand

- Population growth is the key driver for residential electricity demand.

Commercial and industrial demand

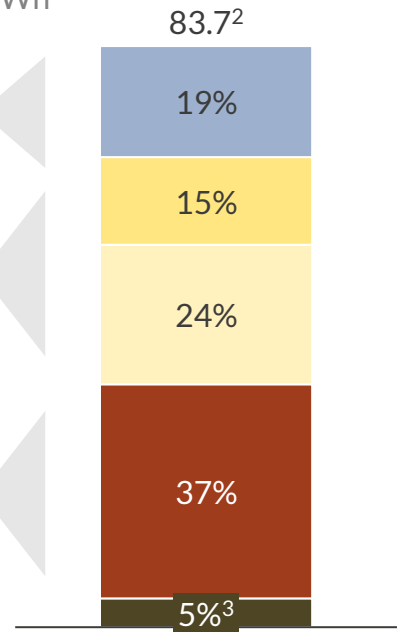
- Chilean GDP growth is the key driver for Commercial and industrial demand of electricity.

Copper Production

- In the past, copper production and electricity demand from mining have not been correlated. Analysis shows that an increase of mining electricity demand is expected as energy intensity for mining increases.

2023 split of power demand[1]

TWh



Aurora's long-term demand forecast also considers:

- **Lithium mining**.
- **Hydrogen** electrolyzers.
- **Electric Vehicles.**
- **Datacenters.**
- Electrification of **climatization.**

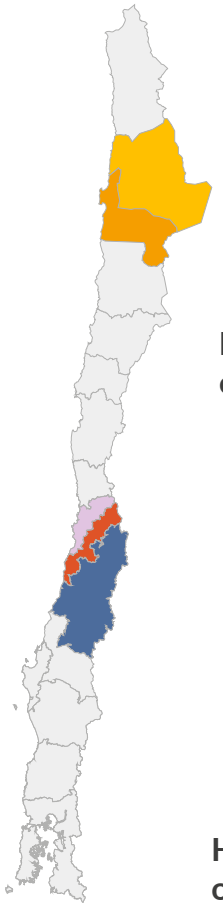
1) Demand sector based on the *Balance Nacional de Energía* (BNE) 2022. 2) Demand considers system demand, including losses. 3) Transport and Energy is kept constant, and passenger electric vehicles are considered in future technology demand.

Sources: BNE, CEN

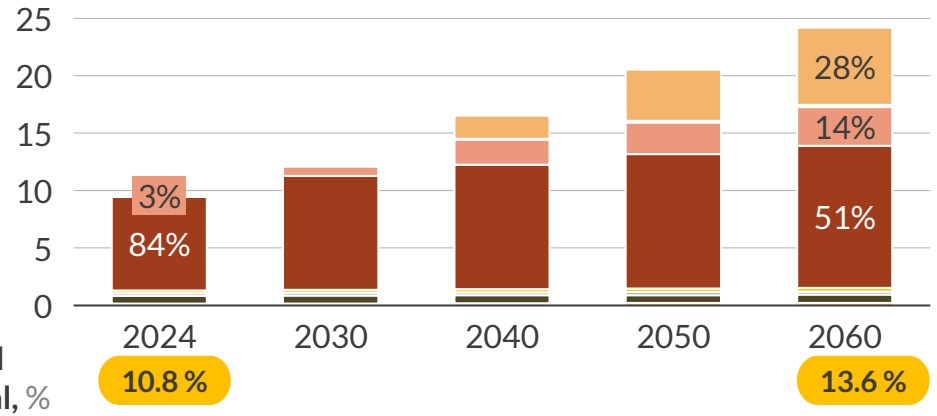
Aurora expects demand profiles in high demand hubs to be impacted by the introduction of new technologies

Preliminary results

High demand hubs[1]

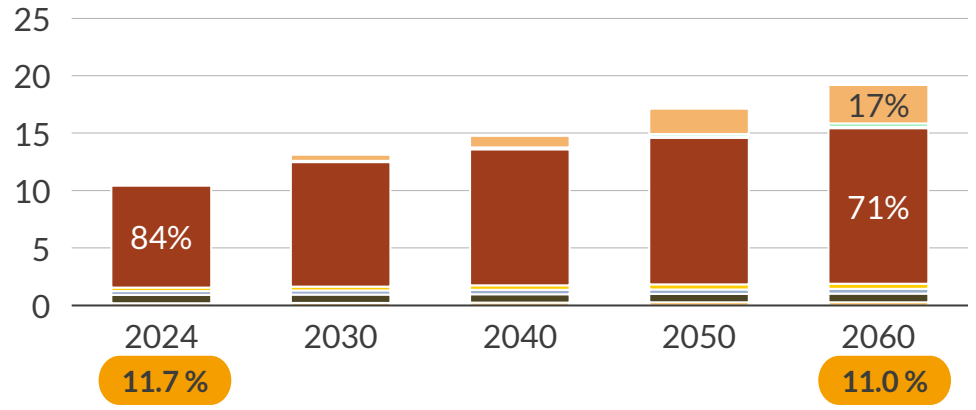


Crucero
TWh



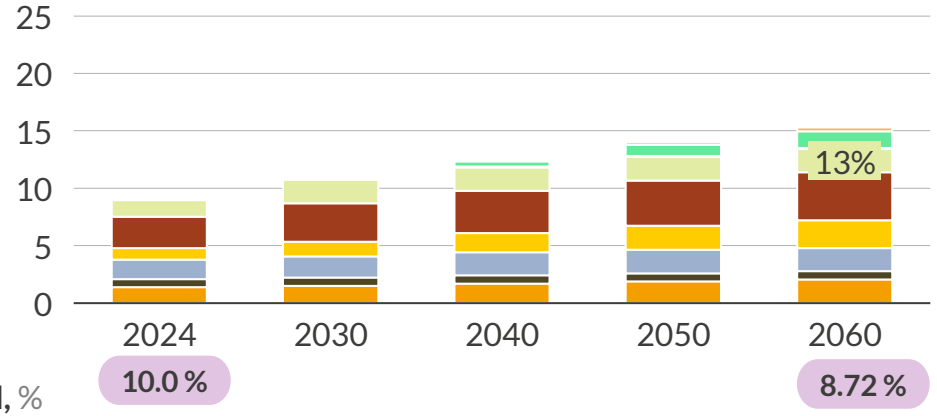
Hub demand over national, %: 10.8 % (2024), 13.6 % (2060)

Atacama
TWh



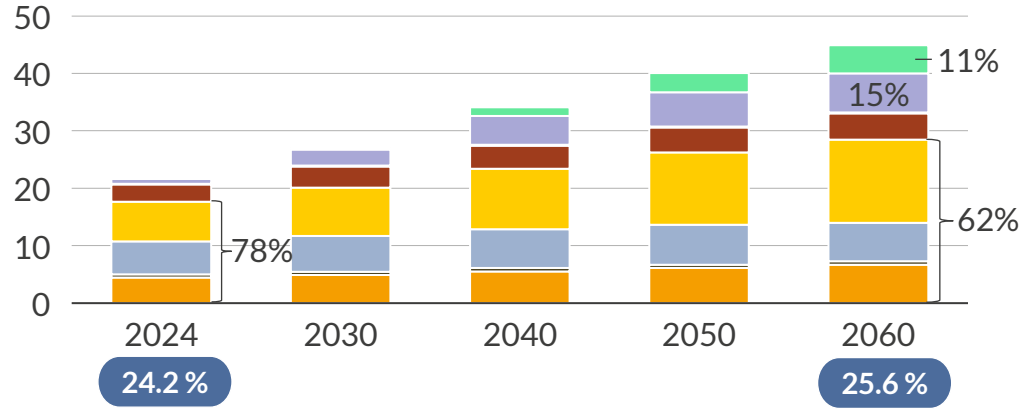
Hub demand over national, %: 11.7 % (2024), 11.0 % (2060)

Quillota
TWh



Hub demand over national, %: 10.0 % (2024), 8.72 % (2060)

Alto Jahuel
TWh



Hub demand over national, %: 24.2 % (2024), 25.6 % (2060)

Commercial | Transport and Energy | Residential | Industry | Mining | Lithium | Datacenters | Climatization | EVs[2] | H2

1) Polpaico is not included in this slide because the evolution is similar to Alto Jahuel and total demand is smaller. 2) EVs include passenger vehicles and busses.

Sources: Aurora Energy Research

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Wind and solar PV already represent 40% of Chile's total installed capacity; these technologies are heavily clustered in specific areas

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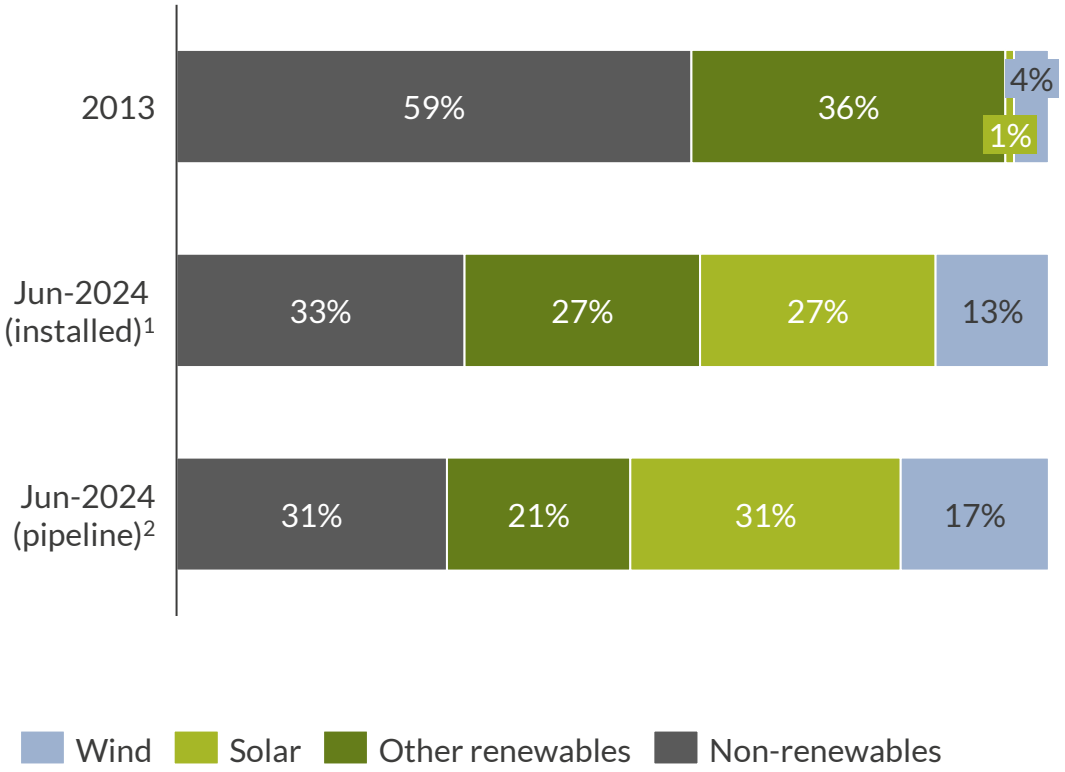
1 **Over the past decade, the intermittent renewables share surged from 5% to 40%, while the thermal share declined significantly. The trend is set to continue, evidenced by advanced-stage projects.**

2 **However, wind and solar PV capacities are clustered in distinct locations: approximately 80% of solar PV is concentrated in the north, while wind is located in Norte Chico and South.**

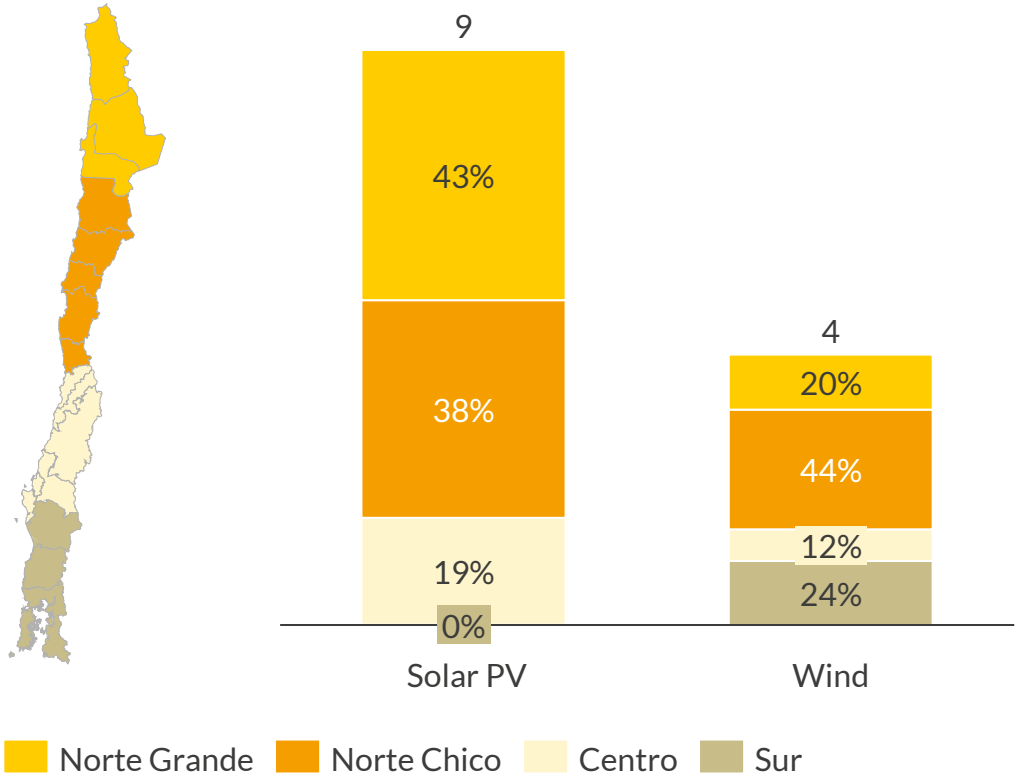
Intermittent renewables installed capacity vs other technologies

%



Intermittent renewables capacity

GW, %



1) Operational as of June 2024. Includes operational capacity as of February 2024, reported by the CNE adding new projects entering operation from March to June by Ministerio de Energía. 2) Pipeline includes only projects under construction, undergoing testing, and with approved environmental impact assessments as of June 2024 Ministerio de Energía report.

Sources: CEN, Ministerio de Energía

Wind tops highest load factors[1] of up to 32% in the south, solar not far behind at 30% in the northern regions

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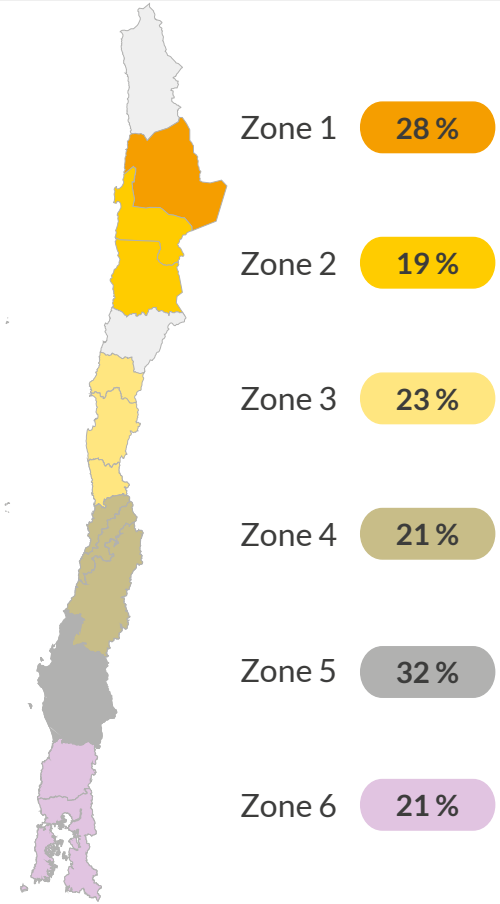
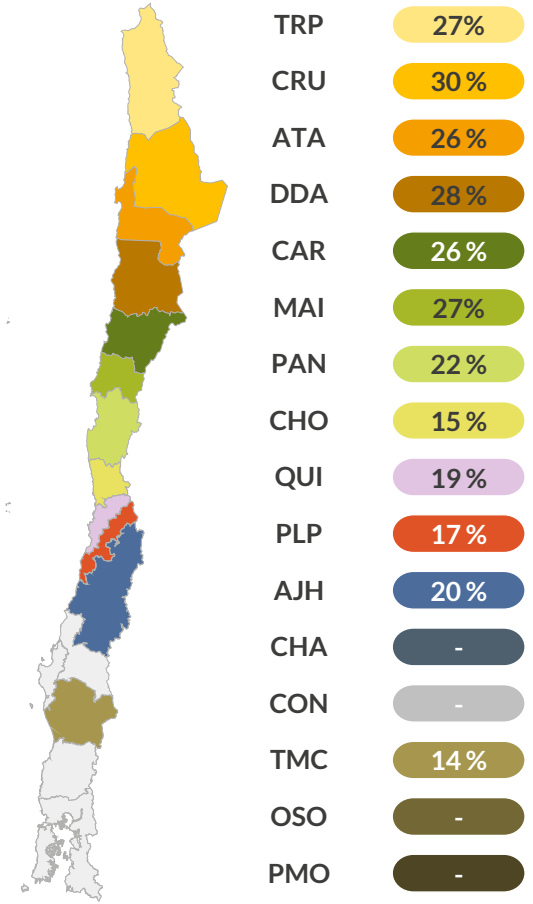
1 While most favorable conditions for wind generation are found along mountain ranges…



- We clustered wind assets in six distinct wind zones, reflecting their geographic distribution and land characteristics.
- Offshore wind is not modeled as there are no such projects in the pipeline in Chile.

2 … solar load factors[1, 2] can go up to 30% in the Northern desert regions of Chile.



- Due to geographical diversity, we create a solar profile for each hub.
- No significant load factor difference between utility-scale and small-scale distributed plants.

1) Average across the year. 2)The hubs without a load factor did not have known operational capacity as of May 2024.

Sources: The Wind Power's database, CEN

Technological advancements and labor capability skills mainly influence CAPEX and OPEX reduction until 2060, being stronger for solar than wind

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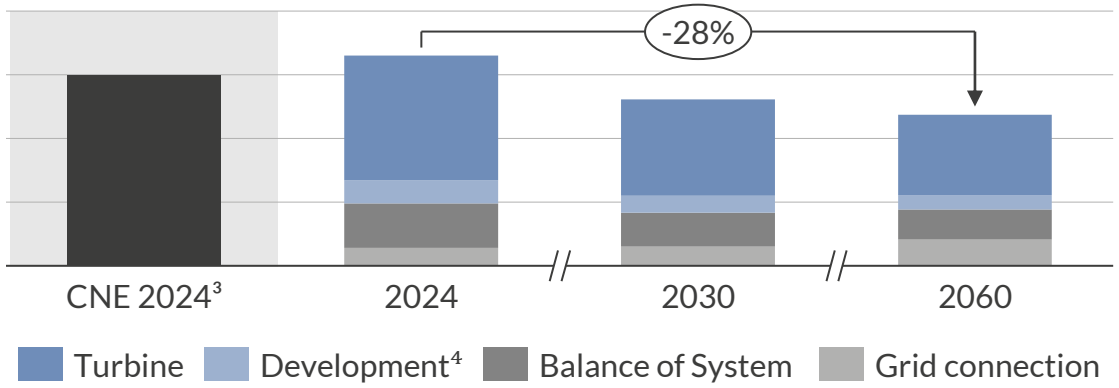
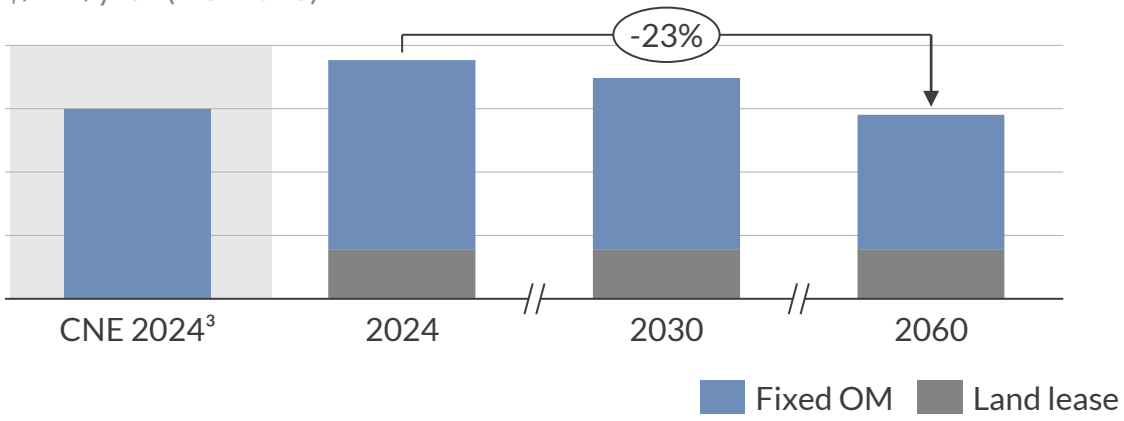
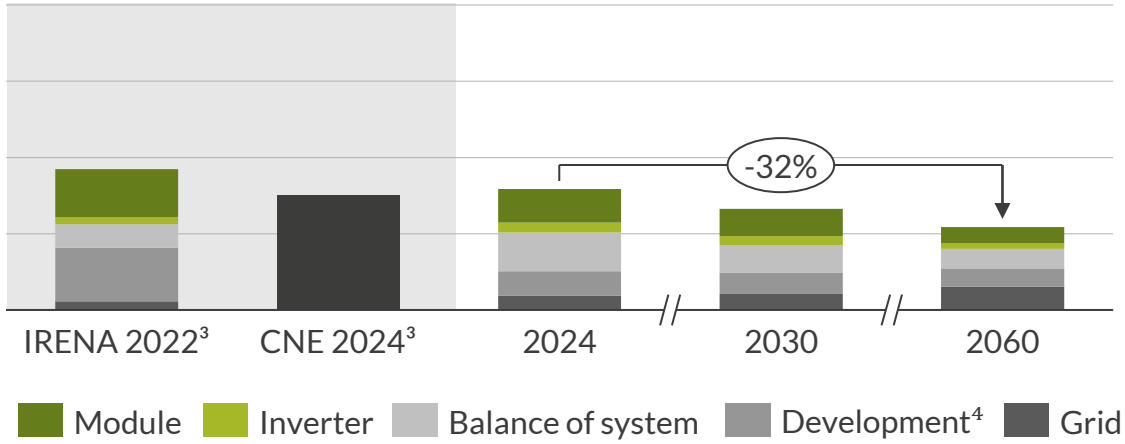
Onshore Wind Utility Scale CAPEX[1]
$/kW (real 2023)



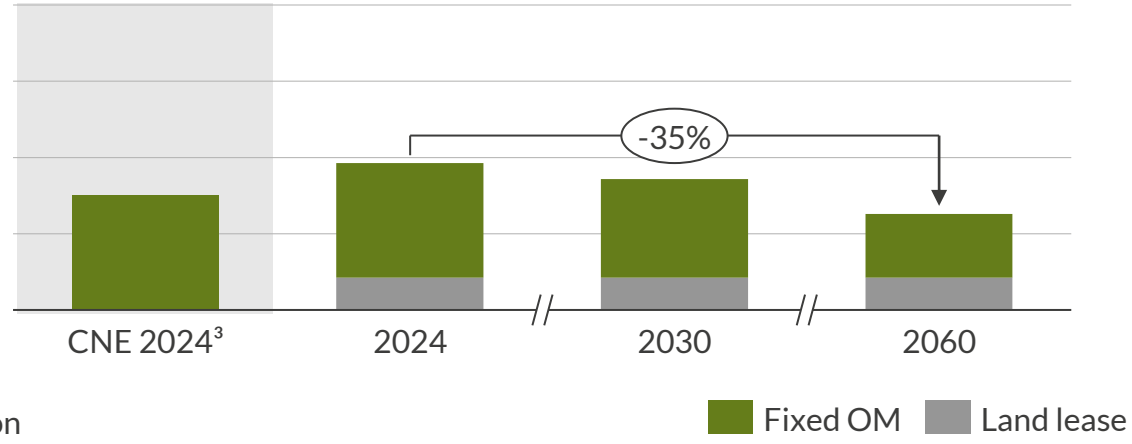
Onshore Wind Utility Scale OPEX[1,2]
$/kW/year (real 2023)



Solar Utility Scale CAPEX[1]
$/kW (real 2023)



Solar Utility Scale OPEX[1,2]
$/kW (real 2023)



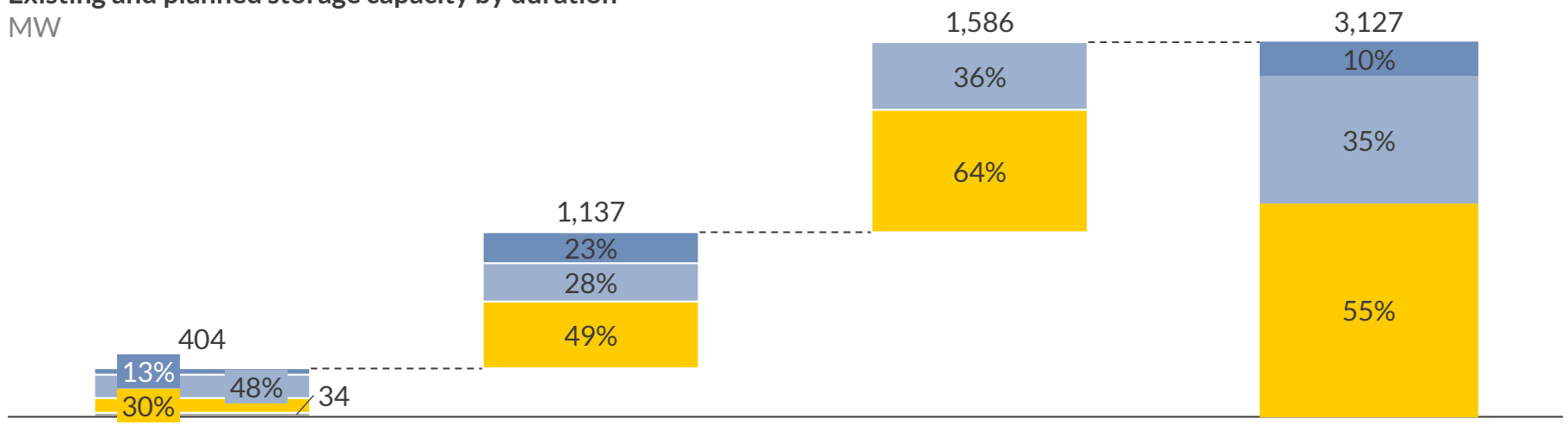
1) Values represent the year asset begins construction; 2) OPEX costs include fixed costs but exclude network charges and property taxes 3) Adjusted number to real 2023 4) Includes installation

Sources: Aurora Energy Research, CNE: *Costos de Tecnologías de Generación*, 2024, CEN: *Estudio Inodú*, 2019.

Long-duration batteries, driven by regulatory changes, comprise 64% of early-stage pipeline

Existing and planned storage capacity by duration[1]

MW



2016

- First mention and definition of battery energy storage systems in Law 20.936.
- Chile's energy transition plan highlights the need to replace thermal capacity with "flexible renewables", making batteries a key solution.

2022

- Energy Storage & Electromobility Law (21,505) promotes renewable energy storage and stand-alone batteries. It introduces a remuneration scheme for BESS in capacity market participation.

2024

- DS 70/2024 modifies capacity payments regulation and explicitly includes stand-alone and co-located batteries into the remuneration scheme.
- De-rating factors are at 100% for batteries ≥5 hours duration.

1) Under environmental impact assessment procedure, it includes only stand-alone batteries. 2) Other include BESS capacity with no duration allocation.

Sources: Aurora Energy Research, Ministry of Energy: *Proyectos en Construcción e Inversión*, June 2024, CEN: *Estudio de Almacenamiento de Energía en el SEN*, 2023, DS 70/2024

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- Since 2022, interest in BESS has surged, with the project pipeline set to at least double installed capacity by Q4 2024.
- Chile's geography, with solar generation in the North and demand in Centro-Sur, creates major transmission and distribution challenges.
- BESS are crucial for managing renewables' intermittency and reducing curtailment, with long-duration systems particularly effective at shifting generation over extended periods.
- Although 70% of operational batteries are short-duration, 58% of projects feature batteries with over 5 hours of storage, highlighting their role in maintaining security of supply, supported by the approval of DS 70/2024.

By 2030, we expect falling commodity prices to lower battery system costs in the near future

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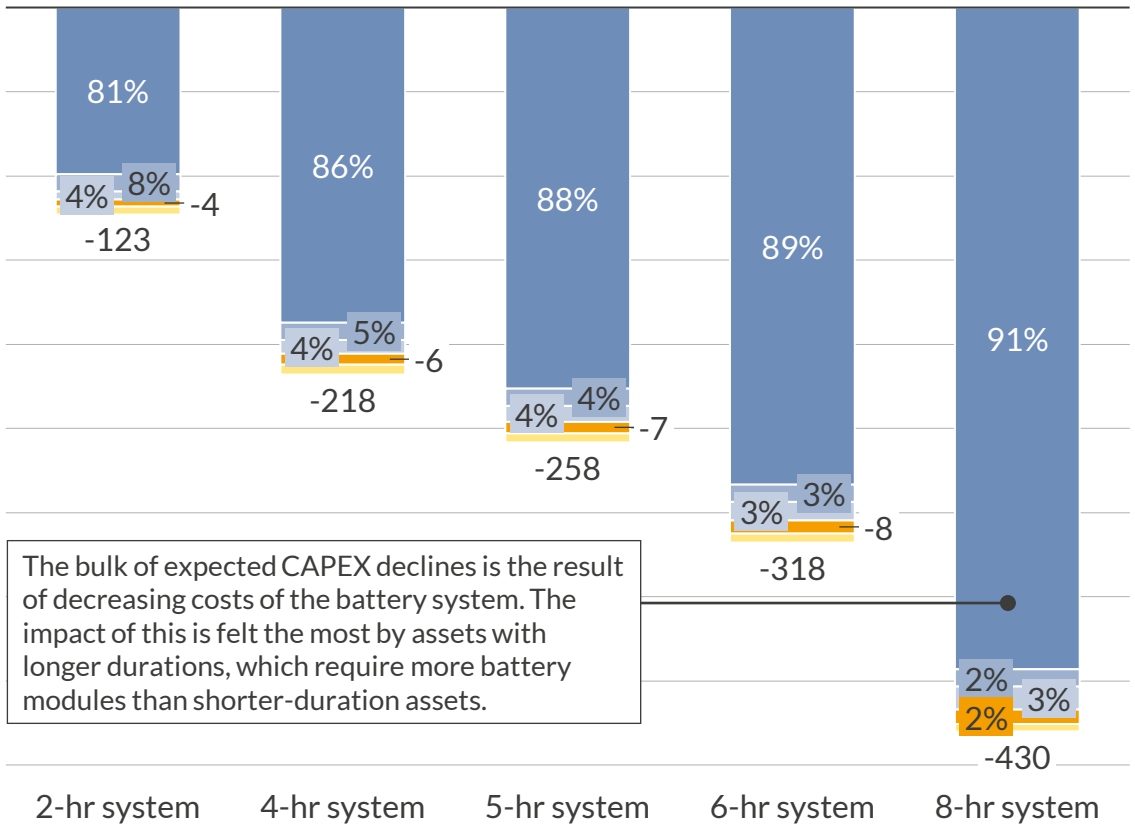
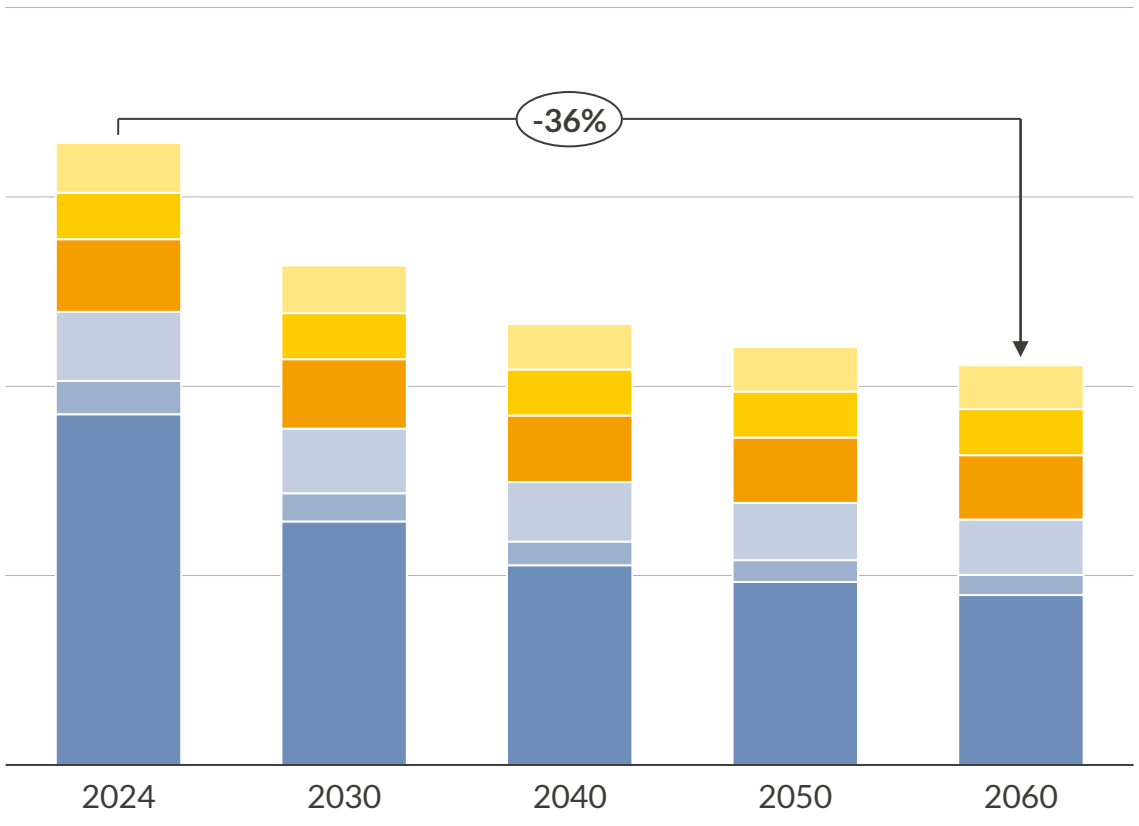
CAPEX changes from 2024 to 2030 by component
$/kW, real 2023



The bulk of expected CAPEX declines is the result of decreasing costs of the battery system. The impact of this is felt the most by assets with longer durations, which require more battery modules than shorter-duration assets.

Li-ion battery total system costs – 5-hr asset
$/kW, real 2023



Battery system | Inverter | Balance of system | Development | Grid connection | EPC soft costs

Sources: Aurora Energy Research, CNE: *Costos de Tecnologías de Generación*, 2024, CEN: *Estudio de Almacenamiento de Energía en el SEN*, 2023.

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Despite increasing storage deployment, as generation and demand become more dislocated, the network must adapt to sustain power flows

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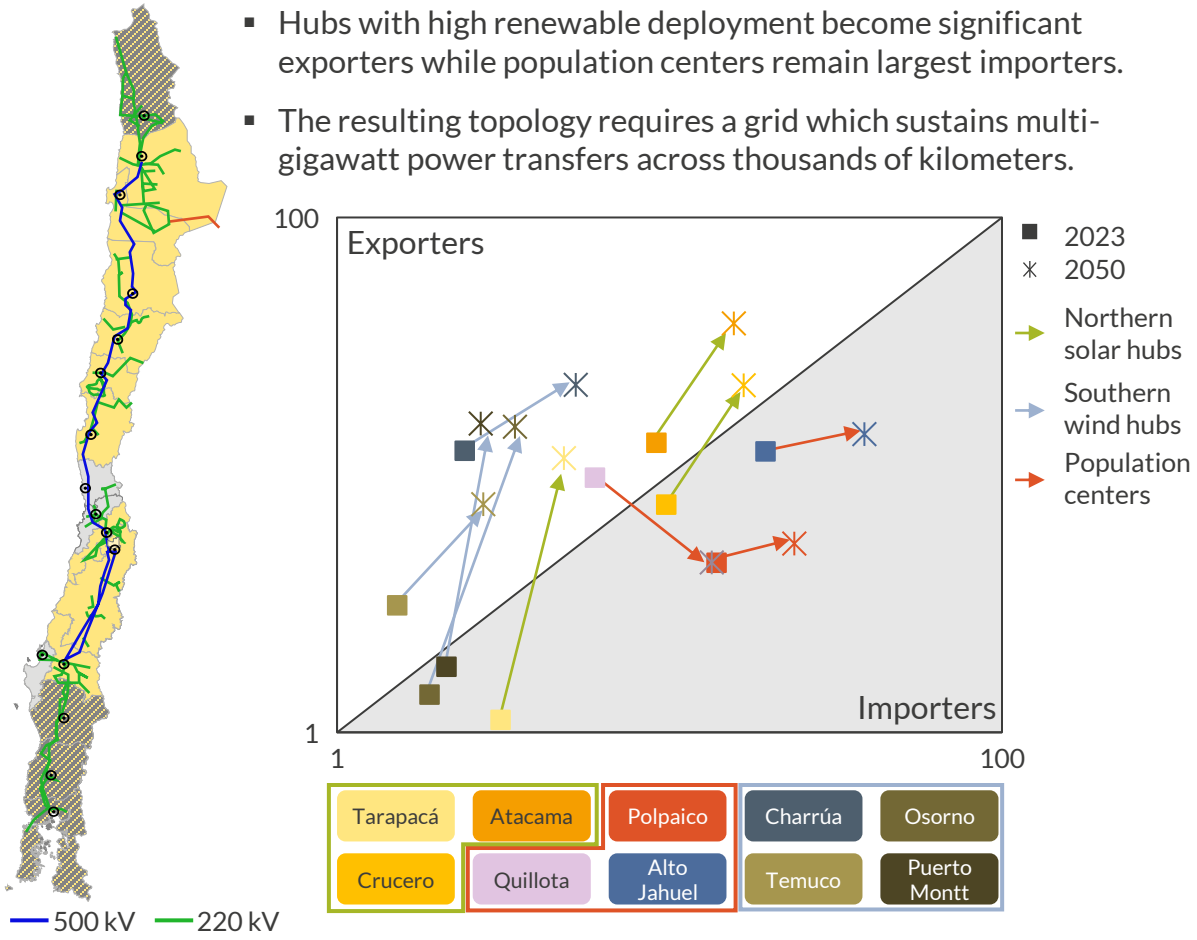
Development of generation vs demand in all hubs from 2023 to 2050[1]
TWh (log scale)



- Hubs with high renewable deployment become significant exporters while population centers remain largest importers.
- The resulting topology requires a grid which sustains multi-gigawatt power transfers across thousands of kilometers.

Background:

- The key challenge for transmission development will be the considerable growth in large, national level power flows across the length of the system.
- In the SEN, the national transmission network consists of lines energized at 220kV and above, supporting power flows between hubs[2].
- In recent years, expansion of national transmission capacity has been driven by the 500 kV network to support power flows transiting multiple hubs.
- This includes the interconnection of the SIC and SING networks in 2017, and the extension of the 500 kV network to Lo Aguirre (PLP) in 2019. The 500 kV network now serves 9 hubs, with further projects in the pipeline.

In the proceeding slides we present the following assumptions for our forecast:

2024-2032	2033-2060
1	2
▪ CEN plans ▪ Projects can take up to 8 years (from planning to operational)	▪ Iterative approach using demand forecast and a generation matrix based on LCOEs to identify transmission projects ▪ Assessment of transmission project net system benefit

1) 2050 values for generation taken from PELP. 2) As defined by CEN. Growth in zonal and "dedicated" transmission networks is assumed through extrapolating historical flows alongside local generation and demand growth, while considering transmission investment plans.
Source: CEN, PELP

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

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