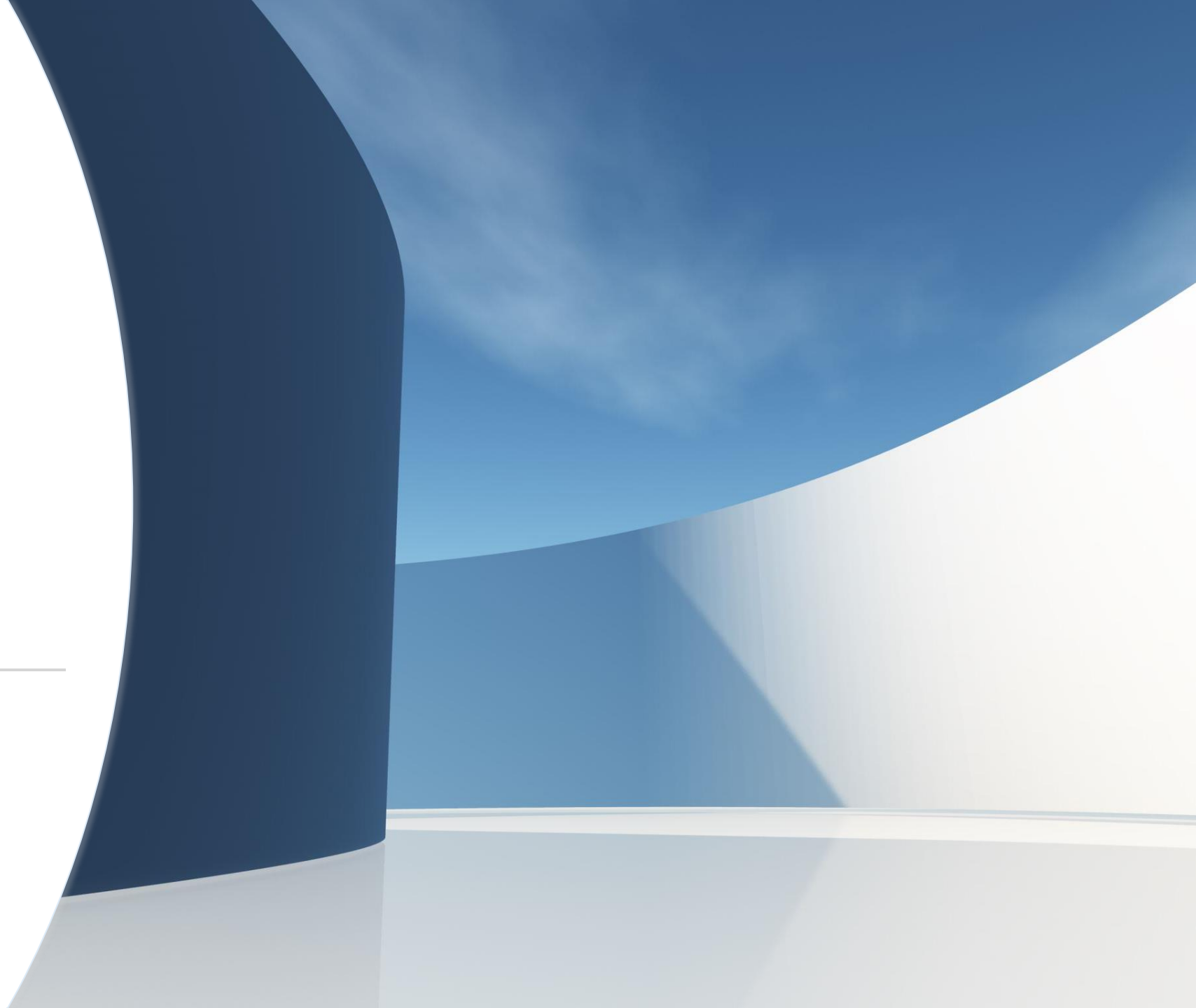
Energy Transition in Chile: Lights and Shadows

Thomas Keller L.

April 2025



Background

Paris Agreement (2015)

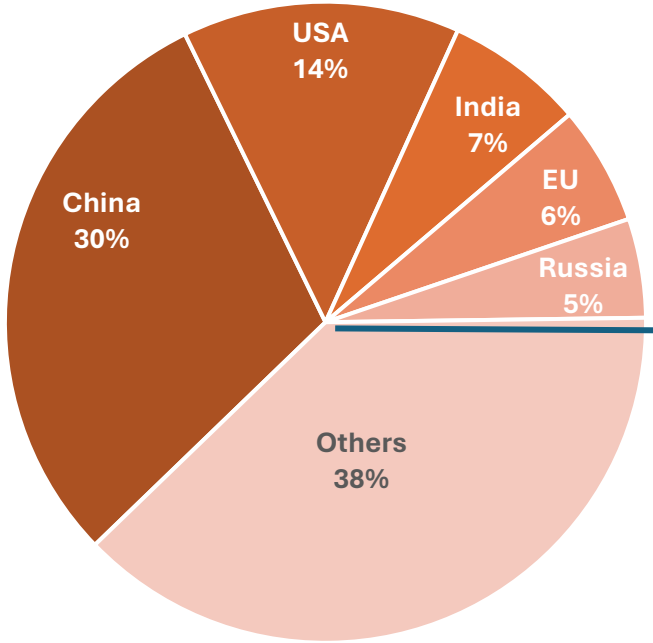
COMMITTMENTS

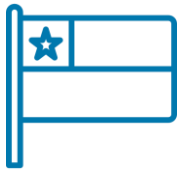
- Contain Greenhouse gas emission / limit temperature increase to 1.5° C pre-industrial level
- Achieve zero net emissions by 2050
- Mitigation & adaptation to consider gender perspective and " fair transition”

INSTRUMENT

- NDCs to be updated every 2 -5 years

% share in GHG emission



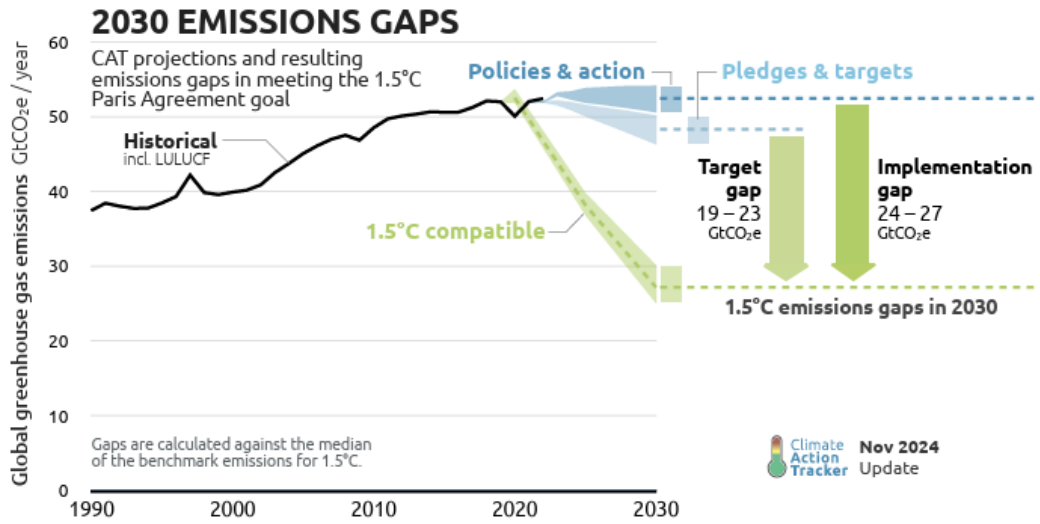


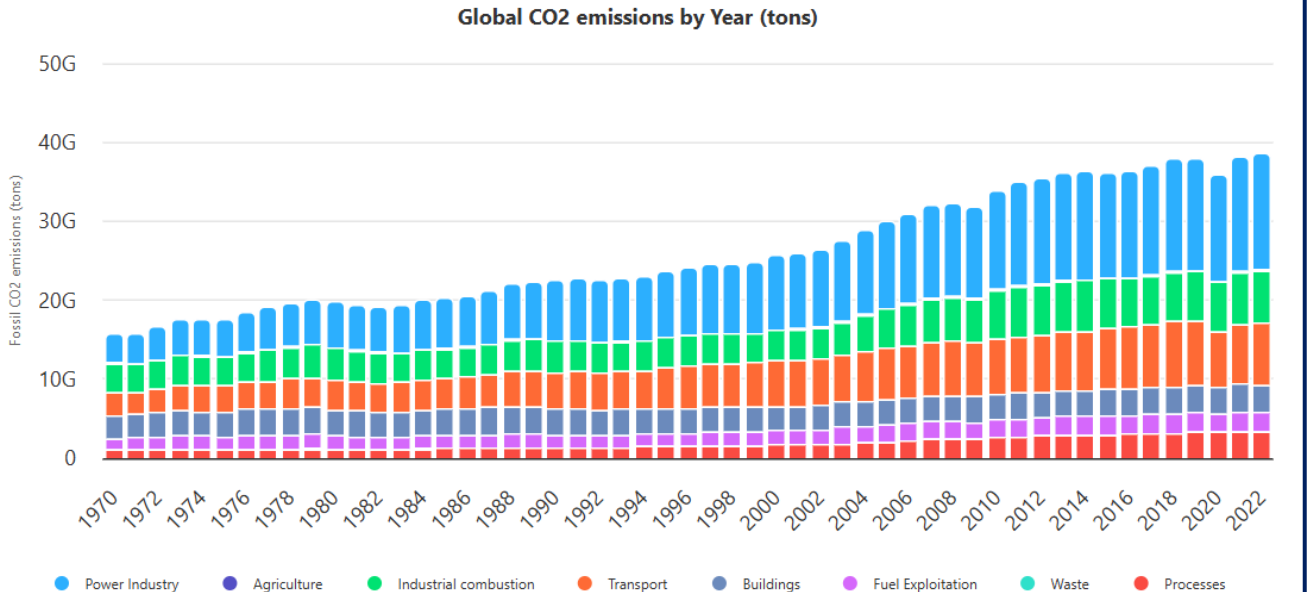
Chile accounts for only 0.1 %

Background

Paris Agreement (2015)

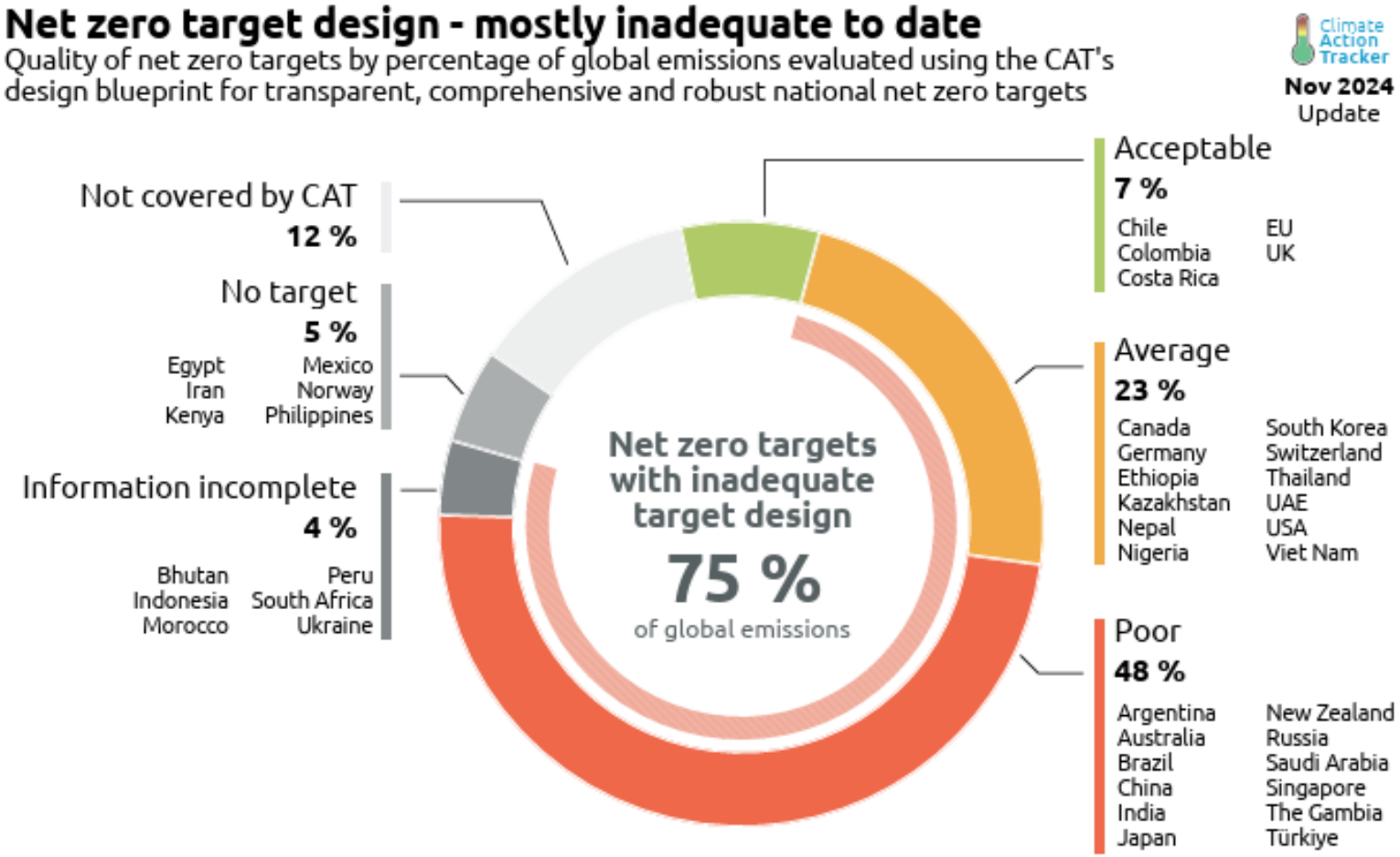
Actual Co2 emissions are off-track





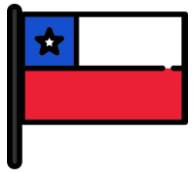
Background- Paris Agreement

And the prospects are not good either



Background

Impact of climate change on Chile



Chile is very vulnerable to climate change
(meets 7 of 9 UN criteria)

lower rainfall

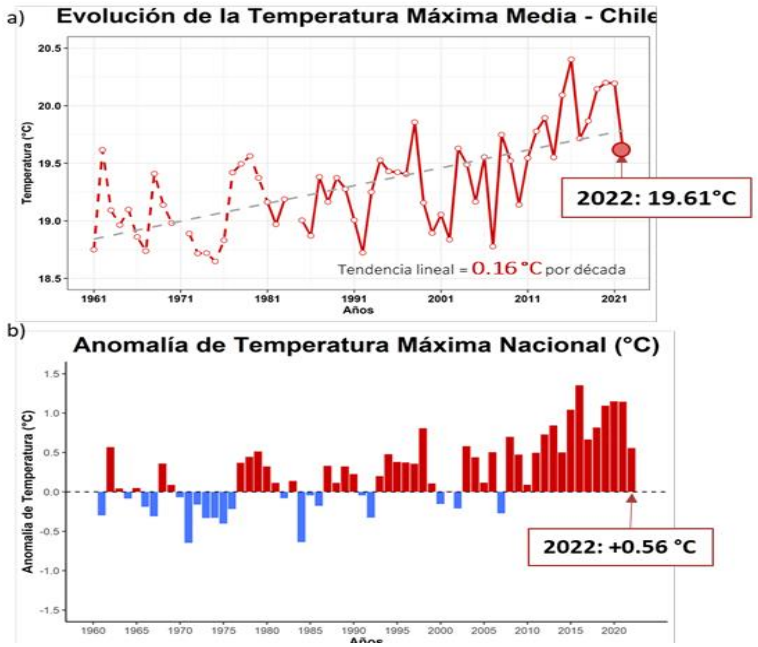
Lower isotherm level

severe events

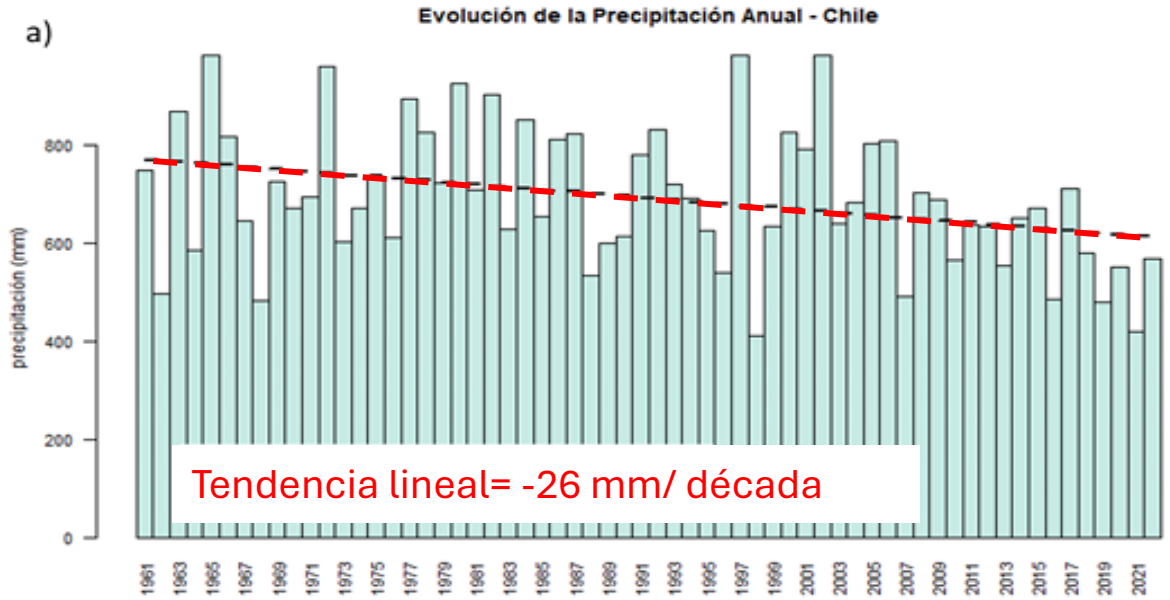
desertification

exposure to higher sea levels

Redcciones comparadas 2019-2023



Redcciones comparadas 2019-2023



Climate Change
Legal Framework

Climate change Law (2022)

- Guidelines and principles to reach de Paris Agreement commitments
- Role of ministries and regional government
- Instruments to be implemented

Long Term Climate Strategy

- Guidelines for climate action through
- Emission Reduction Targets by Sector to achieve net zero by 2050

Mitigation & Adaptation Plans (by Sector)

Chile Climate Change Strategy main goals

2025

- 65% of installed coal plants decommissioned
- Inc rease protecred wetlands by 15.000 hectares

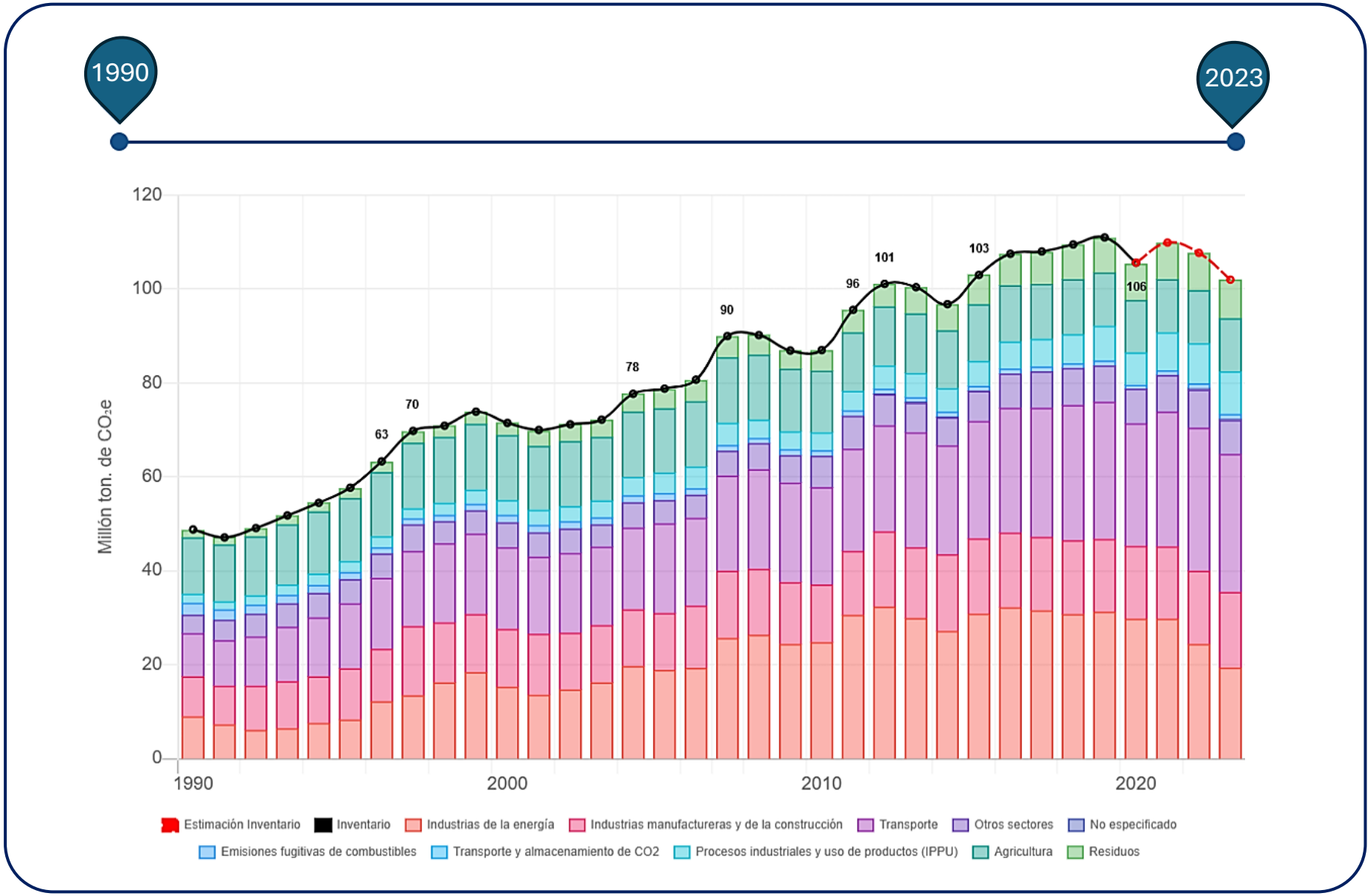
2030

- Renewable power represents 80% of total generation
- Zero emission plans ifor mining fleets implementes
- C02 emissions at 95 MT (108 2022)

2040

- Green hydrogen accounts for 20% of fuel consumption
- Zero emissions for 100% of public transportation

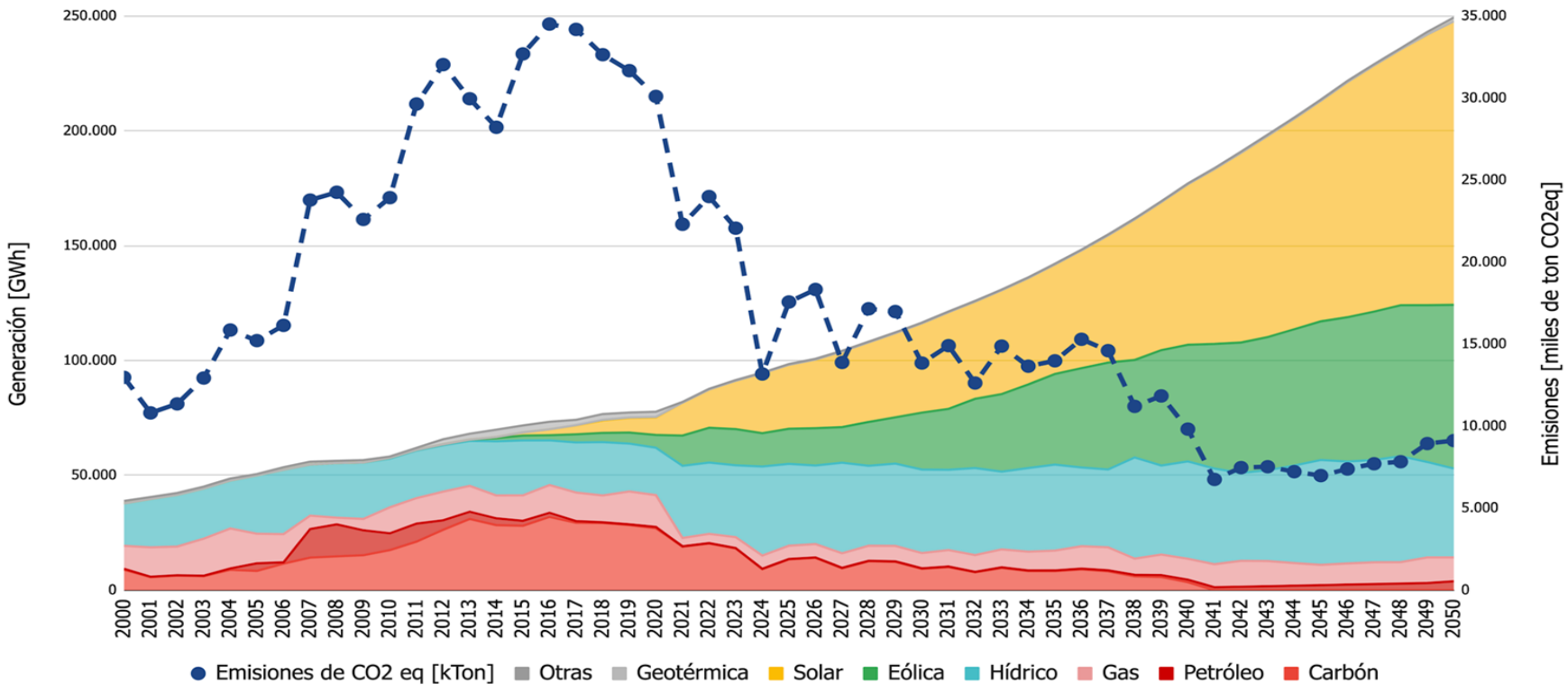
C02 Emissions in Chile by Sector



GHG Emissions in Chile - Energy

In Chile, electricity generation has already reached the peak of GHG emissions and the future is renewable, solar and wind

Generación por tecnología y emisiones GEI 2000 – 2050 de Chile

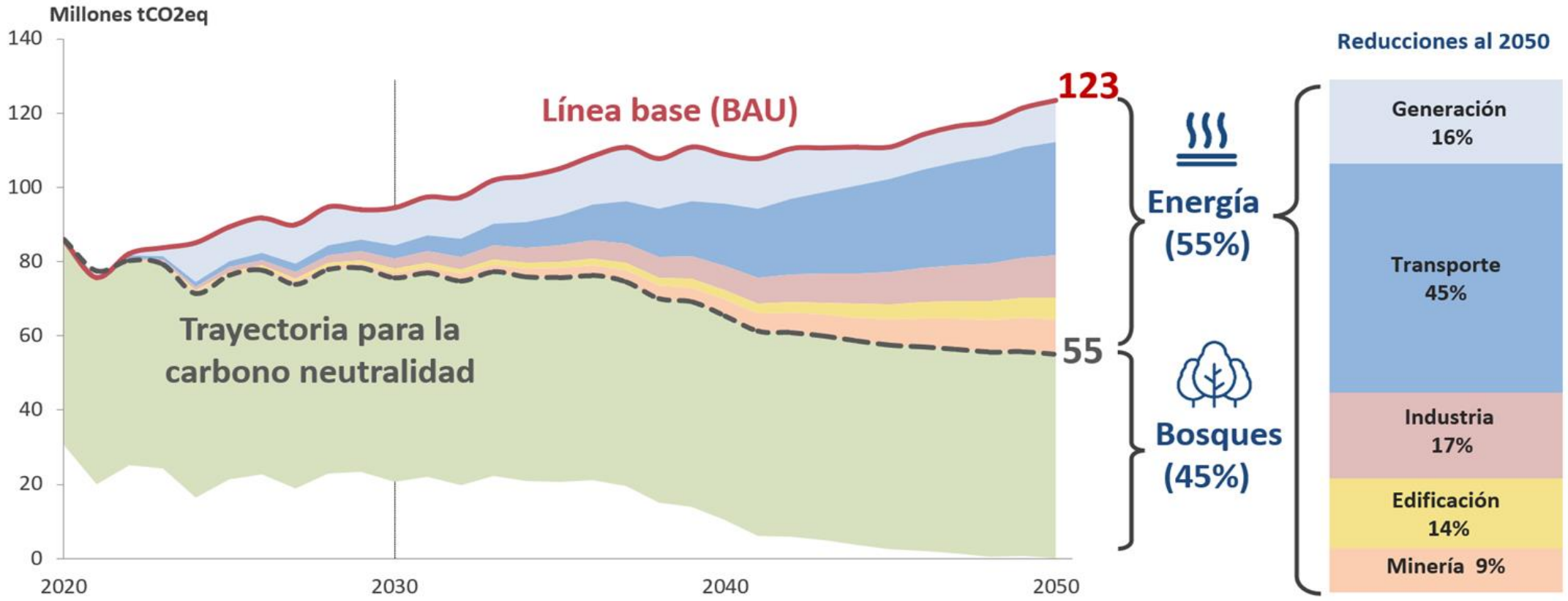


Fuente: Elaboración propia con datos del Estudio Trayectorias del sector energético chileno hacia la carbono neutralidad, Ministerio de Medio Ambiente , Coordinador Eléctrico Nacional y Comisión Nacional de Energía

Climate Change Strategy

The road to net zero

In Chile, in the period 2020 – 2030, **the generation sector will contribute with more than 60% of the reduction in GHG emissions**

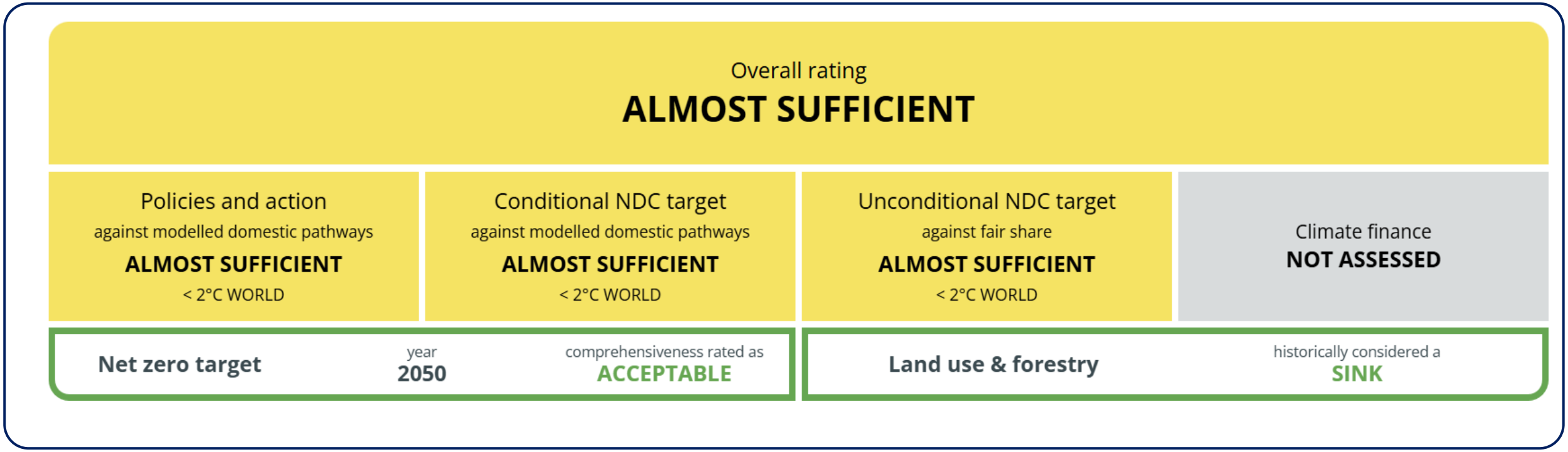


Fuente: Estudio Trayectorias del sector energético chileno hacia la carbono neutralidad en el contexto del OD7, E2Biz, 2020

Climate Change Strategy

What is the outlook?

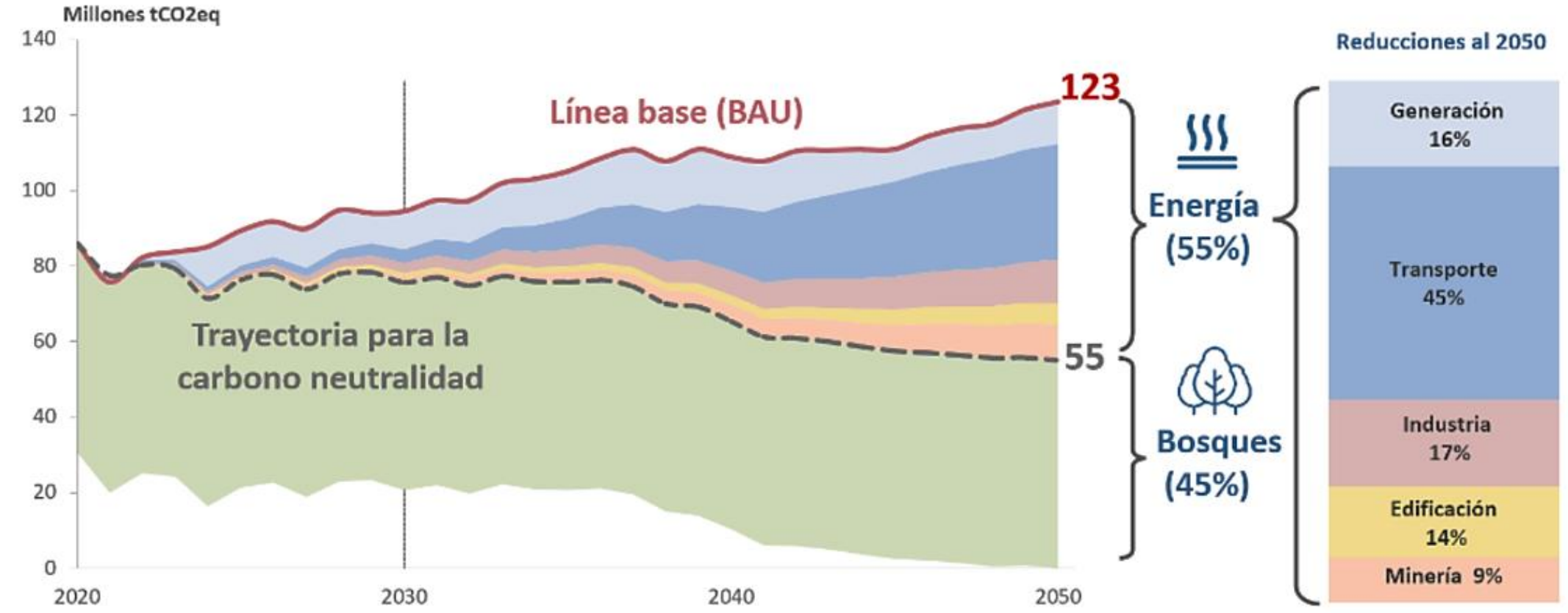
Chile climate action performance rating (CAT, Nov.2024)



Net zero

The role of Energy

Power generation's target contribution to net zero



Fuente: Estudio Trayectorias del sector energético chileno hacia la carbono neutralidad en el contexto del OD7, E2Biz, 2020

Net zero

The role of Renewables

- Its pivotal role is mainly based on competitiveness of solar and wind

Solar plants load factor ❯ **Up to 35 % in the North - Up to 28% in centre-south.** Large areas available

Wind plant load factor ❯ **Up to 60 % in Magallanes** and **48% in the North** (albeit in limited areas)

- Intermittency can be mitigated with BESS storage
- Capex of these technologies expected to decline further

Regulation to support renewables

Minimum share for non-conventional renewables (NCR) (*)

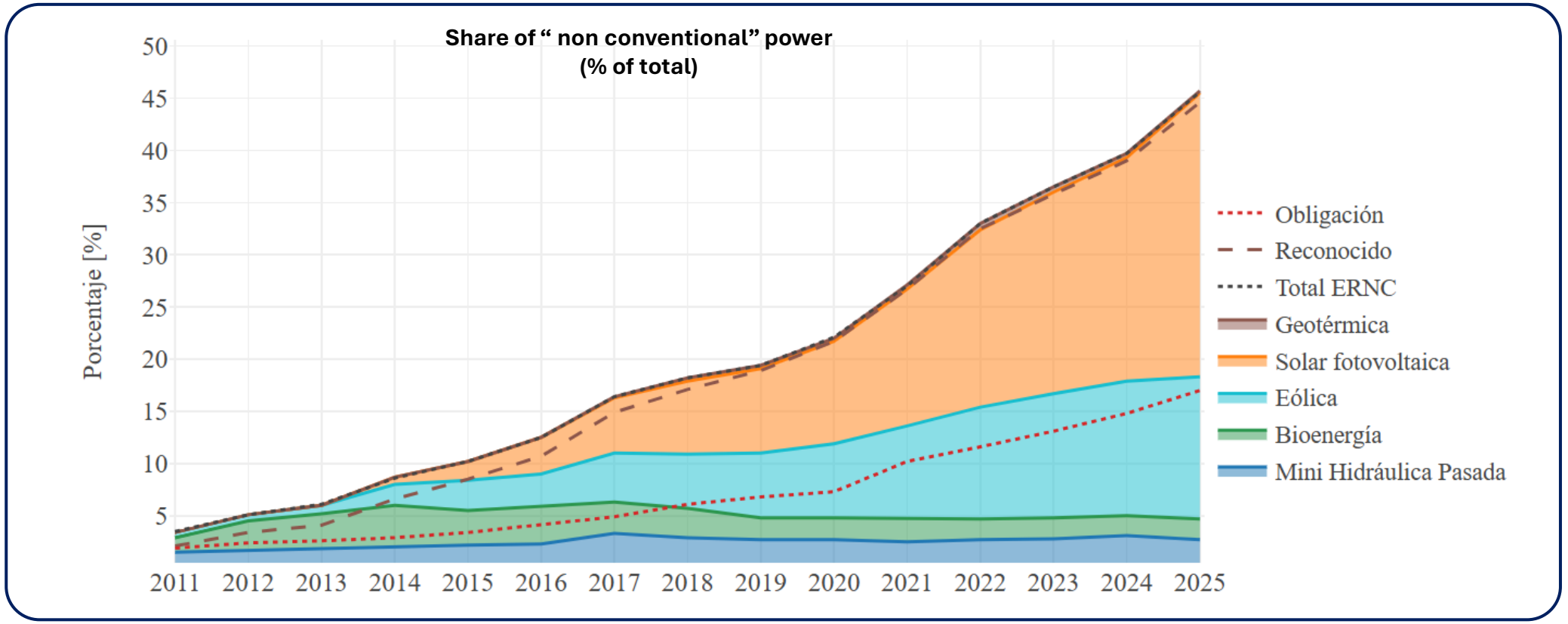
Scope

- Generators must sell a minimum % NCR power (*)

Impact

- None, actual

(*) In practice , all renewables except hydro above 9 MW capacity.



Regulation to support renewables

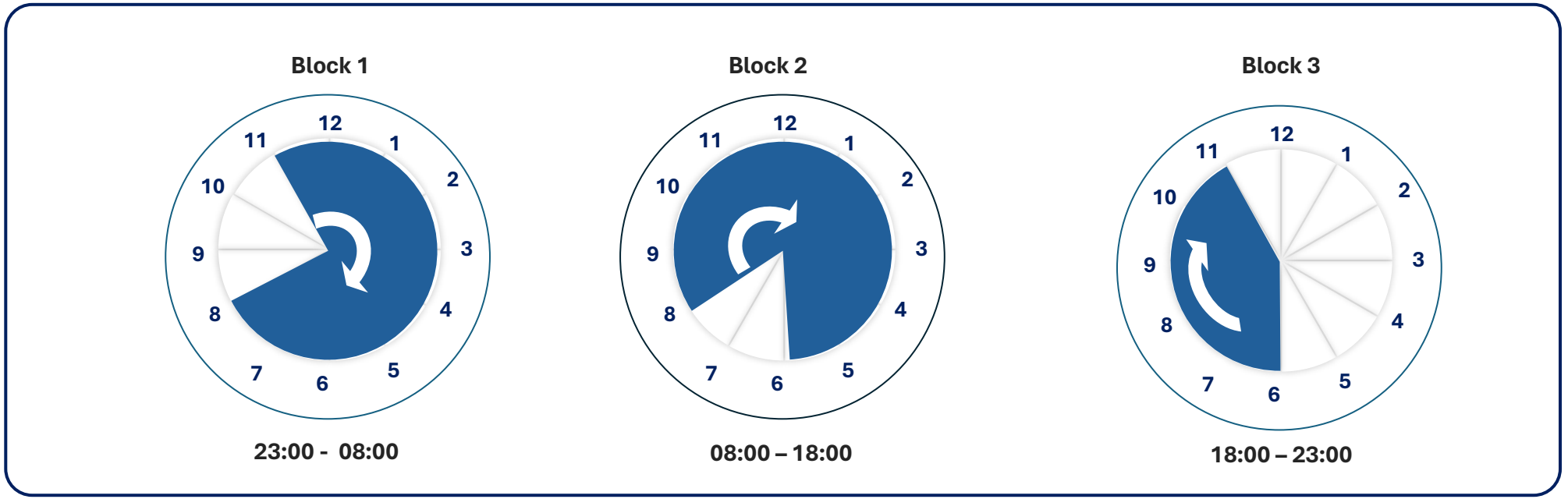
Hourly block pricing

Scope

- PPAs to supply regulated clients (40-50%¿ of market) consider 3 -hourly blocks
- These PPAs are long - term agreements with distribution companies
- PPAs awarded on minimum 24-hour supply cost basis

Impact

- Facilitates participation of intermittent (renewable) power in bidding process (no exposure to spot market)
- Facilitates project financing



Regulation to support renewables

CO2 emission pricing

Scope

- US$ 10/ ton for designated (mainly large fixed) emission sources
- CO2 price not considered in determination of dispatch merit order

Impact

- No impact on actual emissions (at least not in short-médium term)
- No incentive to maintain (or improve) performance of coal and gas fired plants

Regulation to support renewables

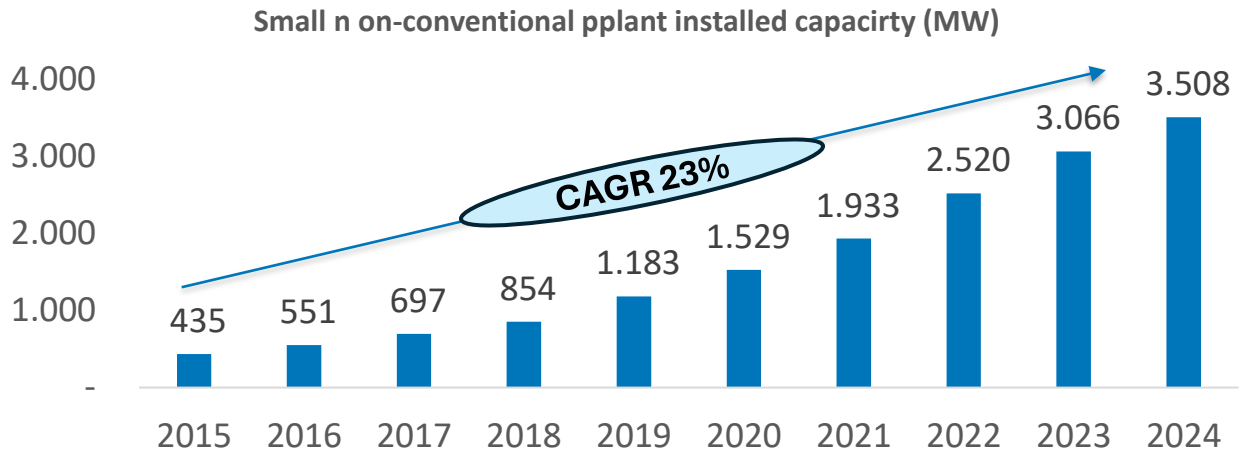
Support of small plants

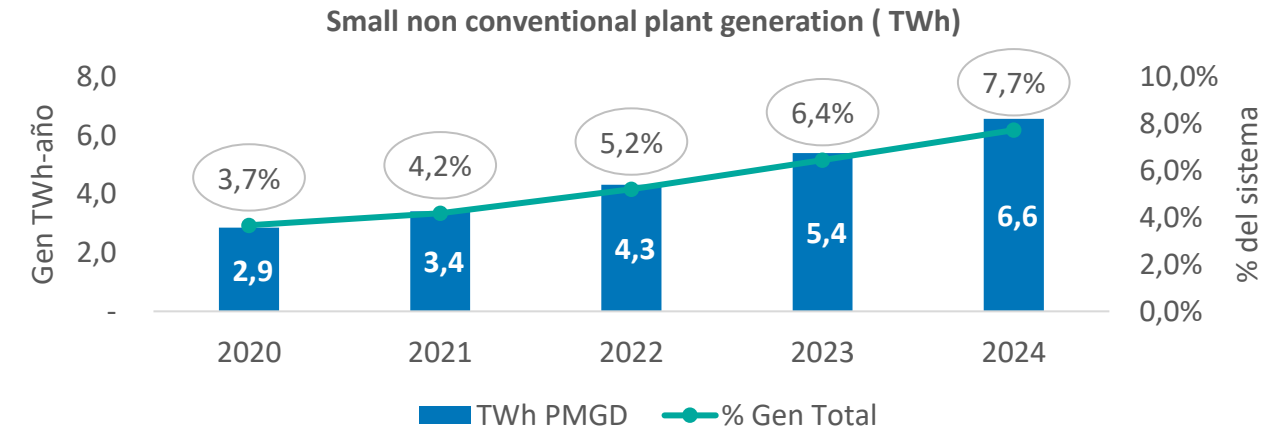
Scope

- Plants with a capacity up to 9 MW
- Simplified environmental approval process
- Not affected by curtailment
- Power injection not controlled by system operator
- Stabilized tariff average 24 -hour price of existing contracts, irrespective of actual hourly supply(generation

Impact

- Massive new capacity
- Significant participation by i global players
- Large stabilized price- marginal cost differential paid for by all other generators (and ultimately users)
- System reliability is adversely affected





Regulation to support Renewables

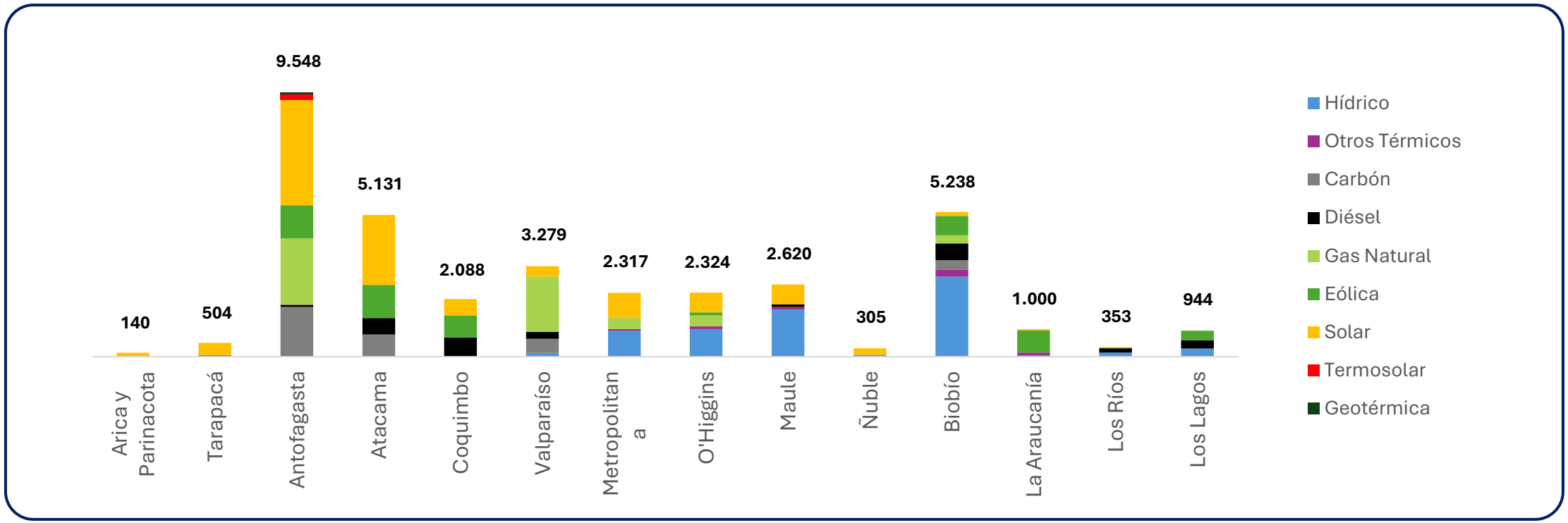
Postage stamp transmission pricing mechanism

Scope

- Transmission costs originally borne by power generators, based on actual infrastructure used
- From 2016, transmission costs are pro-rated among all clients, irrespective of where power is generated

Impact

- Little incentive to minimize transmission costs
- Most new capacity built far from main consumption
- Bottlenecks in transmission



Regulation to support Renewables

Coal plant decommissioning

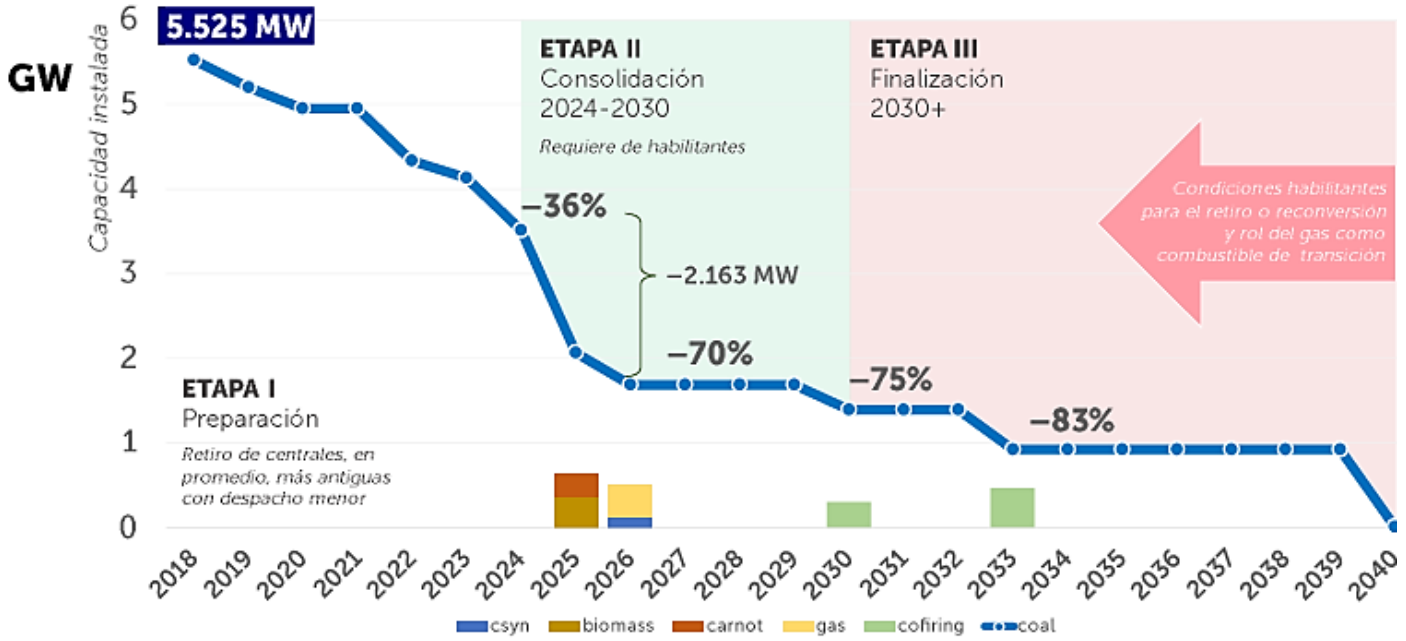
Scope

- 2019 agreement provides for closure of coal plants

Impact

- Actual closures/new commitments exceed agreed schedule
- Lower capacity to control /secure power frequency & tension in the system

Coal fired plants decommissioning schedule

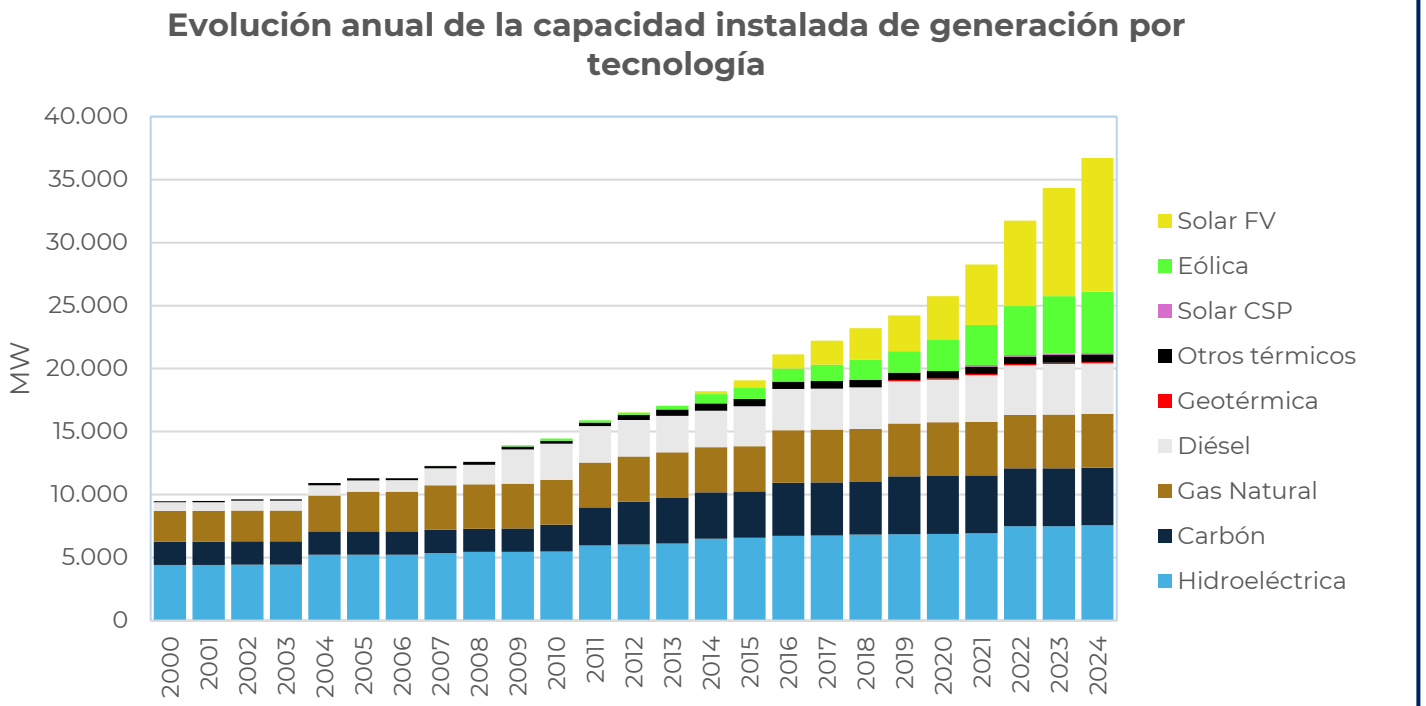


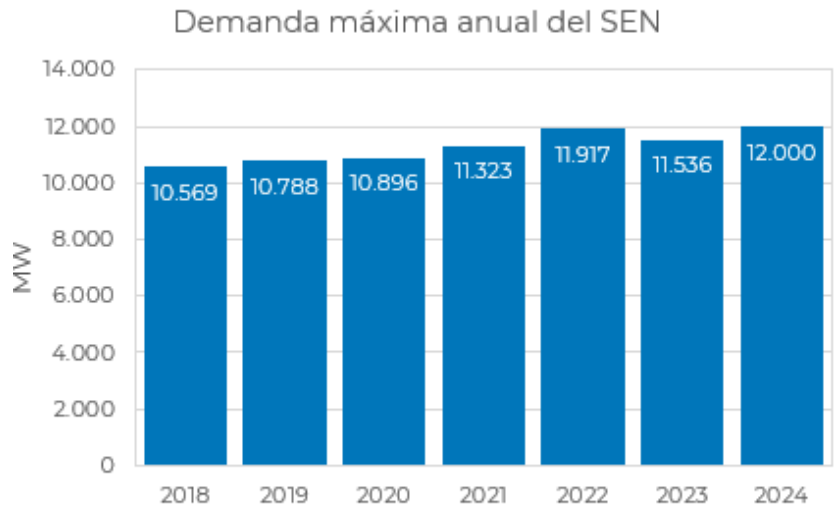
Fuente: elaboración propia.

Transition in the power sector: results to date

Renewable power dominates capacity increase

Installed capacity by technology



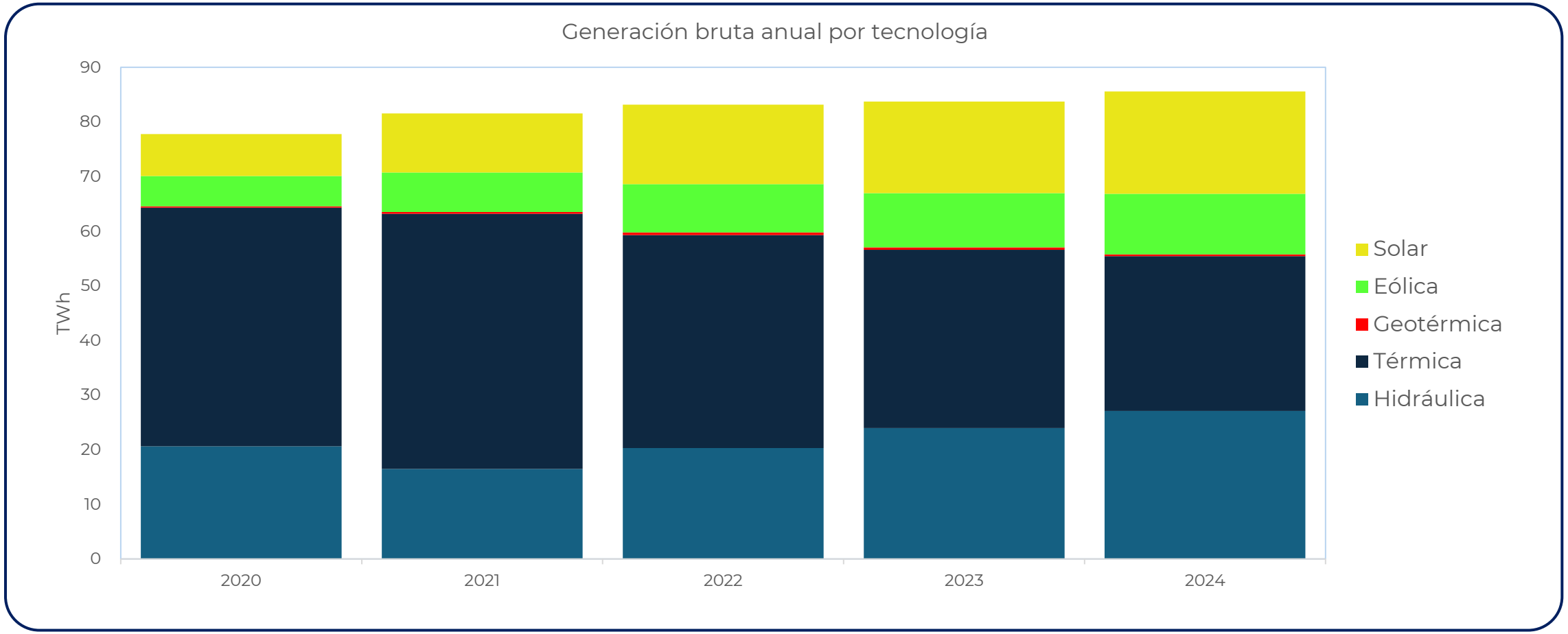


Fuente: Elaboración propia con datos del CEN y de la CNE

Transition in the power sector: results to date

Renewable power generation increases its share

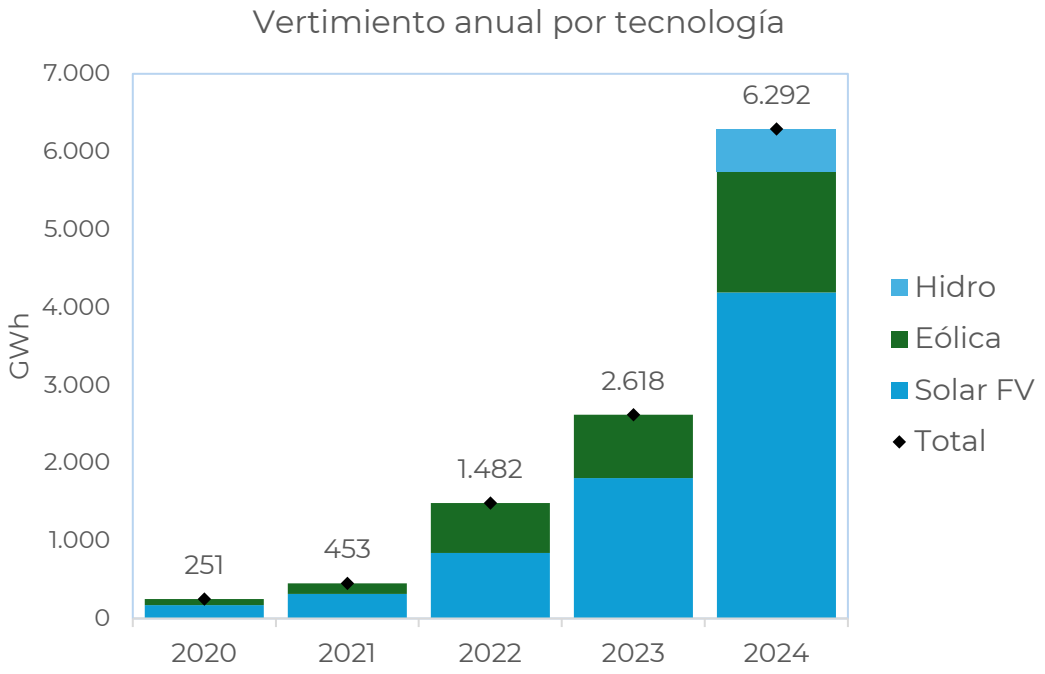
Power Generation (TWh)

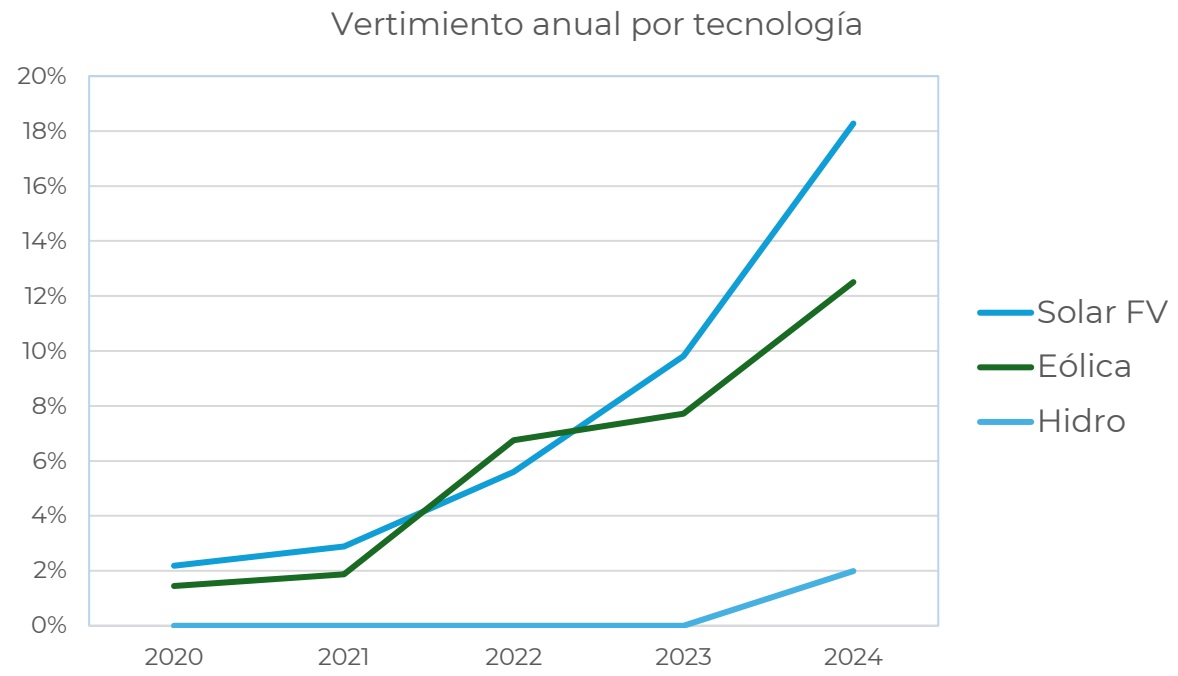


Transition in the power sector: results to date

Generation/transmission capacity imbalance: A "decoupled system"

Annual curtailment (GWh)

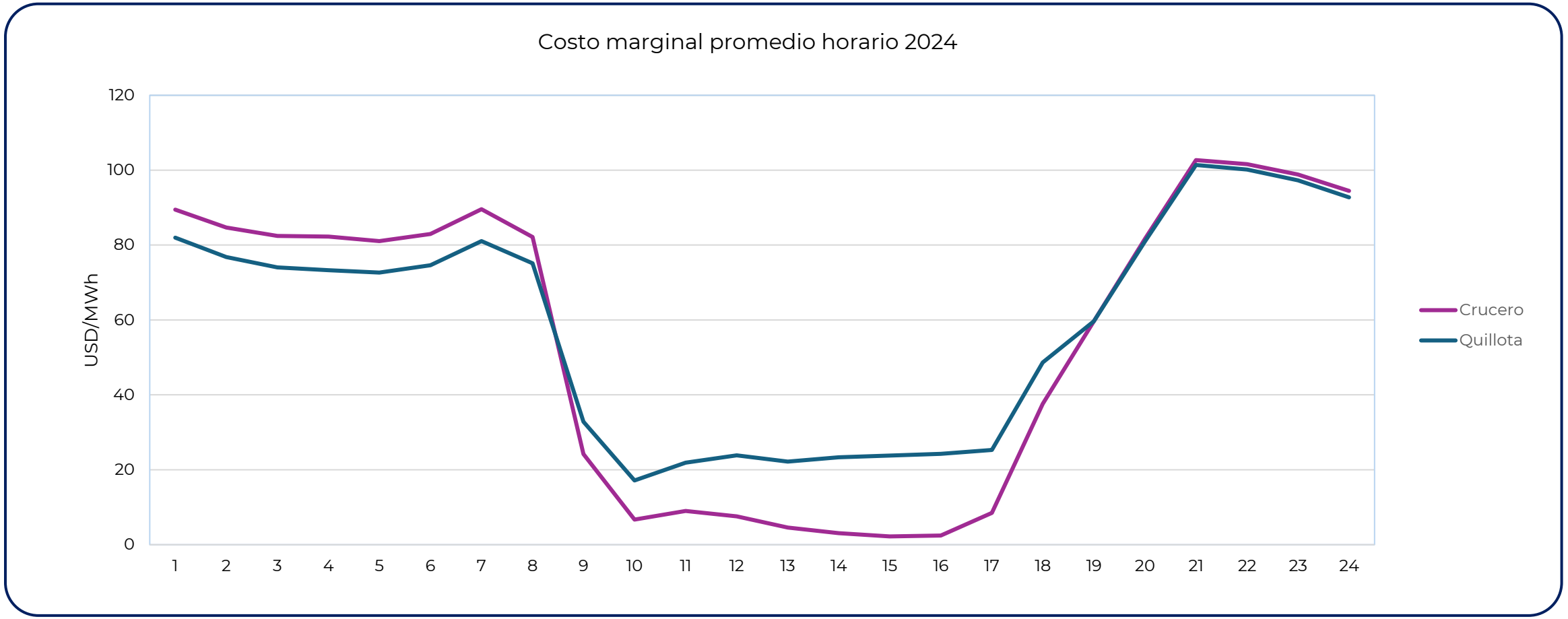




Transition in the power sector: results to date

Marginal costs

Average Marginal (energy) cost 2024 (US$/MWh)



Transition in the power sector: results to date

Many renewable players in Distress

CASE: Solar generation in the north...	SITUATION	IMPACT
not contracted	Most generation remunerated at "0" price	• Investent cost not covered
contracted 24*7	Exposure to "lateral“ hours (marginal cost)	• Purchase price of " lateral" power not covered by contract price
contracted with distribution companies	Exposure to " lateral" hours AND "decoupling"	• Purchase price of "lateral" power not covered by contract price • Inyection /withrawal marginal cost difference not covered by contract price

Energía

Mainstream inicia proceso de reorganización judicial para dos de sus sociedades en Chile

Se trata de Huemul Energía SpA y Cóndor Energía SpA, las que forman parte de la plataforma eólica y solar Andes Renovables de 1,4 GW en Chile.

Energía Mainstream ...

Mainstream, el segundo mayor actor eólico y solar en Chile, inicia reorganización judicial de sus operaciones en el país

Víctor Guillou

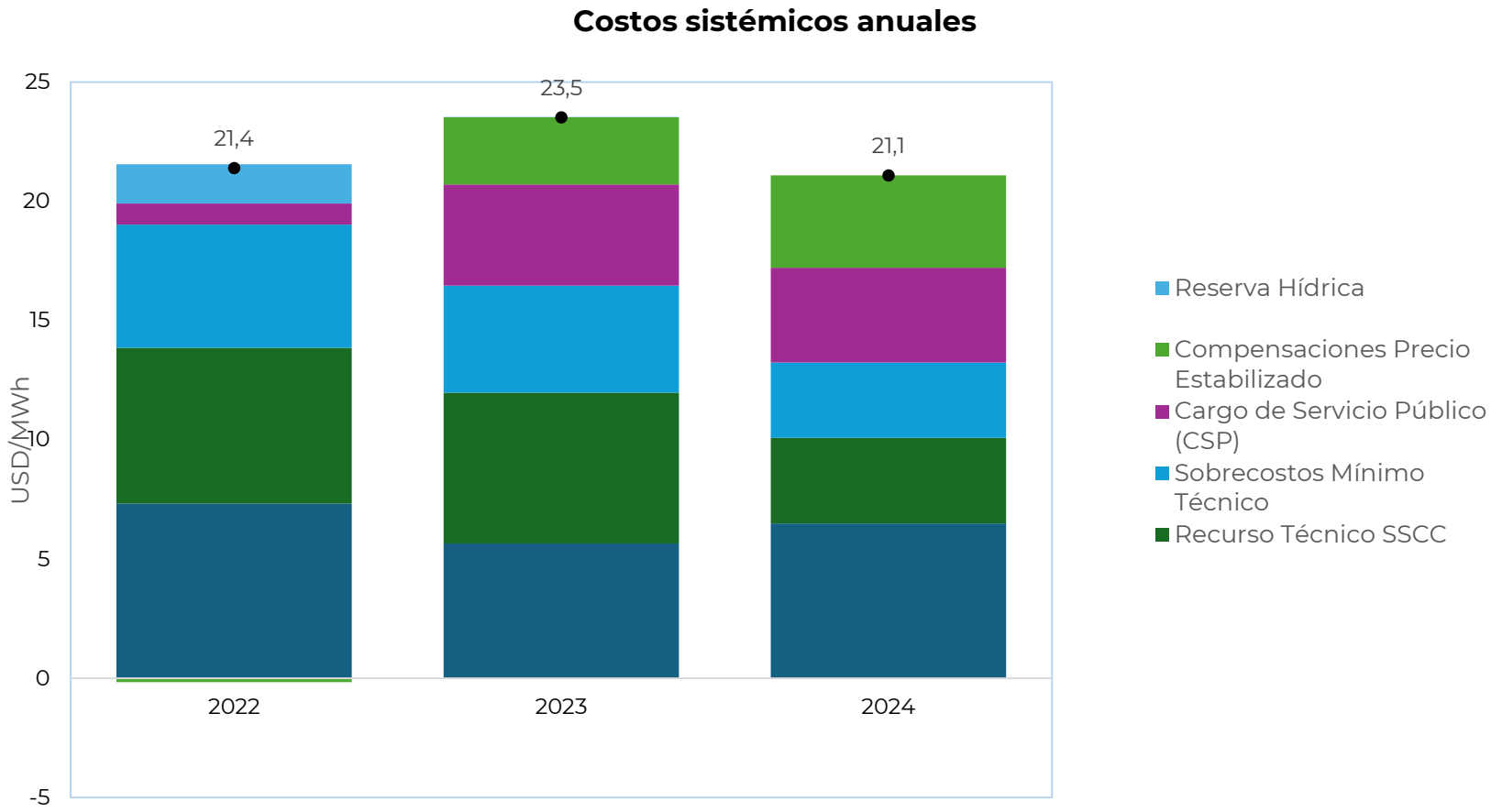
20 JUL 2023 06:44 PM

Tiempo de lectura: 5 minutos

Transition in the power sector: results to date

Systemic costs have increased

System Charges: (part of) the cost of green power

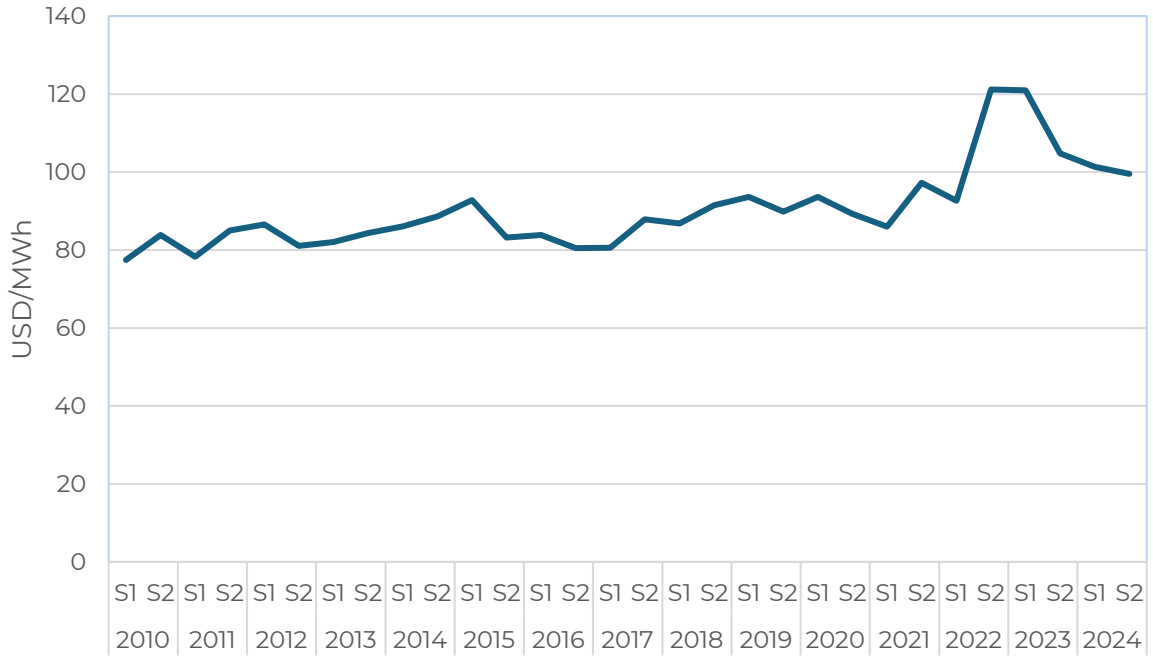


Transition in the power sector: results to date

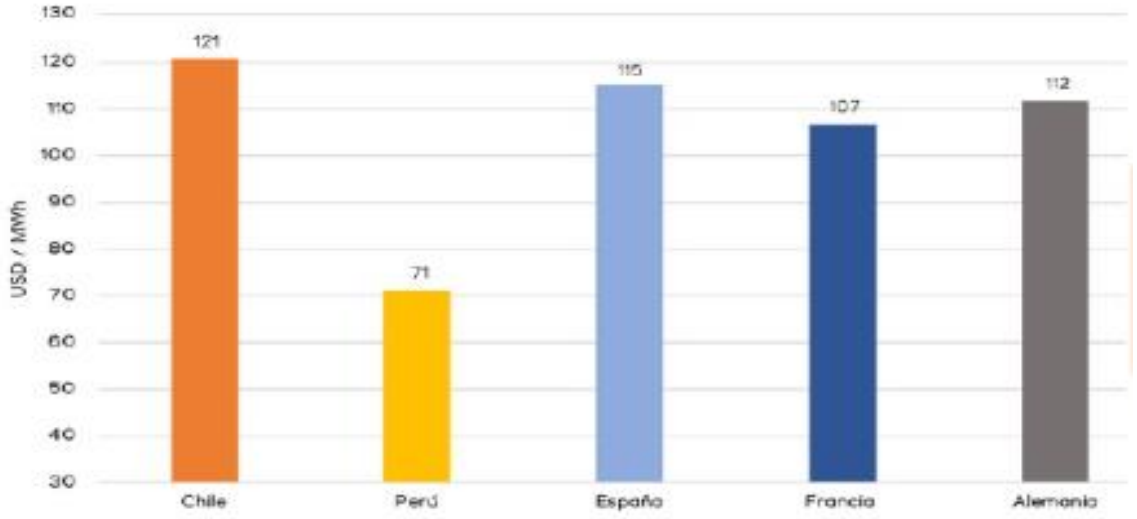
Prices have not decreased as expected

Energy/ Power prices

Average energy prices- distribution companies (US$ /MWh)



Comparative power prices – large industrial users (US$ /MWh)



Fuente: Elaboración propia en base a datos de OSINERGMIN (Perú) y AEGE (España)

Transition in the power sector: results to date

Reliability of the system challenged

- Lower capacity available to provide System Frequency and tension control
- Transmission bottlenecks
- Huge ramp-up/down (Cycling) of plants
- High share of "small plants“: system control hampered /mitigated by expensive contingency safeguards

MUNDO

“Apagón masivo afecta al 99% del país”: Así informó la prensa internacional sobre el corte de luz en Chile

Así informó la prensa internacional sobre el corte de luz en Chile - Agencia Uno / T13

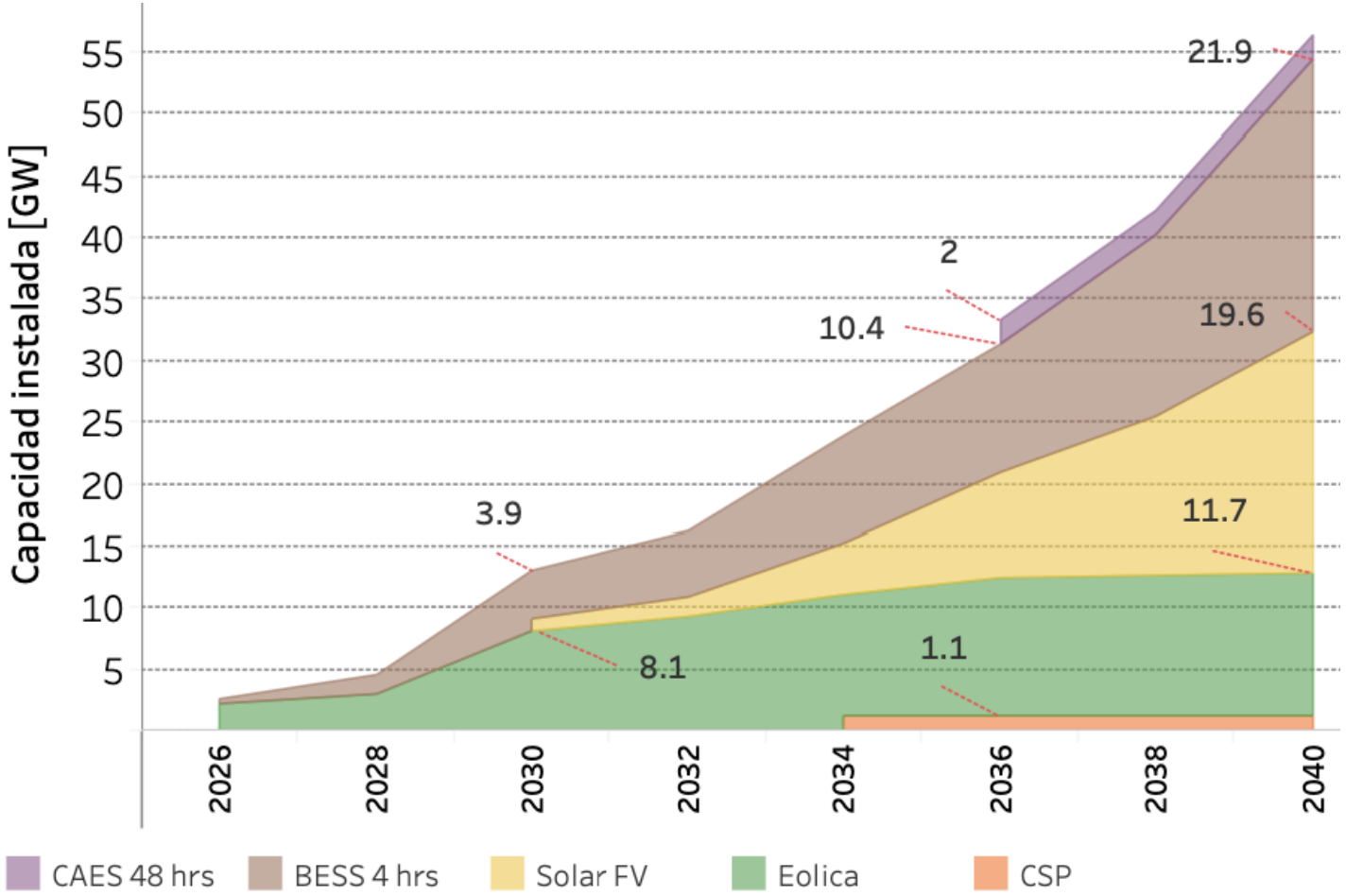
Net Zero target in Power generation : the way forward

Available technologies

	(US$ /MWh) LCOE	Variable Cost
Solar	20 ⇔ 30	n.a
Wind	35 ⇔ 50	n.a
BESS - stand alone (*)	25 ⇔ 35	n.a
Solar + BESS	45 ⇔ 55	n.a
CCGT	n.a.	60 ⇔ 70
Coal	n.q.	70 ⇔ 80
Diesel	n.a.	180 ⇔ 250

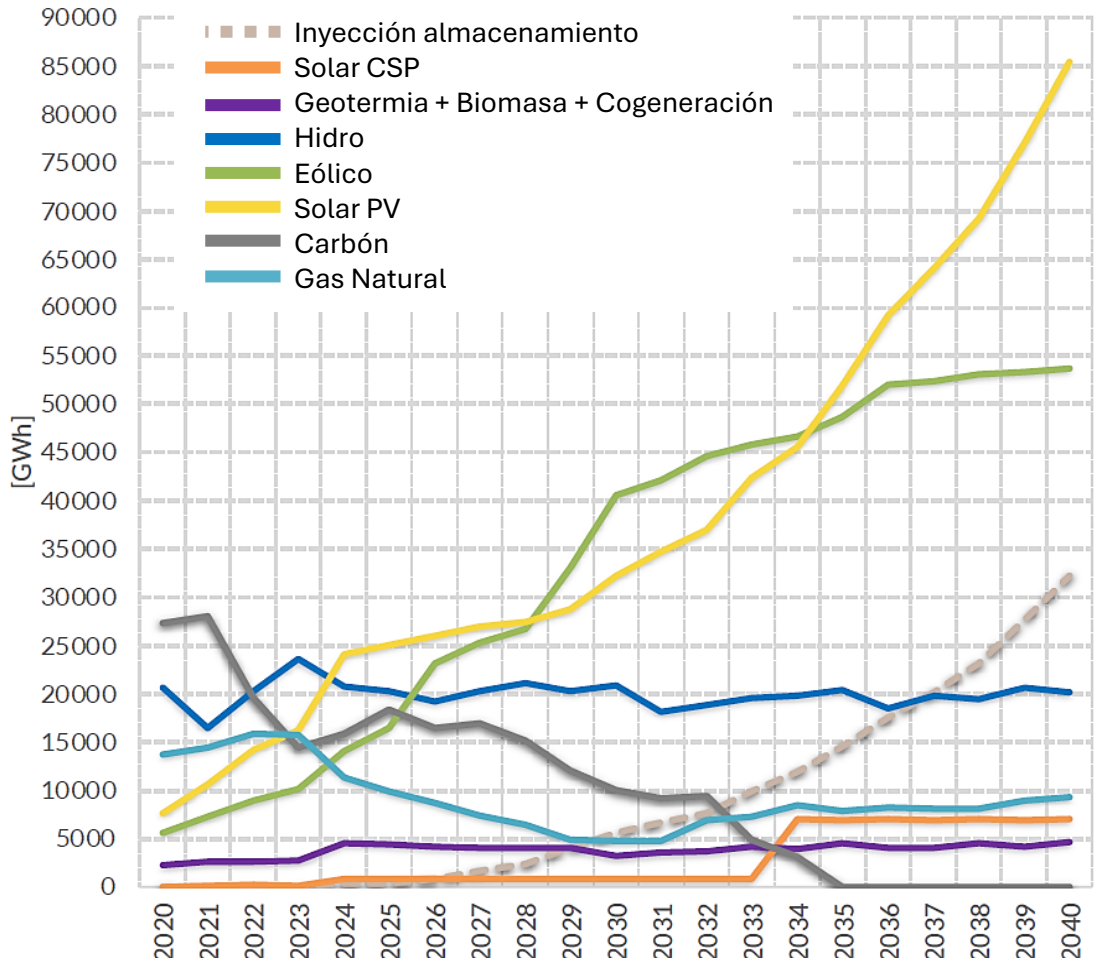
An aggressive transition scenario

New capacity



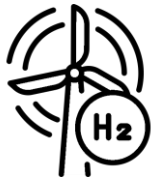
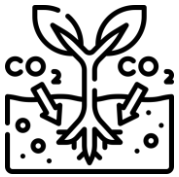
An aggressive transition scenario

Power generation



Energy transition in Chile : The Way Forward

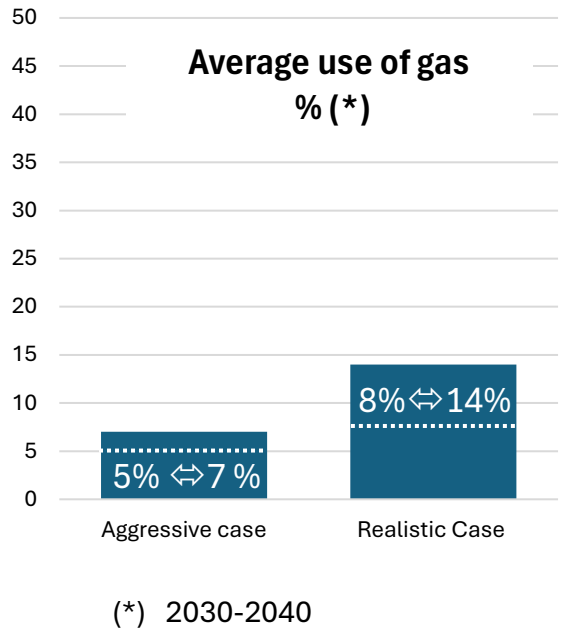
Main challenges (excl. power generation)

	KEY LEVERS	CHALLENGES
 **Transport Sector**	• Electric passenger / commercial vehicles • Hydrogen longer distance vehicles	• Vehicle replacement rate assumptions • Cost /price assumptions
 **Green Hydrogen Promise**	• Cheap power • Capex reduction	• High cost • Infrastructure
 **Forest CO2 sequestration**	• New Plantations	• Deforestation • Wildfires

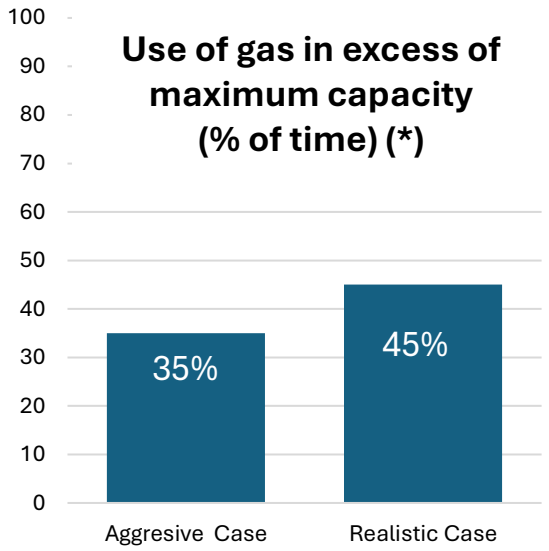
The role of gas going forward

Key drivers

- Variability of solar/wind generation (depth of DUNKELFLAUTE)
- System safety margin requirements
- Timing of transmission capacity expansion
- Coal plants decommissioning schedule
- Interest rates (cost of capital)
- Long term LNG price
- CSP competitiveness



(*) 2030-2040



(*) 2030-2040

Energy Transition

Key regulatory changes required

- Recognition (remuneration) of capacity/ability to respond to (mainly) short term supply/demand imbalances
- Small non-conventional power generation must (also) be subject system operator control and curtailment
- Adjust remuneration of installed capacity to reflect actual contribution
- Probably move form marginal cost dispatch to short term demand/supply pricing

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