CHILE

FRONT-LOAD NET ZERO CASO CHILE

100% DECARBONIZATION OF ELECTRICITY IN 10 YEARS!

Sept 15, 2022
Santiago

CONTENIDO

Etapas en la transición de descarbonización

Etapas presentes in todos los estudios de descarbonizacion Path 100 (140 estudios de paises)

	Etapa 1 "Construir un sistema limpio robusto y capaz de desplazar el carbón"				**Etapa 2** "Cerrar las ultimas plantas inflexibles & establecer almacenamiento de largo plazo con combustibles sustentables"		
QUE HACER	Agregar solar & eólico	Add BESS* for A/S Comenzar agregar plantas flexibles a gas	Comenzar a cerrar plantas carbón e inflexibles	Agregar combo Solar – BESS	Finalizar el cierre de plantas carbón	Adicionar renovables, BESS & plantas flexibles a gas	Cerrar las plantas inflexibles	Convertir las plantas flexibles de gas as combustibles sustentables **
POR QUE	**Incrementar % de renovables**	**Evitar e vertimiento & asegurar capacidad firme**		**Permite solar shifting**	**Mayor reducción de carbono**	**Alcanza > 90% renovables**	**Remover activos que NO tienen un rol**	**Job Done!**

5…10 años

** Hydrogen, Ammonia, Carbon neutral methanol & methane

* BESS= Battery storage

FLEXIBLE PLANT GAS/H2 READY

Traditional Peaker

- Operates only during annual peak hours
- Low Capacity Factors (0 to 10%)
- Provides capacity margin
- Characteristics:
  - Low CAPEX
  - High heat rate
  - High starting cost

Transition flexible Balancer

- Operates in pulses (300-1000 pulsing starts per year)
- Medium capacity factors (10-30%)
- Important role in balancing renewables
- Characteristics:
  - Adaptable
  - Fast start
  - Fast ramp
  - Minimal starting cost
  - Efficient at different load profiles

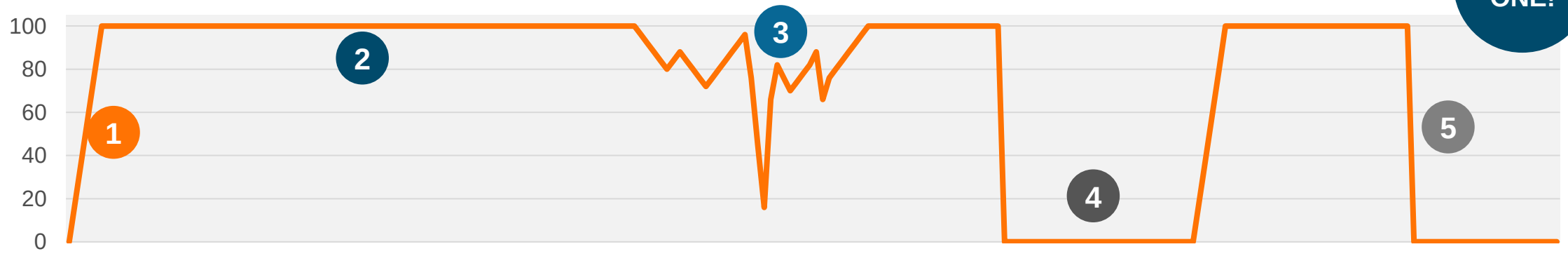
Decarbonized flexible Balancer

- Operates when batteries are empty
- Low capacity factors (<10%)
- Infrequent starts dependent on system conditions
- Characteristics:
  - Operate with zero-carbon fuels
  - Minimal starting costs
  - Flexible output (0-100% of nameplate capacity)
  - Lowest possible heat rate

WÄRTSILÄ

OUTPUT (%)

ALL IN ONE!



1 FAST START	2 BASELOAD	3 LOAD FOLLOWING	4 LOW-LOAD OPERATION	5 FAST STOP
• Power to grid in 30 s • 2 min to full power • Start up efficiency	• Highest simple cycle efficiency • Multi unit → high firm capacity	• High part load efficiency • Very fast loading and unloading • Run only as many units needed	• Very fast unloading • In multi-unit configuration less engines running needed for low load	• 1 min shutdown • No minimum up time • No minimum down time

ETAPAS EN LA TRANSICIÓN DE DESCARBONIZACIÓN

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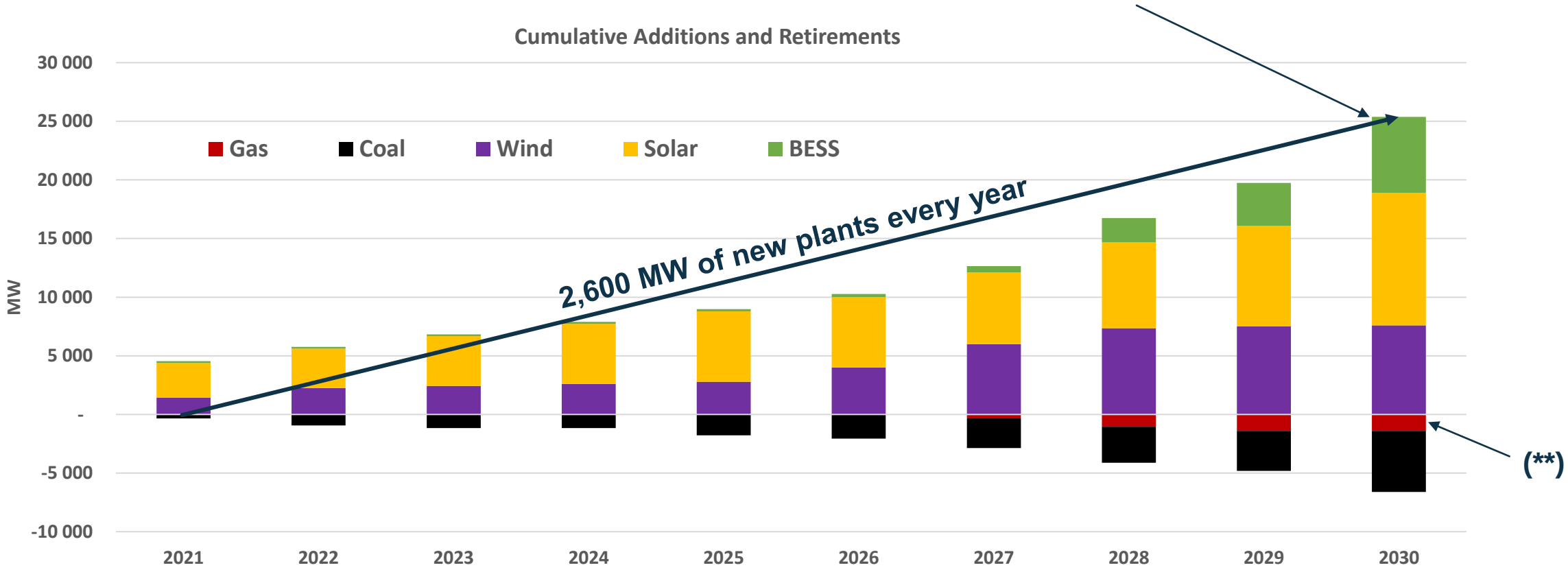
PRESENTATION CONTENTS

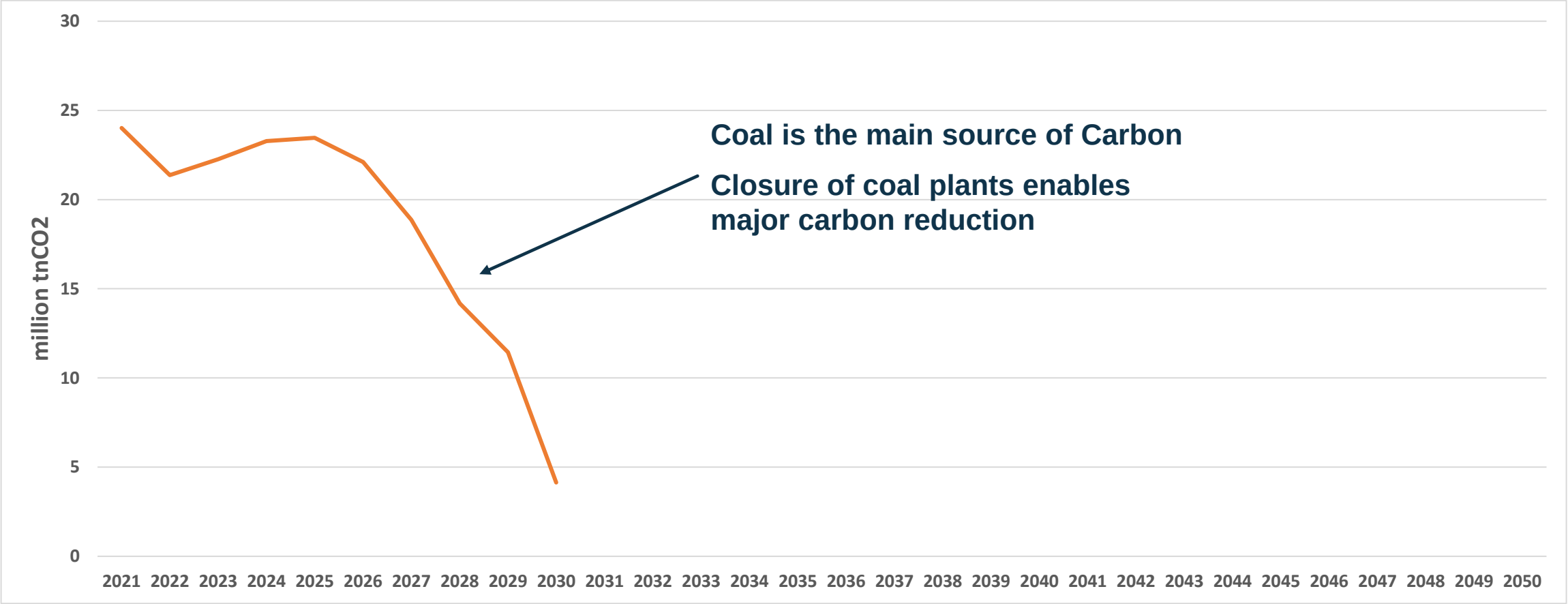
Current Plan - Cumulative capacity additions & retirements during the 2020´s

To enable coal closure, 26,000 MW (*) of new plants need to be built

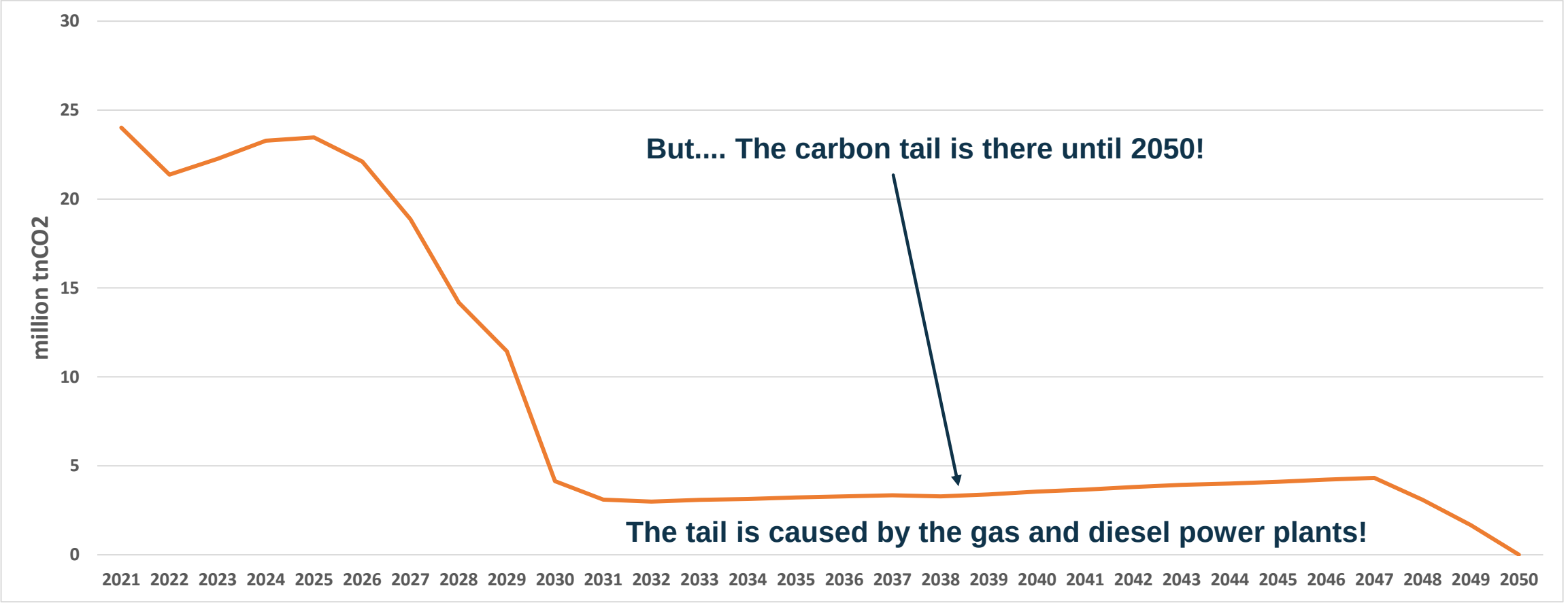


(*) Assuming normal high operational availability and reliability of all technologies. Recent statistics show lower availability for example to coal plants (only 75 % at times)
This would lead to a need to construct larger quantities of renewables, storage and flexible thermal earlier during the decade
(**) Gas power plants older than 35 year are retired by Plexos if they after rehabilitation cannot provide adequate value for the power system

Current Plan emissions until 2030



Current Plan emissions until 2050



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1 Wärtsilä Chile Path to 100 modelling studies

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4 Benefits of early decarbonization in 2032

5 Key takeaways

5 STEPS TO “GET RID OF THE TAIL” AND DECARBONIZE BY 2032!!!!

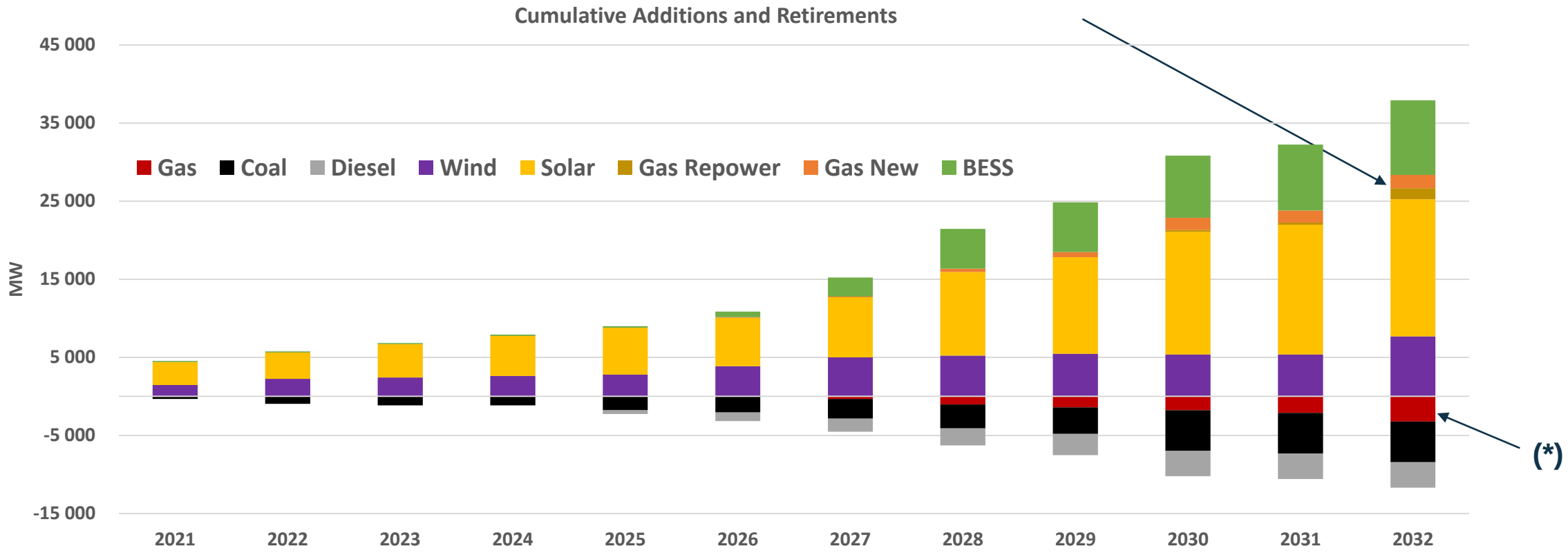
1. DURING 2020´S ADD 28 GW OF RENEWABLES AND BATTERY STORAGE *
2. STARTING 2028 ADD 2 GW OF FLEXIBLE & SUSTAINABLE GAS CAPACITY **
3. RETIRE ALL COAL & DIESEL OIL PLANTS BY 2030
4. IN 2032, CONVERT THE FLEXIBLE GAS PLANTS TO GREEN HYDROGEN-BASED FUELS (TOTAL 3.1 GW)
5. END OF 2032 100 % DECARBONIZED ELECTRICITY!!

* Geographic locations important, defined in 4 zones in the Wärtsilä study

** Fast starting plants which can be converted to green hydrogen-based fuels at any chosen time

Proposed capacity additions & retirements until 2032

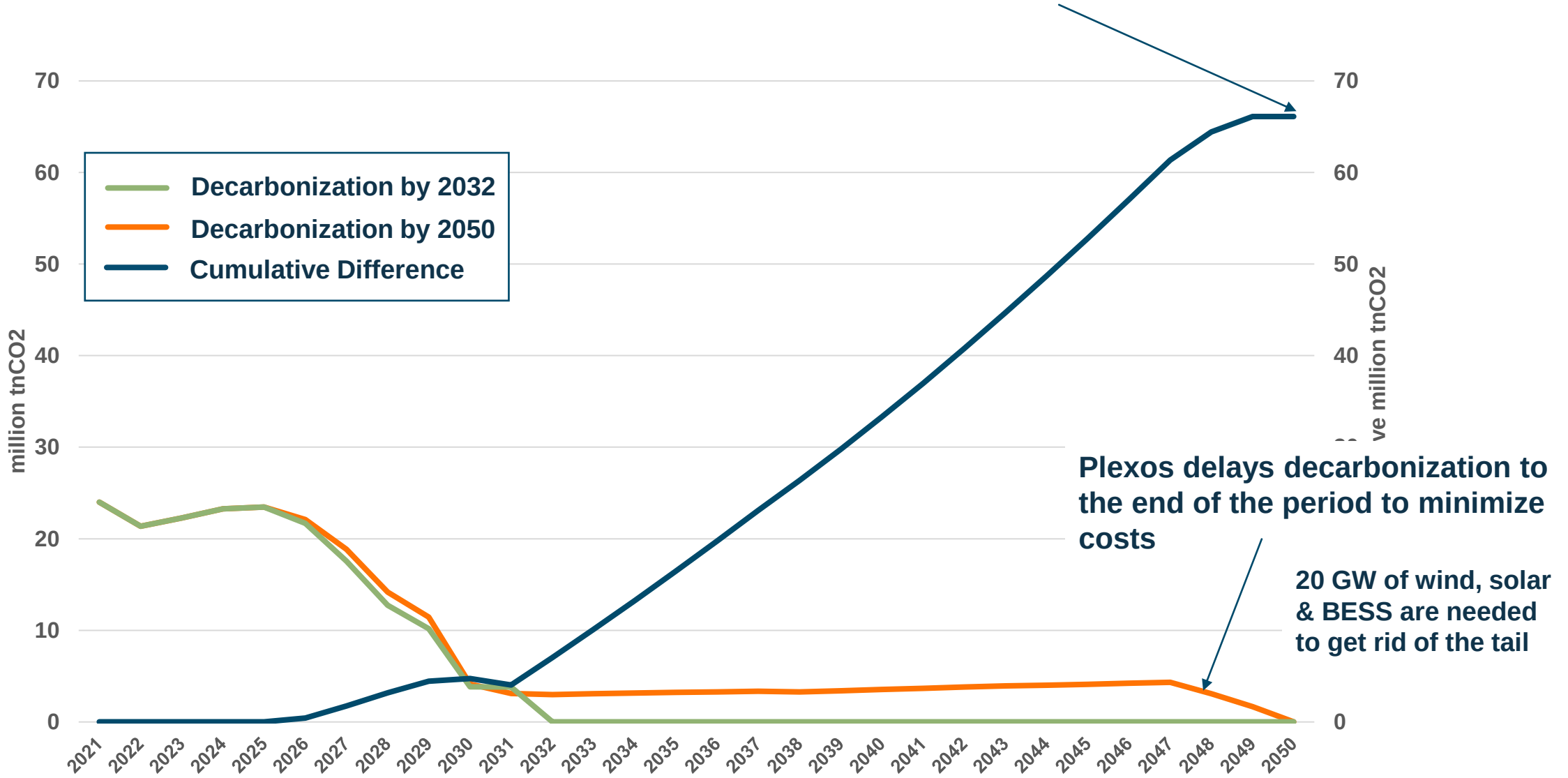
Replacing diesel and coal plants with 3.1 GW of Gas/H2 ready plants enables full decarbonization by 2032!



(*) Old gas power plants are retired by Plexos if rehabilitation and fuel conversion makes them uneconomical assets for the power system

CO_2 EMISSIONS

Decarbonization by 2032 reduces cumulative carbon by 66 MTons!

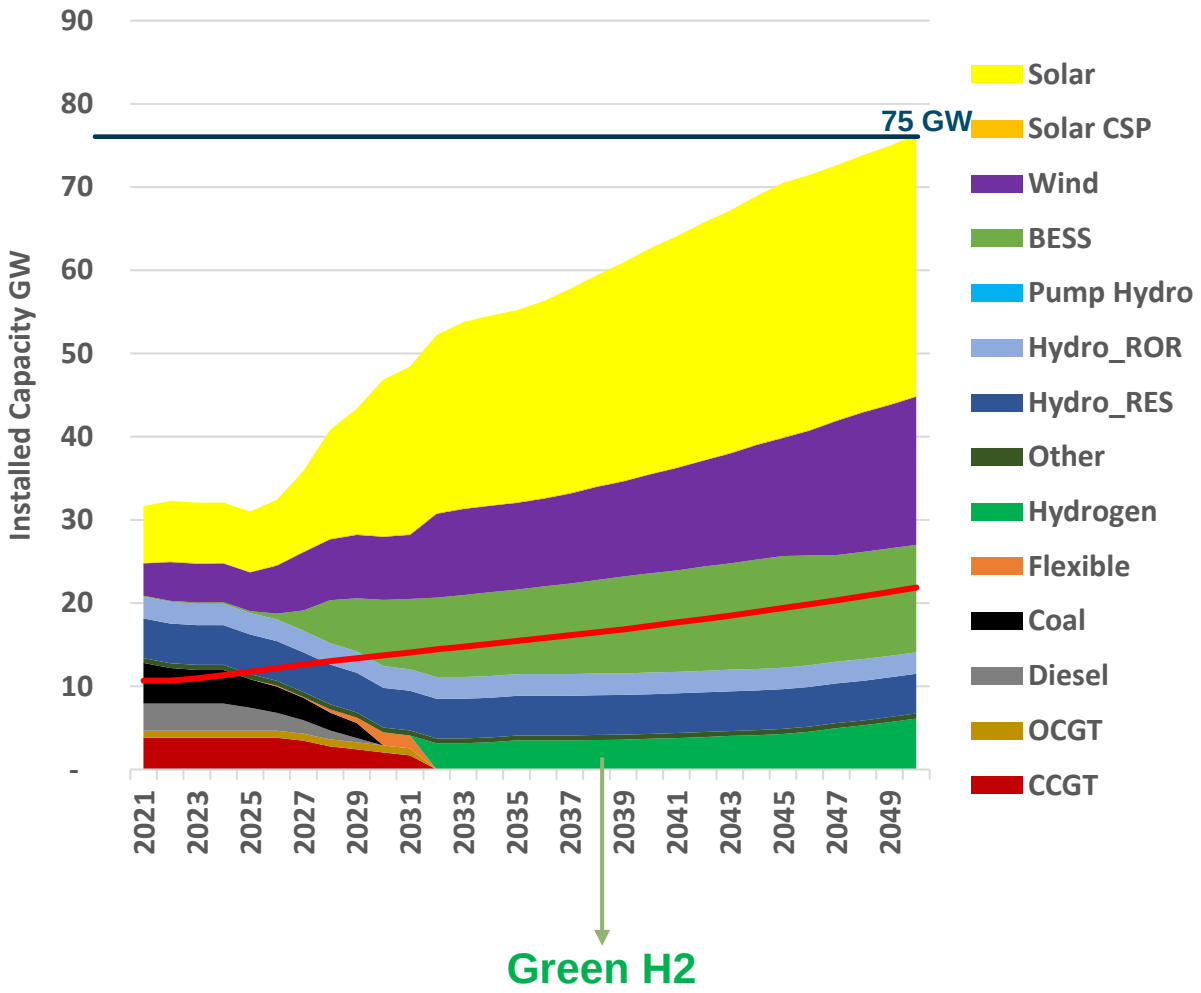


Plexos delays decarbonization to the end of the period to minimize costs

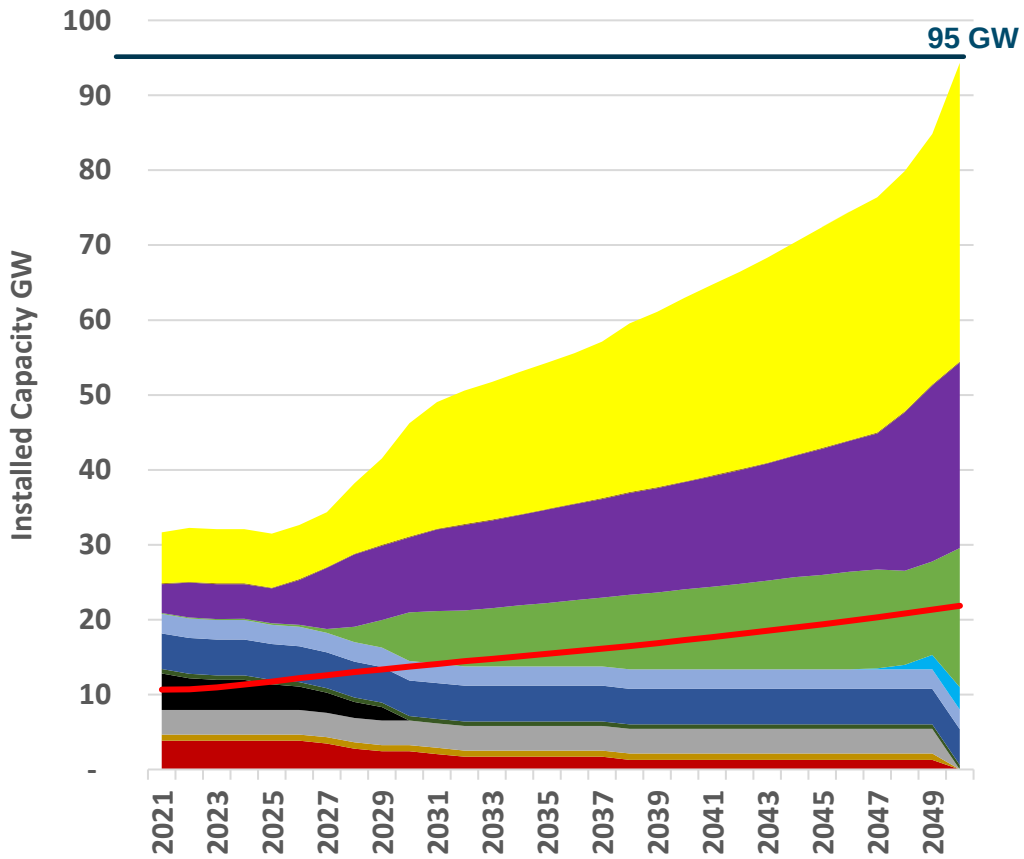
20 GW of wind, solar & BESS are needed to get rid of the tail

INSTALLED CAPACITY 2021 - 2050

Decarbonization 2032



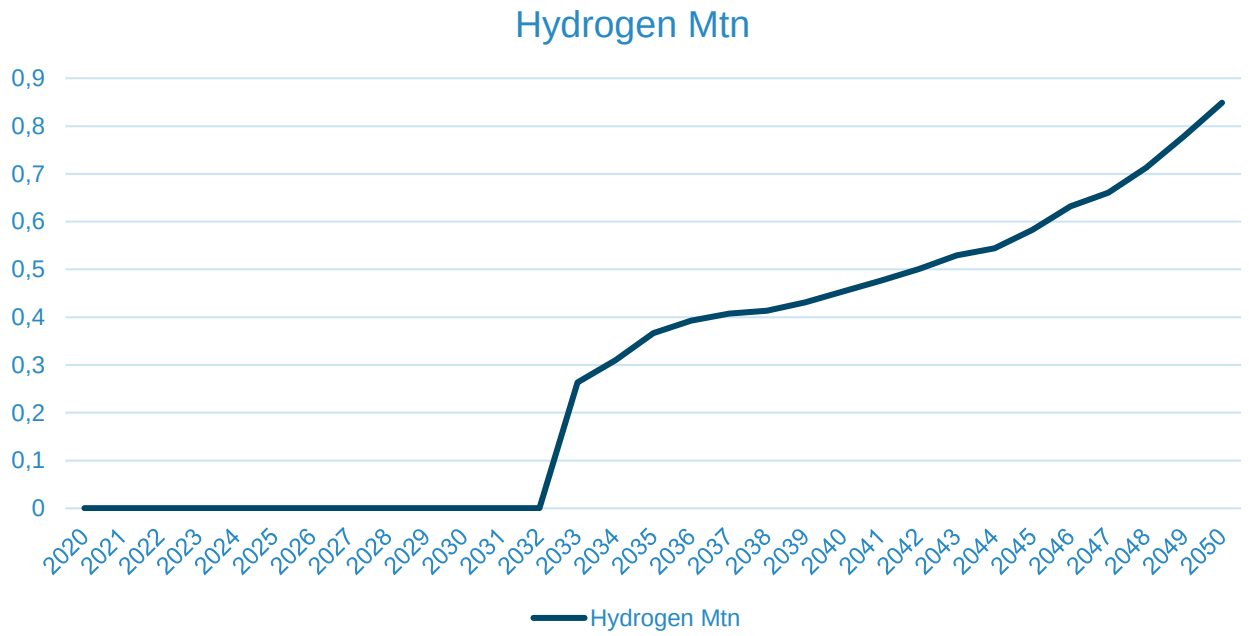
Current plan – Decarbonization 2050



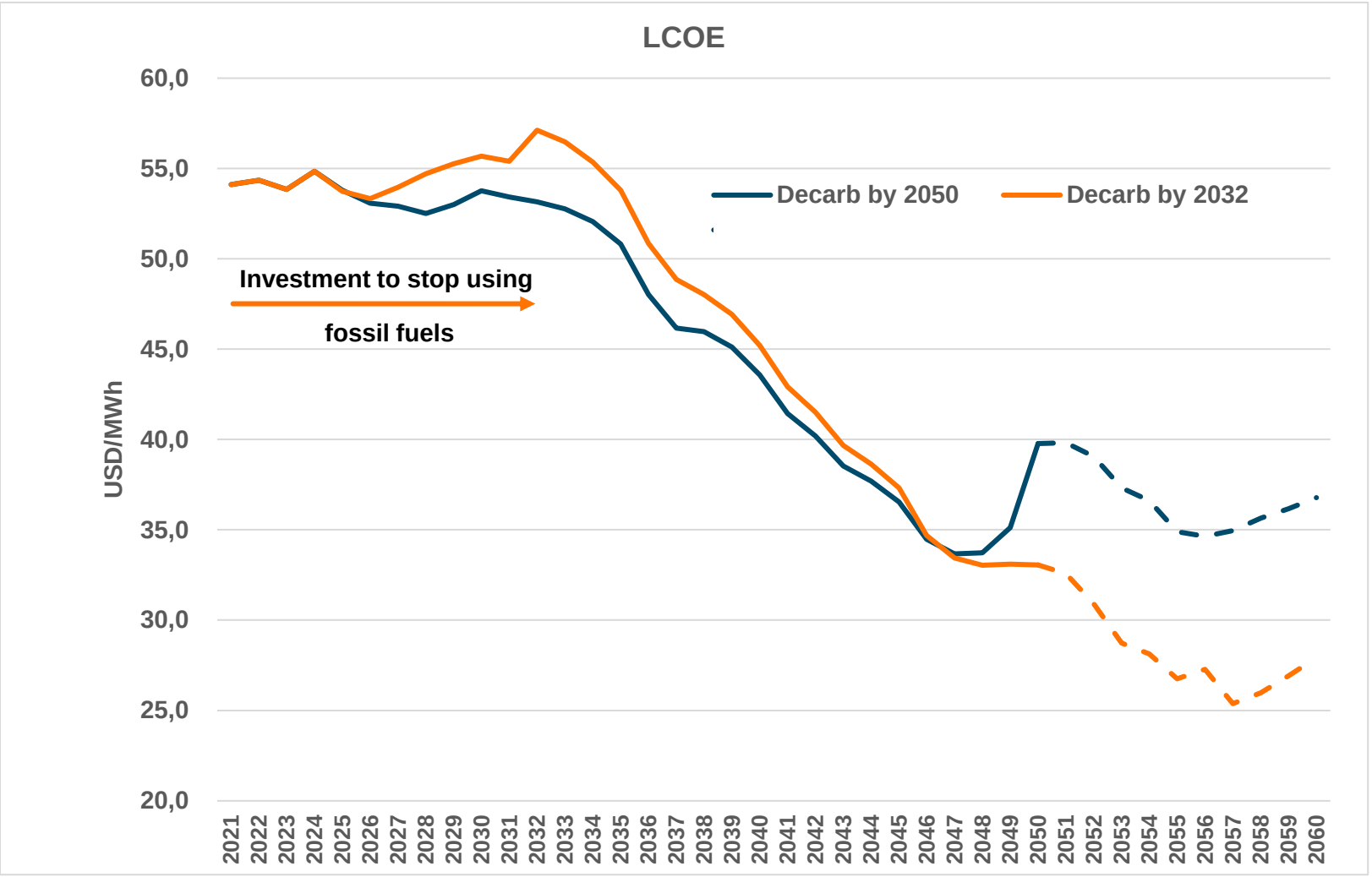
Sustainable gas power plants use only a fraction of available domestic Hydrogen

Chile Hydrogen Strategy

Annual Hydrogen offtake of hydrogen-fired power plants



ANNUAL GENERATION COSTS - DECARBONIZATION 2032 VS 2050



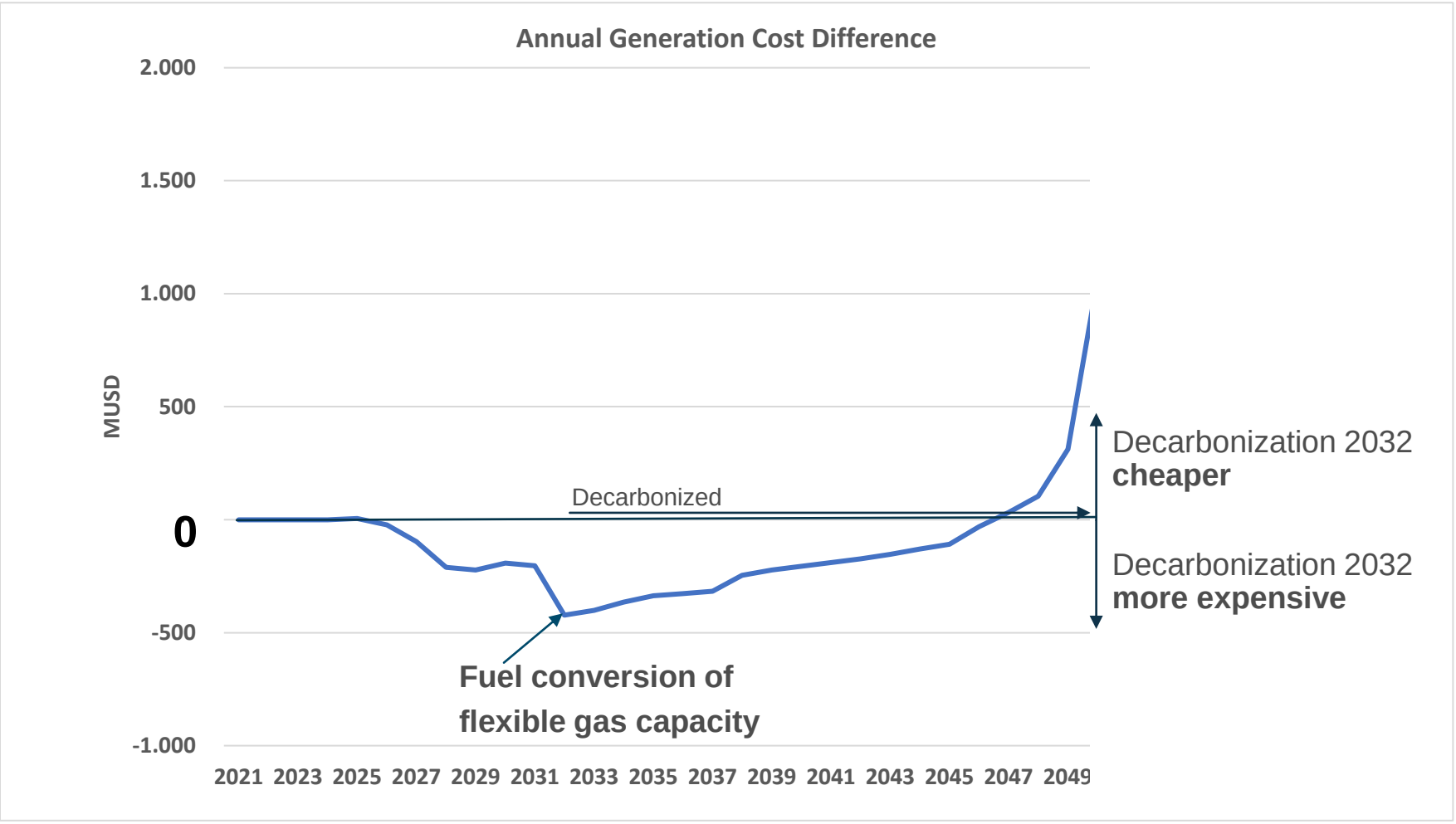
Contrary to common belief decarbonatization reduces energy cost

Dramatically reduced fuel price volatility risk

Late decarbonization pushes up generation costs strongly after 2047 (40%)

- 20 GW of additional wind, solar and BESS need to be constructed
- If the polluting diesels were maintained in the system until 2050, a capacity payment of 1,400 M$ dollar would have to be paid to them during 2030-2050 compared to the sustainable gas plants (not included in the cost graph)

ANNUAL GENERATION COSTS DIFFERENCE - DECARBONIZATION 2032 VS 2050



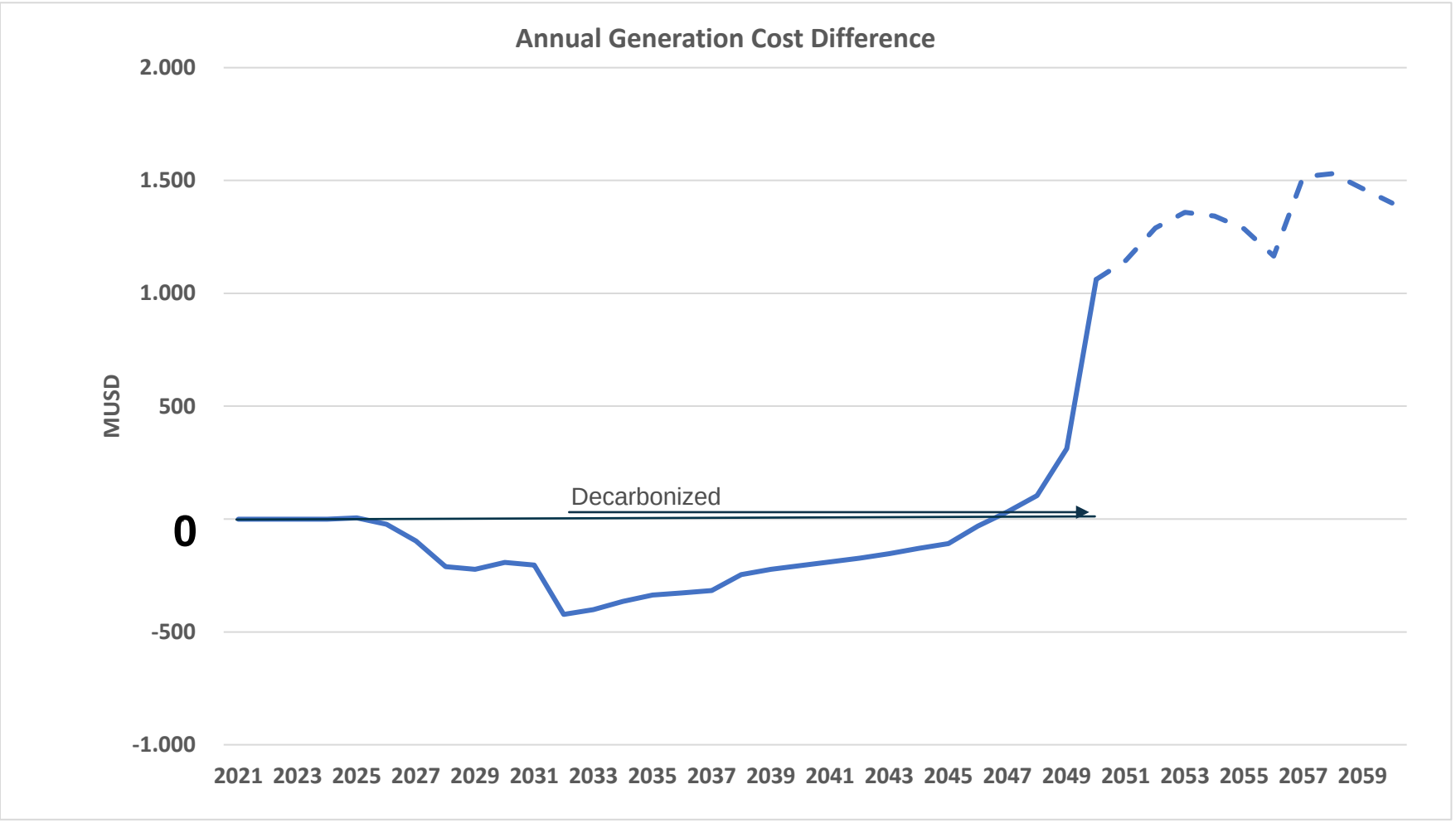
Total cumulative generation cost between 2022 – 2050 is 2,7 % higher with decarbonization in 2032 than decarbonization in 2050

- There will always be a cost related to getting rid of the last carbon

Total cumulative generation cost difference between 2022 – 2050 is minor in comparison with the **huge benefit of decarbonizing the system by 2032** instead of 2050

The cost profile is shifted. Most of the costs in 2030 are fixed, and the variable fuel costs have decreased dramatically compared to the costs in 2021.

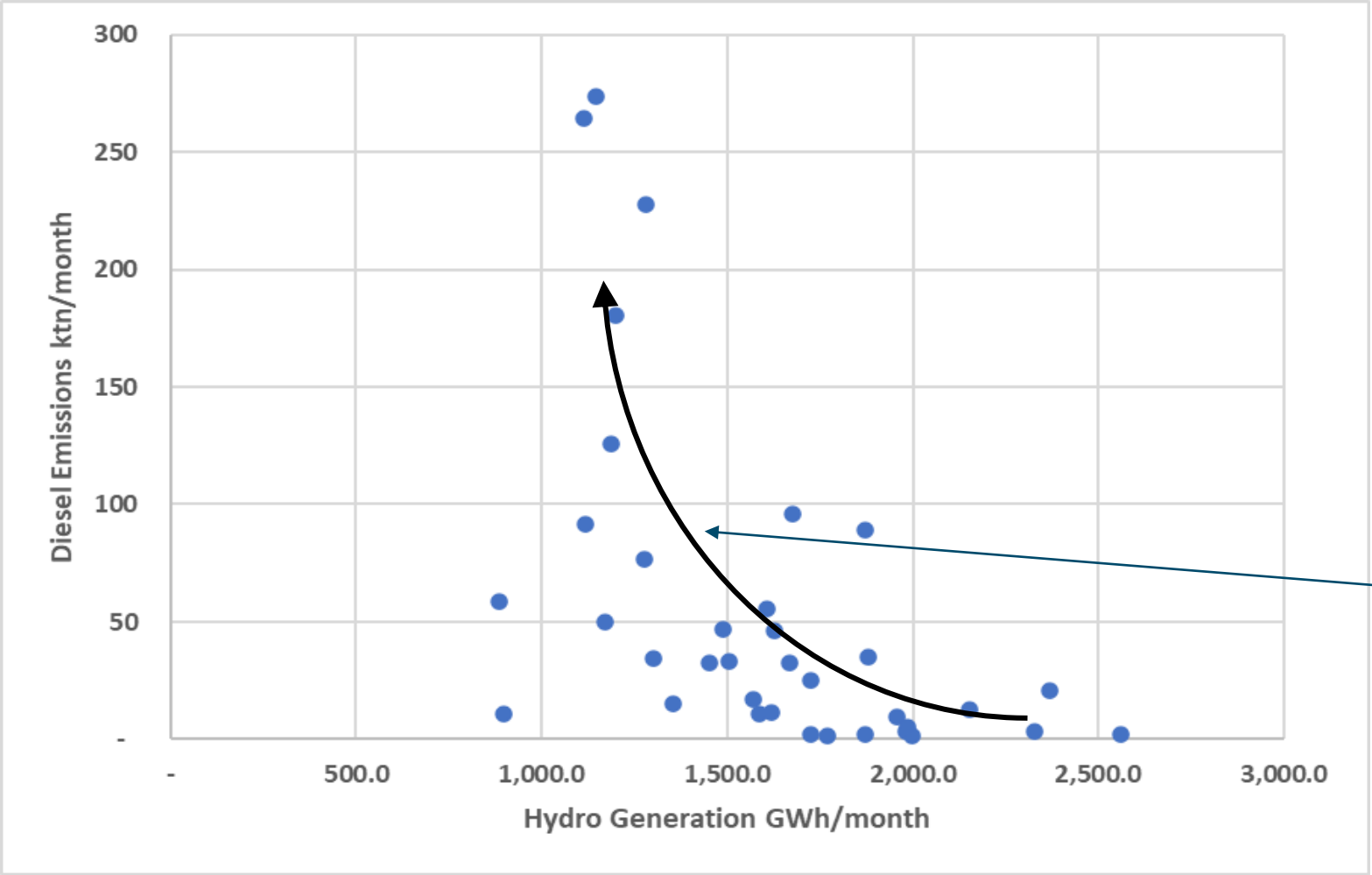
ANNUAL GENERATION COSTS DIFFERENCE - DECARBONIZATION 2032 VS 2050



Cumulative generation cost over 2022 – 2060 is 6.0 % LOWER with decarbonization 2032 than 2050

- Using sustainable fuel in power plants providing firm power reduces total power system size from 95 GW to 75 GW (20 GW / 27 % less!)
- Total investment savings of 14,337 M$

THE DIESELS WILL POLLUTE DURING DRY YEARS



Based on historical data

If maintained until 2050, 5,000 M$ of capacity payments are paid to the polluting diesels as a "security of supply insurance"

The same security is provided by the flexible gas plants that are converted to hydrogen-based fuels in 2032

- It is much better to pay the capacity payments to the clean, sustainable gas plants for the "reliability insurance" than for diesels
- Due to better efficiency, modern flexible gas power plants use less fuel than diesels, and provide much lower emissions due to cleaner fuels
- After fuel conversion the security insurance is 100 % carbon neutral

The diesels will not be part of the decarbonized power system for Chile

- Diesels use fossil fuels until retired, and produce high carbon when operated
- There is a clear relationship between hydrology and diesel running hours, and the carbon emissions
- It is not possible to convert the diesels to use Hydrogen

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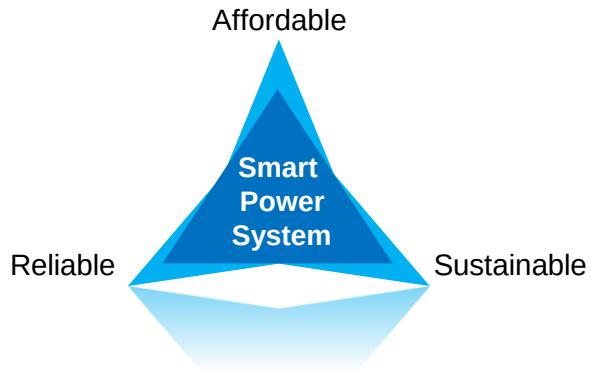
SUMMARY BENEFITS OF EARLY DECARBONIZATION IN 2032



Sustainability

- Chile a Zero Carbon nation 2033 onwards (on electricity)
- 66 MT emission reduction during 2033 – 2050

Reliability

- 3,1 GW firm generation capacity → Improved security of supply under all weather conditions

Affordability

- Total cumulative generation costs
  - 6 % savings over 2022 – 2060 with > 1,200 M$ annual savings after 2050
- 20 GW smaller power system total installed capacity (75 GW vs 95 GW) enables > 14,000 M$ saving in investments
- 1,900 M$ saving in cumulative thermal capacity payments during 2022-2050

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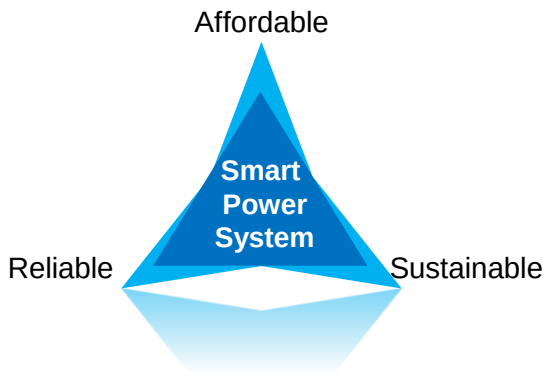
KEY TAKEAWAYS

- Chile has an ambitious plan to close coal plants by 2030, as part of decarbonizing electricity by 2050
- There is a technically and economically viable way to **decarbonize Chilean electricity by 2032!**
- This is an opportunity to
  - Become the **first country in the world to achieve carbon neutrality in the electricity sector**
    - Align power system development with national hydrogen strategy & use domestic sustainable fuels as long-term energy storage
    - Establish a global example of a most cost-efficient power system with minimal over-build
  - Ensure **better security of supply in any weather**
  - **De-risk fuel price and volatility impact**

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