International Workshop on
Dynamic Stability Challenges of the Future Power Grids

Lesson learned after the 2025 Chilean Blackout

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Chile

Monday, 7 September 2026, Winterthur, Switzerland

2025 Chile Blackout

International Workshop on Dynamic Stability Challenges of the Future Power Grids, DynPOWER 2026 Winterthur, Switzerland

Our group

https://c-ses.cl/
https://www.linkedin.com/in/c-ses-usach/

- **Facilities:** 3 Laboratories
- **Researchers:** 3 Faculty; 2 Postdoctoral Researchers; 3 PhD students; 6 Master's students; 9 Undergraduate students
- **Staff:** 1 Technical Manager, 1 Administrative Manager, 1 Communication Manager
- **Funding:** ~ USD $5 million (last 5 years)
- **Active project areas:** Real-time simulation, EMT models, Grid-Enhancing Technologies, Optimal Sustainable Construction, Optimal Fleet Management for E-Mobility, Artificial Intelligence for Control Room Applications.

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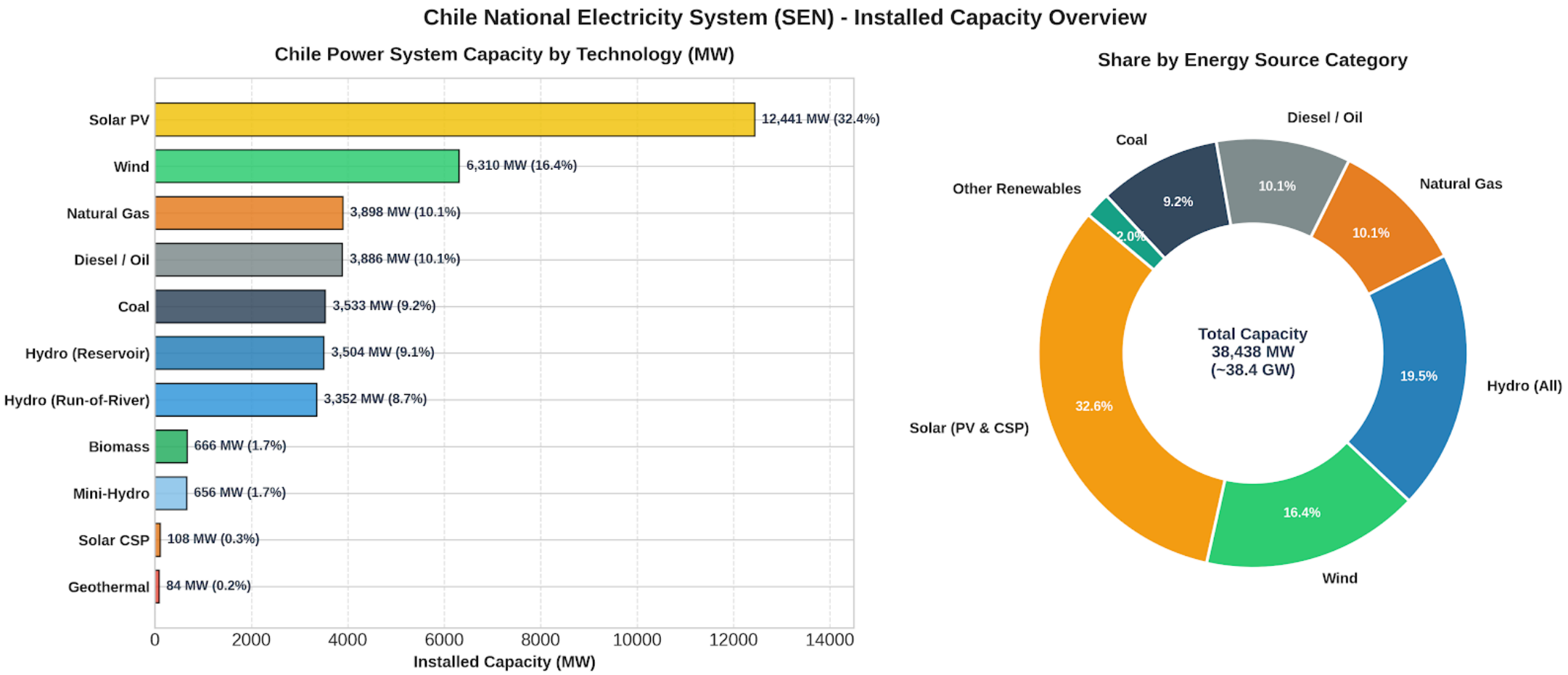
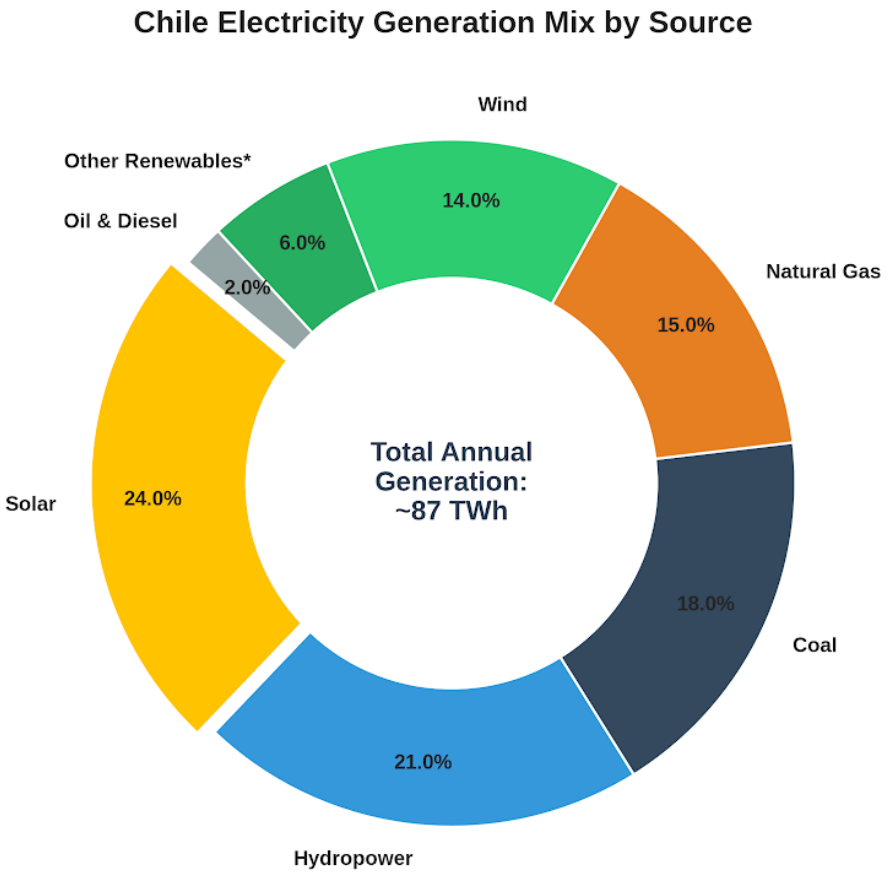
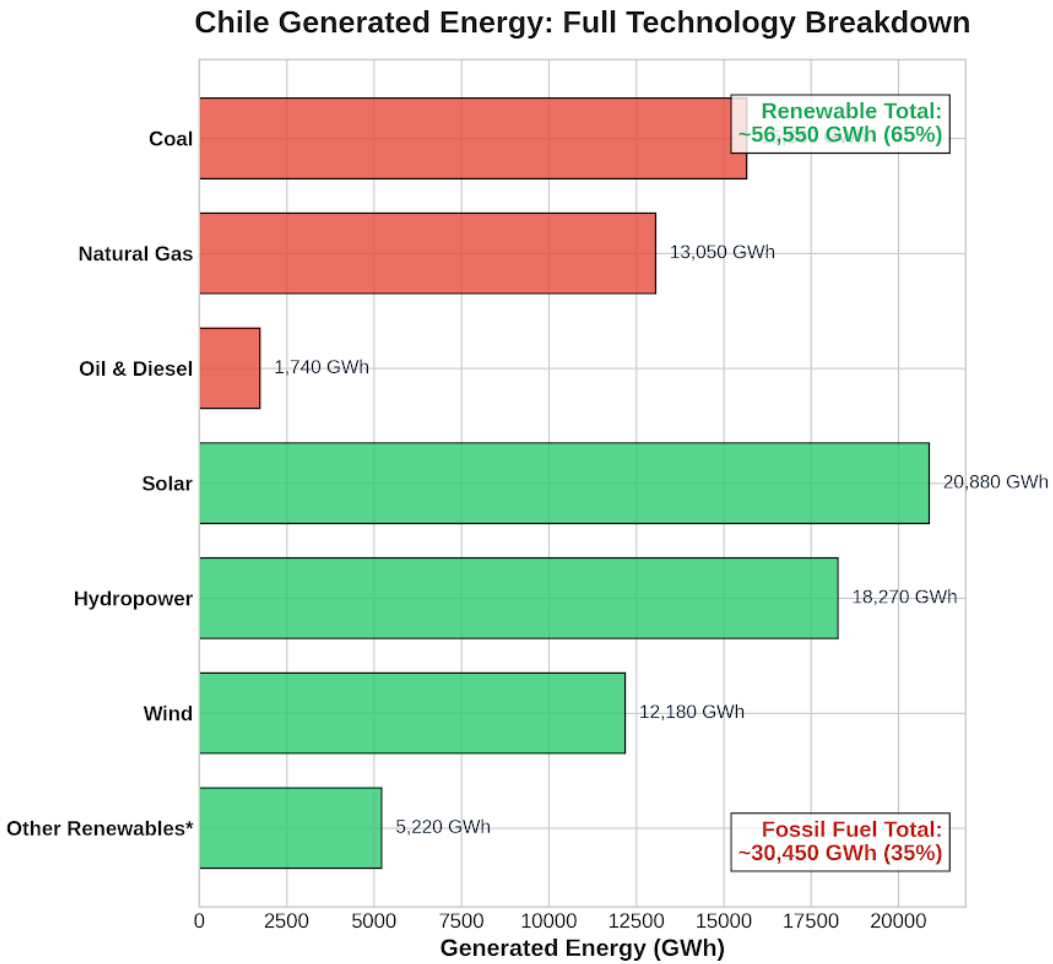
CENTER FOR SUSTAINABLE ENERGY SYSTEM

Chile Installed Capacity

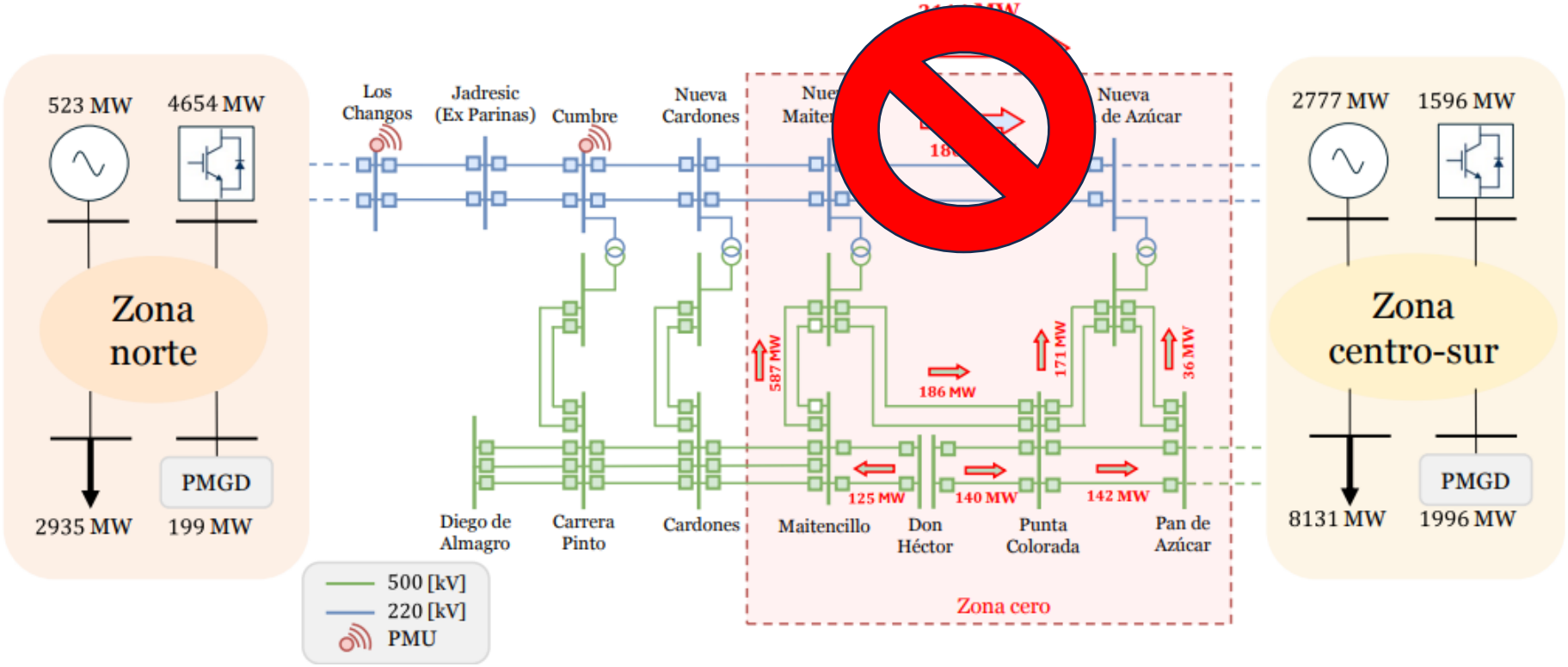


Chile 2025 Energy





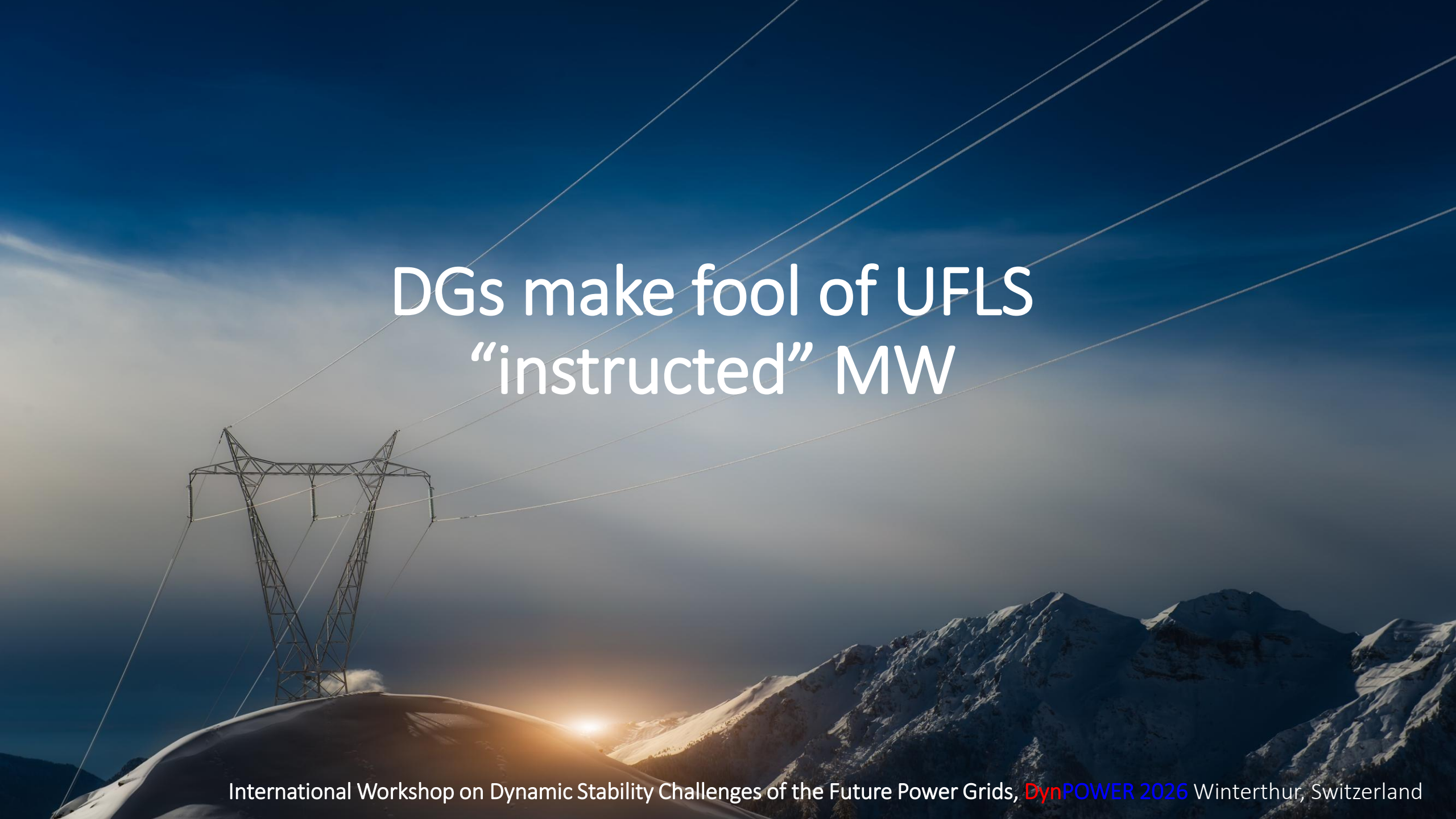
2025 Chile Blackout



1) DGs make fool of UFLS "instructed" MW.
2) Absence of a SIPS opening the 220 corridor after the opening of the 500 one.
3) Absence of converters' help (not the cause nor the solution).
4) The awareness that AS were meant to maintain power balance under "static" input conditions.

The 220 corridor stayed closed, causing oscillations for 1.5s; enough for the south/north islands to be unstable before the opening of the 220 corridor by overcurrent

- DGs make fool of UFLS “instructed” MW.
- Absence of a SIPS opening the 220 corridor after the opening of the 500 one.
- Absence of converters’ help (not the cause nor the solution).
- Control room real-time awareness features



DGs make fool of UFLS “instructed” MW

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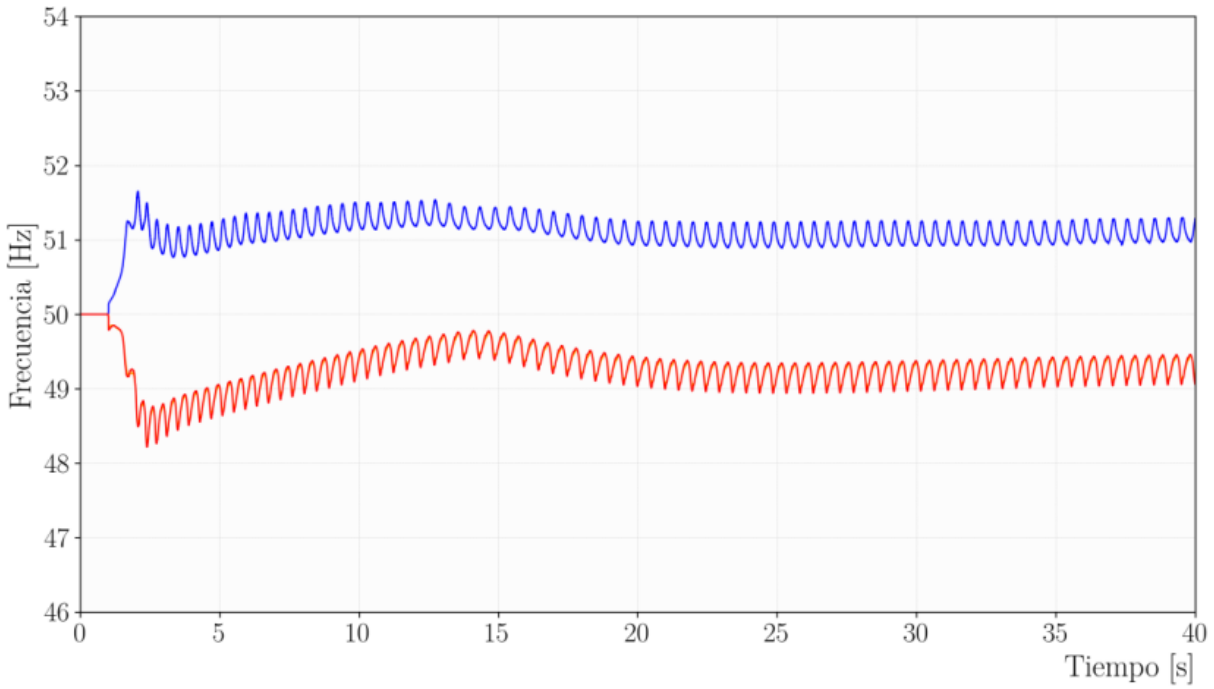
DGs make fool of UFLS “instructed” MW

Time	Disconnected DG Power	Accumulated	Type
$t = 0.7$	122.23	122.23	SIPS
$t = 1.1$	184.59	306.82	UFLS 1
$t = 1.5$	70.96	377.78	UFLS 2



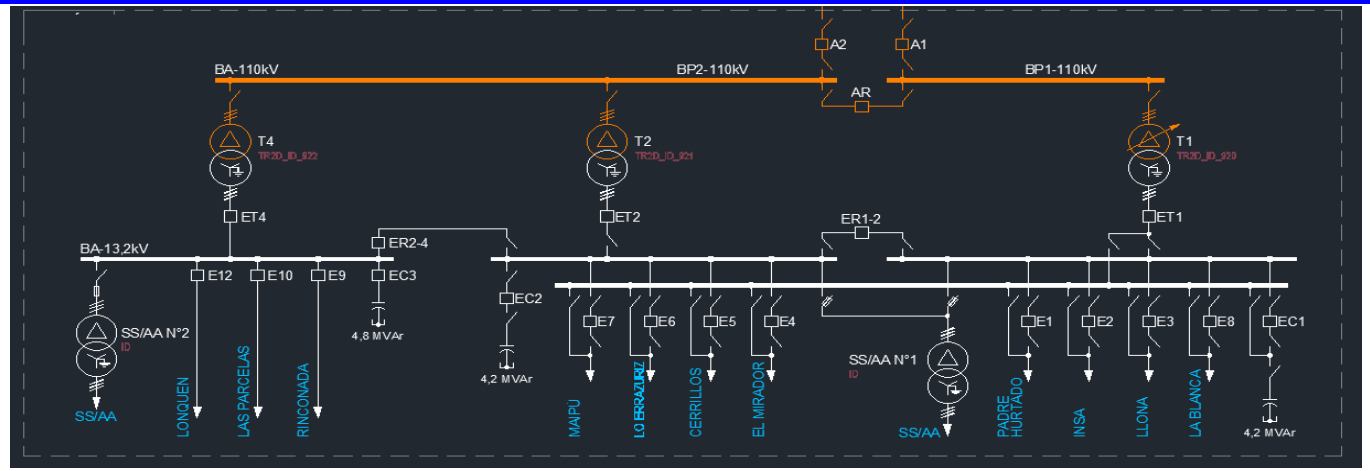
- UFLS implemented in distribution feeders get generation disconnects unintentionally.
- Simulations show that the unintended disconnection would have led to sustained oscillations, even though the 220 corridor was disconnected.

DGs make fool of UFLS “instructed” MW

Controlador

RTAC SEL

DNP3
IEC61850



Rele

GE F60

DNP3
IEC61850

Rele

SEL 351-A

DNP3
IEC61850

V , I

V , I

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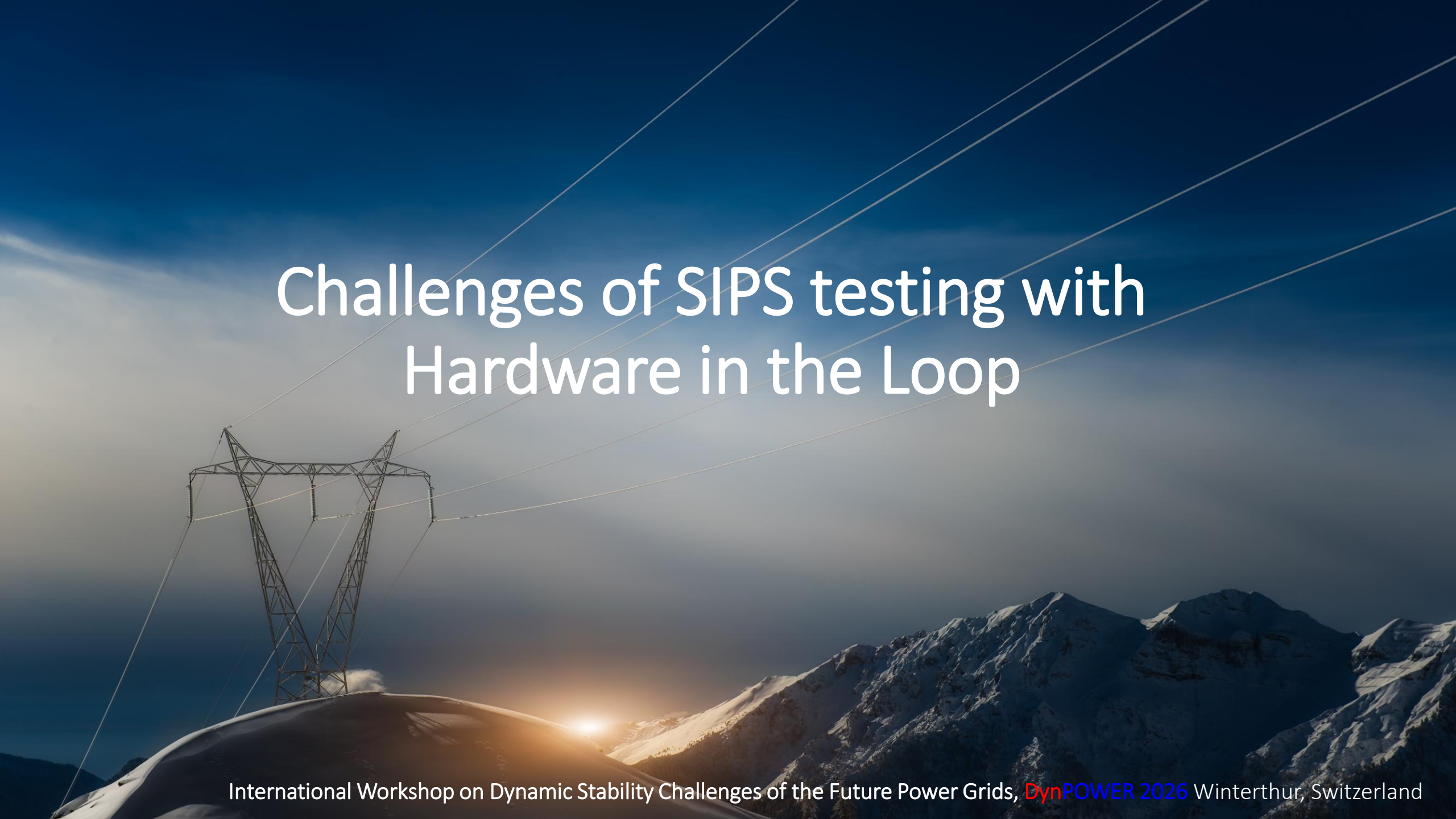
- A SIPS can compute the actual flow of a feeder at the substation level and determine the combination of feeder that sum up to the instructed power (currently working with a “reclosers’ network”



Challenges of SIPS testing with Hardware in the Loop

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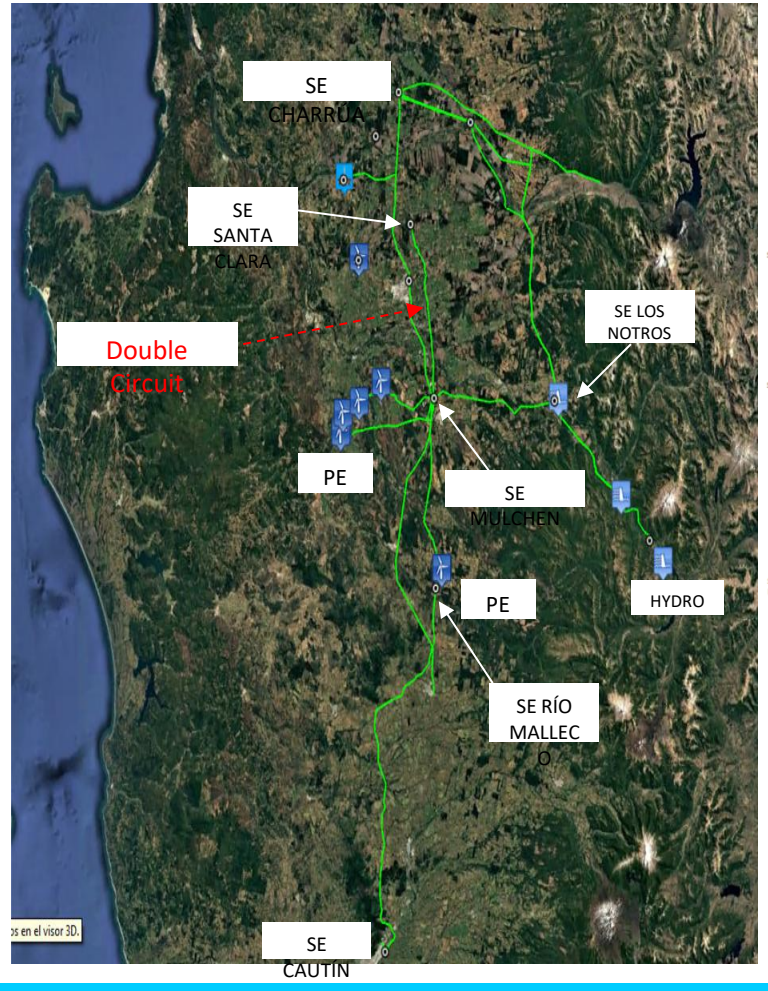
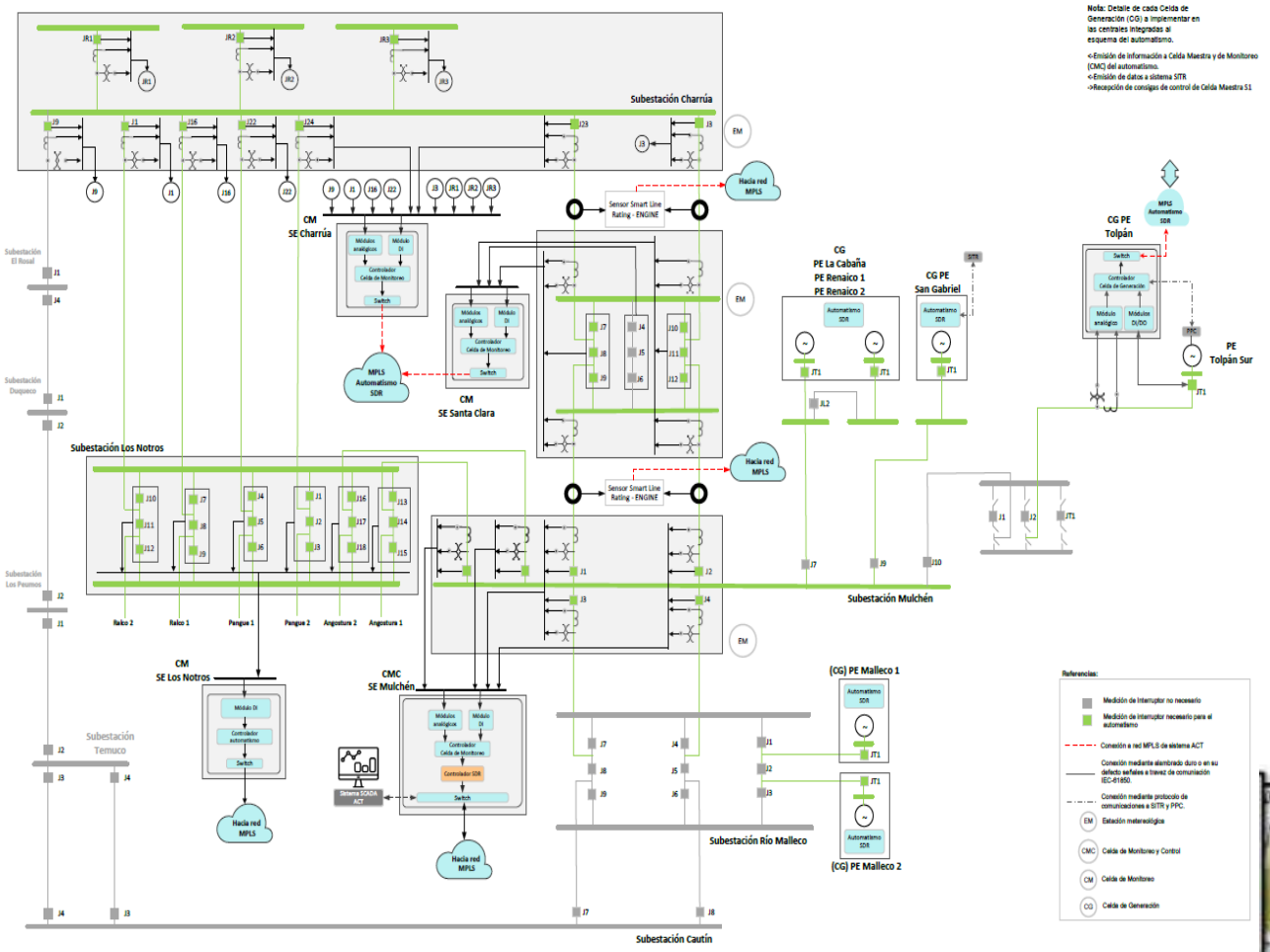
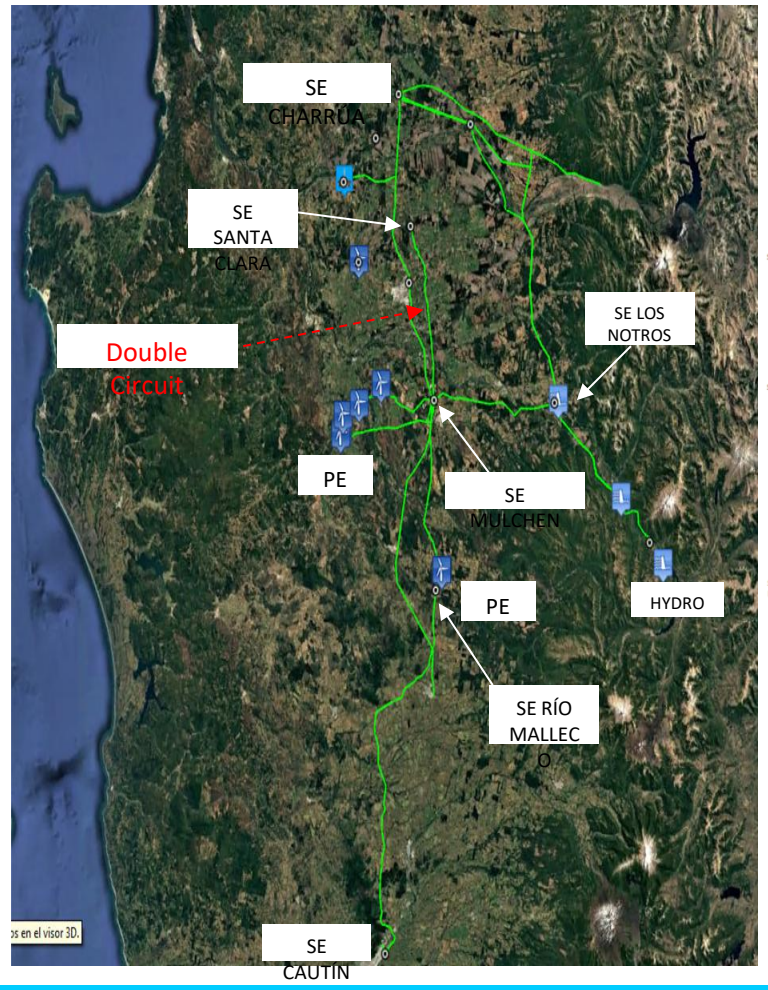
Challenges of SIPS testing with Hardware in the Loop

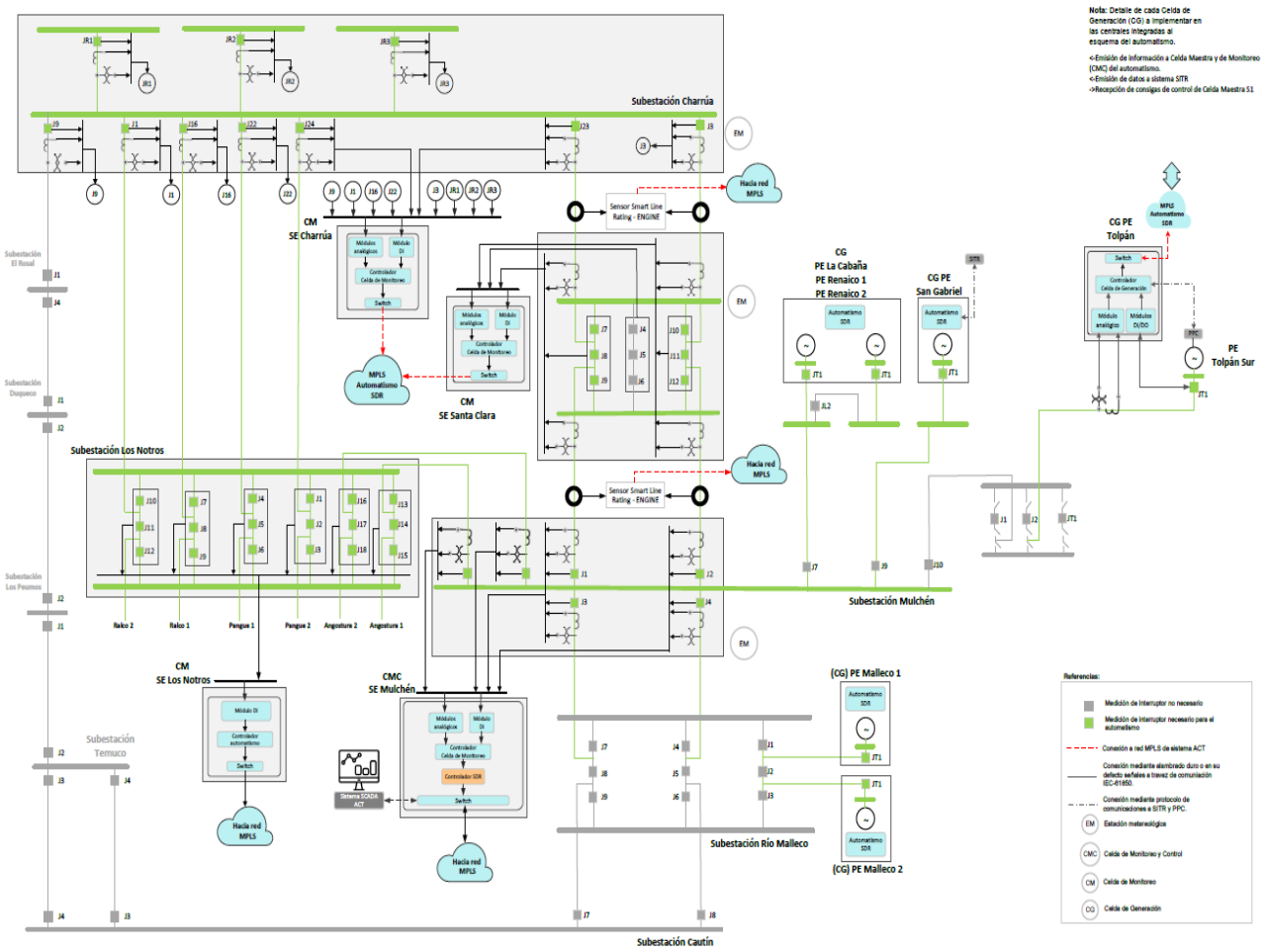




- Great wind resource curtailed by NINBY-delayed TX projects
- Vendor develops a controller to maximize power flow (minimize curtailment)

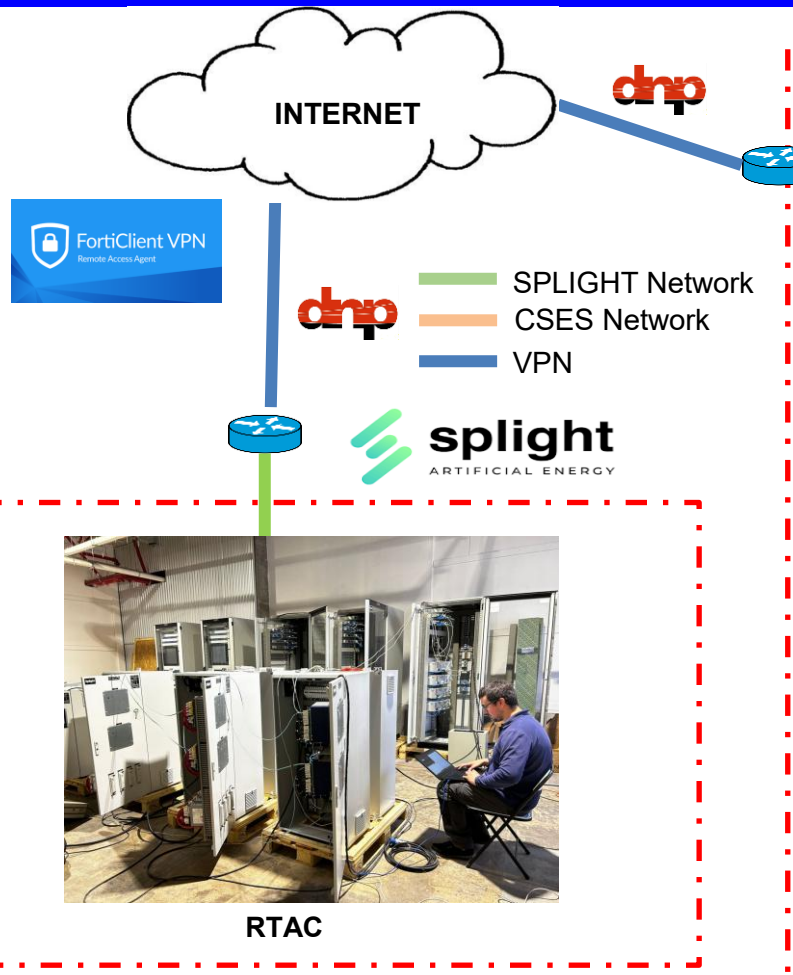
Challenges of SIPS testing with Hardware in the Loop

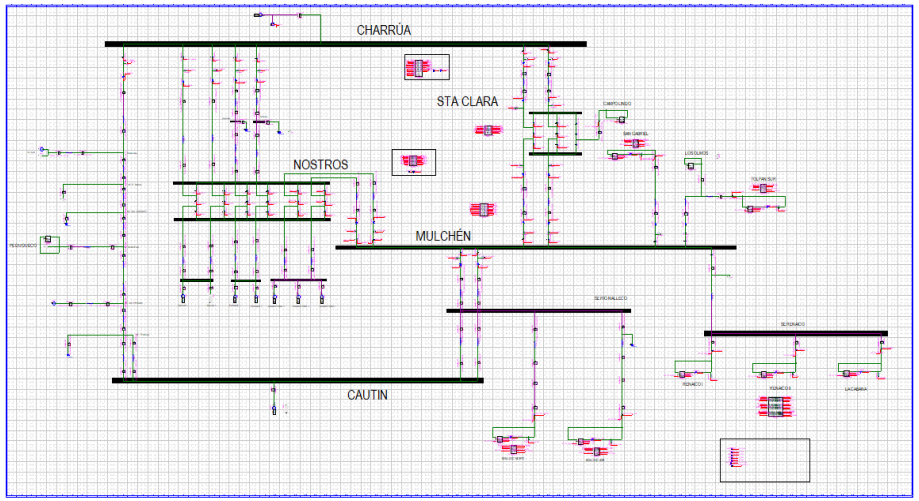




- Because of the size of the grid segment, the System Operator wanted to see “all the dynamics” of the grid.
- Suicidal in terms of the number of RT simulation cores (System Operator wanted EMT).

Challenges of SIPS testing with Hardware in the Loop





- Hypersim (OPAL-RT) was used to model de segment.
- Reduced-order, one-machine equivalents to avoid 1000-core simulations of the south/north rests of the grid.
- PMU and Digsilent comparisons to show correspondence with reality.
- A Challenge for the group.

Absence of converters' help (not the cause nor the solution)

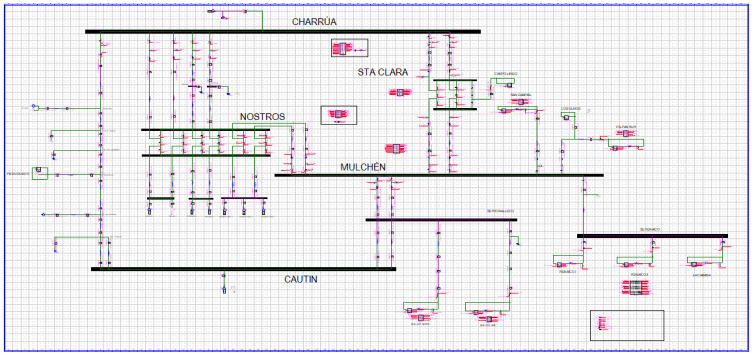
Absence of converters' help (not the cause nor the solution)

https://www.youtube.com/watch?v=S9QAXbANxvw

IBR were not involved directly in the 2025 blackout, but the absence of any substantial response (in comparison to SG) was uncovered:

- June 1, 2026, the System Operator published a guide to verify Grid Forming (with the intention of <<we think>> asking IBR to support the grid under all or of a set of those attributes).
- It mostly follows that of Australia.

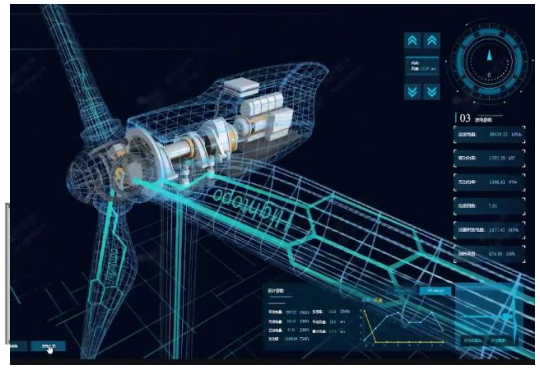
Absence of converters' help (not the cause nor the solution)

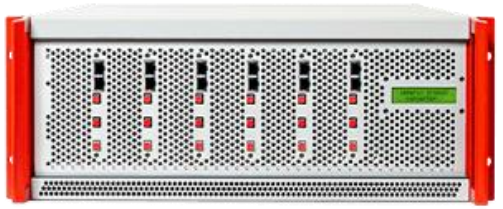


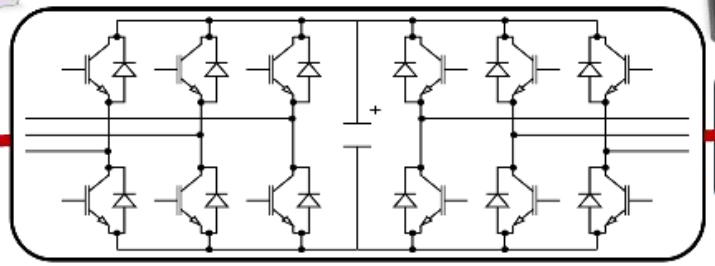
Filtros pasivos

Rack
IGBTs

Filtros pasivos







Amplificador
OP8110-3

Protección
OP1263

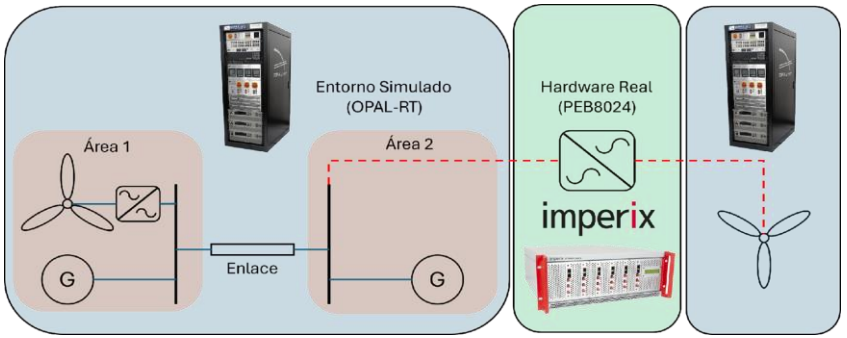
Protección
OP1460

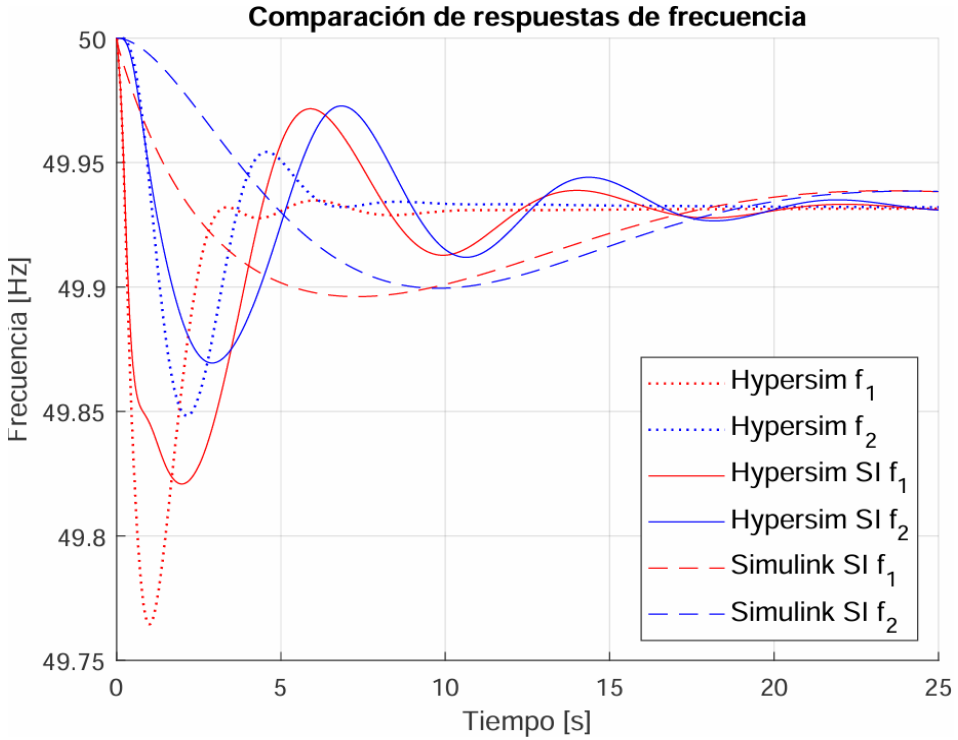
Amplificador
OP8110-6

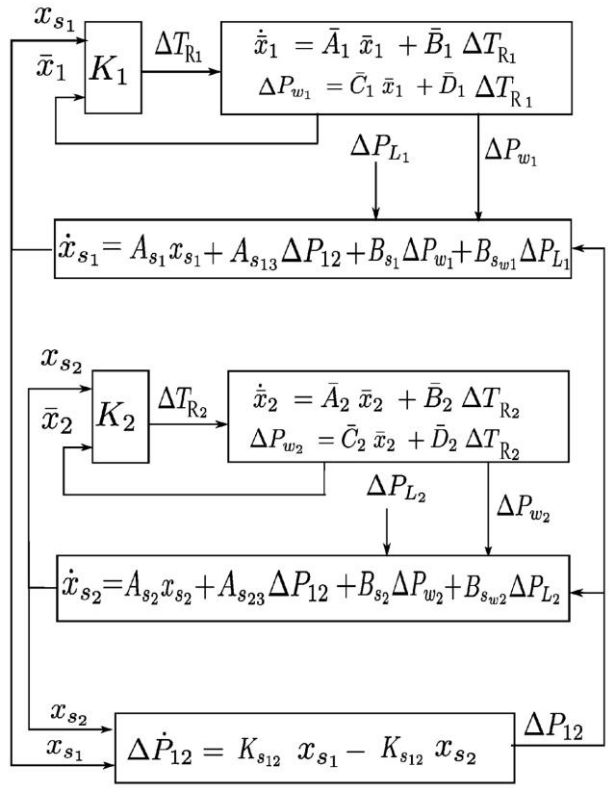
PMU
Vizimax

The group had previously performed a synthetic inertia multi-farm, multi-area algorithms tested in power hardware in the loop of couple of KW…

Absence of converters' help (not the cause nor the solution)







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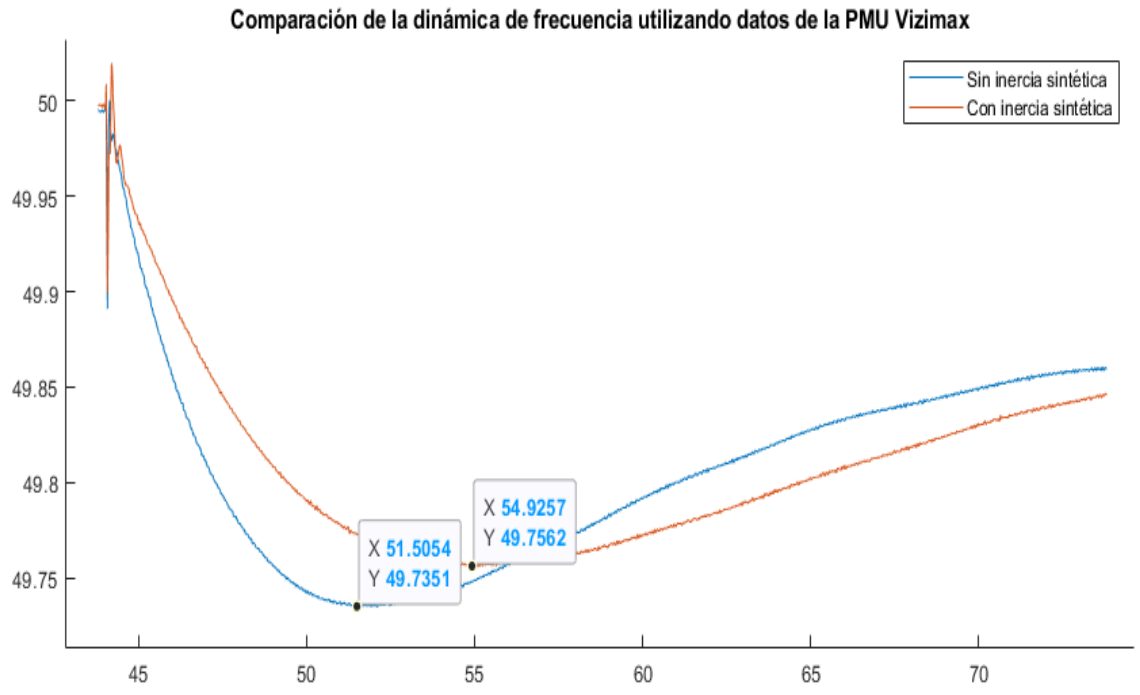

While actual BESS inverters are of the order of **few hundred of KW to a couple of MW…**

1. BESS Diego de Almagro Sur II (228 MW / 912 MWh)

- **Inverter Rating: 4.4 MW** per central inverter skid/station.
- **Inverter Count: 67 inverters**.
- **Configuration:** Paired with 201 battery containers (1.2 MW / 4.8 MWh each), connected in 33 kV medium-voltage circuits.

2. BESS Celda Solar (228 MW / 912 MWh)

- **Inverter Type:** Integrated string inverters built directly into each Tesla Megapack container.
- **Integrated Inverter Power:** Each Megapack unit integrates a power conversion system (PCS) rated at approximately **1.1 MW to 1.15 MW**.

Absence of converters' help (not the cause nor the solution)

1 Visión general

1,1 Información general

Título	**CEN-CM-2673 Proyecto ACRED-OTR**
Resumen	**El Servicio de Acreditación de Despachadores y Operadores de Tiempo Real (ACRED-OTR) tiene por objeto contratar a una institución de prestigio nacional que actúe como ente evaluador independiente para el proceso de acreditación técnica de los Despachadores del Centro de Despacho y Control (CDC), extensible en una etapa futura a Operadores de Centro de Control de Coordinados (CC).**
Comprador	**Jorge Sauterel**
Resultado	**Orden de compra**
Correo electrónico	**jorge.sauterel@coordinador.cl**

- Currently, the group is applying to a grant with TRANSELEC (TX company in Chile), to install a testing lab in an empty 220kV bay (9 MW).
- The idea is to provide the company with training/regular certification for the Substation operators (they also have a mayor role in the durations of the blackout) along with testing to generation companies' IBRs.
- Hopefully, the synthetic inertia project can scale up to a real test.

Control room real-time awareness features

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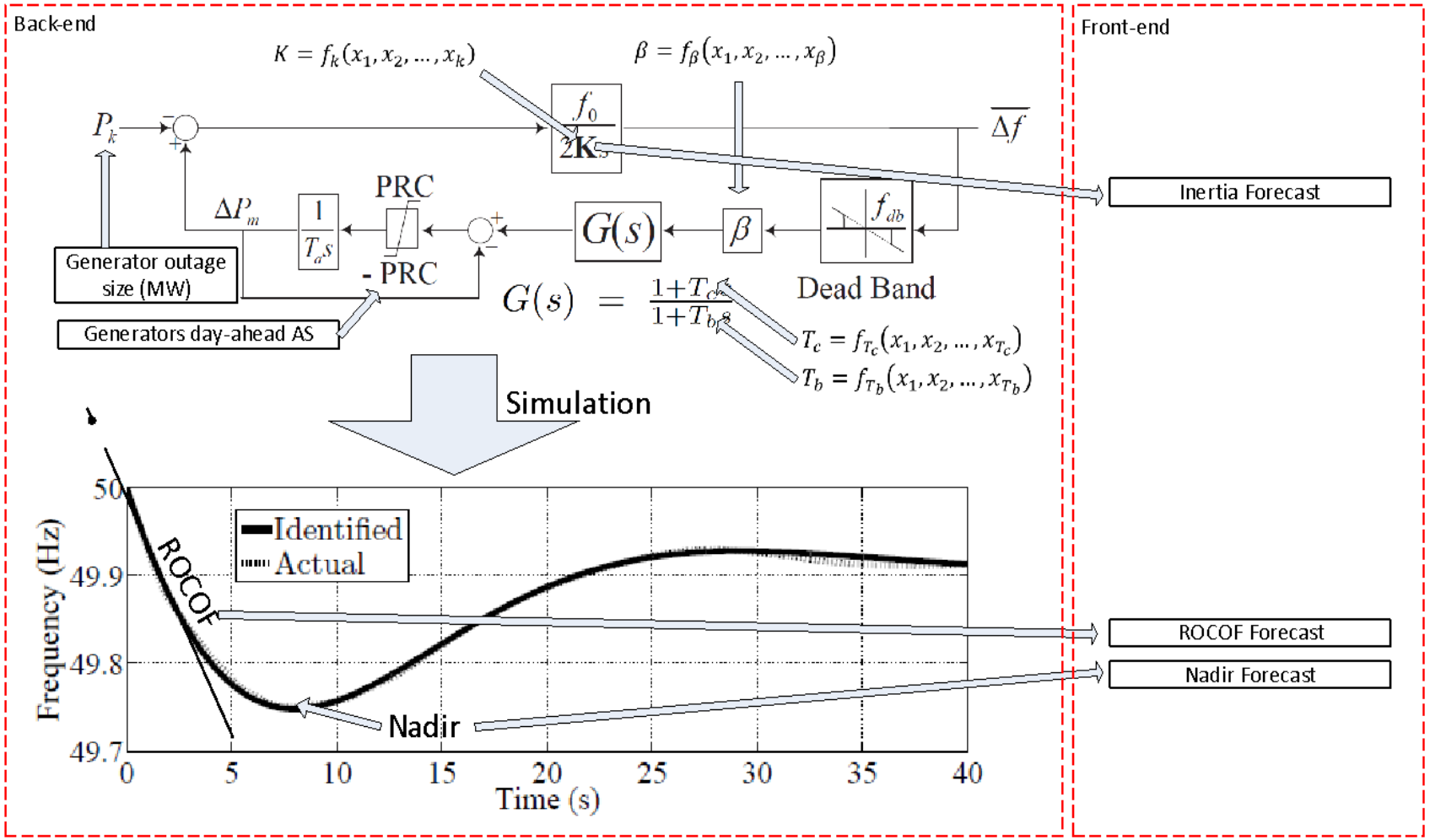
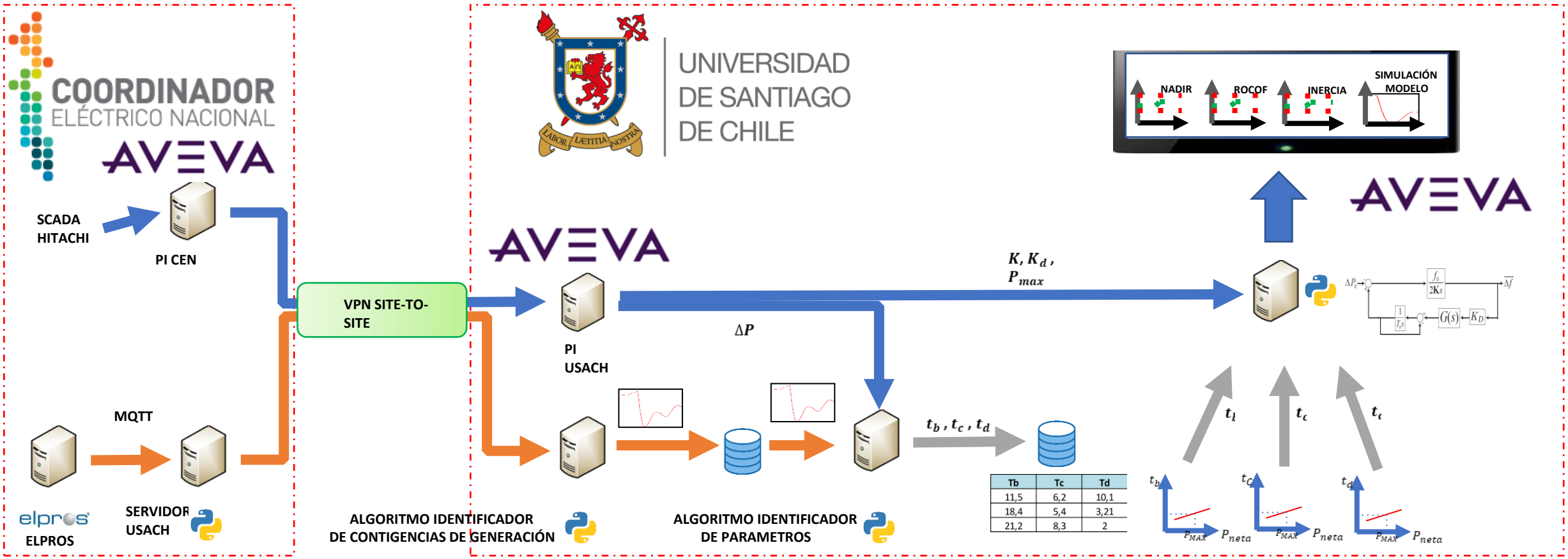
Control room real-time awareness features

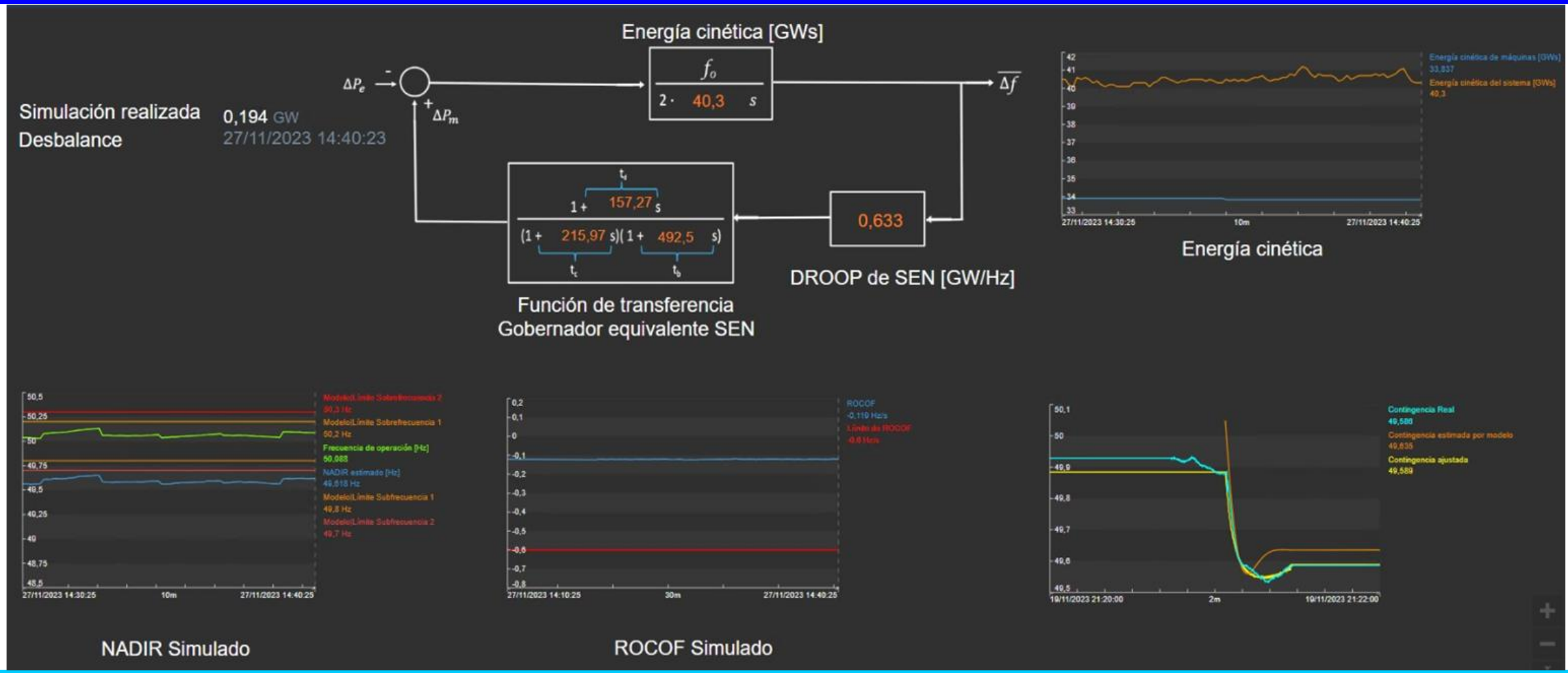


-The basic idea is to have a “accurate enough” reduced-order model of the system to run predictions on the dynamics of frequency control

Control room real-time awareness features



Control room real-time awareness features



Control room real-time awareness features

Detailed simulations of the Chilean power system

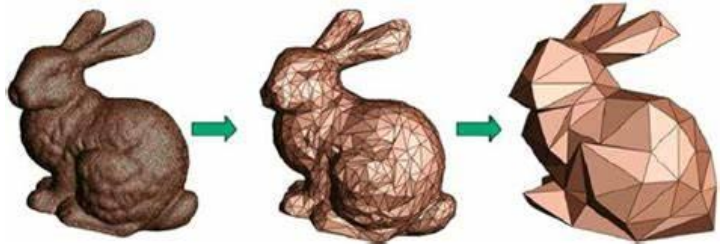
Simulations

Step 1

Database built from detailed simulations

Training data

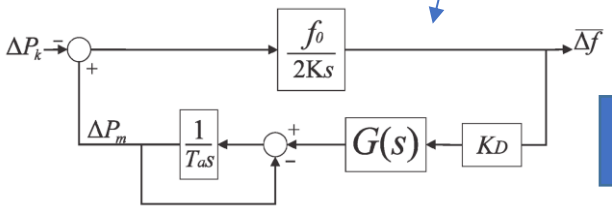
Step 2



Reduced-order model with suitable parameters

Model

Step 3



Data-driven technique to estimate the time variability of Hybrid twin parameters

Hybrid twin

Set of relevant scenarios and contingencies

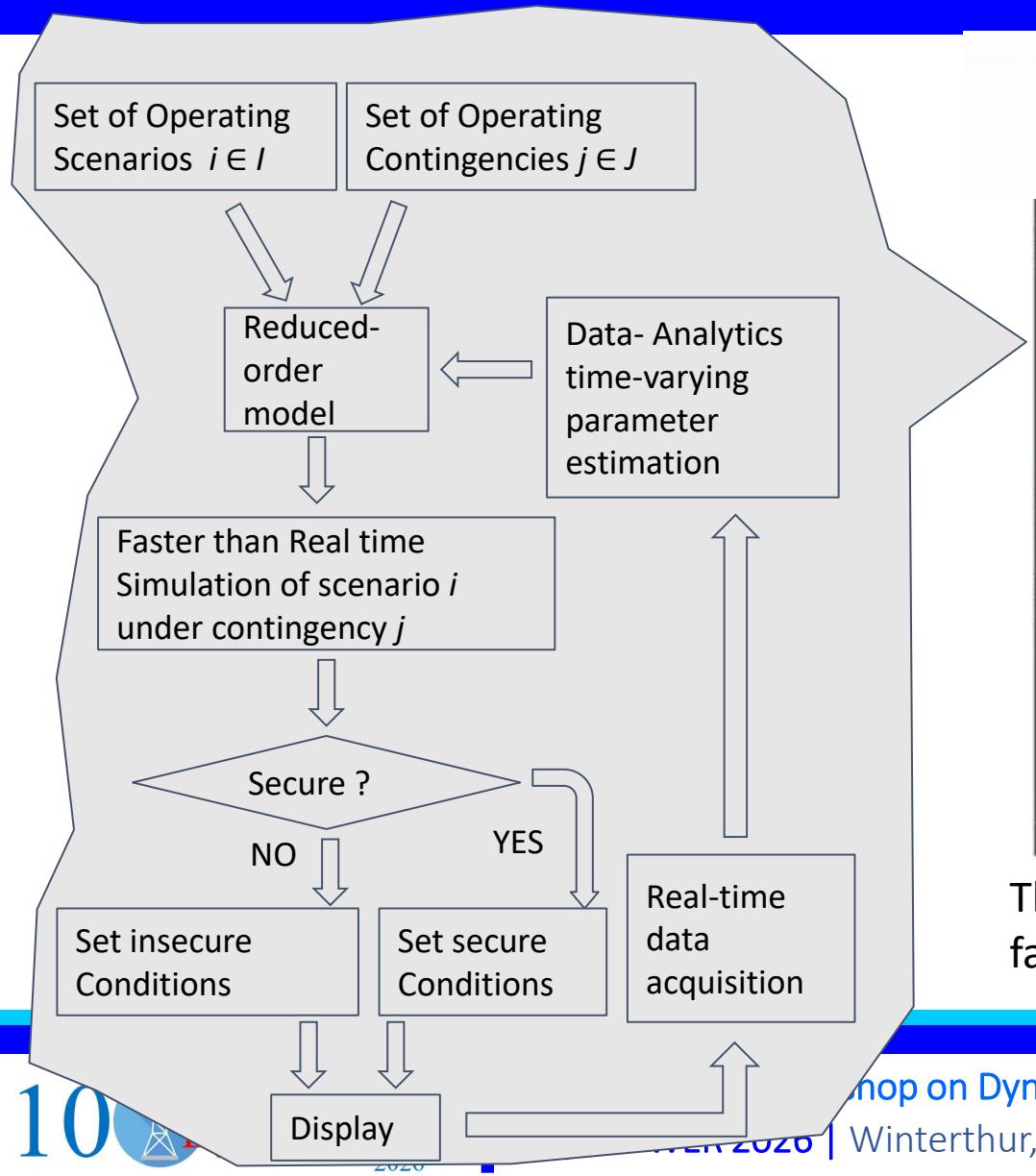
Real time data

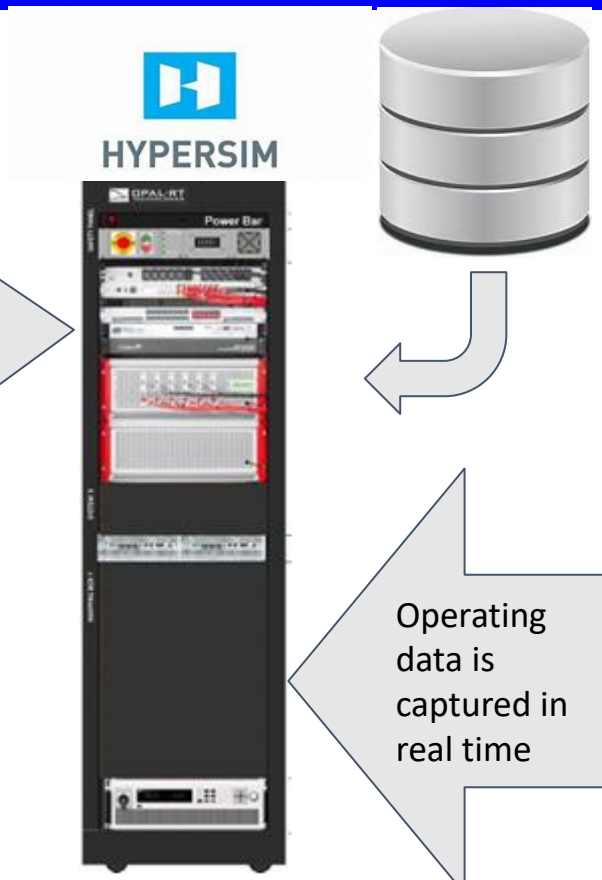
Step 4

RTS 2

Hybrid twin is used to perform faster than real time simulations of scenarios and contingencies with estimated parameters

Control room real-time awareness features





Operating data is captured in real time

The Hybrid twin DSA is ran faster than real time

- Control room can implement preventive action by knowing tentative threads.
- Important AS procurement parameters can be extracted to execute “real-time” AS markets.

Final Remarks

- Blackouts move the electricity sector
- IBRs penetration is faster than technological research
- Control room real-time application are becoming essential to:
  - detect stability threats under highly volatile operating points and contingencies, and
  - quantify ancillary service in terms of amount and other features in future shorter-than-a-day ahead markets.

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