#CE4EUislands – Workshop: Energy Storage opportunities for EU Islands: about batteries and beyond…

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EEM's Experience in Managing Energy Storage Assets in Madeira Island's Electrical System

The Autonomous Region of Madeira experience: Batteries and Pumped Hydro

Diogo Vasconcelos
EEM – Empresa de Electricidade da Madeira, S.A. (DEP-Studies and Planning Directorate)
Madeira Island's "#CE4EUIslands - 30 for 30 Challenge" Transition Team

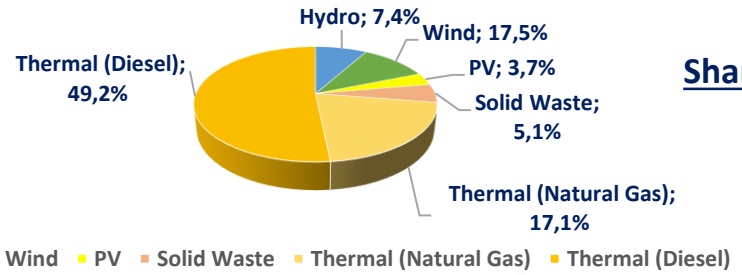
São Miguel, Azores, 16th of May 2025
www.eem.pt | dvasconcelos@eem.pt

EEM – Empresa de Electricidade da Madeira, S.A.

(Electricity Producer, TSO, DSO, Supplier)

AUTONOMOUS REGION OF MADEIRA

Power Generation Mix – 2024– Madeira Island



Islands Goals:

→ 50% RES by 2025/26

→ ≥ 60% RES by 2030

MADEIRA ISLAND

Share of RES in Madeira: 33,7%

Total Installed Power - 389,08 MW

Peak Demand ≈ 156,66 MW (16/12 – 18h00)

Total EE emission to the grid ≈ 917,71 GWh

Population ≈ 246 000 inhabitants (Source: Censos 2021)

Area: 741 km²

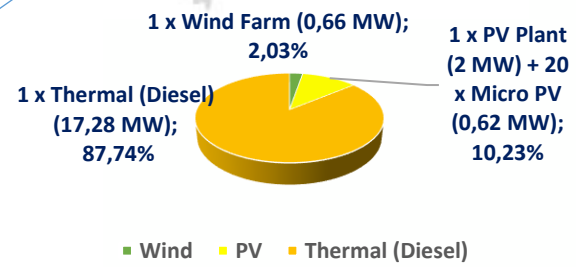
≈ 900 km
(no interconnection)

PORTO SANTO ISLAND

Share of RES in Porto Santo: 12,3%

≈ 50 km
(no interconnection)

Power Generation Mix – 2024 Porto Santo Island



Total Installed Power - 20,67 MW

Peak Demand ≈ 7,67 MW (16/08 – 21h00)

Total EE emission ≈ 35,78 GWh

Population ≈ 5 151 inhabitants*

*(Source: Censos 2021)

Area: 42,48 km²

TOTAL POPULATION ≈ 251 000 inhabitants Source: EEM **EEM Clients ≈ 145 213 Madeira | 5 101 Porto Santo**

EEM's ENERGY STORAGE ASSETS: Reversible Hydro Power

Socorridos Reversible Hydroelectric Power Plant

Installed Power: 24,0 MW

Pumping Inst. Power: 3 x 3,75 MW

Initial Operation: 1994 → 2006 (Reversible)

Source: EEM

Calheta III Reversible Hydroelectric Power Plant

Installed Power: 30,0 MW

Pumping Inst. Power: 3 x 5,5 MW

Initial Operation: 2021

Source: PO SEUR

Also acts as: Synchronous Condenser

EEM's Hydro Power Plant	Reversible Hydroelectric System Water Reservoirs					
	VOLUME (m^3)			Power (MW)		
	Total	Useful	Head (m)	Production	Pumping System	Energy (MWh)
Socorridos	40 000	30 000	457	24	10	30
Calheta III*	1 000 000	860 000	650	30	17	1 273
Pumping*	70 000	65 000				**100**

Also acts as: Synchronous Condenser

BESS Porto Santo I

Nominal Power: 5,4 MVA / 4,3 MW

Capacity: 3,3 MWh

Provisional Acceptance (PA): 06/2020

Source: EEM

Eligible Total Cost: 3.576.843,12 €

EU Financial Support: **641.958,64 €**

BESS Madeira I –Vitória

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Nominal Power: 23,7 MVA / 15 MW

Capacity: 16,4 MWh

PA: 09/2022

Eligible Total Cost: 9.308.857,27 €

EU Financial Support: **7.788.276,32 €**

Source: EEM

Co-financed by POSEUR (Cohesion Fund):

POSEUR
PROGRAMA OPERACIONAL SUSTENTABILIDADE E EFICIÊNCIA NO USO DE RECURSOS 2014 20

REGIÃO AUTÓNOMA DA MADEIRA

PORTUGAL 2020

UNIÃO EUROPEIA
Fundo de Coesão

BESS Porto Santo II

Nominal Power: 12 MVA / 8,92 MW

Capacity (BoL): 17,89 MWh

Provisional Acceptance (PA): 06/2024

Source: GR.Madeira

Total Cost (Investment): 12.354.688,14 €

Actual EU Financial Support: **11.770.798,00 €**

BESS Madeira II - Caniçal

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Nominal Power: 27 MVA / 18,7 MW (AC)

Capacity (BoL): 16,1 MWh (AC)

Provisional Acceptance (PA): 01/2025

Total Cost (Investment): ≈ 15.900.000,00 €

Actual EU Financial Support: **15.891.820,00 €**

Source: Hitachi Energy Portugal | EEM

Financed by Portugal's Recovery and Resilience Plan (PRR):

PRR Plano de Recuperação e Resiliência

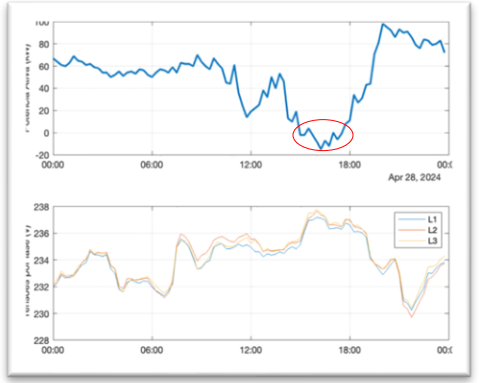
REGIÃO AUTÓNOMA DA MADEIRA

REPÚBLICA PORTUGUESA

Financiado pela União Europeia NextGenerationEU

EEM's Participation in European Projects (H2020|HEU|CEF)

Source: INESC TEC / VG COLAB / EEM



Demo 2 – Pump Hydro Storage System Combined with BESS & Synchronous Condensers [Portugal]

INESC TEC, VG Colab, EEM

Main Tasks:

- Development of the day-ahead dispatch tool;
- Development of the inflows forecasting algorithms (Hydro Prediction using Neural Networks);
- Predictive Performance of LSTM Models for Hydropower Systems;
- Development of the dynamic security assessment algorithm;
- Pilot-scale testing & deployment of a **VRFB** (**Vanadium Redox Flow Battery ESS**)…

i-STENTORE

innovative Energy Storage TEchnologies TOwards increased Renewabels integration and Efficient Operation

Co-funded by the European Union

https://istentore.eu/

Main Goal (TSO/DSO): Enhance grid stability & resilience in non-interconnected electrical systems

EEM's MOST VALUABLE ASSET: Human Resources (HR)

31/12/2024

Source: OE Região Madeira

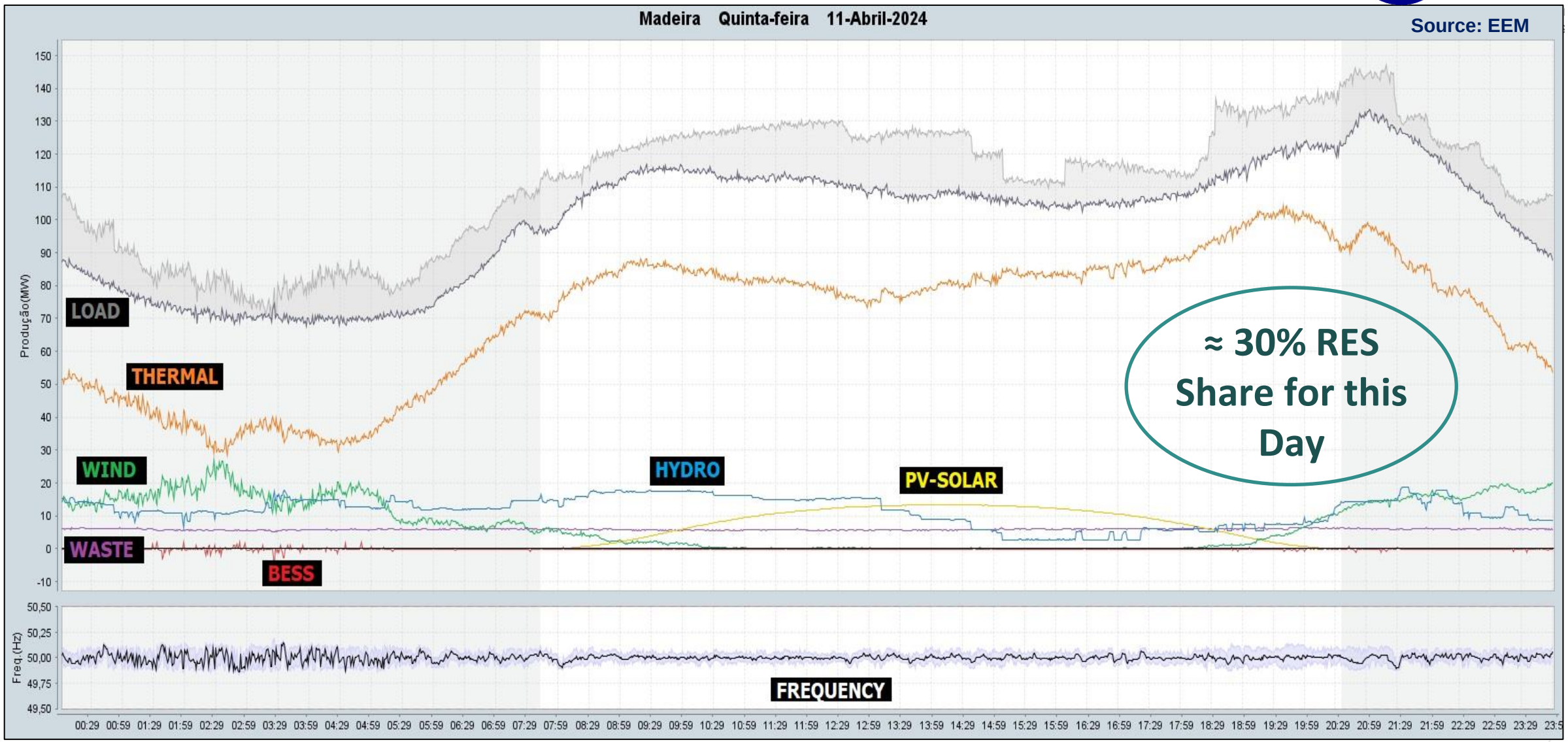
Source: DN Madeira

Source: EEM

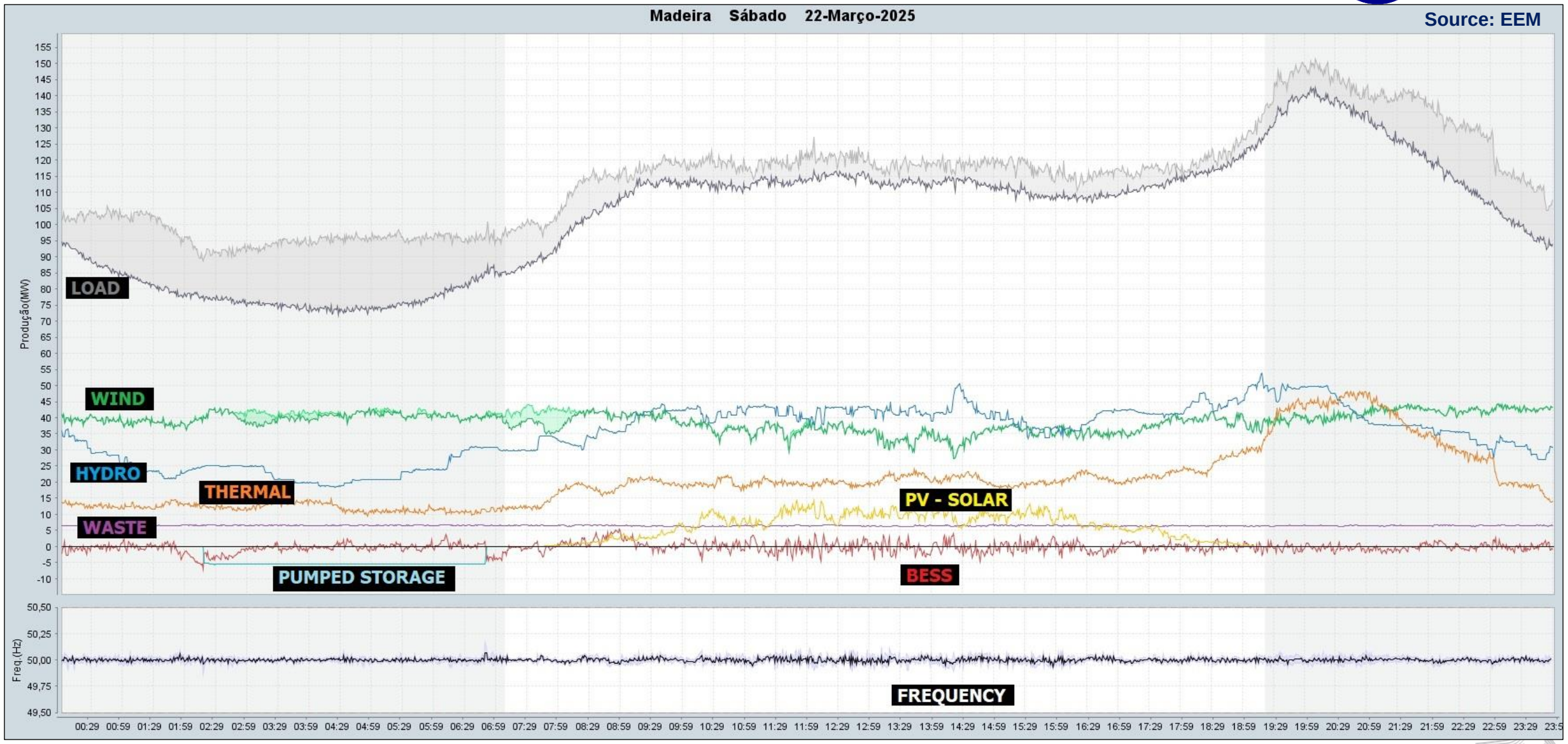
#620
Total Employees

#571 Employees in Madeira Island

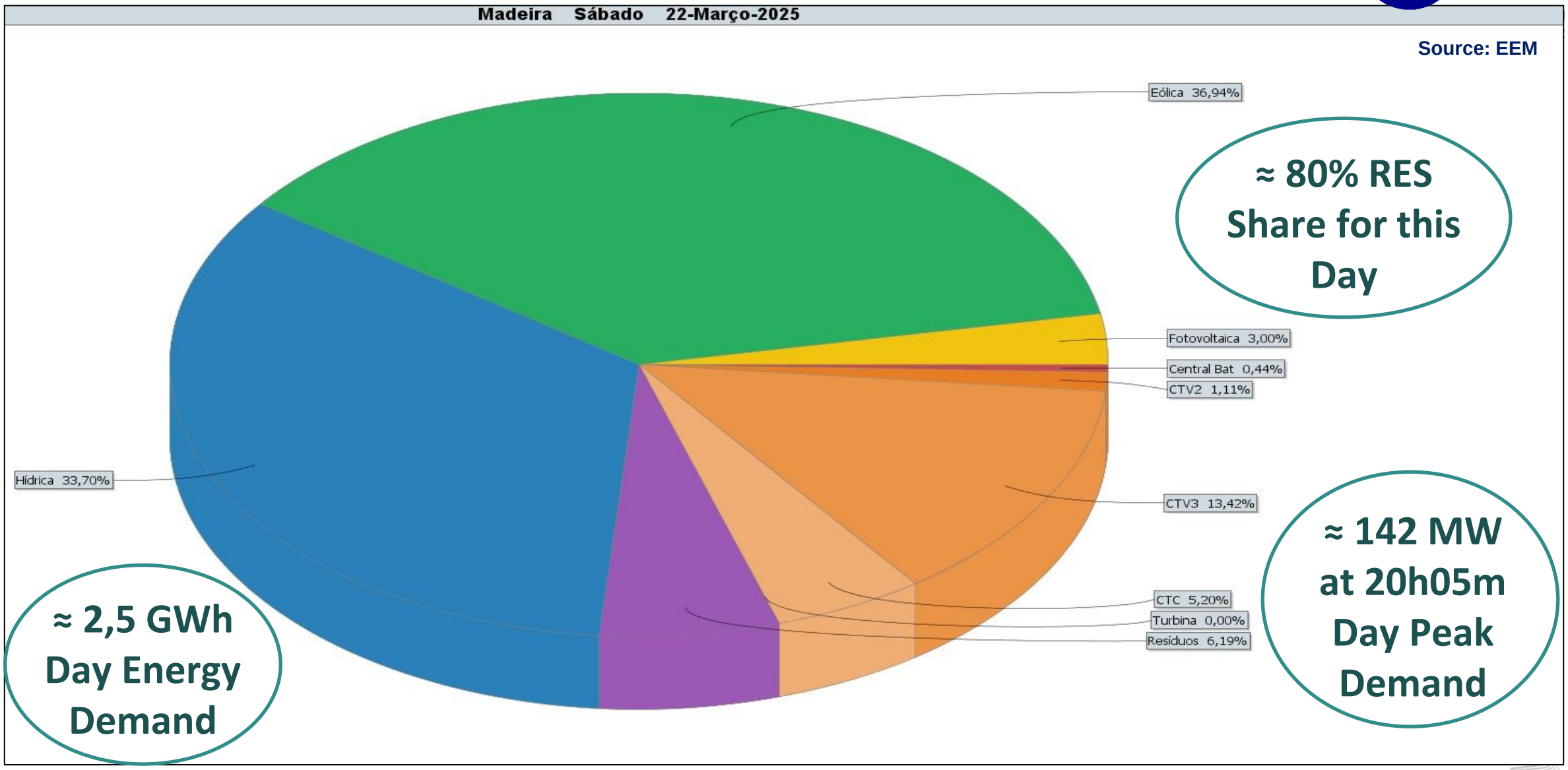
“AVERAGE” DAY LOAD DIAGRAM



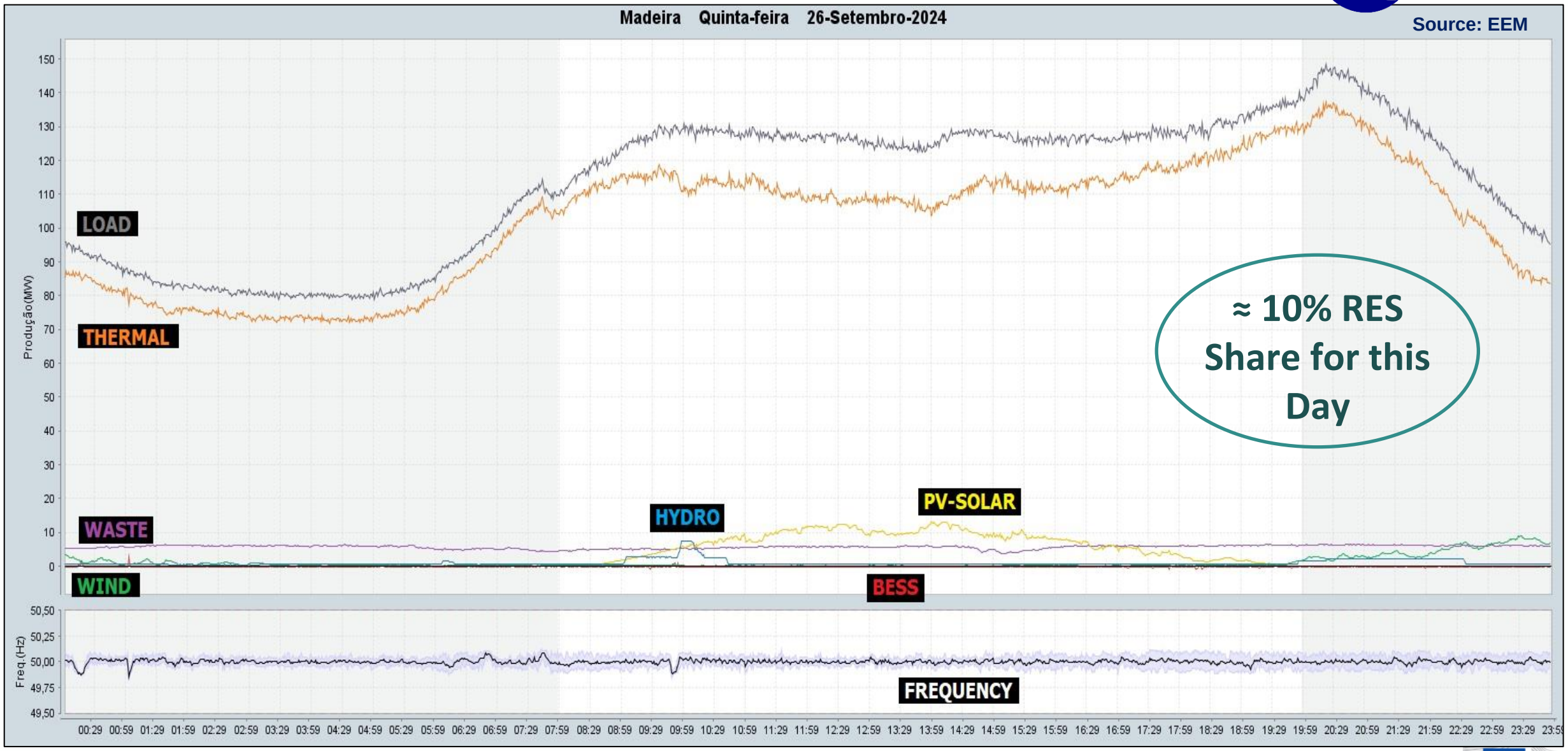
“AMAZING” DAY LOAD DIAGRAM: Energy Storage Impact



“AMAZING” DAY LOAD DIAGRAM: Energy Storage Impact



“DISAPPOINTING” DAY LOAD DIAGRAM



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System Services in non-interconnected electrical systems

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Capabilities to ensure the safe operation of the electric system:

- **A-** Inertia capability
- **B-** Frequency regulation capability:
  - **B1-** Primary regulation
  - **B2-** Secondary regulation
- **C-** Voltage control/regulation capability
- Short-circuit capacity

Critical issue: high values of df/dt (RoCoF)

Traditional mix system generation	System services			
Technology	**A-Inertia**	**B1_Frequency primary regulation**	**B1_Frequency secondary regulation**	**C-Voltage regulation**
Thermal Generation (Gas, Fuel/Diesel engines)	X	X	X	X
Hydro	x	-	x	X
Wind	x	-	-	x
PV	-	-	-	x
Waste incineration	x	-	-	x
Result	**X✓**	**X✓**	**X✓**	**X✓**
Result without thermal generation	**x**	**-**	**x**	**X✓**

Mix system generation, without thermal	System services			
Technology	**A-Inertia**	**B1_Frequency primary regulation**	**B1_Frequency secondary regulation**	**C-Voltage regulation**
Synchronous condenser with inertia	X			X
Battery Power Plant	-	X	X	X
Hydro reversible (Storage, pumping and operation as a synchronous condenser)	x	-	X	X
Wind	x	-	-	x
PV	-	-	-	x
Waste incineration	x	-	-	x
Result without thermal generation	**X✓**	**X✓**	**X✓**	**X✓**

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Lessons learned?

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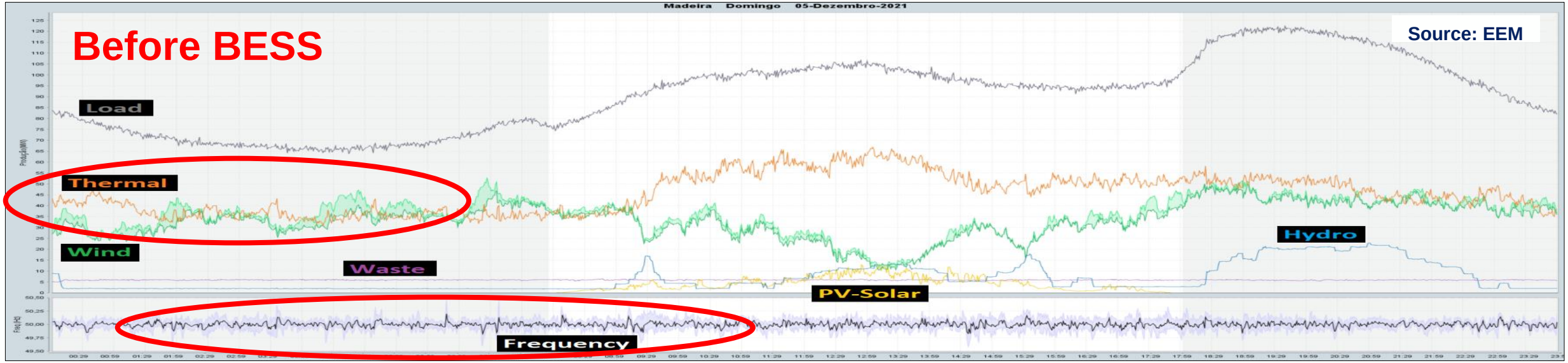

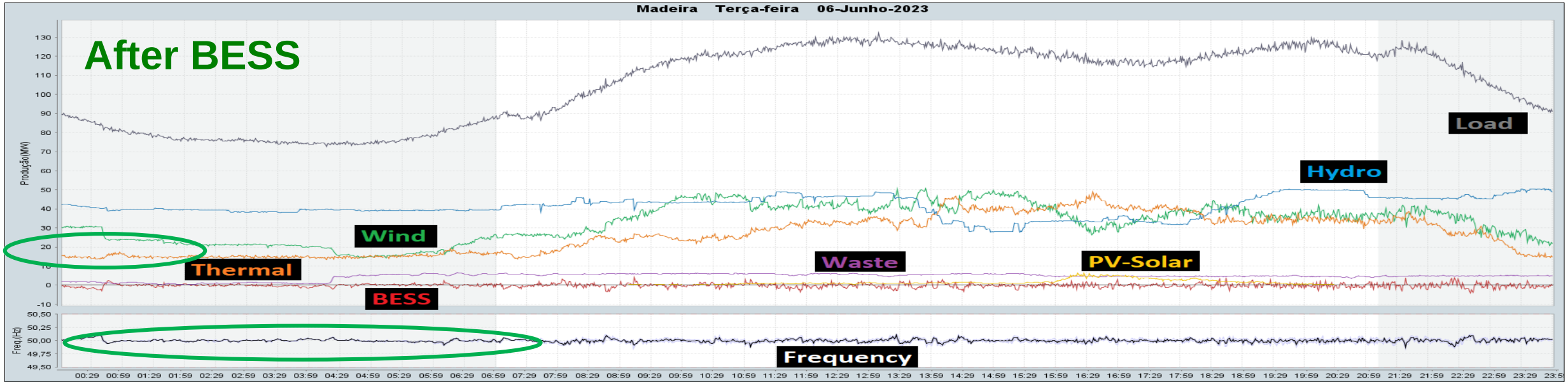

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BESS support and importance for System Security:

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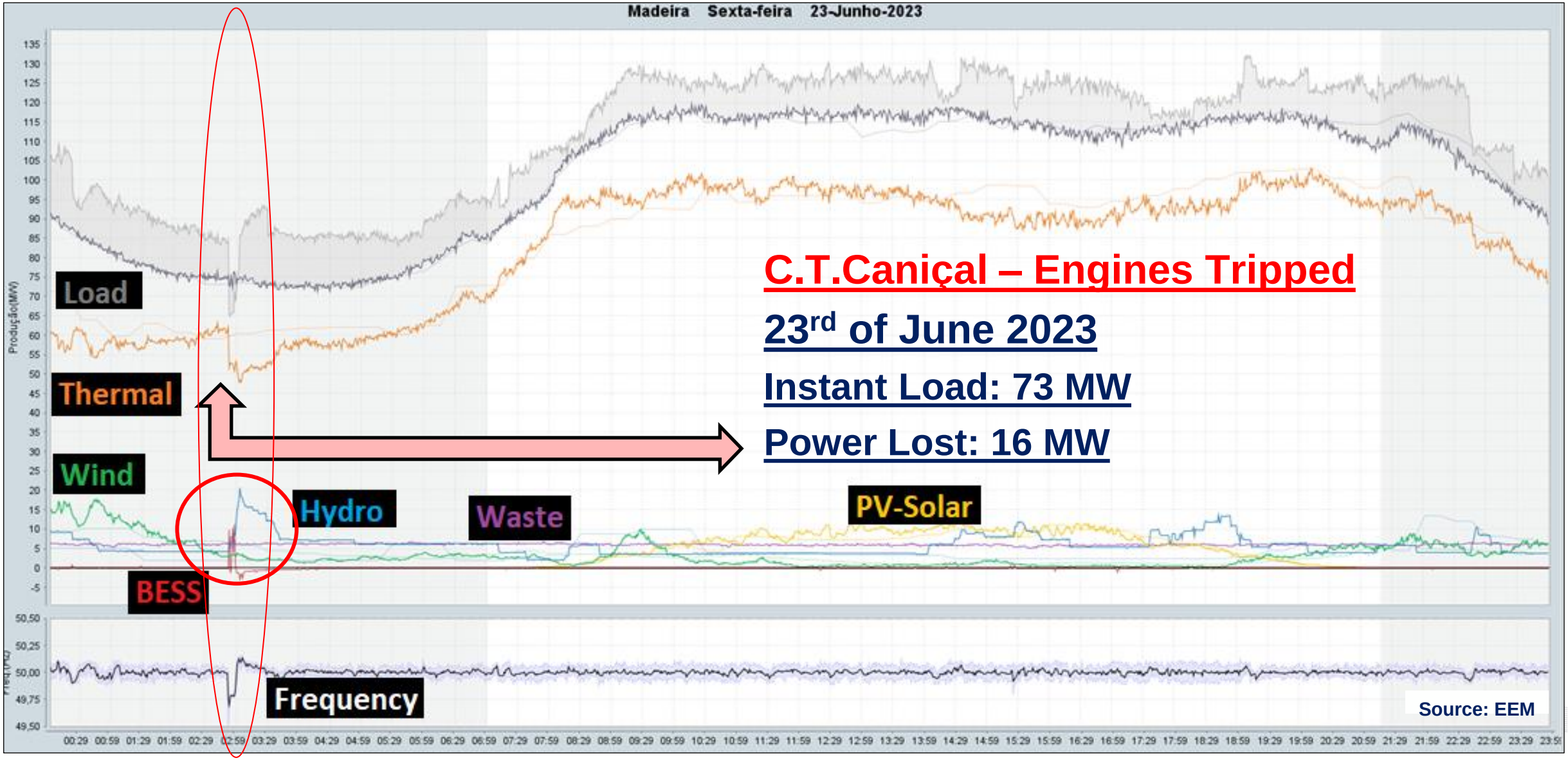

HOW TO MANAGE A SYSTEM WITH HIGH & LOW RES?

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PAST

- **Grid instability** (hard to control frequency and voltage), with the risk of electricity blackouts;
- **High dependence** of thermal generators to provide ancillary services to the grid, removing space for the renewables integration and thus resulting in some **curtailment** of **RES production**;
- Low energy **storage capacity**;
- Absence of **controllable loads**;
- Major challenges in the power grid stabilization and security of supply (**intermittent RES / loads**, DER);
- **No** weather **forecast data**;
- **No specific regulatory framework** for non-interconnected islands…

PRESENT

Structuring the electrical system to operate without fossil fuels:

- **HW/SW** support:

  -**TSO → SCADA/AGC** – Use of consolidated management instruments | Smart Grids technologies (weather forecast models and dataset, sensing, remote command, communication systems…) | Coordination with global management system (AGC);
- Storage assets (**Reversible Hydroelectric Power Plants** and **Battery Energy Storage Systems (BESS)** with grid-forming capability);
- **Synchronous Condenser*** (second half of 2025);
- **DSO → ADMS/**Distributed Energy Resource Management System **(DERMS) →** part of an **ADMS architecture;**
- **High level** trained technicians (HR);
- Regulatory and legal framework that ensures **new RES** installations to support the electrical system (local **Grid Code** since 2019)…

FUTURE

- ✓ Greater and higher-capacity **storage assets** (“**GWh**” water reservoir, very large-scale BESS…);
- ✓ More **Demand Side Flexibility + DSM** features;
- ✓ **AMI –** Advanced Metering Infrastructures (smart-meters information → **smartening and digitalization of the grid** + real time customer consumption profiles);
- ✓ **EVMS –** Electrical Vehicle Management System → V1G/V2G smart-charging, innovative projects deployment from past European Pilot Projects;
- ✓ Support from more hybrid and decentralized **RES installations** - attractive conditions for private investment in **RES sector** under competitive circumstances;
- ✓ Support from Madeira **prosumers and aggregators** – more (renewable) energy communities (**REC**);
- ✓ Alternative, **“more sustainable” thermal power plants** (decommissioning of old thermal plants);
- ✓ **A.I. support** for smarter, more efficient, reliable, and sustainable power grids and support **of SW applications**…

- Diogo Vasconcelos (PM-DEP-EEM)

dvasconcelos@eem.pt

Thank You!

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Need more information?

HYDRO:

https://www.youtube.com/watch?v=D2fZgd8e3PM

https://www.youtube.com/watch?v=QMuZm8B81hI

BESS:

Central de Baterias EEM

https://www.youtube.com/watch?v=9tub8osqnY0

https://youtu.be/S9tpRr5iX5Q

https://youtu.be/wJq89TitUeA

Source: EEM