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University of Cyprus



PV curtailment crisis in Cyprus

Mitigating curtailment issues through data-driven algorithms

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Outline

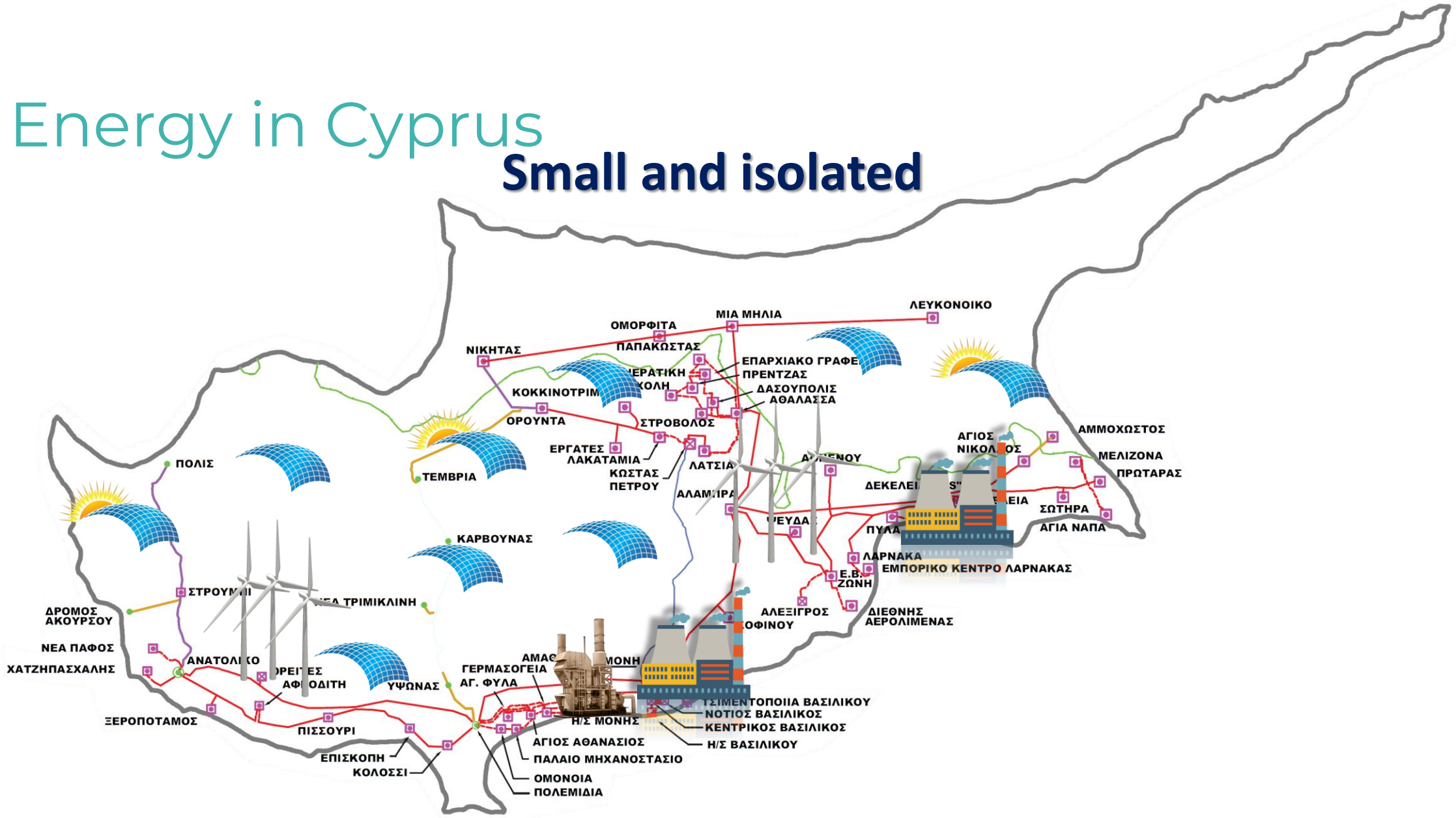
- Energy in Cyprus
- Crisis in Cyprus
- Future needs and mitigation measures
- Challenges – Ongoing work
- Moving forward



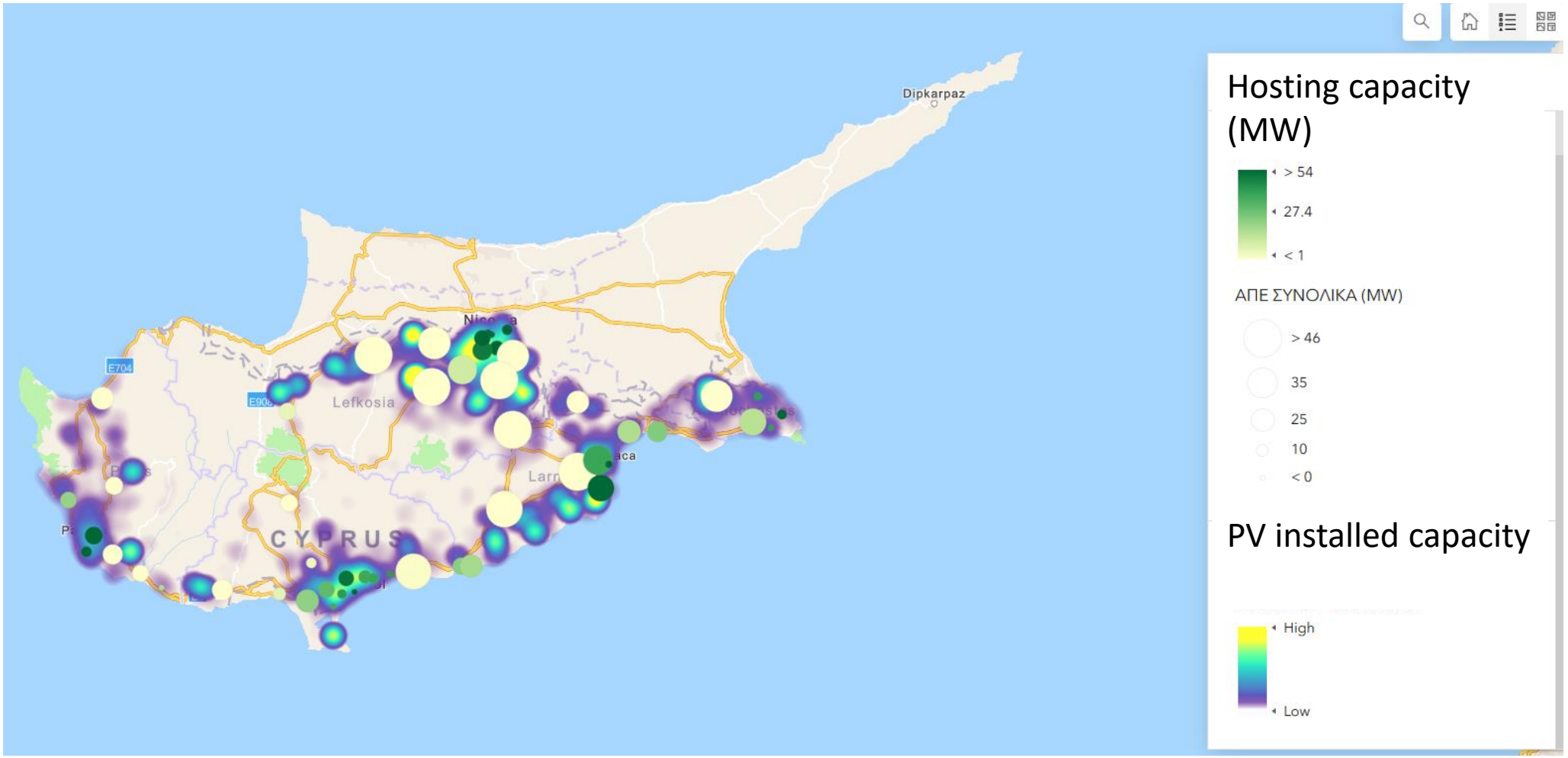


Energy in Cyprus

Small and isolated

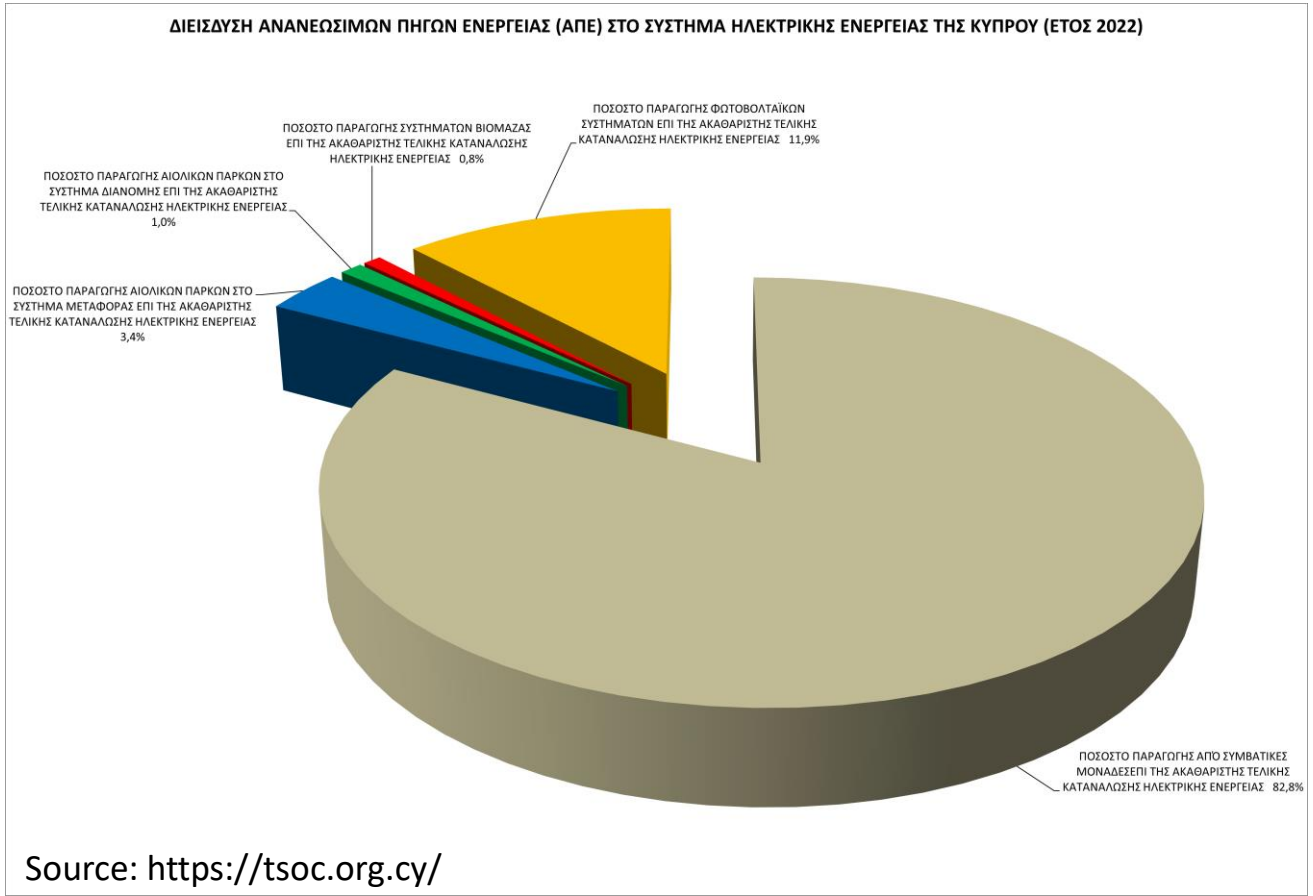


Energy in Cyprus



Renewable energy in Cyprus

- RES share was 15% in 2021 and 17% in 2022



Source: https://tsoc.org.cy/

RES installed capacity 2022

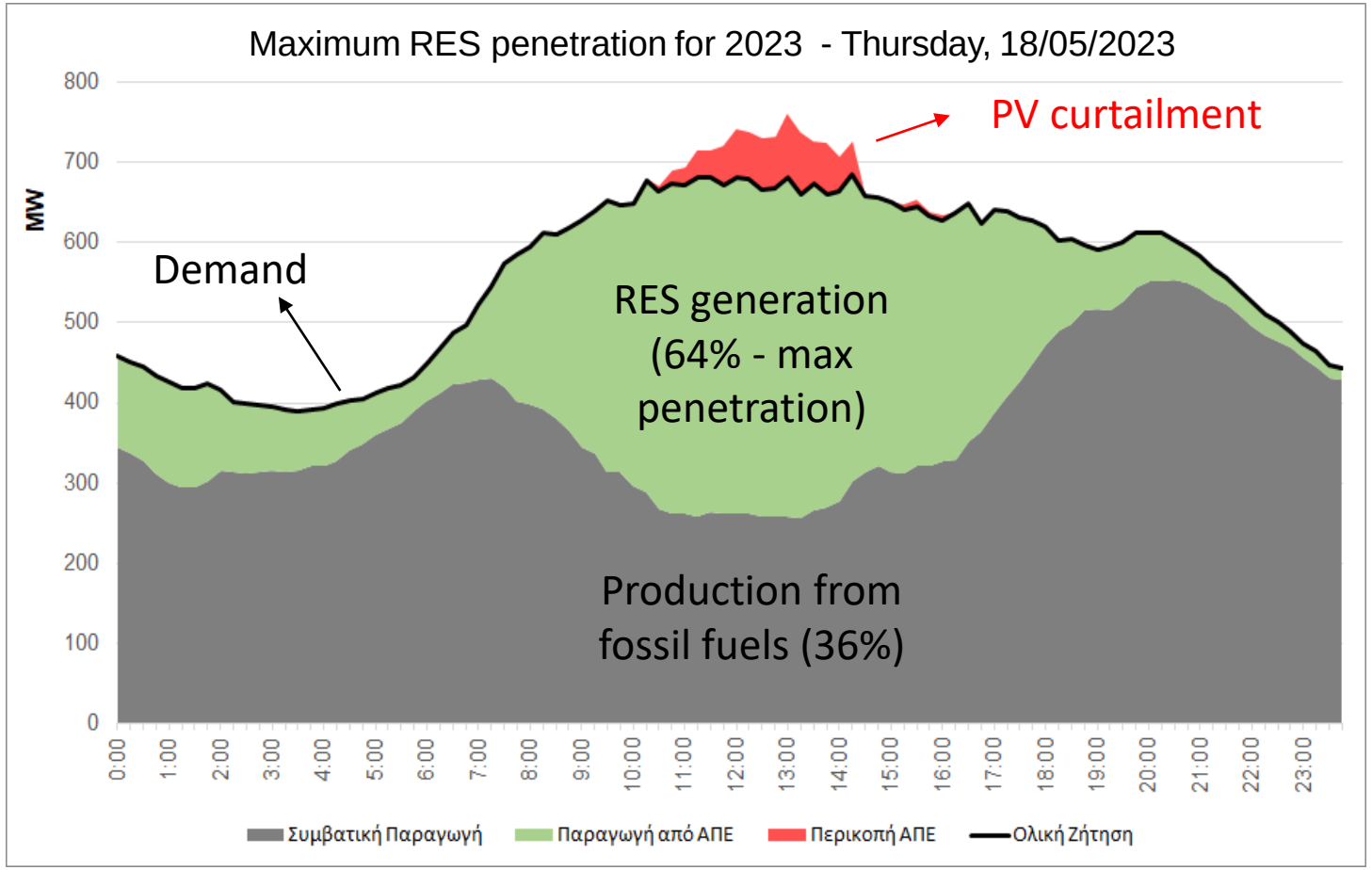
PV: 390 MW

Wind: 157 MW

Biomass: 3 MW

Renewable energy in Cyprus

- RES share increased to 21.5% in 2023



RES installed capacity Oct 2023

PV: 600 MW (800 MW pending approval)

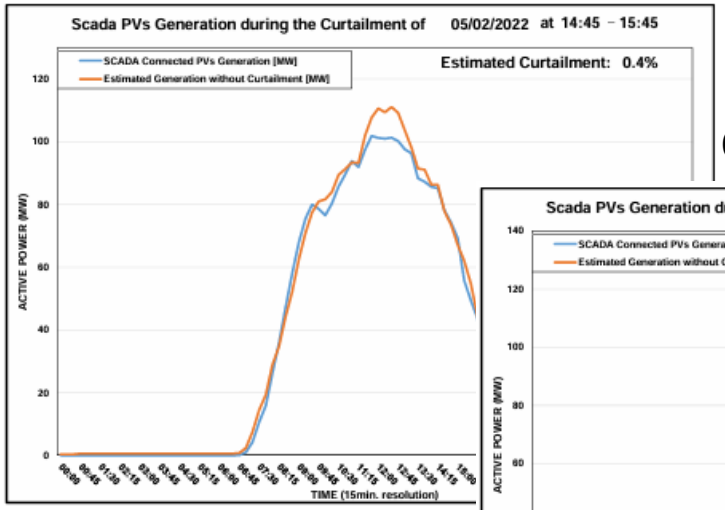
Wind: 158 MW (12 MW pending approval)

Biomass: 12.1 MW

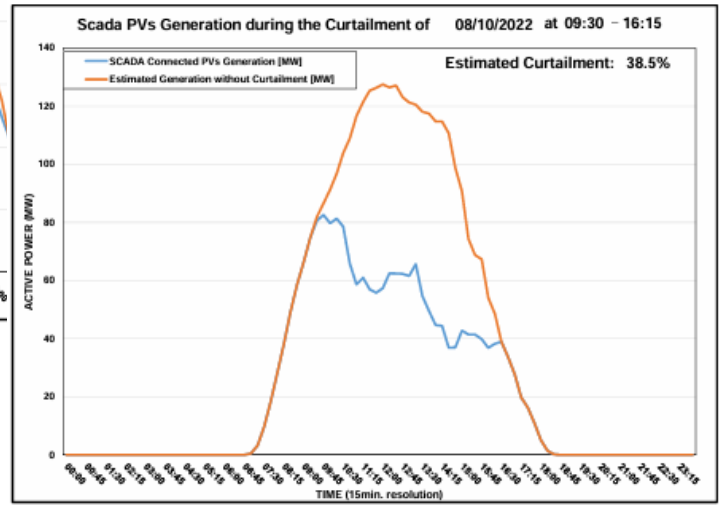
Crisis in Cyprus – RES curtailments

- Need for limiting the RES generation to ensure stable and safe operation of the Cyprus electric system
- Annual generated green energy curtailments: 3.3% in 2022 and 13.4% in 2023 (occurred mainly in Autumn and Spring due to low load conditions)

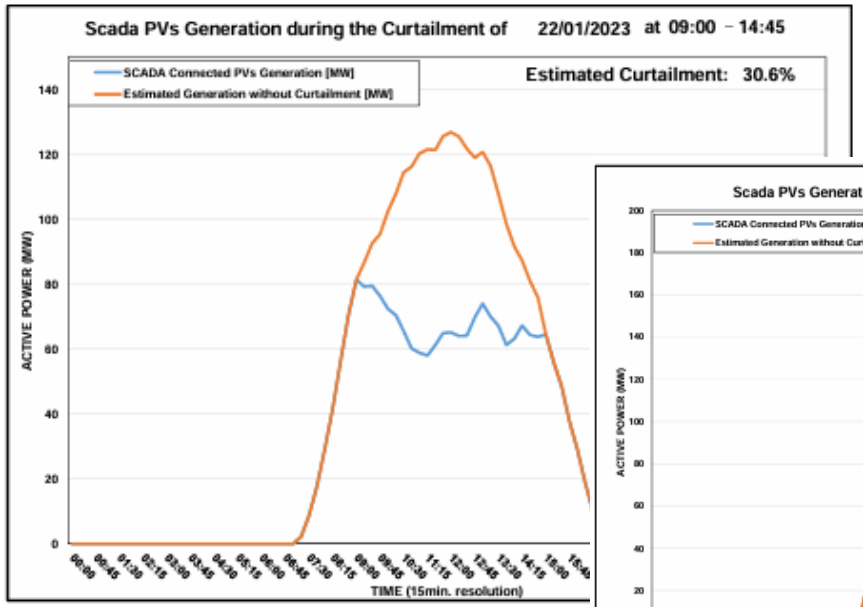
Feb 2022 (Sat)



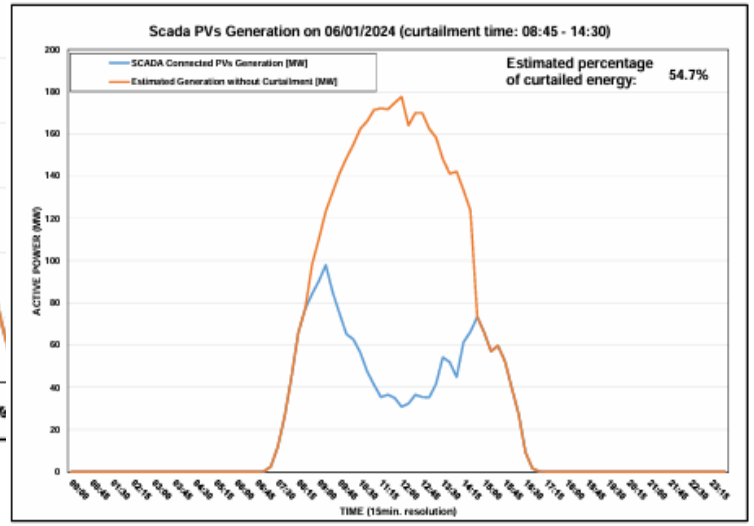
Oct 2022 (Sat)



Jan 2023 (Sun)



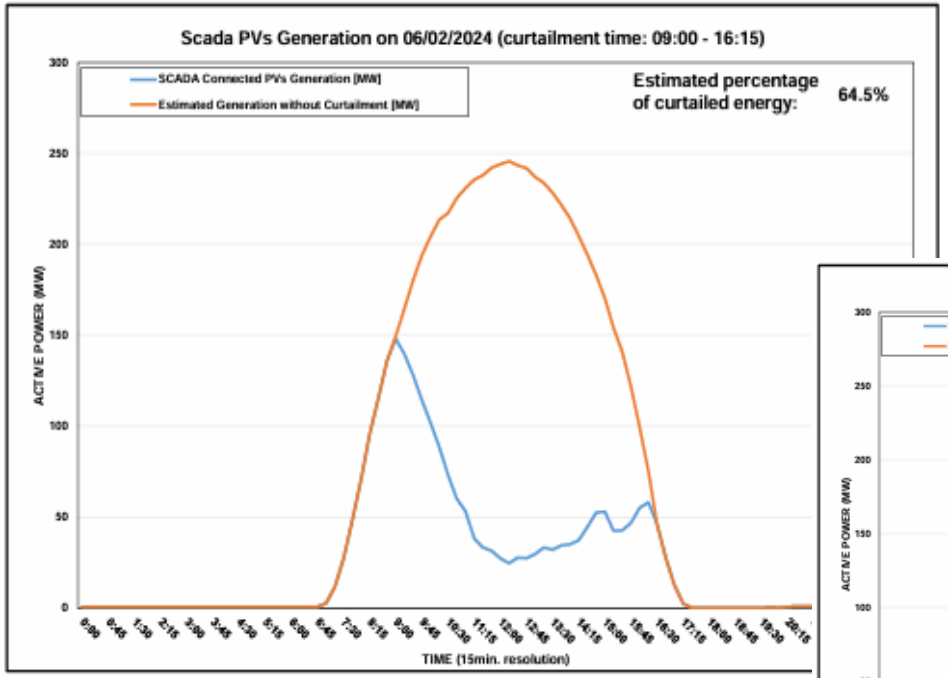
Jan 2024 (Sat)



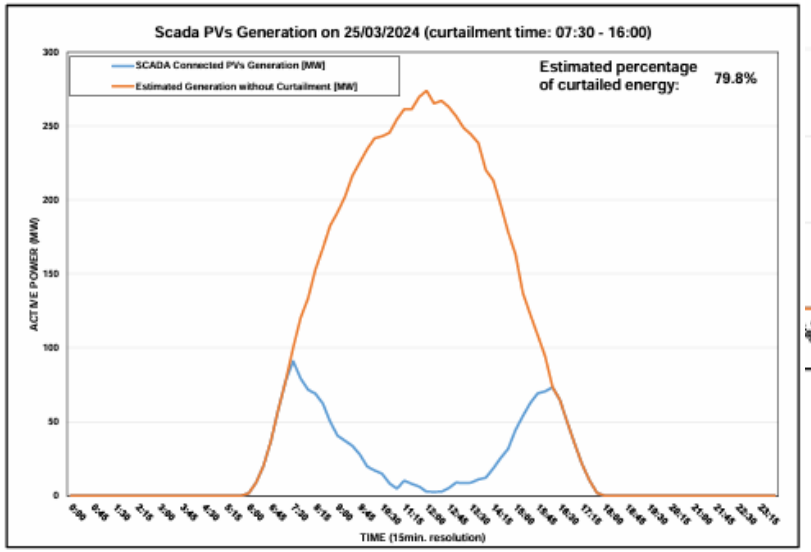
Crisis in Cyprus – RES Curtailments

- Cyprus is set to curtail 28% of renewable electricity in 2024

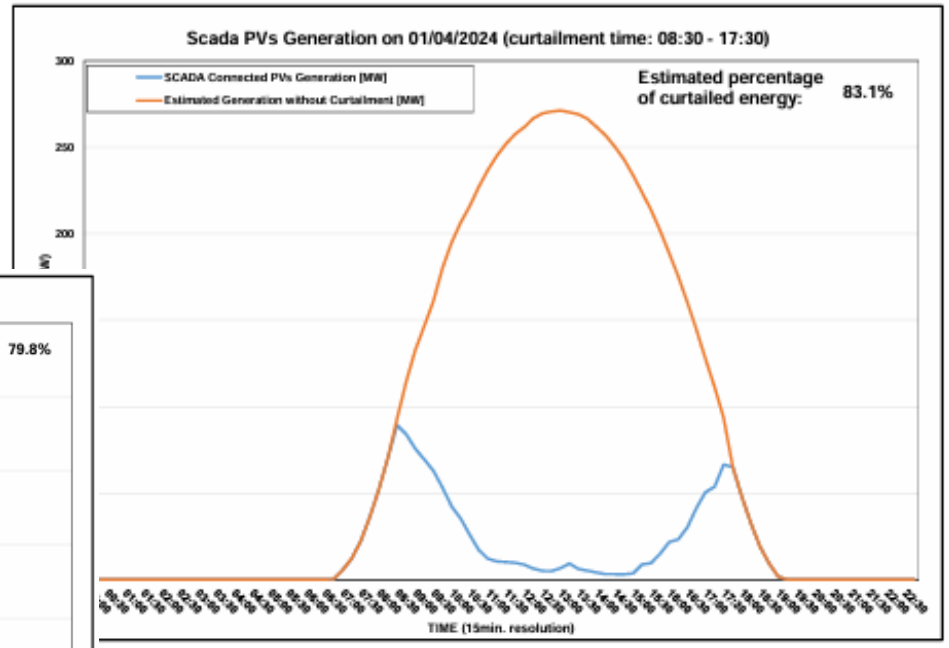
Feb 2024 (Tue)



Mar 2024 (Bank holiday)



Apr 2024 (Bank holiday)



Future needs and mitigation measures

- Expected **massive RES penetration** in the next decade
- During low load conditions (40% of the year), **further RES penetration will increase energy RES curtailments**
- **Mitigating curtailment issues**:
  - Introduction of **energy storage systems** to store excess energy (no utility scale energy storage installations at the moment)
  - **Electricity interconnections** with neighboring countries to export excess RES generation
  - **Flexibility solutions** - implementation of **data-driven algorithms** for forecasting RES generation and PV curtailment, smart energy management and demand-side flexibility

Mitigating curtailment issues

Energy storage systems (ESS)

- Approximately 500 MWh of ESS with a rated power of 450 MW are needed to maintain RES energy curtailments < 1% for total PV total installed capacity up to 850 MW [1]

Interconnecting with neighboring countries

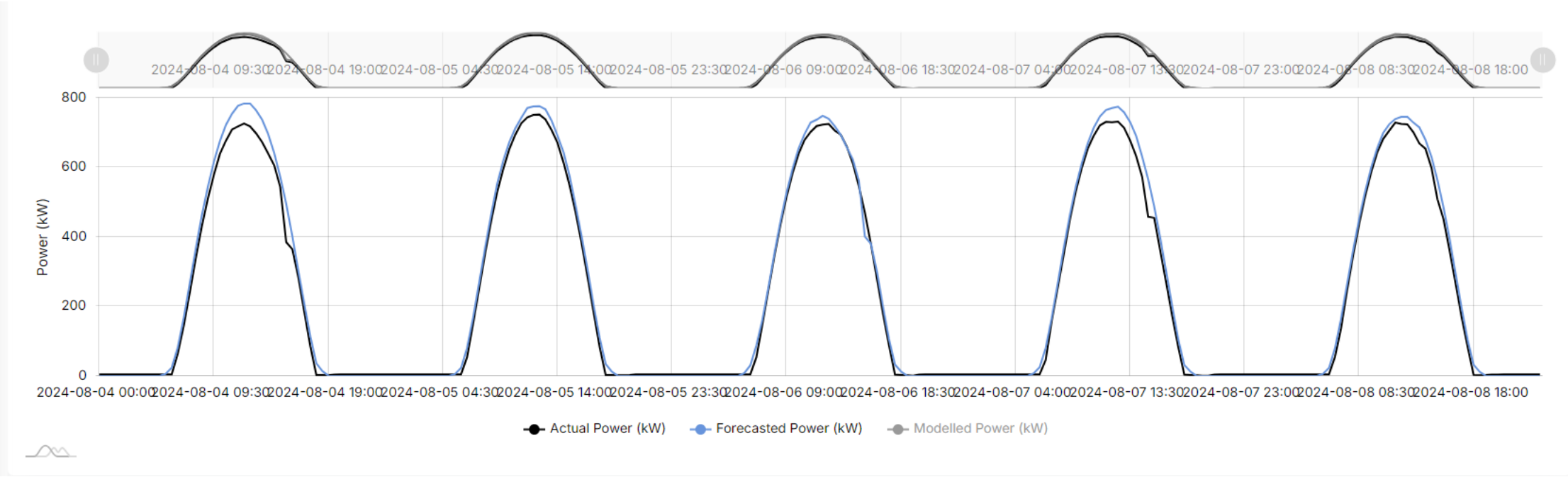
- Prospective electrical grid interconnection - **Great Sea Interconnector** (formerly EuroAsia interconnector) between the Greek, Cypriot, and Israeli power grids (undersea cables)

[1] “The redesign study of the power system of Cyprus 2021-2030”, TSOC- DSO (Electricity Authority of Cyprus), Tech. Rep., July 2021.

Challenges – Ongoing work

Data-driven solutions:

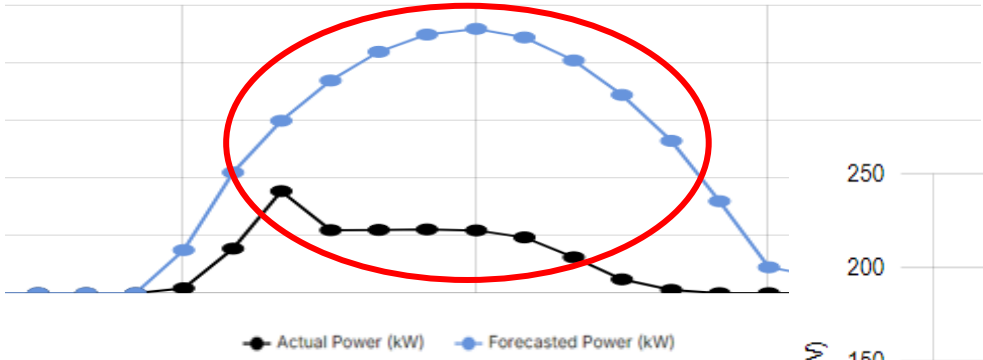
- Accurate forecasting algorithms for RES (mainly PV) generation and electricity consumption

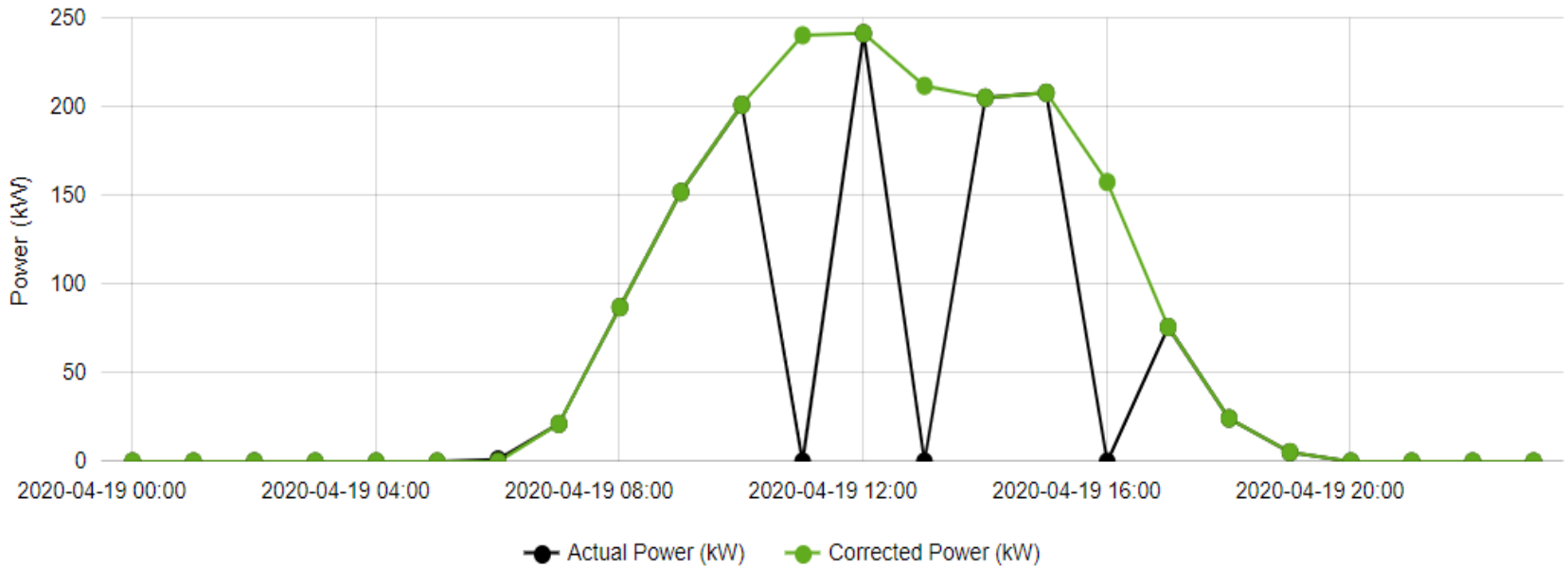


nRMSE	3.35%	1.71%	1.64%	2.82%	1.93%

Challenges – Ongoing work

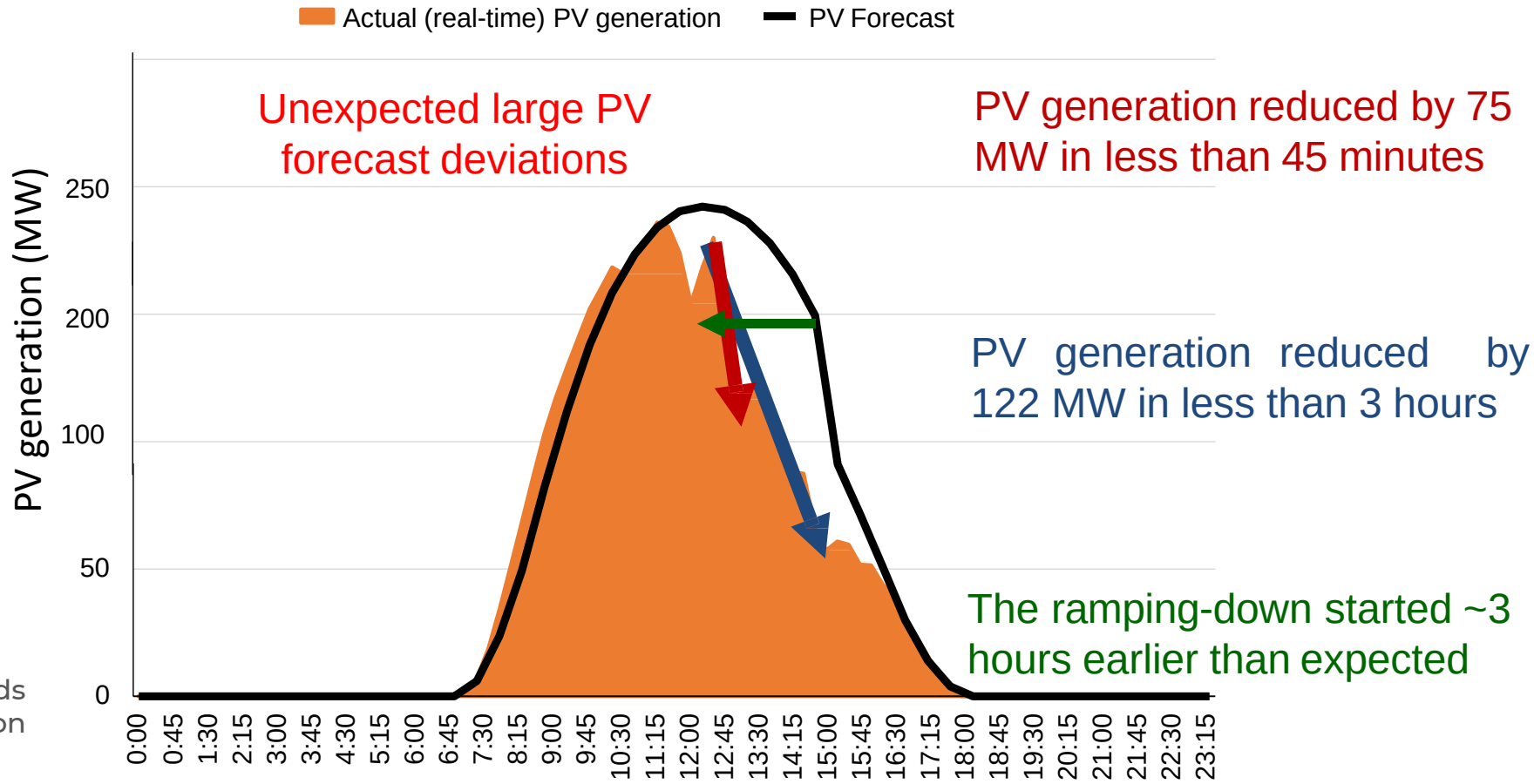
- Low quality of data → Low accuracy forecasts and big errors
- Correction of the low-quality datasets for improved forecasting





Challenges – Ongoing work

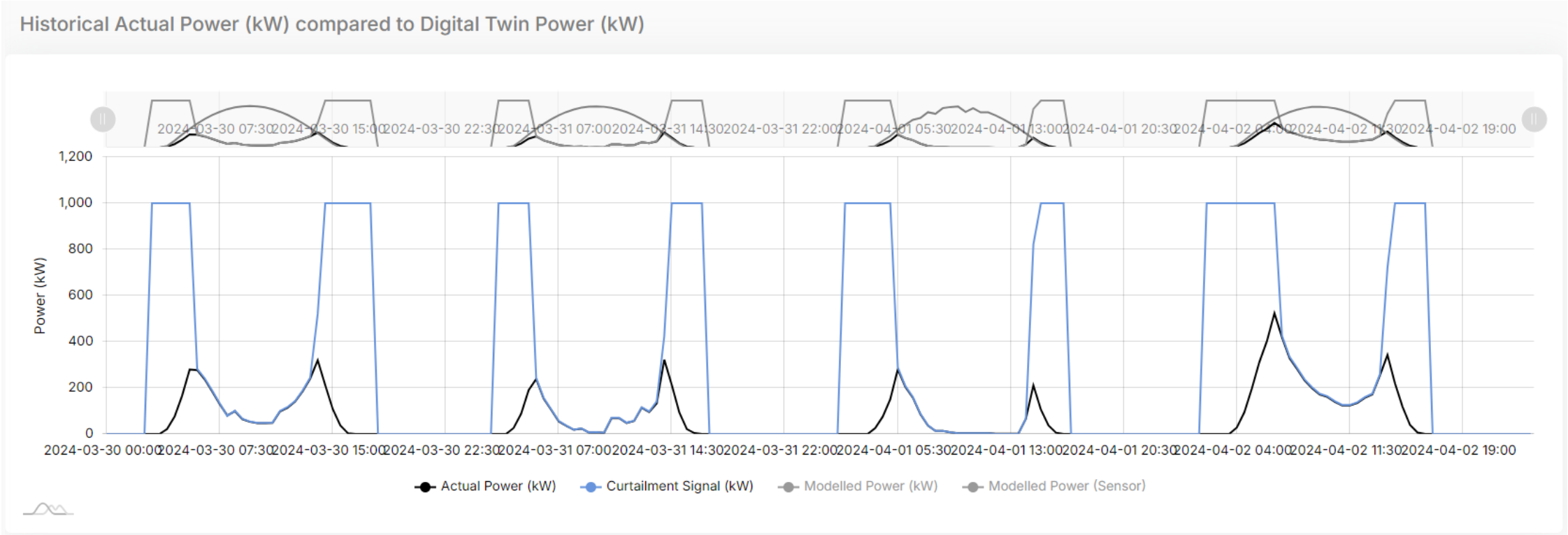
- Day-ahead PV generation forecasting and sudden cloud coverage



Source: S. Stavrinos, "Challenges and Needs of the Cyprus Power System Transmission System Operator of Cyprus", 2023

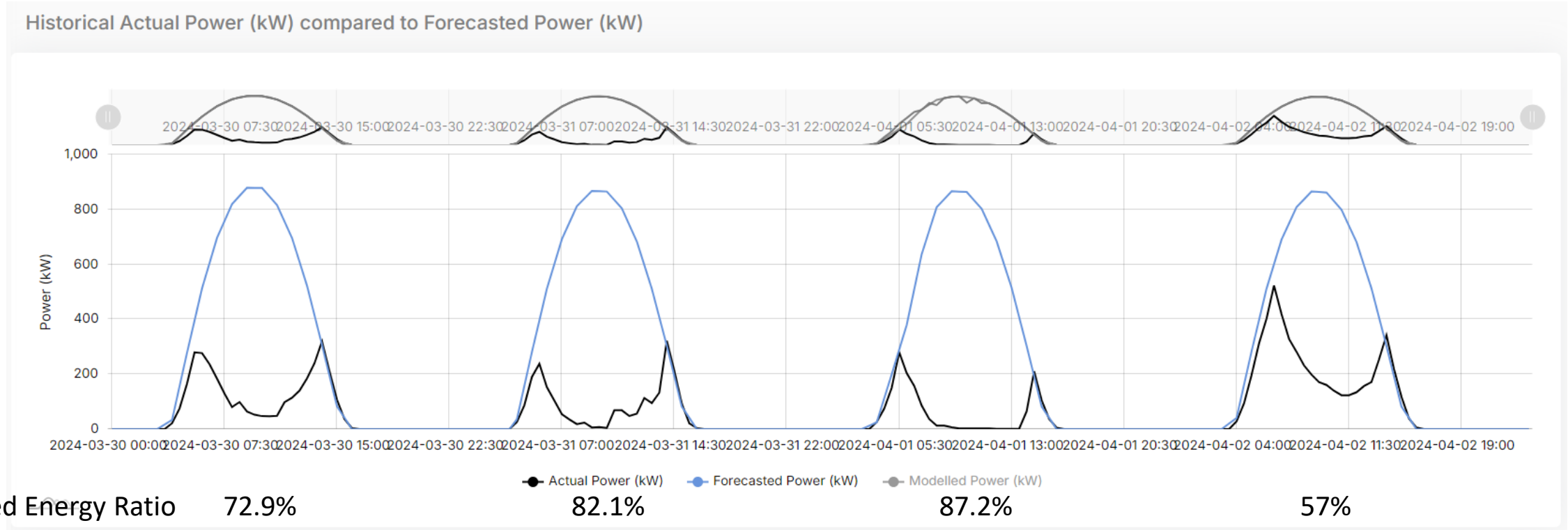
Challenges – Ongoing work

- Day-ahead PV generation forecasting and PV curtailment
- PV curtailment signal



Challenges – Ongoing work

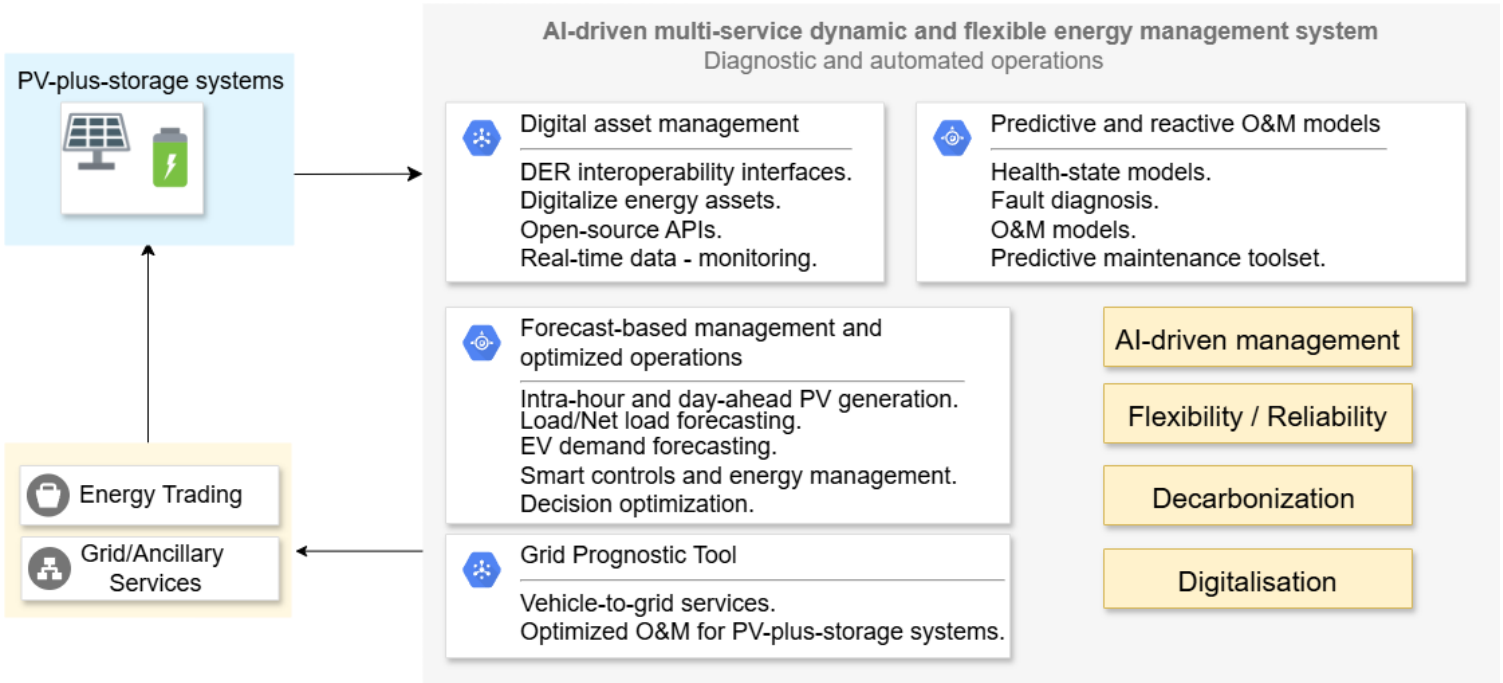
- Day-ahead PV generation forecasting and PV curtailment
- Algorithms for PV curtailment energy loss estimation



Curtailed Energy Ratio	72.9%	82.1%	87.2%	57%

Challenges – Ongoing work

- Analysis of historical patterns (trends and seasonality) and curtailment signals to develop accurate forecasting algorithms for PV curtailment
- Intelligent curtailment algorithms for achieving minimum required curtailment
- Smart energy management system to optimize energy flows



Moving forward

- Cyprus is currently facing significant challenges due to the increasing RES penetration
- These challenges will become more profound as the target for RES penetration will increase in the upcoming years
- The current electric system cannot accommodate this rate of RES increase without significant changes
- ESS, system flexibility and accurate data-driven algorithms are of paramount importance for minimizing RES curtailments

Acknowledgments

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Thank you for your attention

Let’s discuss

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