Imperial College London

PROVISION OF ENERGY AND FREQUENCY CONTAINMENT ANCILLARY SERVICES IN UNIT COMMITMENT

Carlos Matamala, Luis Badesa, and Goran Strbac
email: cmatamal@ic.ac.uk

SUMMARY

- This work focus on operational system flexibility for secure operation **in low-inertia systems**.
- A lack of synchronous resources operating in the grid can lead to security issues in the case of outages by violating frequency needs such as **RoCoF, nadir, and q-s-s**.
- Ancillary services such as **inertia, EFR, and PFR**, will be considered to provide this flexibility.

RESEARCH PROBLEM AND METHODOLOGY

The problem that we are trying to solve is:

- The model correspond to a **Frequency-Constrained UC** formulated as a Mixed-Integer Second-Order Cone Program (MISOCP).
- The methodology optimally clear a market of ancillary services for frequency control, while explicitly considering the participation of different providers of ancillary services such as inertia, PFR and EFR.
- This central dispatch schedules the necessary **frequency security ancillary services** considering that the largest dispatched unit in the system can face an outage.
- The problem **minimise the total fuel costs** of the system.

The case study considers:

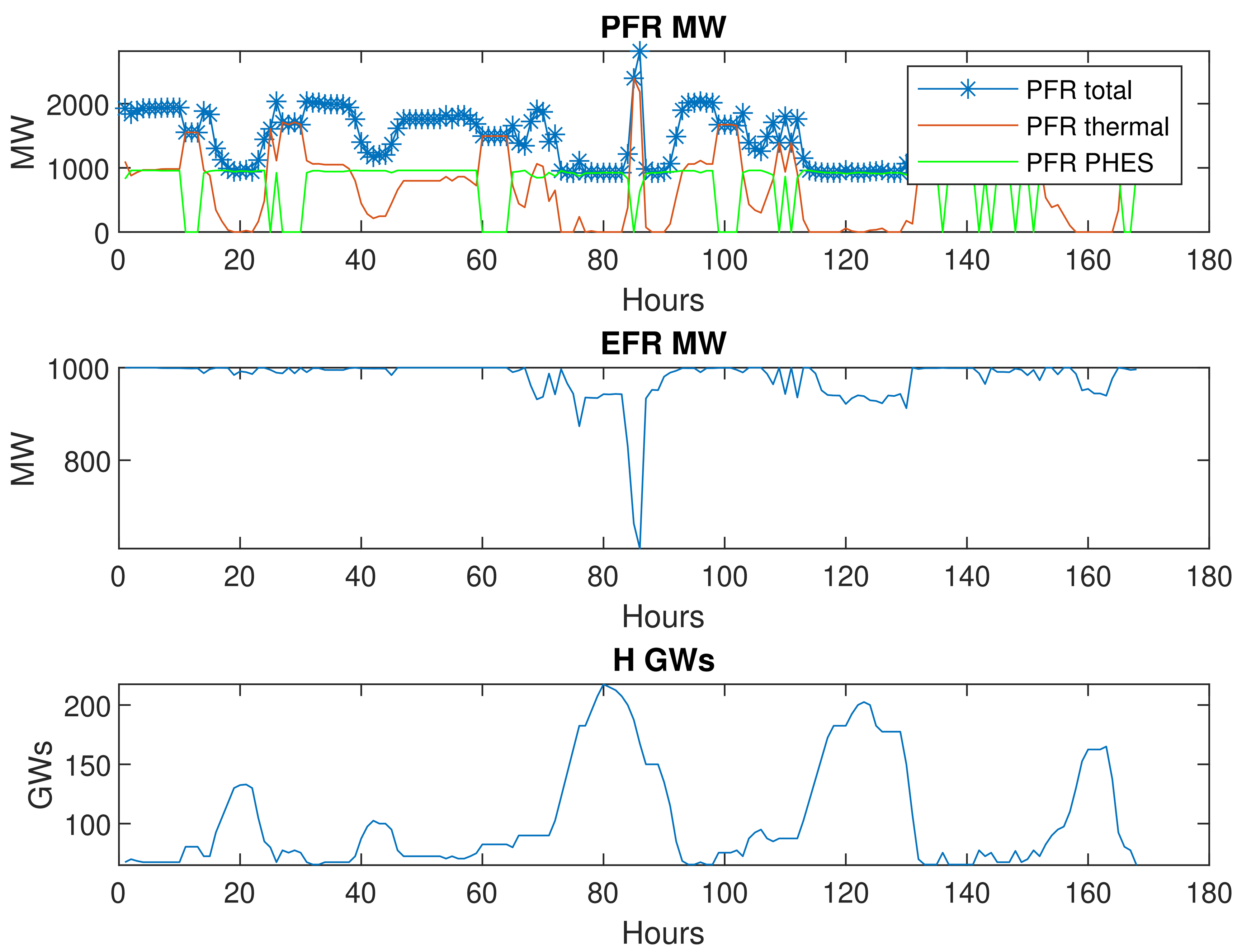
- The **GB electricity system** is considered in a **2030** scenario that corresponds to the 'Leading the way' scenario within National Grid's 2022 Future Energy Scenarios depicted in [1].
- **Generation mix** represents: **six types of thermal units** in which CCGT and OCGT can provide PFR. **Two types of energy storage**, PHES that can provide PFR; and BESS, that can provide EFR. **Three types of renewables** (onshore wind, offshore wind and solar PV) are also modeled, which can only provide energy.
- **A multi-period** framework considering a typical day is considered to represent a set of credible operating condition for the GB system.

FREQUENCY-CONTAINMENT UC

The model is defined as a Frequency-Containment UC optimisation problem. The objective function minimise fuel costs; *private* constraints limit the provision of energy and ancillary services from different market players; while *system-wide* constraints, associated with system's requirements, determine the total requirements to meet demand and ancillary services provision.

This work is based on a previous model developed in [2]–[4], and it is currently being improved to represent a more realistic operation of the system.

FIGURE 1

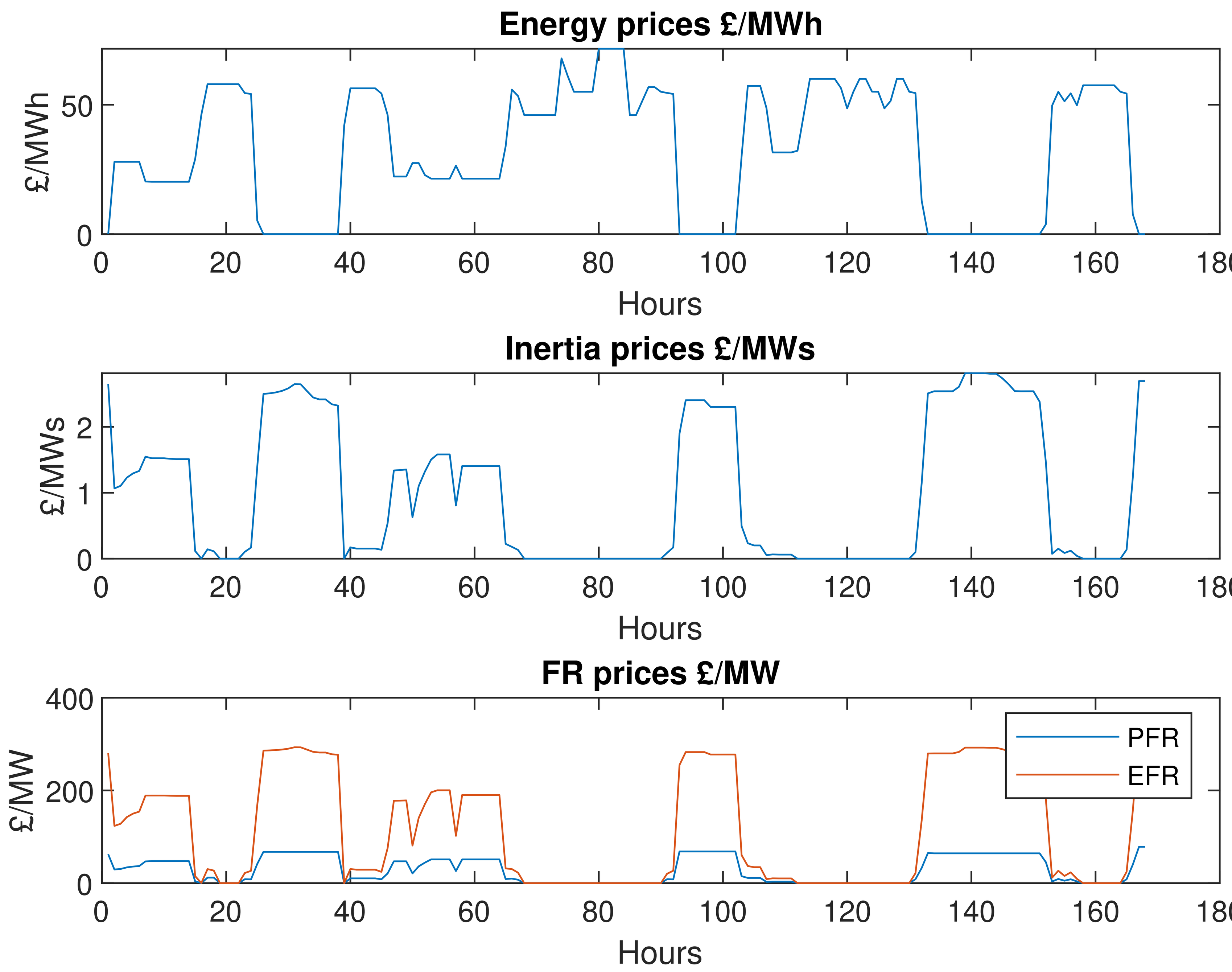


ECONOMIC VALUE OF FREQUENCY SERVICES

Fig. 1 shows the amount of **PFR, EFR and synchronous inertia** for an operation day in the GB system in 2030. As it can be seen in most of the operative hours, there are low-inertia levels, which makes this service to be valuable for the system. Also, it is shown that there is an important support of PFR and EFR during these low-inertia hours.

High RES penetration hours create zero energy prices. However, as can be seen in Fig. 2, during this low-inertia hours, ancillary services markets exhibit importance, increasing their prices, demonstrating how valuable are these services for the system.

FIGURE 2



Conclusions from our studies on value of alternative services:

- The co-optimization of these technologies would bring **economic incentives** to market players, while at the same time **maintaining frequency security** in the system.
- Frequency response services play a key role for low-inertia operating conditions, providing the necessary frequency security for the system.

FUTURE WORK

- Analyse these results in a multi-period framework, considering a more realistic market driven approach.
- Explore how RES could fit in this market providing ancillary services.
- It would be important to understand the relation between these frequency security services and other services such as secondary reserve, as these services can compete with each other in a multi-period framework.

REFERENCES

[1] N. G. ESO, "Future energy scenarios," *National Grid Electricity System Operator: London, UK*, 2022.

[2] L. Badesa, C. Matamala, Y. Zhou, and G. Strbac, "Assigning shadow prices to synthetic inertia and frequency response reserves from renewable energy sources," *IEEE Transactions on Sustainable Energy*, vol. 14, no. 1, pp. 12–26, 2023. DOI: 10.1109/TSTE.2022.3198324.

[3] L. Badesa, G. Strbac, M. Magill, and B. Stojkovska, "Ancillary services in great britain during the covid-19 lockdown: A glimpse of the carbon-free future," *Applied Energy*, vol. 285, p. 116 500, 2021, ISSN: 0306-2619. DOI: https://doi.org/10.1016/j.apenergy.2021.116500. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0306261921000593.

[4] L. Badesa, F. Teng, and G. Strbac, "Optimal portfolio of distinct frequency response services in low-inertia systems," *IEEE Transactions on Power Systems*, vol. 35, no. 6, pp. 4459–4469, 2020. DOI: 10.1109/TPWRS.2020.2997194.