To what extent can hydrogen electrolysers (HEs) contribute for a secure operation of future power systems during low inertia periods?

Fernando Ribeiro

fernando.j.ribeiro@inesctec.pt

–

Supervisor(s): João A. Peças Lopes[1], Filipe J. Soares[1], André G. Madureira[2]

1. INESC TEC, Porto
2. LIST, Luxembourg

MIT Portugal
2022 Annual Conference

Problem formulation

A climate-neutral Europe will require the integration of large amounts of Hydrogen Electrolysers (**HEs**) in the power system. HEs are **controllable loads**, able to quickly respond to a command signal, therefore will become valuable assets for **balancing** future power systems while performing their main task, i.e. generating hydrogen.

1. **Green hydrogen production** will be **maximized** at times of abundant renewable energy generation;

2. The grid is **fragile** in these periods because conventional power plants are displaced by units with **no inertia**;

Q: If a contingency happens in a period of low system inertia in the particular case of Iberian Peninsula, can the HE fleet guarantee frequency stability?

Indicators to be guaranteed at all times by the system operator:
- Frequency nadir, objective: >49.2Hz
- Quasi-steady state frequency, objective: >49.8Hz
- Rate of Change of Frequency (**RoCoF**), objective: <1Hz/s

Methodology

Power systems dynamic simulation (MATLAB/Simulink)
- Two-node power system: Iberian Peninsula and Central Europe modelled for 2040 under low inertia conditions

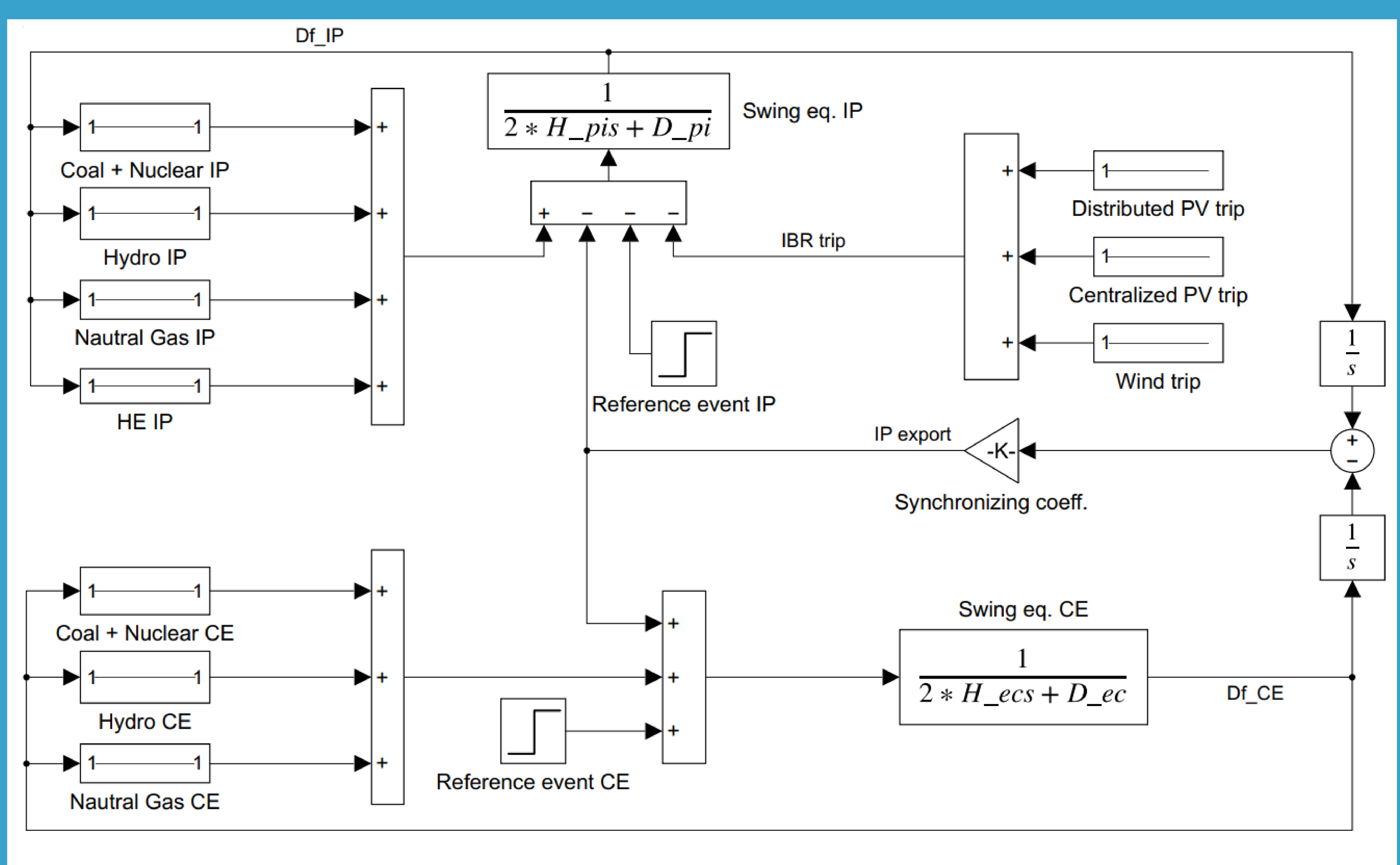

Fig. 1 – Dynamic simulation model

Ancillary service (AS) provision:
- Frequency Containment Reserve (**FCR**),
  - Provided either by conventional resources (hydro, natural gas) or HEs
- Synthetic Inertia (**SI**) provided by HEs
  - Response proportional to RoCoF
- Fast Frequency Response (**FFR**) provided by HEs
  - Response triggered when frequency is below 49.7Hz

Contingencies under study:
- Reference incident (1GW loss)
- Inverter-based resources (**IBR**) trip (instant active power loss: 3GW)

Main results

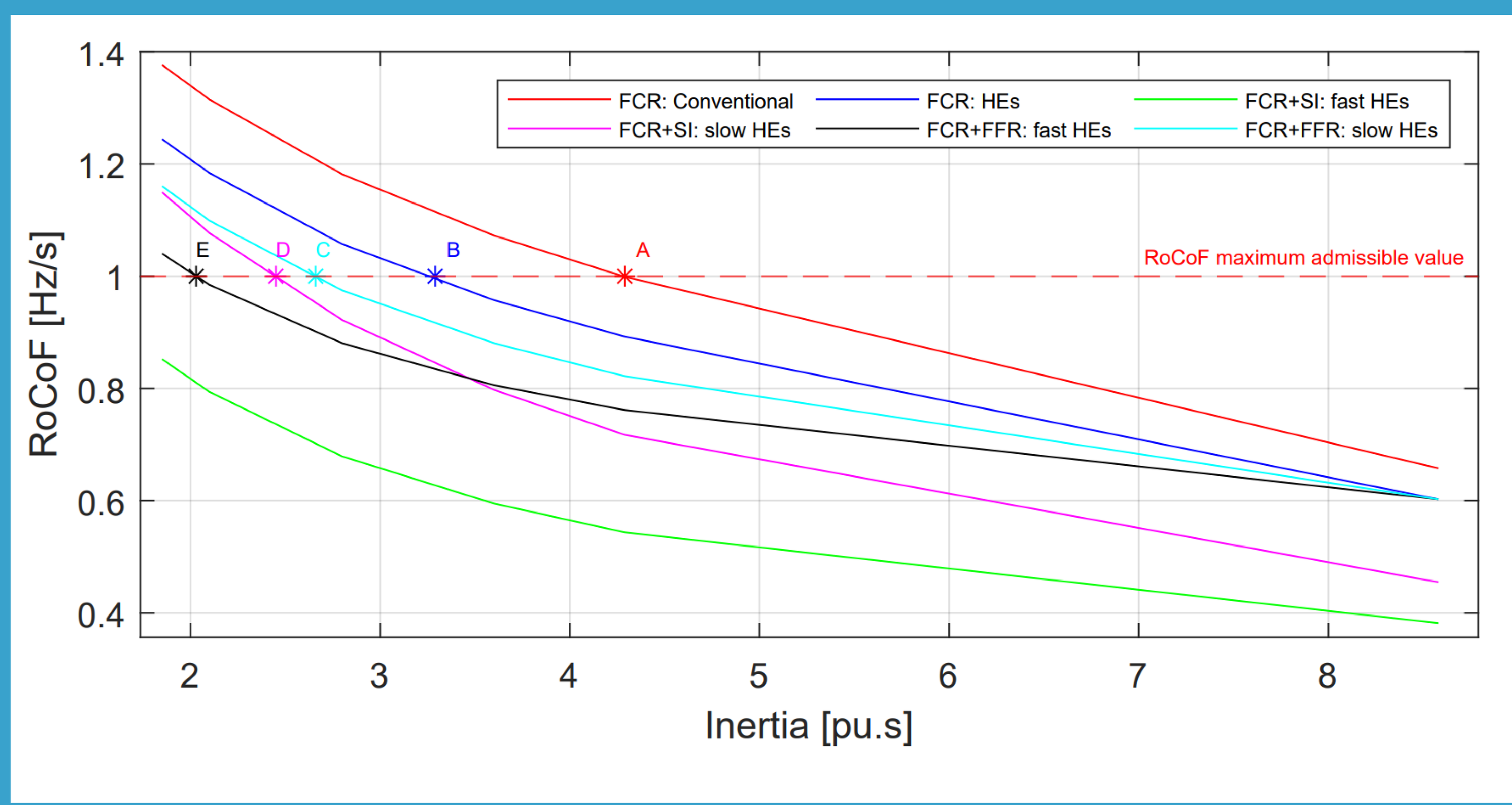

Fig. 2 – RoCoF after IBR trip depending on inertia and AS provided

Observations:
- Conventional generation participating in FCR is able to guarantee RoCoF stability down to inertia = ***A**,
- If inertia is between ***A** and ***B**, FCR is able to guarantee RoCoF stability only if provided by HEs,
- If inertia is below ***B**, additional services to the FCR are required,
- **SI** control performs **marginally better than FFR**,
- Only a combination of factors (large **volume** of **SI** provided by a fleet dominated by ***fast*** HEs) is able to guarantee that RoCoF is secured < 1 Hz/s in case of very low inertia values.

Other results:
- Reference incident poses no threat (neither frequency nadir, quasi steady state frequency, nor RoCoF)
- Increasing AS volume does not guarantee RoCoF stability,
- Fast HEs perform significantly better than slow HEs but only up to a certain AS volume, after which there is no improvement,
- Improving measurement acquisition delay has very limited impact.

Conclusions

Future power systems, particularly the Iberian Peninsula, may be faced with stability insecurity (RoCoF >1Hz/s) after an IBR trip.

HEs can assist system operators in stabilizing the power system after contingencies. However, even if fully exploited, the potential of a large HEs fleet (12GW in 2040) cannot *per se* guarantee system stability at all times.

HEs should then be seen as **part** of the **solution**, minimizing the use of purposely built machines for increasing inertia such as synchronous compensators.

Publications

- *The Role of Hydrogen Electrolysers in the Frequency Containment Reserve: A Case Study in the Iberian Peninsula up to 2040* - **accepted for presentation** in the 5^{th} International Conference on Smart Energy Systems and Technologies (SEST), Endhoven, September 5-7, 2022
- Journal paper to be submitted to Electric Power Systems Research (EPSR)

Funded by:

FCT Fundação para a Ciência e a Tecnologia — MIT Portugal

under the Doctoral Grant SFRH/BD/151414/2021 | Sustainable Cities