Study Committee C1

Power System Development and Economics

Paper 11030_2022

Energy transition system prospective and operability studies in Spain

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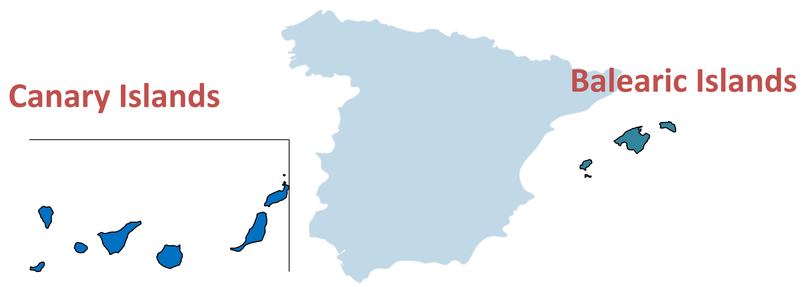
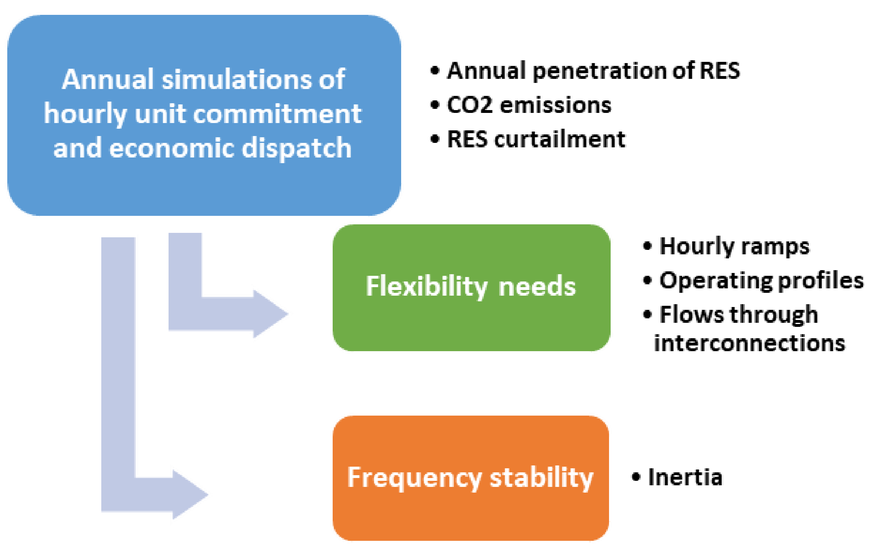
Motivation

The energy transition implies a substantial change never before experienced in the electricity system, characterized fundamentally by a significant growth of renewable generation to make possible the decarbonisation objectives set both in the European environment (Framework on climate and energy for 2030) as well as at the national level in the draft of the National Energy and Climate Plan (NECP).

The analysis presented focuses on the systems of the Canary and Balearic Islands, being, for its isolated nature, the systems where these challenges are more demanding.



Method/Approach



Objects of investigation

The prospective studies of the operation challenges of the Canary and Balearic Islands have been carried out for the time horizons 2026 and 2030 taking as reference the scenarios of the NECP and those already performed in the framework of the 2021-2026 electricity network planning process.

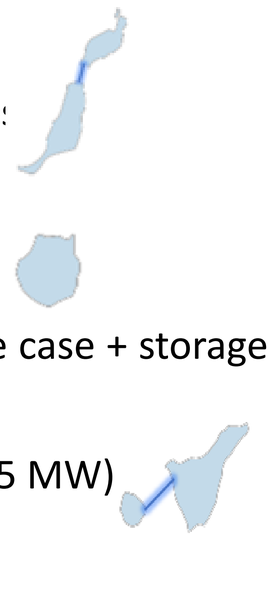
The set of studies performed is aimed at identifying and, as far as possible, anticipating the challenges and needs for the safe operation of the system in future medium and long-term scenarios and evaluate the technical feasibility of the future operation of the system.

Experimental setup & test results

By means of comparison to a base case, a series of sensitivities have been studied from the balance flexibility and frequency stability perspective.

➢ <u>Canary Islands sensitivities</u>:

- Lanzarote-Fuerteventura base case 2026 + batteries (72MW)
- Gran Canaria base case 2026 + storage (200 MW)
- Lanzarote-Fuerteventura + Gran Canaria 2030 base case + storage (200 MW)
- Tenerife-La Gomera base case 2026 + batteries (165 MW)
- La Palma base case2030 + batteries (12 MW)



➢ <u>Balearic Islands sensitivities</u>:

- H2026 base case without reinforcement link to mainland
- H2030 completed link to mainland

Discussion

- Explore the possibilities of thermal groups to reduce the technical minimum, increase its ramping capabilities and diminish the connection times in a large amount of renewable/storage capacity scenario.
- Assess the possibilities of replacing synchronous generation must-run units by synchronous compensators by grid-forming controls in RES, HVDC and FACTS technologies.
- Enlarge the portfolio of possible reserve providers in the system, including renewables, storage, demand side management, interconnections etc.

Conclusion

- For the Canary Islands systems, storage and AC island interconnections have been identified as key providing the needed system flexibility and strength to maximize RES penetration.
- Balearic system descarbonization lies in improving its interconnection capacity with not-far Iberian Peninsula by means of a second HVDC link, plus fully integrated batteries and synchronous condensers that allow a maximization of the use of HVDC links and submarine AC links between islands.

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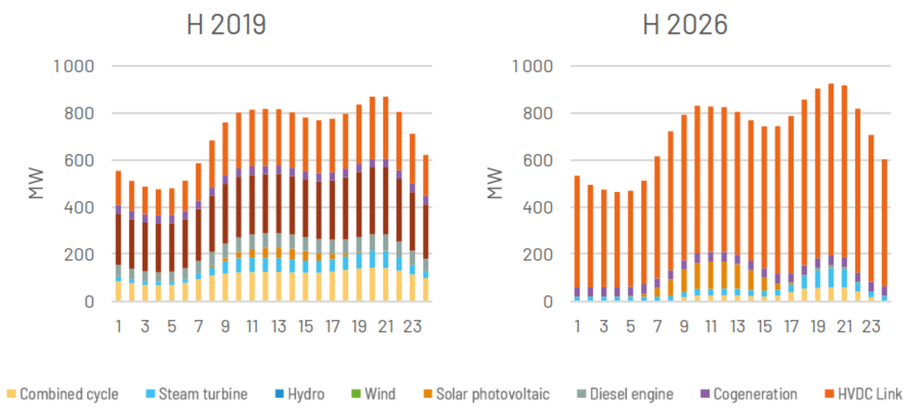
Balearic Electricity System: Balance results

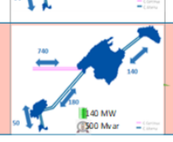
The strategy to get the decarbonisation of the Balearic Electricity system is based on the reinforcement of the interconnection between Iberian Peninsula and Balearic Islands (HVDC interconnection, batteries and synchronous condensers).

Demand coverage on the Balearic Islands by technology. Comparison 2019 and 2026 (with 2xHVDC)



It can be seen from the above Figure that 2026 balance results show a great coverage of the demand in the system coming from the Iberian Peninsula through the 2 HVDC links.

Main results of balance analysis

Scenarios	Maximum capacities in the links	Description	Peninsula-Mallorca Islands interchange	Mallorca-Menorca interchange	Mallorca-Ibiza interchange	Emissions	Cost of generation	Average cost
H2026 Base		Base case	5115 GWh	216 GWh	886 GWh	462 Kton	94 M€	83 €/MWh
H2026 delay		Delay of the Peninsula-Baleares interconnection reinforcement	▼ -62%	▼ -26%	▼ -27%	▲ 314%	▲ 389%	▲ 29%
H2030		Base case (with second Mallorca-Menorca link)	▲ 3%	▲ 87%	▲ 5%	▼ -28%	▼ -33%	▼ -33%

Negative effect
Positive effect

The whole reinforcement package of the interconnection between the peninsula and the Balearic Islands would **make** possible to **more than double** the **energy transmitted from the peninsula to the Balearic system** and increase exchanges by 35% and 37% between Mallorca-Menorca and Mallorca-Ibiza respectively. Additionally, **CO_2 emissions would be reduced by 76%** in 2026 and the **variable costs of generation** in the Balearic Islands **would be reduced by 80%.**

Canary Electricity System. Balance results

It is essential to have storage systems that allow the integration of existing and planned renewable generation.

Main results of balance analysis

Scenarios	System	Description	Curtailment	%Curtailment (*)	%RES over elect. prod.	Emissions	Variable cost of generation	Average Cost
GC 2026	Gran Canaria	Base case	769.0 GWh	34.0%	38.0%	1717.0 kton	472.0 M€	118.0 €/MWh
GC 2026 Pumping		With Chira-Soria pump storage plant	▼ -73%	▼ -25%	▲ 13%	▼ -20%	▼ -26%	▼ -25%
GCLZFV 2030	Gran Canaria - Fuerteventura - Lanzarote	Without Chira-Soria pump storage plant, without batteries and wiht GC-FV link	1173.0 GWh	34.0%	37.0%	2642.0 kton	890.0 M€	142.0 €/MWh
GCLZFV 2030 Pumping		With Chira-Soria pump storage plant, without batteries and with GC-FV link	▼ -64.8%	▼ -22%	▲ 11%	▼ -17%	▼ -25%	▼ -25%
LZFV 2026	Lanzarote - Fuerteventura	Base case	260.0 GWh	36.0%	24.0%	948.0 kton	285.0 M€	146.0 €/MWh
LZFV 2026 Bat		With batteries	▼ -72.7%	▼ -26%	▲ 9%	▼ -11%	▼ -21%	▼ -21%
TFLG 2026	Tenerife - La Gomera	Base case	347.0 GWh	19.0%	33.0%	2000.0 kton	624.0 M€	141.0 €/MWh
TFLG 2026 Bat		With batteries	▼ -43.2%	▼ -8%	▲ 3%	▼ -6%	▼ -11%	▼ -11%
LP 2026	La Palma	Base case	70.0 GWh	55.0%	18.0%	169.0 kton	52.0 M€	162.0 €/MWh
LP 2026 Bat		With batteries	▼ -47.1%	▼ -26%	▲ 11%	▼ -12%	▼ -13%	▼ -10%

Negative effect
Positive effect

(*) The differences are shown as percentage points (pp)

- The pump storage project in Gran Canaria provides a **20% reduction in annual CO_2 emissions**, an increase in the contribution of renewable generation to demand coverage from 38% to 51%.

- The battery storage system allows:

  - In Lanzarote-Fuerteventura: **a reduction of annual CO_2 emissions** of around **11%** and the renewable generation goes from supplying 24% to 33% of the demand.

  - In Tenerife: an **increase in the share of renewable** generation **from 33% to 36%** with an increase in renewable production of 10%.

  - In La Palma: a **reduction of annual CO_2 emissions by 12%,** an increase in the contribution of renewable generation to demand coverage from 18% to 29%.

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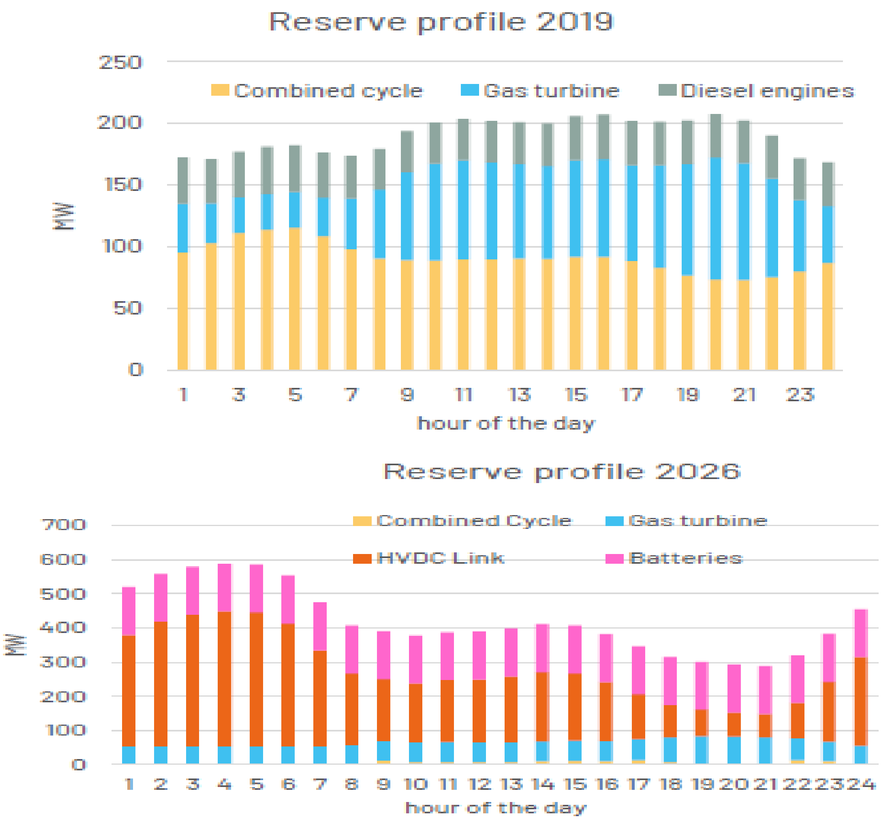
Balearic Electricity System

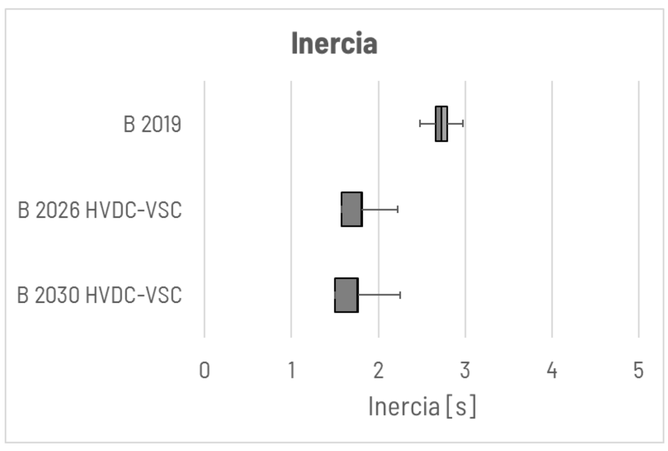
Flexibility

HVDCs allow reserve profile is based on energy from mainland.



Frequency stability

Balearic system stability is **challenging** due to a **decrease** of **inertia. HVDCs** are critical to keep the system safe and with **minimum must –run** with CO_2 emissions.



Synchronous compensators are required in this system in order to ensure the correct operation of the HVDC links and help to diminish RoCoF.

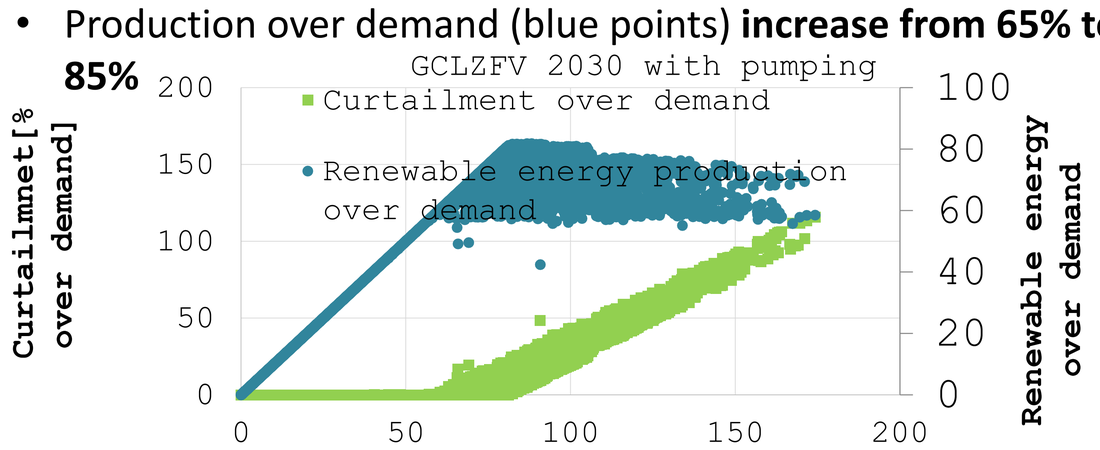
Need for additional inertia is detected for 20% of the time, which may be provided through the adequate design of the proposed **synchronous compensators** or with **advanced power electronics controls.**

Canary Electricity System

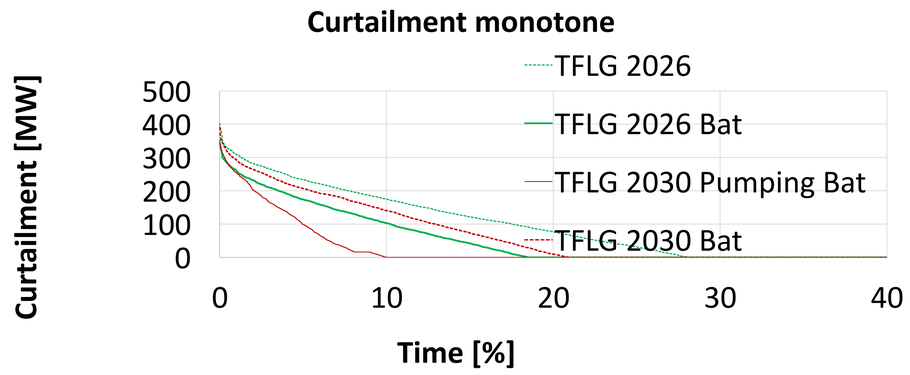
Flexibility

In 2030 , and due to pumping, In Lanzarote-Fuerteventura + Gran Canaria system:

- Renewable energy over demand grows from **20% up to 50%** (green points)
- Production over demand (blue points) **increase from 65% to 85%**

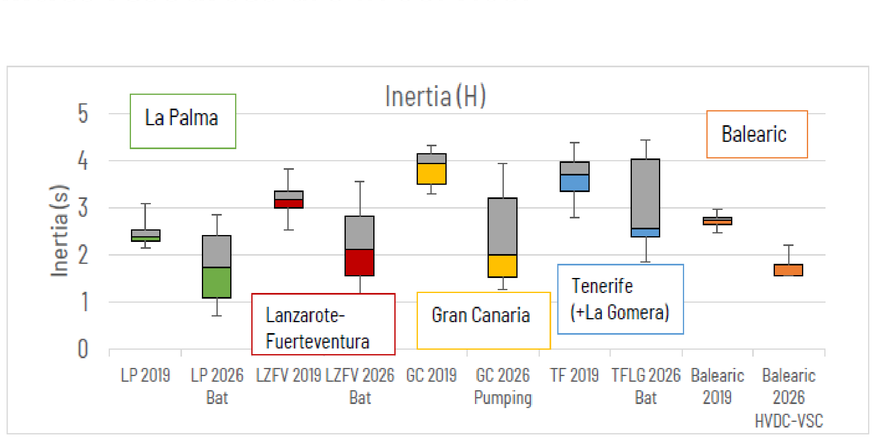


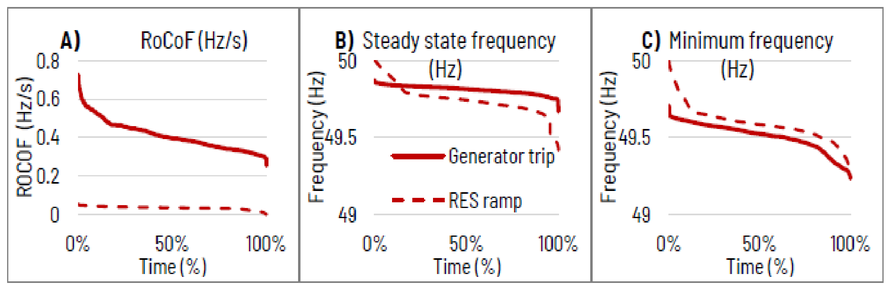
- Pumping and batteries can reduce the curtailment until **10% in 2030 in TF-LG system.**



Frequency stability

Although inertia decrease ROCOF, minimum and steady state frequency keeps in **safe range** if synchronous must run and **flexibilities resources** are in service.





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