IEA Wind
Task 25
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Analysis of different storage technologies in the Spain NECP for 2030

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Content

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Operational flexibility

- Ability of the system to withstand to the uncertainty and variability in generation and electricity demand, while maintaining the desired reliability at an affordable cost

Which aspects of operational flexibility can be measured?

- Variation of the (net) power demand at short-term horizon
- Upward and downward hourly ramps

MW/h

- Balance between generation and demand
- Operating reserves
- Firmness: contribution of each unit during the critical peak (net) demand hours

MW

- Variation of the (net) energy demand at different time horizons
- Daily, weekly, and seasonal variations

MWh

Phases in measuring operational flexibility

1. **Dimensioning.** Establishing a flexibility product margin

Ratio between product availability and product requirement = $\frac{\textit{max operational flexibility available}}{\textit{max operational flexibility requirement}}$

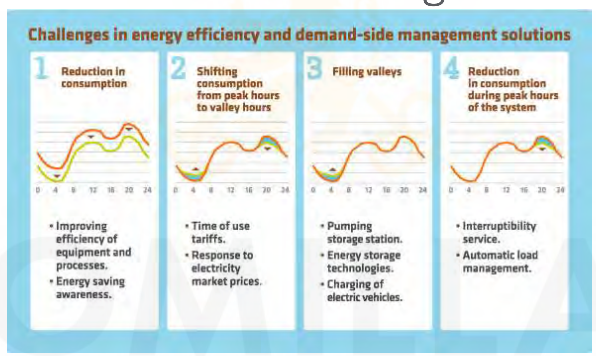
2. **Operational flexibility.** Run a cost-driven model and determines how all the flexibility products are covered

Flexible technologies

CCGT

Storage hydro

Demand side management

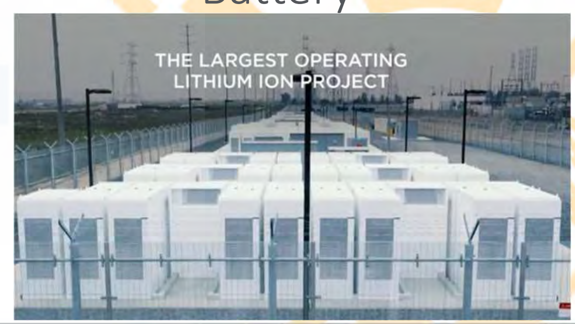


EV

Pumped-hydro storage

Solar thermal - CSP

Battery



Inflexible technologies

Solar PV

Wind

Key questions

Is there enough flexible power?

Which is the contribution of each technology to each flexibility product?

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Spanish NECP 2030

- Peak demand 47.8 GW
- Installed capacity 154.4 GW
- Annual demand 263 TWh

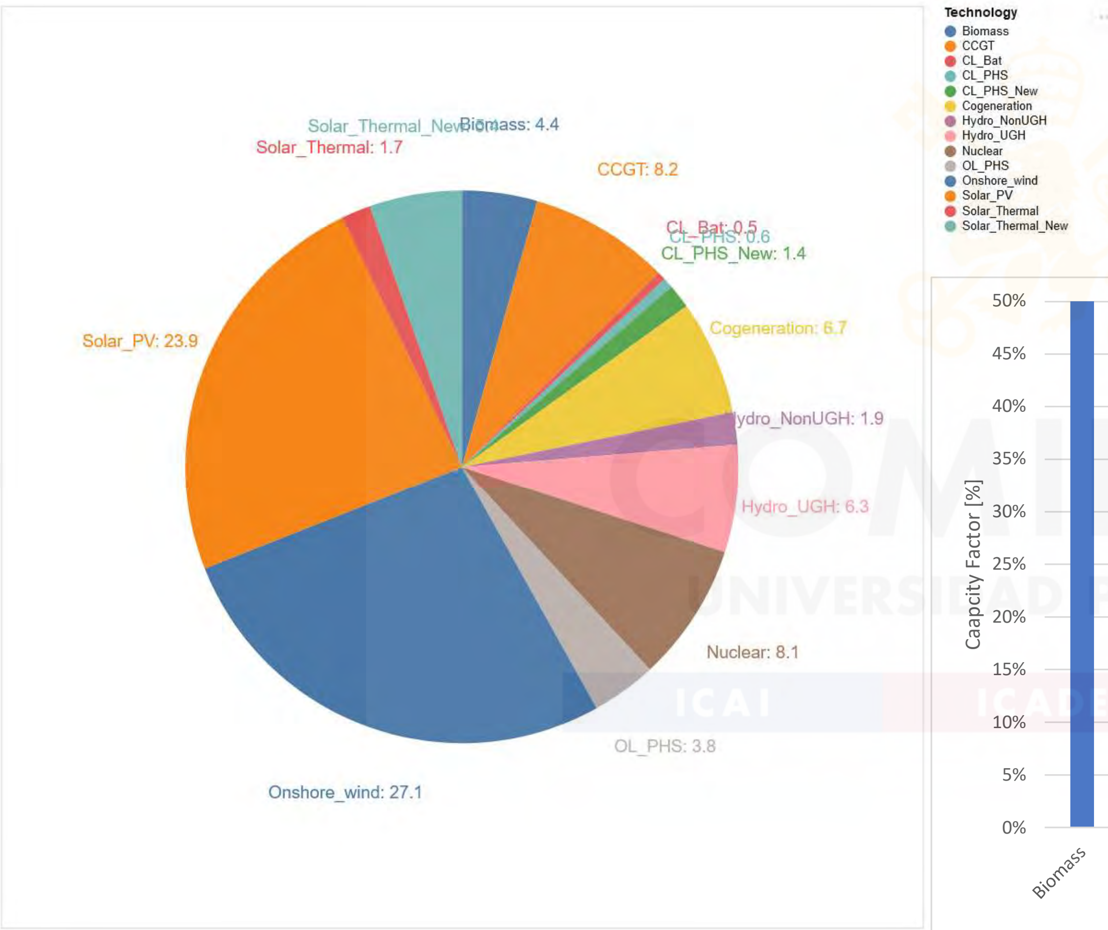
Nuclear	3,050
CCGT	24,560
Run of River Hydro	3,640
Storage Hydro	10,972
Open Loop Pumped-Hydro Storage	2,683
Close Loop Pumped-Hydro Storage	3,300
Close Loop Pumped-Hydro Storage (additional)	3,566
Batteries (additional)	2,500
Wind Onshore	27,370
Wind Onshore (additional)	21,180
Wind Offshore (additional)	200
Solar PV	15,550
Solar PV (additional)	22,854
Solar Thermal	2,300
Solar Thermal (additional)	5,000
Others renewable	1,730
Others non-renewable	3,980

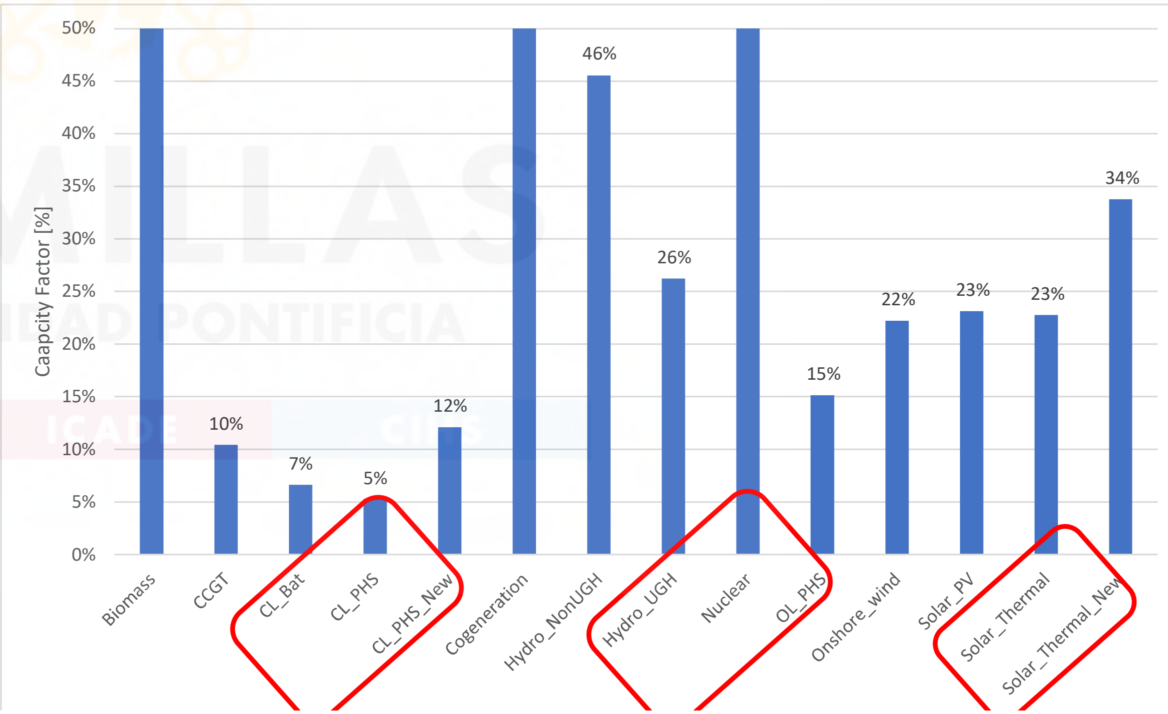
Dimensioning
Upward and Downward Hourly Ramps

	2019	2019	2030	2030			
	Down	Up	Down	Up	Min	Max	
Demand	-3,659	5,389	- 3,874	5,706			
Wind	-1,882	2,069	- 4,131	4,541			
Solar PV	-1,610	1,618	-11,880	11,941			
Net Demand	-4,203	5,633	-10,326	12,615			
CCGT	-3,369	3,180			-6,000	6,000	1
Storage Hydro	-1,425	1,430			-2,885	2,963	2
Pumped-Hydro Storage (pumping)	-1,804	2,326			-3,819	3,747	3
Pumped-Hydro Storage (turbining)	- 972	1,373					
Solar Thermal	- 840	1,321					

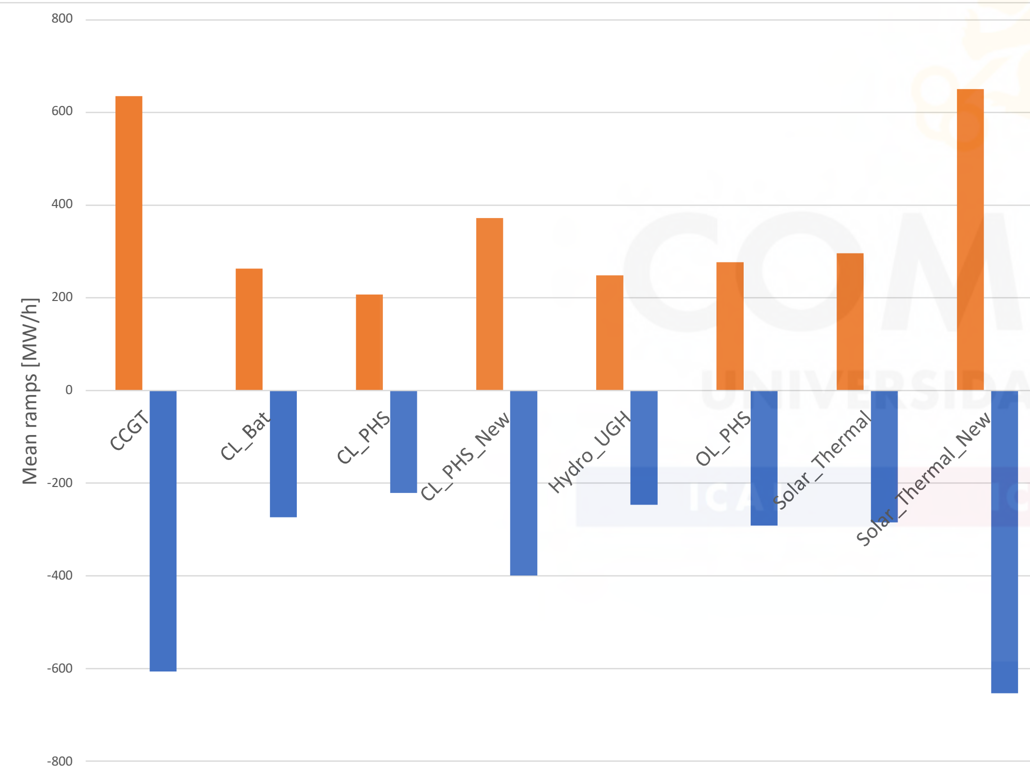
1 Assuming 20 CCGT units committed out of 50 installed
2 Quantiles 0.5-99.5% of downward and upward hourly ramps. They can be provided in any type of hydrologic year
3 Minimum and maximum downward and upward hourly ramps

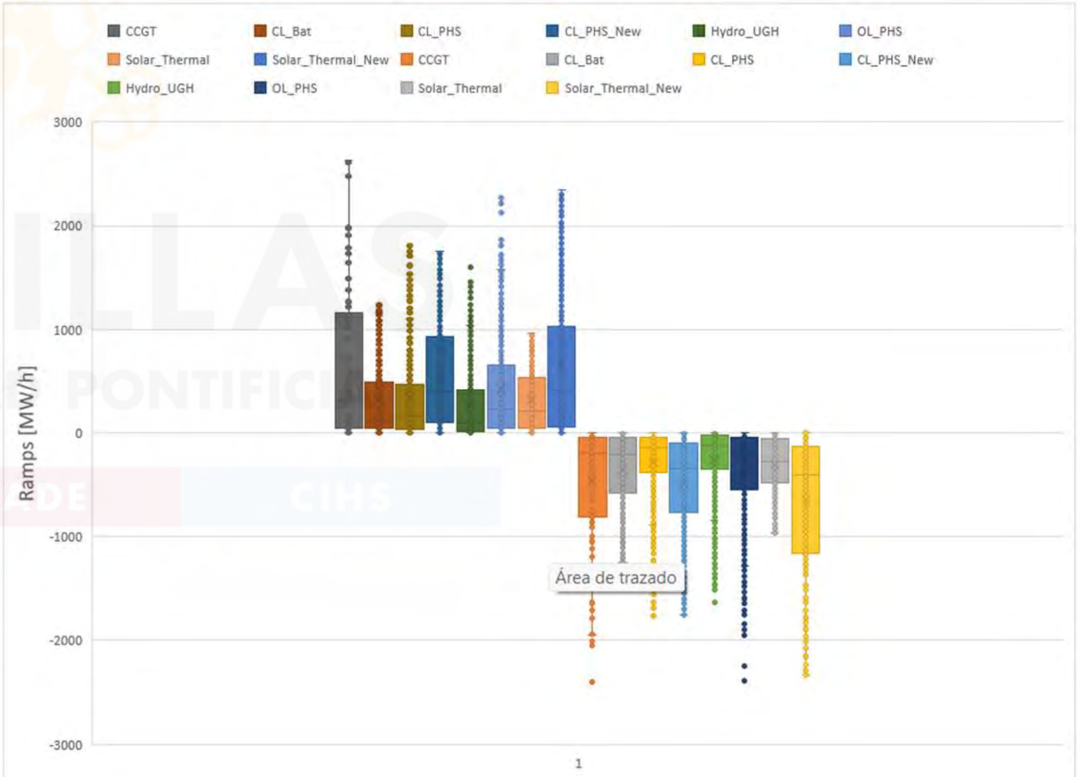
Cost-based system operation





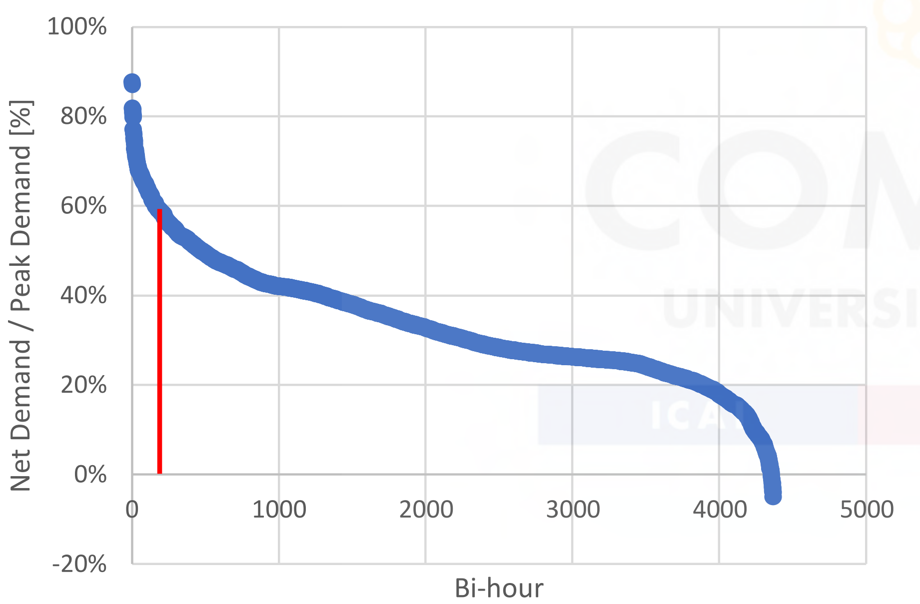
Flexibility at operation
Mean and boxplot of up/down ramps

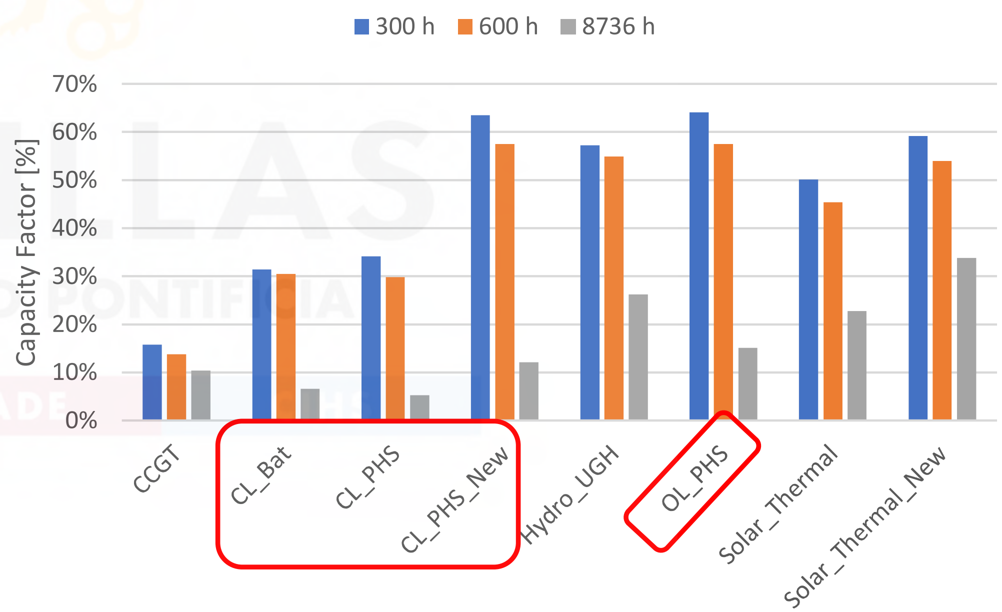




Flexibility at operation
Capacity factor
ELCC – Approximation-based method

Capacity factors of the technologies at peak hours of net demand

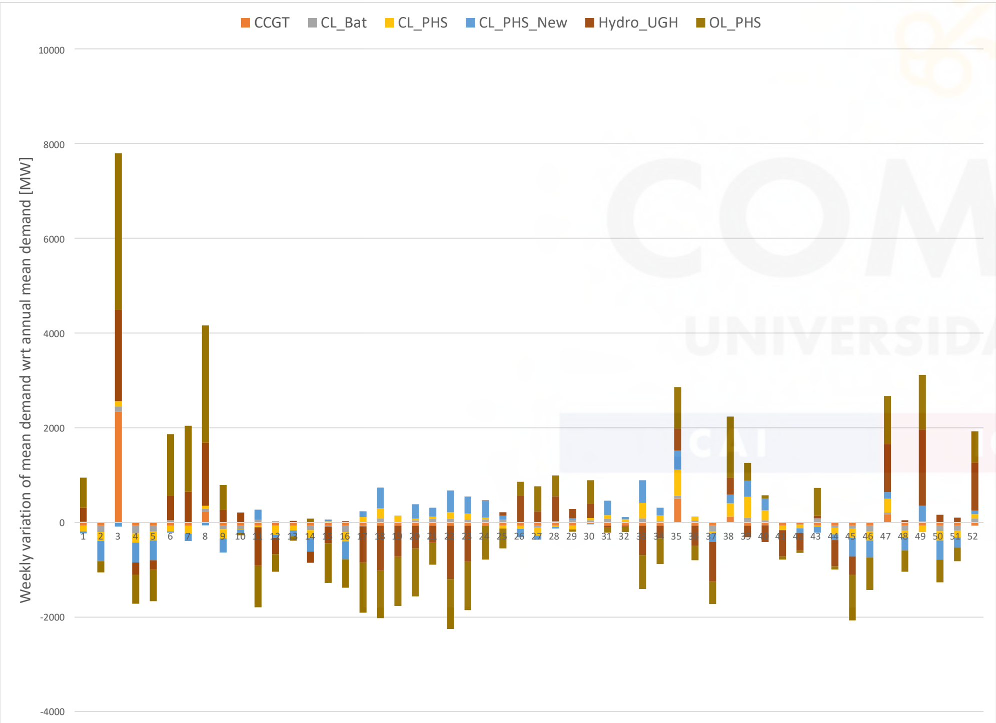




S. Huclin et al. "Exploring the roles of storage technologies in the Spanish electricity system with high share of renewable energy" Energy Reports 8: 4041-4057, November 2022. 10.1016/j.egyr.2022.03.032

Flexibility at operation
Weekly variation of the energy demand

Contribution of each technology to the weekly variation of the demand with respect to the mean annual demand



Mean variation of the technology with respect to the installed capacity

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1. Introduction
2. Case Study
3. Conclusions

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Conclusions

- Upward and downward ramps of the net demand increase dramatically in 2030 due to high wind and solar share
- Ramps are approximately evenly provided by different flexible technologies, but with large dispersion
- Although the annual capacity factors of the storage technologies is <20%, they strongly increase to >50% in critical net demand hours. High contribution to the system firmness
- Ratio of the contribution of different flexible technologies with respect to the installed capacity to the weekly variation of the demand can be very high and reach almost 100% for storage technologies

Projects analyzing Spanish NECP for 2030

- Impact of the electric vehicle in the electricity markets in 2030 developed for Repsol, aims at analyzing the impact on the electricity markets of the mainland Spanish system of the high penetration of electric vehicles in a 2030 scenario.
- Analysis of the expansion and operation of the Spanish electricity system for a 2030-2050 time horizon, developed for Iberdrola, aims at evaluating the potential and role that each generation, storage and consumption technology can play in the future mix of the Spanish electricity system.
- Assessment of the storage needs for the Spanish electric system in a horizon 2020-2050 with large share of renewables, developed for the Instituto para la Diversificación y Ahorro de la Energía (IDAE), aims at assessing, from a technical and economic point of view, the daily, weekly and seasonal storage needs for the Spanish electricity system in the 2020-2050 horizon.
- MODESC – Platform of innovative models for speeding the energy transition towards a decarbonized economy, developed for the Ministry of Science and Innovation, aims at developing of a global platform that integrates innovative energy simulation and impact assessment models that allow speeding the decarbonization of the electricity system including the electrification of the energy demand.
- Improving energy system modelling tools and capacity, developed for the European Commission, aims at improving the description of the Spanish energy system in model TIMES-SINERGIA, from the technologies considered or a higher time resolution to the detailed modeling of the power sector, such as the inclusion of transmission constraints.

Thank you for your attention

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https://opentepes.readthedocs.io/en/latest/index.html

GitHub - IIT-EnergySystemModels/openTEPES: Open Generation, Storage, and Transmission Operation and Expansion Planning Model with RES and ESS (openTEPES)