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FlexPlan

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Iberian Regional Case (RC): planning results and conclusions

Santiago García
TECNALIA

Agenda

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2. Final test inputs
3. Congestions, Curtailment and Candidates
4. OPF and GEP costs
5. Case versions comparison
6. Conclusions
7. Reference documents

1. Introduction

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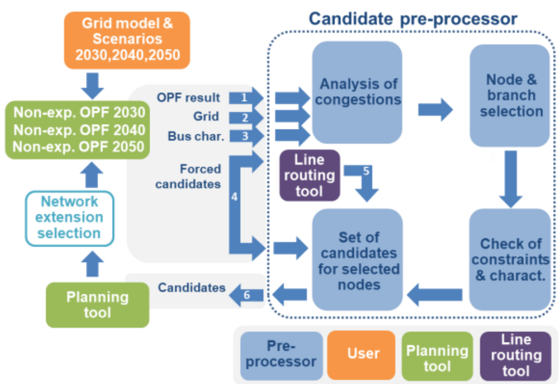
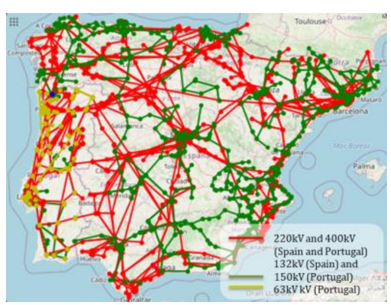
AIM

- Propose grid expansion insights for the Iberian region networks





SUMMARY

- Networks of Portugal and Spain are considered, from transmission to distribution
- An OPF is run first to find the optimal power dispatching, the related power flows, LMs, PTDF, etc.
- The pre-processor is run to propose some network extension candidates
- Candidates can be modified (added or removed) manually.
- The planning tool solves the Grid Expansion planning problem and choses which investments make the system cost lower.
- This is made in loop for the 3 decades under study.
- Several smaller and bigger cases are run before the final case, to test the planning tool and the pre-processor.

2. Final test inputs (I)

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TESTING RESTRICTIONS

- The big size of the problem presented several challenges that were solved in this case by:
  - Reducing the amount of the distribution networks.
  - Consider the whole year by means of 4 representative weeks, each of them characterized by a weight.
- The maximum tolerance of the GEP problem was set to a 0,01%.
- The number of candidates for grid extension was 100.

TESTING CASES

- After running the case, it was observed that the number of candidate branches was much higher in distribution (D) than in transmission (T).
- To understand better this outcome, 3 tests were run with slightly different candidates:
  - v1: 3 T branches among the 100 candidates. With respect to v2, 4 T branches are removed. These branches had congestion risk, but where not congested (influenced)
  - v2: 7 T branches. This case shows the results of the pre-processor. This is the reference case.
  - v3: 11 T branches out of 100 candidates. 4 selected D branch candidates were substituted by T branches ranked lower according to the congestion severity index.

2. Final test inputs (II)

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INPUT NEWORK IN NUMBERS

- The 2030 network considered as first input for the Iberian RC simulations has the following asset number.

Description of the network (2030)	
Number of nodes	**6292**
in transmission network	1832
in distribution network	4460
Number of AC branches	**6720**
in transmission network	2606
in distribution network	4114
Number of transformers	**995**
Number of storages	**124**
Number of flexibility loads	**0 (total loads: 3705)**

REPRESENTATIVE WEEKS

- The year is represented by 4 weeks obtained by clustering. The year is also representative from the last 30.

Selected weeks, year 2014, DE scenario	
Week no.	**Weight**
12	10,4
22	17,3
29	15,6
47	8,7
Total	**52**

INSTALLED POWER

- The Scenario developed in the project, based on the TYNDP has been considered as input

Spanish Scenario DE				
	Technology	**Installed Power (GW)**		
		Pan-EU	**Final**	**Diff.**
Generation and storage	**PV**	51-136	**51-136**	0
	Wind	45-74	**45-74**	0
	HydroRoR	3.7	**5.2**	1.5
	HydroRes	11.0	**8.5**	-2.5
	OtherRES (Biomass…)	2.2	**2.8**	0.6
	Nuclear	2.7	**3.2**	0.5
	Gas	25.8	**24.6**	-1.2
	Pumped storage	9.5	**9.6**	0.1
	Storage	9.5	**9.6**	0.1
	Total hydro	24.1	**23.3**	-0.8
	Total fixed Generation	54.8	**54.0**	-0.8
	interconnection FR	5	**5**	0.0
	interconnection MA	0.6-44	**0**	0.6-44
	Load	47-64	**47-64**	0

2. Final test inputs (III)

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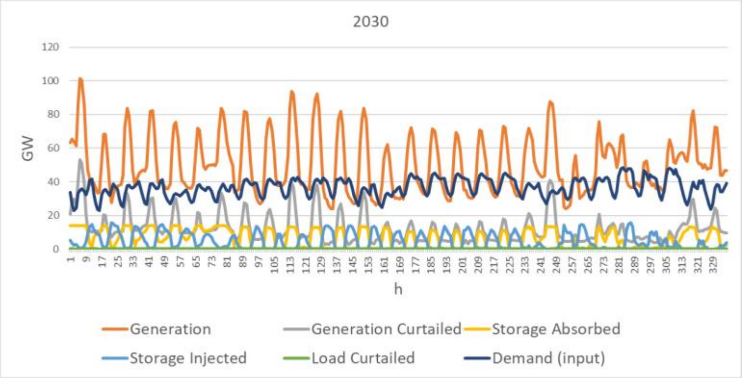
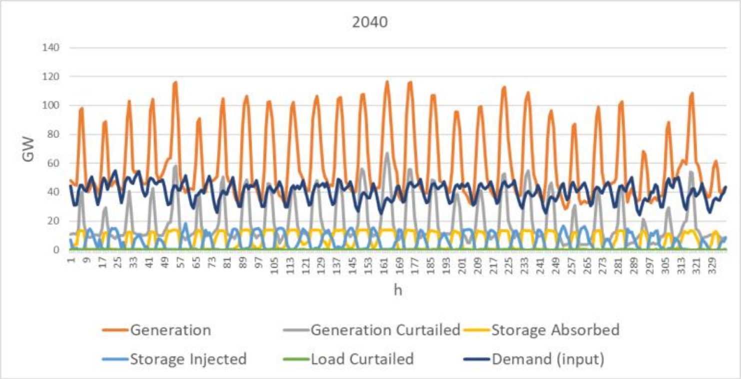
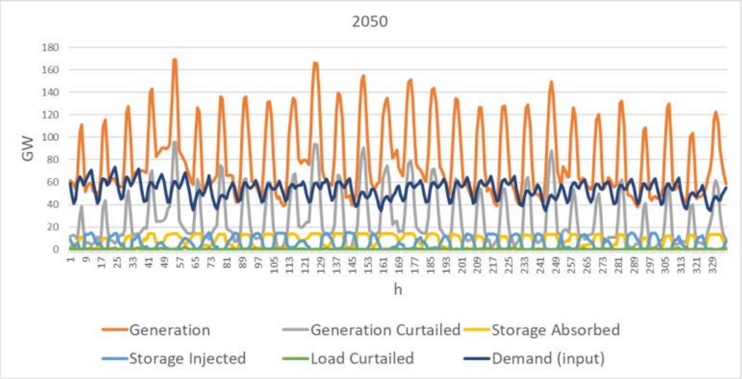
SCENARIO CHARACTERISTISCS

- Generation is much higher than demand, what leads to generation curtailment. The difference increases with time (2030, 2040, 2050)
- Load curtailment is also present.







3. Congestion, Curtailment and Candidates (I)

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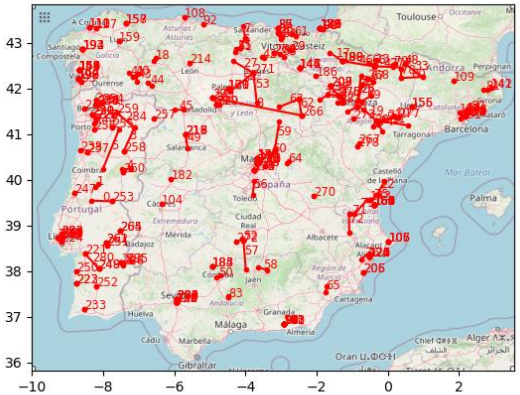
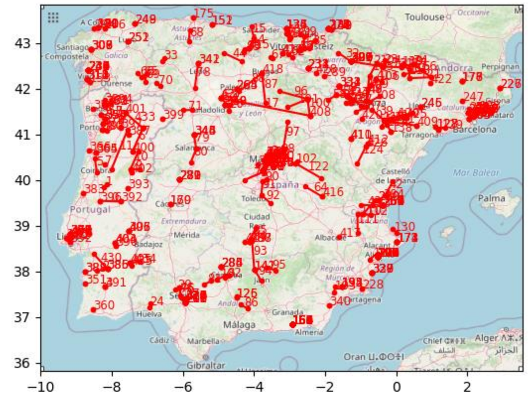
CONGESTIONS

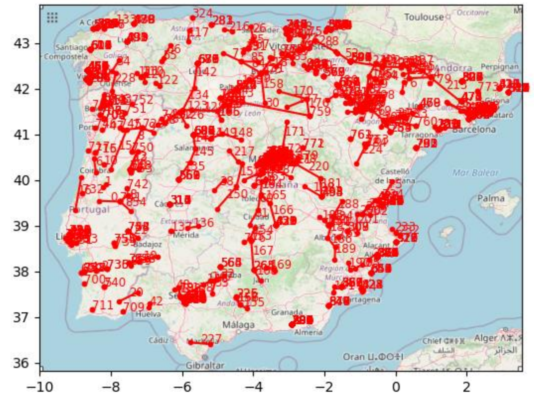
- Lines and transformers with LMS different to zero for the 3 target years.
- Congestions increase with time



2030



2040



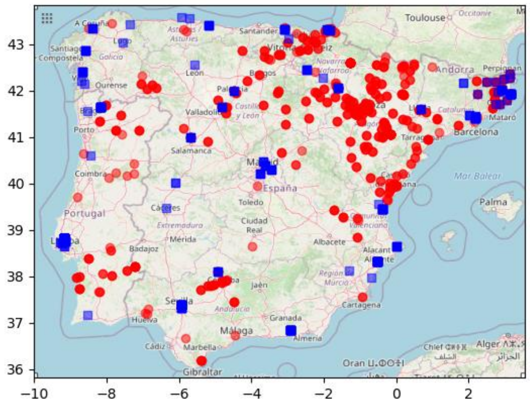
2050

Asset	Number of Congestions		
	2030	2040	2050
Transmission Branch	84	132	235
Distribution Branch	164	253	500
Transmission transformer	32	44	53
Distribution transformer	7	7	72
Total	287	436	860

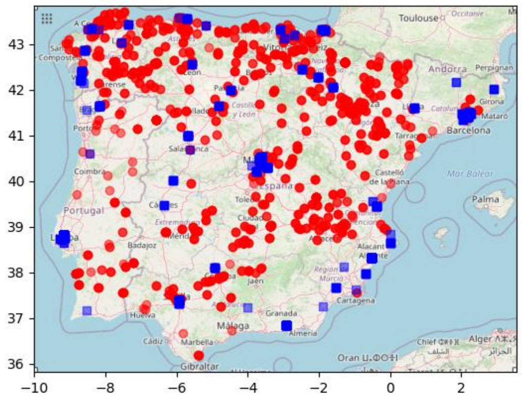
3. Congestion, Curtailment and Candidates (II)

CURTAILMENT

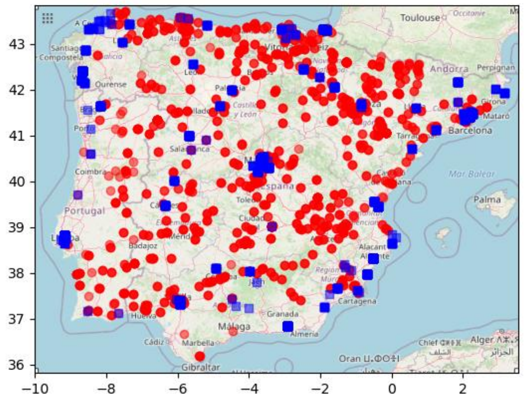
- Generation and load curtailment for the 3 target years.
- Curtailment increases with time



2030



2040



2050

Curtailed generators (plotted as red circles) and loads (plotted as blue squares) for the Iberian Peninsula RC

3. Congestion, Curtailment and Candidates (III)

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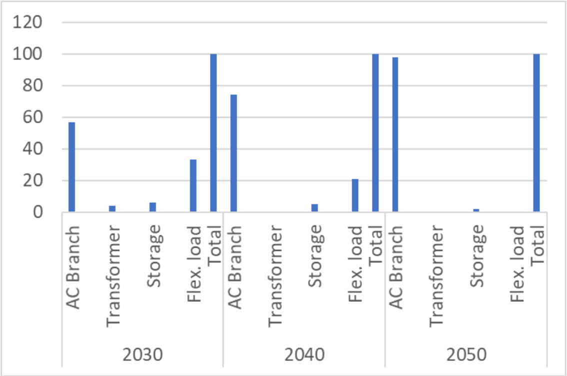
CANDIDATES

- Network candidates provided for the three target years.
- Low number of candidates in transmission, most severe congestions appear in distribution. From the second year on, branch candidates do not appear in transmission.
- Quite balanced number of candidate investments and rejections.
- Flexible loads reduce load curtailment and the related system cost.

Candidates	v2. 7 candidates in transmission in 2030																							
	2030								2040								2050							
	AC Branch		Transformer		Storage		Flex. load	Total	AC Branch		Transformer		Storage		Flex. load	Total	AC Branch		Transformer		Storage		Flex. load	Total
Total number	57		4		6		33	100	74		0		5		21	100	98		0		2		0	100
Investment decissions	6	Transm.	0	Transm.	2	H2	9	49	0	Transm.	0	Transm.	0	H2	5	44	0	Transm.	0	Transm.	1	H2	0	38
	30	Distr.	2	Distr.	0	Flow			37	Distr.	0	Distr.	2	Flow			36	Distr.	0	Distr.	1	Flow		
Investment rejections	1	Transm.	2	Transm.	0	H2	24	51	0	Transm.	0	Transm.	0	H2	16	56	0	Transm.	0	Transm.	0	H2	0	62
	20	Distr.	0	Distr.	4	Flow			37	Distr.	0	Distr.	3	Flow			62	Distr.	0	Distr.	0	Flow		



Total number of candidates for 2030, 2040, 2050

4. OPF and GEP costs

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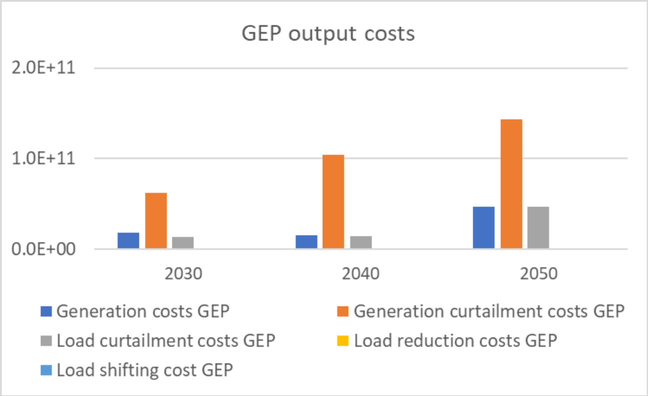

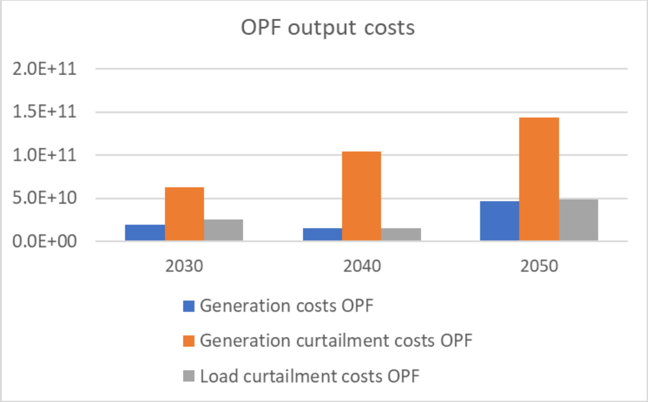

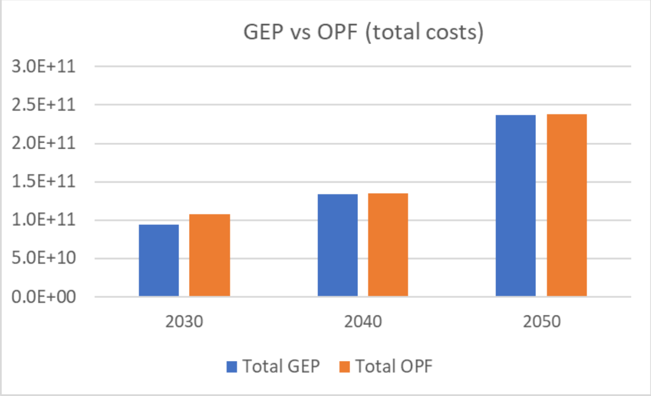

SYSTEM COSTS

- The OPF cost is higher than the GEP costs: after the extension of the network, costs are reduced.
- Highest costs are generation curtailment costs, due to the big unbalance between generation and demand.
- Load curtailment costs are also very high, similar to generation costs, because distribution networks seems to be very saturated.

5. Case version comparison

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v1 vs v2 vs v3

- After a small number of transmission candidates resulted, we wanted to check if the number of transmission candidates had an impact on results.
- The increase of transmission candidates caused a memory error in the system, that is why we tried with few (3, 7, 11).
- The total costs of the system according to the 3 versions results in v1 (3 T candidates) providing a lower total cost and v3 (11 T candidates) providing the highest cost.
- Increasing the number of candidates in transmission does not provides better results for the system (congestions are not solved in distribution, for example).
- Considering the congestion ranking provided by the pre-processor, gives better results (influenced lines, if not in the ranking, do not improve the result).

Candidate	2030			2040			2050		
	v1	v2	V3	v1	v2	V3	v1	v2	V3
AC Branch Transmission	3	7	11	4	0	0	0	0	0
AC Branch Distribution	52	50	46	70	74	75	100	98	100
Tranf. Transmission	1	2	2	1	0	0	0	0	0
Tranf. Distribution	2	2	2	0	0	0	0	0	0
Storage H2	2	2	2	1	0	0	0	1	0
Storage Flow battery	6	4	4	4	5	5	0	1	0
Flexible load	34	33	33	20	21	20	0	0	0
Total	100	100	100	100	100	100	100	100	100

Candidate type and number in each of the versions

GEP output costs (max.)	v1 vs. v2 vs. v3 (Max. GEP cost)			
	2030	2040	2050	Total
Generation costs GEP	v2	v2	v2	v2
Generation curtailment costs GEP	v1	v1	v1	v1
Load curtailment costs GEP	v3	v1	v3	v3
Load reduction costs GEP	v3	v3	v1	v1
Load shifting cost GEP	v3	v3	v1	v1
Total GEP	v1	v1	v2	v3

Maximum GEP cost per cost item

GEP output costs (min)	v1 vs. v2 vs. v3 (Min. GEP cost)			
	2030	2040	2050	Total
Generation costs GEP	v1	v3	v1	v1
Generation curtailment costs GEP	v3	v3	v3	v3
Load curtailment costs GEP	v1	v3	v1	v1
Load reduction costs GEP	v1	v1	v3	v2
Load shifting cost GEP	v2	v2	v3	v2
Total GEP	v3	v3	v1	v1

Minimum GEP cost per cost item

6. Conclusion

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- The Iberian RC case was run, as the rest of the cases in the project, considering some simplifications to make the problem tractable.
- The considered scenario is quite unbalanced in terms of Generation (very high renewable production) and Demand (not so big increase).
- The main congestions are found at the distribution level.
- As result, the system suffers from high generation and load curtailment, which represents high costs.
- The pre-processor apparently provides adequate candidates as inputs for the tool.
- Finding appropriate cost values (for generation, curtailment, value of loss load, demand response, etc.) is difficult. Therefore, sensitivity analyses are proposed. We could not do this in the frame of the project because of a lack of time.

9. Reference documents

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FlexPlan public deliverables at https://flexplan-project.eu/publications/:

- **D5.2**. Grid development results of the regional studies

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Thank you…

Santiago García Lázaro

Contact Information

Affiliation: tecnalia MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

Phone: +34 664 111 760

Email: santiago.garcialazaro@tecnalia.com

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