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FlexPlan

RC Iberia | 17th February 2023

Grid model and scenario data to build the Iberian Regional Case (RC)

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1. Introduction

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AIM

- The objective of building a use case of the Iberian region is to validate the planning tool developed in the FlexPlan project.

SCOPE

- the Iberian Regional Case (RC) includes the networks of Portugal and Spain.
- Two aspects are covered:
  - Network: transmission and distribution networks are considered.
  - Scenario: renewable generation and demand data is provided as input for the different time frames and scenarios.

Visible Earth, NASA

https://www.visibleearth.nasa.gov/images/137643/the-iberian-peninsula/137645l

2. Grid modelling Spain. Transmission and subtransmission (I)

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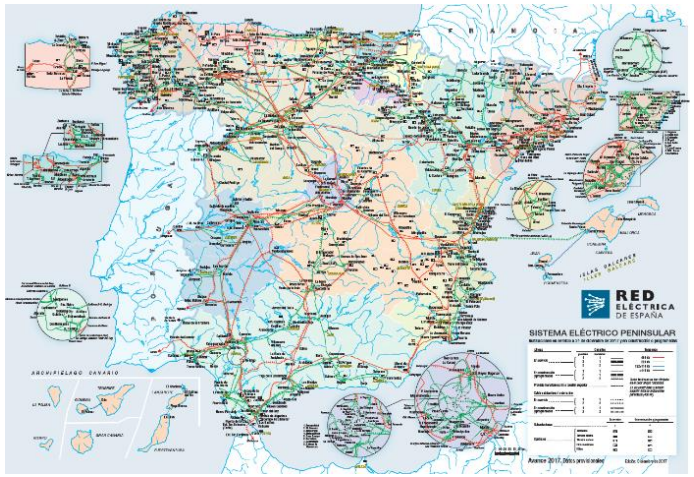
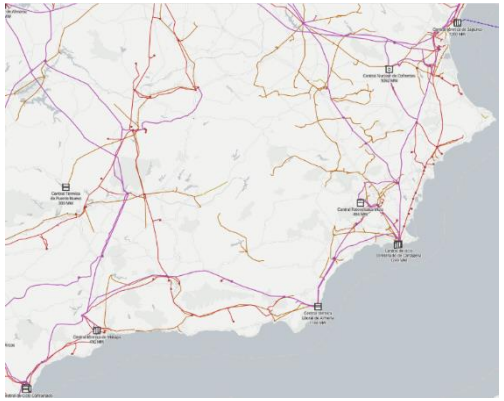
REFERENCES

- ENTSO-E grid model, including only transmission data (220 and 400kV)
- Locational input of substations (network nodes) originally from Gridkit but:
  - Not all nodes present.
  - Mismatches were observed.
- To build the subtransmission network (132 kV), the Open Street Map (OSM) was used:
  - Incomplete
  - Only topographical information (no line or transformer characteristics)
- Google Maps was used to check and look for locations.
- REE pdf map was used for checking at transmission and to help build the network at sub-transmission.
- Only peninsular Spain has been modelled



REE Map (pdf format)



OSM Map

2. Grid modelling Spain. Transmission and subtransmission (II)

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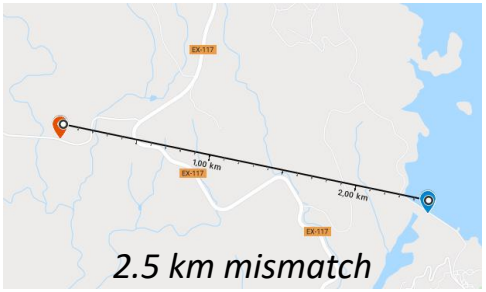

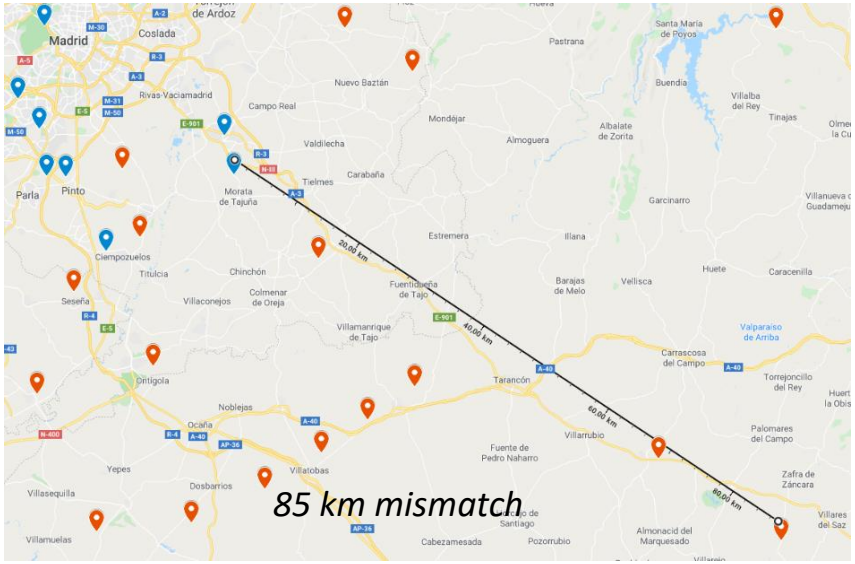

LOCATION OF BUSES

- Location is useful to characterize the buses (e.g. urban/semiurban/rural)
- All nodes where checked in transmission, for around 85% the exact location was found, for the rest approximate location.

Transmission network buses/nodes
(red: 400kV; orange: 220kV; purple: interconnections outside Iberia)

2. Grid modelling Spain. Transmission and subtransmission (III)

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Node Name	Location		Type	Voltage Levels (Base kV)	Installed Capacity (MW) and year	REE map Name
	Latitude	longitude				
'A,G/A,GURREA'	42.082313	-0.718063	Wind Plant	220		A. Gurrea
'A,LE/A,LEYVA'	40.386563	-3.717188	Substation	220		Antonio Leyva
'A,ZIN/A,ZINC'	43.577475	-5.975591	Load: metal	220		A. Zinc
'ABA/ABADIANO'	43.138938	-2.596438		220		Abadiano
'ABANT/ABANTO'	43.328063	-3.087563		400		Abanto
'ABE/ABEGONDO'	43.219120	-8.297905		400		Abegondo
'ABE/ABEGONDO'	43.219120	-8.297905		220		Abegondo
'ABONO/ABONO '	43.553157	-5.722930	Thermal Plant: CC	220	921MW (1974)	Aboño
'ABRER/ABRERA'	41.507688	1.894313		220		Abrera
'ACE/ACEBIZKA'	43.314080	-3.001287	Load: steel	220		A.C.B.
'ACE/ACEBIZKB'	43.314080	-3.001287	Load: steel	220		A.C.B.
'ACECA/ACECA '	39.942940	-3.857227	Thermal Plant: CC	220	800MW (2005)	Aceca
'ACE/ACERIASA'	43.440813	-3.846188	Load: steel	220		Aceriasa
'ACE/ACERINOX'	36.180335	-5.435832	Load: steel	220		Acerinox
'ADRAL/ADRALL'	42.323930	1.395560	Substation	220		Adrall
'AEB/AEBARCEL'	41.304188	2.073313	Load: Airport T2 (BCN)	220		Aena Este
'AENA/AENA '	40.509620	-3.597880	Load: Airport (MAD)	220		Aena
'AEN/AENOESTE'	41.288196	2.071435	Load: Airport T1 (BCN)	220		Aena Oeste
'AGU/AGUACATE'	40.36489	-3.74821	Substation: GIS	220	150 MVA	Aguacate
'AGUAY/AGUAYO'	43.095674	-4.000112	Hydro plant: pumped	220	360MW (1982)	Aguayo
'AGUAY/AGUAYO'	43.095674	-4.000112	Hydro plant: pumped	400	360MW (1982)	Aguayo
'ALAR/ALARCOS'	38.94802	-3.96326	Substation	220		Alarcos
'ALBAL/ALBAL '	39.397810	-0.445180	Substation: GIS	220		Albal
'ALB/ALBARELL'	42.39781	-8.15893	Hydro plant	220	60.14 MW	Albarellos
'ALB/ALBATARR'	41.57802	0.62169	Substation: GIS	220		Albatarrec
'ALC/ALCALA 2'	40.510930	-3.319810		220		Alcalá II
'ALC/ALCARAMA'	42.02843	-2.01506	Wind	220	51.85 MW	Alcarama
'ALCIR/ALCIRA'	39.14893	-0.45685	Substation	220		Alcira
'ALCOA/ALCOA '	43.701930	-7.478930	Load: metal (Aluminium)	400		Aluminio
'ALC/ALCOBEND'	40.54873	-3.65116	Substation: GIS	220		Alcobendas
'ALC/ALCOMOLA'	42.48643	-3.36568	Substation. Wind near	220		Alcocero de Mola
'ALCO/ALCORES'	37.386508	-5.856410	Substation	220		Alcores

Extract of generation and load plant characterization table

GENERATOR & LOAD MODELLING

- Generators, loads (industrial type) and other information was identified in the model.
- Hydro plants were modelled as storage, estimating the energy content by considering the volume of the reservoirs and the height of the dam.
- Dispatchable units were characterized per their installed power and considering the future plans for Combined Cycle, nuclear, etc. Environmental info was also provided.
- Non-dispatchable/renewable units were considered integrating the future installed power information and the knowledge of existing plats, trying to match the calculated scenario information total numbers.

2. Grid modelling Spain. Transmission and subtransmission (IV)

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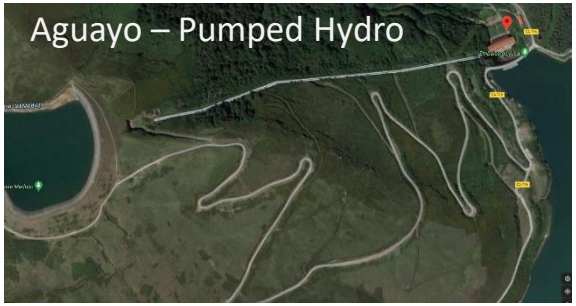
IDENTIFICATION OF SUBSTATIONS

- Example on location checks in Google Maps



Some substation examples at transmission network

2. Grid modelling Spain. Transmission and subtransmission (V)

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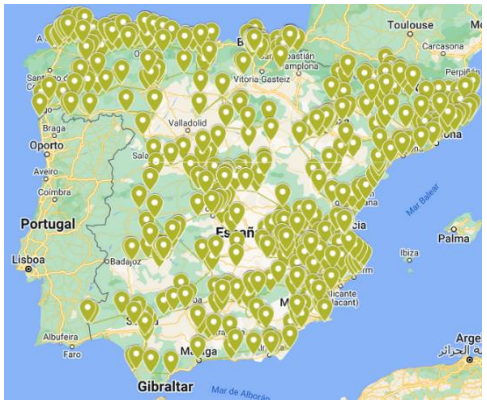
BUILDING THE 132KV NETWORK

- A simplified network was built based on the REE map: some nodes were and branches were eliminated, trying to respect the general topology.
- Bus location and generator and load identification was similar to the transmission network case.
- Even if not exact all lines have been considered of 132kV.
- Average values were considered to model branches and transformers.



Sub-transmission network buses/nodes

Some substation examples at sub-transmission network

3. Grid modelling Spain. Distribution

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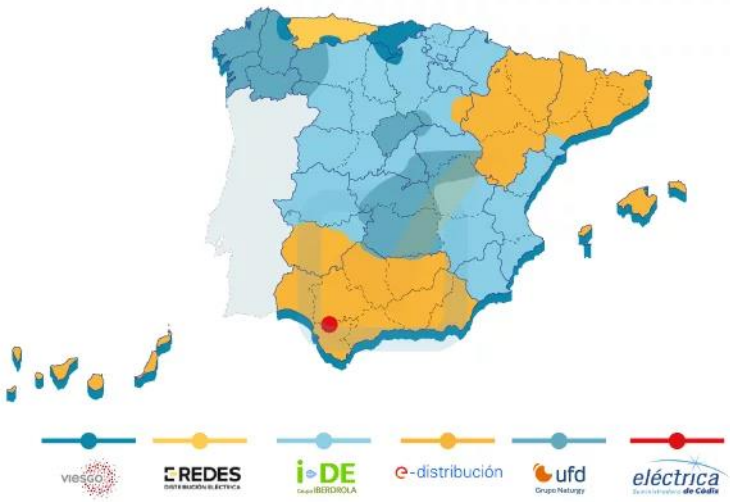
DISTRIBUTION NETWORK MODELLING

- Real distribution network models were not available for the project (confidentiality issues).
- Synthetic networks were created from statistical data of some real networks (RSE methodology).
- The following parameters were considered to build the networks:
  - Topology: percentage of node levels from substation.
  - Probability function (graph) of the loads in the network.
  - Probability function (graph) of the cumulative resistance from the primary substation.
- No location information was provided for the synthetically generated buses.
- The diversity of distribution network characteristics in Spain, due to different SOs, was not considered.



Main System Operators (SO) and their network deployment area. Spain
(https://tarifasgasluz.com/distribuidoras)

4. Grid modelling Portugal. Transmission (I)

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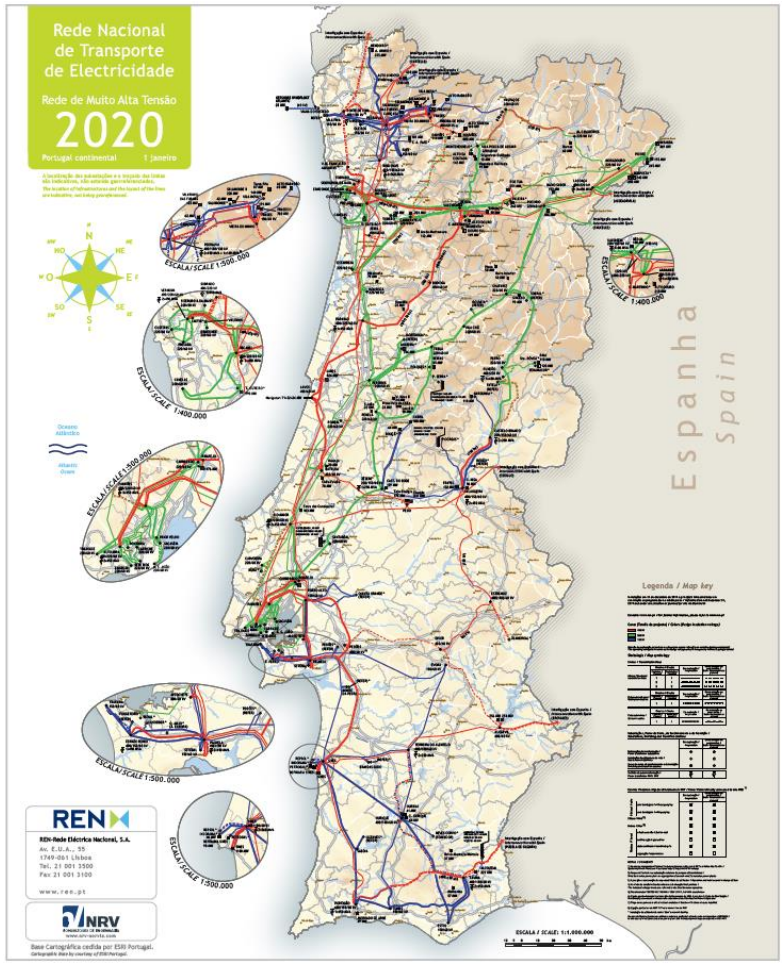
REFERENCES

- Transmission and sub-transmission: Full model included in ENTSO-E data set:
  - 400 kV, 220kV, & 150 kV.
  - 63kV (sub-transmission): transformers are modelled.
- Locational information completed manually, more than 90% of nodes have exact location.



4. Grid modelling Portugal. Transmission (II)

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GENERATOR & LOAD MODELLING

- Generators, loads (industrial type) and other information was identified in the model, in a similar way to the Spanish case

id	names	latitude	longitude	Type	nomina	Capacity_M	Capacity	BusN	classBus	naturalResou
ZEZERE_150	ZEZERE	39.544988	-8.327347	Substation	150			1	SBSTAIRR	
V_NOVA_150	V.NOVA	41.679447	-7.982313	Hydro plant (dispatchable)	150	150		2	PWPLHYDR	RSRCWATR
SALAMON_150	SALAMON	41.691742	-8.091246	Hydro plant: pumped storage	150	55		3	PWPLHYDR	RSRCWATR
CABRIL_150	CABRIL	39.917932	-8.132222	Hydro plant (dispatchable)	150	220		4	PWPLHYDR	RSRCWATR
SETUBAL_150	SETUBAL	38.536487	-8.861985	Substation	150			5	SBSTAIRR	
F_ALENT_150	F.ALENT	38.055255	-8.127066	Substation	150			6	SBSTAIRR	
BOUCA_150	BOUCA	39.853297	-8.218846	Hydro plant (dispatchable)	150	45		7	PWPLHYDR	RSRCWATR
P_ALTO_150	P.ALTO	38.898129	-8.880393	Substation	150			8	SBSTAIRR	
A_RABAG_150	A.RABAG	41.73796	-7.853358	Hydro plant: pumped storage	150	90		9	PWPLHYDR	RSRCWATR
TABUACO_150	TABUACO	40.986871	-7.5358	Substation	150			10	SBSTAIRR	
TABUACO_HF_150	TABUACO_HF	40.98684	-7.5352	Hydro plant (dispatchable)	150	60		526,527?	PWPLHYDR	RSRCWATR
V_FURNA_150	V.FURNA	41.763434	-8.20911	Hydro plant: pumped storage	150	180		11	PWPLHYDR	RSRCWATR
PMFF4_SX_150	PMFF4/SX	0.95756	-11.2684	Switching Station	150			12	SWITSTAT	
TUNES_150	TUNES	37.165173	-8.263257	Substation	150			13	SBSTAIRR	
FRATEL_150	FRATEL	39.543707	-7.802804	Hydro plant (dispatchable)	150	132		14	PWPLHYDR	RSRCWATR
F_FERRO_150	F.FERRO	38.581767	-9.120502	Substation	150			15	SBSTAIRR	
PALMELA_150	PALMELA	38.57282	-8.858301	Substation	150			16	SBSTAIRR	
SINES_150	SINES	37.997025	-8.762788	Substation	150			17	SBSTAIRR	
VALDIGE_150	VALDIGE	41.138808	-7.757729	Substation	150			18	SBSTAIRR	
RIBADAV_150	RIBADAV	41.40302	-8.389259	Substation	150			19	SBSTAIRR	
C_FRADES_150	C.FRADES	41.69318	-8.02797	Hydro plant: pumped storage	150	230		20	PWPLHYDR	RSRCWATR
FAFRA_GR_150	FAFRA/GR	0	0	This substation does not exist anymore (I believe it's out of service in the model, but	150			21	SBSTAIRR	
GUIMARA_150	GUIMARA	0	0	This substation does not exist anymore (I believe it's out of service in the model, but	150			22	SBSTAIRR	
V_FRIA_150	V.FRIA	41.653608	-8.753002	Substation	150			23	SBSTAIRR	
EVORA_150	EVORA	38.555285	-7.882231	Substation	150			24	SBSTAIRR	
TRAFARIA_150	TRAFARIA	38.665097	-9.222841	Substation	150			25	SBSTAIRR	
FAFE_150	FAFE	41.445982	-8.177053	Substation	150			26	SBSTAIRR	
P_LIMA_150	P.LIMA	41.678536	-8.638713	Substation	150			27	SBSTAIRR	
OURIQUE_150	OURIQUE	37.667314	-8.189773	Substation	150			28	SBSTAIRR	

Extract of generation and load plant characterization table. Portugal

5. Grid modelling Portugal. Distribution

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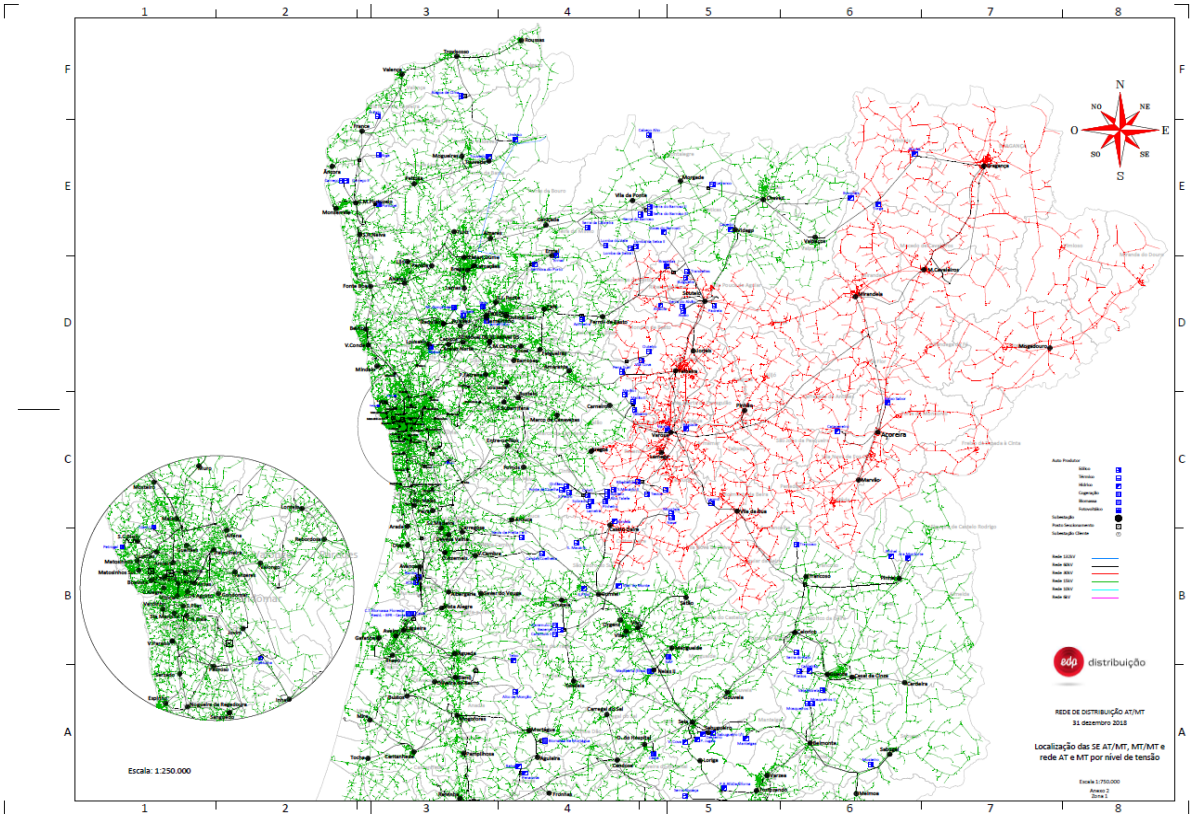
DISTRIBUTION NETWORK MODELLING

- The distribution network model for Portugal was available.



Distribution network for PT

6. Scenario information (I)

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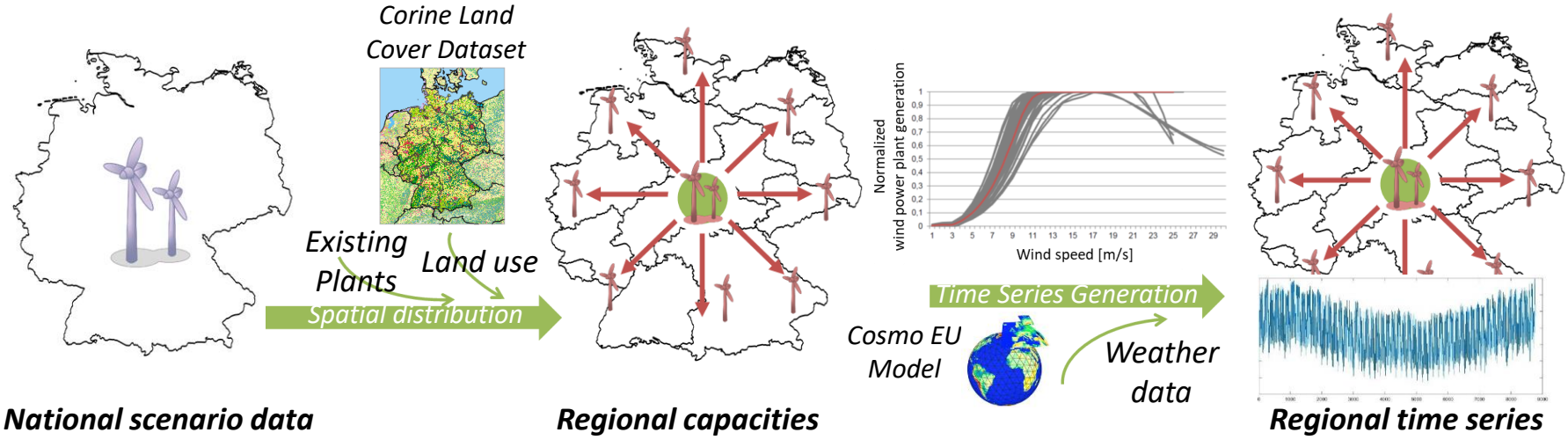
PAN-EURPEAN SCENARIOS CREATION METHODOLOGY

- Generation scenarios were created based on TYNDP data for 3 target years: 2030, 2040, 2050.
- Starting from the big numbers of the scenarios, time series generation profiles are created for renewable energy, based on weather data for locations: for each node in the network model, a profile of 8760 power values is created, for each resource (wind, solar, hydro, biomass).

- The same is done for demand: to each node in the network a demand is assigned based on population density.
- Border exchange is also calculated.
- 3 Scenarios were considered initially: Distributed Energy (DE), Global Ambition (GA) and National Trends (NT).



6. Scenario information (II)

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SPANISH CASE

- As result, for the Spanish case, the following numbers are provided.
- These are an input to build the RC
- Dispatchable units show consistency with the current network and future plans.

	MW	DE			GA			NT		
		2030	2040	2050	2030	2040	2050	2030	2040	2050
Generation and storage	PV	51399	90474	135674	37271	58945	86744	43434	65048	86663
	Wind	44704	56200	73821	46406	63306	86331	48580	53510	58439
	HydroRoR	3640	3640	3640	3640	3640	3640	3640	3640	3640
	HydroRes	10975	10975	10975	10975	10975	10975	10975	10975	10975
	OtherRES	2226	2226	2226	2226	2226	2226	2226	2226	2226
	Nuclear	2716	0	0	2718	0	0	2718	0	0
	Lignite							0		
	Hard Coal									
	Oil									
	Gas	25761	25760	14587	25760	25759	14587	25761	25760	25761
	Biomass					0				
	Pumped storage	9520	9520	9520	9520	9520	9520	9520	9520	9520
	Storage	9520	9520	9520	9520	9520	9520	9520	9520	9520
	Total hydro	24135	24135	24135	24135	24135	24135	24135	24135	24135
	Total Generation	150941	198795	250442	138516	174371	214021	146854	170678	197223
	interconnection FR	5000	5000	5000	5000	5000	5000	5000	5000	5000
	interconnection MA	1458	5762	43891	592	1356	35629	858	3430	29180
	Load	46705	55271	63790	45703	51608	57513	45400	53085	60770

7. Final model information

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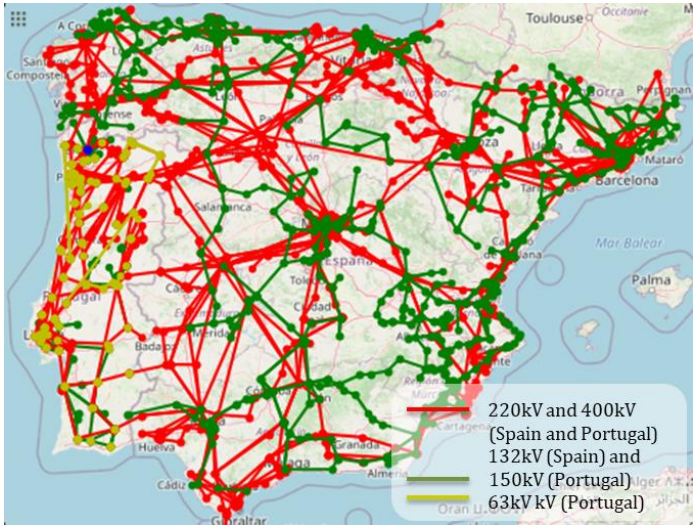
FINAL MODEL

- The information from transmission, sub-transmission and distribution networks was integrated.
- No border is considered between Portugal and Spain.
- The number of distribution network was reduced, to reduce the computational burden. Around 10% of the networks were considered, and those with highest congestion risk were selected.

FINAL SCENARIO

- DE was adopted as scenario for all RCs.
- In the Spanish case, the time series were generated at transmission node level. Therefore, it was necessary to share that generation and load downstream among the sub-transmission nodes.
- The created pan-European scenario was adjusted based on the knowledge about the network.



Modelled electricity network in RC Iberia

Spanish Scenario DE				
	Technology	Installed Power (GW)		
		Pan-EU DE	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	2.2	**2.8**	0.6
	Nuclear	2.7	**3.2**	0.5
	Lignite			
	Hard Coal			
	Oil			
	Gas	25.8	**24.6**	-1.2
	Biomass (included in Other RES)			
	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

Generation Installed power per type

8. Conclusion

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- A grid and scenario suitable for the validation of the planning tool has been created.
- The grid modelling has been considered as close as possible to the real one, but simplifications have been taken, because:
  - There is a lot of data to be considered and it was not all available.
  - The network had to be tractable computationally speaking.
- Nevertheless, a good network model has been created for the Iberian RC.
- The scenario was created with a methodology developed in the project and it was considered as an input for the RC Iberian case.

9. Reference documents

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

- **D4.1**. Pan-European scenario data
- **D4.2.** Pan-European simulation results
- **D5.1.** Data set and planning criteria for the regional studies

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Thank you…

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