Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation

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Strategic Energy Roadmap

Issue paper on Case Study 6.2

Centralized vs. Decentralized development of the electricity sector

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Executive Summary

- Expected renewable generation will challenge system operation
- Case study 6.2. analyzes the impact on the system, with a focus on transmission network development, of two different scenarios that represent a centralized vs. decentralized development of renewables
- The case study leverages on the use of two different models: Enertile (system optimization) and TEPES (power transmission expansion planning)
- The decentralized scenario uses more rooftop PV, while the centralized option focuses on offshore wind
- Preliminary results show that the decentralized option has higher system costs
- Transmission grid investment is higher in the centralized case but also large in the decentralized option

Objectives of the case study

- The large installed capacities of renewables will challenge system operation
- Building new transmission lines is increasingly complicated
- Innovative transmission technologies (HVDC, FACTS) increase the available options
- Distributed generation and storage can transform existing power flows
- Research questions:
  - What will be Europe's electricity infrastructure needs?
  - What are the main impacts of renewable energy sources and demand response?
  - What are the main grid architectures that should be considered?
  - What is the impact of innovative transmission technologies on optimal grid architectures?

EXPECTED OUTPUT

- Insights into contrasting developments of the electricity sector with respect to the required infrastructure and storage investments and system costs
- European-wide recommendations on common and differing adaptation strategies to different evolutions of the renewable generation portfolio
- Insights about the interaction between electricity infrastructure needs and the general policy adopted for RES and emerging generation
- Understanding the implications of the deployment of several differing network architectures based, for example, on incremental AC reinforcements, long HVDC lines or a super-grid overlay
- Identifying the main interactions between the general policies adopted for RES generation, the resulting RES generation deployment and the type of network architecture, including the technology solutions that are most suitable for deployment
- Identifying the most important needs for innovation focused on emerging transmission technologies (in terms of their deployment and research triggering cost reductions of these

Two models for an integrated perspective: Enertile

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enertile

- Enertile is an energy-system optimization model developed at the FH ISI Institute for System and Innovation Research
- It focuses on the power sector but includes others (heating/cooling, transport)
- It has a high technical and temporal resolution
- Includes conventional generation, renewables, CHP or DSM
- The potential for RES is calculated at a very detailed (grid) level

Zonal level. Nodes indicated as dots.

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Two models for an integrated perspective: TEPES

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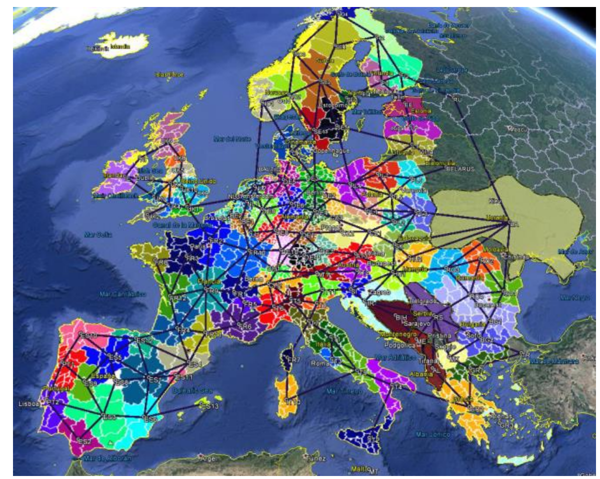
TEPES

- TEPES performs power transmission expansion planning for large systems
- It considers a detailed description of the grid (around 250 nodes, linearized power flows)
- The model identifies the main optimal transmission corridors to reinforce
- TEPES is dynamic and stochastic (in demand, RES, etc)
- Candidate lines are proposed by the model and include HVDC and PSTs
- Returns detailed grid costs and operation, nodal prices…



Detailed transmission grid

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THE SCENARIOS

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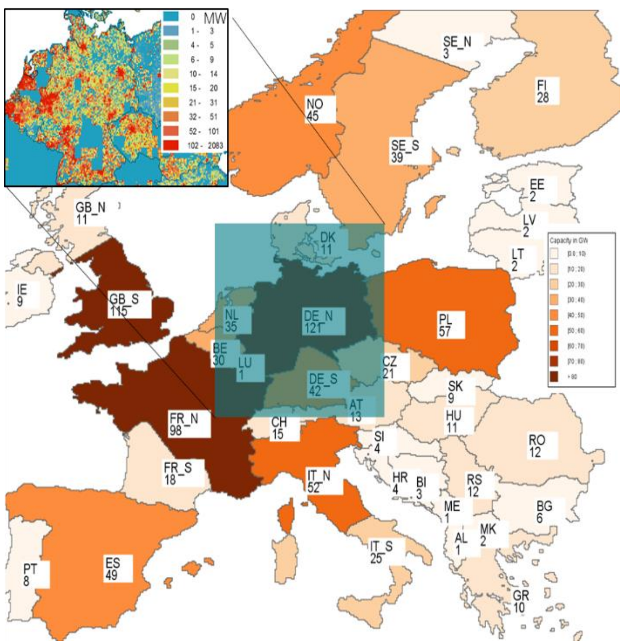
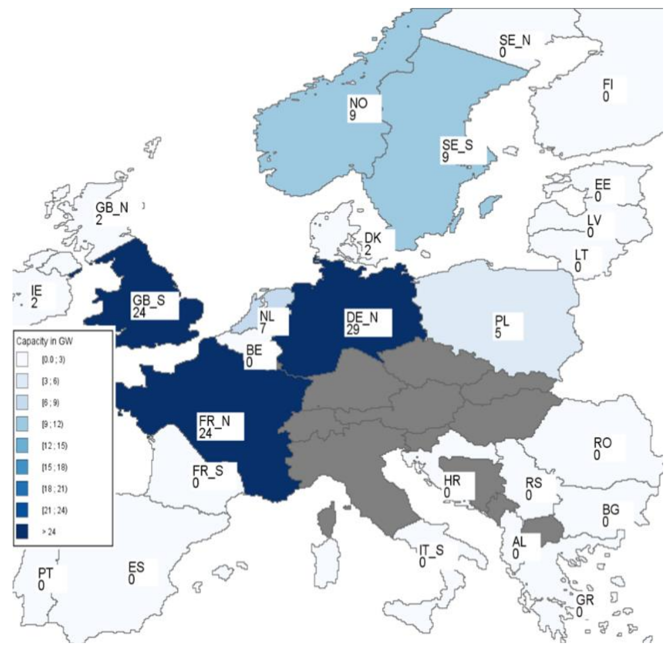
- The scenarios are built as boundary conditions (albeit reasonable) for the 2050 development of renewables.
- The decentralized case study imposes a ca. 25% share of demand to be served with decentralized renewables (rooftop PV).
- The centralized case imposes that more than ca. 530 TWh of energy demand are met with offshore wind.



Rooftop PV in the decentralized scenario



Offshore wind in the centralized scenario

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Preliminary results

- The decentralized scenario has higher system costs than the centralized scenario
  - The generation mix for renewables in the decentralized scenario is more expensive
  - In addition, it requires more flexibility in the operation of the system
- The centralized scenario requires stronger expansion of the electricity transmission grid
- Both scenarios require a strong expansion of the transmission grid

TAKEAWAYS

- Transmission grids are the backbone for the decarbonization of the electricity sector in Europe
- This is true also for a decentralized scenario
- It is necessary to take transmission needs into account when planning the expansion of the system, as they can have a considerable effect
- Public acceptance is the main currency of the energy transition.
- International cooperation is beneficial.
- Further analyses in this case study will consider in detail the differences between the two extreme grid architectures computed for the scenarios considered and the impact of the use of innovative transmission technologies.

Thank you!

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Detailed results of transmission expansion: centralized case

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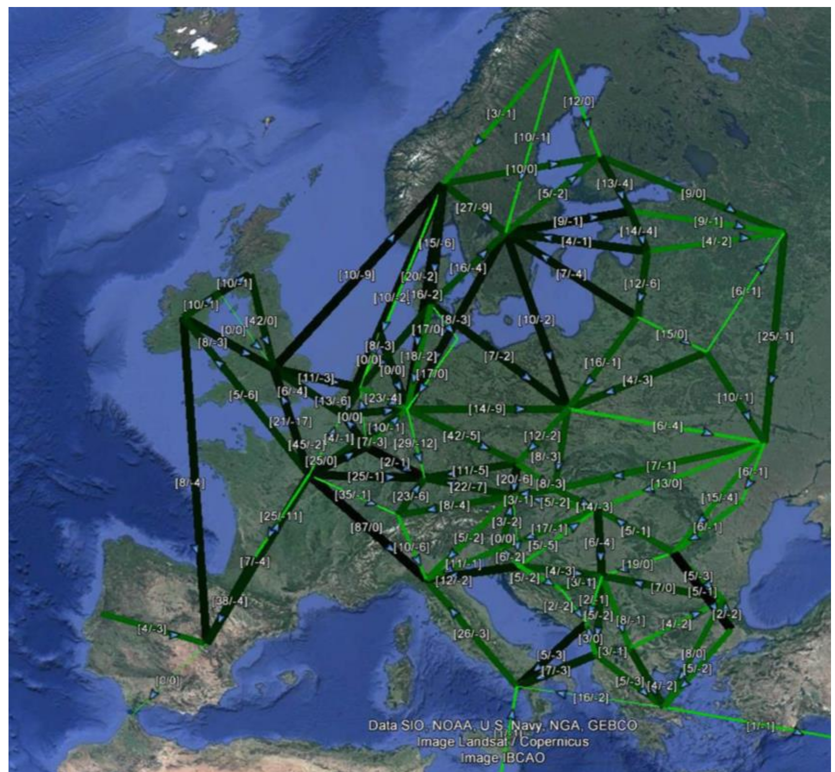
- Total annualized grid investment: EUR 10.2 bln
- Operation cost associated to the system (fuel cost, NSE): EUR 19.5 bln
- Marginally more congested
- Top expanded corridors:
  - FR_N-LU
  - DE_S-LU
  - FR_N-IT_N
  - ES-FR_S
  - BE-DE_N
  - AT-CZ
  - BE-NO
  - AT-IT_N
  - NO-DE_N
  - NL



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DETAILED RESULTS OF TRANSMISSION EXPANSION: DECENTRALIZED CASE

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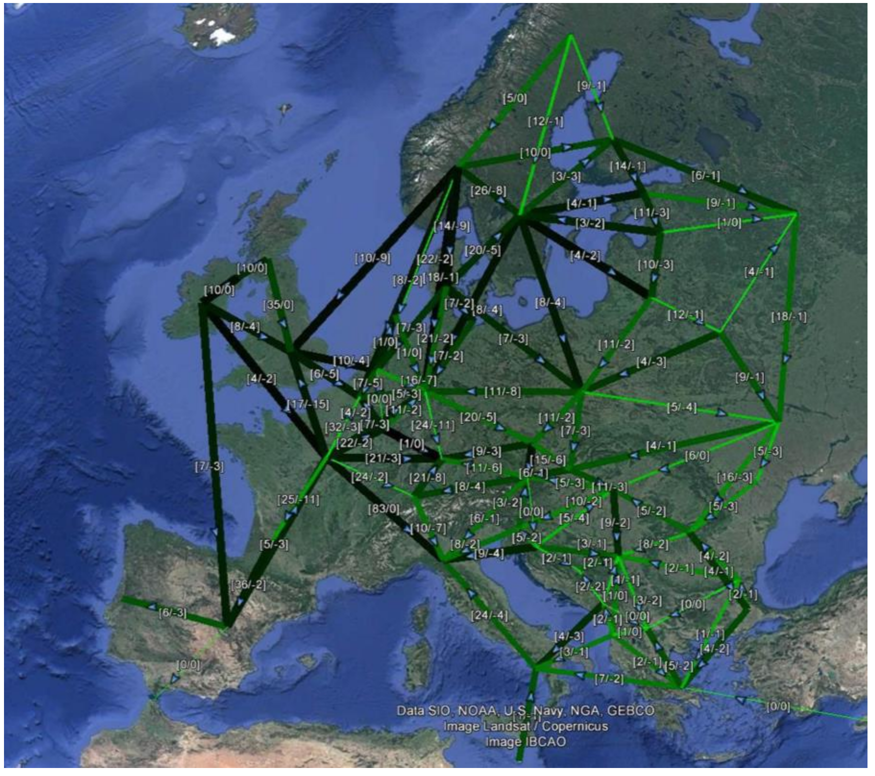
- Total annualized grid investment: EUR 8.6 bln
- Operation cost associated to the system (fuel cost, NSE): EUR 15.8 bln
- Marginally less congested
- Top expanded corridors:
  - FR_N-LU
  - DE_S-LU
  - FR_N-IT_N
  - ES-FR_S
  - BE-DE_N
  - AT-CZ
  - BE-NO
  - AT-IT_N
  - NO-GB_S



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