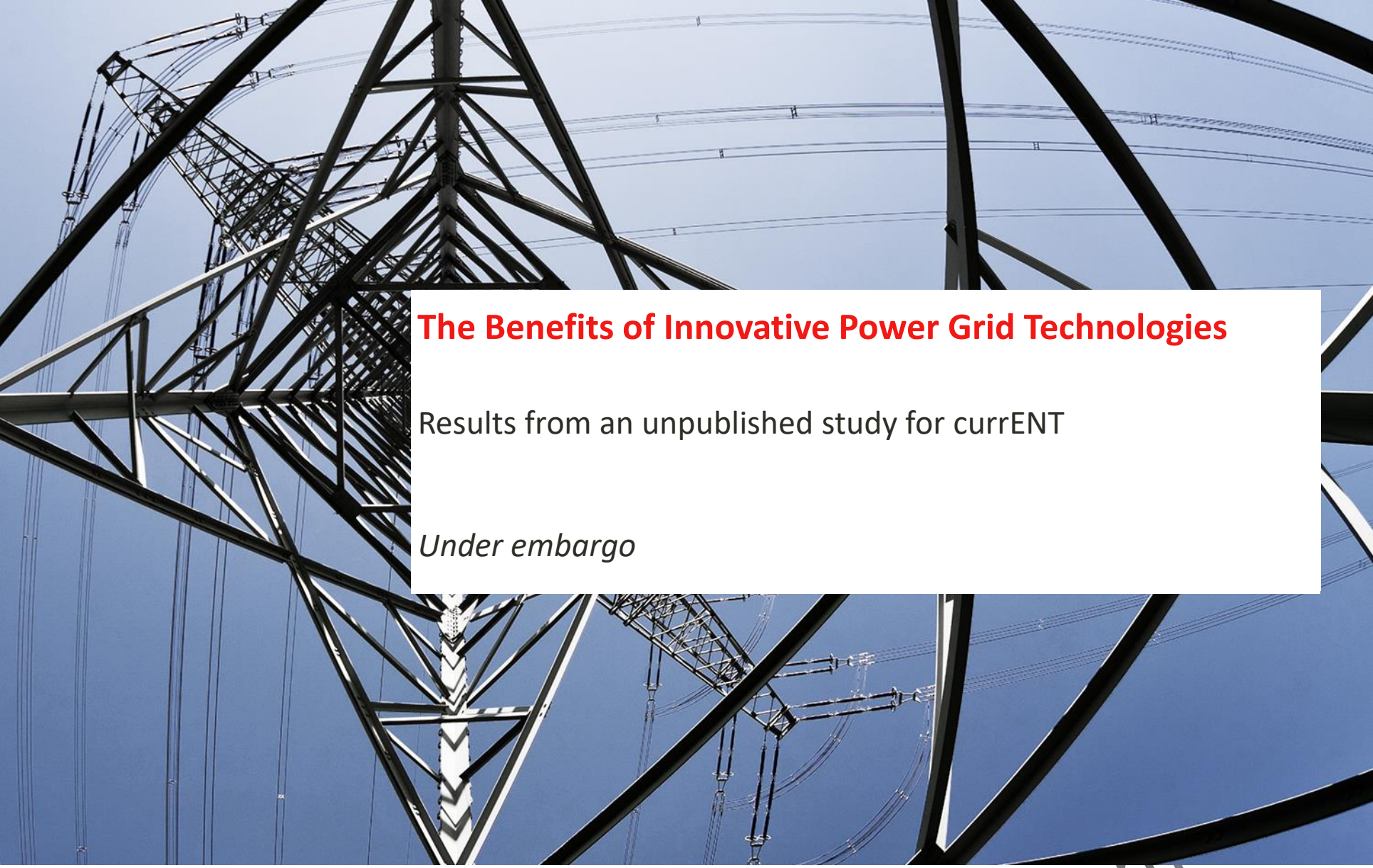

The Benefits of Innovative Power Grid Technologies

Results from an unpublished study for currENT

Under embargo

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Main messages and conclusions

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Scope of the study

Background	▪ Long-distance transmission of electrical energy has increased significantly over the past decades will increase further ▪ Driven by electrifying all energy sectors ▪ Rapidly growing share of renewable energy power generation, often installed at far from load centers ▪ Grid reinforcement is needed and planned, but has fallen behind due to public resistance ▪ Innovative technologies available to help ensure cost-efficient grid reinforcement
Technologies considered	▪ Dynamic Line Rating (DLR): TRL 9 [1] ▪ Modular Static Synchronous Series Compensator (M-SSSC): TRL 7-9 ▪ Superconductor DC system: TRL 5-6

Methodological approach	▪ Study focusses on savings in redispatch costs possible due to applying innovative grid technology in the target year 2030
	▪ Cost savings are calculated by comparing a reference scenario without the three technologies to 4 different technology scenarios
	  ▪ 3 individual scenarios: DLR or M-SSSCs or Superconductors
	  ▪ 1 combined scenario: all technologies applied

1) *TRL: Technology readiness level awarded by ENTSO-E technopedia*
   TRL 9 – System ready for full scale deployment
   TRL 8 – System incorporated in commercial design
   TRL 7 – Integrated pilot system demonstrated
   TRL 6 – Prototype system verified

Scenario for target year 2030 – assumptions

- Market simulation

- *Green-Deal approximated*
- *Gas-fired power plants more profitable than lignite and hard coal (EUR 80 per tonne CO_2)*
- *Cross-border trade intensifies*
- *Germany becomes net importer*
- *Flow-based market coupling in Core-Region → 70% MinRAM applied*

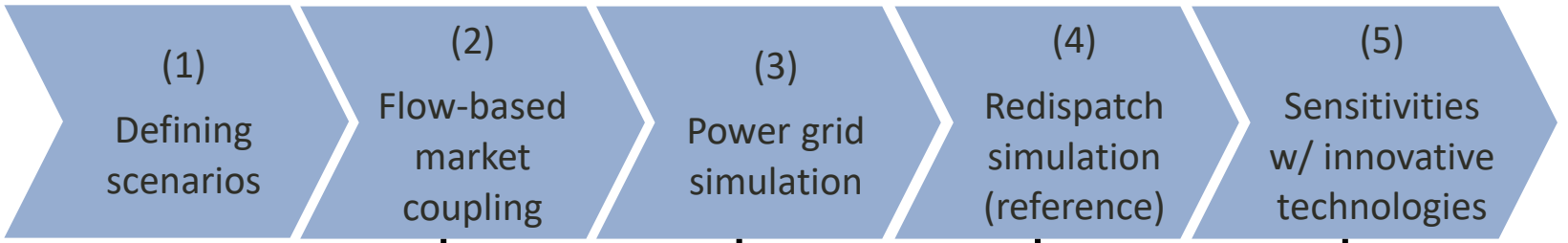
- Load Flow and Redispatch Simulation

- *Power grid modelling in whole continental Europe*
- *Fully integrated cross-border congestion management in France, Belgium, The Netherlands, Luxembourg, Germany and Austria*
- *All power grid reinforcement projects assumed to be on time (rather optimistic)*

Except for one HVDC connection within Germany, for which a design with superconductors was explored

Quantitative Assessment of Innovative Technologies

Modelling steps



Results

- Marked-based infeed of generation assets
- Nodal load and power injections in the power grid

- Congestion in the power grid
- Identify areas with high overloads

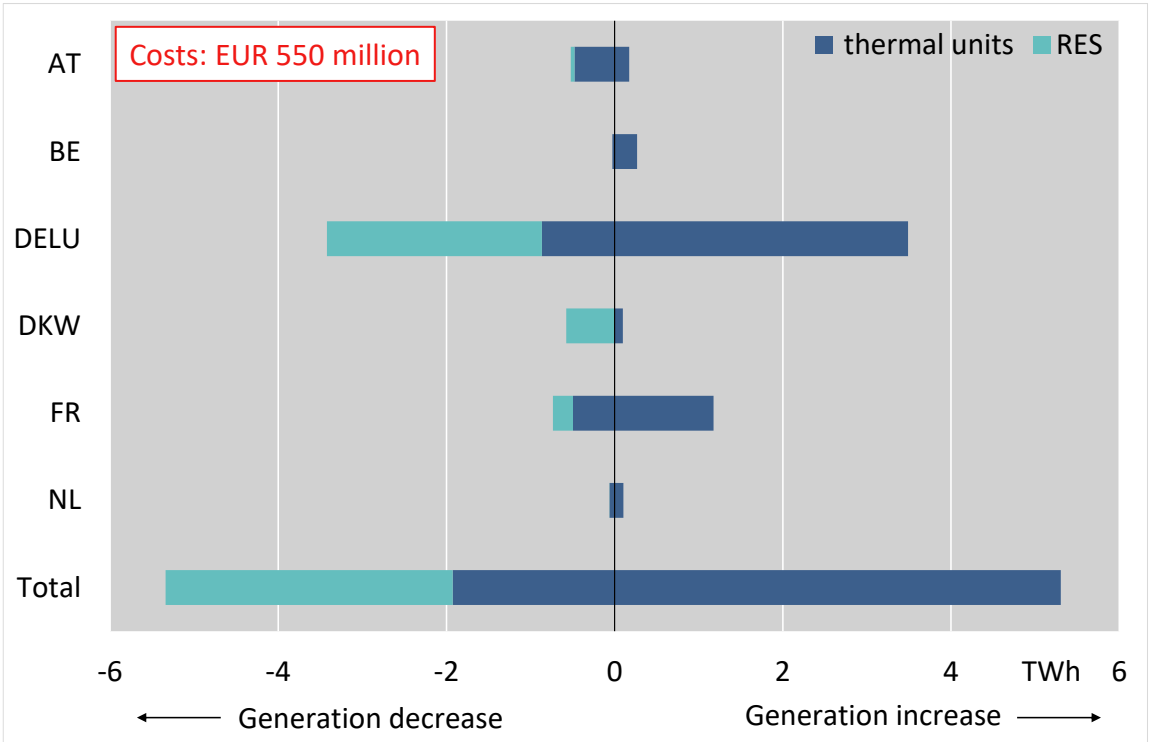
- Relieve congestion with least costs
- Calculate cost savings brought about by innovative technologies:
  - High penetration of **sensor-based DLR**
  - Application of **M-SSSCs** load flow control
  - Additional HVDC connection in Germany realized with **superconductors**

→ **Main outcome of the study are savings in redispatch costs**

→ **Further benefits of innovative technologies were considered qualitatively**

Main Messages & Conclusions

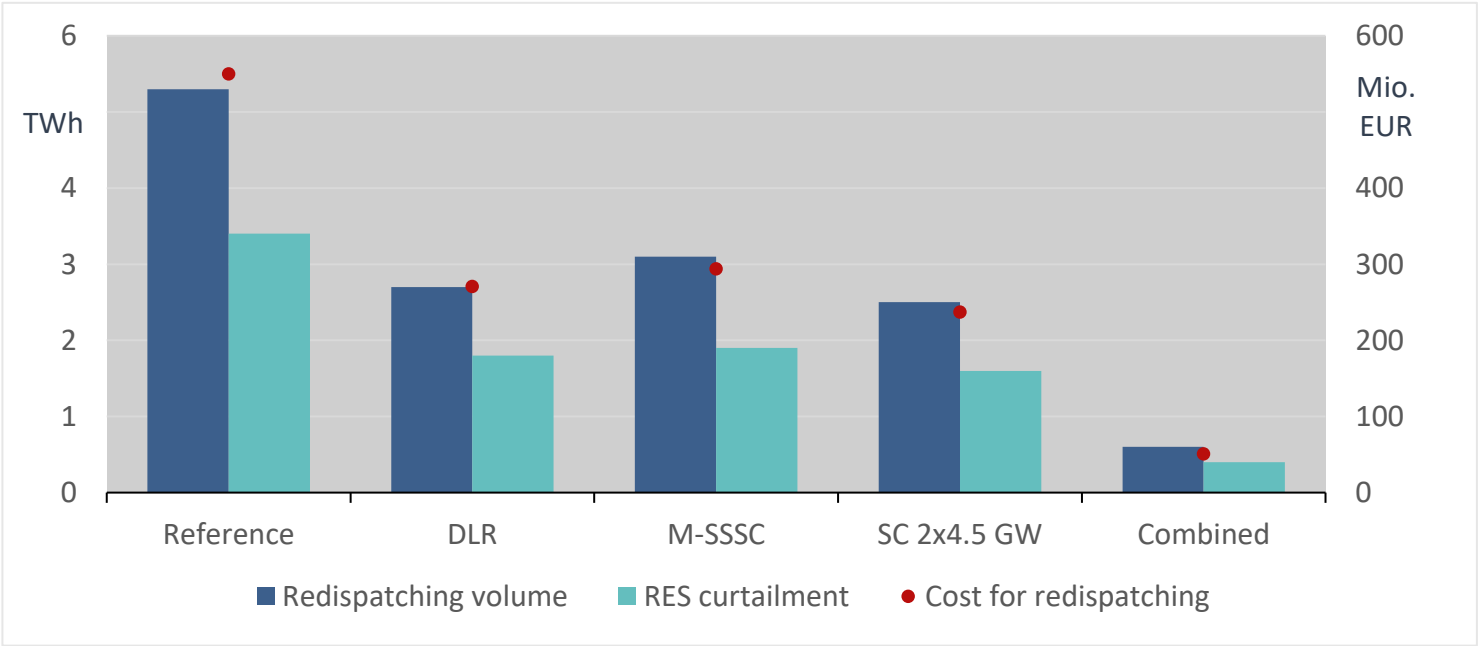
Redispatch volume base case



→ Redispatching volume relatively low due to optimistic assumptions on grid expansion
→ Most of the redispatching located in Germany
→ Significant RES curtailment in DE (of which 80% is related to wind onshore)

Main Messages & Conclusions

Modelling results



- → **In the considered scenario, Dynamic Line Rating and Smart Valve technology each reduce the volume of redispatch and costs by roughly 40%-50%**
- → **Additional HVDC connection with Superconductor technology could reduce the redispatch costs by roughly 60% (or 30% compared to normal HVDC cable at same cost level)**
- → **Combining the three technologies results in volume and costs savings of roughly 90% compared to the reference case, proving complementarity of approaches**

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Main Messages & Conclusions

Significant impact	▪ Dynamic Line Rating, M-SSSC and Superconductors can each significantly reduce the volume of congestion and congestion management costs in highly loaded transmission systems, thus helping to integrate RES generation and limiting need for RES curtailment
Complementarity	▪ While each of the innovative technologies will help optimize the power network individually, our study shows in addition the complementary benefit of those technologies
Additional benefits possible	▪ Further benefits might include improved integration of markets, reduced price differences, faster employment of renewable generation, faster electrification of fossil fueled consumption and more emission cuts ▪ Explicit analysis has not been part of the present study
No substitute for grid expansion	▪ Efficiency and optimization using innovative technologies and the investments in reinforcement and expansion of networks, should be considered together to ensure a secure and cost-efficient green energy transition to society

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