Model-based Assessment of Potential Future Demand Response Utilization in Germany - Selected Results and Implications for Integrated Assessment Models

Expert workshop within the ADVANCE project

“Innovation in Relation to Building energy demand in IAMs”

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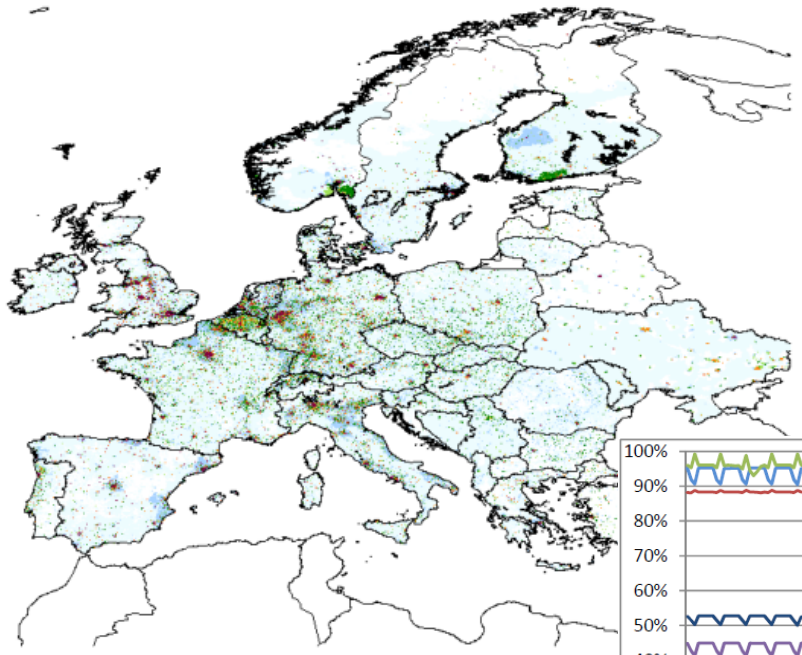
Research Questions

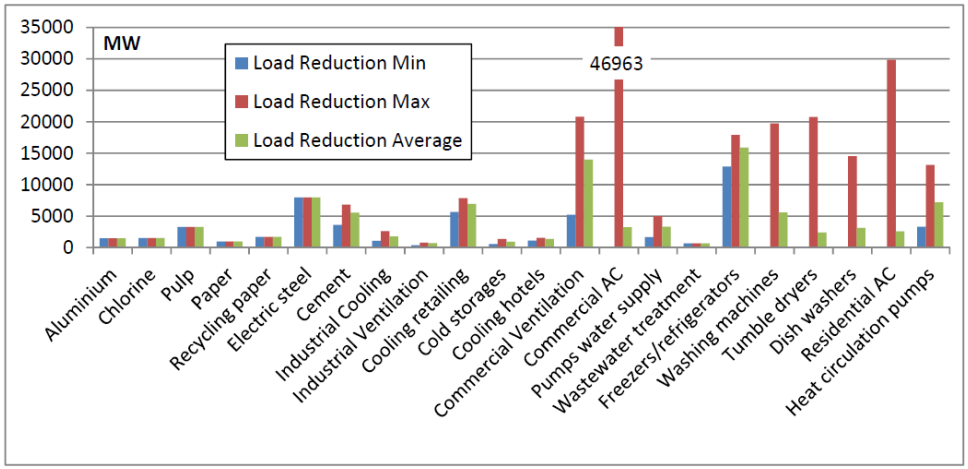
- What are the theoretical potentials for demand response (DR) in Europe?
- Is the exploitation of these potentials an economic alternative to other balancing options?
- What are the load balancing impact and typical operation pattern of DR?
- How is DR interacting with alternative balancing technologies?
- To what extent can DR reduce supply costs and CO_2 emissions?

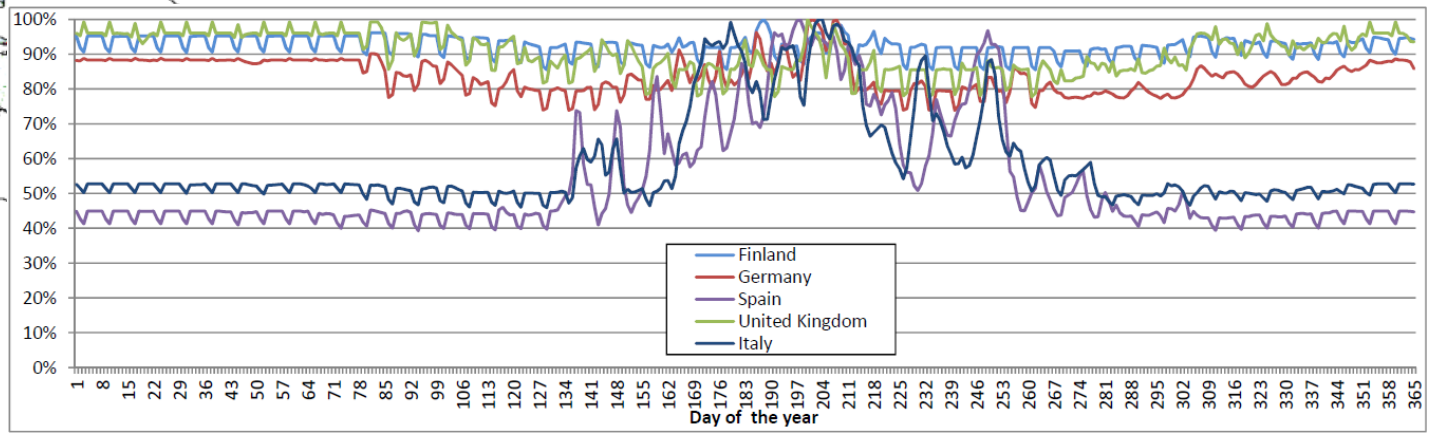
Assessment of Theoretical DR Potentials in Europe

- Consideration of 30 flexible electric loads across all demand sectors
- Derivation of hourly load profiles
- Geographic disaggregation to 1 km² raster

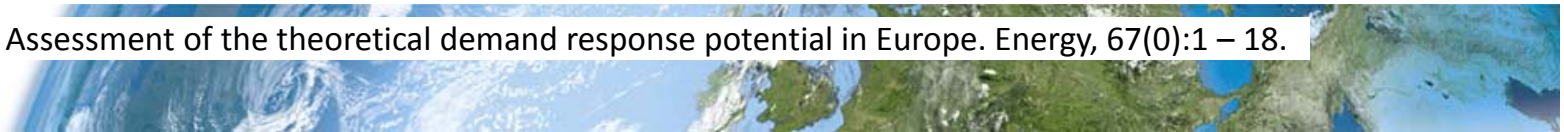


Theoretical potentials, values of 2010



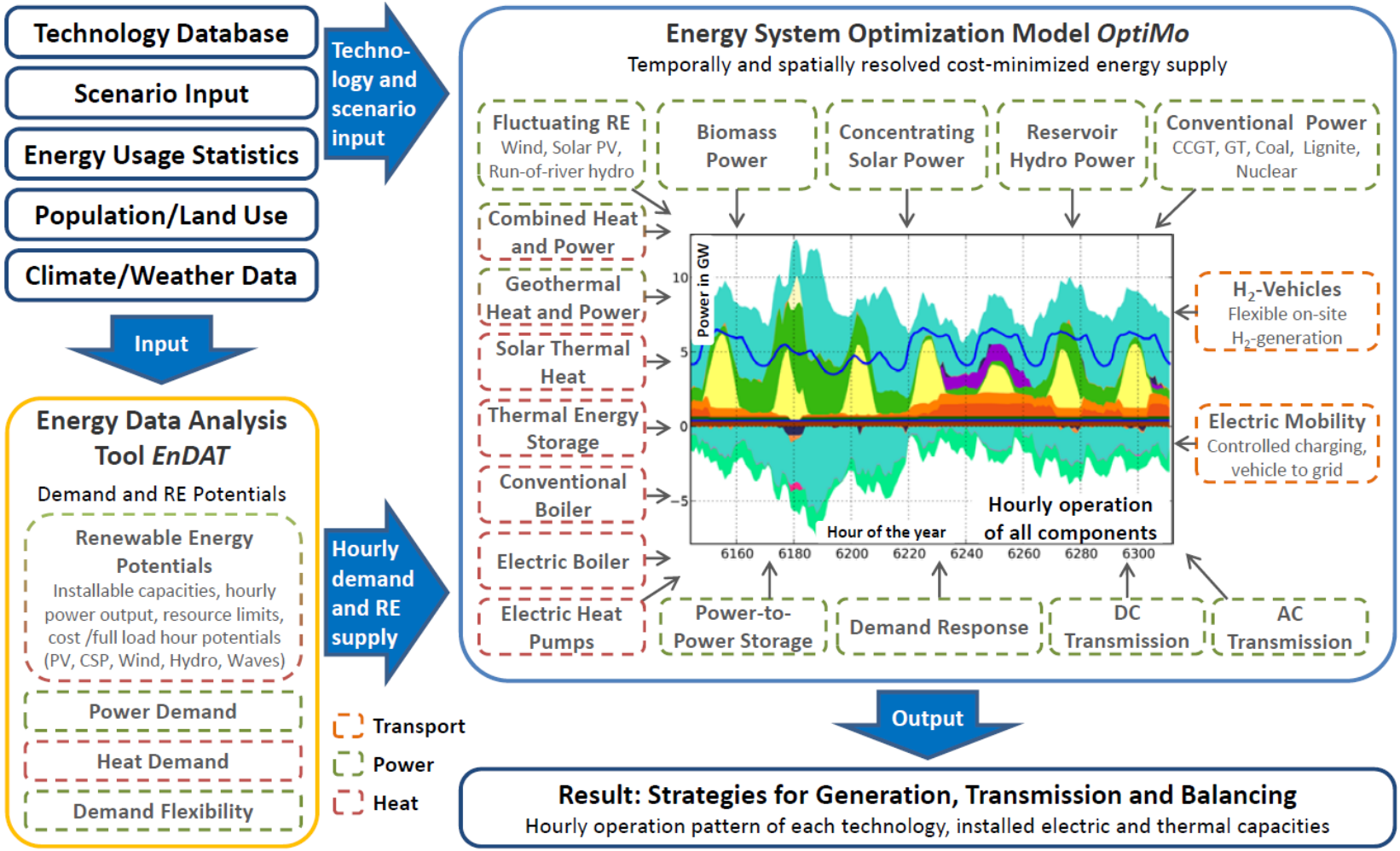


Gils, H. C. (2014). Assessment of the theoretical demand response potential in Europe. Energy, 67(0):1 – 18.



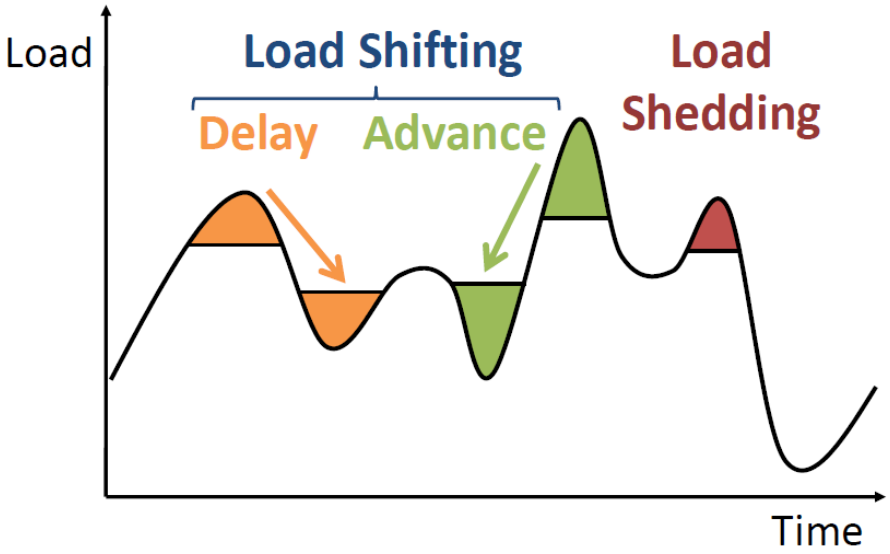
REMix Model Structure

- Deterministic linear optimization model realized in GAMS
- Assessment of investment and hourly system dispatch during one year



DR Model Representation in REMix

- Representation of load shedding, load delay and load advance
- Modelling as energy storage with limit in storage time and availability
- Load profiles of DR consumers limit the hourly load reduction and increase
- Implementation of limits in frequency of DR utilization
- Theoretical potential is used as capacity limit and reduced to social potential
- DR development and utilization associated to capital and operational costs



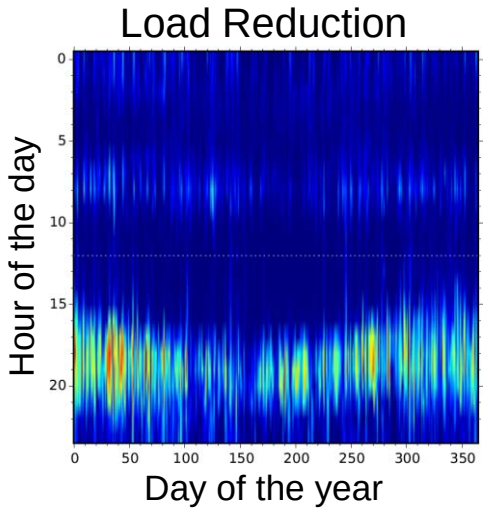
Gils, H. C. (2015). Balancing of Intermittent Renewable Power Generation by Demand Response and Thermal Energy Storage. PhD thesis, Universität Stuttgart *(submitted)*.

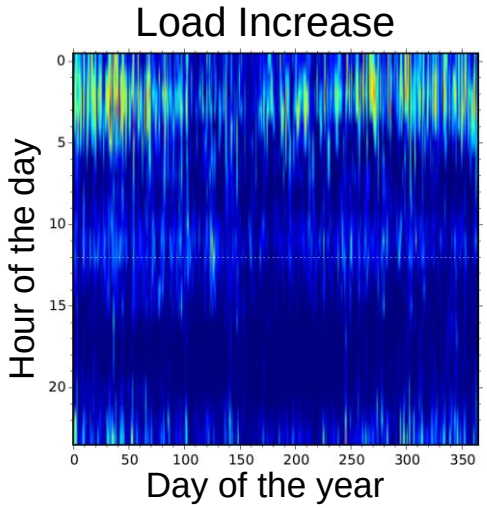
Case Study on DR Utilization in Germany

- Model application aims at a better understanding of the potential future contribution of DR to the balancing of VRE fluctuations in Germany
- Focused on a European supply system with RE supply share exceeding 80%
- Germany is considered as part of an interconnected European environment
- Scenarios differing in wind and PV share, transport sector structure, as well as availability of long term storage, transmission grid expansion and CSP import

Key Results on DR Utilization in Germany

- Potentials exploited almost exclusively in industry/commerce
- Residential DR limited to electric heat and electric vehicles
- DR mostly limited to short time residual load peak shaving
- Substitution of firm generation capacity by DR
- DR has minor impact on curtailment
- DR can generate supply cost reductions





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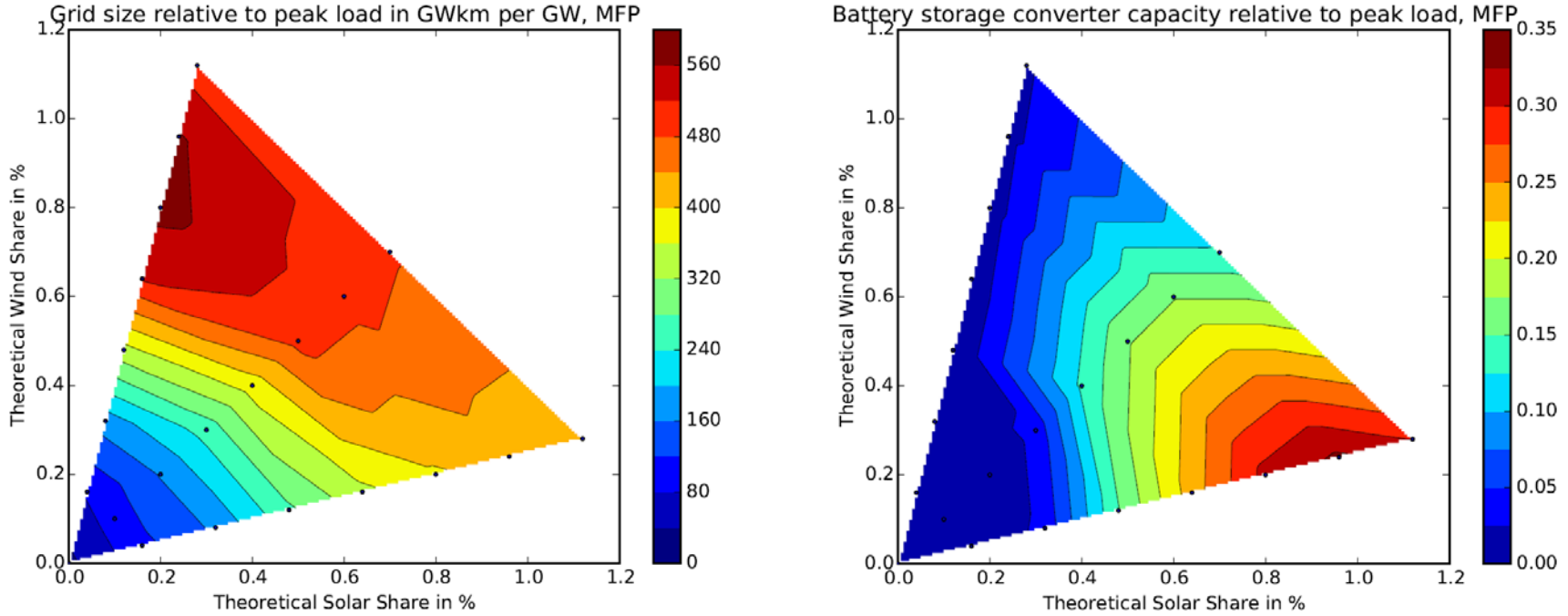
REMix Simulations within the ADVANCE Project

- Evaluation of VRE integration costs in Europe with REMix
- Least-cost installation and dispatch of generation, storage and transmission
- Consideration of different VRE shares, solar-to-wind ratios and CO_2 costs

Exemplary results of grid extension and battery storage installation



Summary and Implications of REMix Results for IAMs

- DR reduces capacity demand and to a minor degree VRE curtailment
- DR can provide cheaper load balancing than other technologies
  - ➢ DR reduces VRE integration costs (even more the case for sector coupling)
  - ➢ Impact on VRE integration must be evaluated in more detail using REMix
- Availability of DR potentials exhibits substantial temporal fluctuations
  - ➢ High temporal resolution required for comprehensive assessment
  - ➢ Approximate consideration by application of a minimum availability
- Industrial and commercial DR potentials are most attractive
  - ➢ Residential DR requires other revenues than inter-regional balancing
- DR may (partially) substitute short-term (battery) storage in PV-dominated regions

Thank you for your attention!

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