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Cross-sectoral Analysis of Future Energy Systems with REMix

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Solar photovoltaic and wind power are increasingly contributing to electricity supply in Europe and worldwide. Due to their intermittent nature, questions of balancing power demand, system stability and the interconnection of electricity, heat and transport sector have become a major focus of energy system research. The bottom-up energy system model REMix (Renewable Energy Mix) has been developed with the aim of providing a powerful tool for the development and assessment of future supply scenarios in high spatial and temporal resolution [1-3].

Methodology

- → REMix is a multi-sectoral energy system model using a linear optimization approach
- → The model relies on a global high resolution renewable energy (RE) resource assessment
- → The modular structure of REMix provides high flexibility in model usage
- → A user interface allows for quick changes in geographical and technological detail
- → REMix currently comprises around 20 technology modules
- → CHP, CSP and conventional power plants are represented in detail
- → REMix is moreover focused on modelling flexible electric loads in all demand sectors
- → Hourly operation of all generation, storage and transmission assets is assessed
- → REMix applications include least-cost green-field capacity expansion analysis, long-term scenario validation and impact assessment of balancing options on RE integration

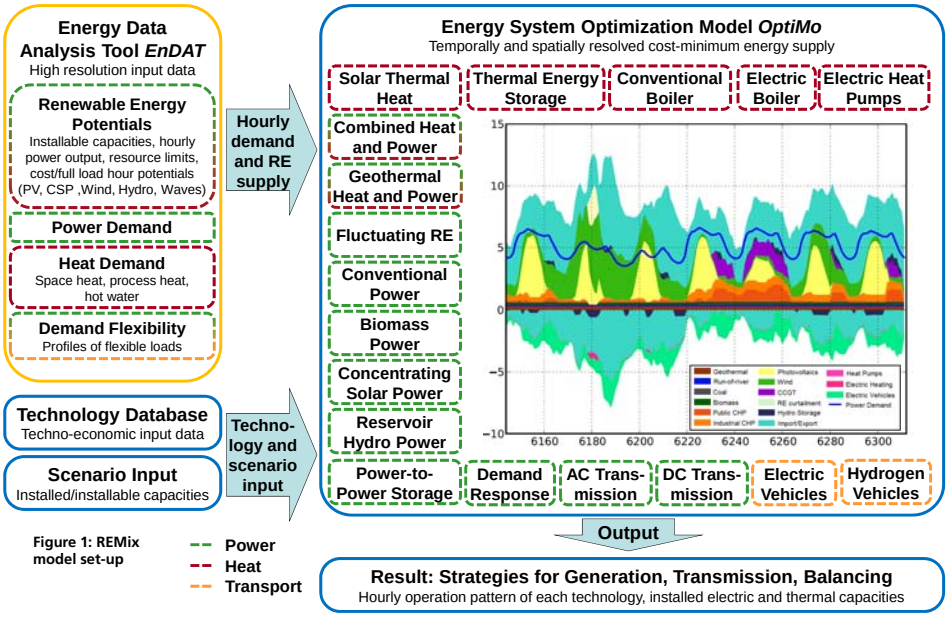

Figure 1: REMix model set-up

Renewable power integration with thermal energy storage in CHP supply

- → Power-controlled CHP operation with heat storage (TES) and electric boilers reduce RE curtailment in Germany by up to 47% [4]

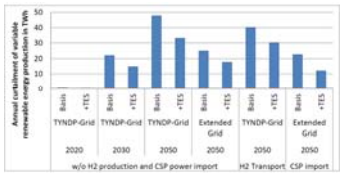

Figure 2: Impact of TES usage on RE curtail-ment in Germany for different scenarios

- → In an 80% RE system, electric boilers provide up to 10% of district heat supply
- → Up to 13% of produced heat are stored

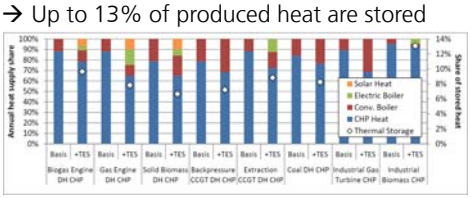

Figure 3: CHP supply structure and TES utilization

- → District heating TES are preferably used in spring, summer and autumn

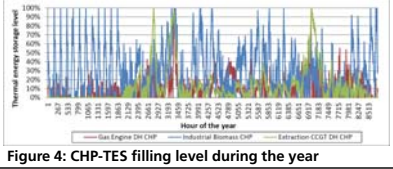

Figure 4: CHP-TES filling level during the year

Balancing impact of demand response and controlled electric vehicle charging

- → Relying on an extensive assessment of the European demand response potential [5]

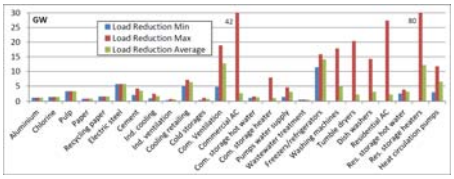

Figure 5: Theoretical DR potential in Europe for the year 2010

- → Hourly values of load flexibility considered
- → Annual load shift in Germany 2050 up to 30 TWh, peak load reduction up to 10 GW
- → Load shifting predominantly from morning and evening to midday and night

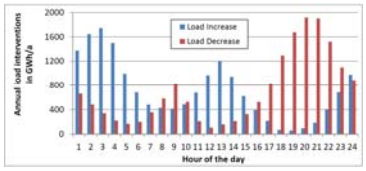

Figure 6: Hourly demand response operation

[1] Scholz Y. Renewable energy based electricity supply at low costs: development of the REMix model and application for Europe. Dissertation, University of Stuttgart, 2012.
[2] Luca de Tena D. Large Scale Renewable Power Integration with Electric Vehicles, Dissertation, University of Stuttgart, 2014.
[3] Stetter D. Enhancement of the REMix energy system model: Global renewable energy potentials, optimized power plant siting and scenario validation. Dissertation, University of Stuttgart, 2014.
[4] Scholz Y, Gils HC, Pregger T, et al.: Möglichkeiten und Grenzen des Lastausgleichs durch Energie-speicher, verschiebbare Lasten und stromgeführte KWK bei hohem Anteil fluktuierender erneuerbarer Stromerzeugung, DLR, Report to the German Federal Ministry for Economic Affairs and Energy, 2014
[5] Gils HC. Assessment of the theoretical demand response potential in Europe. Energy 2014;67:1–18.
[6] Fichter T, Trieb F, Moser M. Optimized Integration of Renewable Energy Technologies Into Jordan's Power Plant Portfolio. Heat Transfer Engineering 2013;35:281–301

Short-term RE integration and expansion planning in MENA countries

- → Detailed unit-specific modeling of RE and conventional power plants [6]
- → Identification of niche markets for RE and short-term integration strategy
- → Addressing specific characteristics of power supply systems in MENA

Figure 7: Capacity expansion for Jordan from the year 2012 to 2022

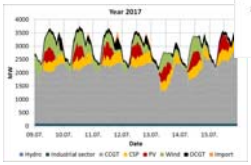

Figure 8: Hourly dispatch including intermittent PV and wind power and dispatchable CSP

- → RE are competitive in the short-term
- → CSP as backbone of future systems providing strongly required dispatchable and firm RE capacity

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