In order to model variable renewable energy (VRE) integration into the power system, Integrated Assessment Models (IAM) need aggregated information on VRE availability and balancing requirements. We present exemplary applications of the high resolution energy system model REMix designed to support the representation of VRE technologies and integration costs in IAMs.

### Linear bottom-up optimization model REMix

REMix relies on a global high resolution renewable energy resource assessment and identifies least-cost supply systems and optimizes their hourly operation.

REMix is focused on modelling flexible electric loads in all demand sectors.

- **DR** suited for reducing capacity demand
- **TES** for cutting VRE curtailments

DR and TES are in all scenarios competitive with alternative balancing options.

### Case study Demand Response and Thermal Storage

Recent REMix studies [4,6] show that consumer demand response (DR) and thermal energy storage (TES) can reduce VRE integration costs in Germany.

#### Methodology

- **Evaluation of 7 scenarios** with 85% RE power supply share in the year 2050.
- **Assessment of the ability of DR and TES to reduce costs and CO₂ emissions.**

#### Highlights

- **DR and TES** are in all scenarios competitive with alternative balancing options
- They are not competing but complementary measures
- In Germany, costs can be reduced by up to 2 billion €, CO₂ emissions by 5 Mt
- **DR** suited for reducing capacity demand, **TES** for cutting VRE curtailments

### Case study VRE Integration Costs in Europe

The research leading to these results has received funding from the European Union’s Seventh Framework Programme [FP7/2007-2013] under grant agreement n° 308329.

#### Methodology

- **Parametric study** of balancing needs associated with VRE penetration and composition in Europe [5], done in the framework of the ADVANCE project.

- **Total system costs** are minimized
- **Concentrating solar power (CSP)** is included in the solar share
- **Output**: backup capacity and energy, storage and transmission needs, curtailments, emissions, LCOE and integration costs

#### Results

**All results for MCP (medium CO₂ price). LCP and HCP show similar patterns.**

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