Forecast of the European electricity demand until the year 2050 and the related impacts on the electricity load curve

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Agenda

- Motivation
- General model setting
- Load curve tool – The concept
- Case study
- Conclusion

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Motivation

Many scenarios were recently published, depicting pathways towards a sustainable European energy system by 2050

Problem definition

- Focus on electricity supply side; low level of detail on demand side
  - Analysis of demand side often based on top-down approach
- Neglect of changing load patterns when matching supply and demand
  - Simple scaling of historic load curve based on annual load forecast, assuming today's hourly consumption structure (i.e. today's electricity load curve)

Aim

- Highly disaggregated electricity demand forecast
- Assessment of the future national hourly load curves considering endogenous structural changes

Context

- KIC InnoEnergy Light House Project : ESA² - Energy System Analysis Agency (http://www.esa2.eu)

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General model setting

FORECAST model

- Long-term energy demand projection model
- Technology discrete bottom-up simulation approach
- Results
  - Annual energy demand on a technology level
  - Energy saving potentials of specific efficiency technologies
  - Related GHG emissions
  - Cost curves for efficiency options

Load curve tool

- Generation of national hourly electricity load curve for one year based on FORECAST results
- Consideration of technology / appliance specific 24h load profiles

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Load curve tool – Concept
A partial decomposition approach

1. Assessment based on **technology discrete** demand projection (FORECAST results)
2. Identification of **most relevant technologies** / appliances featuring **most significant relative change** in demand between base year and projection year
3. Load curve projection considering **non-relevant** technologies via **scaling** the load curve of the base year
4. Creating load curves for the change in demand of **the relevant** technologies/ appliances by using technology specific, temperature or time based 24h **load profiles**
5. Determination of **entire load curve** for projection year by **summing up** scaled load curve of non-relevant appliances and the load curves of the changes in relevant appliances

Advantages

- Consideration of characteristic outliers
- No need for knowledge about all technology / appliance specific load profiles

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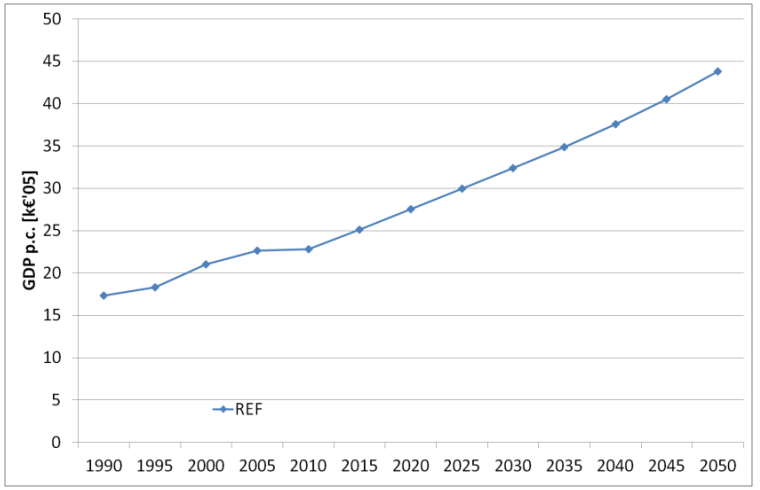
Case study
Scenario configuration

Reference scenario

- Main drivers taken from EU Energy Roadmap 2050, Reference scenario
  - Steady GDP growth
  - Further population growth until 2040
  - Further rise in fossil fuel prices
  - EUA prices stabilize at about 50 €/t by 2050



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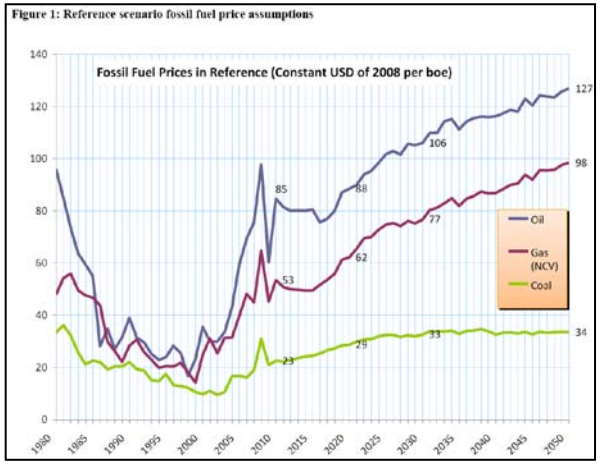
  - Only cost effective efficiency technologies experience market diffusion



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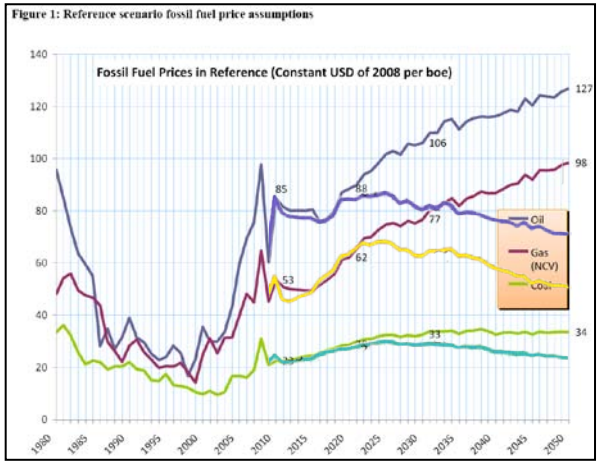

Decarbonisation scenario

- Decarbonisation scenario with a strong focus on energy efficiency and renewables
  - Same GDP and population as in Reference case
  - Lower fuel prices, but higher EUA prices (up to 450 €/t_{CO2})
- Technology assumptions
  - Strong diffusion of efficiency technologies

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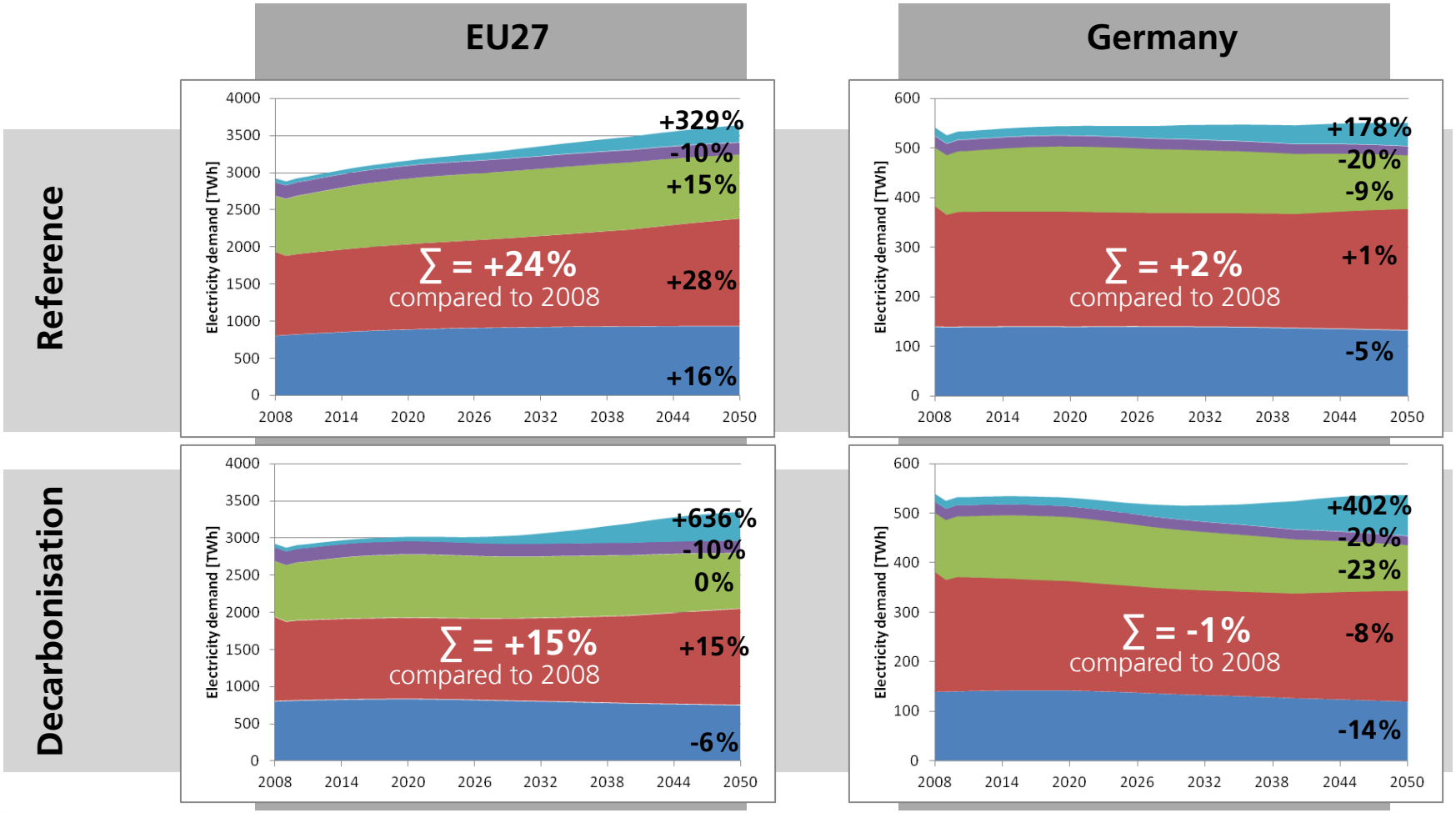
Case study
FORECAST results – Electricity demand



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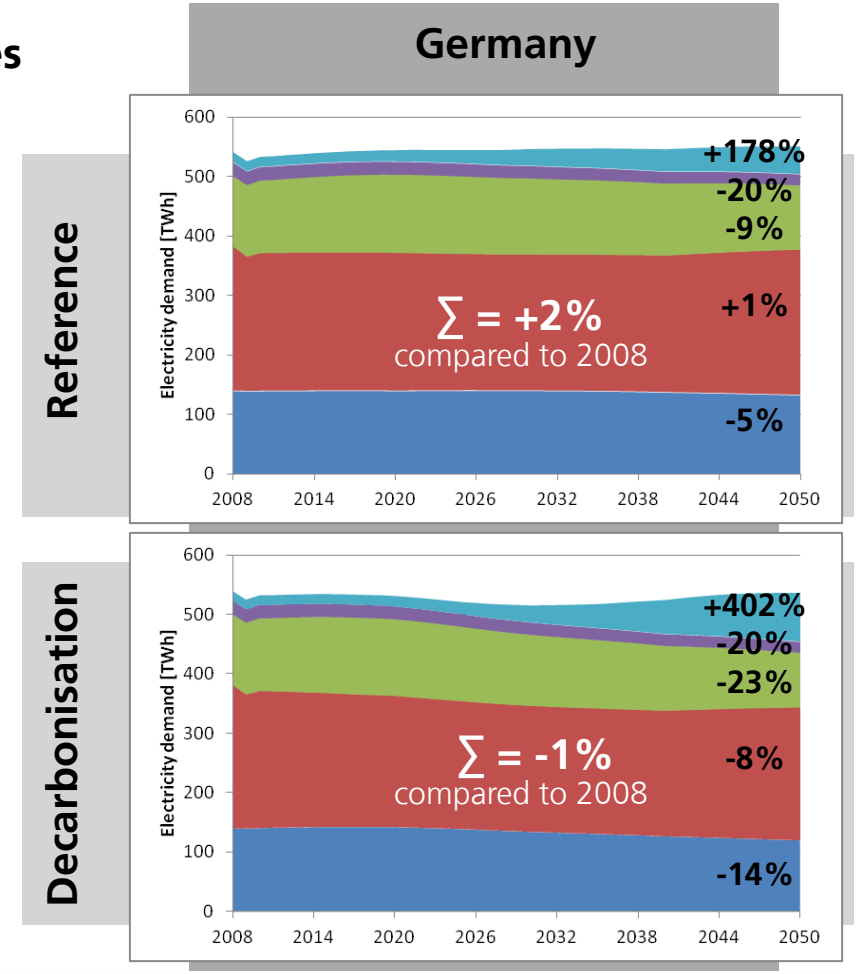
Case study
FORECAST results

Most relevant applications and technologies for load curve adjustment:

	$\Delta_{a,abs}$ [TWh]	$\lvert\Delta_{a,abs}\rvert / \sum\lvert\Delta_{a,abs}\rvert$	$\Delta\lvert_{a,abs}\rvert / d_{total,2050}$
E-Mobility	+29,5	14,6%	5,4%
Heat pumps	+13,5	8,9%	3,3%
Storage heater	-8,2	3,9%	1,4%

	$\Delta_{a,abs}$ [TWh]	$\lvert\Delta_{a,abs}\rvert / \sum\lvert\Delta_{a,abs}\rvert$	$\Delta\lvert_{a,abs}\rvert / d_{total,2050}$
E-Mobility	+66,4	22,3%	12,4%
Heat pumps	+40,6	13,6%	7,6%
Storage heater	-12,0	4,0%	2,2%



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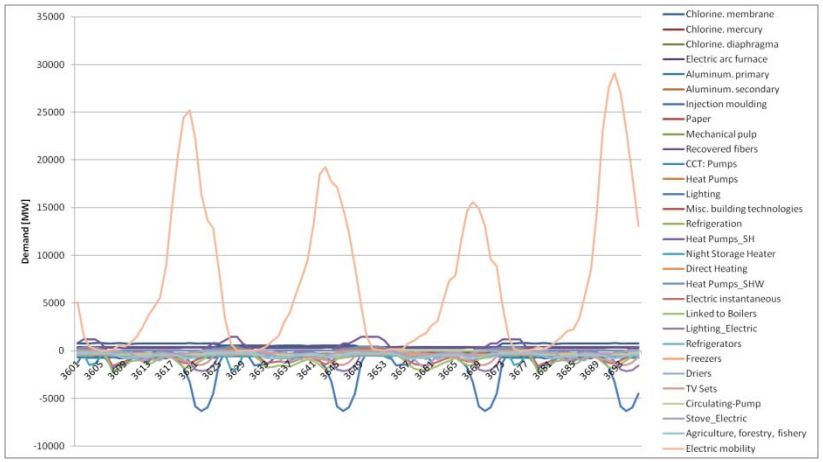
Case study
The German load curve



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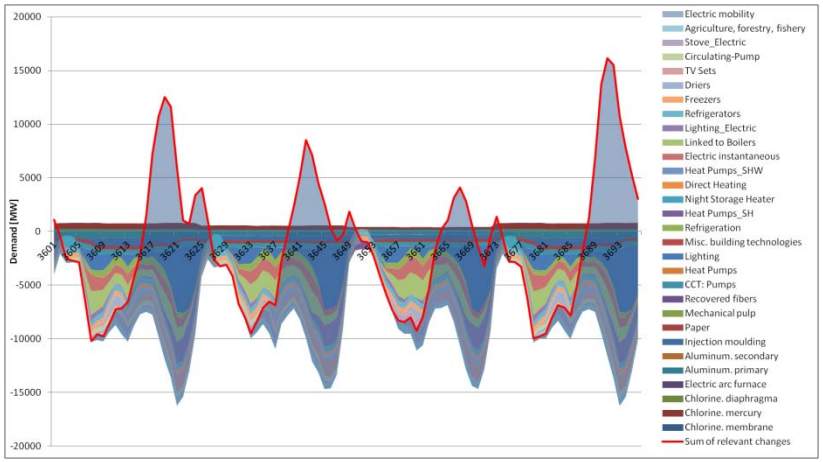

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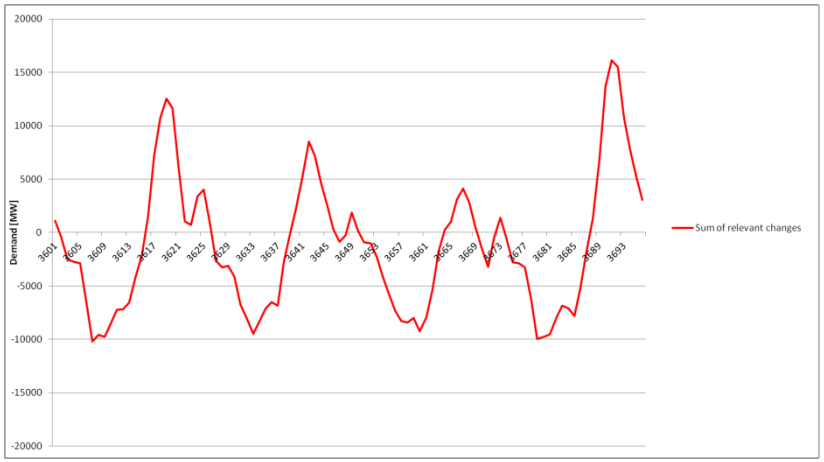

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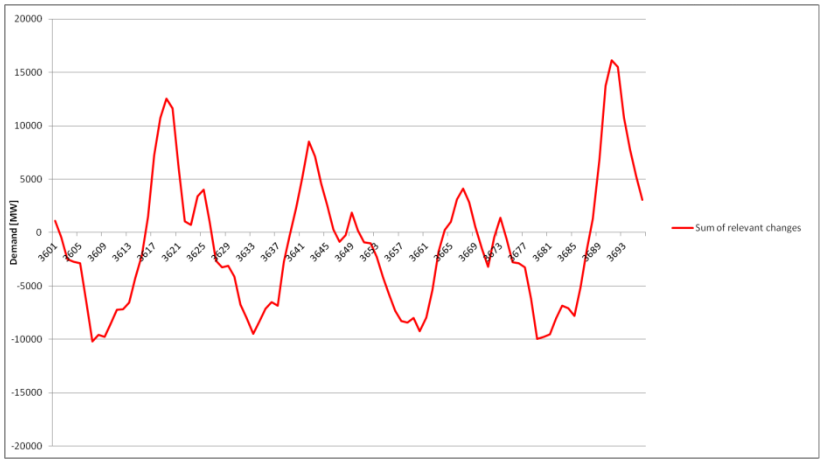

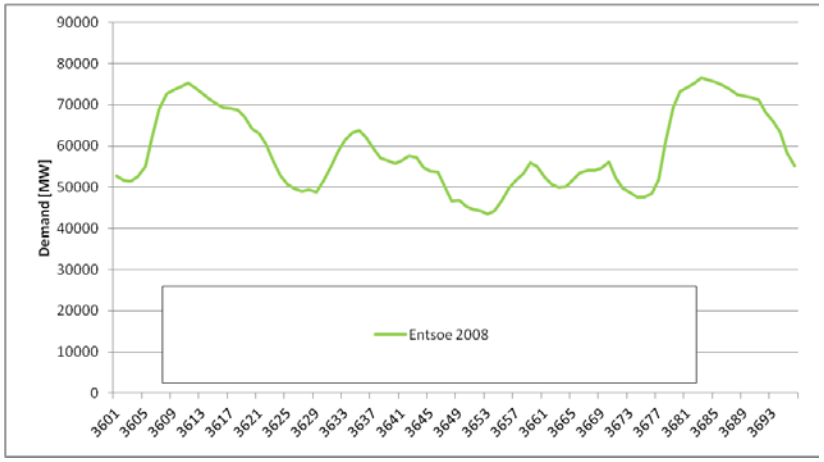

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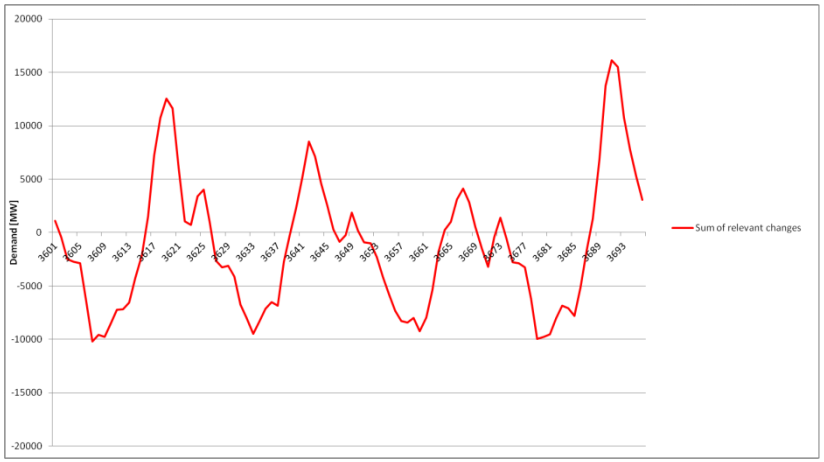

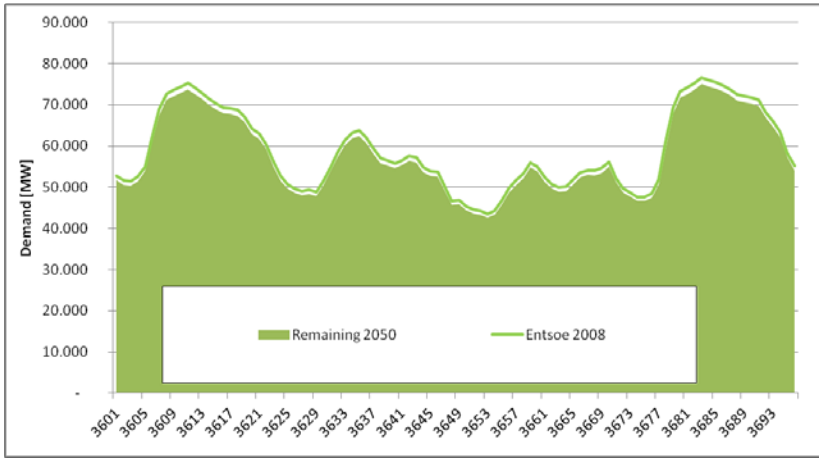

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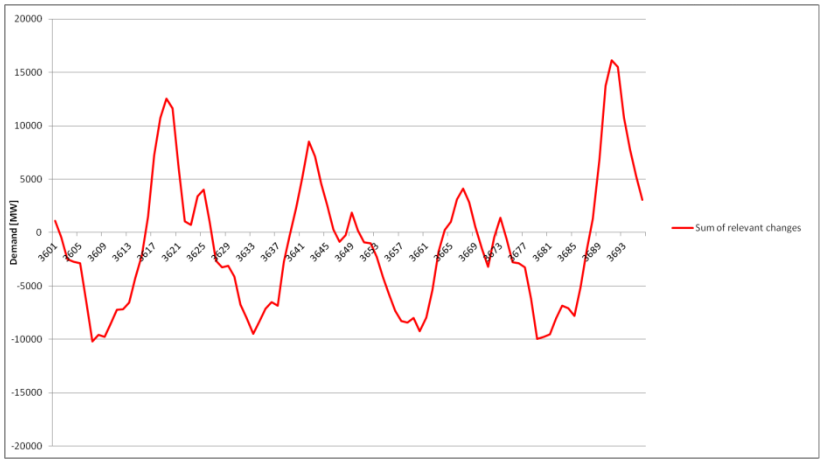

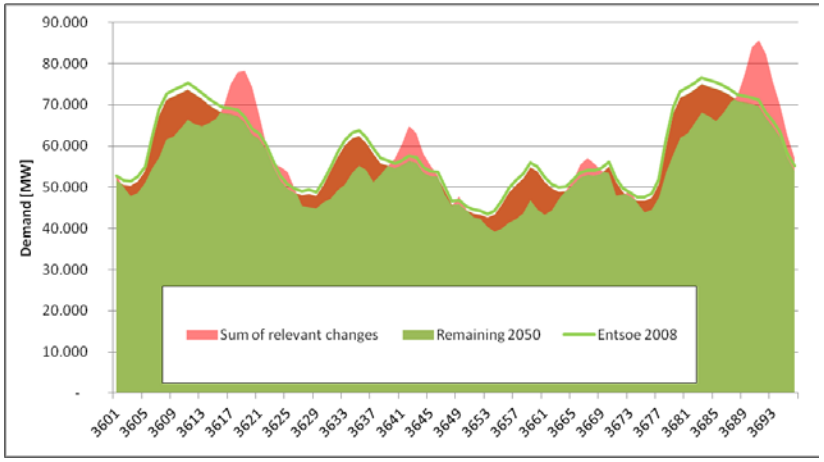

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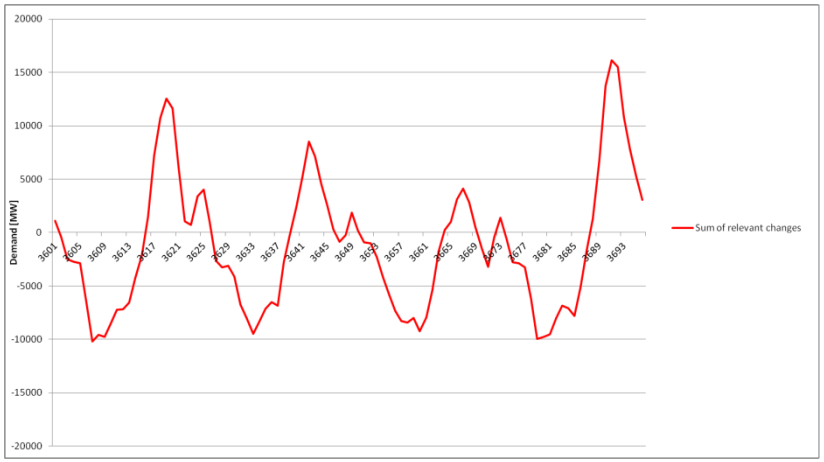

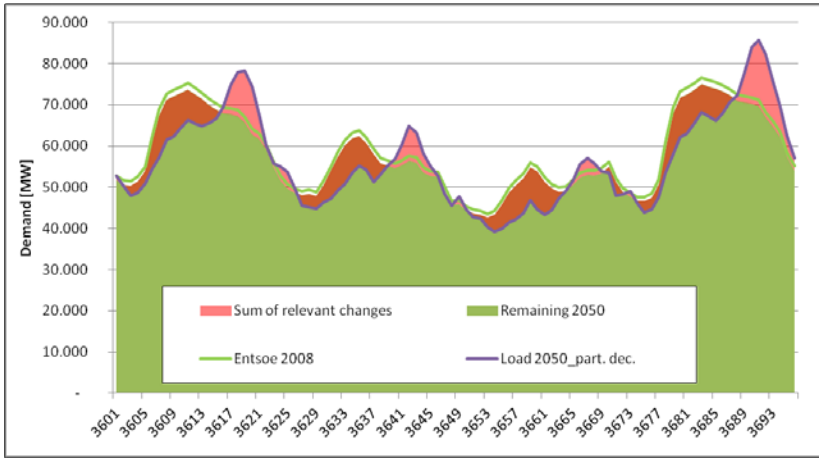

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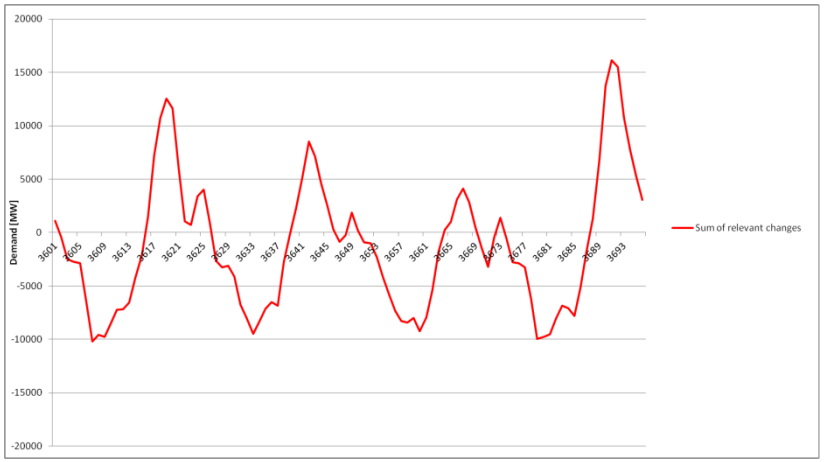

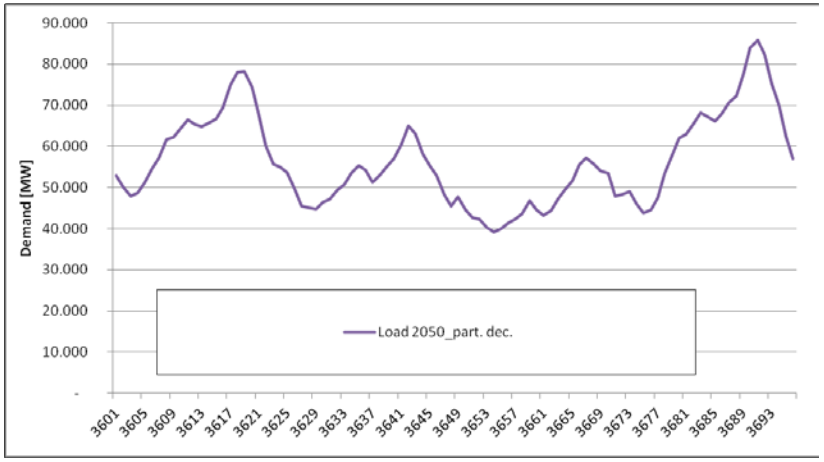

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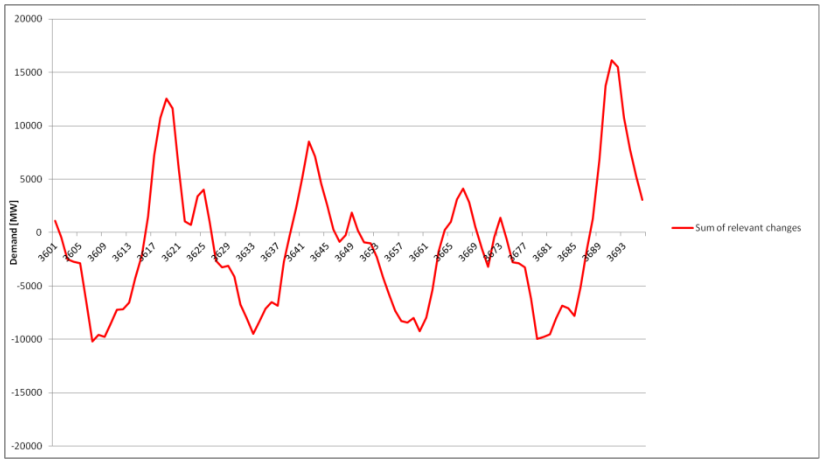

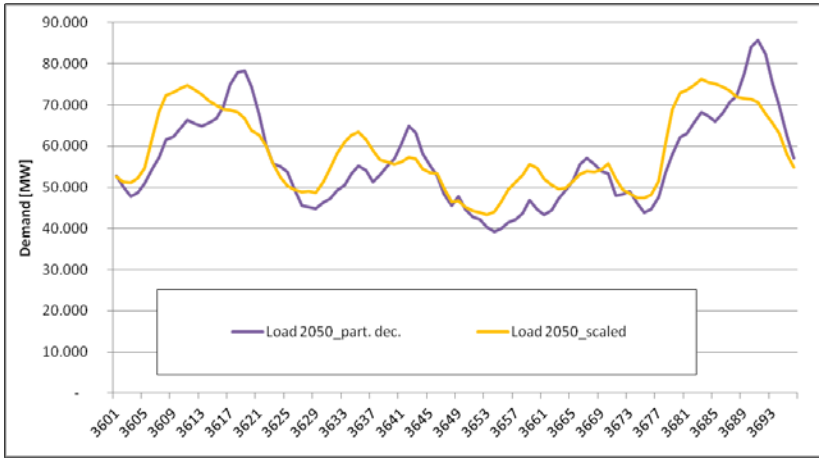

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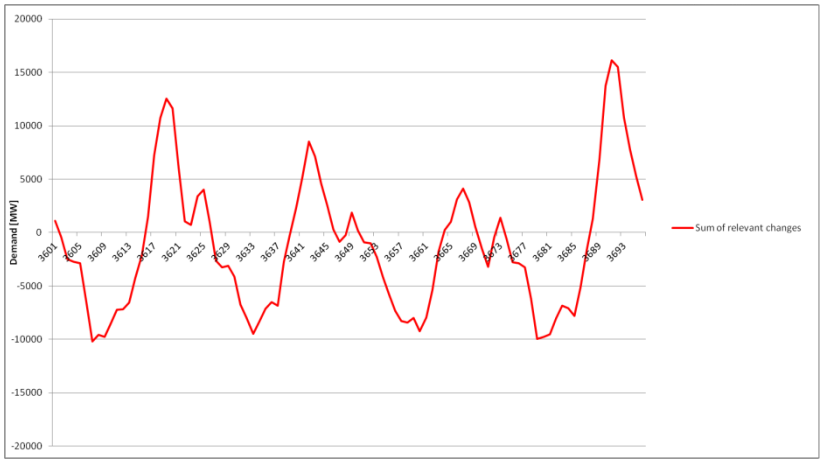

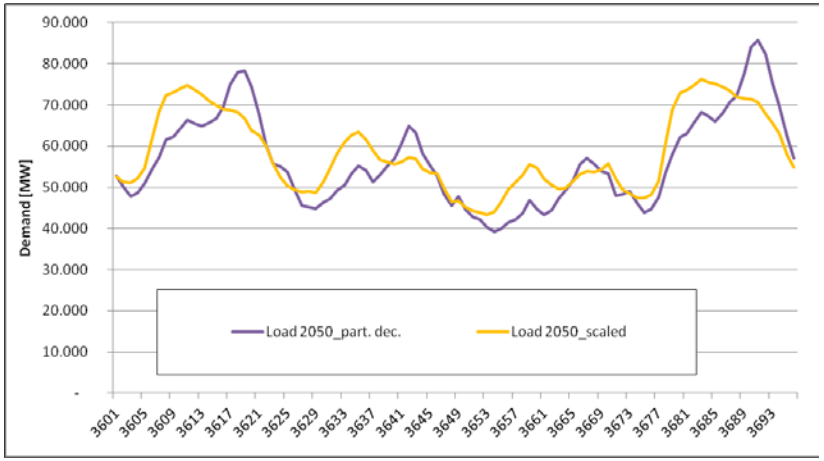

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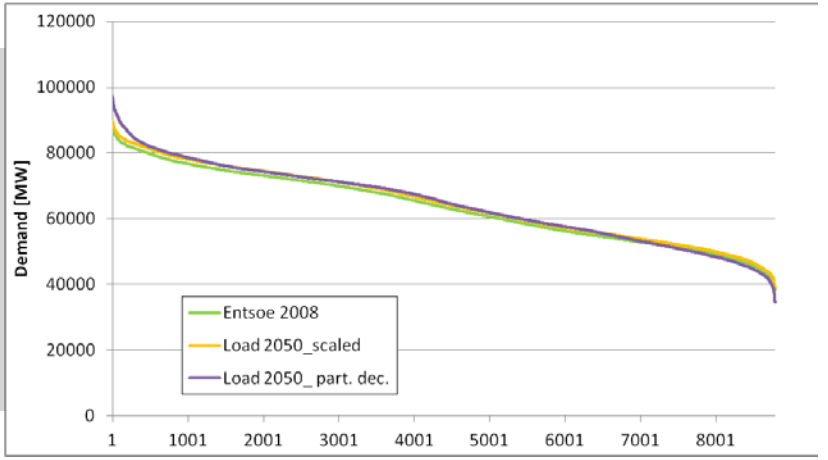
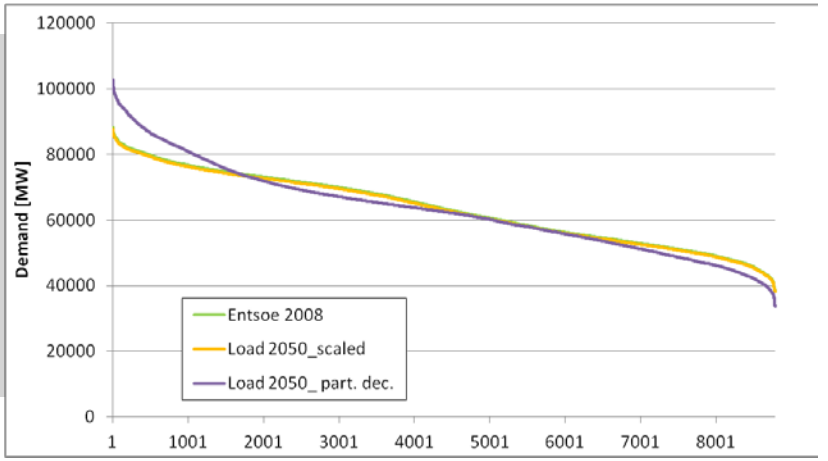


Decarbonisation



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Conclusions & outlook

Considering the future **design of the electricity load curve** represents an indispensable asset when assessing the **compatibility** of the envisaged energy **efficiency** measures and a future **energy supply** system

- The load curve will experience **structural changes** through shifts in electricity demand
- A **simple scaling** of the historic load curve neglects changes in the hourly load
  - Inappropriate basis for **designing** the future electricity supply system and investment decision in new generation capacities
  - **Underestimation** of maximum load, peak load hours and volatility
- The **partial decomposition** approach permits to keep the characteristic shape (stochastic deviations and abnormalities) while adapting the fundamental structure
- The need for **load management** or alternative strategies (additional grid infrastructure, flexible generation or storage capacities) becomes even more important

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THANK YOU FOR YOUR ATTENTION!

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