Wir schaffen Wissen – heute für morgen

Aspirations for electrification: Does the future electricity demand profile matter for electricity supply? – Temporal aspects of energy systems modelling

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Hybrid Energy Modelling – Linkages and Interdisciplinarity,
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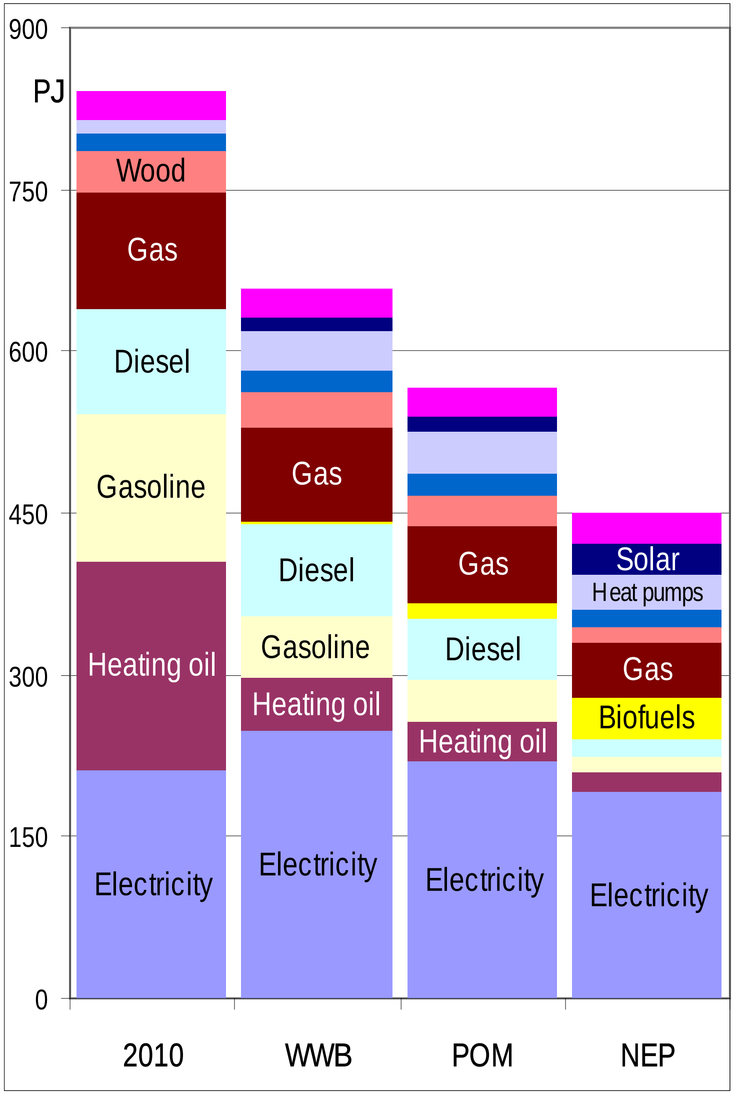
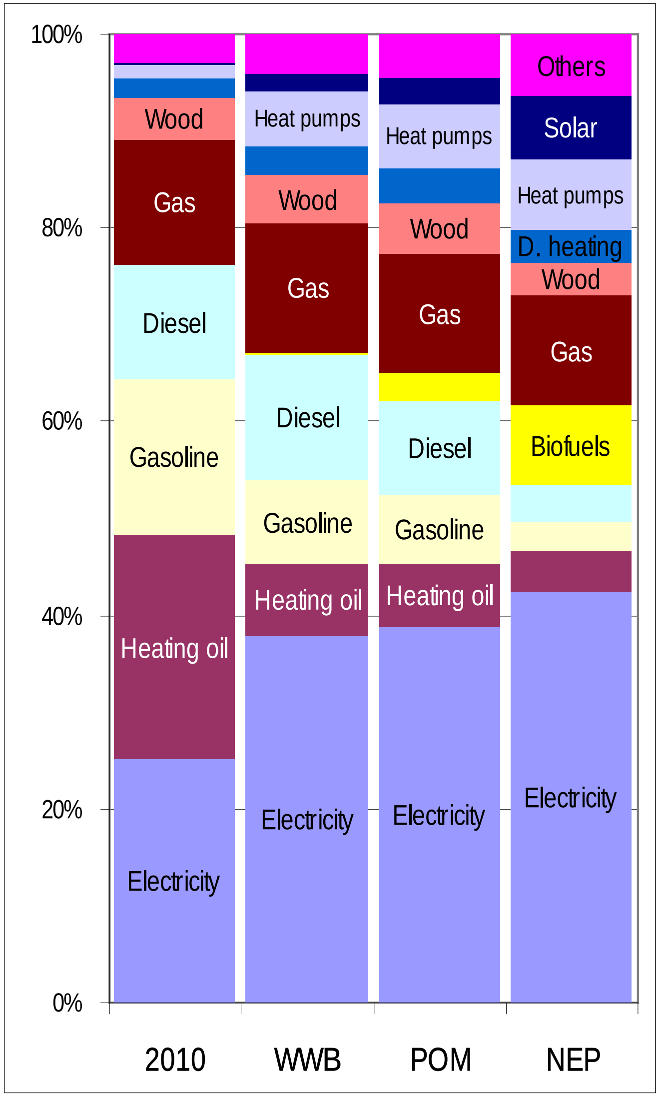
Outline

- Background
- Motivations and objectives
- Swiss TIMES energy systems model (STEM)
- Illustrative scenarios
- Results
- Conclusions
- Open questions

Background

Electrification of Swiss energy system in Swiss Energy Strategy 2050

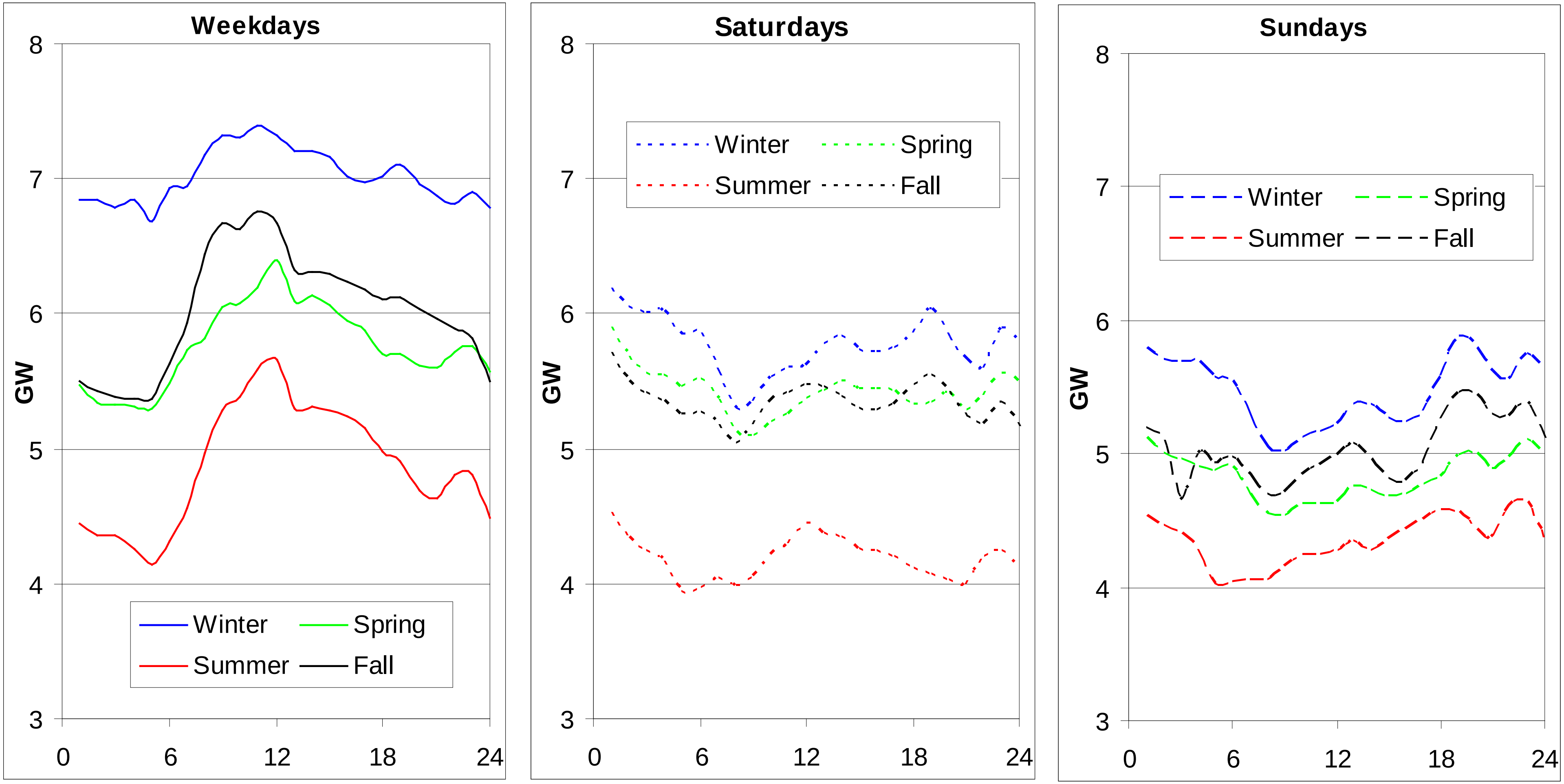




WWB-Business as usual
POM-Policy Measures
NEP-New Energy Policy

Background

Electricity demand profile today

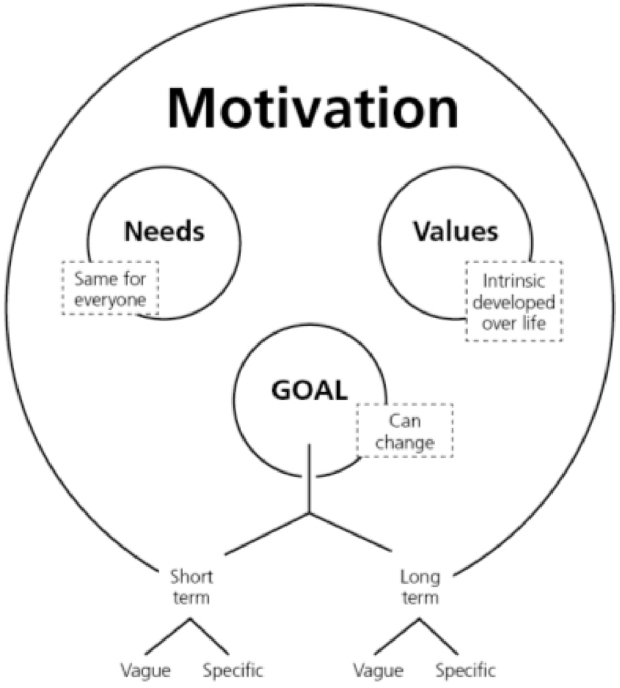


Can these demand profiles be extrapolated for the future?

Motivations and objectives

Motivations

- Ambitious electrification to decarbonize
- Integration of high share of renewable (to nuclear phase out)
  - Variably in electricity supply
- Application of electricity dispatch models
  - Historical electricity demand profile for future years
- Interdependency of demand-supply technologies
  - Alternative fuels and technologies (e-mobility vs. gas-mobility)

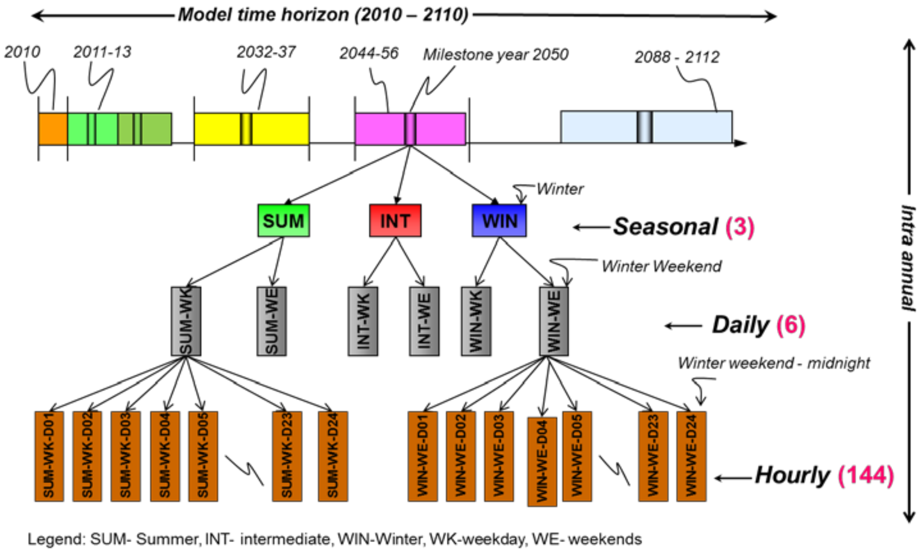


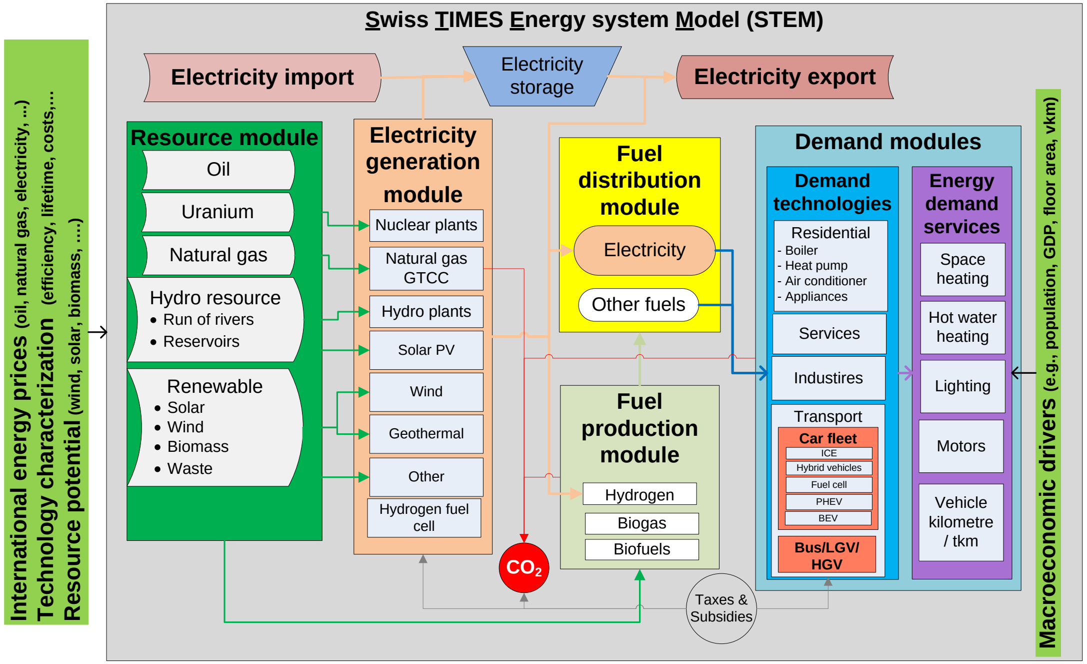
Objectives

- Dynamics of electricity demand and load curve
- Energy systems model with high temporal resolution
- Insights from a set of Swiss energy of scenarios

Swiss TIMES Energy systems Model (STEM)

- Time horizon: 2010 – 2100
- Hourly representation of weekdays & weekends in Summer, Winter and an intermediate season (144 timeslices)
- Five end-use sectors with subsector description
  - Six industrial subsectors
  - Four categories of residential heating (existing-, new-, single- and multi-family houses)
  - Agriculture, shipping and aviation for calibration
- Detailed electricity and energy conversion modules
  - Existing and new electricity/heat generation technologies, hydrogen, biofuels, etc.
- Fully calibrated to the Swiss Federal Office of Energy's 2010 energy balance
  - Final energy demand, CO_2 emission, car stock, power plants,…..





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Scenarios

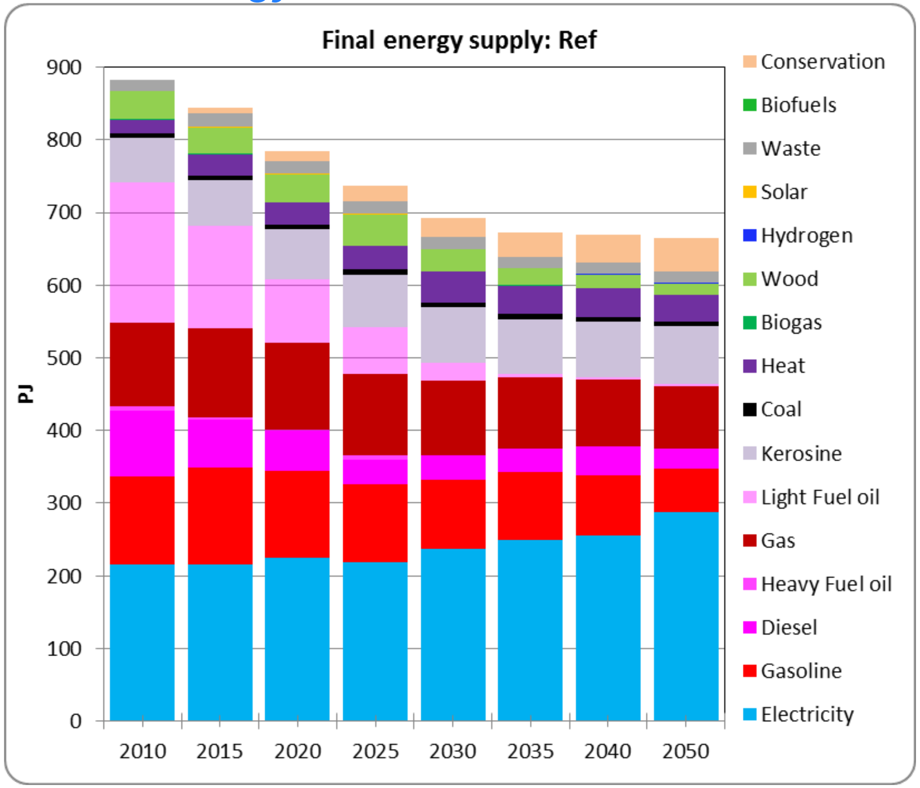
Ref scenario – Business as usual

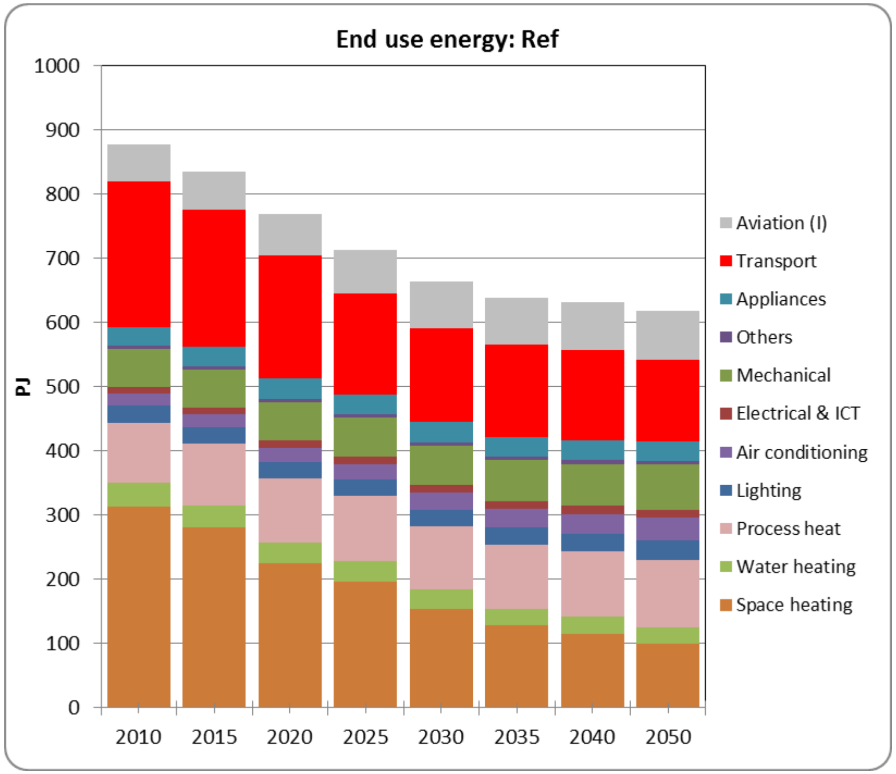
- Socio-economic demand drivers from Swiss Energy Perspective 2050
- Nuclear phase out and annual self-sufficiency in electricity supply

Parametric variants			In Ref scenario	Variants	Scenario name
1	V1	Central gas power plant	Yes	No	NoGas
2	V2	Imported electricity (Gross)	Yes	No	NoElcImp
3	V3	Imported electricity in winter	Yes	No	NoElcImpWin
4	V4	Conservation measures	Yes	No	NoRCSV
5	V5	Discount rate	2.5%	10%	DC10
6	V6	Fuel taxes (transport & heating)	Yes	No	NoFuelTax
7	V7	Imported electricity price	High	Low	LowElcImpPrice
8		V1 + v2			NoGas-ElcImp
9		V2 + V4			No-ElcImp-RCSV
10		V1 + V2+v4			NoGas-ElcImp-RCSV
11		V1+V5			NoGas-DC10

Results

Final energy demand - Ref

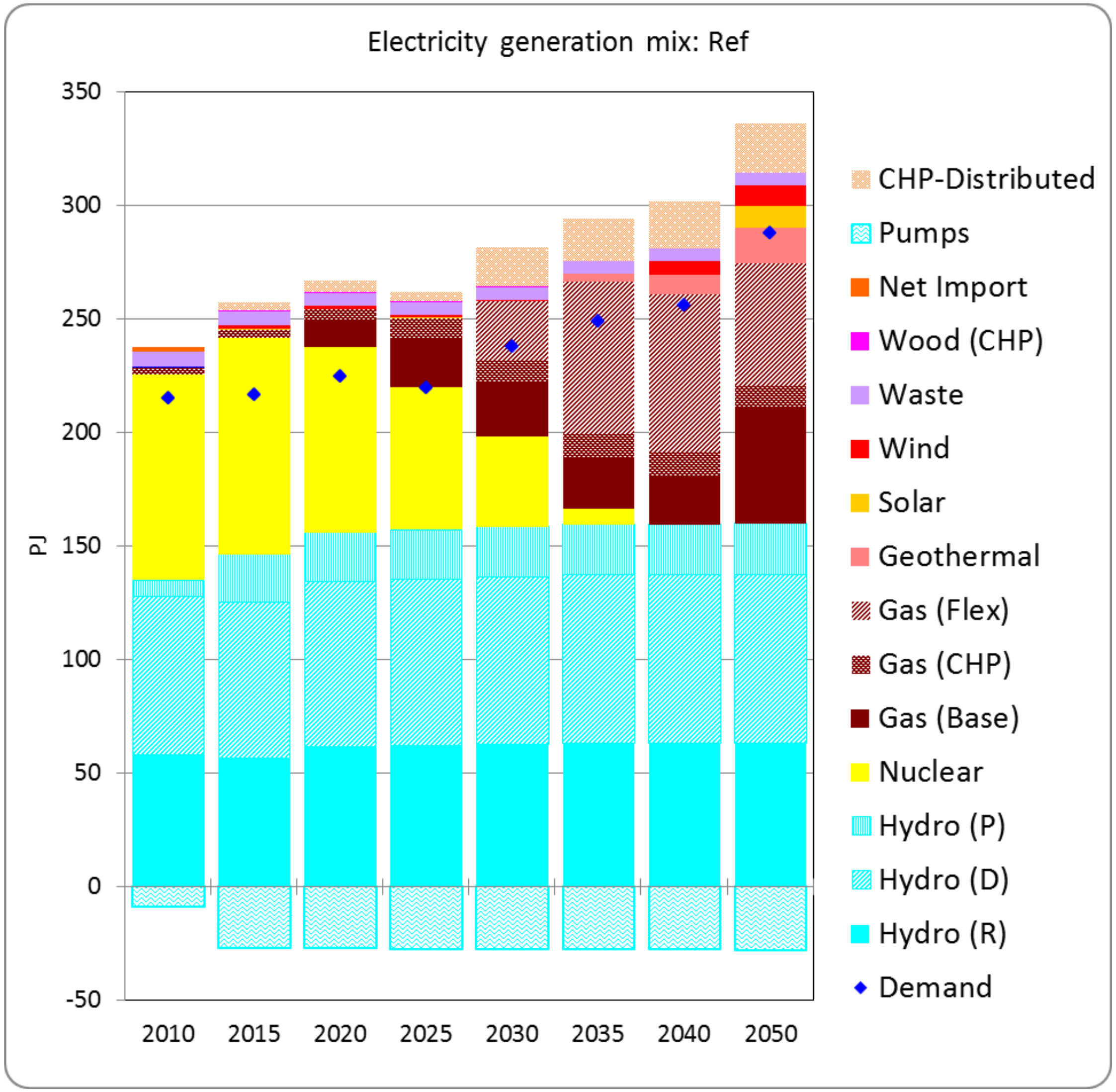




- Final energy demand declines about 30% by 2050
  - End-use energy efficiency
  - Fuel substitution/switching
  - Uptake of building energy conservation measures
- Electricity demand increases

- Space heating → declines two-thirds by 2050 → building conservation / efficiency of heating technologies.
- Transport fuel demand → declines 40% → most of the reductions from car fleet
- Electricity demand for air-conditioning almost doubles (from a low base)

Results – Electricity supply



Ref

- Electricity demand grows at 0.7% per annum
- Nuclear plants are replaced by natural gas combined cycle plants
- 12% of the electricity supply is from renewable in 2050

Electricity demand drivers…

- Heat pumps
- Electric mobility
- Air-conditioning

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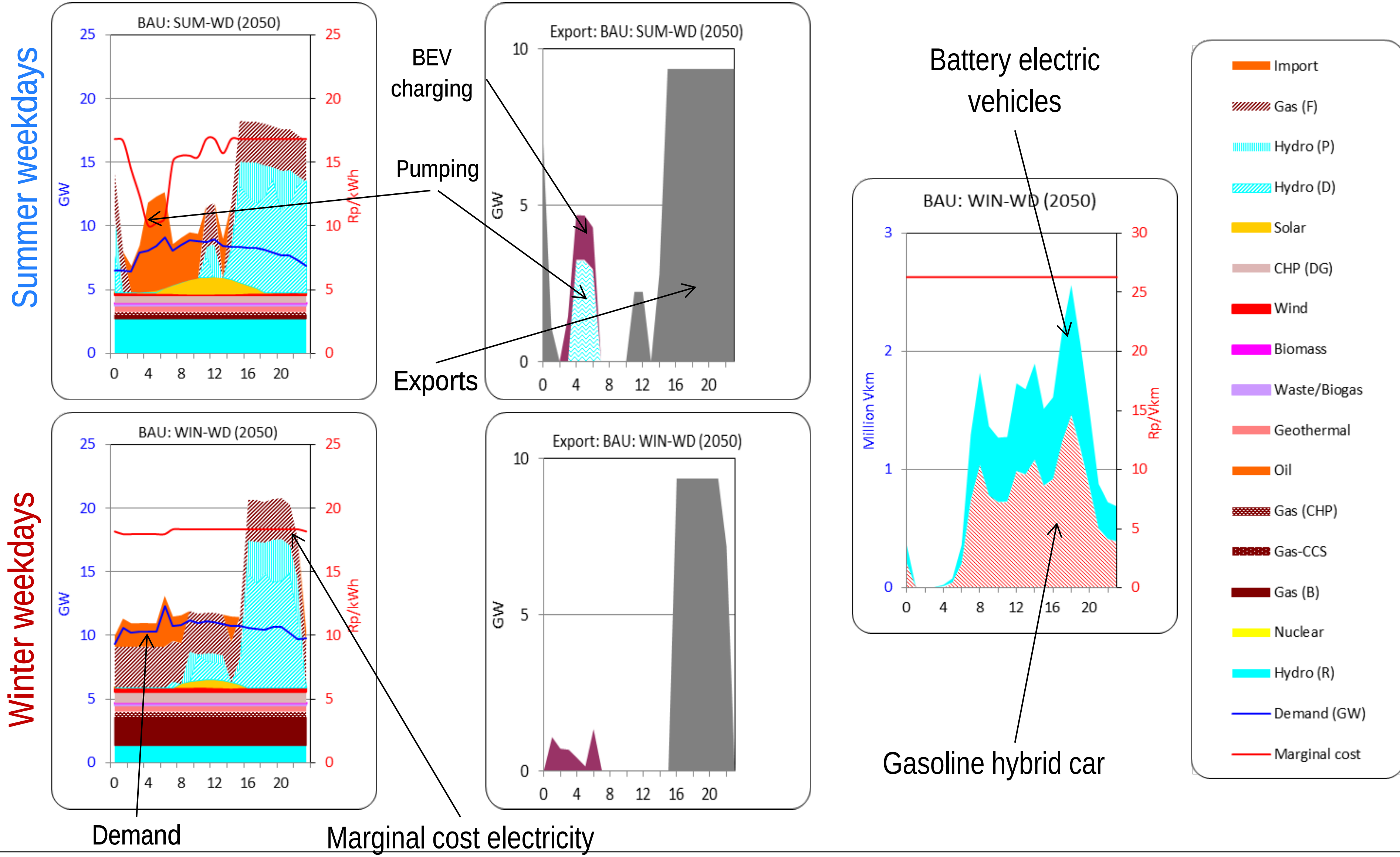
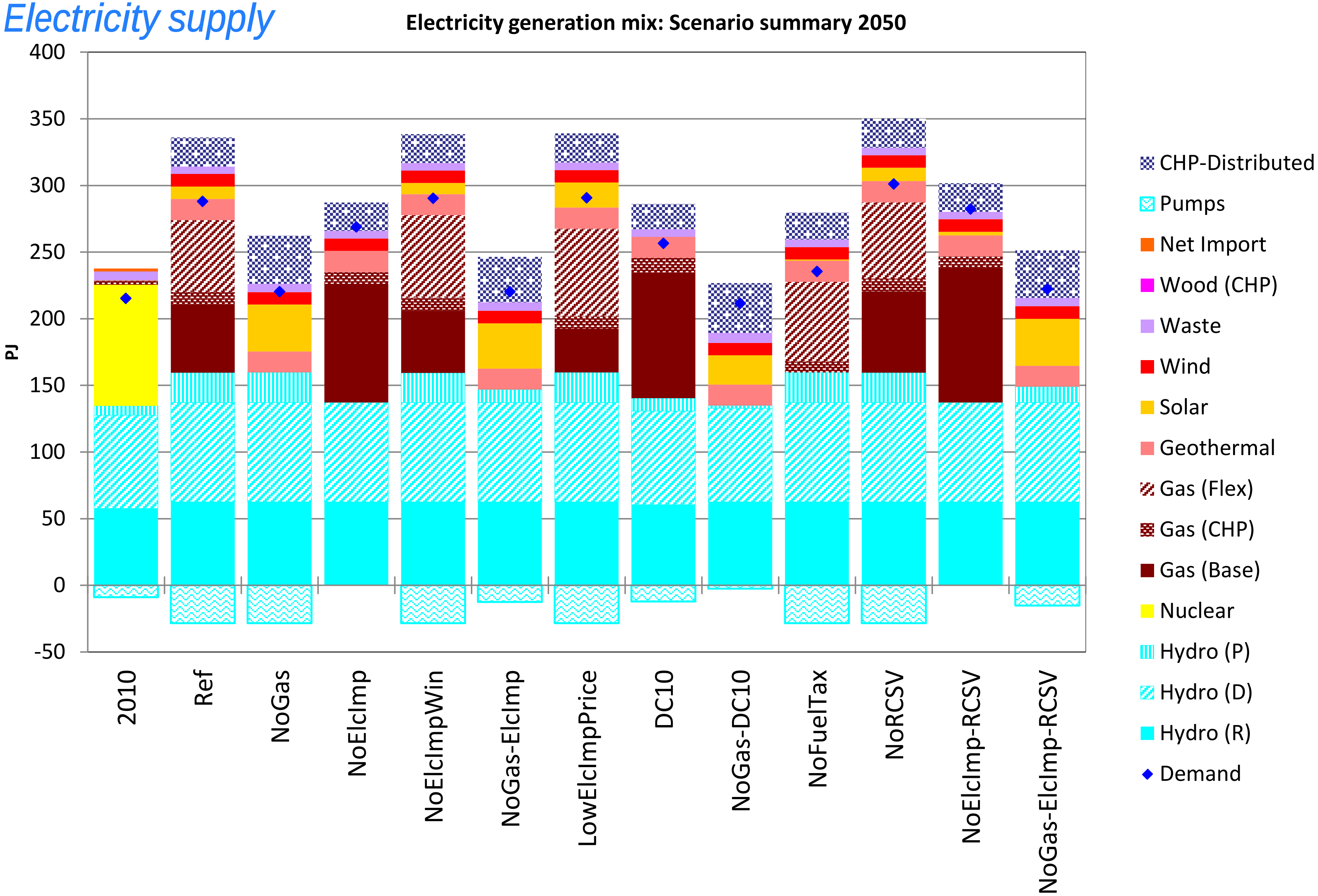
Results

Electricity supply-demand balance - Ref scenario - Weekday



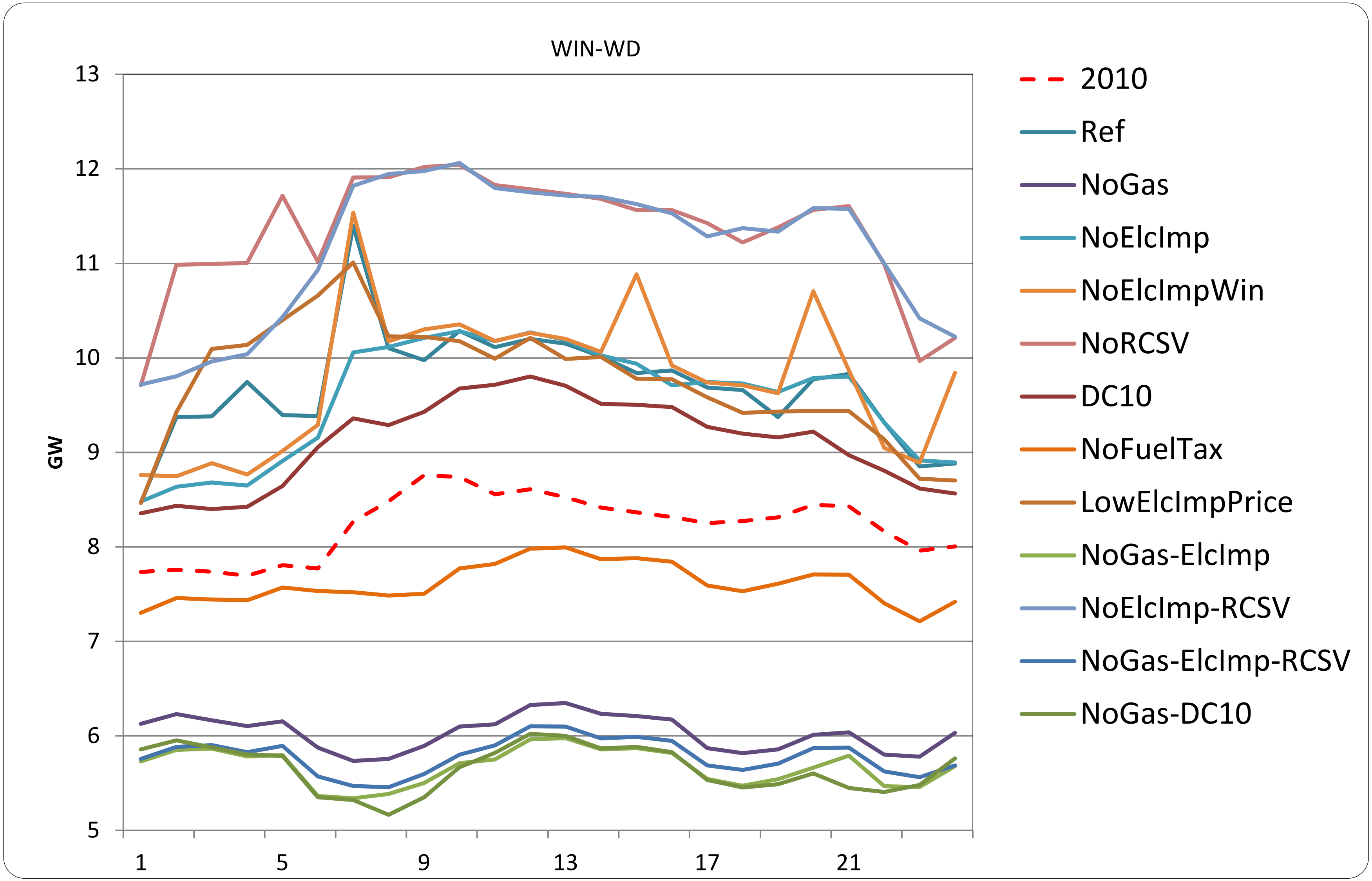
Results

Electricity supply



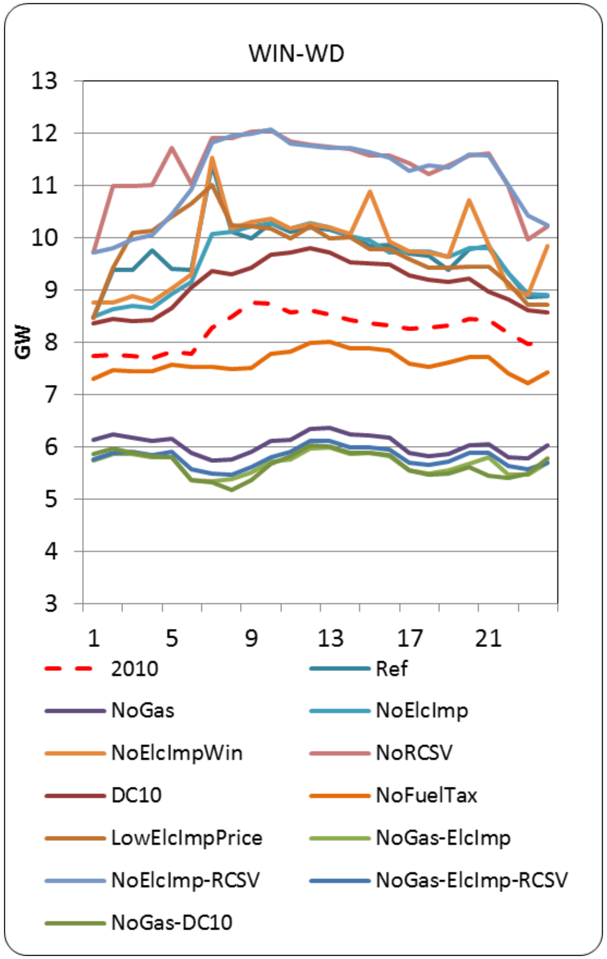
Results

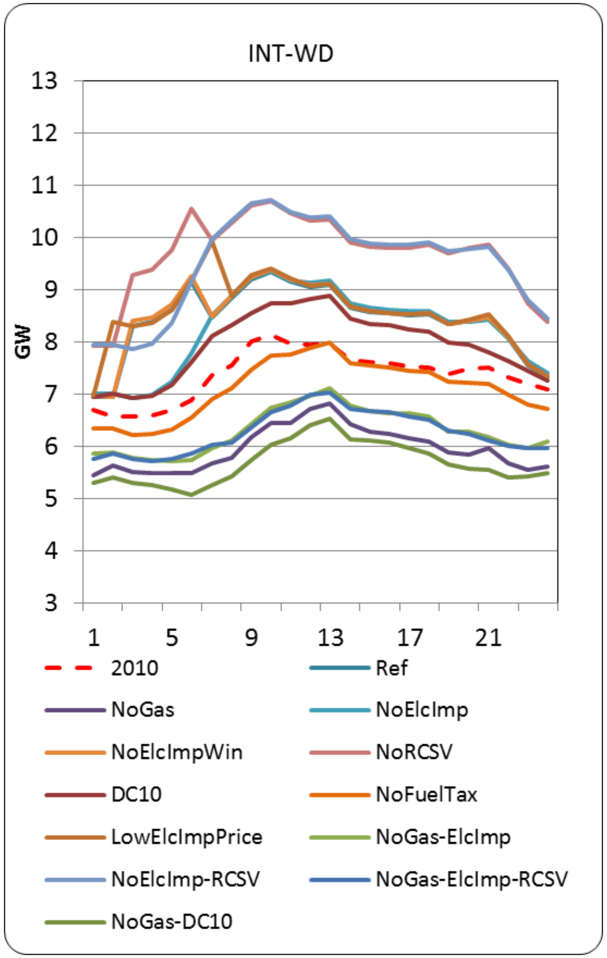
Electricity supply in Winter weekdays

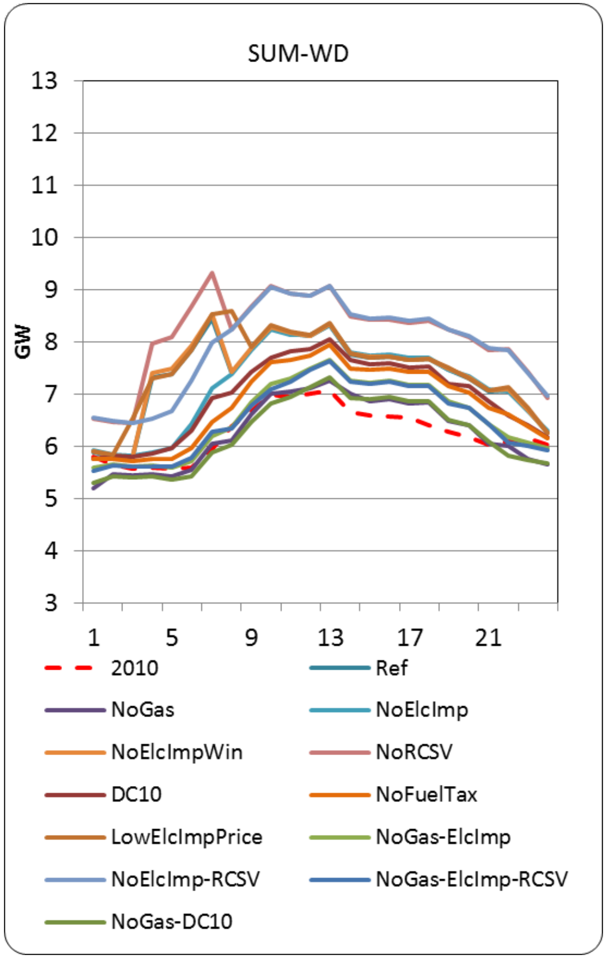


Results

Electricity demand on weekdays

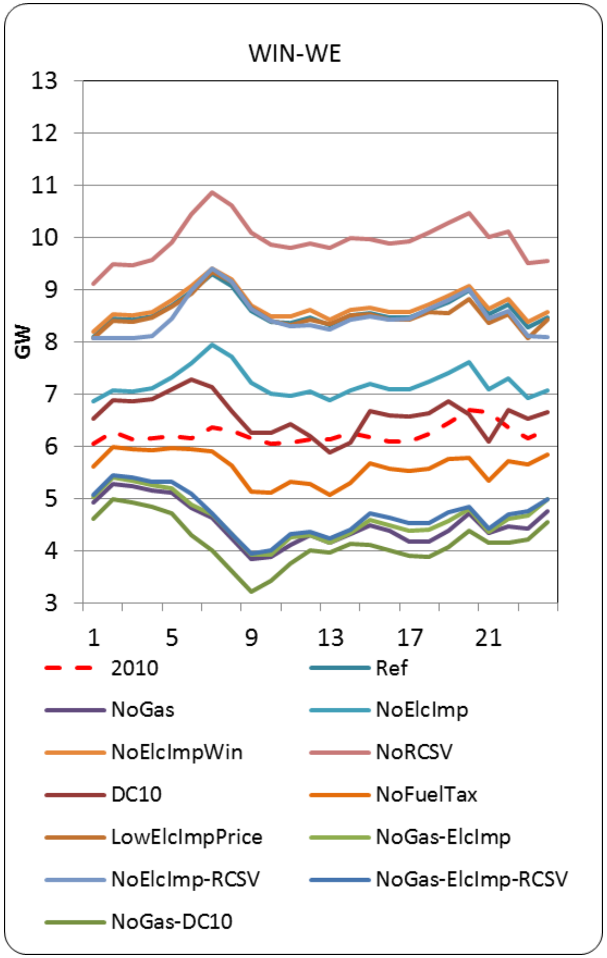


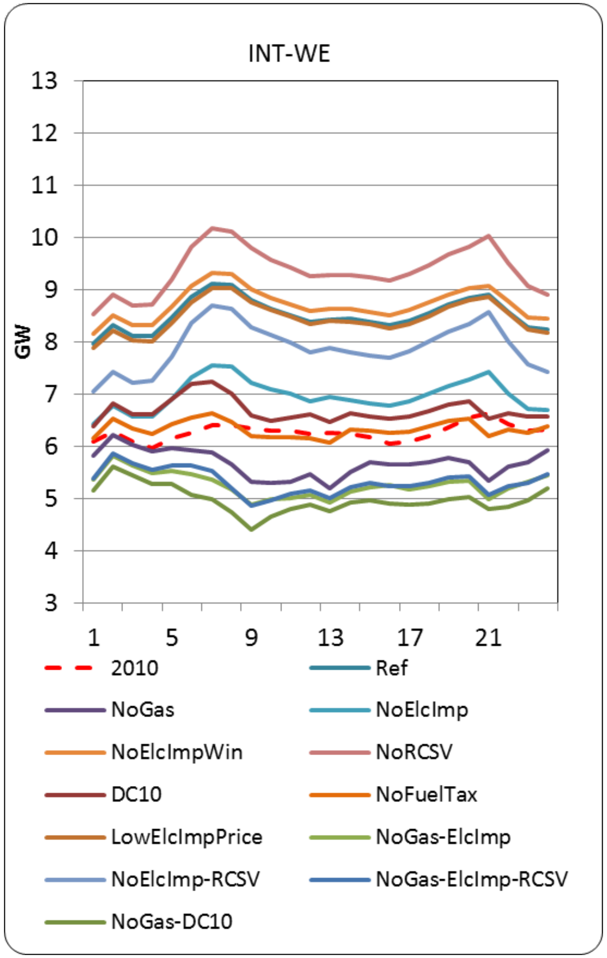


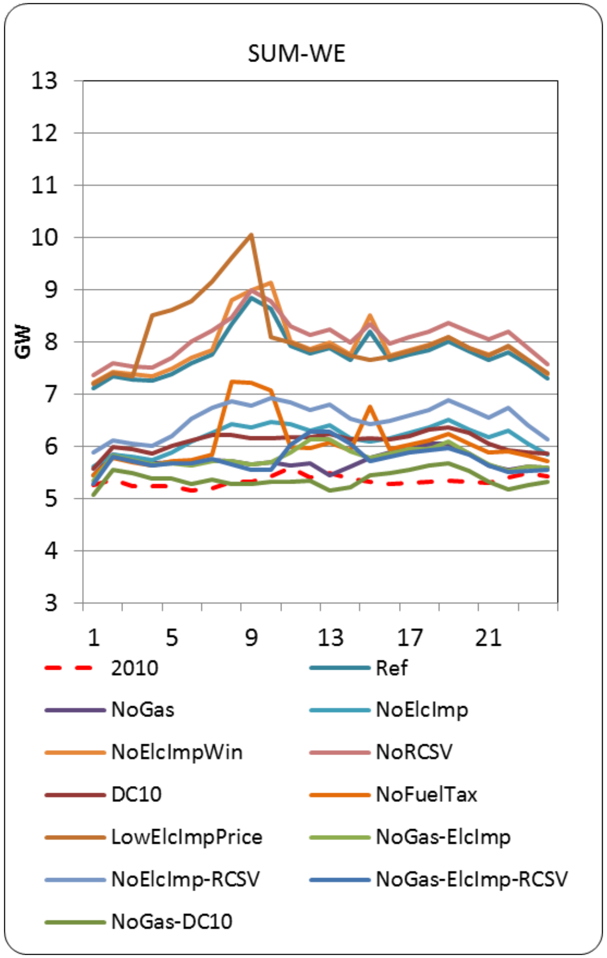


Results

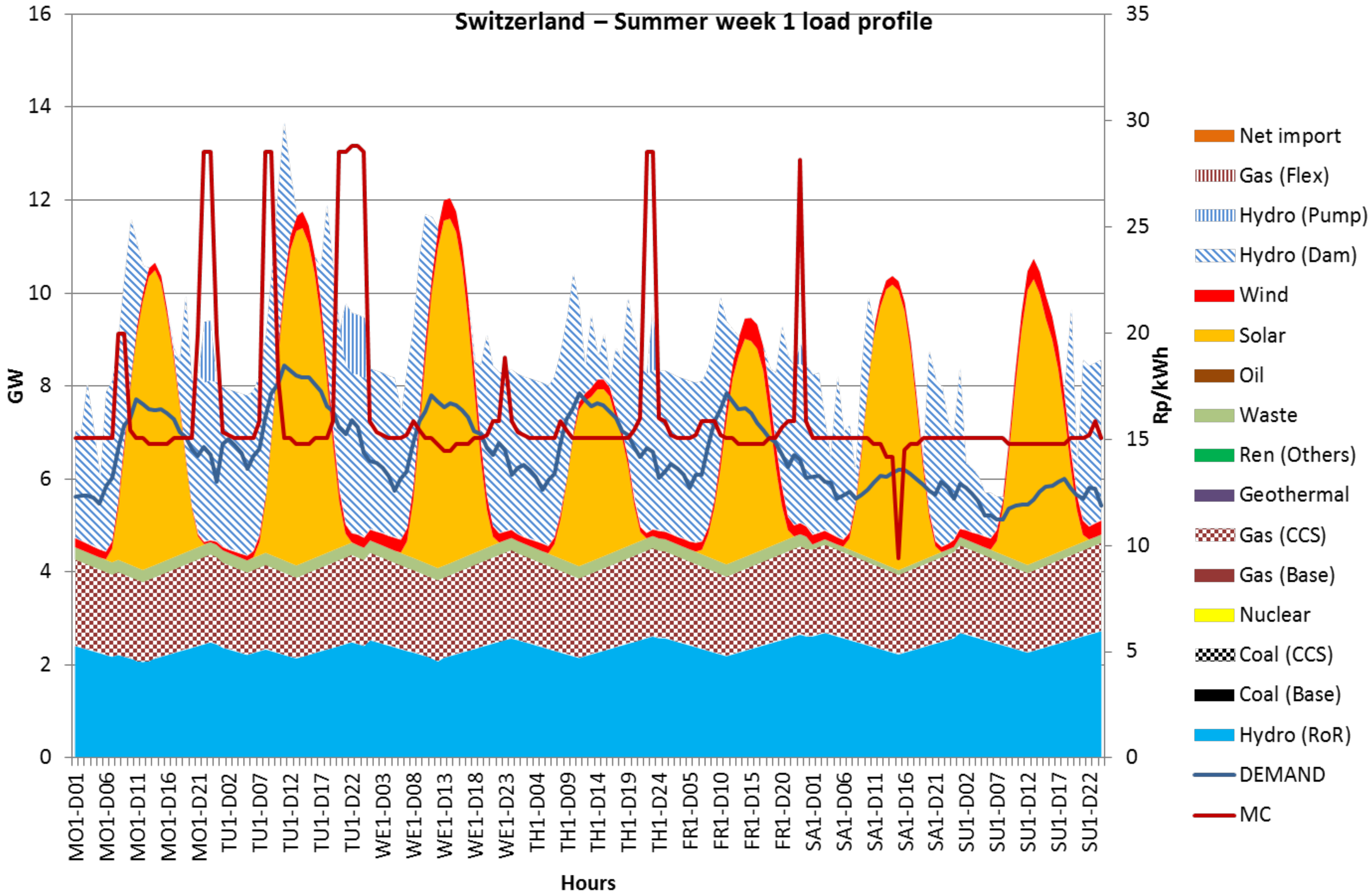
Electricity demand on weekends







Ad-hoc dispatch in TIMES - CROSSTEM Results



- One year snapshot – dispatch of three consecutive weeks (1512 timeslices)
- Fixed capacity from long term model

Source: Rajesh Pattupara, 2015

Conclusions

- Several factors drive future electricity demands – ***supply and demands are highly interdependent***
  - Certain supply-demand technologies drive the demand profile *(heating, e-mobility, cheap supply of electricity, availability of capital)*
- Electricity demand profile (MW) is ***not always linear*** to the electricity (MWh) demands
- Energy **systems model** shows dynamics on interdependency
- Swiss energy system easily cope with high variations in supply demand due to high share of flexible hydro power plants

Further references: R. Kannan, H. Turton, 2014, **Switzerland Energy Transition Scenarios – Development and Application of the Swiss TIMES Energy System Model (STEM)**, Final report to the Swiss Federal Office of Energy, Bern http://www.psi.ch/eem/stem

Open questions

Nearly impossible to have higher temporal resolution in energy systems model

- Model data availability
- Computational /solution time
- Understanding model outputs

- How can we incorporate the systems dynamics or interdependency in an electricity dispatch model or other tools?
- How do we include spatial aspect of supply-demand?
- Coupling of models are always an option
    - Difficult to maintain too many models

Thanks!

Thanks for your attention!

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