



Wir schaffen Wissen – heute für morgen

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**Alternative Low carbon electricity pathways under a  
European nuclear phase-out – Achievement of climate goals**

- Motivation – European nuclear phase-out and its consequences
- Overview of the CROSSTEM Model
- Scenarios & Key Assumptions
- Preliminary results
- Conclusions

- **Low carbon pathway for electricity** – EU Roadmap 2050
- **“Nuclear Renaissance”** – Switzerland and France to continue with its nuclear program. Italy to have 25% of net generation from nuclear by 2030. Germany to extend life times of existing plans<sup>1</sup>.
- **Fukushima Accident** – Socio-political consequences
- **Nuclear phase-out**
  - Germany by 2022
  - Switzerland by 2034
  - Italy to continue with its nuclear moratorium
  - France to reduce share from 75% to 50% by 2025 (?)

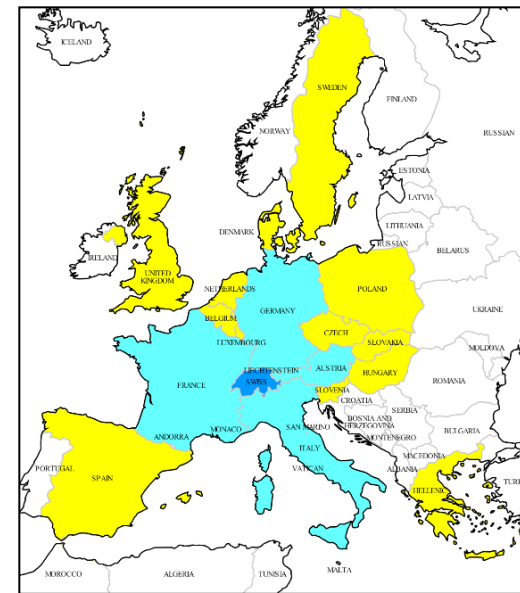
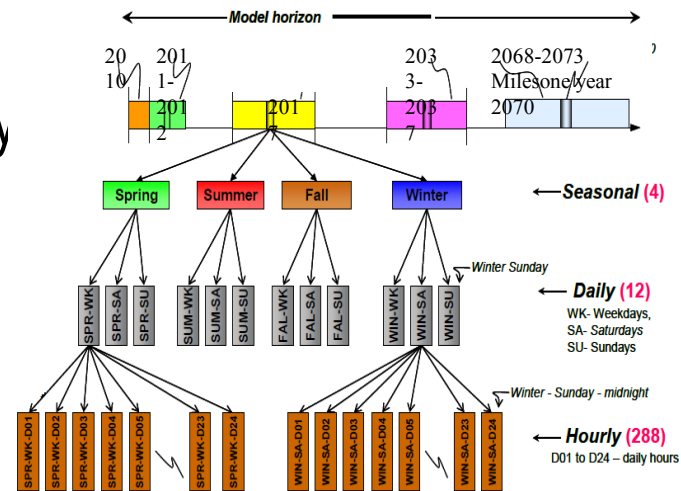
. 1. <http://www.world-nuclear.org>

- **Alternative supply options** – Germany substituting nuclear power with coal based generation → 43% (2010) to 52%(2013)
- **Green house gas (GHG) reductions** – Complete de-carbonization of power sector by 2050

## *Alternative low carbon sources of electricity*

- Technical, Economical and Social challenges and uncertainties

- **CROSs** border **Swiss TIMES Electricity Model**
- Austria (AT), France (FR), Germany (DE), Italy (IT) and Switzerland (CH).
- TIMES modelling framework – Bottom up, Perfect foresight, cost optimization framework
- Time horizon: 2010 – 2070
- An hourly timeslice (288 timeslices)
- Detailed reference electricity system with resource supply, renewable potentials and demands for 5 countries (defined exogenously)
- Calibrated for electricity demand and supply data between 2000-2010
- **Endogenous** electricity import / export based on costs and technical characteristics



- **Reference Scenario (REF)** – No specific constraints on technology choice, nor any emission targets. Existing nuclear fleet of CH, DE and FR can be replaced.
- **“No Nuclear” Policy Scenario (NoNUC)** – Nuclear policies of the 5 countries implemented. Nuclear phase-out in CH by 2034, DE by 2022, and reduction in share of nuclear in FR to 50% by 2025.
- **Climate Scenario (CLI)** – NoNUC scenario with a cap on the total CO<sub>2</sub> emission from electricity generation is applied across all regions. Level of decarbonisation to reach 60% of 1990 levels by 2030, 95% by 2050.

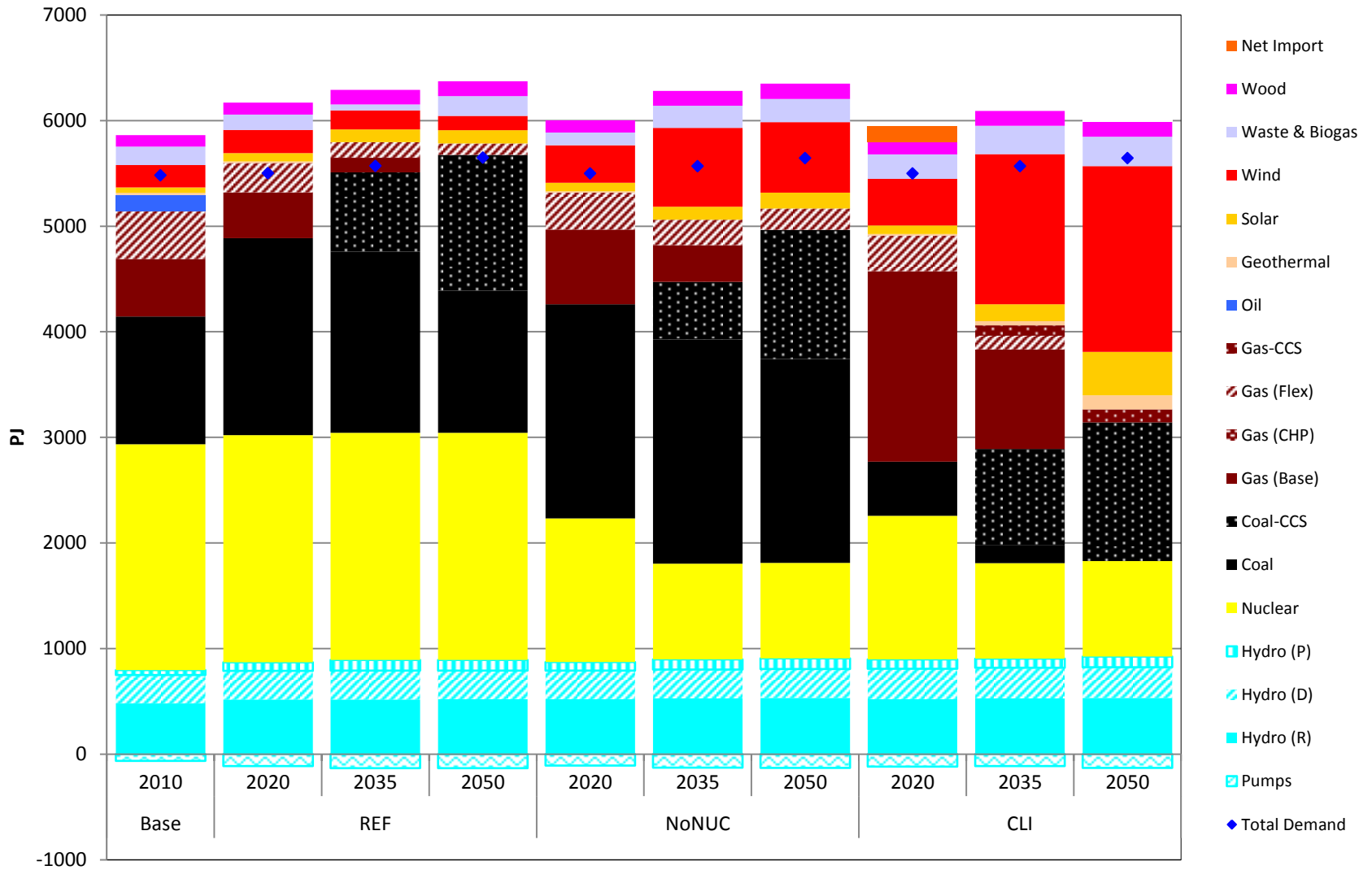
## Key Assumptions

- **Electricity Demand** – AT, DE, FR and IT demands from EU Trends to 2050 (Reference scenario). CH demands from BAU scenarios in the Swiss Energy Strategy 2050.
- **Trade with “fringe regions”** – Historical limits applied
- **CO2 price** – European ETS prices implemented (SES 2050, Bfe)
- **Fuel Prices** – International fuel prices from WEO 2010.
- **Copper Plate regions** – No transmission and distribution infrastructure within each country. Interconnectors between regions, with no trade loss.
- **Endogenous trade limits** – Based on historical trends. Net importers cannot become net exporters and vice versa. Not applied to CLI

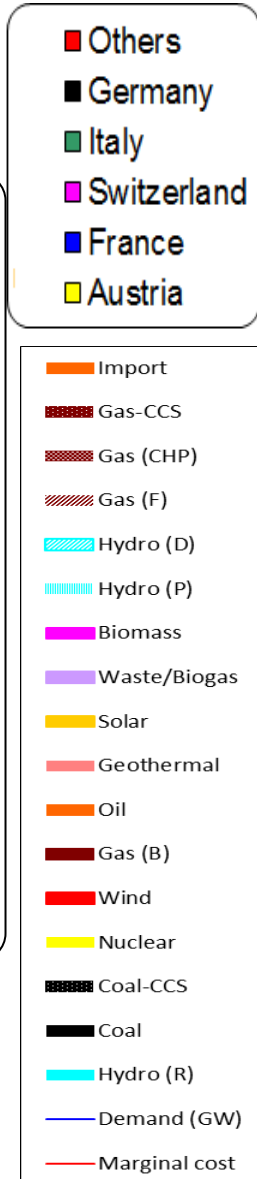
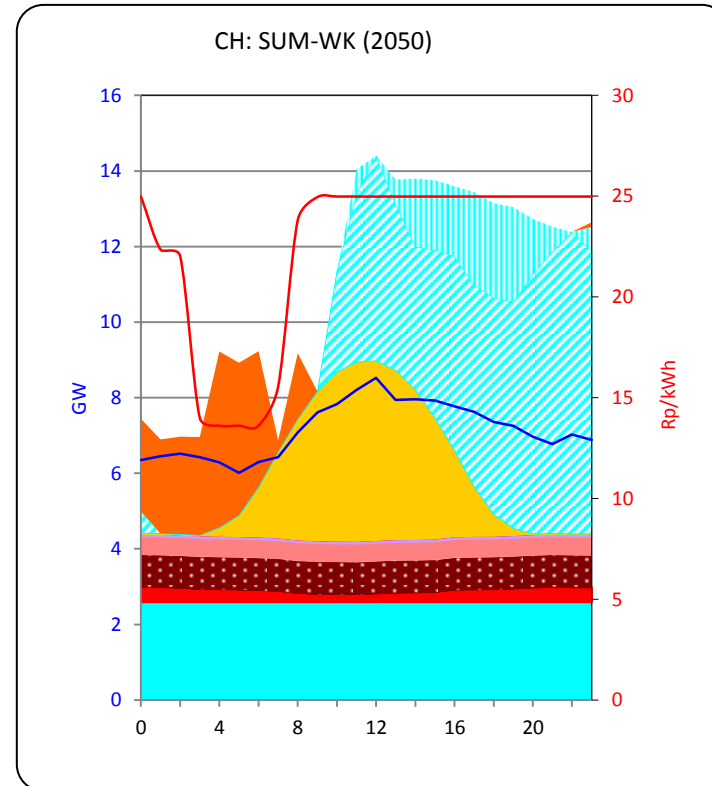
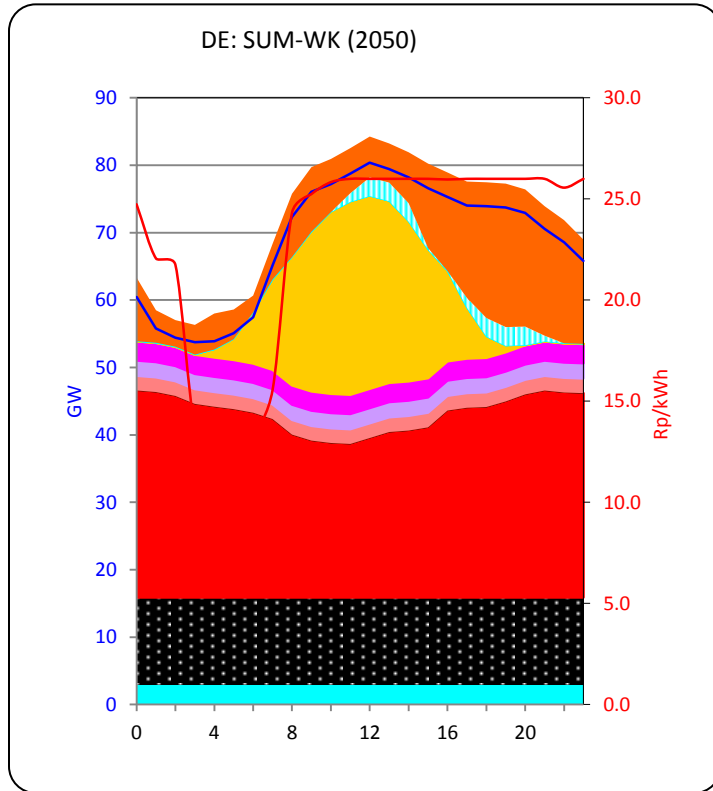


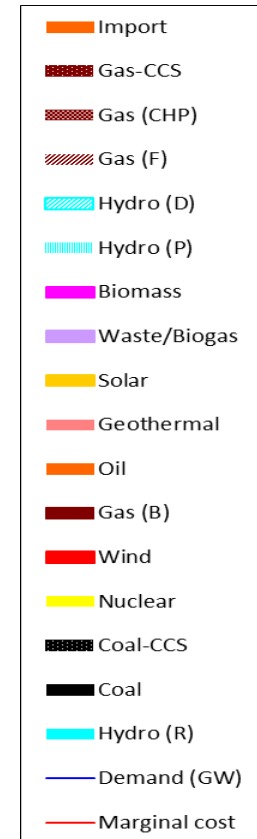
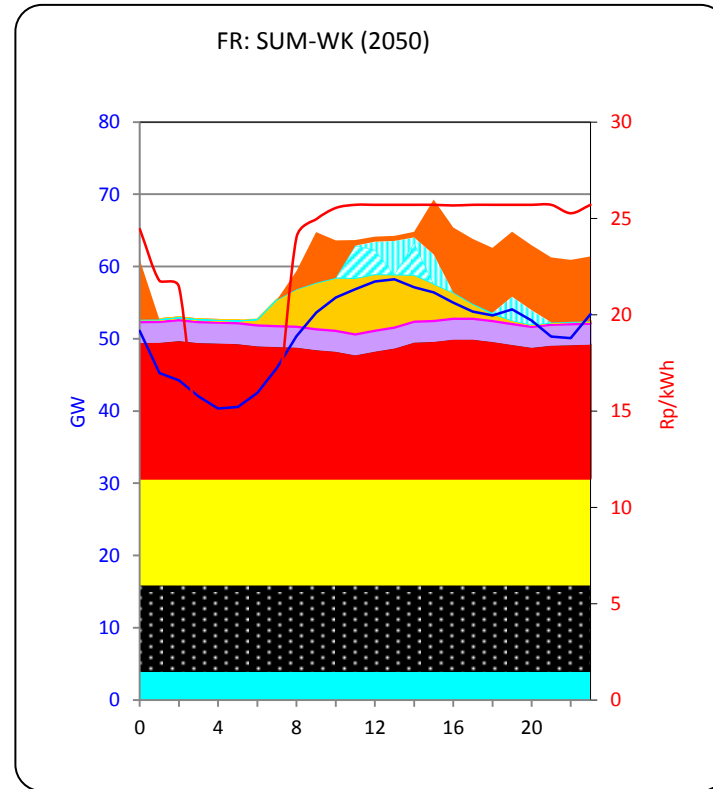
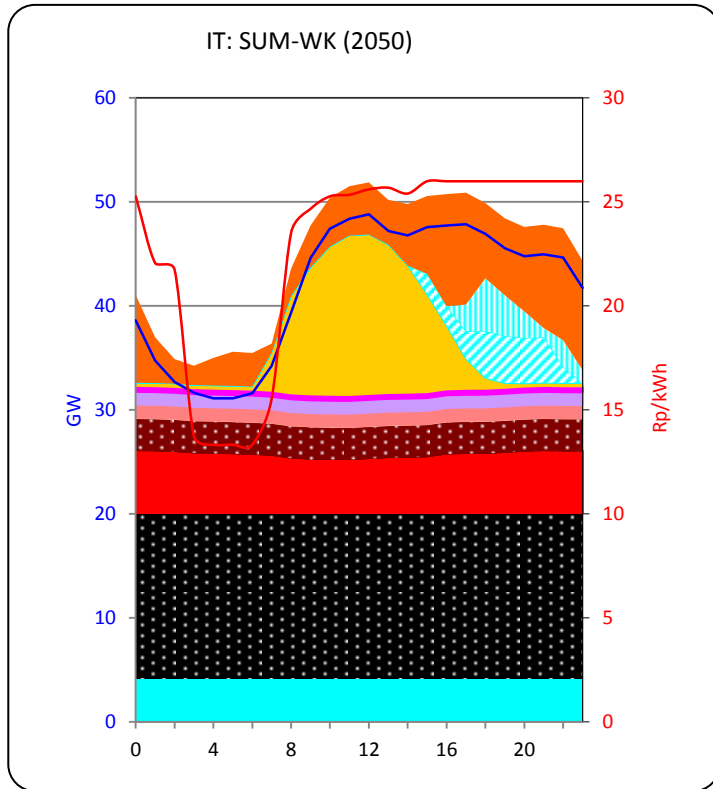


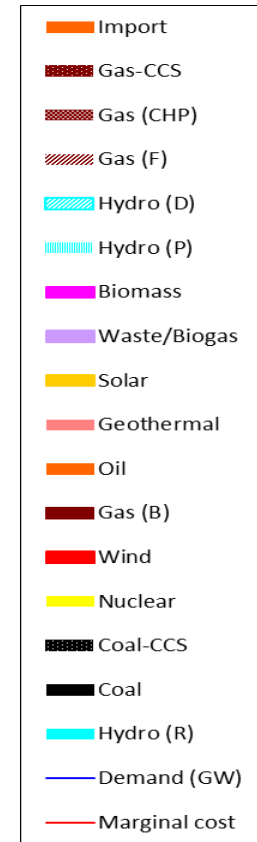
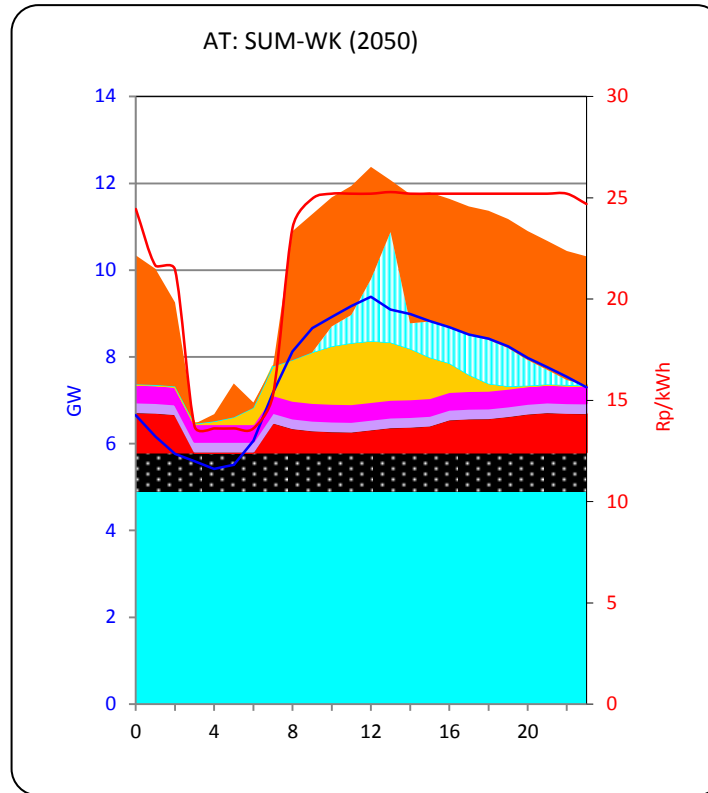
## Electricity generation mix – 5 countries aggregated



## CLI – Summer Weekday - 2050

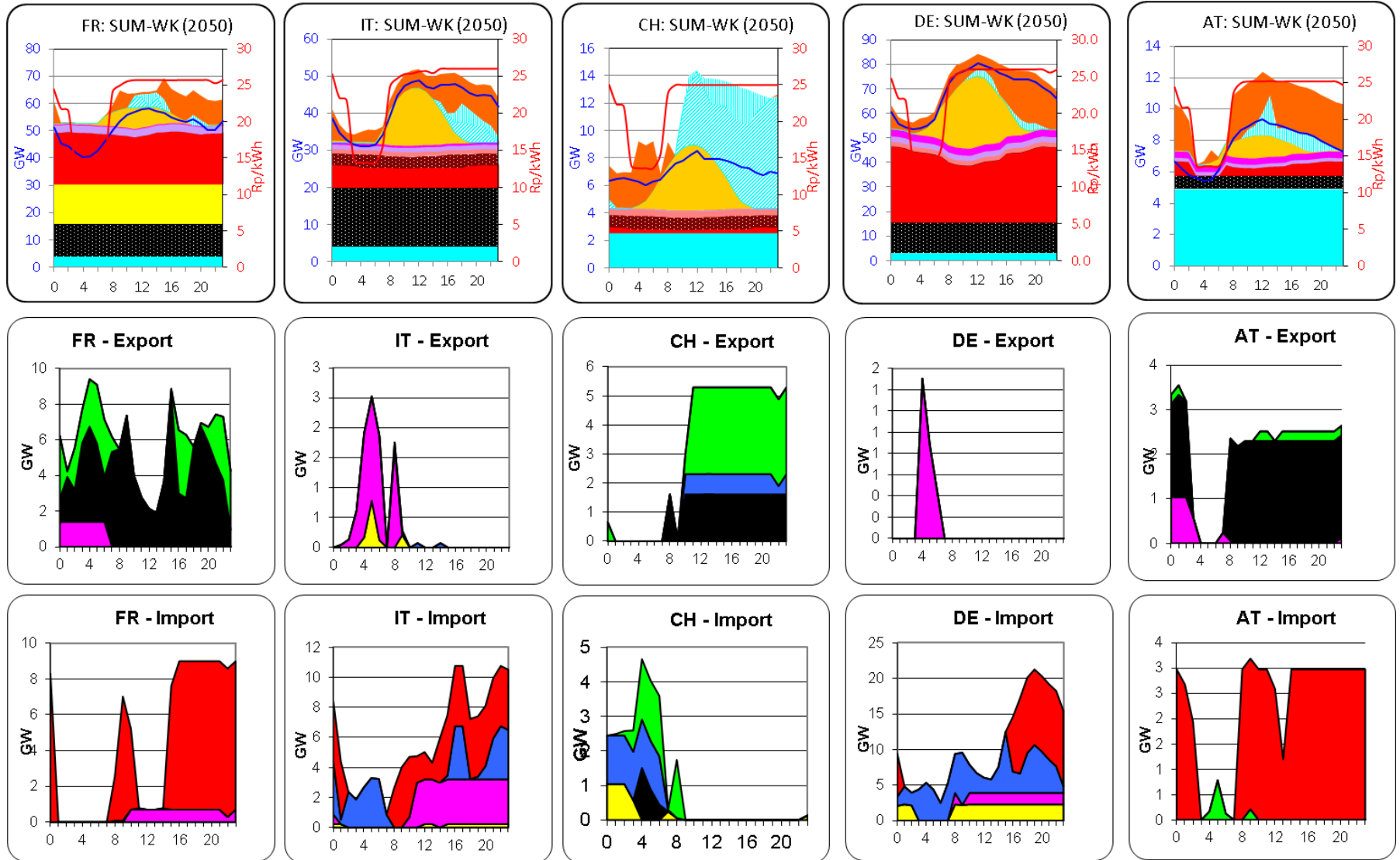




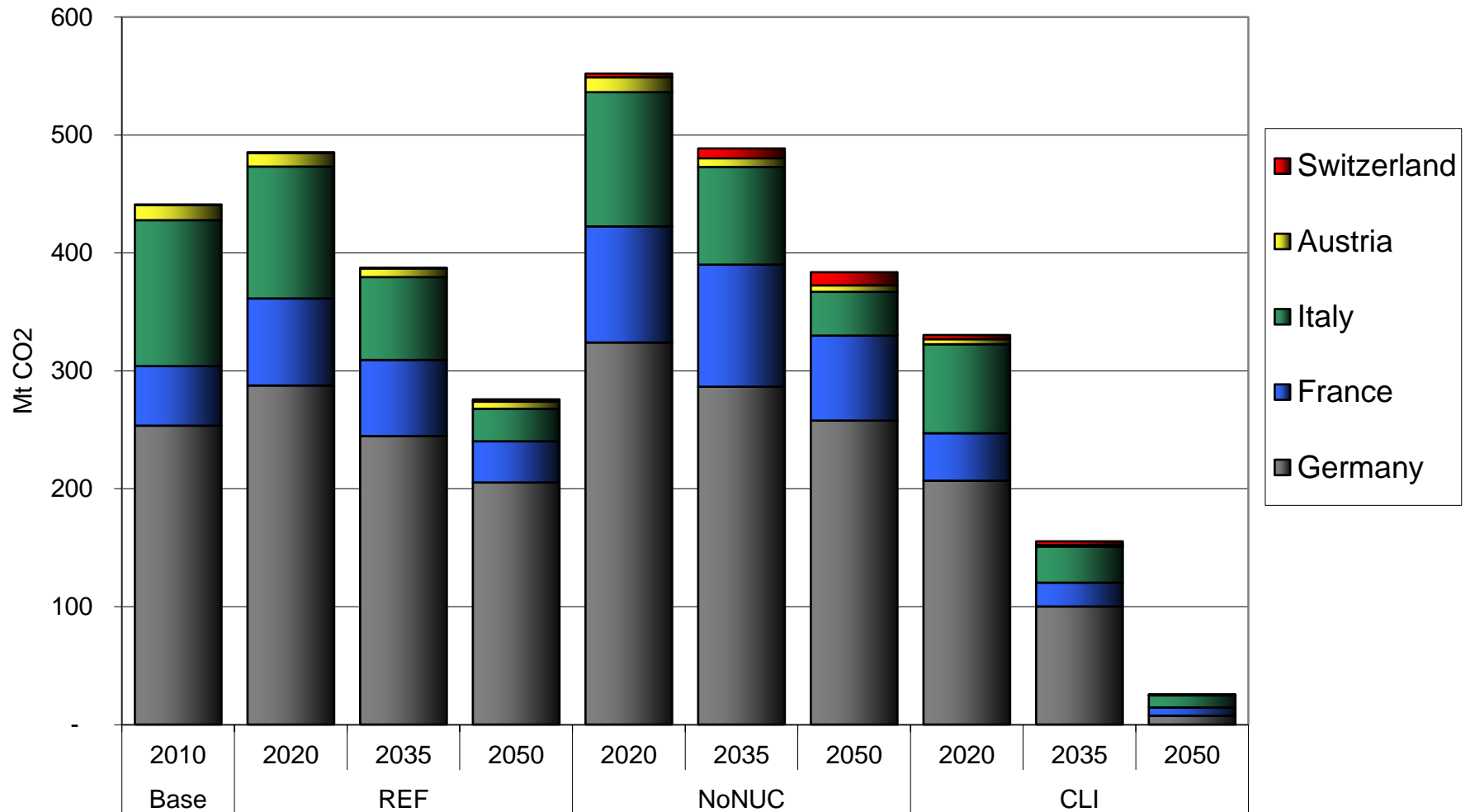


# Load Curves – CLI - Summer Weekday 2050

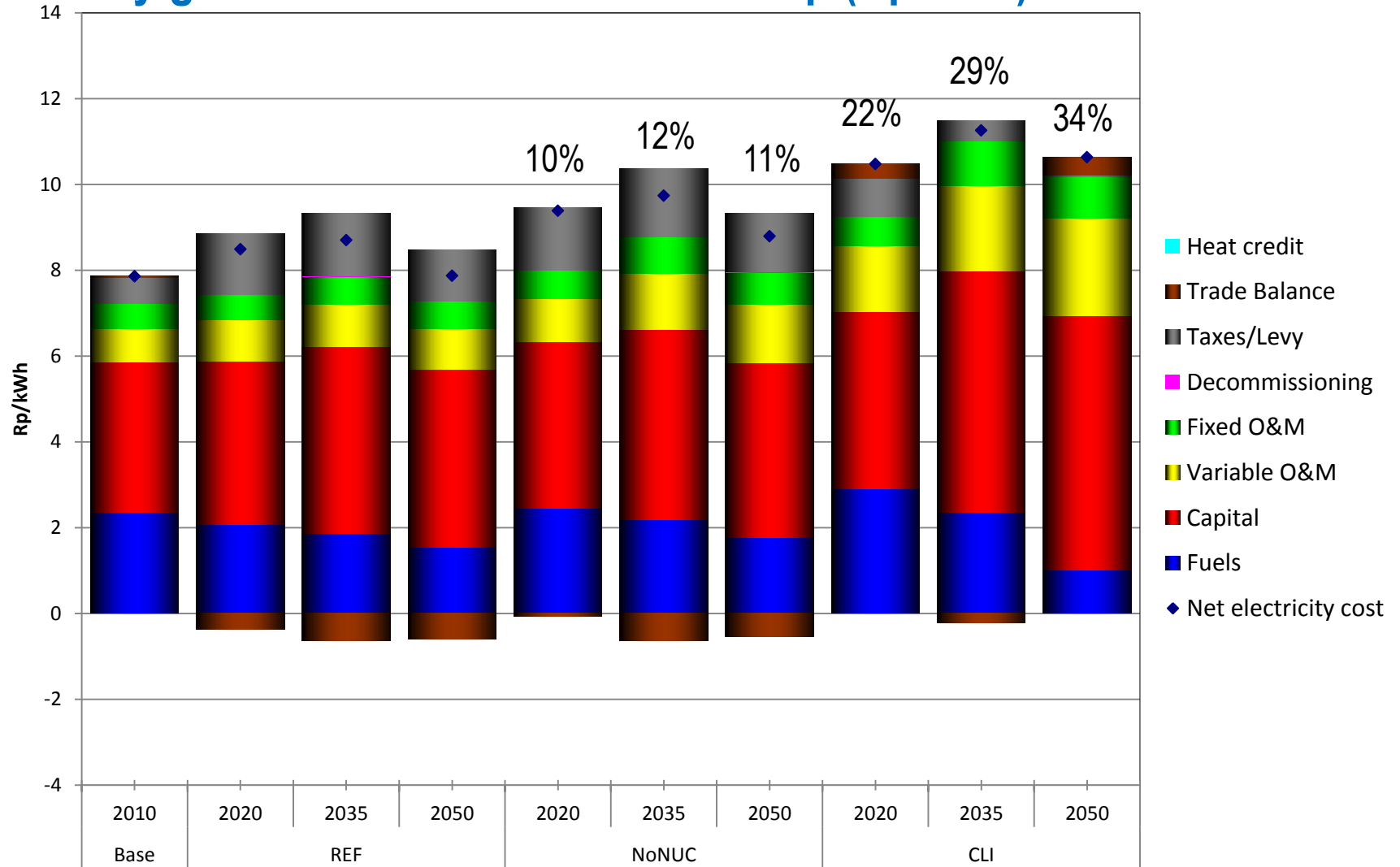
■ Austria   
 ■ France   
 ■ Switzerland   
 ■ Germany   
 ■ Italy   
 ■ Others



## CO<sub>2</sub> emissions – Regional disaggregation



## Electricity generation costs – Cost breakup (Rp/kWh)





## Limitations & Uncertainties

- CROSSTEM is not a pure dispatch model.
- Modelling of representative days – Overall simplifications
- T&D infrastructure not explicitly modelled.
- Trade with fringe regions
- Model assumes perfect information, perfect foresight, well functioning markets and economically rational decisions – Optimal solution for 5 countries together, not for each country

- Model of the electricity system of Switzerland and its neighbouring countries over a long term horizon combined with dispatch aspect completed.
- A range of alternative low carbon electricity generation pathways for the five countries has been explored.
- Decarbonisation of the power sector is plausible, but significant investments necessary, along-with higher market liberalisation → market coupling
- Early uptake of renewables & deployment of CCS technology vital to achieve stringent CO<sub>2</sub> emissions reduction targets.
- More sensitivities required to analyse impacts of fringe region trade, trade limit, CCS potentials, renewable potentials

Thank you for your attention !!!



# Energy Economics Group

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