PAUL SCHERRER INSTITUT

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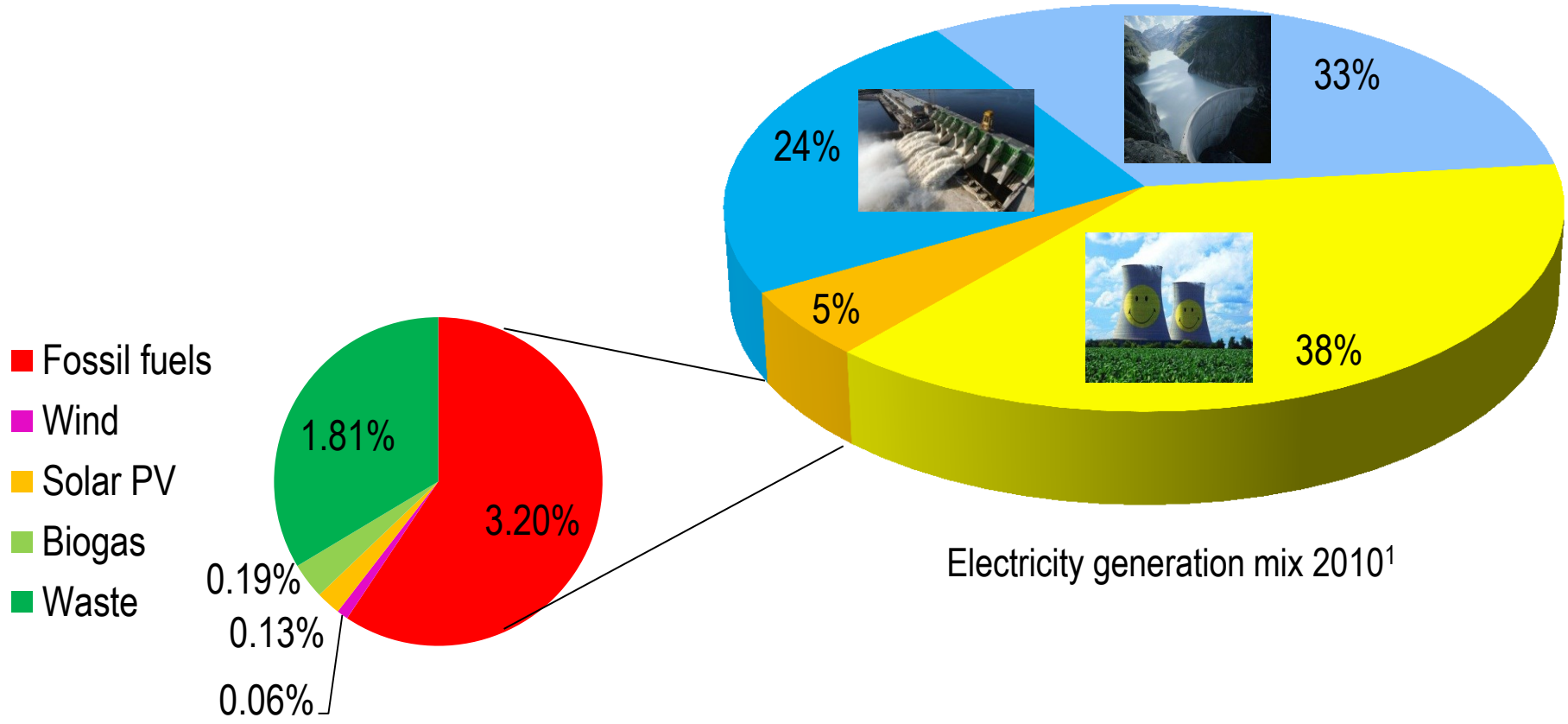
Influence of long term electricity sector developments in Europe on the Swiss electricity system: Risks and opportunities for electricity trading

Outline

- Introduction
- Objectives
- CROSSTEM model
- Scenarios
- Preliminary results
- Issues and Challenges
- Outlook

Introduction

- Electricity accounts for one quarter of Swiss energy demand
- Large differences in seasonal output, seasonal demand.
- Creates seasonal dependence on electricity import.



Electricity generation mix 2010[1]

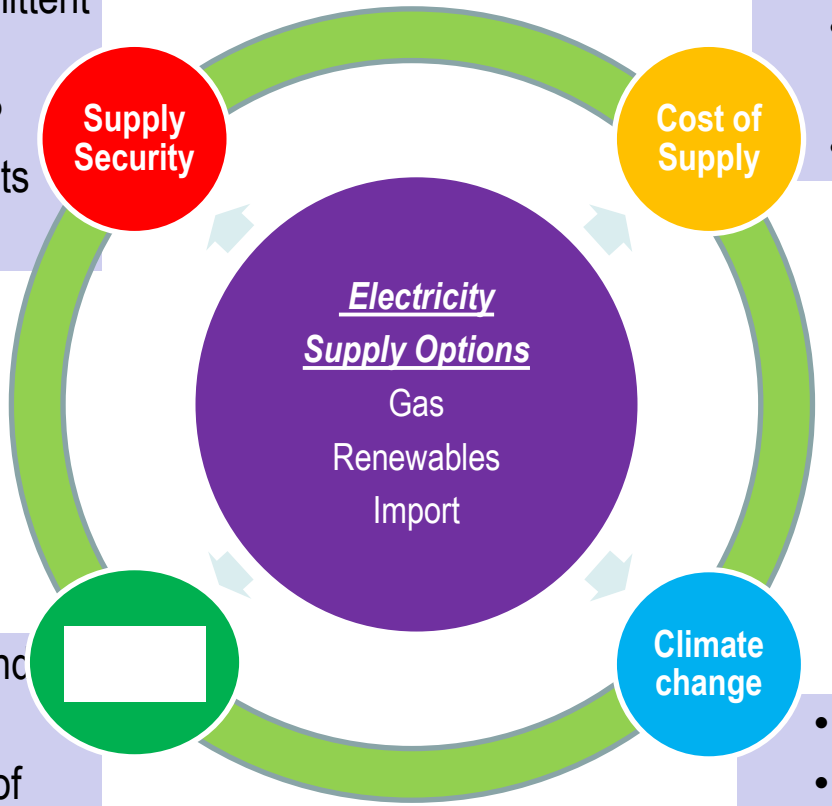
1. "Zukunft Stromversorgung Schweiz", Swiss Academy of Art and Sciences, 2012

Future of Electricity sector

- Nuclear phase out – No replacement of existing Nuclear power plants at the end of their lifetime. Last power plant off grid by 2034.
- The Swiss Energy Strategy (SES) 2050
- Uncertainty regarding future supply options – A combination of gas based generation, renewables and electricity imports are mentioned.

Future of Electricity sector – Tradeoffs

Developments in Europe
- Integration of intermittent Renewables
- Nuclear phase-out?
- CO_2 emission targets
- Gas imports



- Cost implications of renewable / low carbon policy
- Revenue from trade

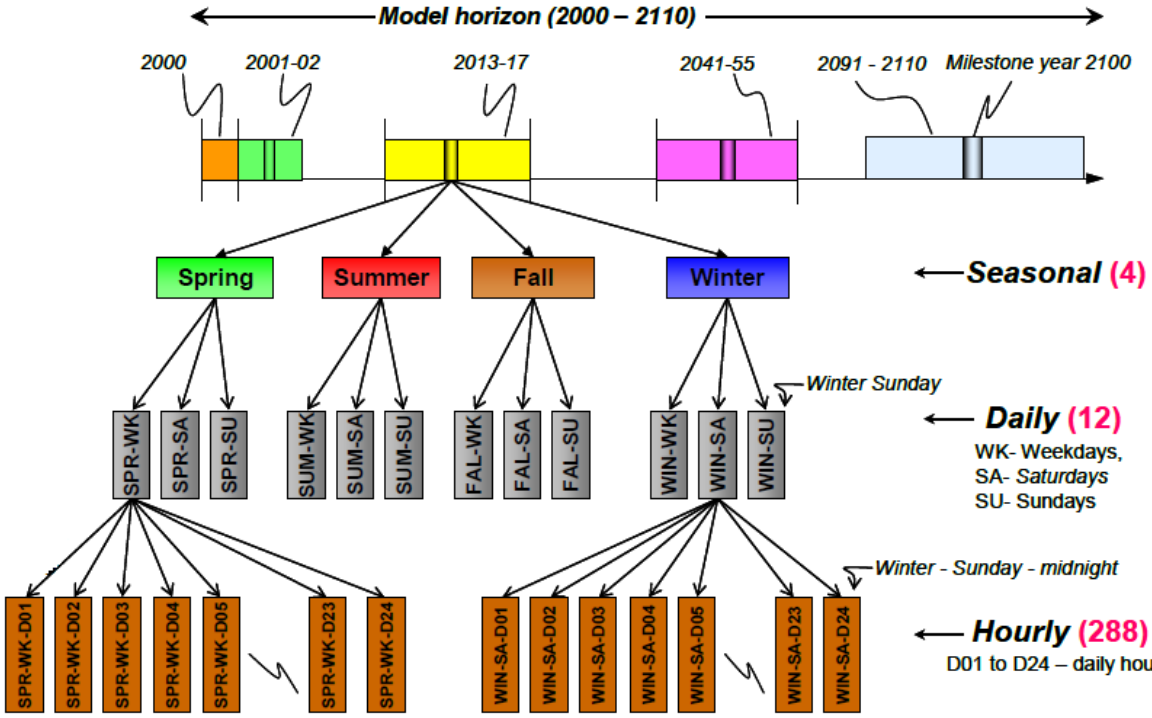
- Balancing supply and demand
- Intermittent nature of renewables
- Electricity imports

- CO2 emission targets
- Expansion of Gas plants

STEM-E – Swiss TIMES Electricity Model

Model Features

- Single region model
- Time horizon: 2000 – 2100 in 18 time periods
- An hourly timeslice (288 timeslices)
- Charac … nergy and emissi…



Key Para…

- Exoge…
- Range
- Electri…

R Kannan & H. … ***electricity model***

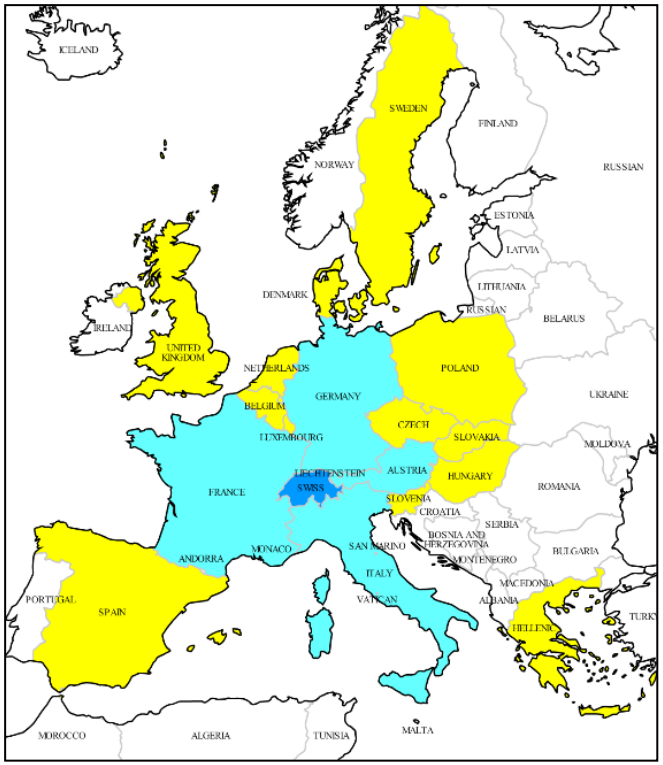
Available at http://energyeconomics.web.psi.ch/Publications/Other_Reports/PSI-Bericht%2011-03.pdf

Objectives

- Analyse developments in the neighbouring countries – Germany (DE), Austria (AT), France (FR) and Italy (IT)
- Quantify the extent to which these developments affect the Swiss electricity sector
- Can Switzerland depend on imported electricity ?

CROSSTEM Model

- **CROS**s border **S**wiss **T**IMES **E**lectricity **M**odel
- Extension of the STEM-E model to include the four neighbouring countries
- Time horizon: 2000 – 2050 in 14 unequal time periods
- An hourly timeslice (288 timeslices)
- Detailed reference electricity system with resource supply, renewable potentials and demands for 5 countries
- Calibrated for electricity demand and supply data between 2000-2010
- Endogenous electricity import / export based on costs and technical characteristics



3 Scenarios selected for Analysis

- ***Base (BASE)*** – No specific constraints on technology choice, nor any emission targets, Swiss BAU CO2 tax applied,

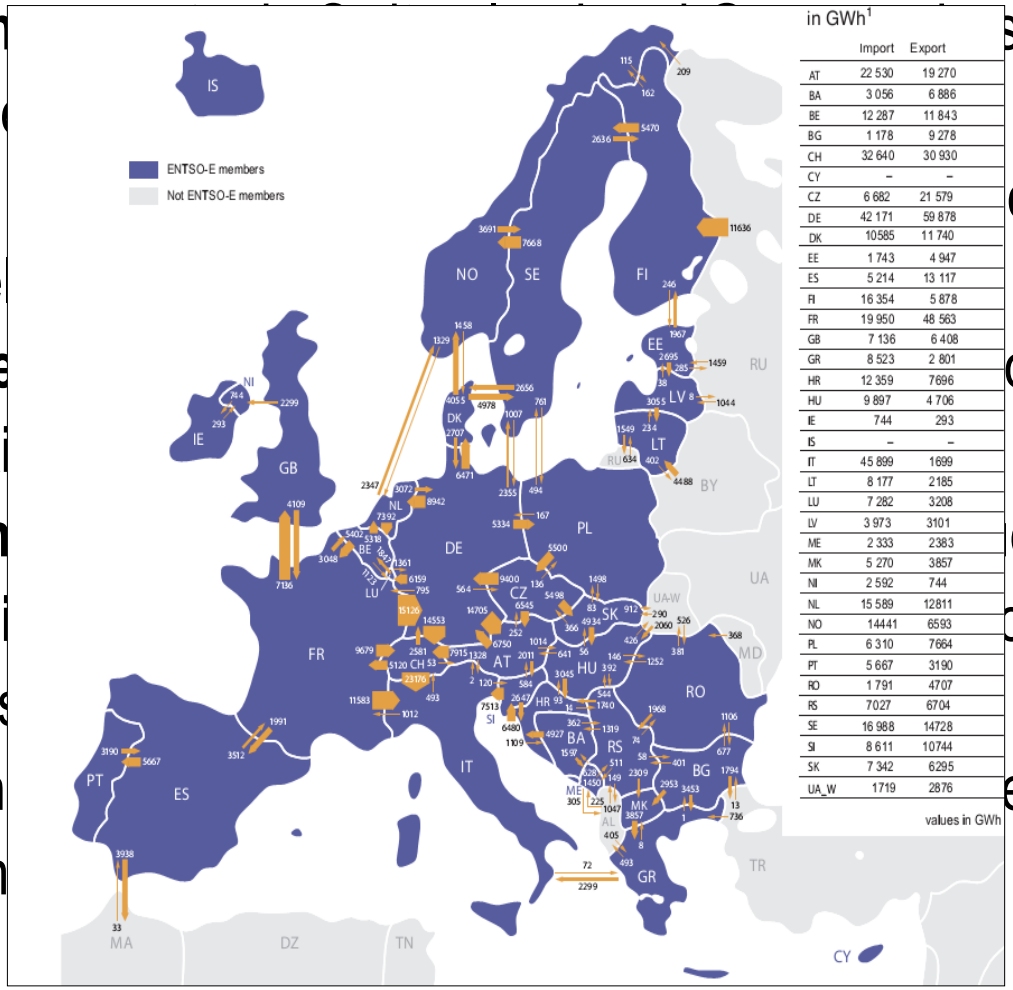
- ***Low Carbon (LC)*** – A cap on the total CO_2 emission from electricity generation is applied across all regions. Level of decarbonisation to reach 60% of 1990 levels by 2030, 98% by 2050[1].

- ***Renewable Scenario (REN)*** – A minimum of 20% of the CROSSTEM demand is to be met by renewable sources by 2020[2], 40% by 2050.
  - Excluding hydro !

2. EU Roadmap 2050 - http://ec.europa.eu/energy/energy2020/roadmap/doc/com_2011_8852_en.pdf

Key assumptions

- **Nuclear ph** …s been assumed. Only Franc…
- **Electricity** …dynamic recursive CGE model…
- **Renewable** …ordance with various nati…
- **CCS poten** …dies
- **Self Suffici** …or future years for all countries…
- **Trade with** …enabled, then historical m…



in GWh[1]

	Import	Export
AT	22 530	19 270
BA	3 056	6 886
BE	12 287	11 843
BG	1 178	9 278
CH	32 640	30 930
CY	–	–
CZ	6 682	21 579
DE	42 171	59 878
DK	10585	11 740
EE	1 743	4 947
ES	5 214	13 117
FI	16 354	5 878
FR	19 950	48 563
GB	7 136	6 408
GR	8 523	2 801
HR	12 359	7696
HU	9 897	4 706
IE	744	293
IS	–	–
IT	45 899	1699
LT	8 177	2185
LU	7 282	3208
LV	3 973	3101
ME	2 333	2383
MK	5 270	3857
NI	2 592	744
NL	15 589	12811
NO	14441	6593
PL	6 310	7664
PT	5 667	3190
RO	1 791	4707
RS	7027	6704
SE	16 988	14728
SI	8 611	10744
SK	7 342	6295
UA_W	1719	2876

3. Bernard and Vielle 2003, 2008 – *A General Equilibrium Model of International – National Interactions between Economy, Energy and the Environment,* Marc Vielle – Personal Communication

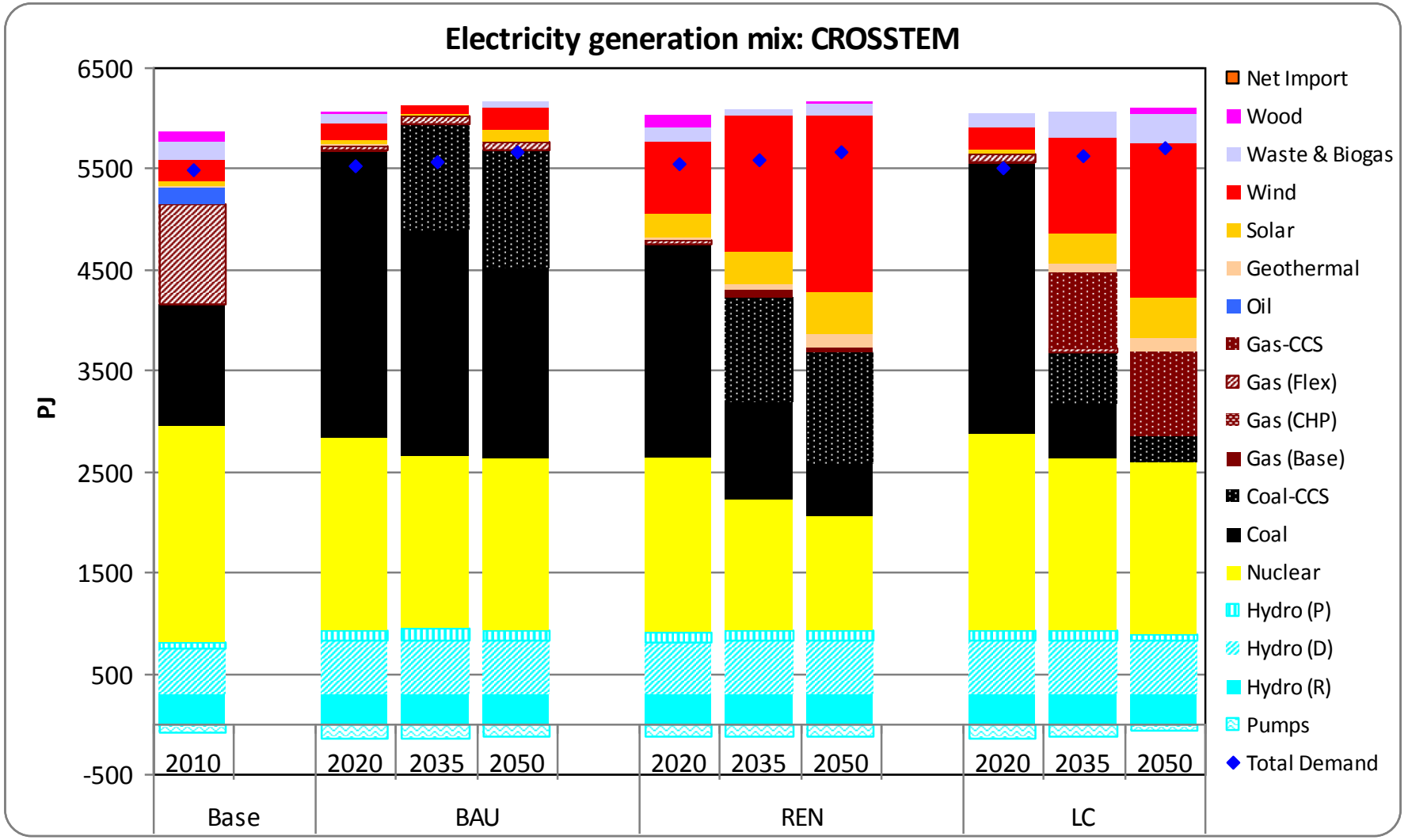
4. NREAP - http://ec.europa.eu/energy/renewables/action_plan_en.htm

Key assumptions

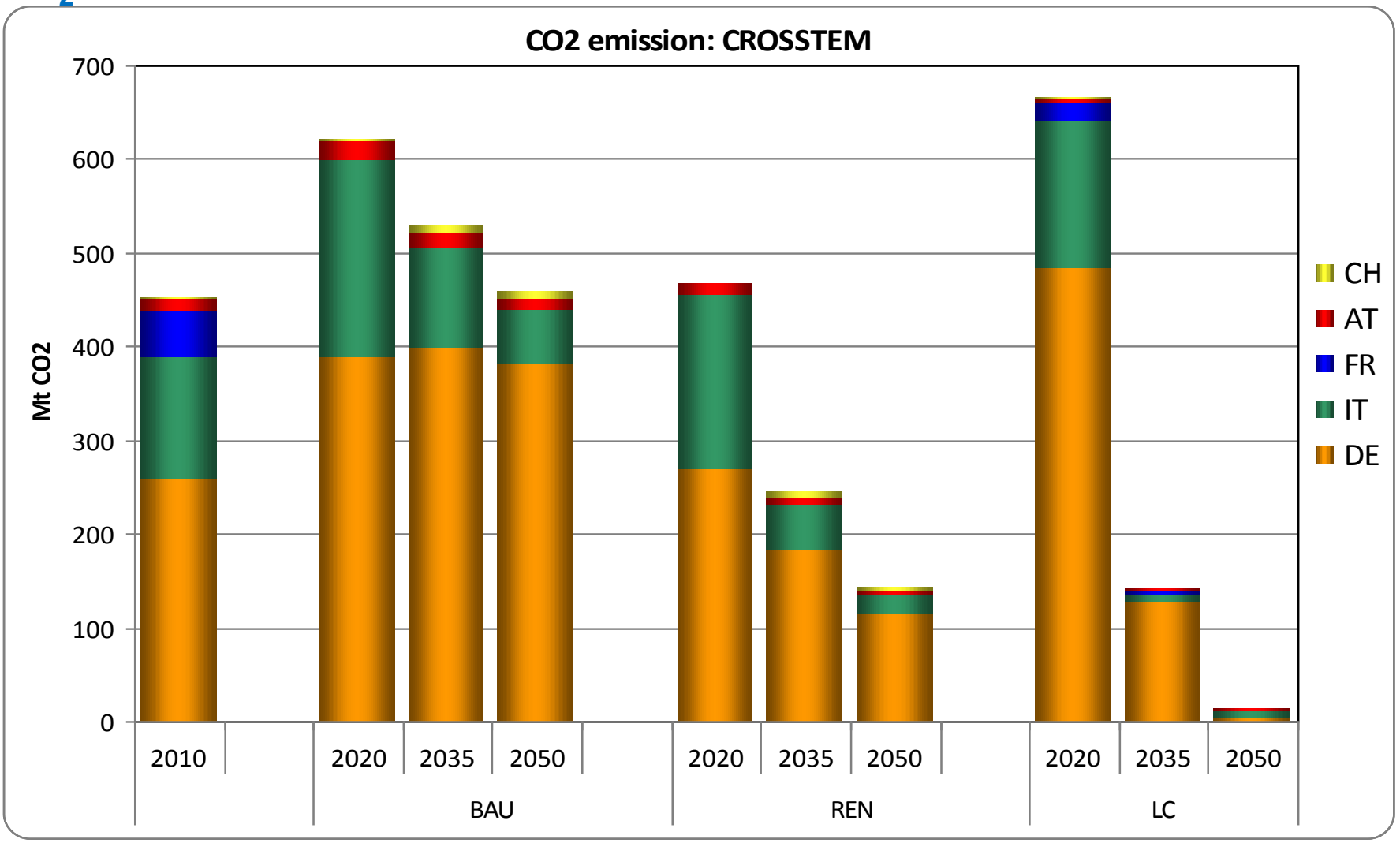
- **CO2 price** – Swiss BAU CO2 tax[5] applied in all regions.
- **Fuel Prices** – Universal fuel prices from WEO 2010[6].
- **No trade loss** – In endogenous and exogenous trade, no trade loss assumed.
- **Copper Plate regions** – No transmission lines, nor transmission costs, only interconnectors between regions

5. BFE (2012b) Energieperspektiven für die Schweiz bis 2050. Energienachfrage und Elektrizitätsangebot in der Schweiz 2000 – 2050.
6. WEO - http://www.iea.org/publications/freepublications/publication/weo2010.pdf

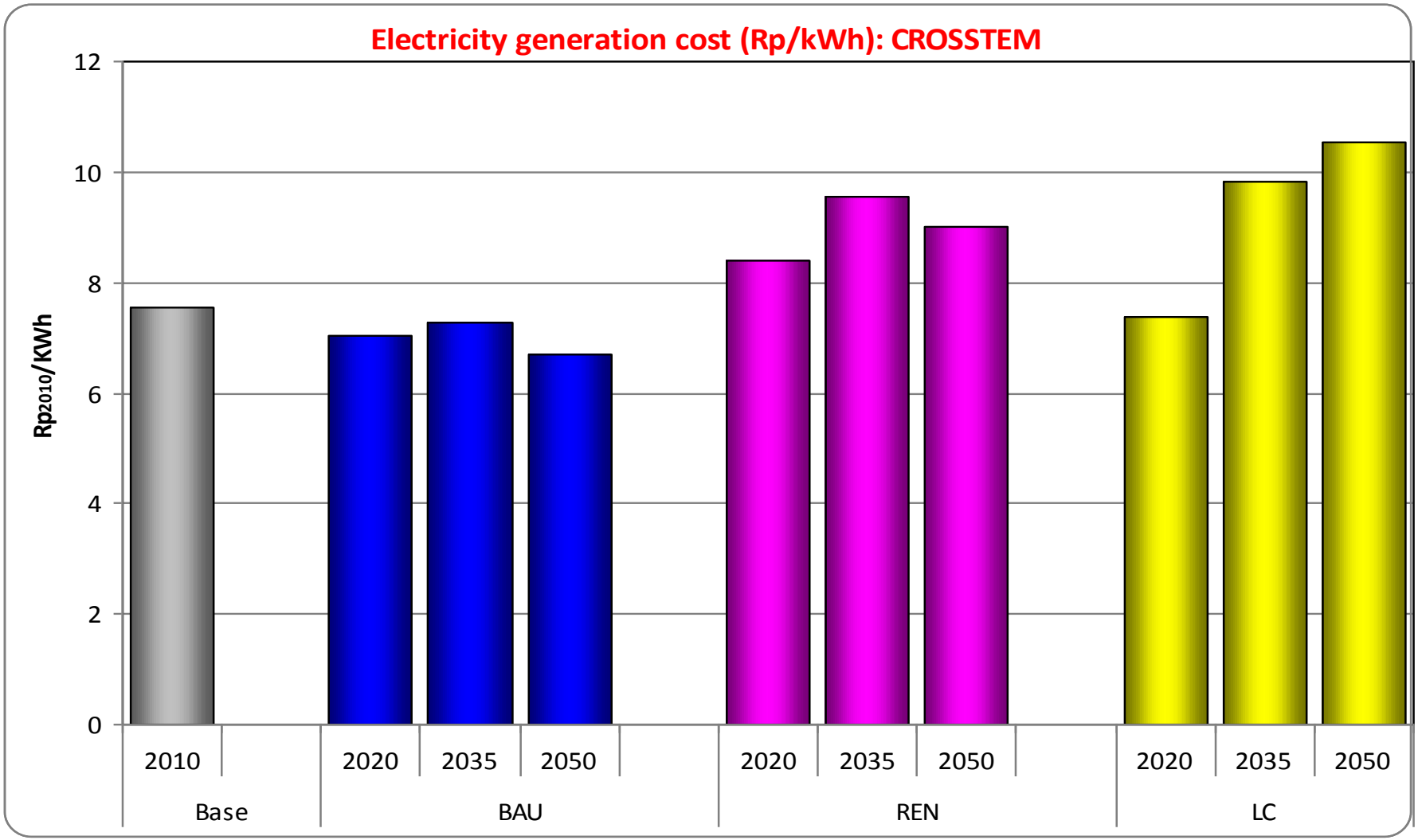
Electricity generation mix – 5 countries



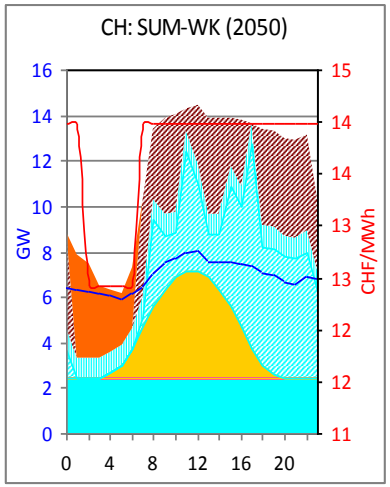
CO_2 emissions – 5 countries

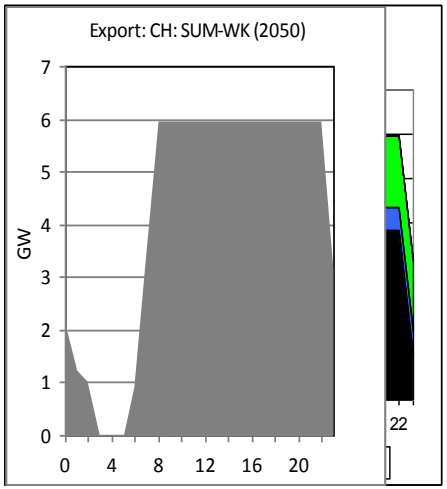


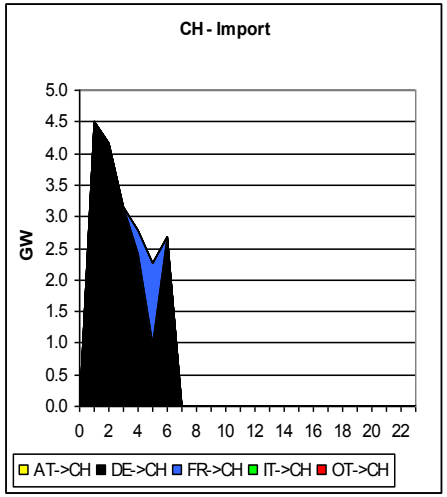
Electricity generation costs (Rp/kWh)

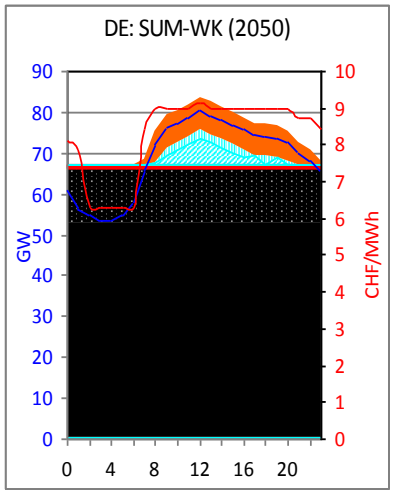


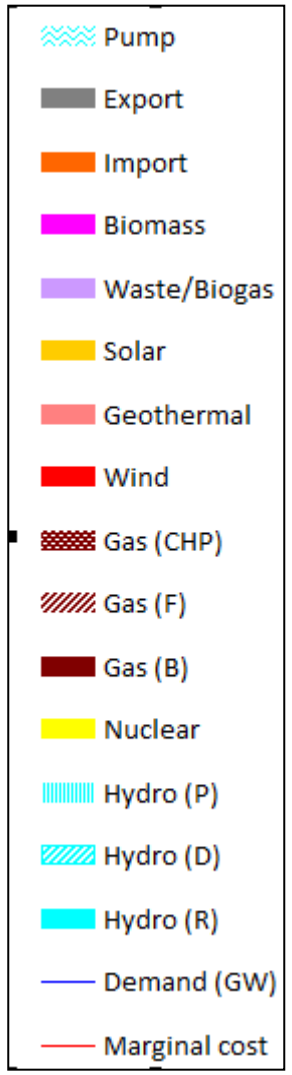
BASE – Summer Weekday - 2050











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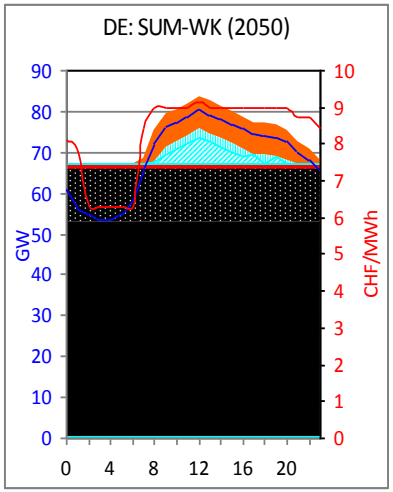
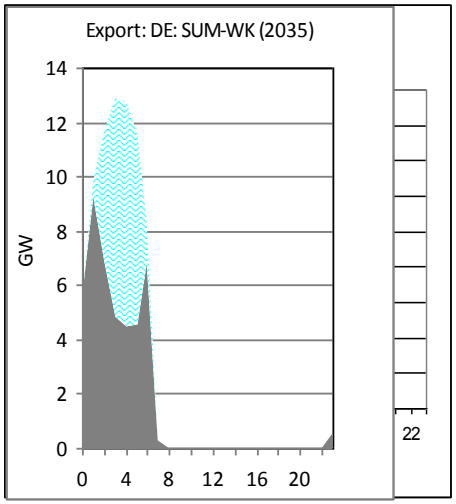
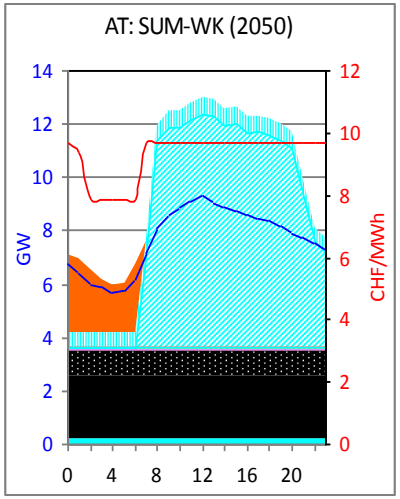
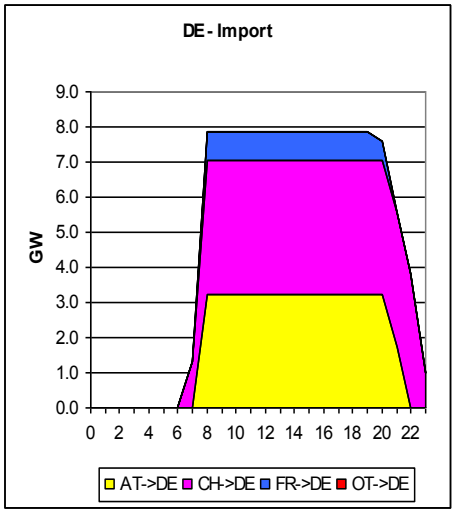
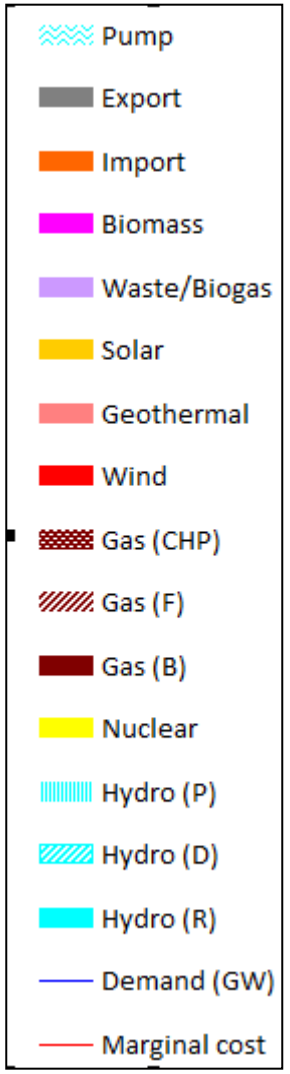




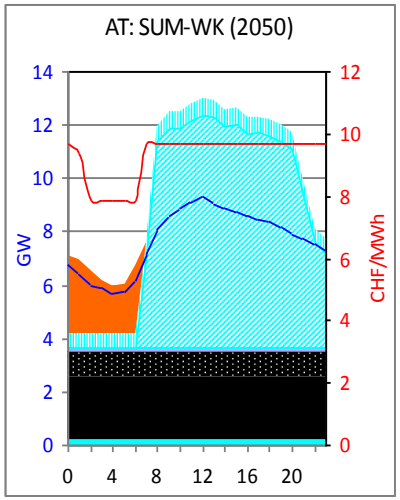


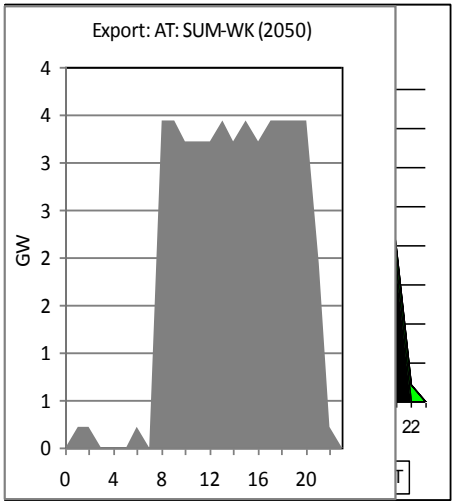


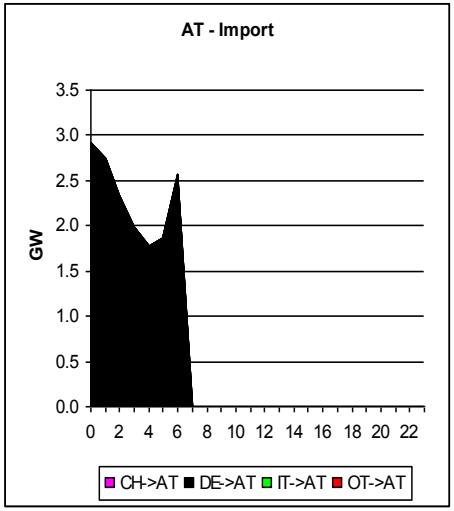


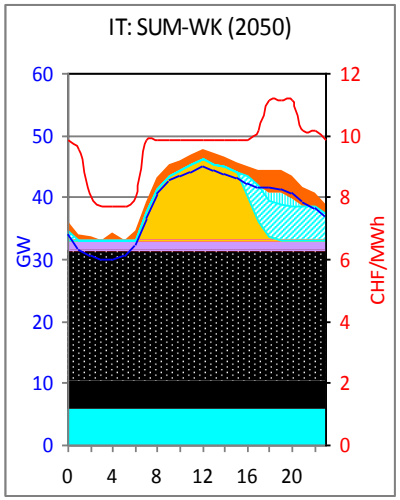
Load Curves

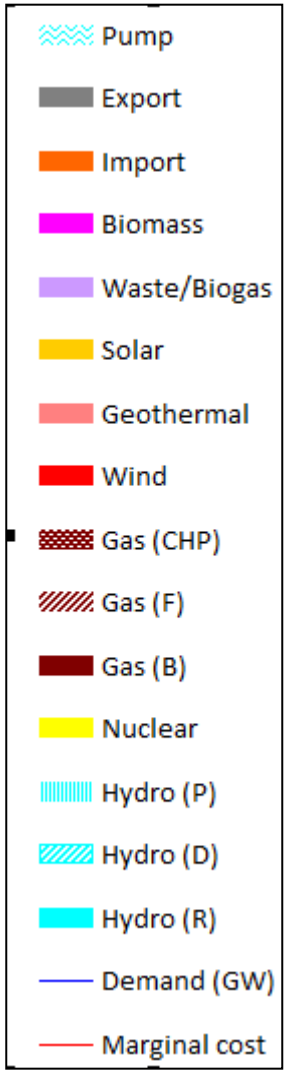
BASE – Summer Weekday - 2050











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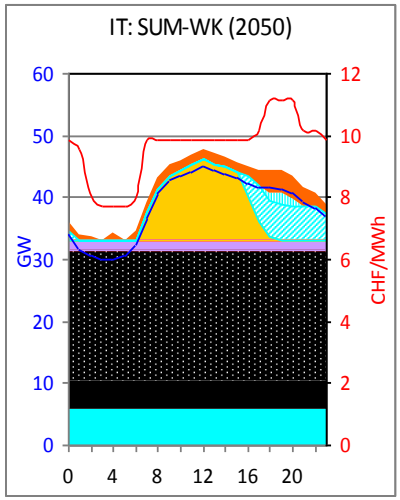
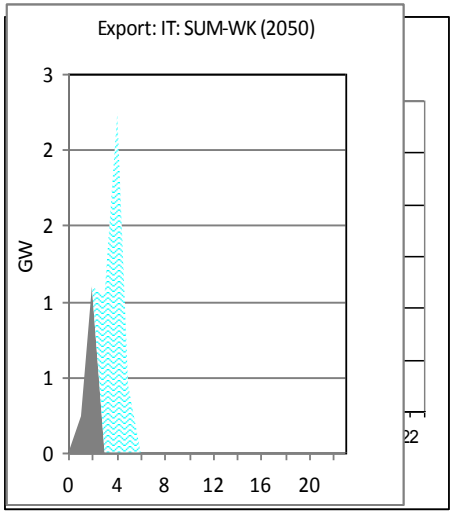
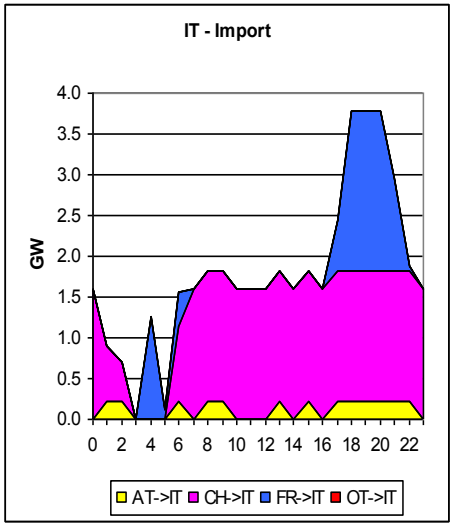
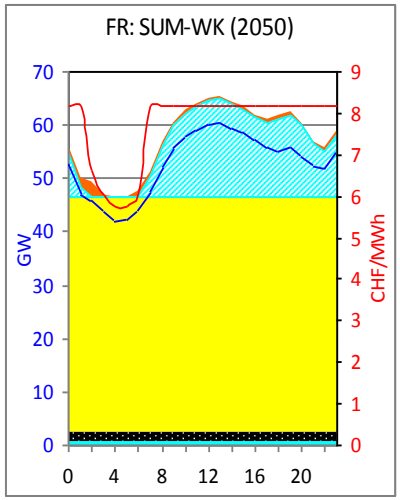
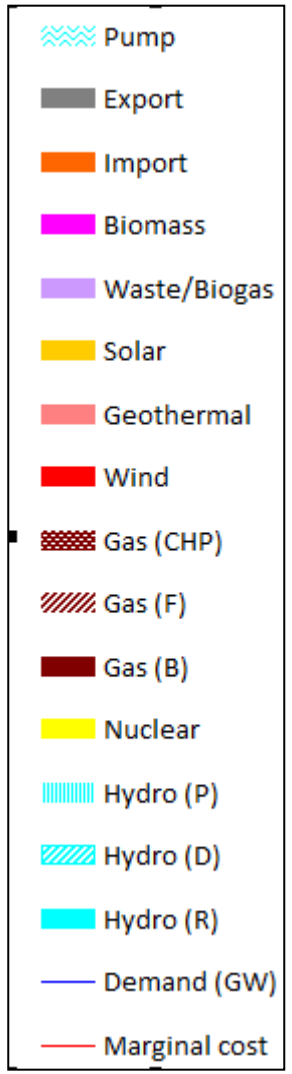




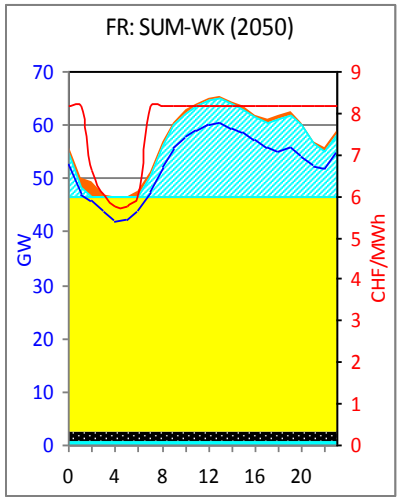


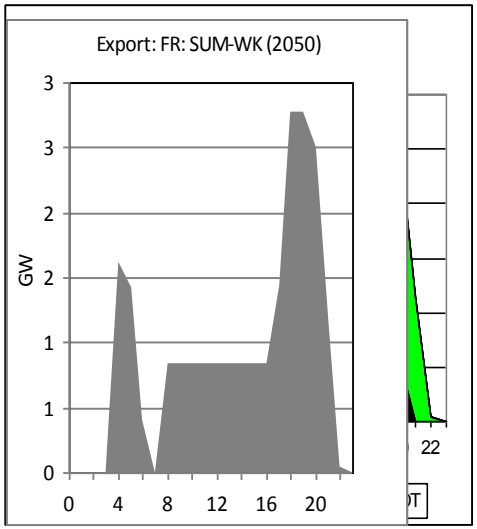


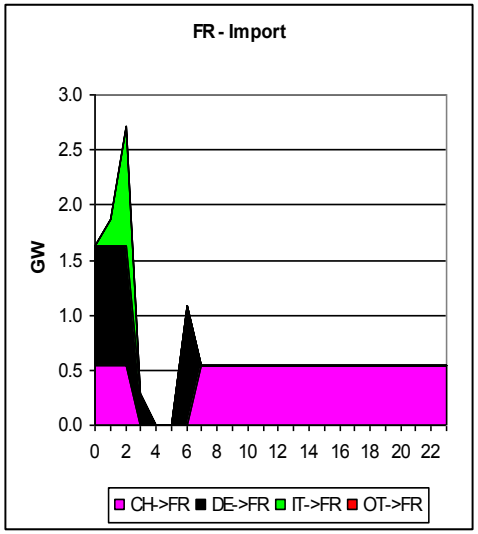


Load Curves

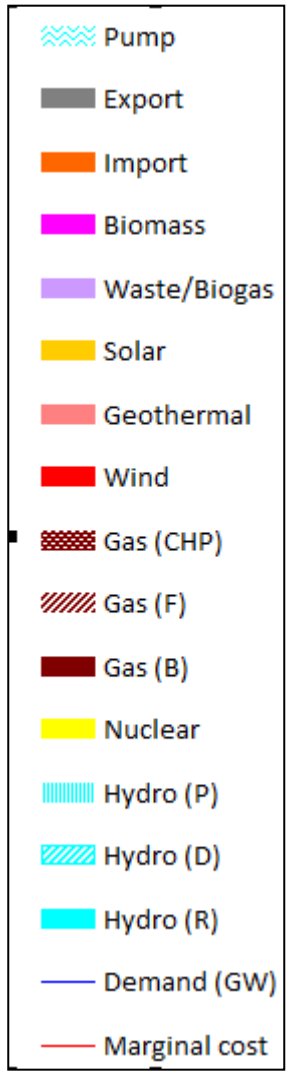
BASE – Summer Weekday - 2050





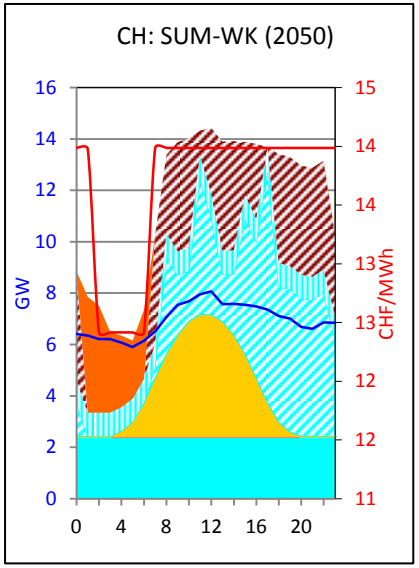


And so on … … …



Load curves – comparison between scenarios

Switzerland – Summer Weekday - 2050



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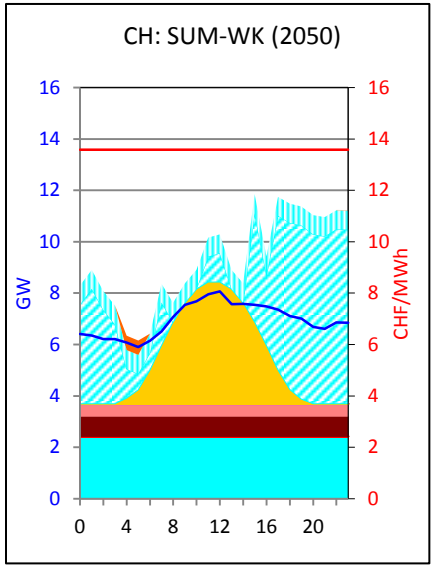

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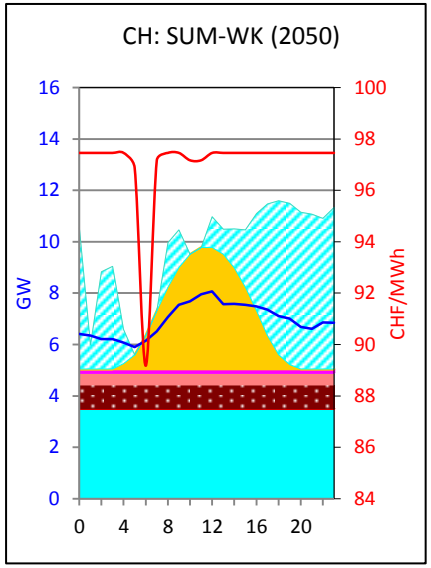
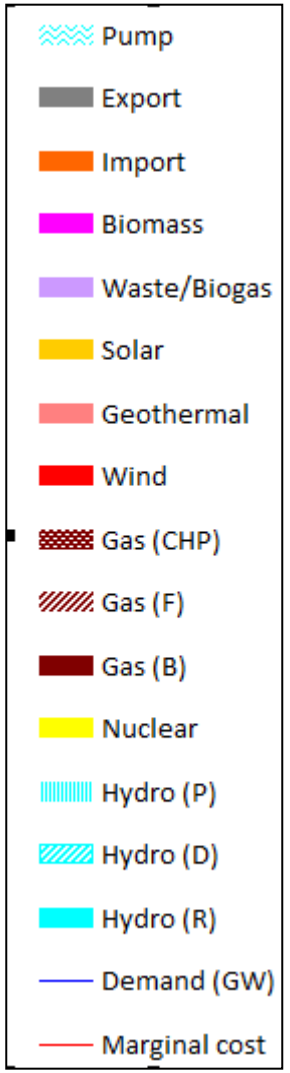
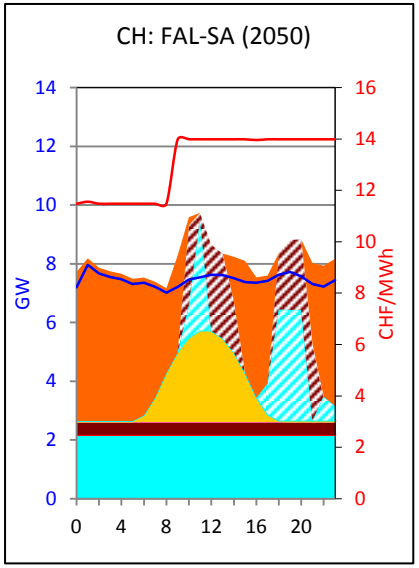


LC



Load curves – comparison between scenarios

Switzerland – Fall Saturday - 2050



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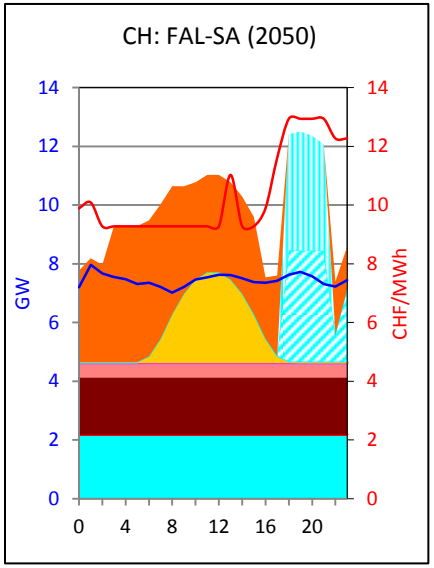

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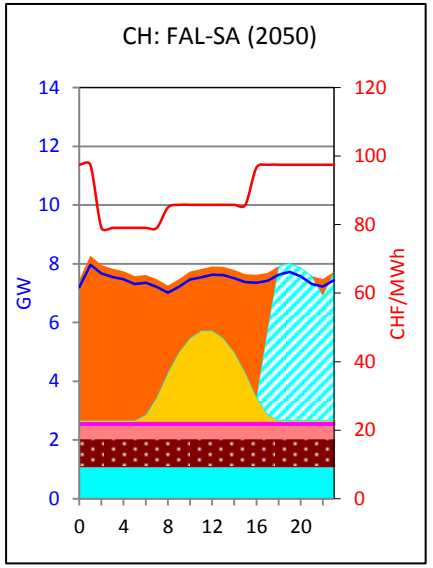

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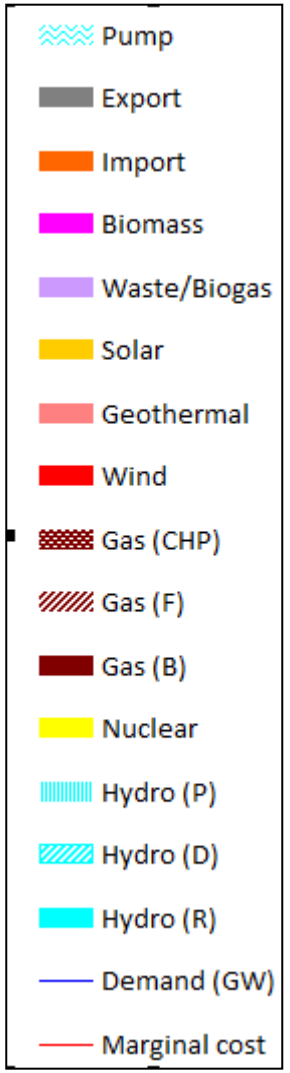

Conclusions

- Model over a long term horizon combined with dispatch aspect achieved.
- Quantified the developments in the neighbouring countries and its impact on the Swiss electricity sector was achieved.
- Importance of pumped storage and trade to balance load demands was analysed
- Results need to be refined - Outlook

Issues and Challenges

Model deficiencies

- **Trade with Fringe countries** – Enable or Disable ?
- **Pumped Storage** – Not pumping at off-peak and discharging at peak

Modelling Challenges

- **Computational time** – 50 hours!!!
- **Data Collection & Uncertainties** – Difficulty in obtaining consistent data from certain countries. Discrepancies between different data sources
- **Scenarios and Policy** – No coherent story line

Outlook

- Continuous improvement of the model – update potentials, technology data, costs, calibration of model – eg. Gas plants in Switzerland
- Refinement of results
- Scenario development and implementation – Analysis of Swiss Energy Strategy in light of European developments
- Possibility for the inclusion of transmission lines
- Methods to improve computational requirements – eg. period definition

Thank you for your attention !!!

Energy Economics Group

Laboratory for Energy Systems Analysis

General Energy Research department & Nuclear Energy and Safety Research Department