Zurich University
of Applied Sciences

School of
Management and Law

Centre for Energy Policy and Economics
Swiss Federal Institutes of Technology

Flexibility in the Swiss Electricity Markets

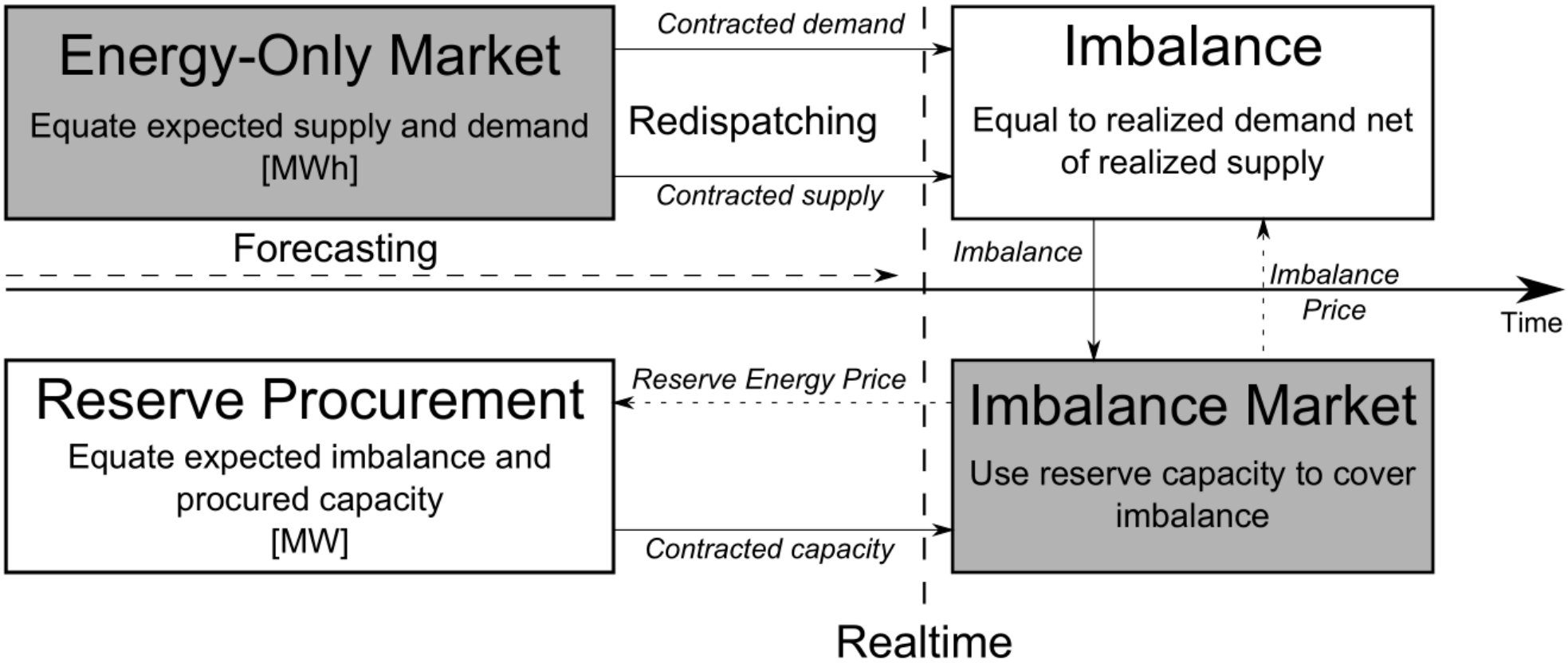
Jan Abrell

Energieforschungsgespräche Disentis 2019, 24.01.2019

Motivation

- Share of renewable energy sources in electricity supply is increasing
- Wind and solar power are stochastic and intermittent
- More flexibility needed to balance increasing forecast errors
- Flexibility:
  - Technical: More flexible market participants
  - Market: Allow participant to act more flexible

Overview Electricity Markets



School of Management and Law

Research Questions

- What does the current energy market design in Switzerland looks like?
- Is there potential for improvement within the existing market design?
- Simulations on the impact of renewable targets in Switzerland

Agenda

- The Swiss Electricity Market
- Simulation: Impact of Renewable Targets in Switzerland
- Conclusions

Energy-only Markets

- Equate
  expected demand and supply
- Day-ahead markets
  Market clearing one day ahead
- Intra-day markets
  Given:
    - New information
    - Day-ahead contracts

  Clear market within a day

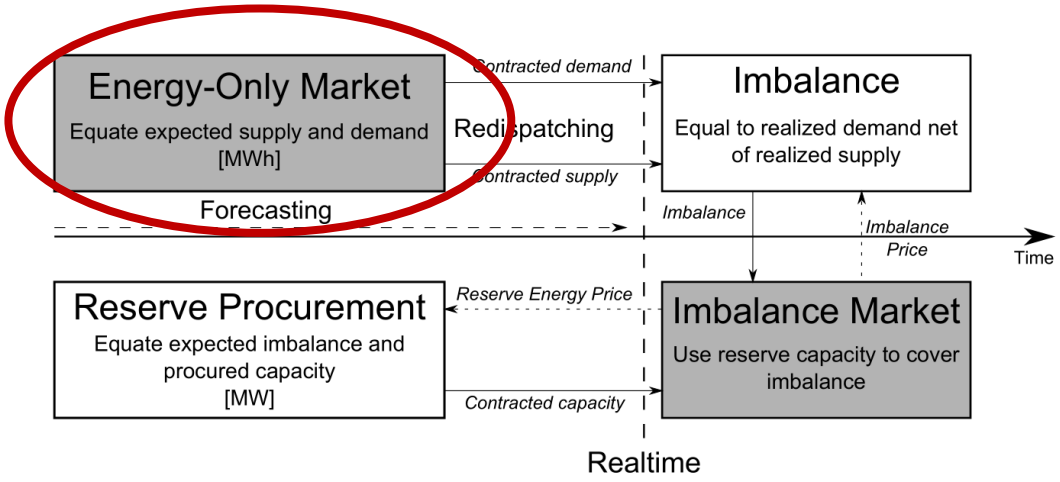
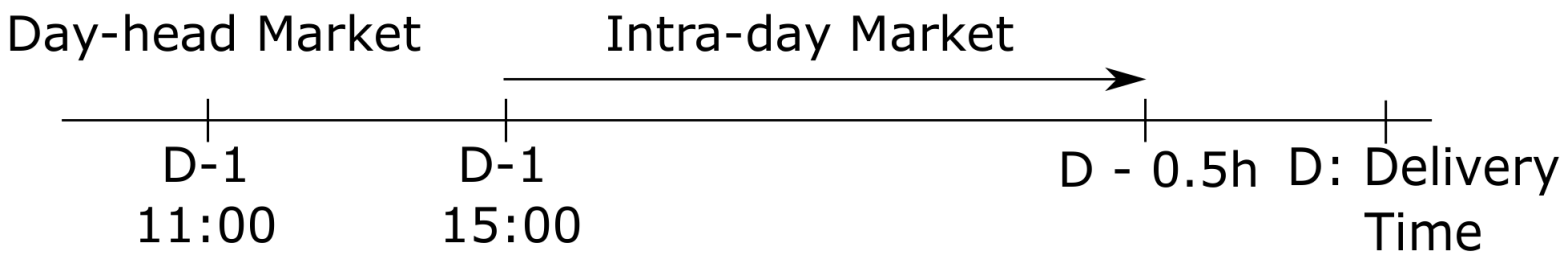


Table 1: Market Design Aspects of Energy-Only Markets

Design Criterion	**Description**
Sub-markets	Organization of successive markets distinguished by their gate closure.
Temporal product specification	Duration of the delivery time period
Locational product specification	Indexing of products by the node or zone in which they are produced/demanded
Trading mechanism	Market clearing at a certain point in time or continuously. Auction mechanism (e.g., simple vs. complex bids)

Energy-Only Markets in Switzerland



Day-ahead:
- Hourly and block contracts
- Uniform price across Switzerland
- Bid range: -500 to 3000 €/MWh
- Gate-closure: 11 am

Intraday:
- 15 minute and hourly contracts
- Uniform price across Switzerland
- Bid range: -9'999.99 to 9'999.99 €/MWh
- Gate closure: D - 30 minutes

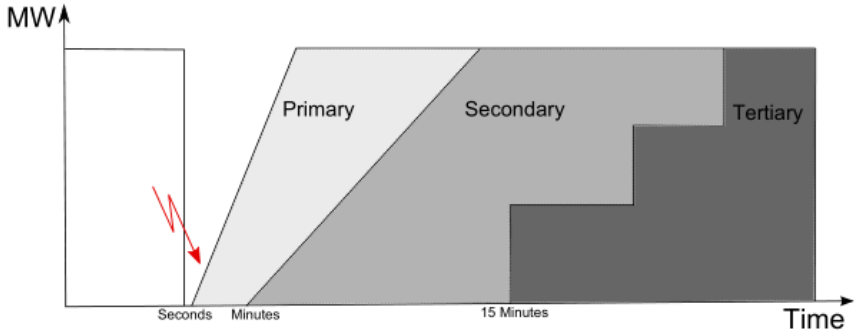
Question:

Is it possible to increase flexibility decreasing intra-day gate-closure to 5 minutes before delivery?

Reserve Procurement

- Reserve capacity is needed to balance unexpected deviations between supply and demand (e.g., variability of load and renewable supply, unexpected outages)

- Three different types of reserves (differentiated by direction):



Notes: Adapted from http://www.e-control.at/industrie/strom/strommarkt/ausgleichsenergie.

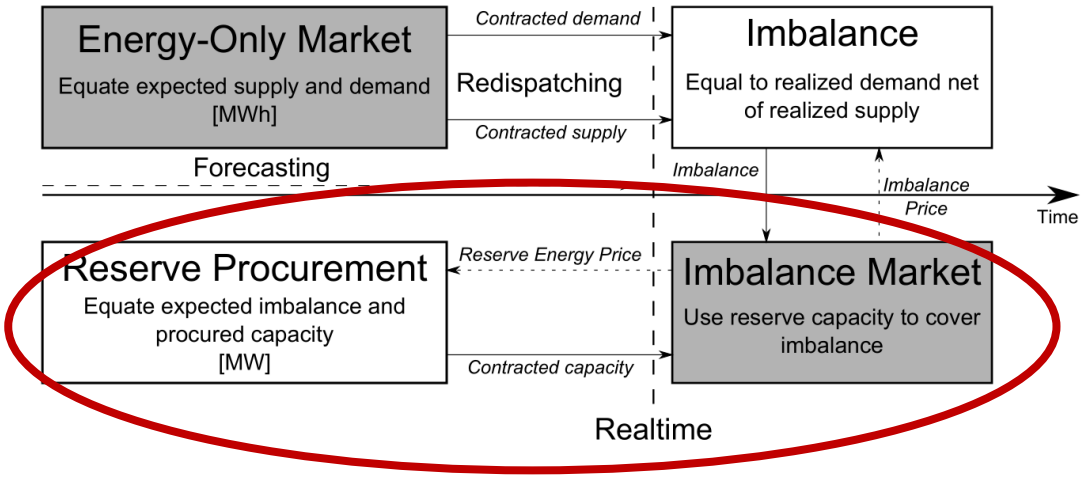


Table 2: Design criteria for reserve procurement

Design Criterion	Description
Temporal product specification	Duration of the delivery time period
Locational product specification	Indexing of products by the node or zone in which they are provided
Trading mechanism	Auction design or mandatory provision
Cost reimbursement	Cost coverage in the case of energy delivery
Demand	Method to determine demand for reserve capacity

zh aw School of Management and Law

Reserve Procurement in Switzerland

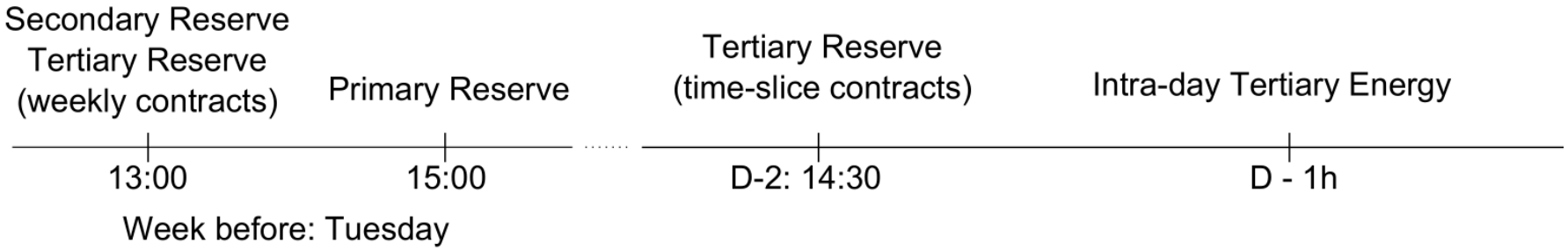


Table 7: Products on reserve markets

	Primary Reserve	Secondary Reserve	Tertiary Reserve	
Product type	symmetric	symmetric	Weekly auction positive/negative	Daily auction positive/negative
Average demand	75 MW	390 MW	200/120 MW	250/130 MW
Contract length	1 week	1 week	1 week	4 hours
Gate closure	week-ahead Tuesday 15:00	week-ahead Tuesday 13:00	week-ahead Tuesday 13:00	2 days-ahead 14:30
Capacity payments	pay-as-bid	pay-as-bid	pay-as-bid	pay-as-bid
Energy payments	-	day-ahead price +- 20 %	have to bid in energy auction	have to bid in energy auction

zh aw School of Management and Law

Reserve Procurement in Switzerland (cont.)

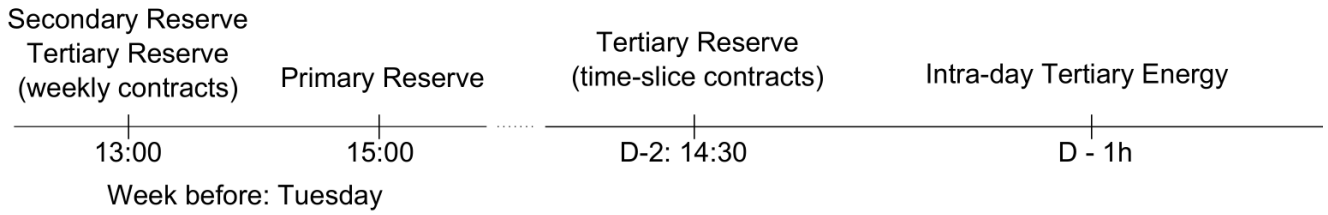
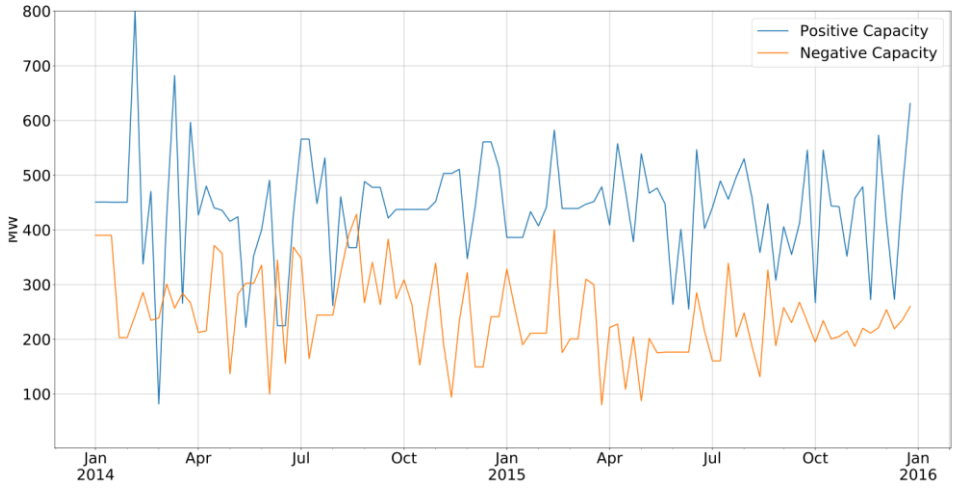
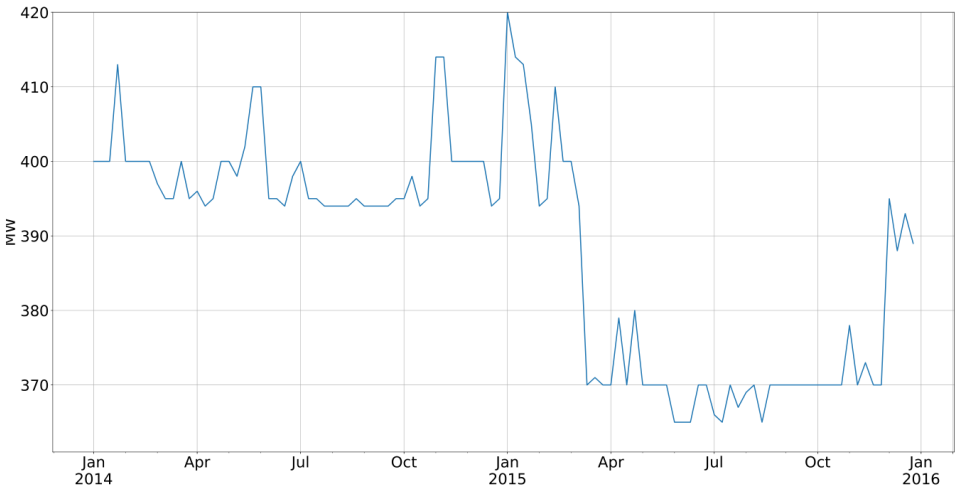


Figure 5: Weekly procured tertiary reserve

Figure 4: Weekly procured secondary reserve



Based on tender data provided by Swissgrid.



Based on tender data provided by Swissgrid.

Question:

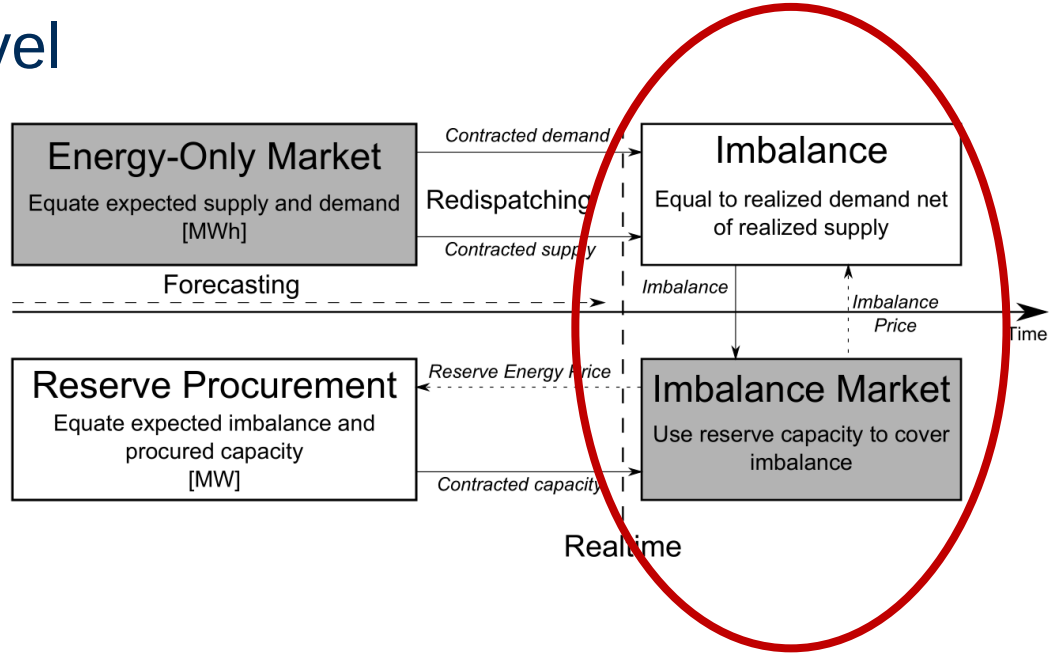
Is it possible to increase flexibility by

(a) decreasing lead times for more dynamic sizing

(b) increasing the contract flexibility (duration, asymmetric secondary reserve)?

Further Points

- Imbalance settlement
  - Organized at balancing group level
  - Two-price system for imbalance pricing



- Market participants

  So far only generators

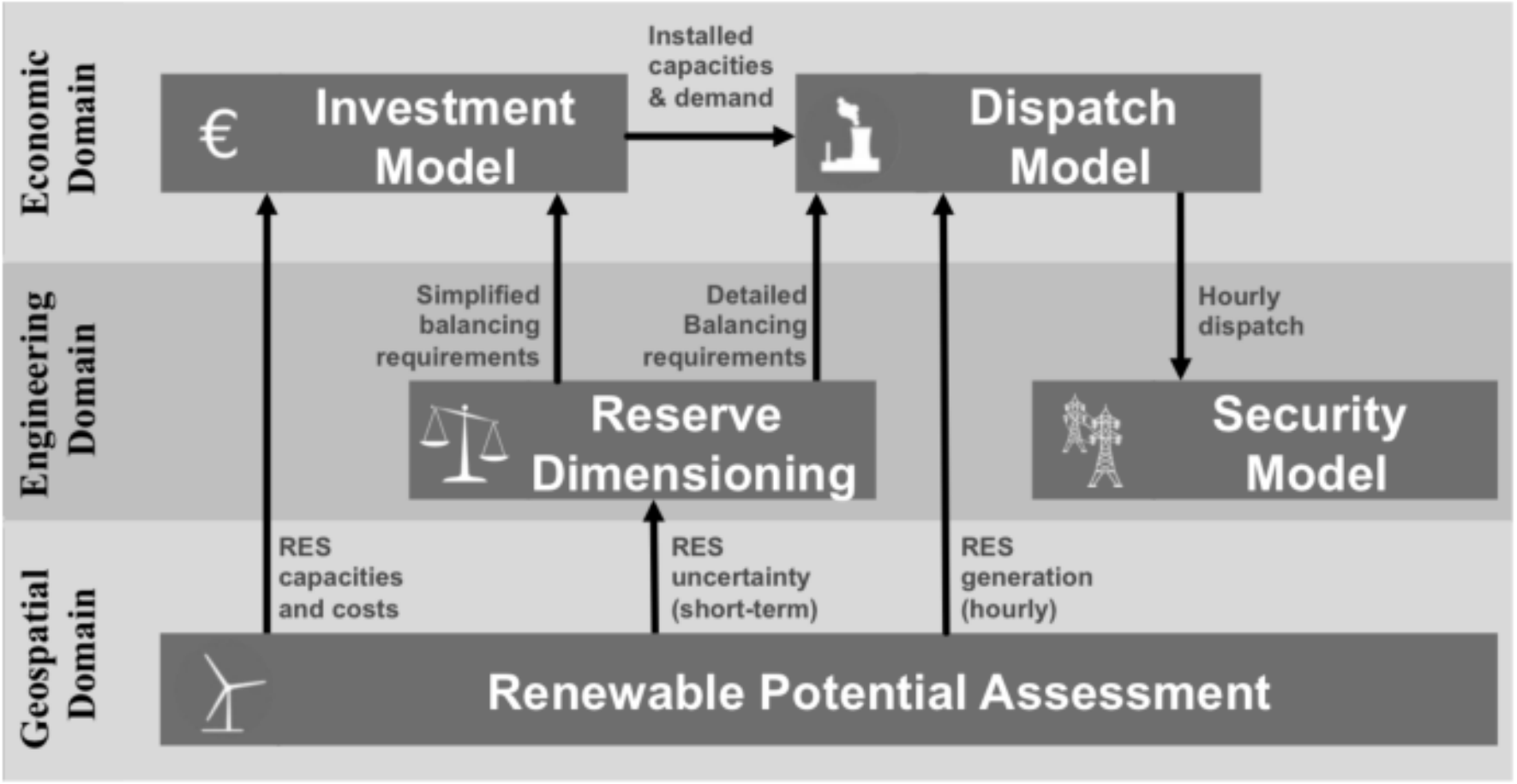
- International trade
  - Cross-border trade until 60 min before delivery time
  - Switzerland not part of market coupling

zh aw School of Management and Law

Agenda

- The Swiss Electricity Market
- Simulations
- Summary and conclusions

Assessing Future Electricity Markets: Modeling Framework



Spatial dimension: Switzerland and first neighbors

Time dimension: Hourly in 5 year steps until 2050

What do we (not) cover?

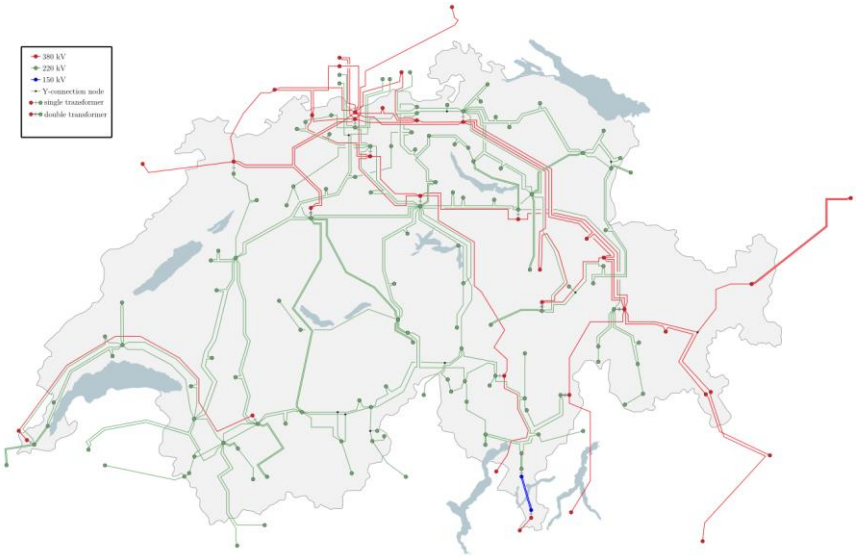
- Hourly market clearing (uniform within country)
  But: Optimized framework without contract length or lead-times

- Reserve procurement depending on renewables
  But: Optimized as hourly contracts with no lead times

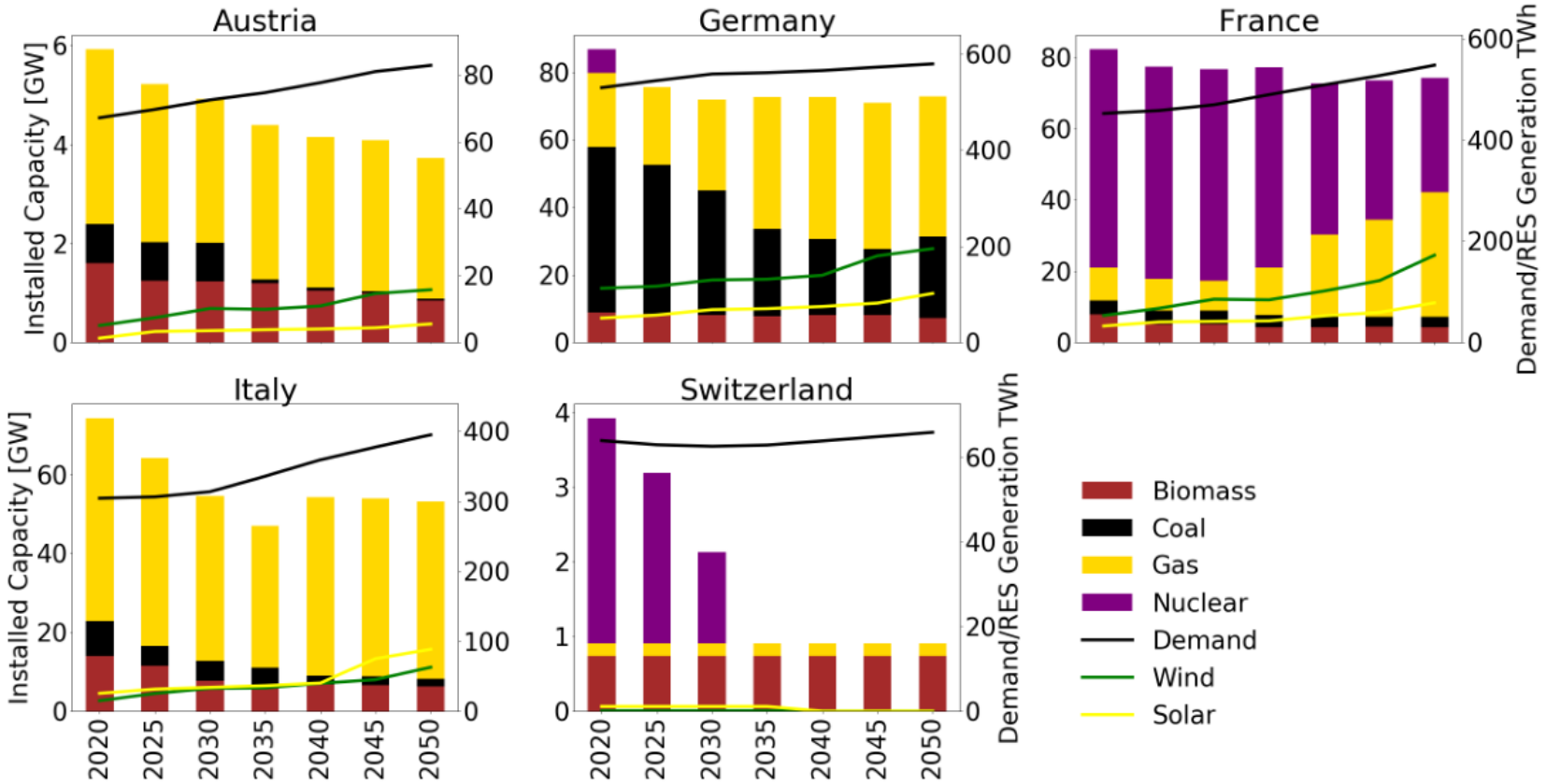
- Spatial dimension
  DC load-flow in dispatch, AC for security analysis

- Hydro power:
  Detailed cascading hydro flows in dispatch model
  Investment model abstracts from cascading hydro

- Detailed assessment of renewable potential/variation
  But: No uncertainty in models



Baseline Assumptions: Capacities

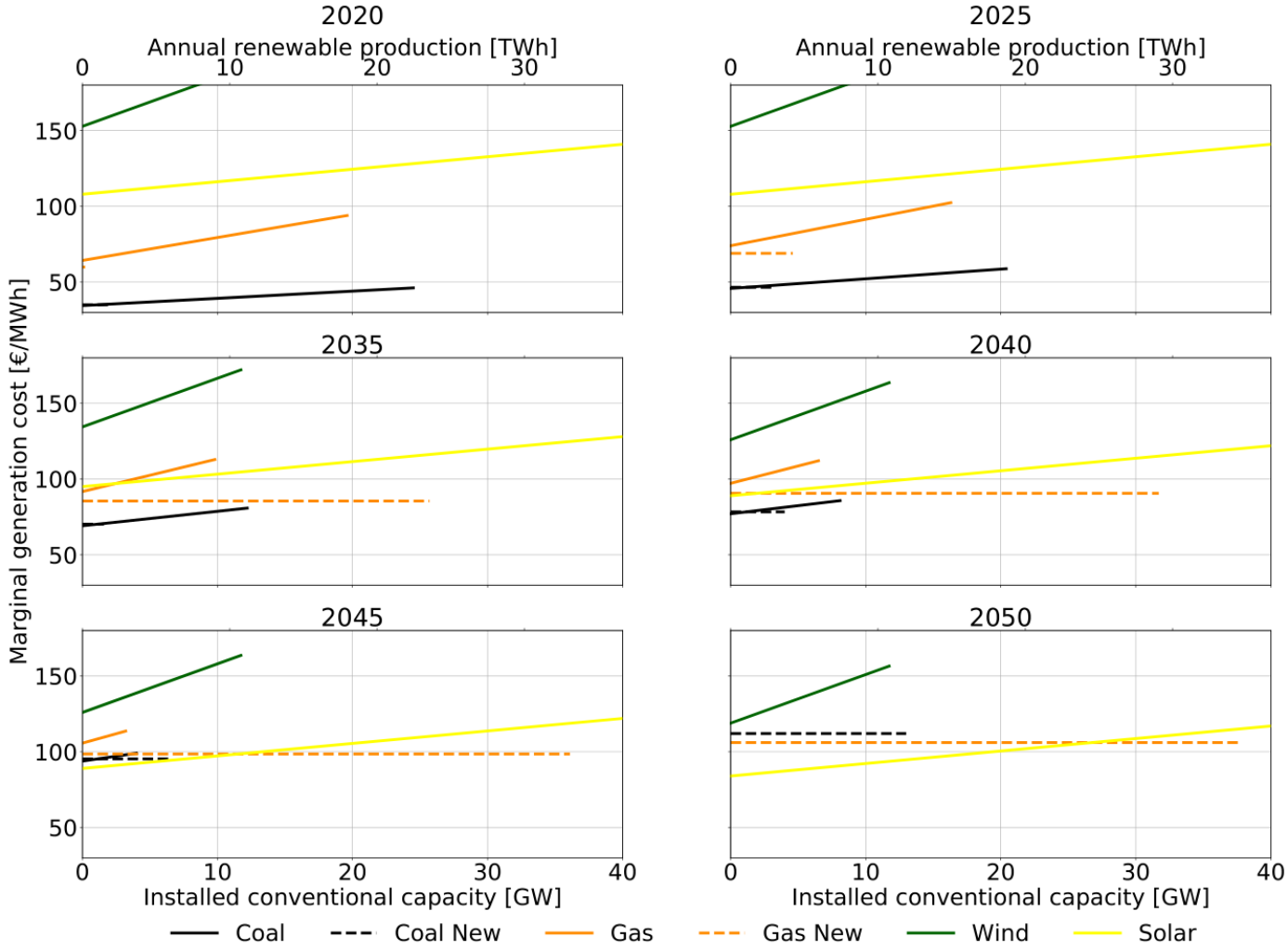


Notes: The graph shows exogenously imposed changes of installed capacity (left axis, GW), demand, and renewable generation (right axis, TWh). Hydro capacities, modestly increasing over time, are not shown.

- Switzerland: Nuclear phase-out until 2050; demand according to Energy Strategie
- Capacity development of neighboring countries based on EU energy reference scenario

Baseline Assumptions: Cost

- Fuel and carbon prices according to EU energy reference and World energy outlook
- Renewable cost based on detailed spatial analysis for Switzerland and neighbors
- Exogenous technological progress for renewable cost (based on EU reference)



School of Management and Law

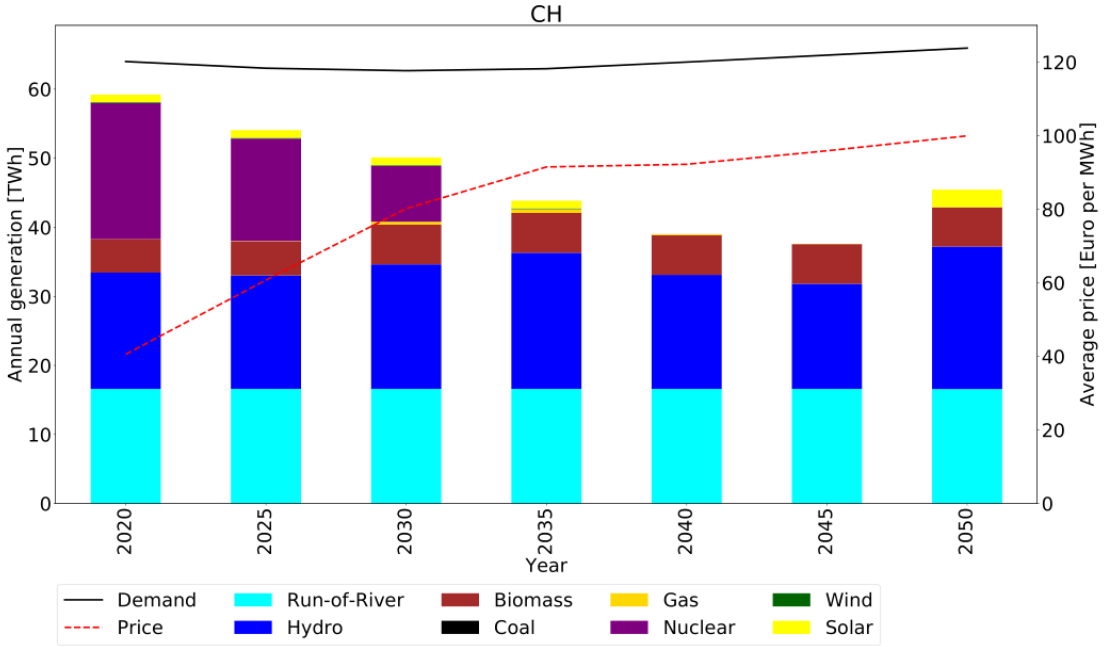
Scenario Overview

<table>
<tr><th>Capacity Mechanism</th><th>RES Policy</th><th>Balancing</th></tr>
<tr><td>None</td><td>None</td><td>Current system
Sizing: Year-ahead
Tertiary/secondary: According to current Swissgrid rules</td></tr>
<tr><td>Strategic storage reserve
Demand: 750 GWh</td><td rowspan="2">RES support
Demand (targets): 4.4, 11.3, 18.4 in 2020, 2035, 2050
Supply: PV, Wind, Biomass</td><td rowspan="2">Maximum flexibility
Renewable generation causes no additional reserve demand</td></tr>
<tr><td>Market-wide capacity market
Demand: Highest hourly demand in each year
Supply: All units in the market according to average availability; interconnectors not eligible</td></tr>
</table>

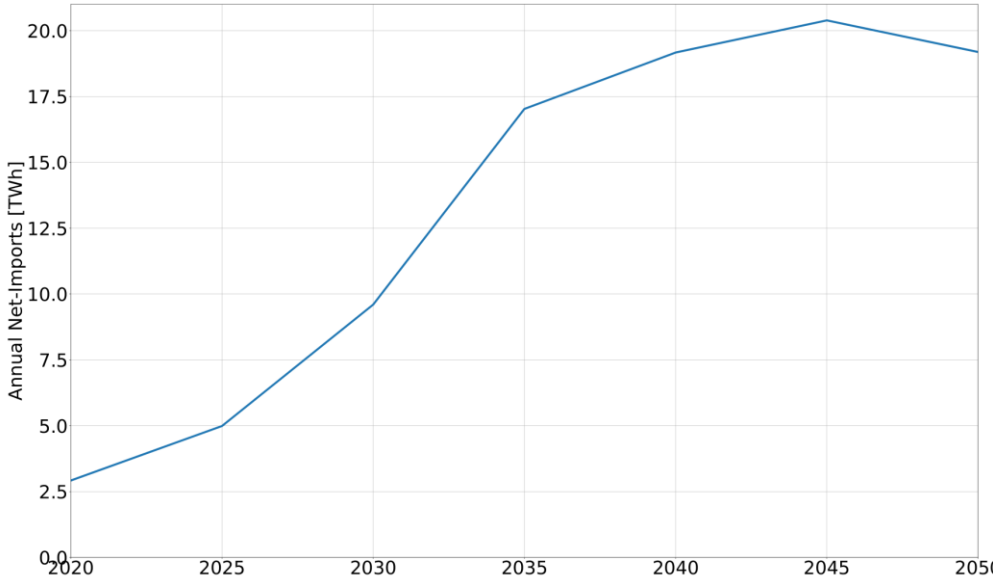
Baseline Results: The Impact of Nuclear Phase-out

- Investments
  - Biomass:
    2025: 130 MW (potential exhausted)
  - PV:
    2050: 2.5 TWh (~4.3 GW)

- Nuclear-phase out mainly balanced by an increase in net-imports

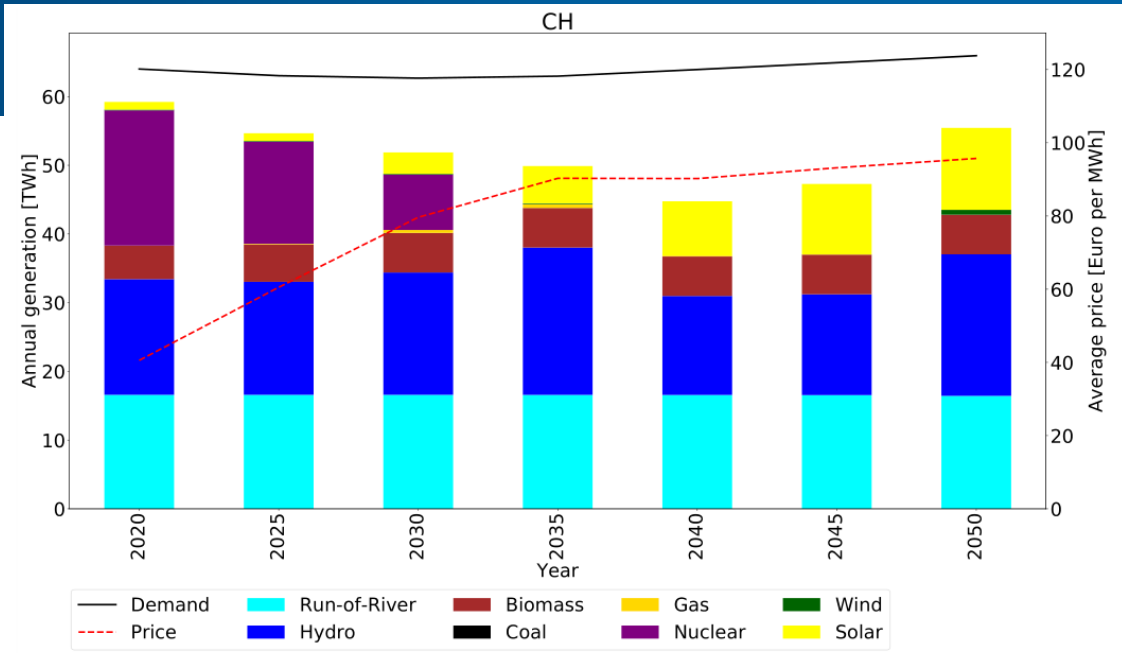


Notes: The graph shows annual generation in Switzerland by generation technology as well as annual demand in TWh (left axis). On the right axis the average electricity price is shown in € /MWh.

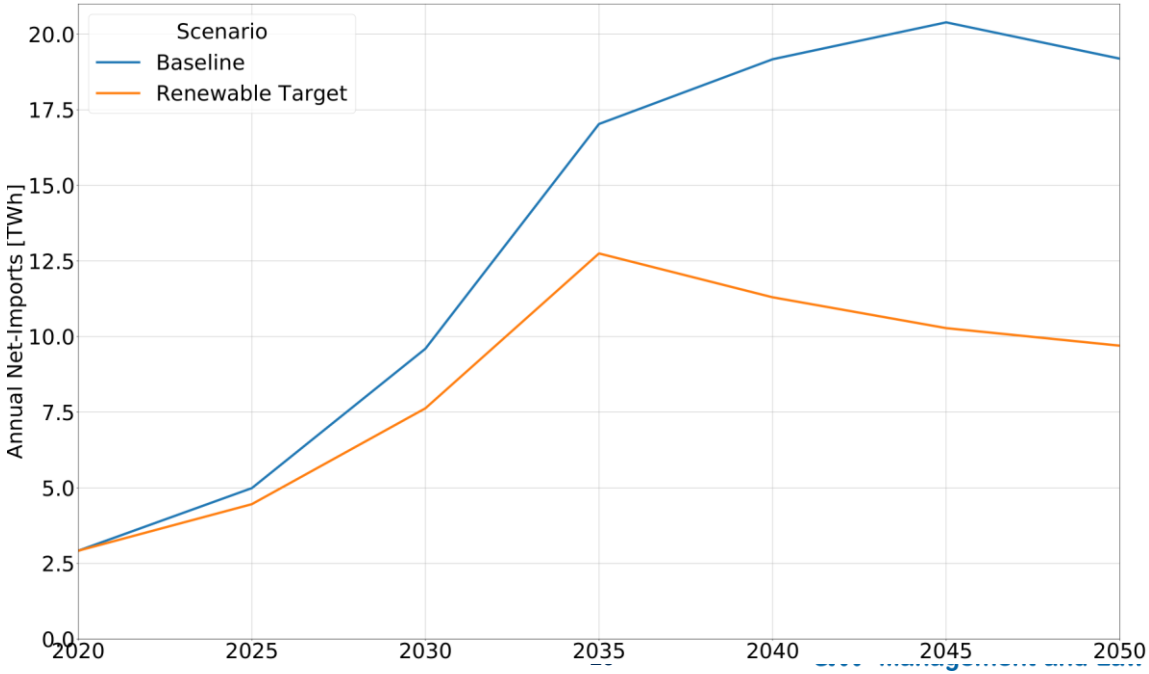


Renewable Targets

- Investment
  - Biomass:
    2025: 130 MW (potential exhausted)
- Renewable generation (2050)
  - PV: 11.9 TWh (~20.3 GW)
  - Wind: 0.7 TWh (~ 0.6 GW)
- Reduction of net-imports due to renewable support mechanism



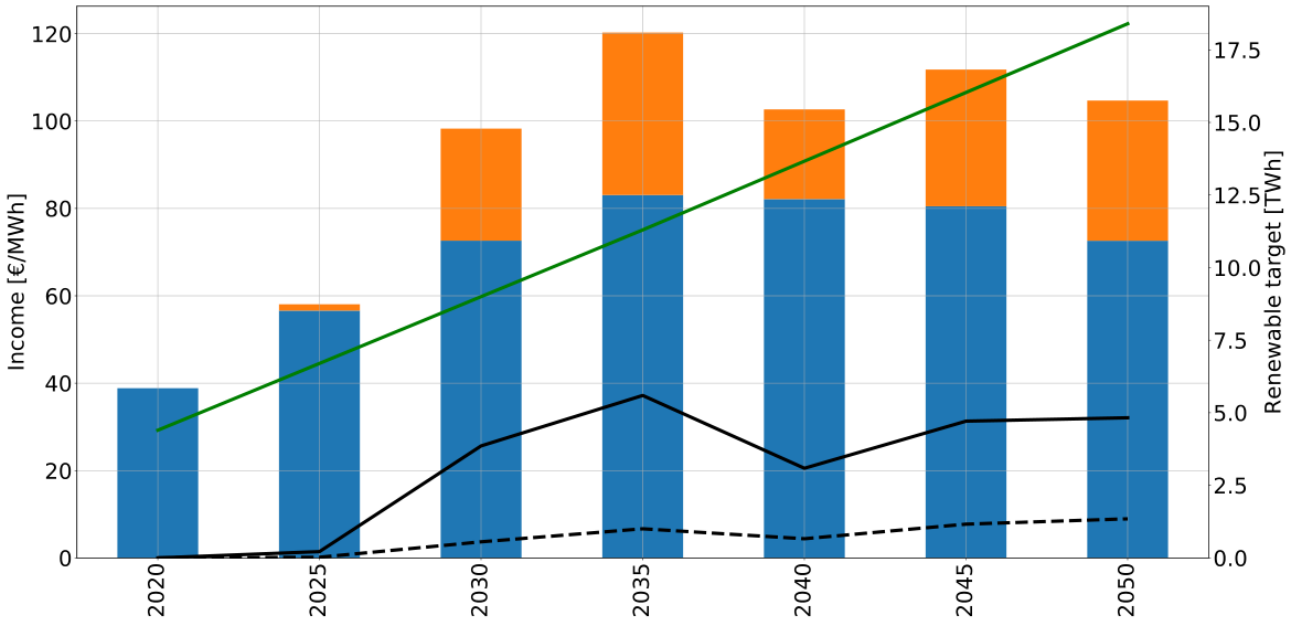
Notes: The graph shows annual generation in Switzerland by generation technology as well as annual demand in TWh (left axis). On the right axis the average electricity price is shown in € /MWh.



Renewable Support Premiums

- Renewables Support Scheme: Renewable Premium
- Premium affected by
  - Relative marginal cost
  - Renewable target
  - Marginal cost in subsequent period
- Premium peaks in 2035 (37.19 €/MWh)
- Demand surcharge in 2050: 8.95 €/MWh

Figure 15: Renewable support premium



Notes: The graph shows the the mean income of solar producers by year (left axis € /MWh). Also shown is the absolute level of the renewable premium (black line) as well as the final demand surcharge to refinance expenses for premium payments (dotted black line; both left axis € /MWh). The demand surcharge is derived as total expenses on renewable support divided by final demand. The right axis measures the renewable target in TWh (green line).

Remaining Scenarios

- Capacity markets
  Virtually no impact as capacity target is already reached
- Storage reserve
  (with minimum requirement of 750 GWh)
  Virtually no impact but slight re-configuration of storage
- Balancing market optimization
  Slight favor of renewables

Capacity Mechanism	RES Policy	Balancing
None	None	**Current system** Sizing: Year-ahead Tertiary/secondary: According to current Swissgrid rules
Strategic storage reserve Demand: 750 GWh	**RES support** Demand (targets): 4.4, 11.3, 18.4 in 2020, 2035, 2050 Supply: PV, Wind, Biomass	**Maximum flexibility** Renewable generation causes no additional reserve demand
Market-wide capacity market Demand: Highest hourly demand in each year Supply: All units in the market according to average availability; interconnectors not eligible		

Table 2: Capacity targets [GW]

Year	2020	2025	2030	2035	2040	2045	2050
Target	10.5	10.4	10.3	10.3	10.5	10.7	10.8

Notes: The capacity target is derived as the annual peak demand of Switzerland. In all years peak demand occurs at February 6 10 am.

Agenda

- The Swiss Electricity Market
- Simulation: Impact of Renewable Targets in Switzerland
- Summary and conclusions

Summary and conclusions

- Within the existing market design, flexibility can be increased by
  - Decreasing intra-day closure (within the control zone)
  - More flexible reserve dimensioning
  - More flexible reserve contracts

- Simulations show that
  - Nuclear-phase out leads to increase in imports
  - Renewable targets decrease the need for these imports
  - Neither capacity market nor storage reserve significantly impact investment behavior