Linking electricity prices and costs in bottom-up top-down coupling under changing market environments

Sophie Maire, Frank Vöhringer, Philippe Thalmann

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Energy: economics, consumer and firm behavior, policy and regulation
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In essence
My talk in a nutshell

- The liberalization of electricity markets alters pricing mechanisms for wholesale electricity.

- This has an effect on the effectiveness of energy and climate policies.

- Must be taken into account when coupling energy (bottom-up) and economic (top-down) models.
Structure

• Electricity market liberalization and wholesale electricity pricing
• The ELECTRA framework
• Scenarios
• Results
• Conclusion
In the CGE model, prices drive the decisions of economic agents!
Wholesale electricity pricing

Traditionally regulated market

- Regulated prices:
  - cover generation costs
  - acceptable profit

Fully liberalized market

- Priced:
  - at marginal cost
  - including scarcity rents

Wholesale electricity pricing

- Incentive for new capacity addition:
  - guaranteed acceptable return on investments
  - subsidies (open or covert)

Modeling

- price = AC + profit

- price = MC (incl. scarcity rents)
European electricity market

Largely liberalized market

Situation of overcapacity
⇒ no scarcity
⇒ no scarcity rents
⇒ no incentive to build new capacity

2016

which evolution?

2050

Fully liberalized?

Or a mix? with capacity markets?
ELECTRA

- ELECTRA : Electricity markets and trade in Switzerland and its neighboring countries

- Project partners:
  - EPFL, Ecole Polytechnique Fédérale de Lausanne
    Sophie Maire, Philippe Thalmann, Marc Vielle, Frédéric Babonneau
  - Econability, Mühleturnen
    Frank Vöhringer
  - PSI, Paul Scherrer Institute, Villigen
    Rajesh Pattupara, Kannan Ramachandran, Hal Turton

- Financed by the Swiss Federal Office of Energy
Models

CROSSTEM-CH
Cross-border Swiss TIMES Electricity Model

GENESwIS
General equilibrium model (CGE) of the Swiss economy
Coupling

Electricity generation costs
- average
- marginal

input shares to electricity generation

wholesale electricity price

CROSSTEM-CH

electricity export revenue & import cost

GENESwIS

sectoral electricity demands

changes to investment costs and operation and maintenance costs

factor & intermediate input prices

Electricity markets
ELECTRA framework
Scenarios
Results
Conclusion
## Scenarios

<table>
<thead>
<tr>
<th>Policy scenarios</th>
<th>Pricing scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Regulated market</td>
</tr>
<tr>
<td>Tax scenario</td>
<td>BAU_REG</td>
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Electricity markets

**ELECTRA framework**

**Scenarios**

**Results**

**Conclusion**
### Scenarios

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<td><strong>Baseline</strong></td>
<td>Swiss BAU scenario&lt;br&gt;ETS scheme (linked with EU ETS)&lt;br&gt;CO₂ tax on heating fuels and gas</td>
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<td><strong>Tax scenario</strong></td>
<td>Electricity tax (10% in 2020, 50% in 2050)&lt;br&gt;Increase CO₂ tax&lt;br&gt;CO₂ tax on transport fuels (from 2035)</td>
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- Regulated market: \( \text{price} = \text{AC} + \text{profit} \)
- Liberalized market: \( \text{price} = \text{MC} \) (incl. scarcity rents)
Costs and prices

Liberalized market:
\[ \text{Price}(<2025) = f(AC,MC) \]

Liberalized market:
\[ \text{Price}(>2025) = MC \]

Regulated market:
\[ \text{Price} = AC + \text{profit markup} \]

Wholesale electricity price assumptions with regards to average and marginal cost from the CROSSTEM-CH model.
Variation btw scenarios & baselines

**Pricing scenarios**
- Regularized market
- Liberalized market

**Policy scenarios**
- Baseline
- Tax scenario

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- price for users ↑
- demand ↓
Percentage change of the marginal cost and average cost in the TAX scenarios for liberalized and regulated markets, relative to the respective baselines.
Electricity generation mix for the baselines and TAX scenarios for liberalized and regulated markets for 2030 and 2050.
Electricity generation mix for the baselines and TAX scenarios for liberalized and regulated markets for 2030 and 2050.
MC and AC variation

Percentage change of the marginal cost and average cost in the TAX scenarios for liberalized and regulated markets, relative to the respective baselines.
Electricity generation costs for the baselines and TAX scenarios for liberalized and regulated markets for 2030 and 2050.
MC&AC variation - system cost

Electricity generation costs for the baselines and TAX scenarios for liberalized and regulated markets for 2030 and 2050.

Higher share of variable costs
AC decreases with lower demand

Electricity markets
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MC and AC variation

Percentage change of the marginal cost and average cost in the TAX scenarios for liberalized and regulated markets, relative to the respective baselines.
Wholesale electricity prices variation

Percentage change of electricity generation price in the TAX scenarios for liberalized and regulated markets, relative to the respective baselines
Retail electricity prices variation

Percentage change of electricity generation and retail electricity prices in the TAX scenarios for liberalized and regulated markets, relative to the respective baselines.
User prices variation

Percentage change of the user price for electricity in the TAX scenarios for liberalized and regulated markets, relative to the respective baselines.

User price of electricity
Liberalized market

User price of electricity
Regulated market

Econability
Sustainable Economics in Research and Practice

EPFL
ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
Electricity demand variation

Percentage change of electricity demand for the TAX scenarios for liberalized and regulated markets, relative to the respective baselines.
In our simulations, an electricity tax is more effective in reducing electricity demand in a liberalized market than under cost-plus regulation.
Implications for Energy Modeling: *Market liberalization matters!*

Do we use the right pricing assumptions?

- **YES***
  - fine

- **NO**
  - adjust
Implications for Energy Modeling: Market liberalization matters!

Do we use the right pricing assumptions?

- YES*
  - fine
- NO
  - adjust

In any case, communicate the assumptions!