Impact of sector coupling on prices

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Introduction

- « A Clean Planet for All »
- Most of strategies (including SNBC) involve electrification and decarbonization of electricity
- But decarbonization of all energy vectors is needed and flexibility could be brought by other energy vectors than electricity → sector coupling and cross-vector integration really developing:
  - Power and transports: Robinius et al. 2017
  - Heat, power and transports: Victoria et al. 2019
  - All sectors:
    - Blanco et al. 2018, Pavicevic et al. 2020 with TIMES (see Alimou et al. 2020)
    - Brown et al. 2018 (but only a part of heating, excluding industry),
    - Shirizadeh et al. 2020
3 modes investigated (1/2)

- **In this study, focus on P2H2**
- Electricity part is the same (85% RES scenario of RTE’s Generation Adequacy Report for 2050 in its current state)
- H2 (and CH4) part: data from SNBC in France and TYNDP abroad (apart from countries that have published their national strategies or have a specific EC study – DE, NL, IT, ES, PT)

- Different modelling of the P2H2 part:
  - **Marginal model**: operation when electricity prices are <30€/MWh
    - Operation during periods of low prices and carbon neutrality
  - **Base model**: permanent operation except when electricity prices are > 250€/MWh,
    - large number of operating hours to make the high investment costs of the electrolysers profitable, without penalizing the electrical system too much during peak periods
    - electrolysis capacity are determined to obtain approximately the same amount of electricity converted
  - **Multi-energy model** (see next)
3 modes investigated (2/2)

Multi-energy model

Multi-energy model: electrolysis operation optimized for the complete energy system

- Load
- Supply
- Storage
- Electrical interconnections

Electricity

Electrolysis

CH4

Methanation (=electrolysis + methanation)

CH4 for electricity

H2

Steam reforming

- Load
- Supply
- Storage
- H2 interconnections → not modelled, infinite grid

- Load
- Supply
- Storage
- Gas interconnections → not modelled, infinite grid
Electrolysis (+methanation) volumes

Weekly volumes of electrolysis/methanation in the 3 modes - average on 10 years

Base model electrolysis production (average over 10 years)

Marginal model electrolysis production (average over 10 years)

Multi-energy model electrolysis and methanation production (average over 10 years)
Impacts on the prices (1/5)

• **On base mode:**
  
  • Zero or negative prices because of lower electrolysis capacity

Average curtailment (TWh) on 10 years

<table>
<thead>
<tr>
<th>Mode</th>
<th>1.137</th>
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<th>0.229</th>
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<td>base</td>
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<tr>
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<td>multi-energy</td>
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Monotone of French prices over one year with the 3 modes
Impacts on the prices (2/5)

Monotone of French prices over one year with the 3 modes

- On base mode:
  - Nuclear plateau
    Nuclear price is fixed at 27€/MWh, based on a “water value” approach that allows the right amount of nuclear fuel to be used, in order to replicate approximately historical production
Impacts on the prices (3/5)

Monotone of French prices over one year with the 3 modes

- On base mode:
  - Gas prices gas-fired generation more requested than for the other modes because more production is needed on almost every time step
Impacts on the prices (4/5)

• On base mode:
  • Plateau at 250€, when electrolysis is cut-off
Impacts on the prices (5/5)

• Other modes
  • Gas-fired generation appears later

• On marginal mode: plateaus for nuclear price (27€) and 30€ (max price for electrolysis)

• On multi-energy mode: smoother curve, the H2 and CH4 systems set prices too
Simplified quantity-price curve

Depending on the level of stocks on the different energies, the prices allow to choose which stock to use.
Simplified quantity-price curve

Depending on the level of stocks on the different energies, the prices allow to choose which stock to use.

Unsupplied energy cost

Price (€/MWh)

Specific electricity demand (inflexible)

$H_2$ price \cdot P2H2 efficiency

$CH_4$ price \cdot P2CH4 efficiency

Renewables

Nuclear

H2 demand

CH4 demand

Hydro

CCGT

Power (GW)
Production mix in the different models

Focus on CCGT

- More used in base mode in order to have more load hours for electrolysers
Production mix in the different models

Focus on CCGT

- More used in marginal than in multi-energy mode → in ME, more EV, less methanation at noon and less CCGT in the evening (because CCGT and methanation are linked in ME mode)
Conclusions

• Multi-energy modeling has important impacts on prices and production volumes
• From an electricity price perspective, H2 and CH4 demand prices are becoming important in price formation
• The trade-off between the stocks of all types of energy (hydrogen, methane, nuclear, hydraulic) is well captured in the multi-energy model

• Future work
  • Improvement of H2 and CH4 modeling (grid, multi-stocks management)
  • District heating to be added to the model