01/06/2021

Impact of sector coupling on prices

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IAEE conference, June 6th-9th 2021

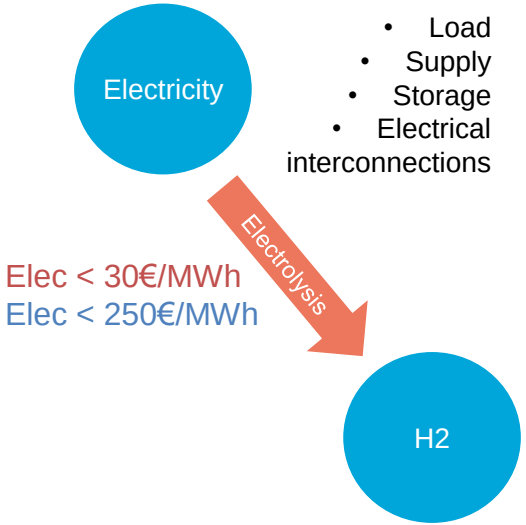
Introduction

- « 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:
  - Heat and power: Zhu et al. 2019, Schill and Zerrahn 2020, Zhu et al. 2020
  - 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)

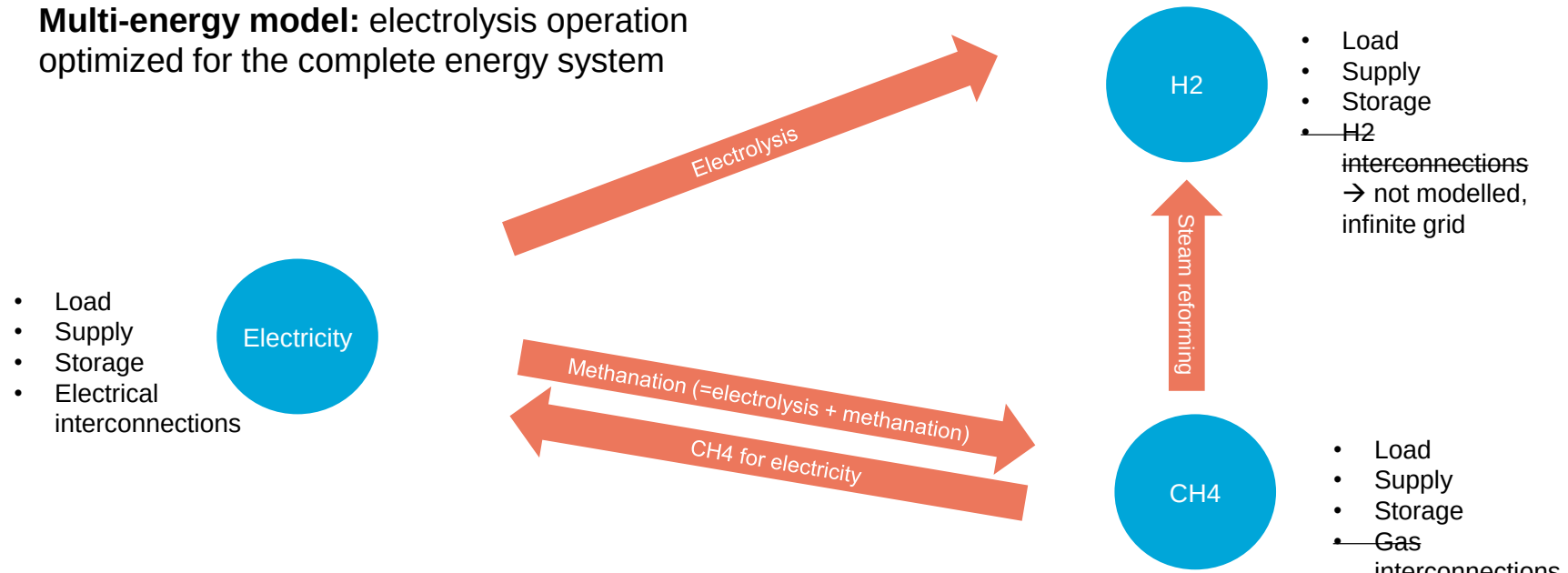
- Different modelling of the P2H2 part:
  - **Marginal model:** operation when electricity prices are <30€/MWh
    - Operation during periods of **low prices** and **carbon neutrality**
  - **Base model:** permanent operation except when electricity prices are > 250€/MWh,
    - **large number of operating 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

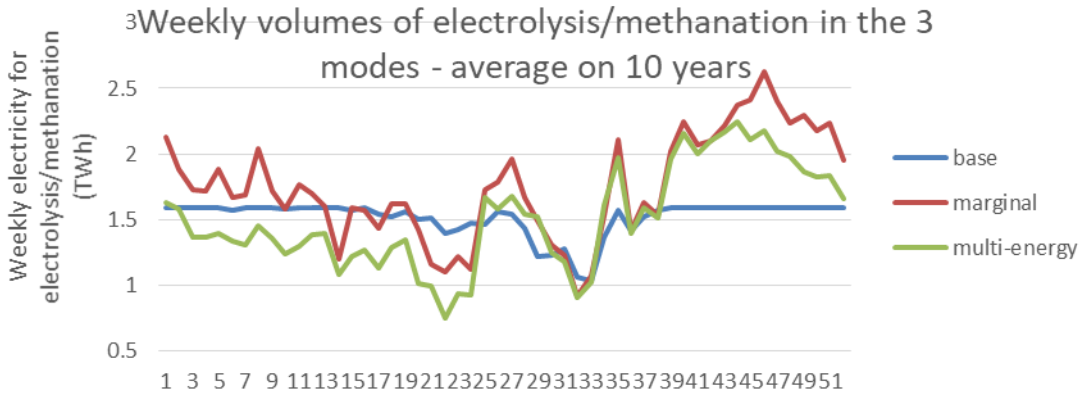


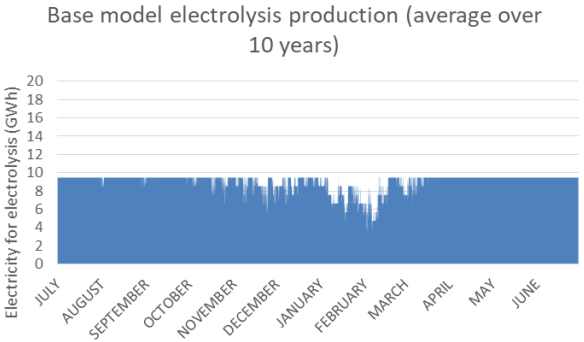
- Load
- Supply
- Storage
- ~~H2 interconnections~~ → not modelled, infinite grid

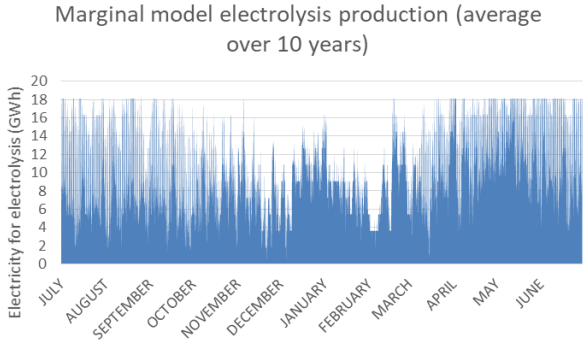
- Load
- Supply
- Storage
- Electrical interconnections

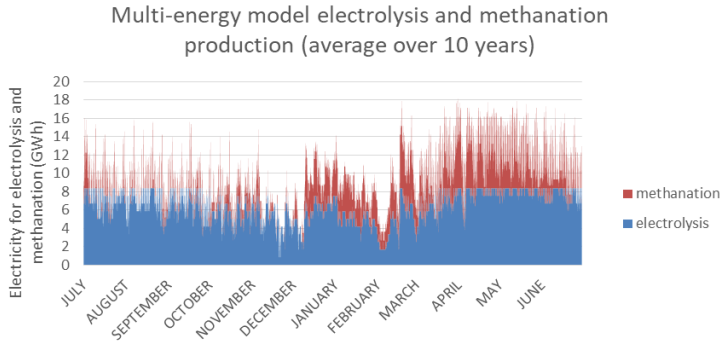
- Load
- Supply
- Storage
- ~~Gas interconnections~~ → not modelled, infinite grid

Electrolysis (+methanation) volumes

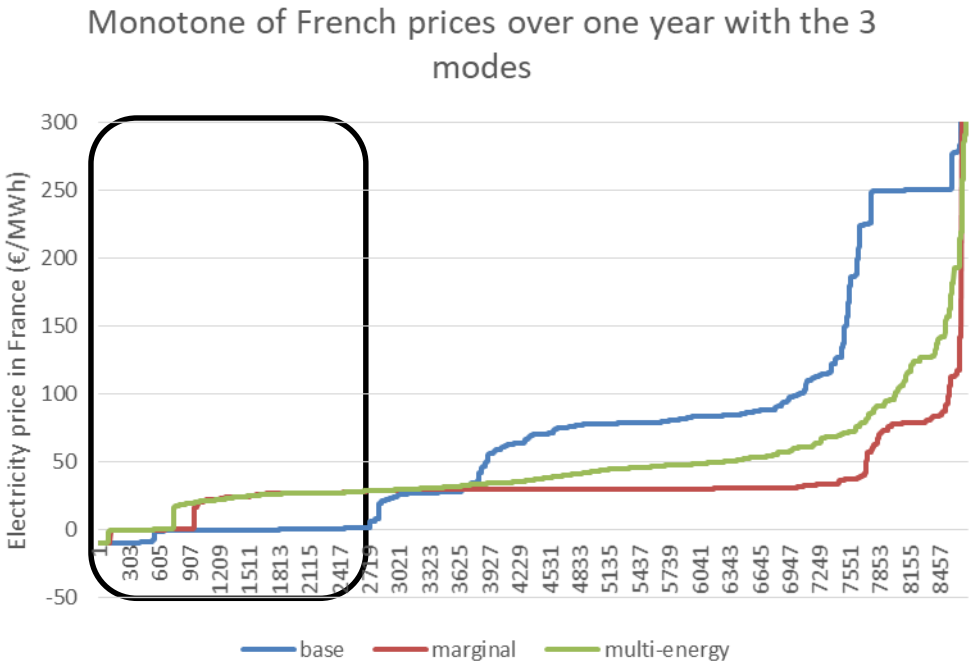








Impacts on the prices (1/5)

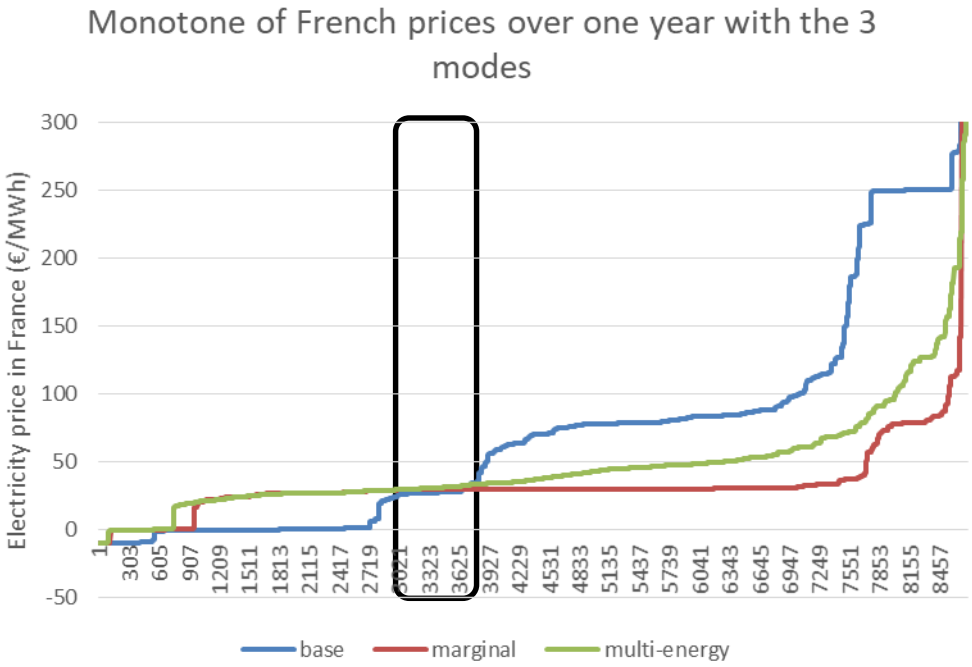


- **On base mode:**
  - Zero or negative prices because of lower electrolysis capacity

Average curtailment (TWh) on 10 years

base	marginal	multi-energy
1.137	0.250	0.229

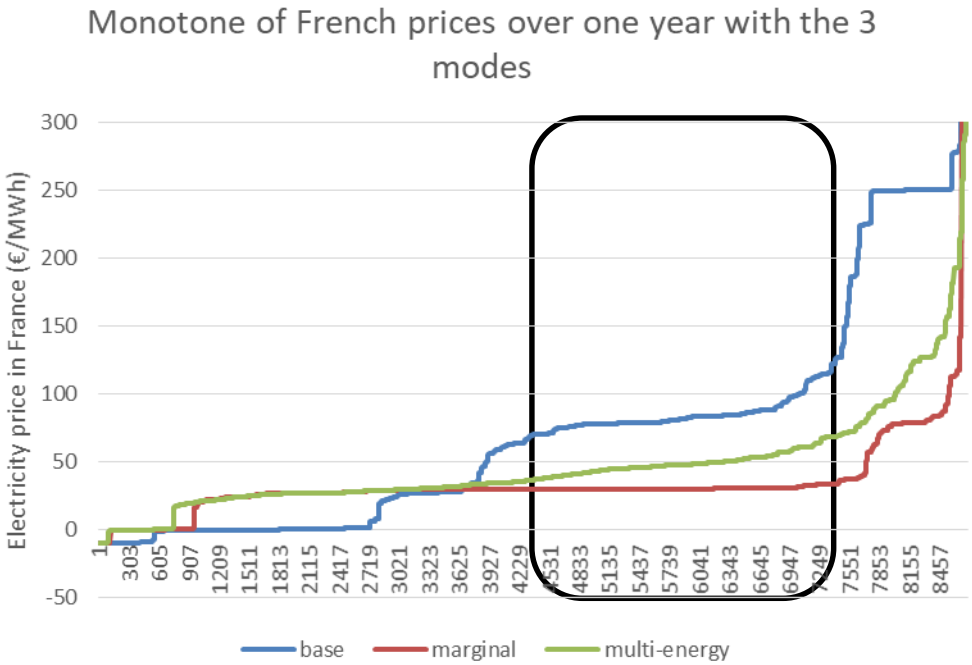
Impacts on the prices (2/5)



- **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

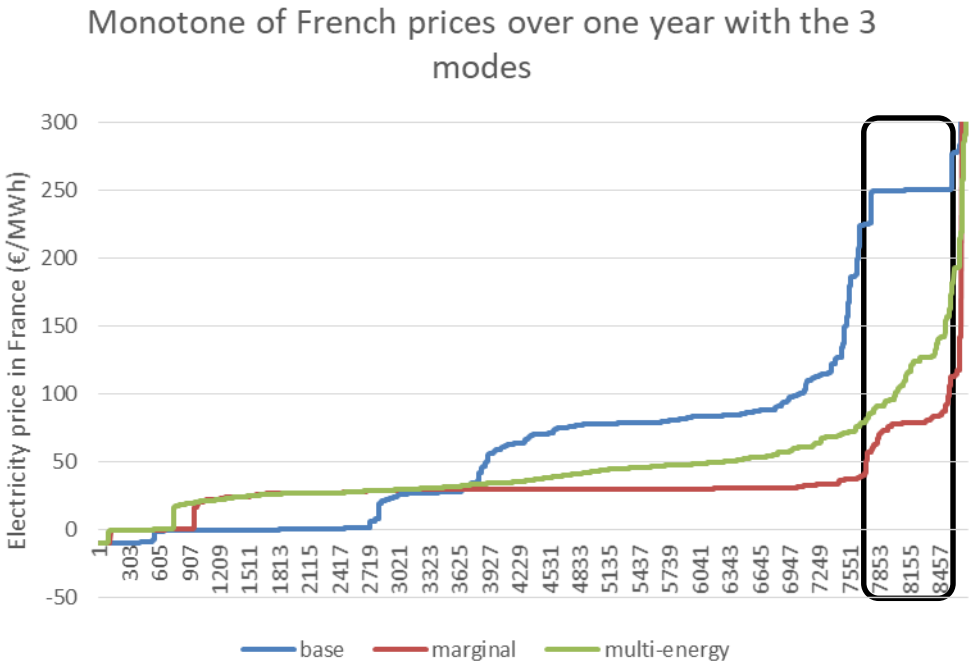
Impacts on the prices (3/5)



- **On base mode:**
  - Gas prices

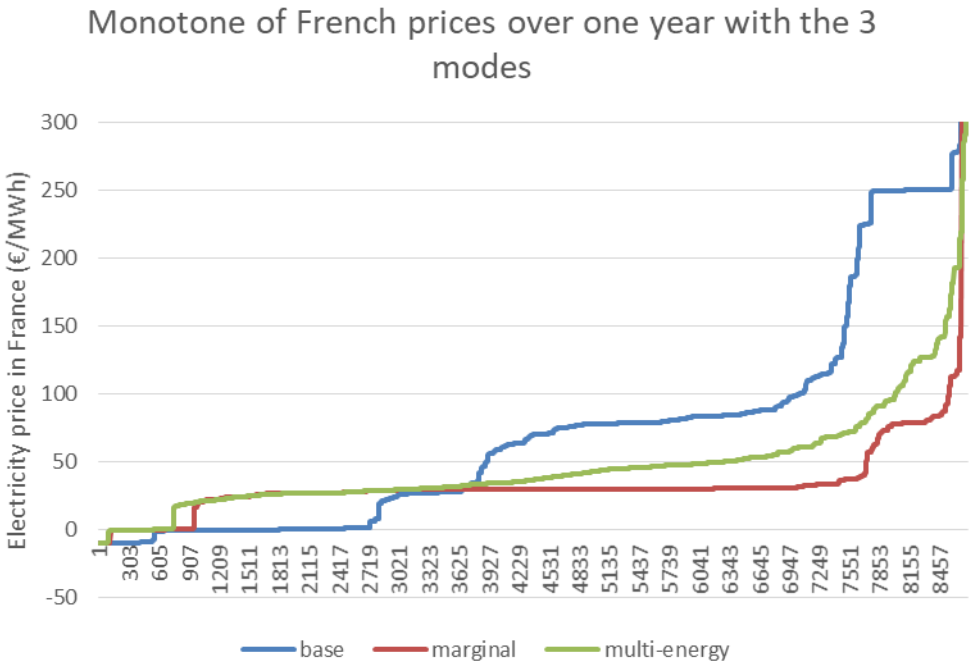
  gas-fired generation more requested than for the other modes because more production is needed on almost every time step

Impacts on the prices (4/5)



- **On base mode:**
  - Plateau at 250€, when electrolysis is cut-off

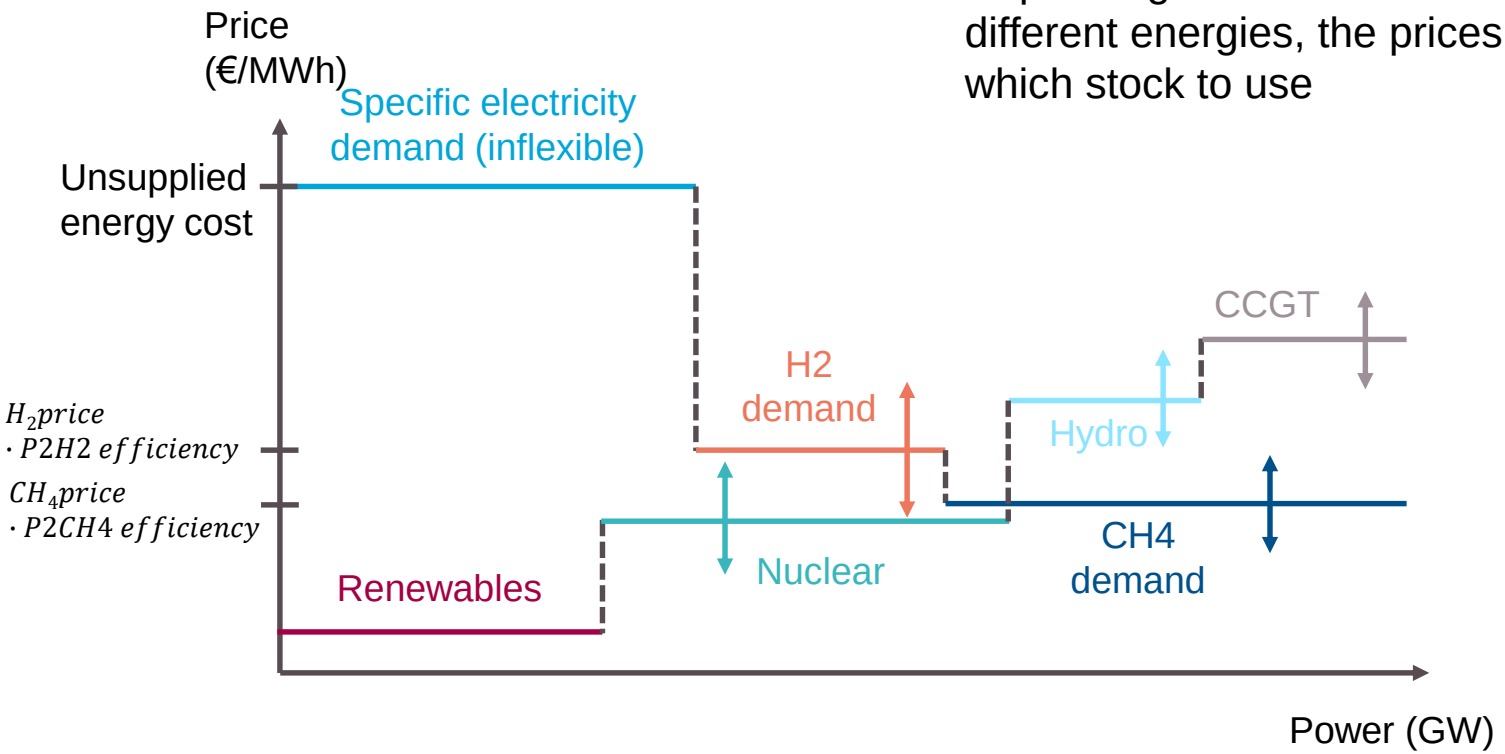
Impacts on the prices (5/5)



- **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



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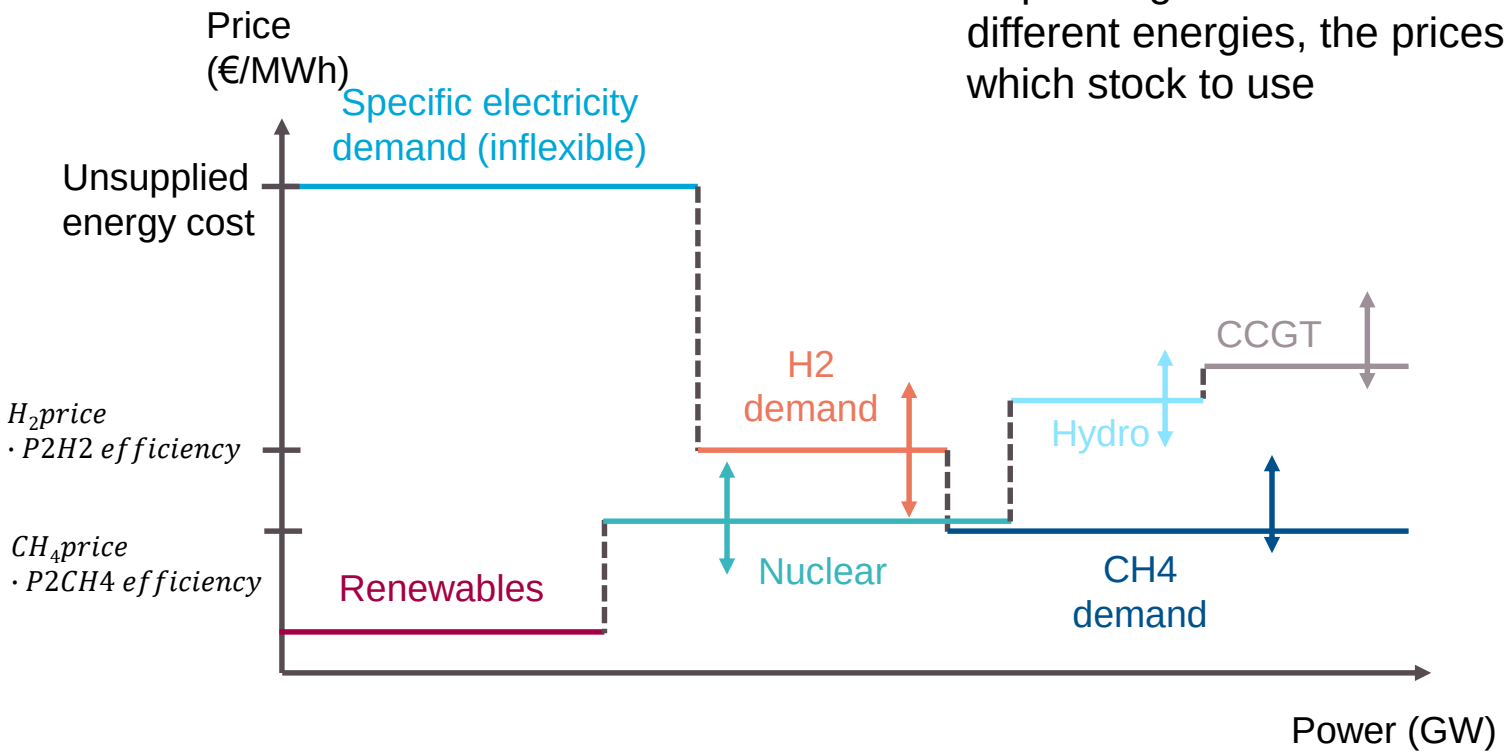
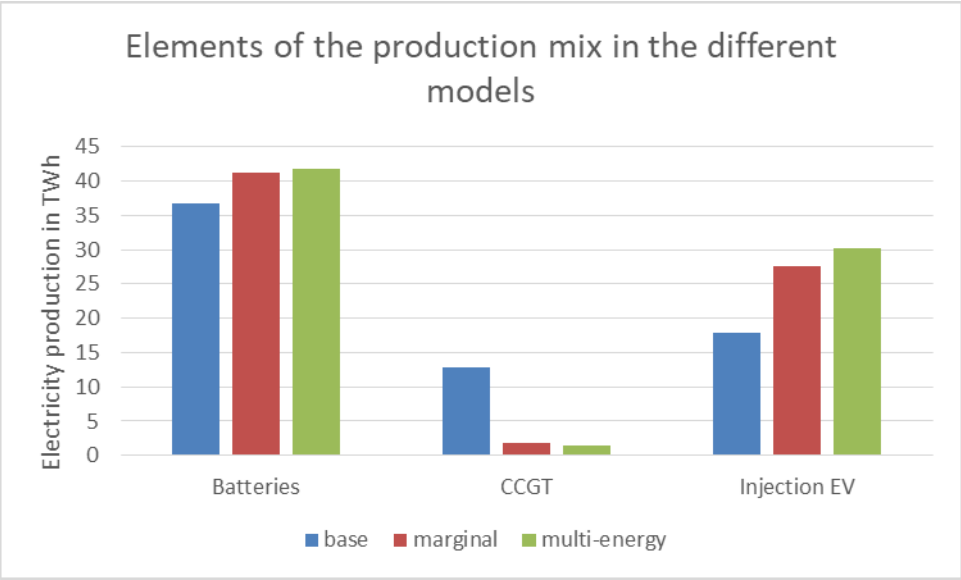


Production mix in the different models



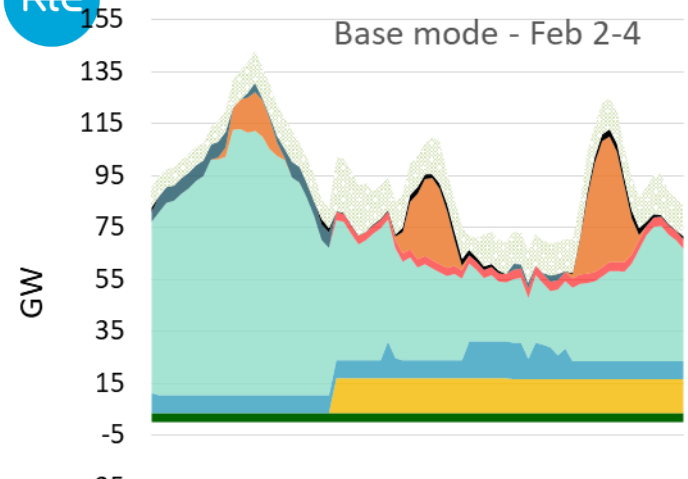
Focus on CCGT

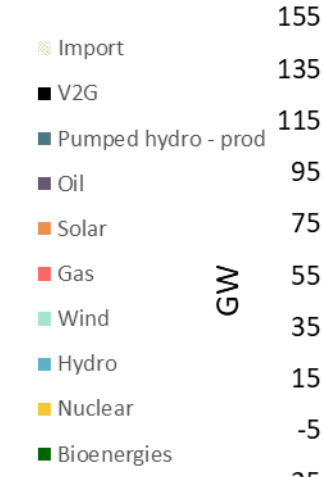
- More used in base mode in order to have more load hours for electrolysers

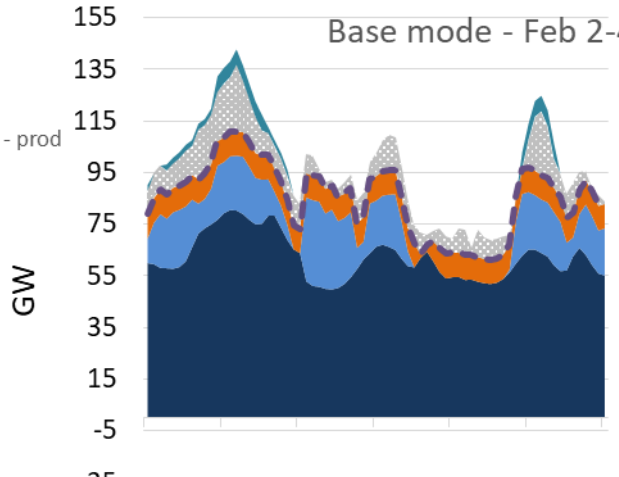
SUPPLY + IMPORTS

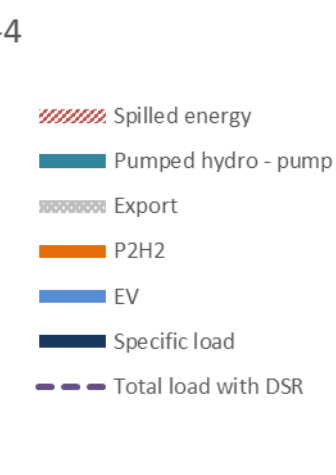
DEMAND + EXPORTS

BASE MODE

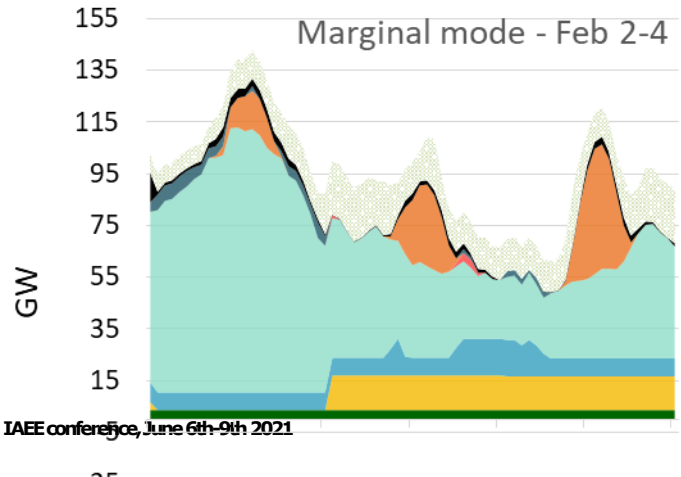


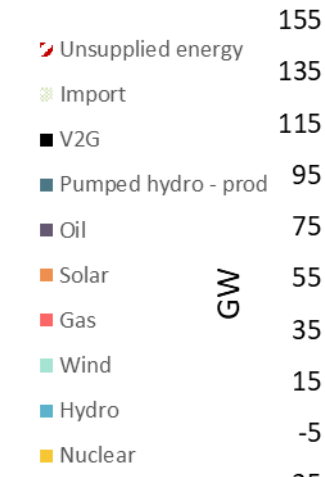


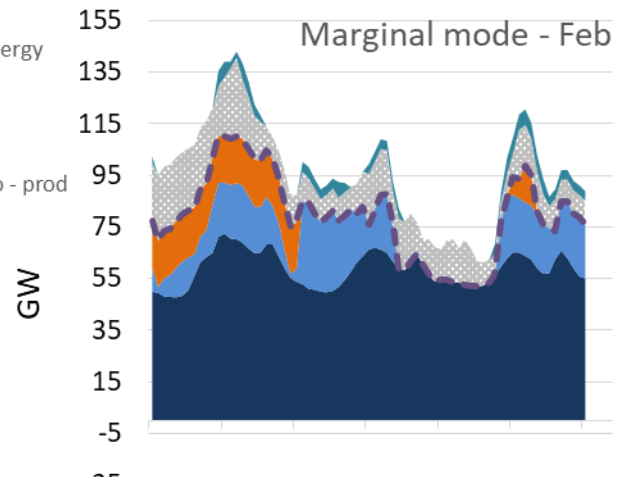


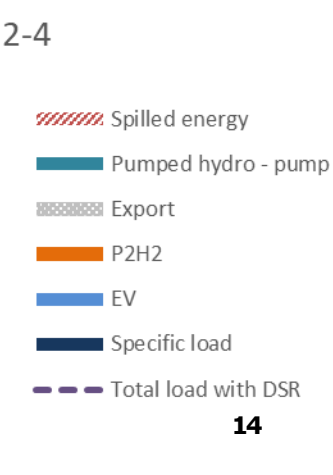


MARGINAL MODE

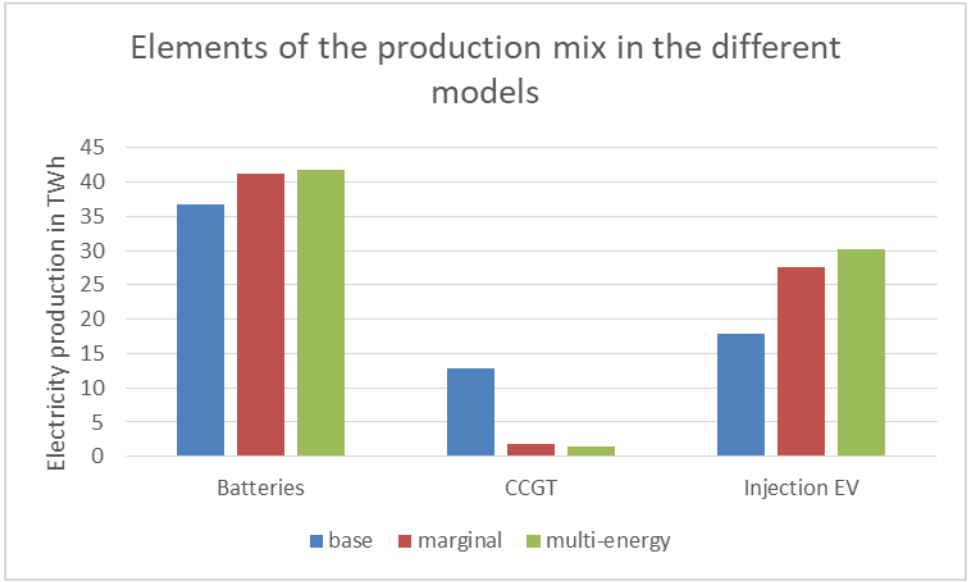








Production mix in the different models



Focus on CCGT

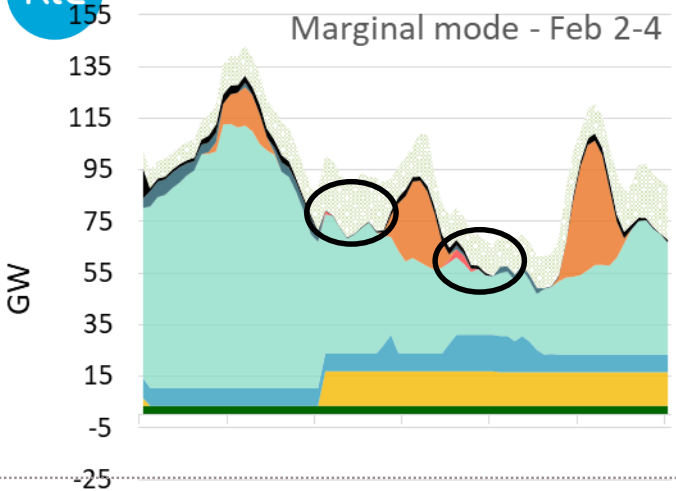
- More used in marginal than in multi-energy mode → in ME, more EV, less methanation at noon and less CCGT in the evening (because CCGT and methanation are linked in ME mode)

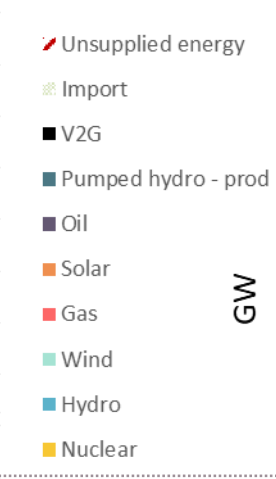
SUPPLY + IMPORTS

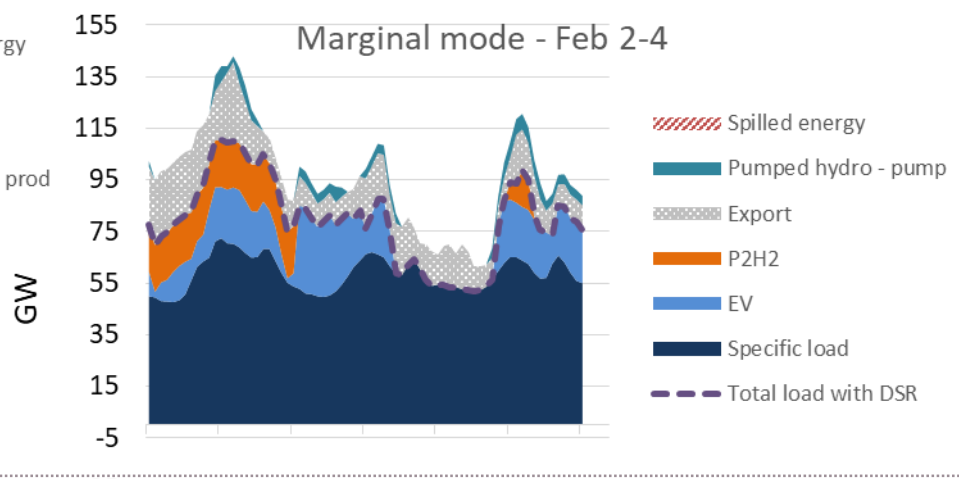
DEMAND + EXPORTS

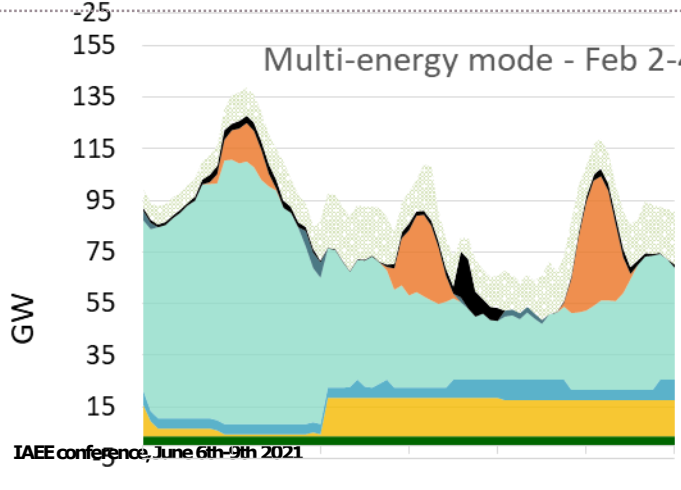
MARGINAL MODE

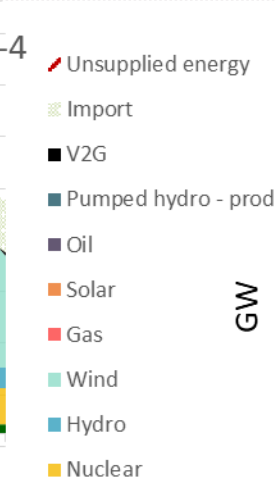
MULTI-ENERGY MODE

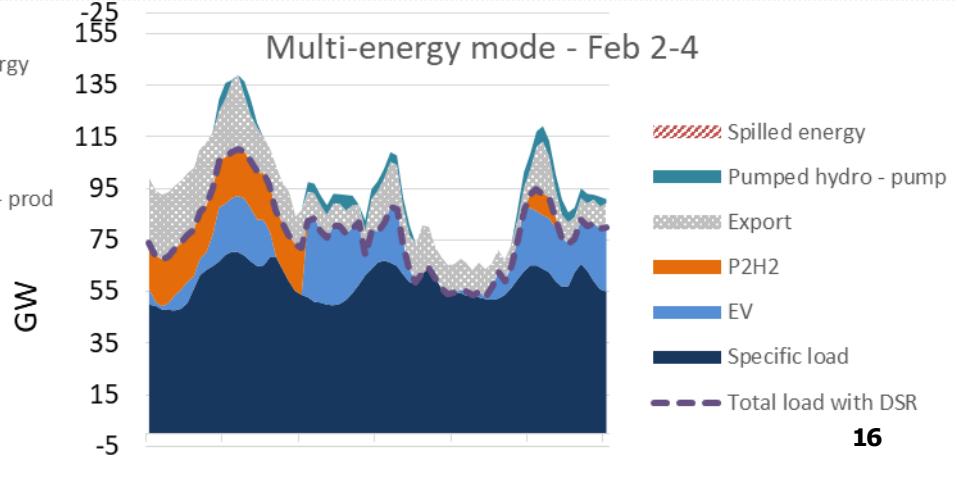












Conclusions

- 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