

Are Energy Storage and Electrolysis competing each other?

A Multistage Stochastic Dynamic Modelling of
the German Case

Table of contents

01

Statement

Energy transition in progress

02

Question

Competition between flexibility sources?

03

Methodology

This SDDP framework

04

Results

Winners & Losers

05

Analysis

Main insights

06

Conclusions

What you can go home with

An aerial photograph of a vast, forested landscape. A winding river flows through the center of the scene, surrounded by dense green trees. In the foreground, a large white wind turbine stands prominently. The background shows rolling hills and a clear sky, suggesting a rural or natural setting.

01

Statement

The ongoing energy transition

Decarbonizing Europe

Ambition: achieve carbon neutrality by 2050

- Energy efficiency
- Renewables
- Hydrogen

New challenges emerge, notably the growing need for **flexibility**



Flexibility: why and how ?



Renewables are not dispatchable...

It becomes challenging to match supply and demand



... And sector coupling will be strengthened

Gas and power systems will become more linked



Hence, flexibility sources are numerous

Electricity storage (PHS, Batteries), electrolysis, Hydrogen turbines, demand response...



« Using all the enablers of the flexibility portfolio of resources is the best way to lower the overall transition cost »

—Alain Malot, energy expert

An aerial photograph of a vast forest landscape. On the left side, a white wind turbine stands prominently. The center of the image is dominated by a large yellow rectangular box containing bold, dark blue text. The background shows rolling hills and a dense forest of trees with varying shades of green and brown, suggesting an autumn or winter setting. The sky is a pale, hazy blue.

**Is the spread of
PtG threatening
other flexibility
sources viability?**

An aerial photograph of a vast, forested landscape. A winding river flows through the center of the scene, surrounded by dense green trees. In the foreground, a large white wind turbine stands prominently. The background shows rolling hills and a hazy sky, suggesting a distant horizon. The overall scene is a mix of natural beauty and modern infrastructure.

03

Methodology

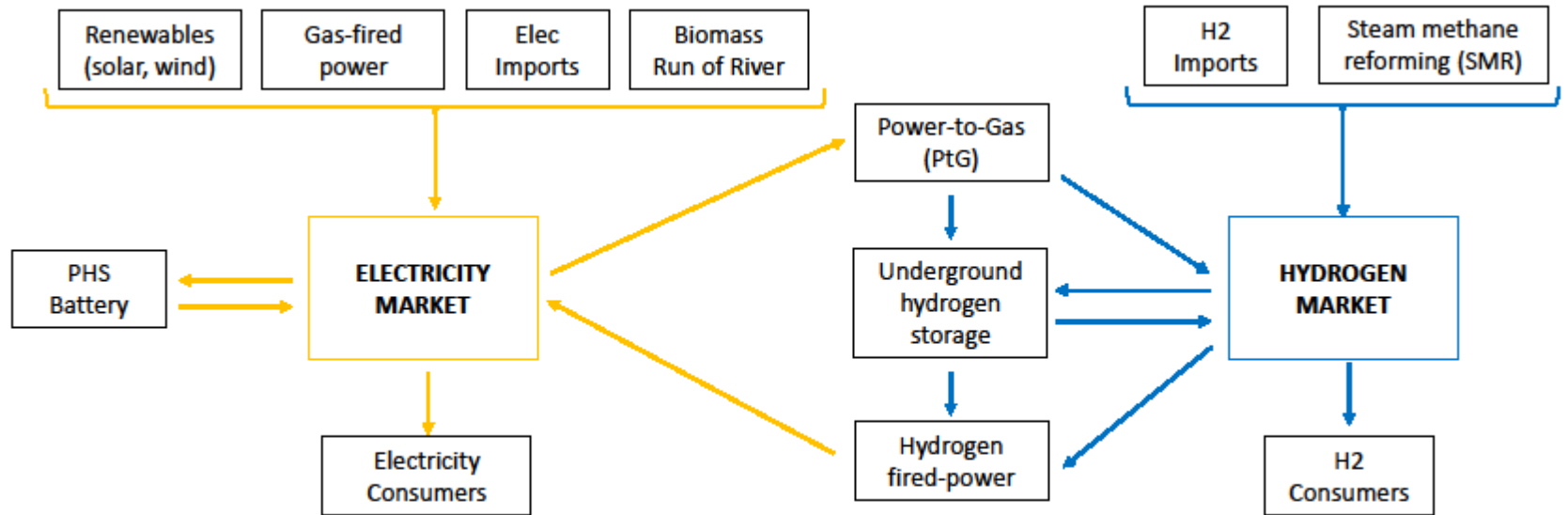
The SDDP framework



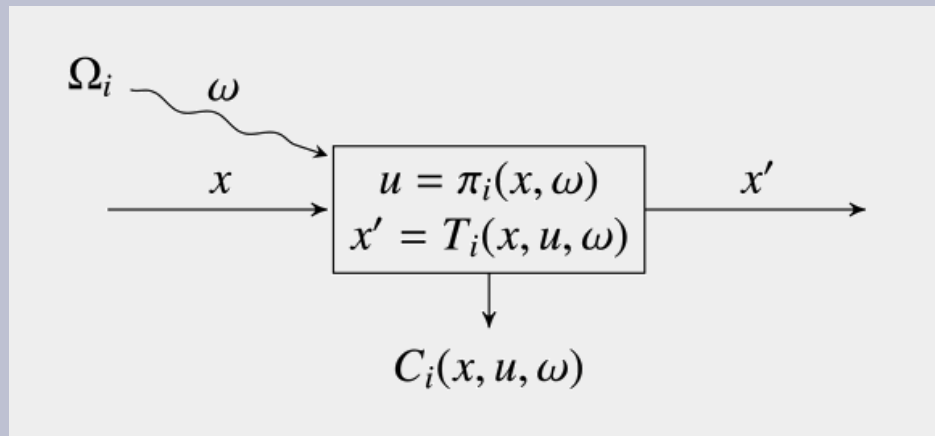
Modelling the German power and H2 markets with **uncertainty**

Using a Multi-Stage Stochastic
Dynamic Programming model to
account for the variability of
Renewables and avoiding to
overestimate flexibility potential

Model Overview: Germany in 2035



How to use a stock optimally?



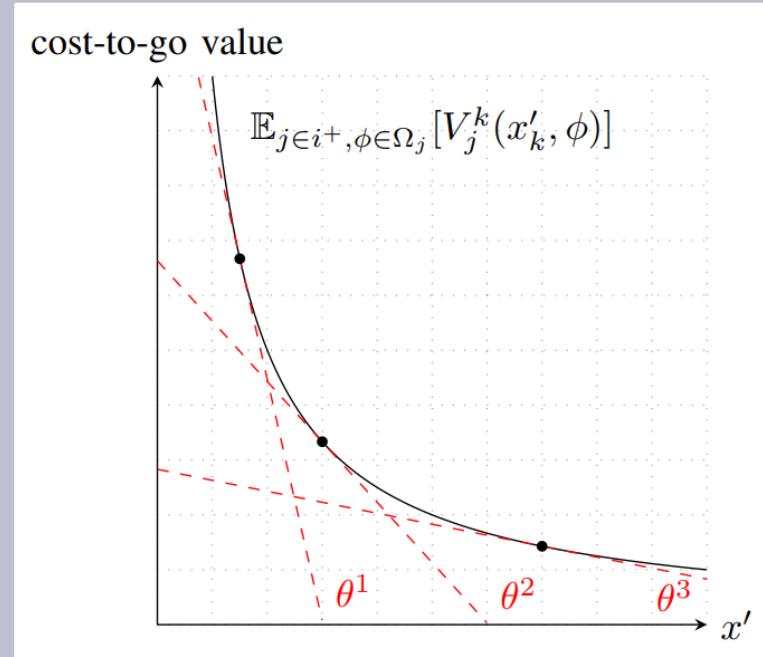
$$\text{minimize}_{\pi} \quad \mathbb{E}_{i \in \mathbb{R}^+, \omega \in \Omega_i} (V_i^\pi(x_0, \omega))$$

$$V_i^\pi(x, \omega) = \min_{x, x', u} C_i(x, u, \omega) + \mathbb{E}_{j \in i^+, \phi \in \Omega_j} (V_j(x', \phi))$$

$$\text{subject to} \quad \begin{aligned} x' &= T_i(x, u, \omega), \\ u &= \pi_i(x, \omega) \in U_i(x, \omega) \end{aligned}$$

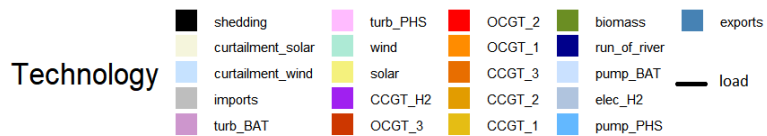
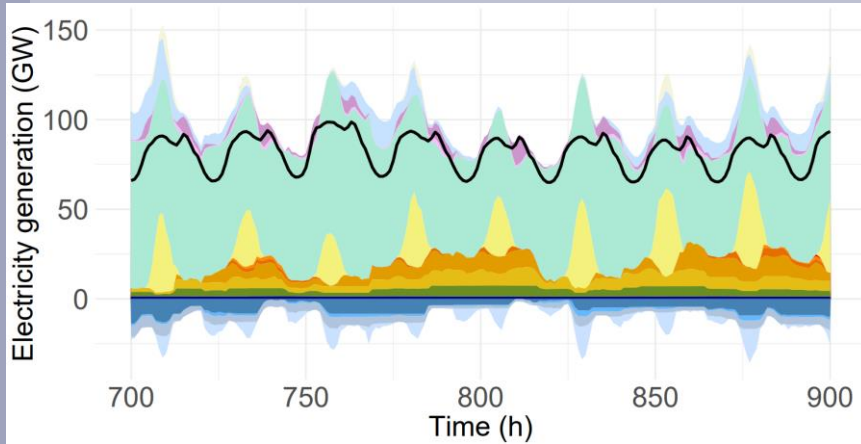
How to use a stock optimally?

- Approximation of the cost-to-go term with Benders cuts
- Back & Forth iterations for building the convex envelope of the function
- Once training ends, we get a « policy » to be run over hundreds of simulations

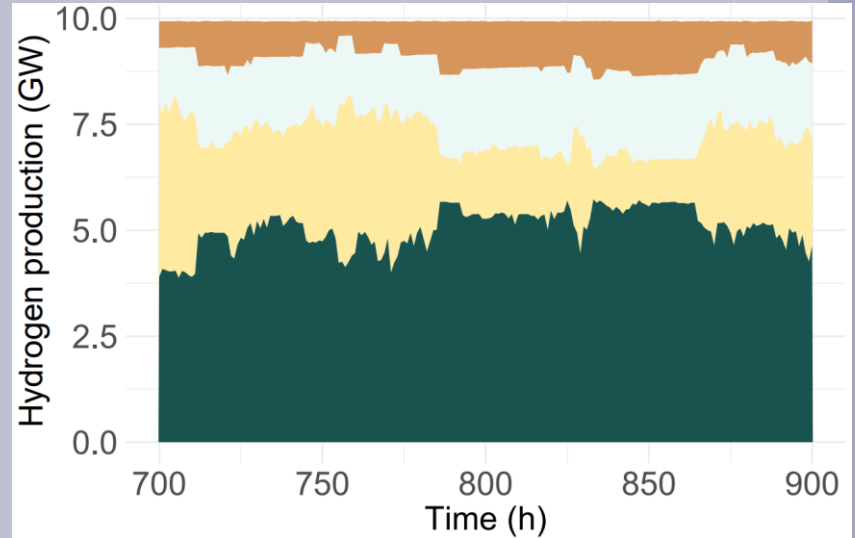


Visual outputs

Power dispatch



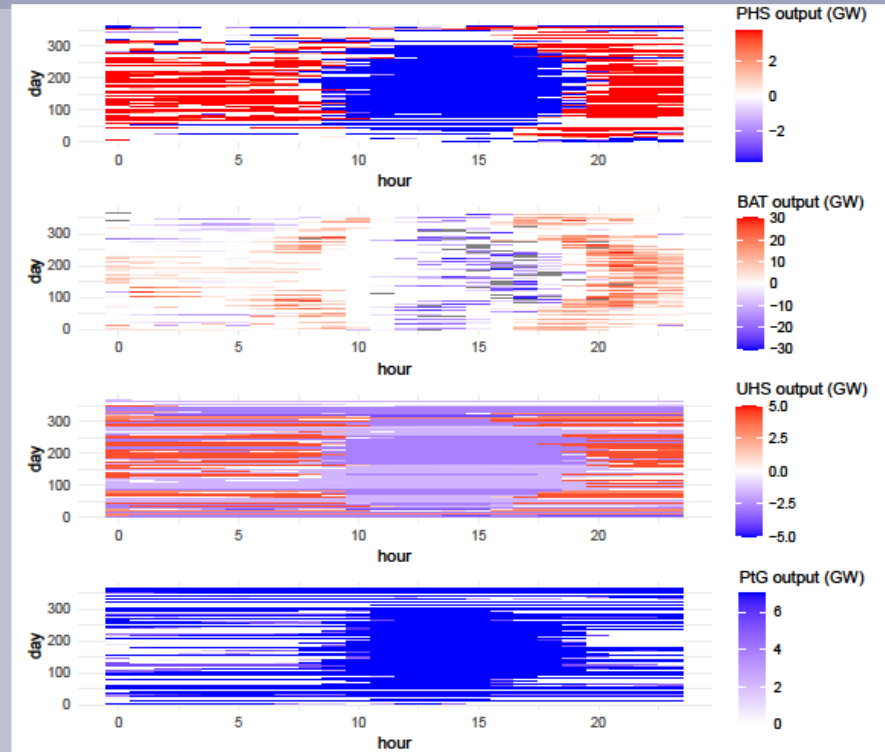
H2 dispatch



Technologies patterns of use

Findings

- Daily cycles are shared by all technologies in summer times
- Batteries offer more power (peaker behaviour)
- Flexibility assets are mapped on renewables production patterns





What impact of an increased PtG capacity?

35%

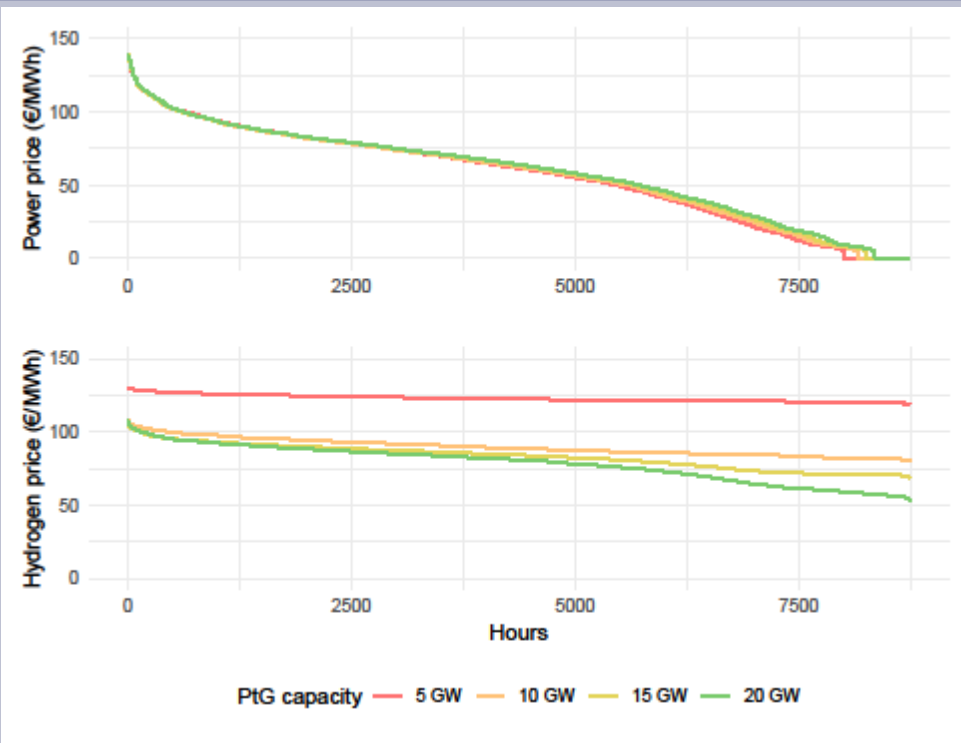
**Reduction in energy curtailment when
the electrolysis capacity goes from 5
to 20 GW. (From 100 TWh to 65 TWh)**



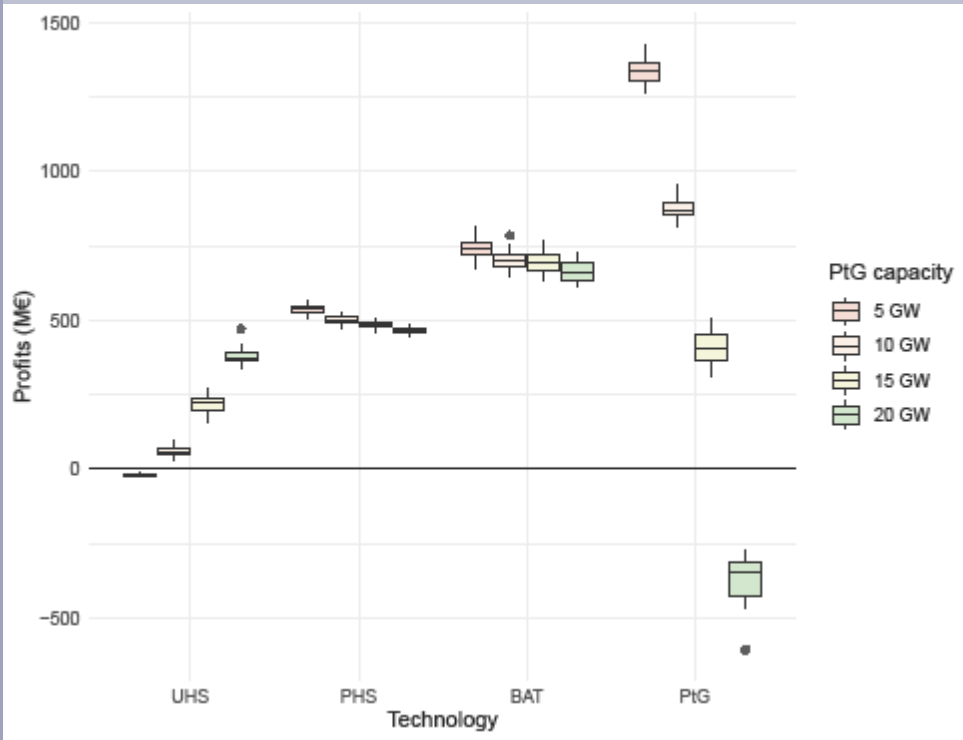
Dynamics on prices

Findings

- Power prices are not very sensitive to PtG capacity
- Tremendous impact on Hydrogen prices (35% reduction)



Winners & Losers



Findings

- UHS is the only technology to benefit from PtG development
- Low impact on PHS and Batteries profits
- Tremendous impact on Electrolysers profits, negative values obtained between 15 and 20 GW installed

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05

Analysis

Main insights

Insights

01

Power-to-Gas is helpful

It is a key tool for decarbonizing hydrogen production and reduces renewables curtailment.

02

PtG fosters the rise of a full H2 infrastructure

Underground Hydrogen Storage are increasingly profitable with PtG development.

03

You are your own worst enemy

Electrolysers lose utilization rate and lower hydrogen prices, sawing off the branch they are sitting on. PHS and batteries are not endangered by it.

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06

Conclusion

What to remember

Study objectives



Modelling

SDDP is applied to model the interaction between two energy systems, with uncertainty



Economics

The spread of PtG is found to greatly benefit the H2 system. Storage assets are not threatened.



Politics

PtG may help lowering the CO2 emissions of Germany, as well as enhancing its energy security by reducing imports

Thanks!

Do you have any questions?

Ange.blanchard@chaireeconomieduclimat.org

Camille.megy@centralesupelec.fr

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