# Are Energy Storage and Electrolysis competing each other?

A Multistage Stochastic Dynamic Modelling of the German Case

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# 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 strenghtened

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**


Is the spread of PtG threatening other flexibility sources viability?

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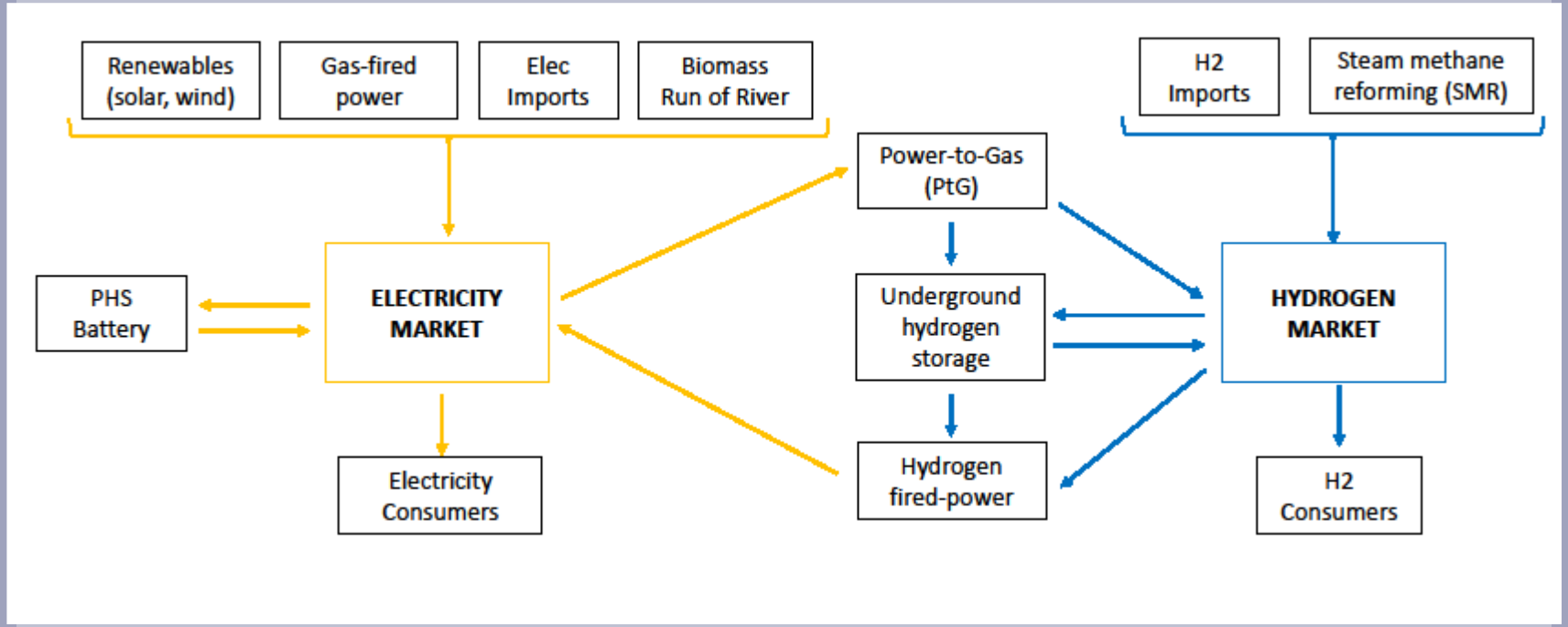
# Methodology

The SDDP framework

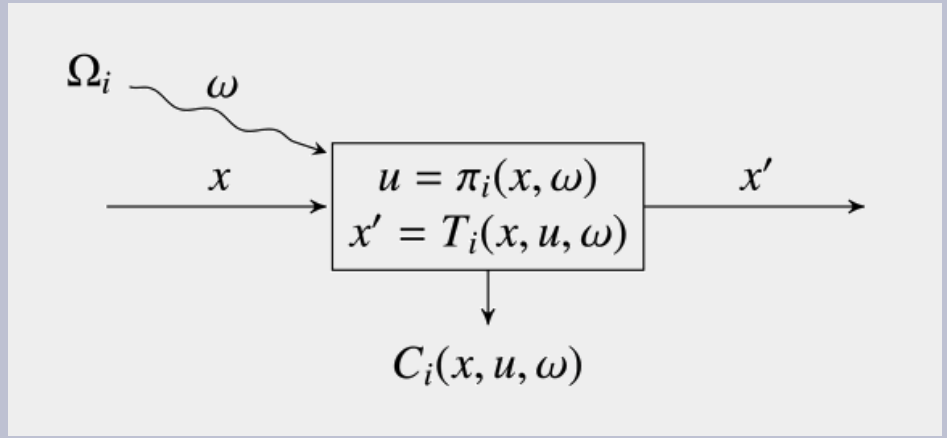
# Modelling the German power and H2 markets with uncertainty

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?



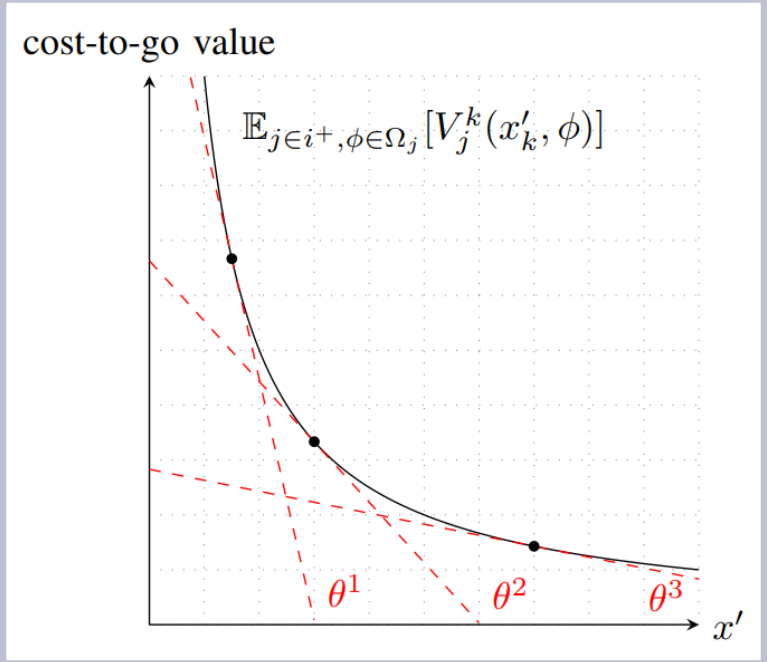

$$\underset{\pi}{\text{minimize}} \quad \mathbb{E}_{i \in \mathbb{R}^+, \omega \in \Omega_i}(V_i^\pi(x_0, \omega))$$

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

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

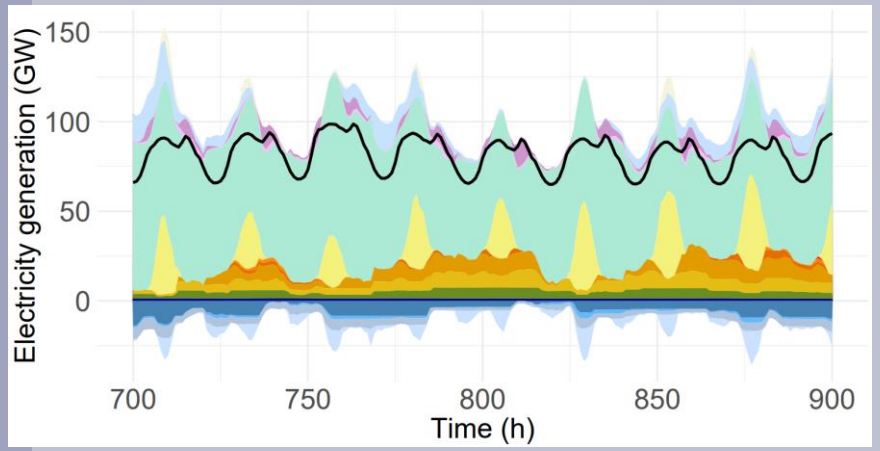
# How to use a stock optimally?

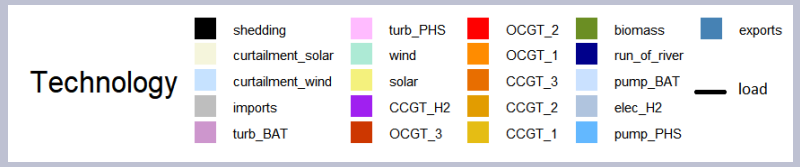
- Approximation of the cost-to-go term with **Benders cuts**
- Back & Forth iterations for building the **convex enveloppe** of the function
- Once training ends, we get a « **policy** » to be run over hundreads of simulations



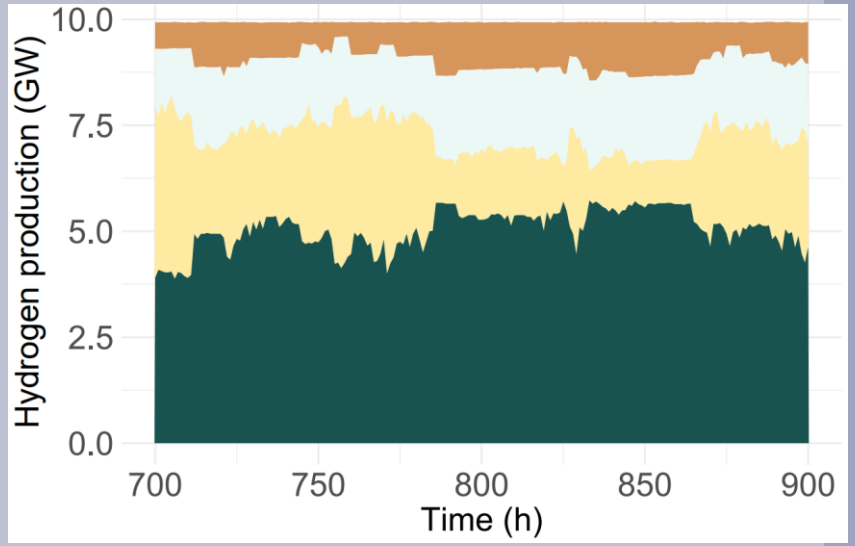
# Visual outputs

## Power dispatch



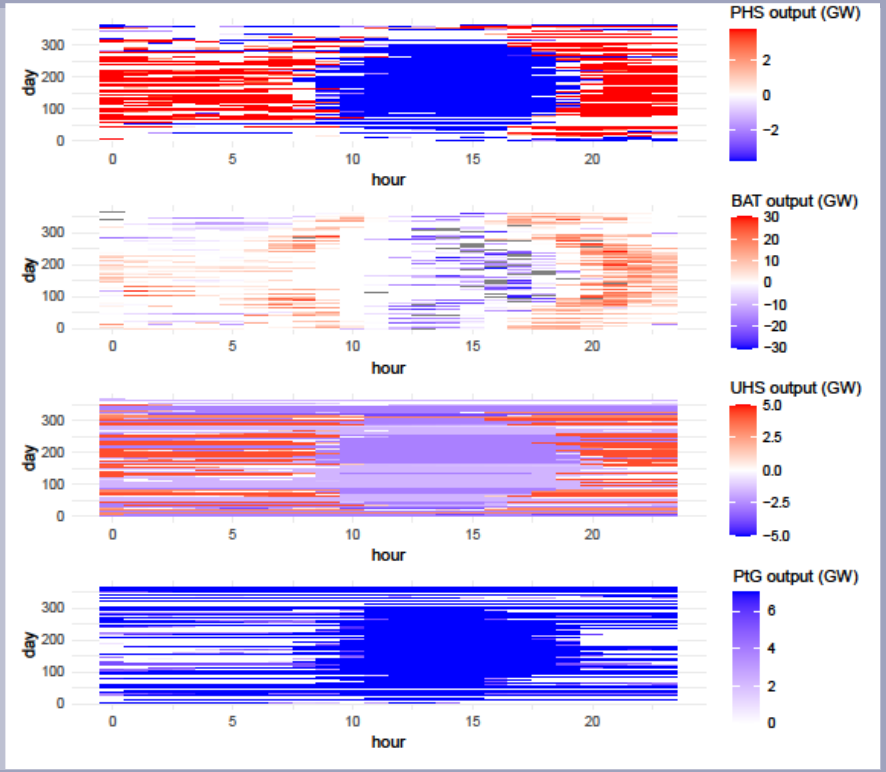

## H2 dispatch




# 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?

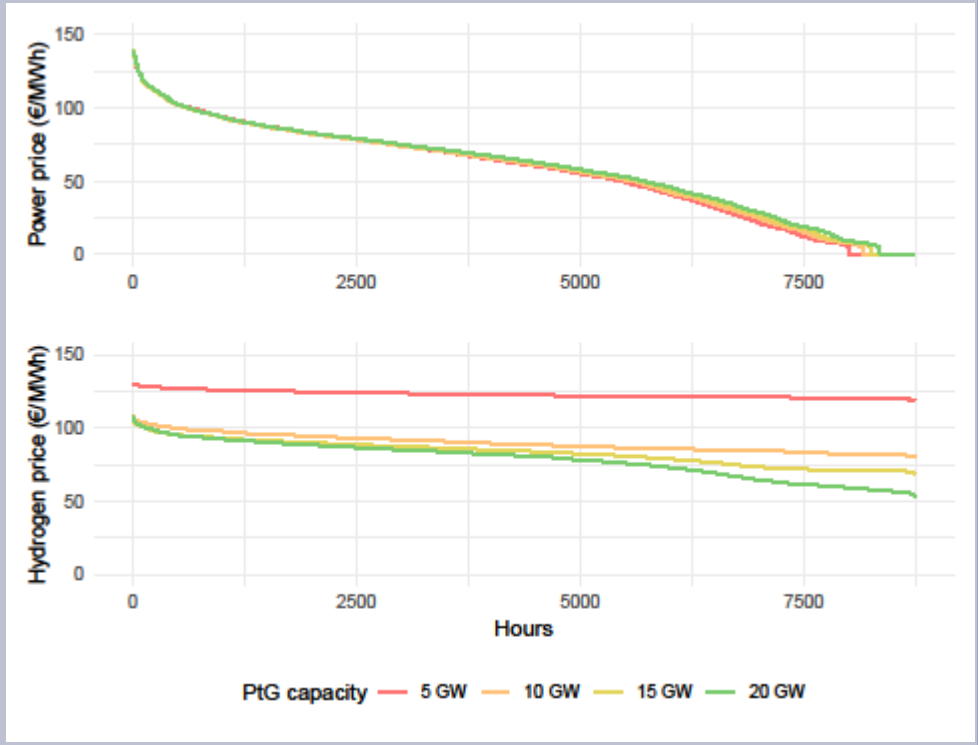
# 35%

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

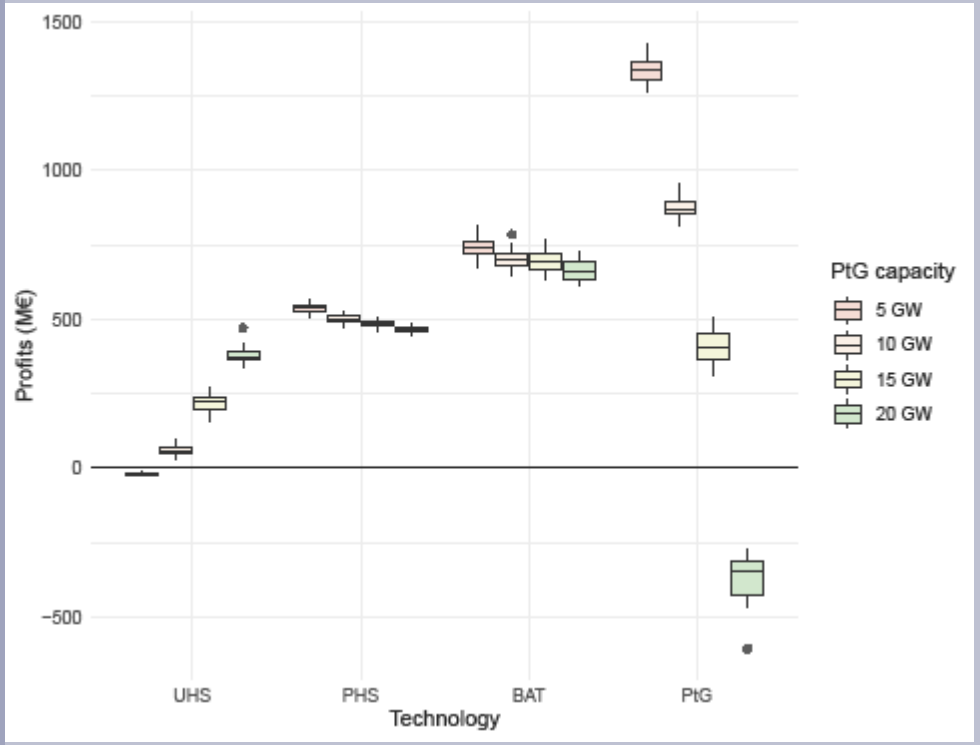
# Dynamics on prices

## 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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# 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**

## Your 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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# 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?**

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