# Three Pillars of Hourly Matching: A Tour From Model Land to Real World

Elisabeth Zeyen & Iegor Riepin
e.zeyen@tu-berlin.de || iegor.riepin@tu-berlin.de
Technical University of Berlin

EURO2024, Hydrogen and Electricity Modeling and Regulation
03 July 2024

# Setting the scene

- Voluntary 24/7 CFE procurement in electricity, Delegated act for H2 Regulation
- Both focus on the "Three Pillars" – set of rules on temporal, spatial and additionality aspects of matching demand and clean power supply
- Today we go through the **three pillars** and discuss:
  – how the pillars are implemented in the real world
  – how the pillars are implemented in mathematical models
  – caveats and challenges of model implementations
  – impact of model setups on results and policy recommendations

Iegor?

# I Pillar: Temporal matching

**Discussion**: Implementing stricter regulations requires assessing the impact on hydrogen production costs.

**Hourly electricity matching is the only reliable way to reduce emissions from green hydrogen: study**

Annual correlation of additional renewable power can push green H2 carbon intensity above that of blue hydrogen made with abated fossil gas, say German researchers

**Proposed stringent EU rules on green hydrogen 'would put the brakes on development'**

New plans on 'additionality' and strict hour-by-hour coupling of wind and solar output to electrolysers would increase the price of renewable H2, says RWE

Publication 13 October 2022 • 04:45

**Sustainaweekly - Not-so-green hydrogen perhaps a necessary evil**

Sustainability Energy transition


**'Far from perfect' | Strict rules in new delegated act will 'make green H2 projects more expensive': Hydrogen Europe**

Announcement is nevertheless welcomed by industry as it will enable companies to 'finalise investment decisions and business models'

Hydrogeninsight (February 2023), Abnamro (October 2022), rechargenews (May 2022), Hydrogeninsight (February 2023)

# Temporal matching: definition

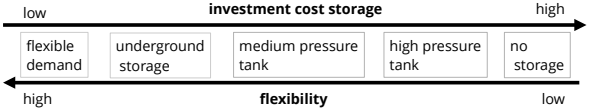
**Hourly matching** is modelled with a constraint (1), which matches electricity demand for eletrolysis process with generation of renewable resources on an hourly basis.

$$\sum_{r \in R} g_{r,t} + \sum_{s \in S} \left( \bar{g}_{s,t} - \underline{g}_{s,t} \right) - ex_t = d_t \tag{1}$$

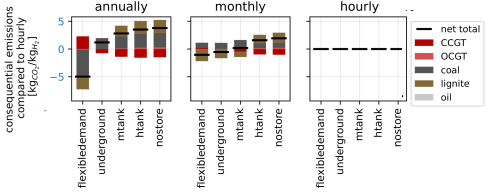
Here eq. 2 from https://iopscience.iop.org/article/10.1088/1748-9326/ad2239/pdf
– maybe here we say along the lines that the main fight in the Delegated Act was for this equation.
– explain the equation
– Now, what are the hidden issues? let's talk about the first point – flexibility.

Elisabeth?

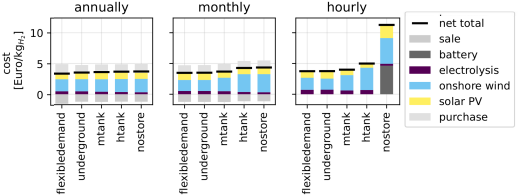
# Temporal matching: flexibility changes everything




## Emissions




## Hydrogen production costs

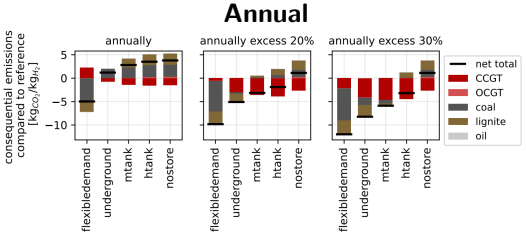


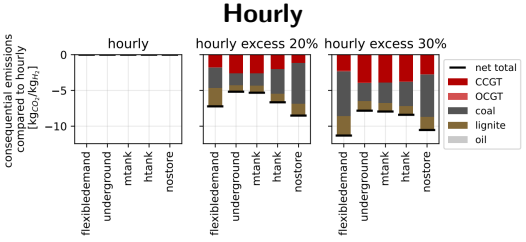

**Flexible** operation **reduces** emissions and costs, but **constant** operations **increase** them.



Zeyen et al. (2023): Temporal regulation of renewable supply for electrolytic hydrogen

# Temporal matching: higher excess sales reduce emissions






Zeyen et al. (2023): Temporal regulation of renewable supply for electrolytic hydrogen

# Temporal matching: (CFE story)

Here, the **hourly matching** constraint is extended to include electricity consumption from the regional grid:

$$\sum_{r \in CFE, t \in T} g_{r,t} + \sum_{s \in STO, t \in T} \left( \bar{g}_{s,t} - \underline{g}_{s,t} \right) - \sum_{t \in T} ex_t + \sum_{t \in T} CFE_t \cdot im_t \geq x \cdot \sum_{t \in T} d_t \qquad (2)$$

The **grid CFE factor** $CFE_t$ in eq. (2) defines the share of carbon-free electricity in grid imports.
– depends how you scope out CFE calculation
– storage tracing
– CFE isn't a parameter but a variable

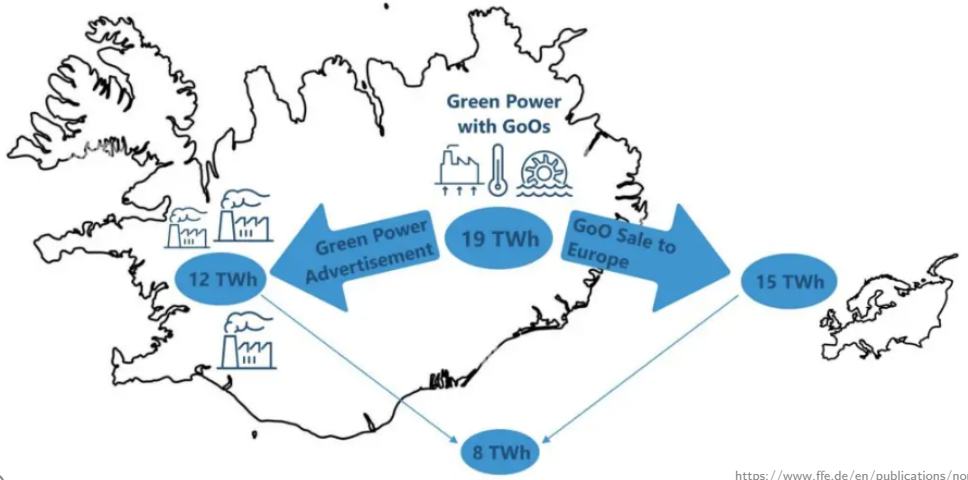
legor




Riepin & Brown (2023): https://zenodo.org/records/7180098

# II Pillar - Geographical matching

Iegor?




https://www.ffe.de/en/publications/norway-and-the-double-marketing-of-renewable-energies/

# Geographical matching

## Microsoft signs 24/7 nuclear power deal with Constellation for Boydton data center

Matched carbon-free energy brings facility close to round-the clock carbon-free energy

June 30, 2023 By: **Peter Judge** 1 Comment

Microsoft has signed an agreement with nuclear power producer Constellation Energy, to bring a data center in Boydton Virginia closer to operating on 100 percent carbon-free energy round the clock.

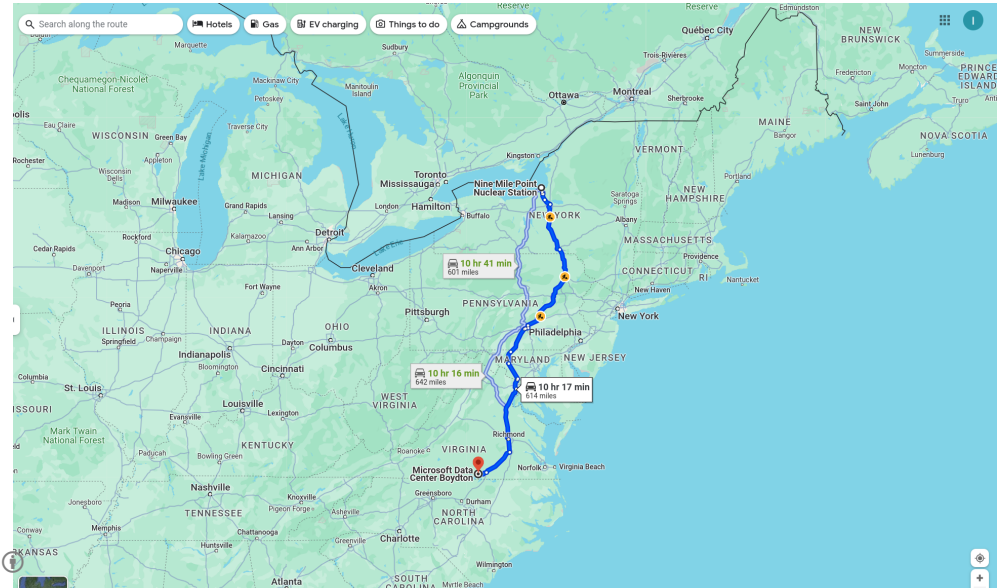
The Boydton facility will receive up to 35 percent in "environmental attributes" based on Constellation's nuclear power production, which will complement Microsoft's recent wind and solar energy purchases to put the data center very close to 100 percent carbon-free electricity 24/7.

Constellation is the largest provider of carbon-free energy (CFE) in the US, with 86 percent of its output coming from the 15 nuclear power stations it owns across the US.

None of these nuclear plants are in Virginia, but the company uses a CFE matching platform to

datacenterdynamics "Microsoft signs 24/7 nuclear power deal with Constellation for Boydton data center" (June 30, 2023)

# Geographical matching



# Geographical matching for green hydrogen production


How far can renewable generation and electrolysis be apart?

- Regulation in the EU: Geographical matching within one **bidding zone**.
- Model implementation is straightforward.

**Challenges**: Especially in large bidding zones there can be **transmission bottlenecks** actually hindering the transport of renewable generation to the electrolysis.




ACER, 2021

# III Pillar - Additionality

Iegor starts?

– start with the fact that it's complex and messy both in real world and in models
– define it (over MW and MWh)
– as a funny reference, we can re-use the Microsoft PPA deal example with existing nuclear power.

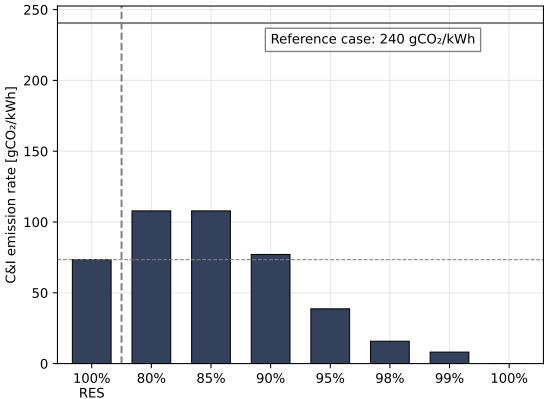
# Additionality: definition challenges

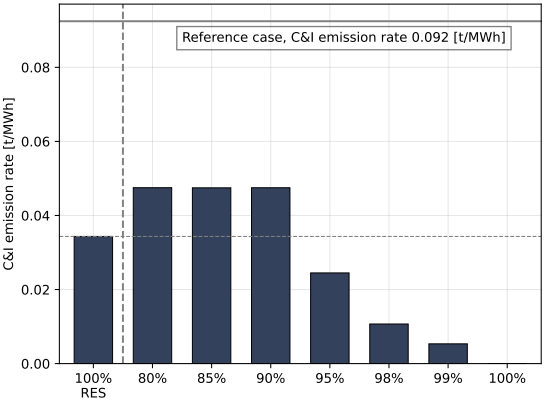
Iegor or Elisabeth?

– additionality in the real world: RED definition, Google definition, DA definition

# Additionality: how to model a background grid 1/2?

legor




Scenario: Germany – 2025 – 24/7 CFE with 10% participation of C&I sector – baseload profile – all costs from DEA 2025. Left: Constrained RES expansion (the Easter Package), Right: unconstrained RES expansion.

# Additionality: how we model a background grid 2/2?

Elisabeth

– here: cooptimisation vs sequential optimisation, results and thoughts about all it.

– conclude with reference to Lissy's paper on additionality

# Take aways (first version)

1. Do not take results for granted, try to challenge everything!
   "We must fight our biases to see the solutions" (Auke Hoekstra)
2. Talk to others in research community, share your concerns!
   "A problem shared is a problem halved" (Old saying)

ChatGPT4 hallucination, 2024

# Contacts, Resources, Acknowledgements

**References:** **Temporal regulation of renewable supply for electrolytic hydrogen (2023)**
**References:** **More about the 24/7 CFE research project (2022-2024)**

**Code:** This work done in a spirit of open and reproducible research:
🔓 code: **github.com/PyPSA/247-cfe**
🔓 code: **https://zenodo.org/records/8324521**



**Send an email:**
Dr. Elisabeth Zeyen, e.zeyen@tu-berlin.de
Dr. Iegor Riepin, iegor.riepin@tu-berlin.de