

Assessing the Role of Floating Offshore Wind in Regional Hydrogen Supply Chains

From long-term planning to temporal variability and cost-climate
trade-offs

PhD research overview

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Supervision

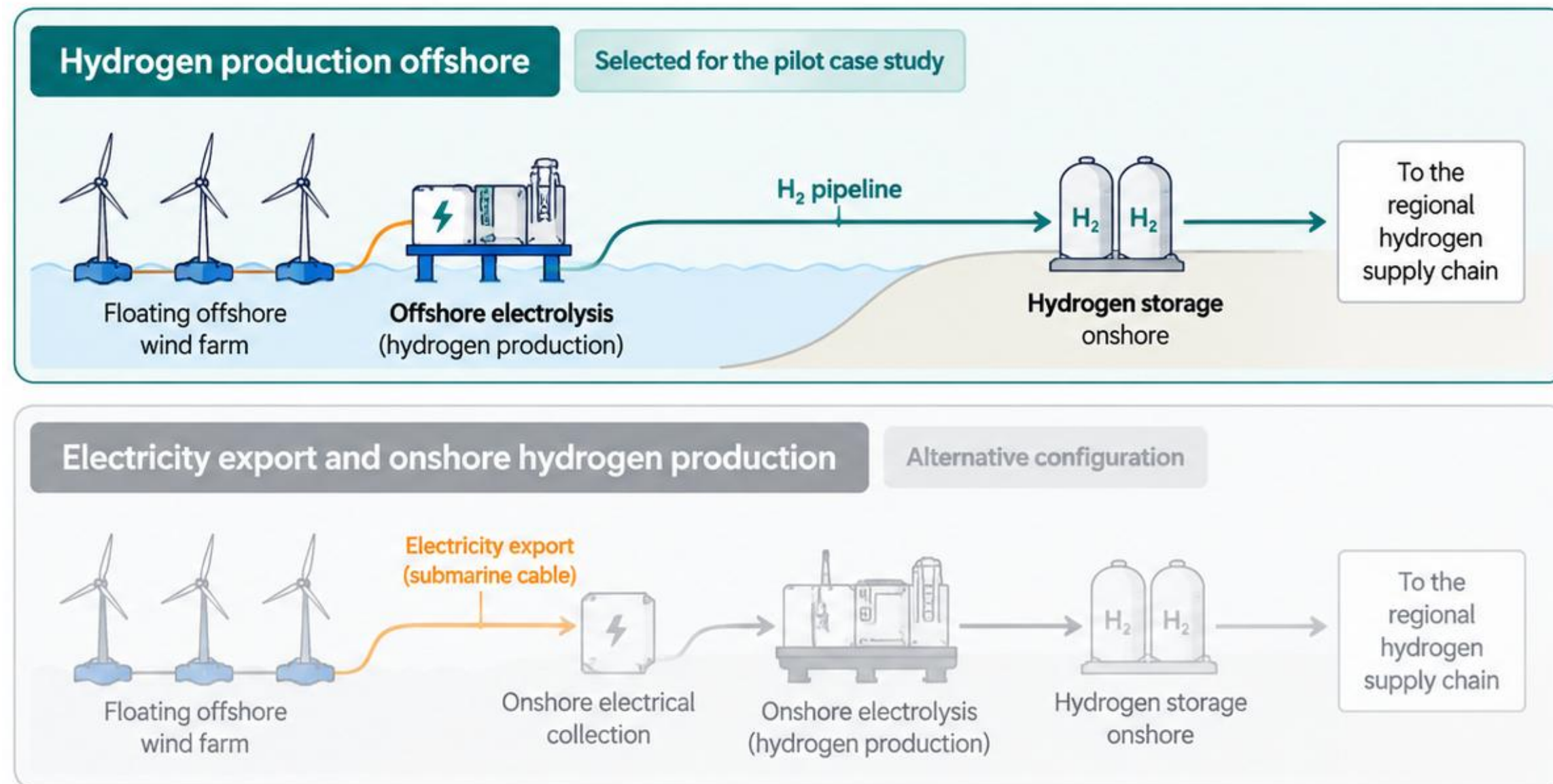
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Why Couple Hydrogen Production with Floating Offshore Wind

- Hydrogen production is strongly constrained by the **availability** and **location** of energy resources
- FOW offers an **additional renewable resource**: it provides **large-scale** low-carbon electricity, particularly interesting for coastal regions
- Different **coupling** concepts lead to different **infrastructure** needs

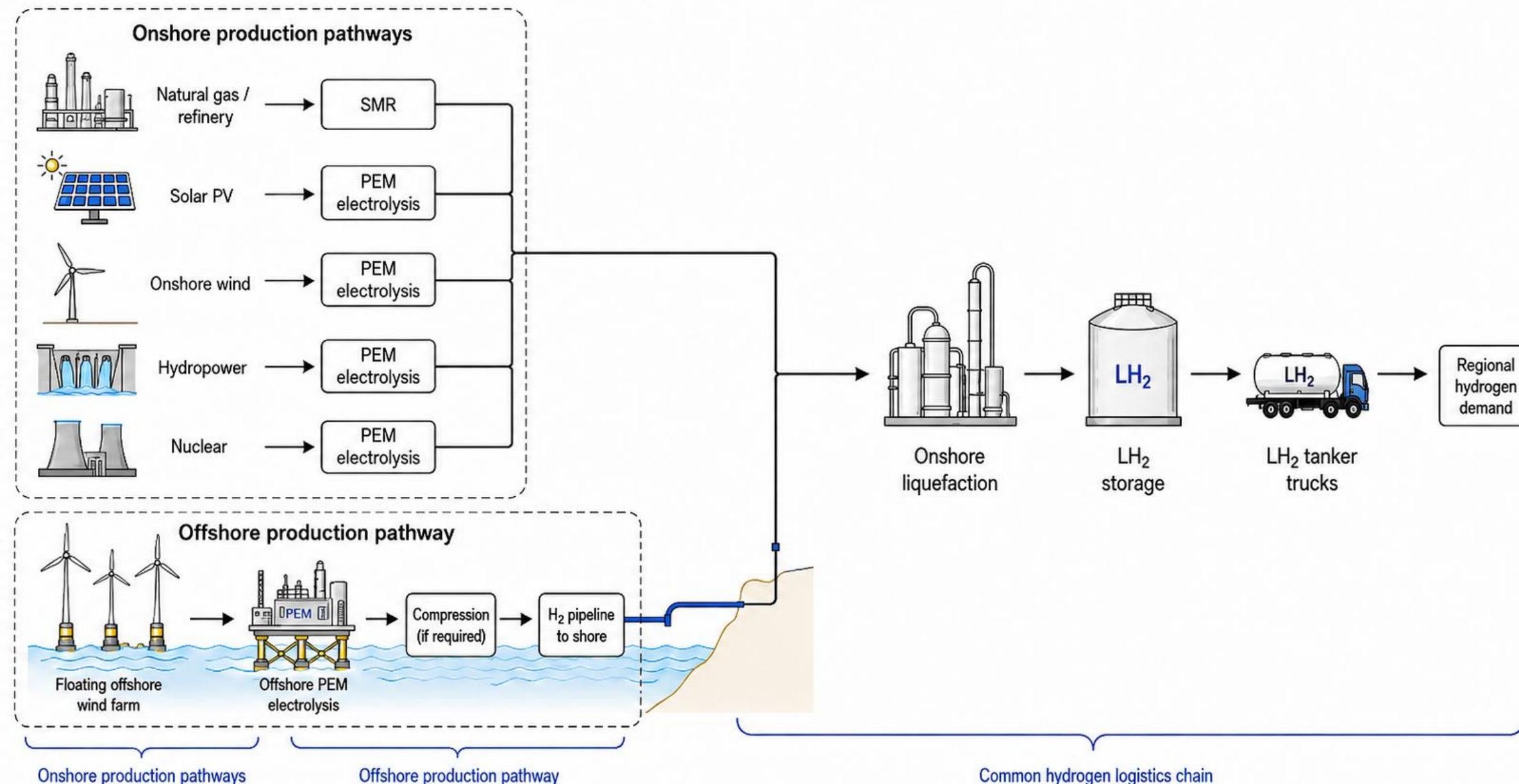
Different ways to couple floating offshore wind and hydrogen production



The pilot case focuses on offshore hydrogen production and hydrogen transport to shore

The Pilot Case: Offshore Hydrogen Within a Regional Supply Chain

Retained hydrogen supply chain for the pilot case study

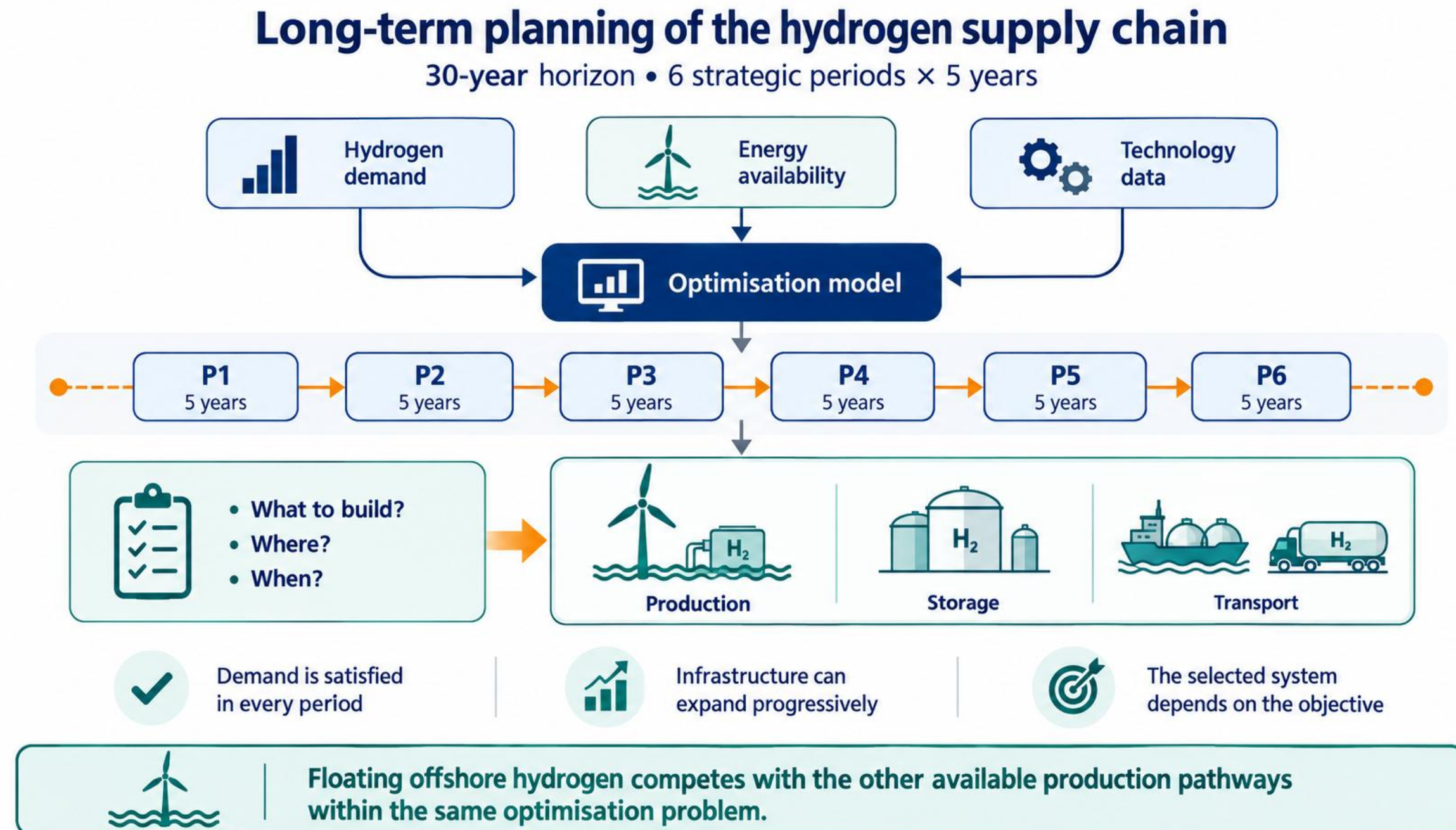


- Regional hydrogen demand can be supplied through **several pathways**
- Onshore production includes **Steam Methane Reforming (SMR)** and **electrolysis** using different electricity sources
- FOW enters the system through **offshore electrolysis** and a **hydrogen pipeline** to shore
- All pathways share the **same downstream chain**: liquefaction, storage and truck distribution

The question becomes: **when and under which conditions does the offshore pathway become part of the optimal supply chain?**

How Is the Hydrogen Supply Chain Planned Over Time?

- Hydrogen demand must be satisfied in each planning period
- New production, storage and transport capacities can be added in each strategic period 5 years
- The model selects the combination of technologies and locations that best meets the chosen objective



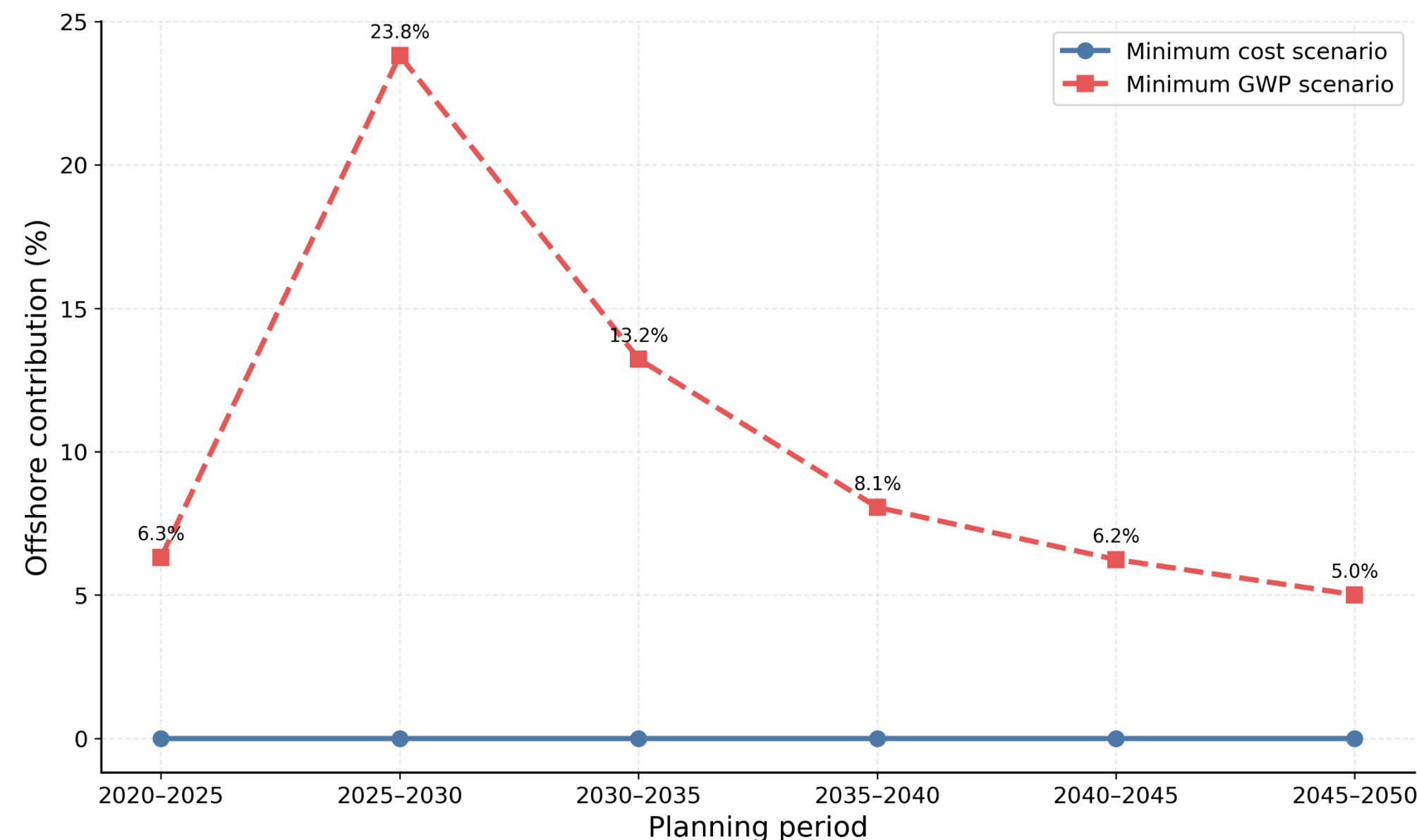
Minimum cost scenario

- 💰 2.9 \$/kg H₂
- 🌿 8.8 kg CO₂-eq/kg H₂
- SMR dominated
- Offshore not selected

Minimum GWP scenario

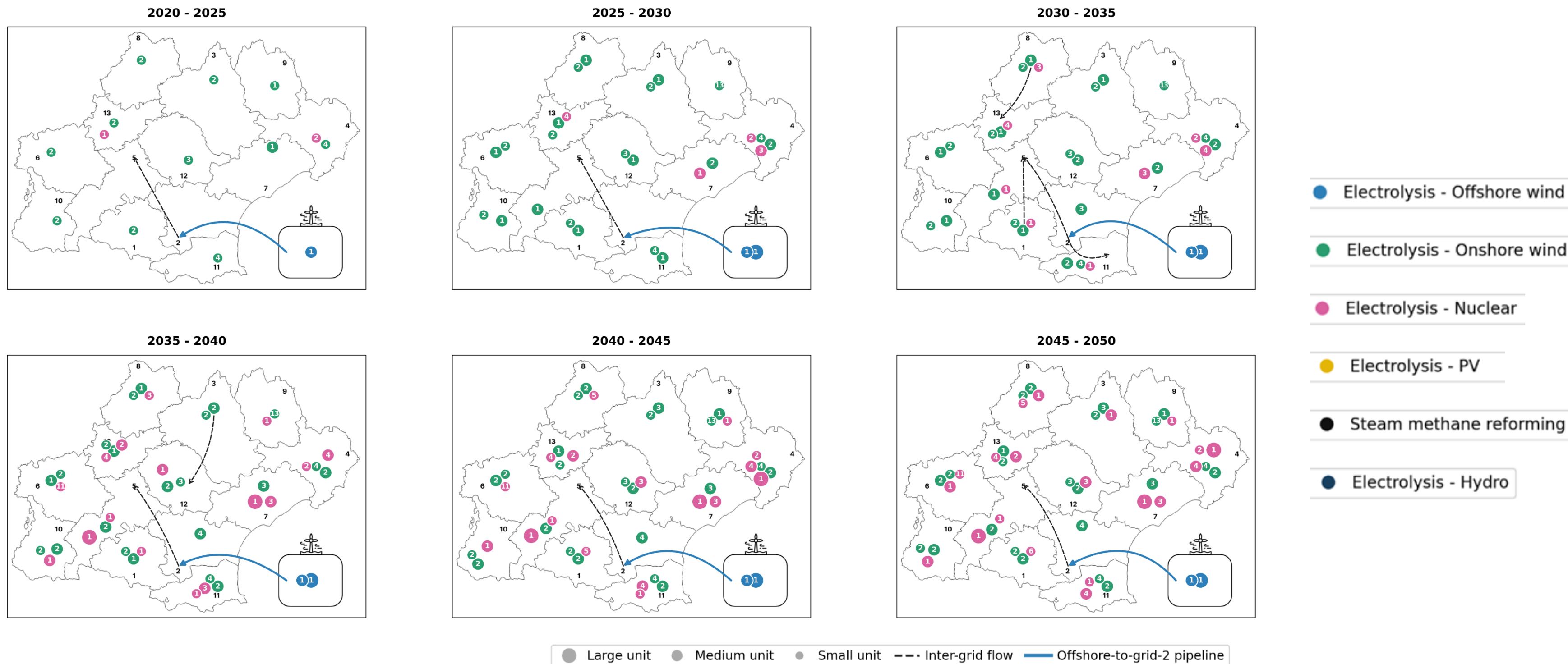
- 💰 8.9 \$/kg H₂
- 🌿 1.24 kg CO₂-eq/kg H₂
- Low-carbon electrolysis dominates
- Offshore contributes to hydrogen production

Relative contribution of floating offshore wind to hydrogen production



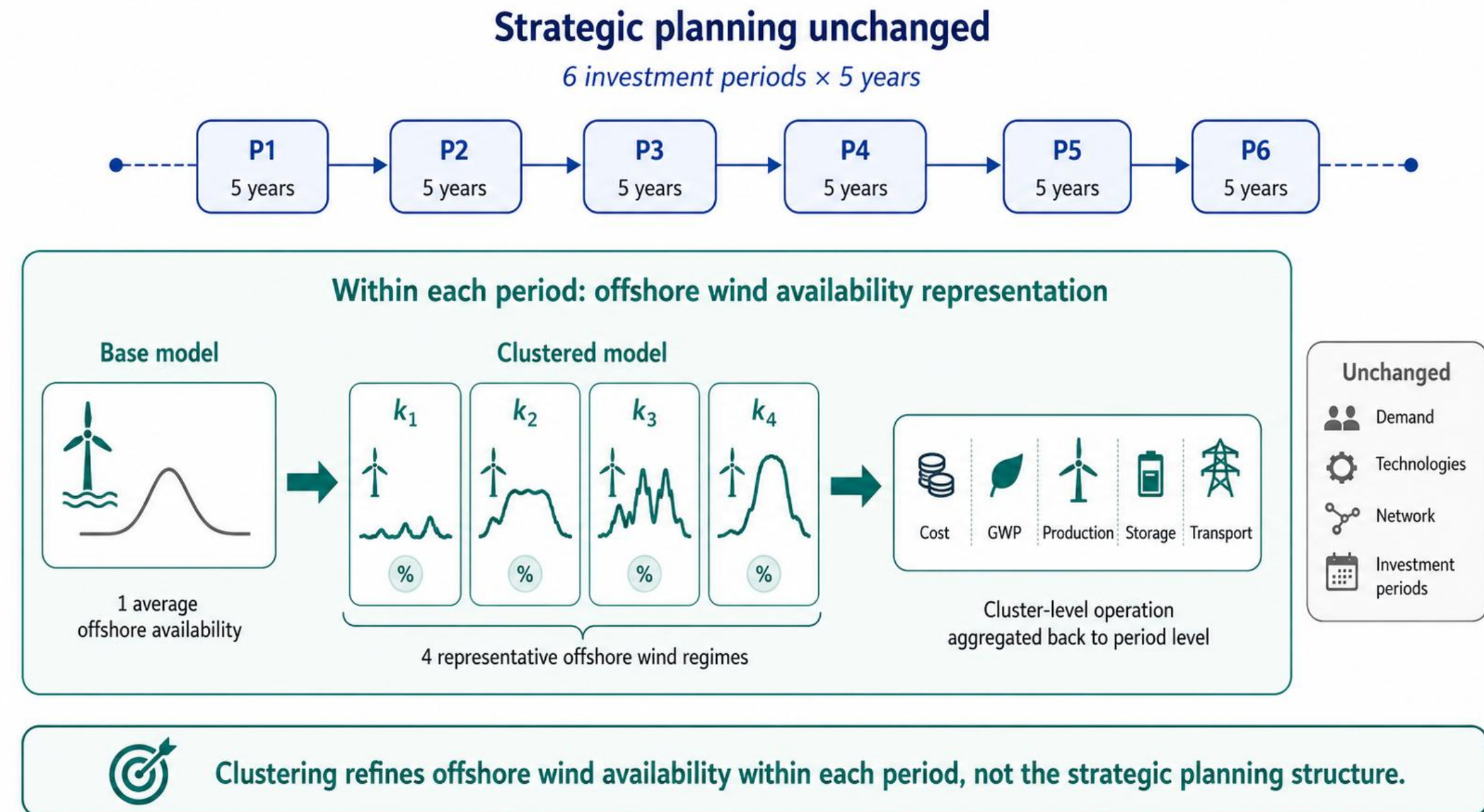
Offshore hydrogen is not selected in the minimum-cost case, but contributes up to 24% of hydrogen production in the minimum-GWP case

Spatial Deployment of the Hydrogen Supply Chains in the Minimum GWP Scenario

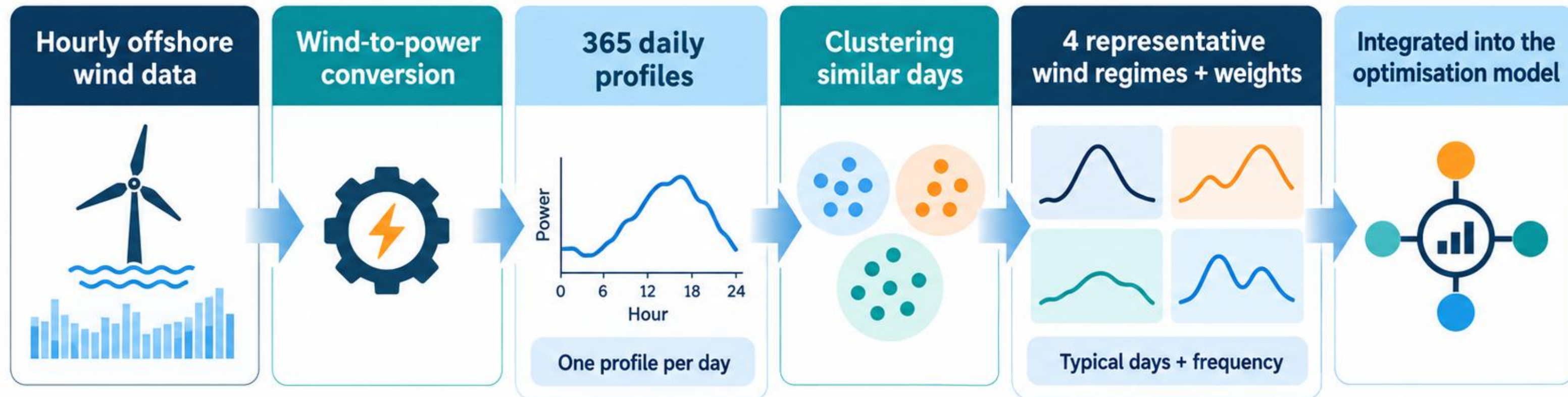


Why Represent Offshore Wind Variability

- Offshore wind is variable by nature: production changes hourly and daily
- Using only an average availability can hide low-wind and high-wind periods
- This matters for hydrogen production, variability affects electrolyser operation and supply chain reliability
- The model needed a more realistic, but still tractable representation of offshore wind availability



From Hourly Wind Data to Representative Operating Conditions



365 daily profiles → **4 representative profiles**

Objective: preserve the main variability patterns while keeping the optimisation problem manageable.

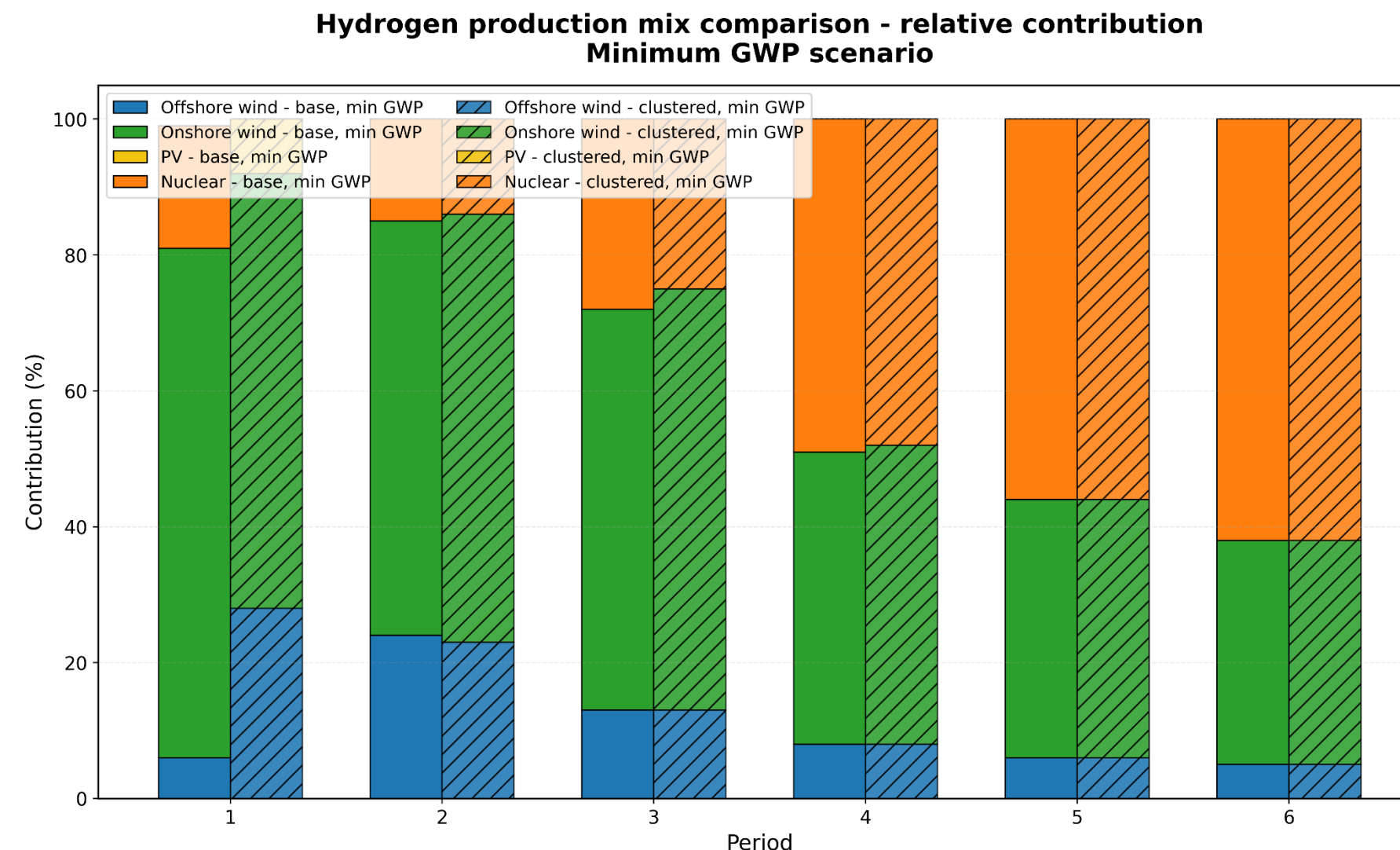
Does Temporal Downscaling Change the Minimal-GWP Scenario Results?

Base model

- LCOH: 8.93 \$/kg H₂
- GWP: 1.24 kg CO₂-eq/kg H₂

Clustered model

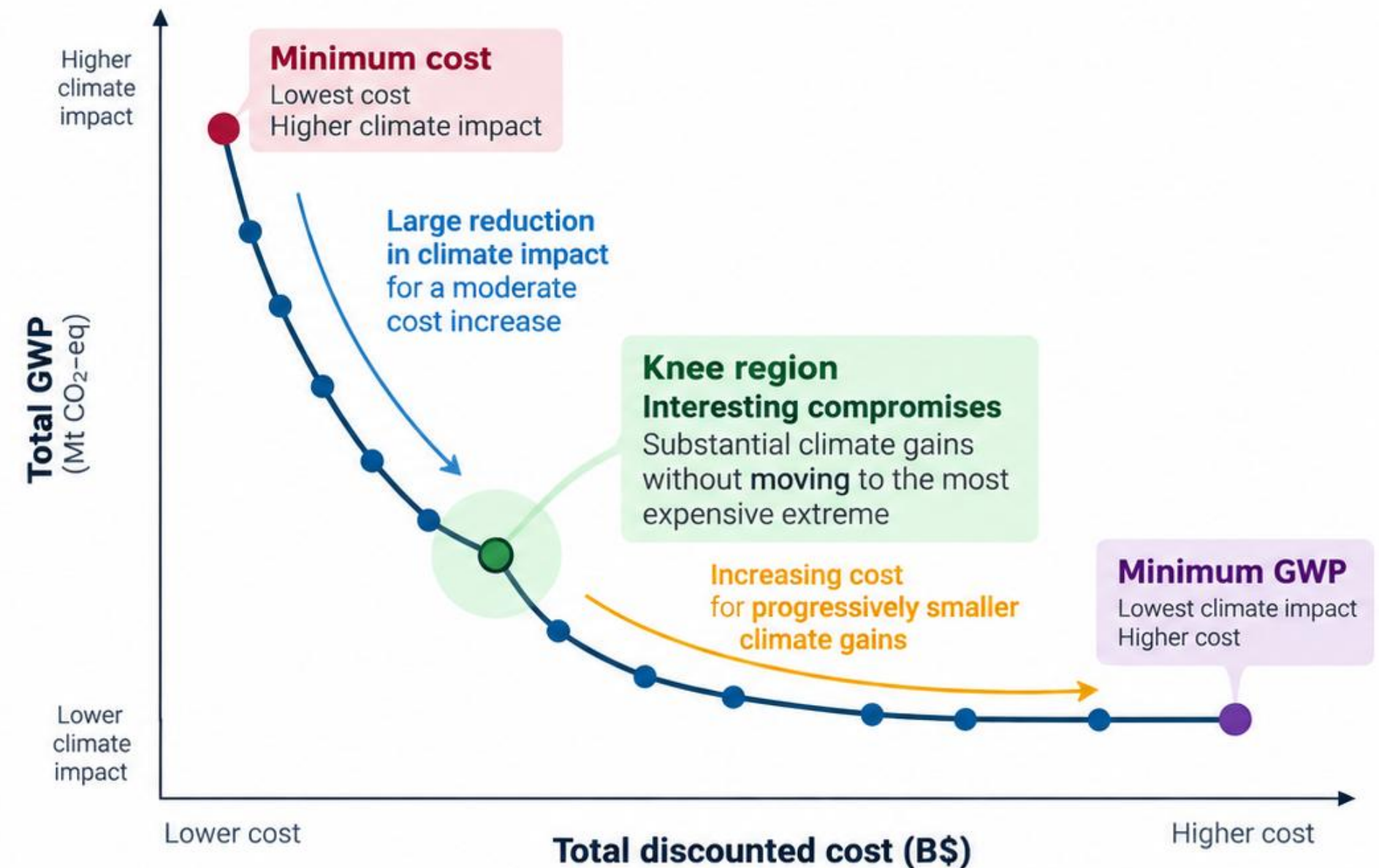
- LCOH: 7.91 \$/kg H₂
- GWP: 1.24 kg CO₂-eq/kg H₂



- Overall low-carbon production structure remains very similar
- Offshore hydrogen remains mainly an early-period contributor
- Temporal refinement changes the operation of the system more than its strategic configuration

From Two Extreme Solutions to a Range of Trade-Offs

- Minimum-cost optimisation identifies the **economic extreme**
- Minim-GWP optimisation identifies the **environmental extreme**
- Between these two points, many **alternative system configurations** are possible
- Multi-objective optimisation is used to identify the **efficient trade-offs** between cost and climate impact



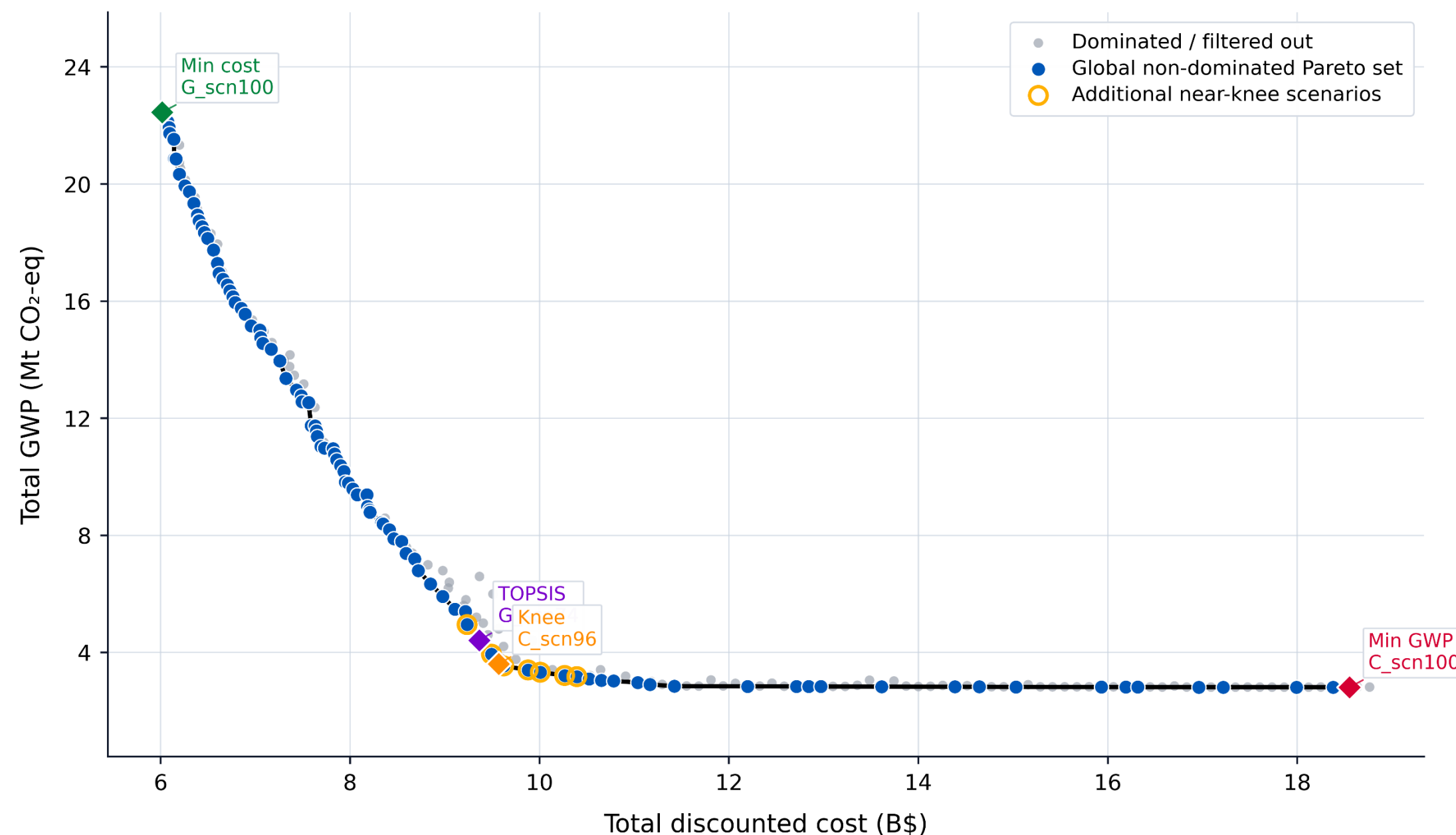
The goal is no longer to find one « best » solution, but to reveal the efficient compromises available to decision-makers

What Does the Pareto Front Reveal for the Occitanie Case

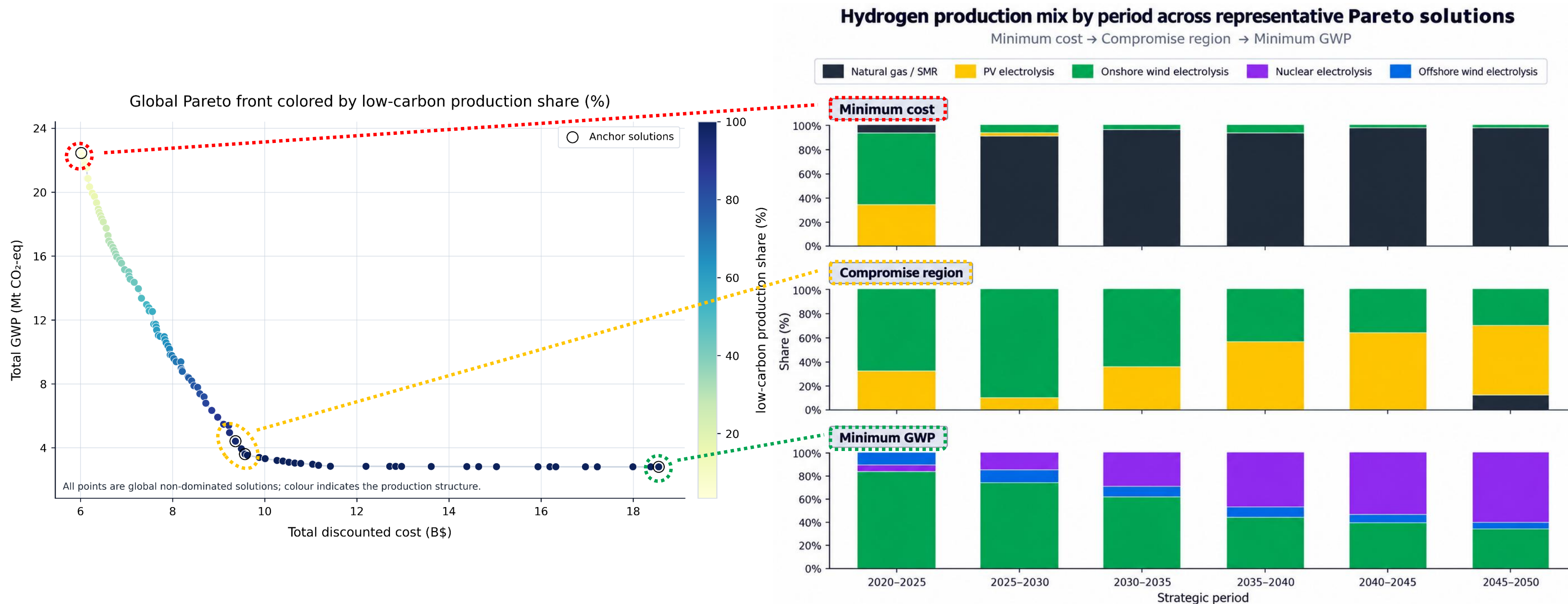
- Large gains are possible early on: significant GWP reductions can be achieved with a relatively moderate increase in cost
- A compromise region appears: around the knee, strong environmental improvements are obtained without reaching the highest-cost solutions
- Further GWP reductions require increasingly large additional expenditure

The value of multi-objective optimisation is not the « optimal » answer, but visibility on the cost of progressively stronger decarbonisation

Global Pareto front and selected scenarios



What Changes in the Supply Chain along the Pareto Front?



Offshore hydrogen is not systematically selected

- In cost-driven configurations, cheaper production pathways dominate
- FOW is not inherently competitive under a pure cost objective

Its role increases when climate performance matters

- Offshore hydrogen appears in low-GWP configurations
- It acts mainly as a complementary low-carbon pathway

Its value depends on how the whole system is represented

- Temporal variability changes how offshore wind is used
- Multi-objective analysis shows that offshore can emerge progressively as the system moves toward deeper decarbonisation

FOW is not a stand-alone answer: its relevance depends on the wider energy mix, system constraints, and the balance sought between cost and climate performance