Power-to-Gas: Real-time Optimization

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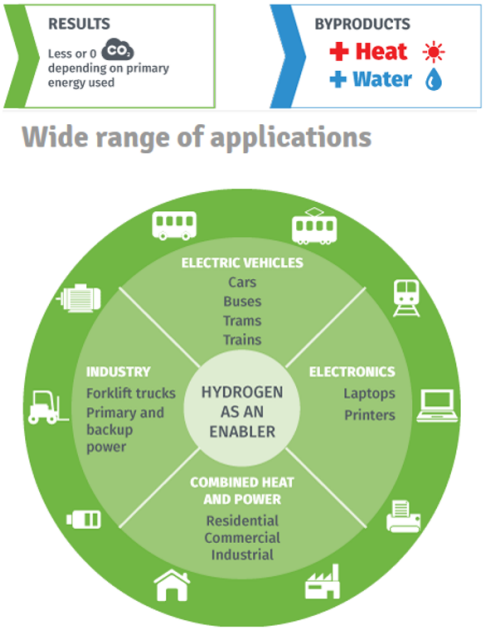
Outline

Introduction

Hydrogen is a promising energy vector in the context of the greening of society.

Fuel cells, as an efficient conversion technology, and hydrogen, as a clean energy carrier, hold great promise for energy and transport applications from the perspective of current energy, environmental and economic challenges. They will allow renewable energy technology to be applied to transport, facilitate distributed power generation, and help cope with the intermittent character of renewables such as wind power.

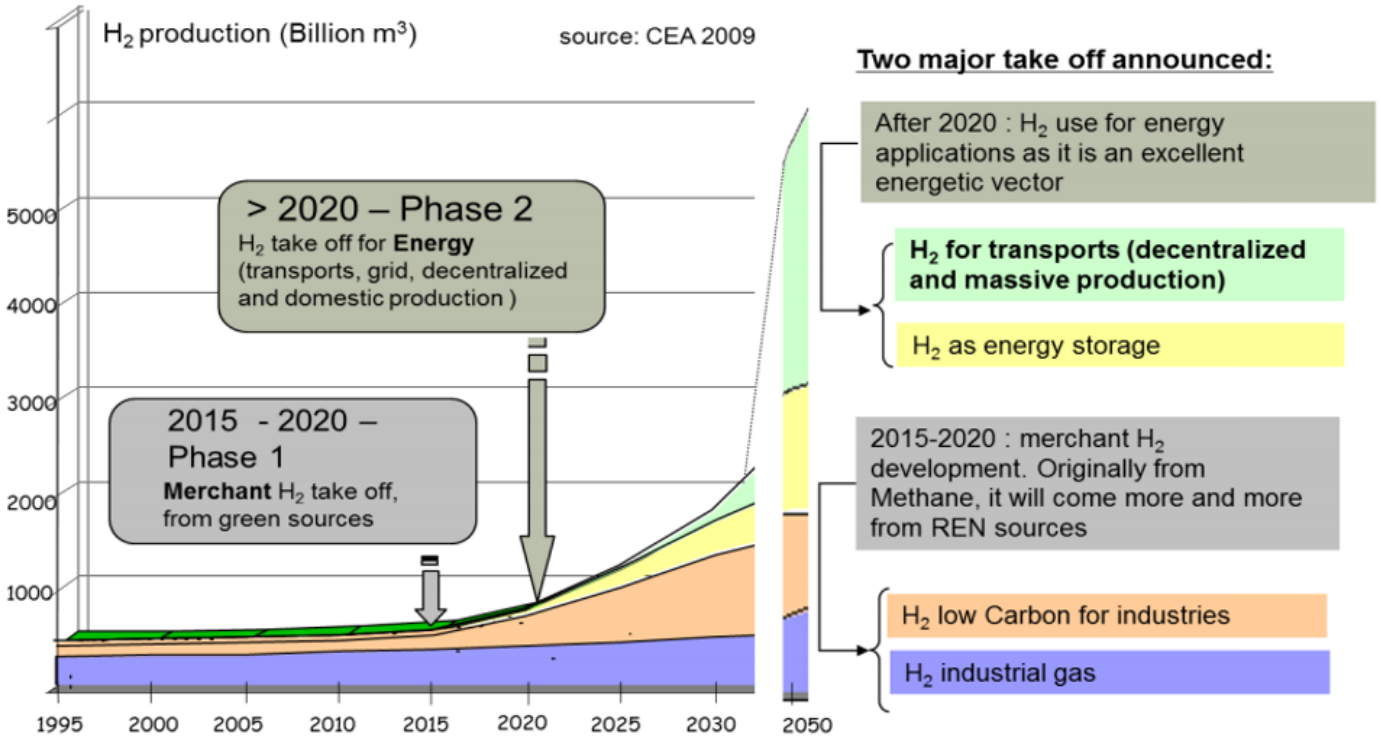


Introduction

Hydrogen is part of the Strategic Energy Technologies Plan (SET) adopted by the European Council.

Introduction

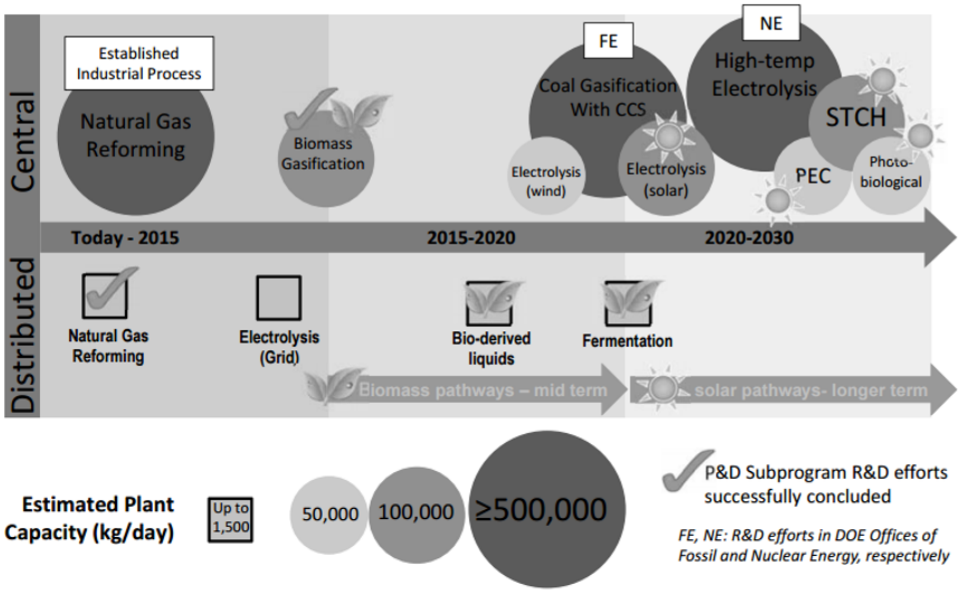
Hydrogen market is foreseen to significantly grow in the future.



Introduction

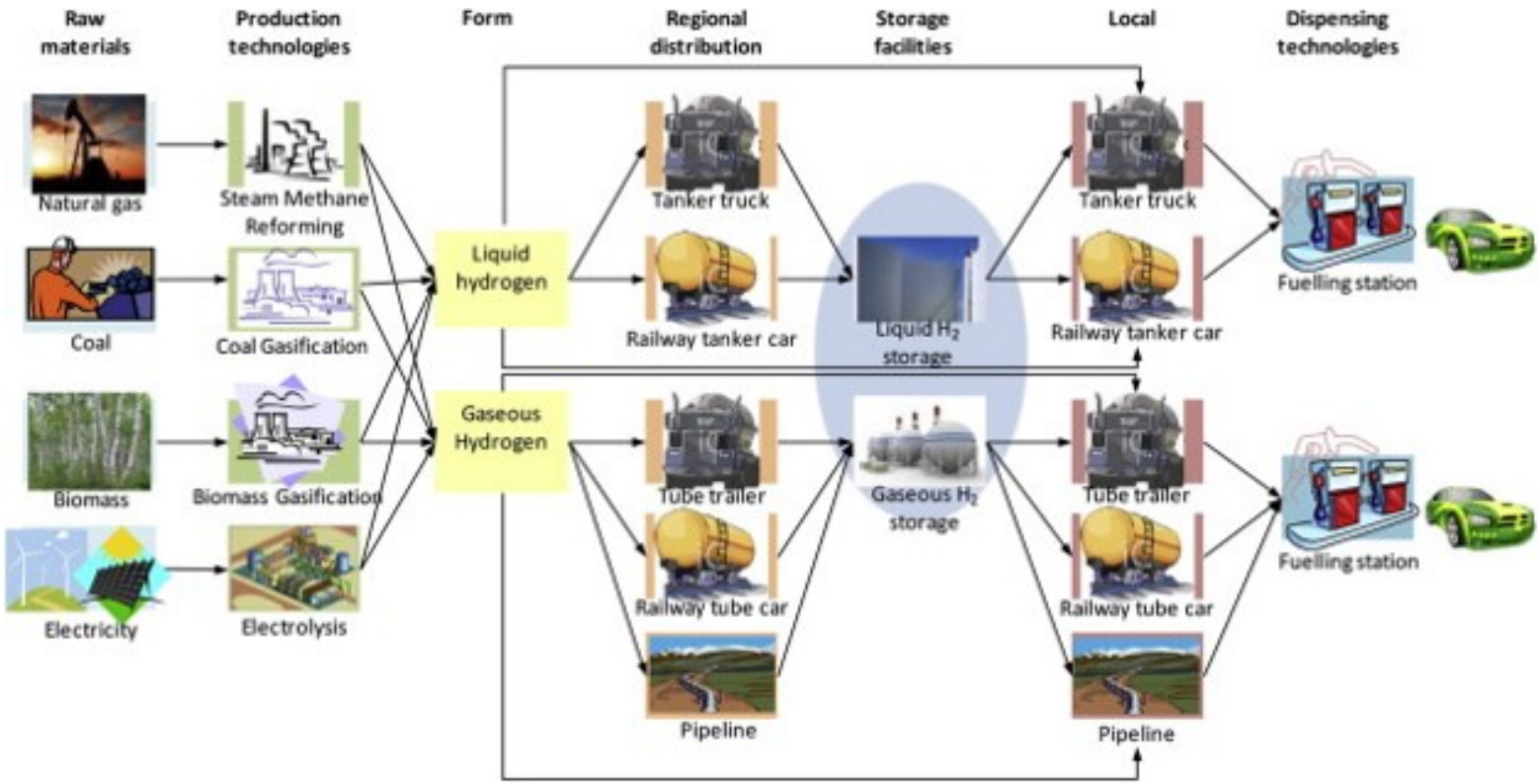
Main hydrogen production pattern, by centralised natural gas reforming, is not adapted to meet expected growth.

- This process is heavy in emissions, due to natural gas cracking and hydrogen transportation.
- Cleaner and decentralised processes better fit green expectations.



Introduction

Upcoming Hydrogen supply chains are multiple.



- They will require advanced planning and management capabilities, currently nonexistent.

Our Company

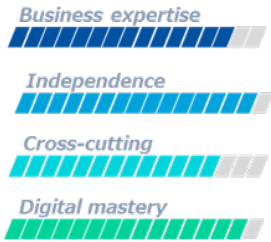
Pers-EE is positioned to address this capability gap.

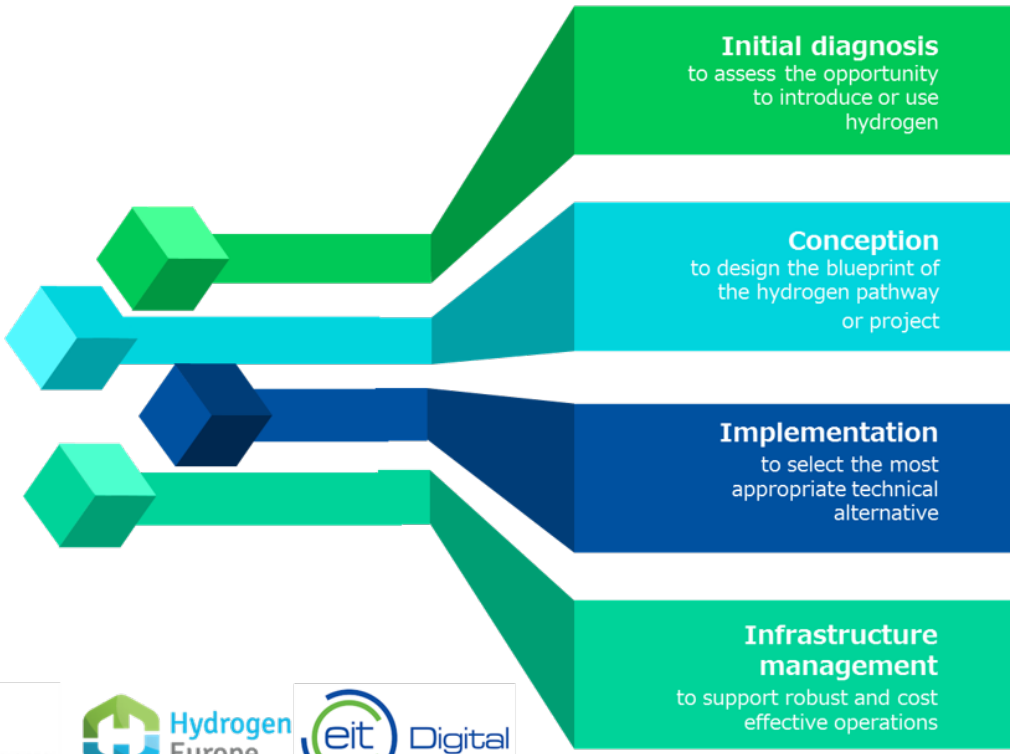
Bringing smart digital solutions to facilitate Hydrogen deployments from initial planning to real time operations

Positioning

Founded in 2013, Pers-EE combines deep hydrogen knowledge together with digital mastery; it positions itself as the operational decision specialist for hydrogen projects and infrastructure.

The company delivers innovative digital solutions targeted at every step of a hydrogen project.





H I A TASK 38 – SubTask D leader
HYDROGEN IMPLEMENTING AGREEMENT

Hydrogen Europe

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Use Cases

Focus is given to a limited number of hydrogen pathways.

Energy Source	Production	Transportation	Storage	Distribution
	By-product H2	Trucking	Gaseous 200b	Trailer swap
Wind/Solar Power Grid	Electrolysis		Gaseous 500b	HRS (cascade)
Biogas	Local SMR			HRS (cascade)

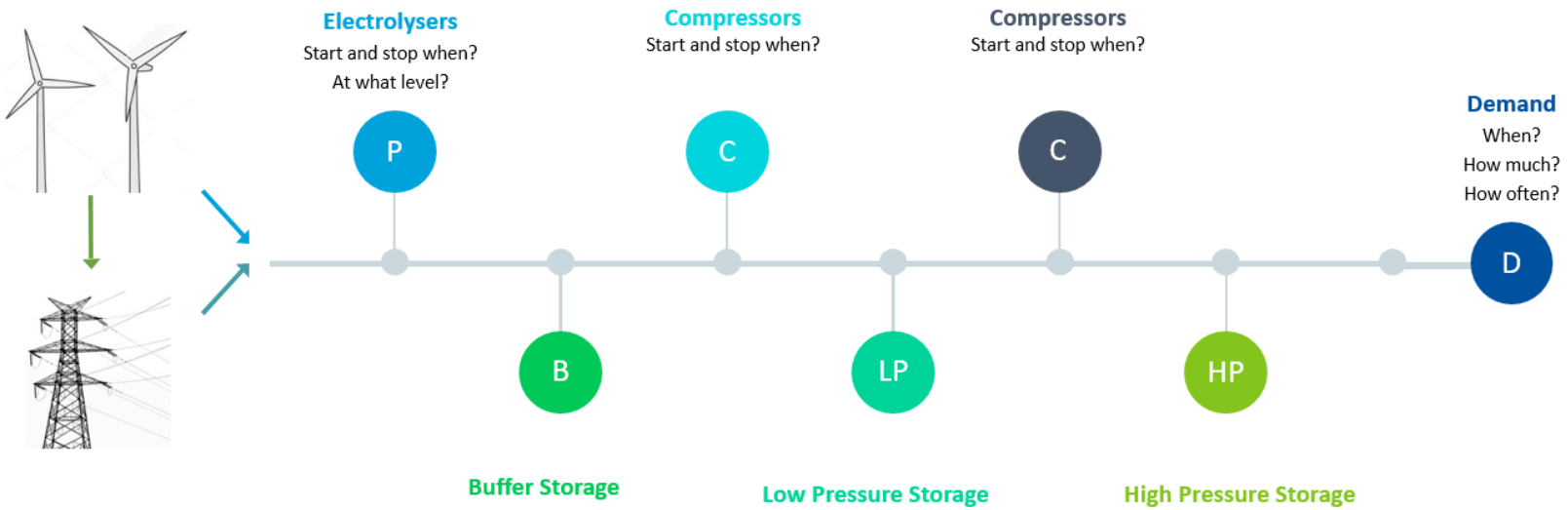
Use Cases

Out of these limited pathways, 3 use cases are under study.

N°	Use case	Overview	Optimisation issue	Modelling
1	Industrial	Hydrogen is produced in a semi centralized manner either through electrolysis or as a by product and distributed by trucks to a network of customers with relatively stable consumption patterns	Dimensioning of the supply chain (Production capacity and Storage/Truck fleet)	Mixed integer linear/nonlinear programming, robust optimization
2	Wind-to-H2	Power produced from wind is used to either produce hydrogen to meet an uncertain demand or traded in the power market.	Day-to-day allocation of wind production and purchase of complementary power need in the market	Stochastic bilevel programming (linear/ nonlinear)
3	Bus depot	A FC-bus fleet is fueled with on site hydrogen production by electrolysis or SMR	Bus refueling scheduling	Mixed integer linear/nonlinear programming

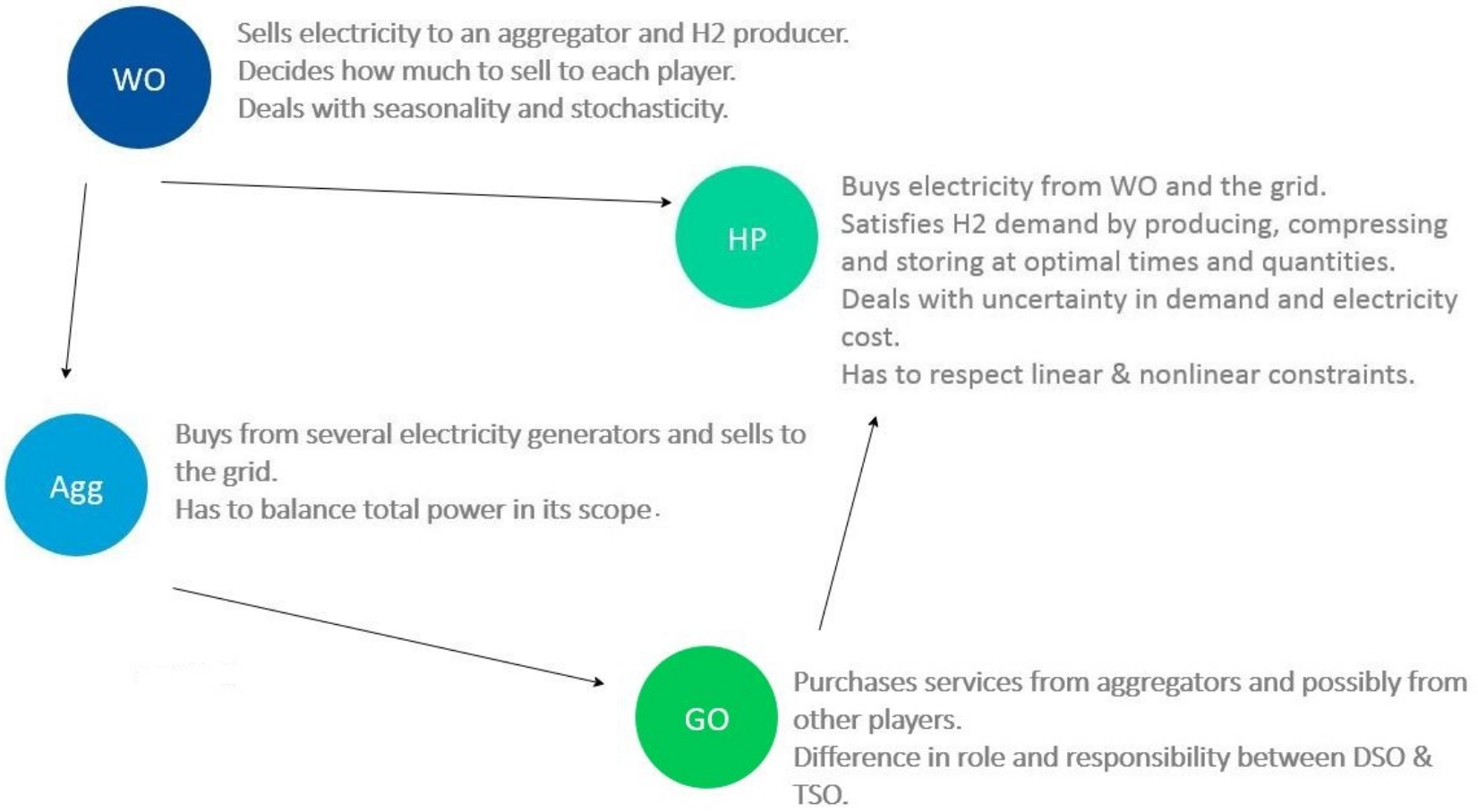
Wind-to-H2

Energy flow of the wind-to-H2 problem along with operational decisions:



Wind-to-H2

Stakeholder description of the problem: wind operator (WO), hydrogen producer (HP), aggregator (Agg), grid operator (GO).



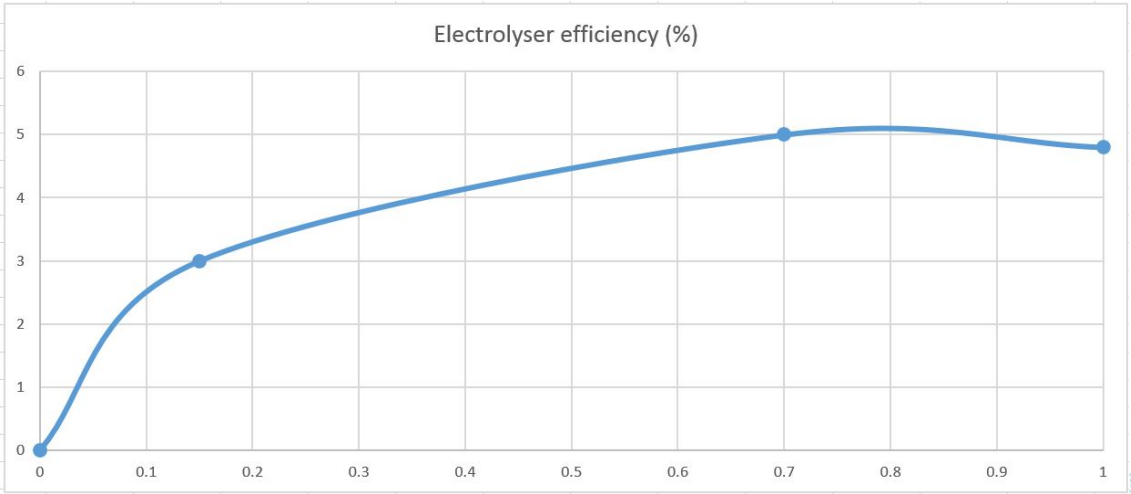
Wind-to-H2

Challenges

- Uncertainty of electricity generation from wind turbines (hourly data available)
- Uncertainty of grid prices (data available, will change)
- Demand fluctuation (forecasts available)
- Real-time optimization is required.

Operational and Legislative Constraints

- Tariffs for using the grid (thresholds for self-consumption and ancillary services) are about to change.
- Many other system constraints related to the energy system and the urban environment
- Possibly nonlinear physical constraints (production, compressors, pipelines etc)



Wind-to-H2

Initial approach to the problem is based on simulating policies.

	WO $\rightarrow$ Agg	WO $\rightarrow$ HP	Agg $\rightarrow$ HP
Policy 1	Second	First	✗
Policy 2	First	Second	✗
Policy 3	First	Second	✓

("$\rightarrow$" stands for "sells energy to")

Simulation

- Observation: 1-day stock capacity is not enough and no need for more than 2-day stock

Average results for 100 randomly (uniformly) generated instances

	Policy 1	Policy 2	Policy 3
Rev of WO (EUR)	high	medium	low
Cost of HP (EUR)	low	medium	high
Lost sales (Nm^3)	high	medium	low
Cost of delivered H_2 (EUR/Nm^3)	3.94	3.73	3.64

Conclusion

- HSC problem is complex: many uncertain parameters, linear & nonlinear constraints and multiple decision makers.
- The legislation will change soon. The market and its players are in the changing process.
- Preliminary simulation study of 3 use cases show that there is room for optimization.
- A **new** and **versatile real-time optimization framework** capturing the upcoming energy system regulatory will leverage **hydrogen** to reach its **full potential** . . .