Why European underground hydrogen storage needs should be fulfilled

Thursday, 4 April, 10:30-13:30 CEST
NH EU Berlaymont Hotel

Gas Infrastructure Europe

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Study launch event

4 April 2024

#study #hydrogenstorage @GIE @_Artelys @Frontier

GIE has commissioned Artelys and Frontier Economics to assess how underground hydrogen storage could contribute to achieving EU energy policy objectives

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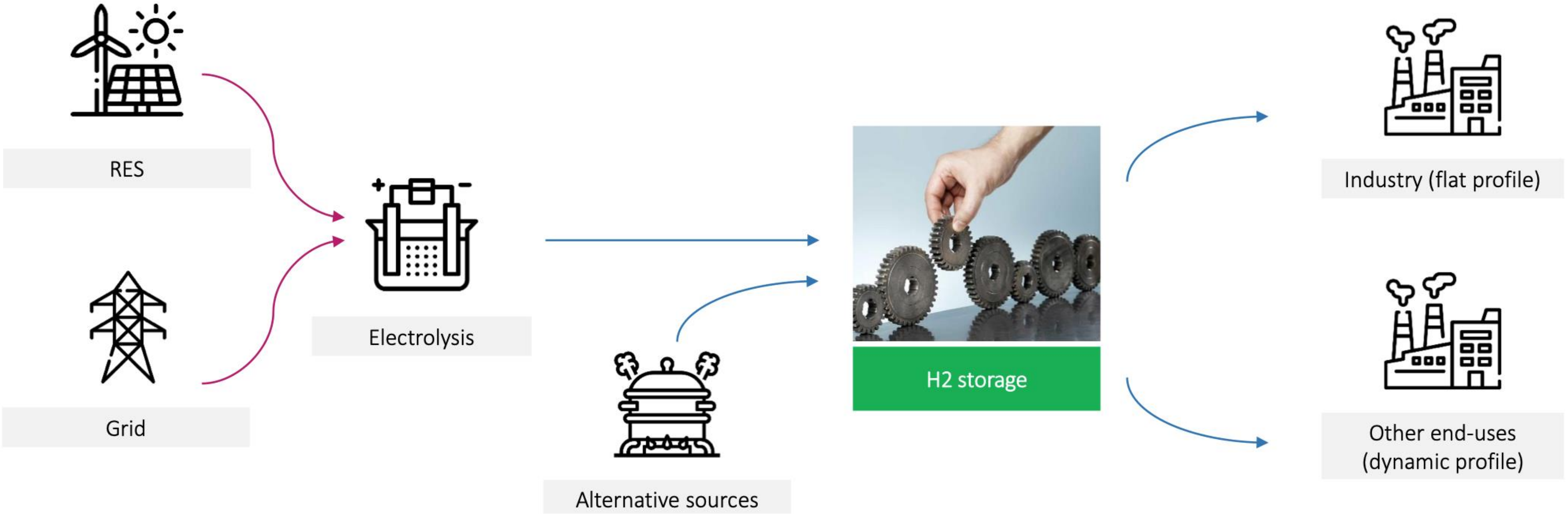
A state-of-the-art modelling exercise has been undertaken to evaluate the needs for underground hydrogen storage in 2030 and 2050

- It is crucial that the modelling framework recognises the services that can be delivered by UHS.
- Structurally, UHS is a technology that enables electrolysers to run flexibly and ensures deliverability to H2 end-uses.



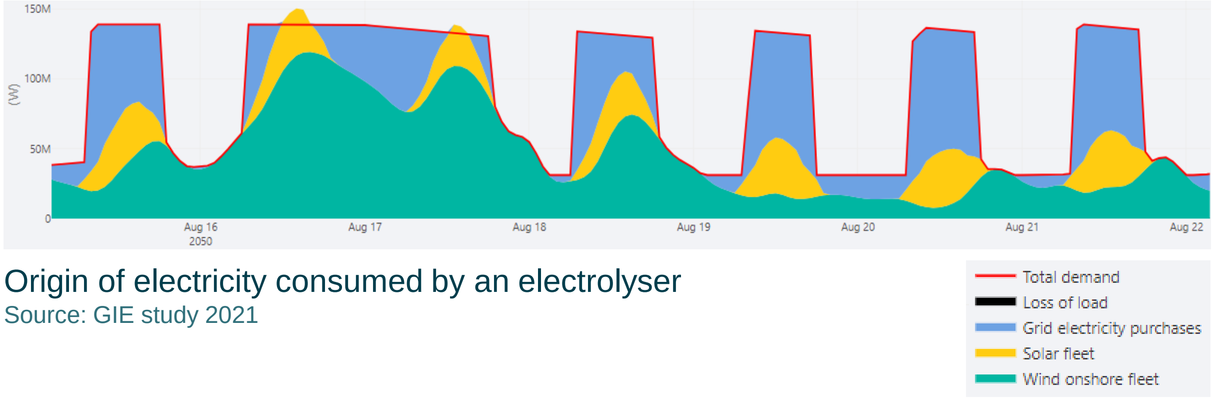
Investing in underground hydrogen storage technologies delivers economic and environmental benefits

- By explicitly representing the interlinkages, synergies and interdependencies between the electricity and hydrogen systems with an hourly time resolution, the **Artelys Crystal Super Grid** model captures the following key phenomena:

✓ **Reduction of RES curtailment** by enabling electrolysers to run during high-RES production episodes.

✓ **Reduction of GHG emissions** by enabling electrolysers to stop during high electricity price episodes.

✓ **Reduction of total system costs** by avoiding an over-dimensioning of other flexibility solutions.



Origin of electricity consumed by an electrolyser
Source: GIE study 2021

- The question we ask the model:

*What is the **optimal** level of investment in UHS technologies, based on the services they can provide to the entire system, the costs of developing and operating UHS and other flexibility solutions?*

The Artelys Crystal Super Grid model looks at how the EU energy system needs to shape up by 2030 and 2050 to reach REPowerEU and Net Zero objectives

Input parameters

- Electricity generation capacities for RES, nuclear, hydropower, etc. aligned with REPowerEU (2030) and a net-zero scenario (2050)
- Demand projections (electricity and hydrogen)
- Catalogue of investment options
  - Electricity interconnectors
  - Batteries and other flexibility solutions
  - Electrolysers and hydrogen pipelines
  - **Hydrogen storage assets**
- Technical and economic characteristics
- CO2 price and commodity prices

Computation

Objective

Jointly optimise investments and operations at country level and hourly time resolution, for 2030 and 2050

Key results

- **Investments** in UHS for 2030 and 2050

- **Operational management** of the electricity and hydrogen systems, and associated KPIs

The modelling shows that 45 TWh of UHS capacities need to be delivered by 2030 to minimise total system costs and meet policy objectives

2030 Modelling results

Total underground hydrogen storage
Capacity (Working Gas Volume)

45 TWh
LHV

Injection capacity
59 GW

Investment costs
26 Bn EUR

2050 Modelling results

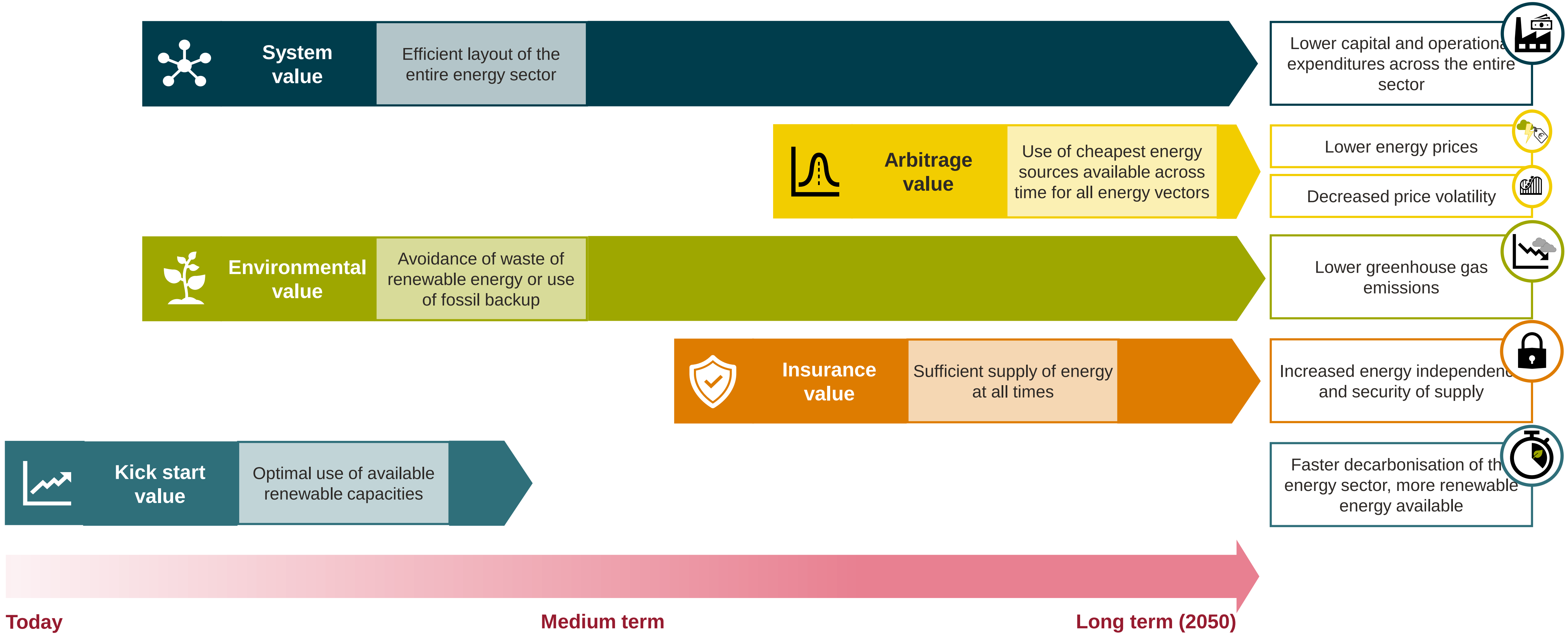
Total underground hydrogen storage
Capacity (Working Gas Volume)

270 TWh
LHV

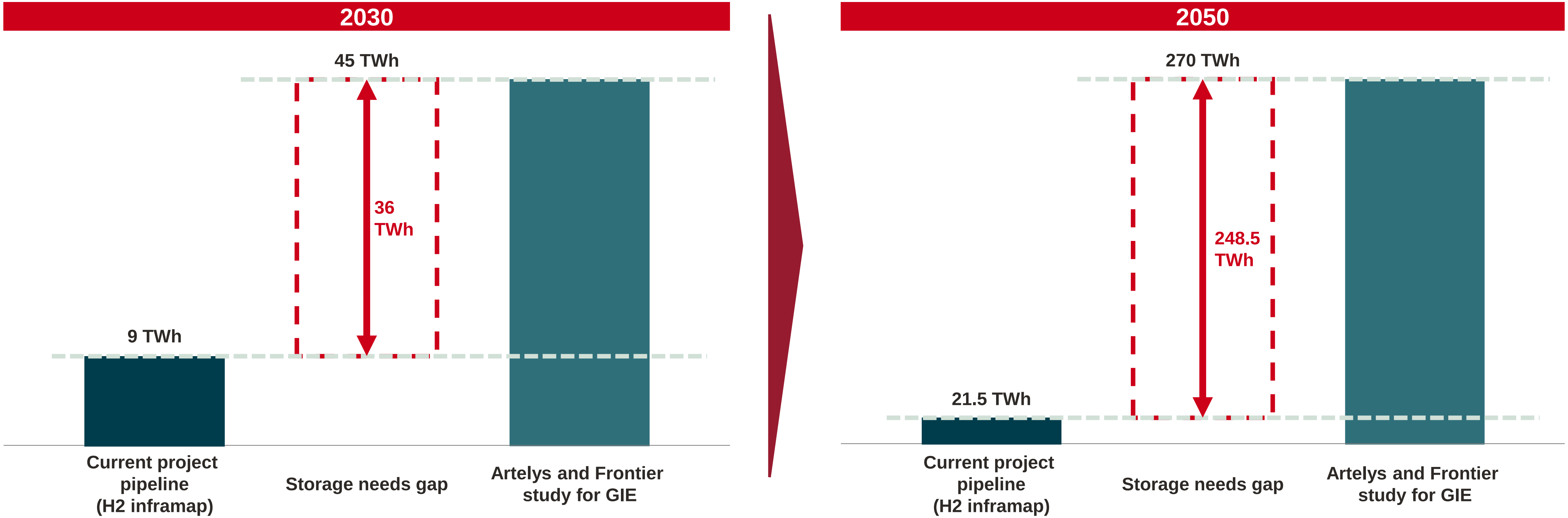
Injection capacity
300 GW

Investment costs
135 Bn EUR

Underground hydrogen storage can deliver significant benefits across time and across energy sectors



Currently-announced projects do not meet the storage needs of the energy system and a significant gap results and increases over time



Analysis carried out based on a snapshot of H2 inframap as of October 2023.

The market alone will fail to meet the gap between planned and optimal developments of underground hydrogen storage

Lack of **maturity in today's renewable and low carbon hydrogen market**

Limited awareness amongst policy makers of the values

- **Lack of visibility and hence long-term uncertainty of UHS business cases**
- **Persistence of complex and lengthy approval processes**
- **Technological uncertainty and outstanding learning effects**

System value	**Higher** capital and operational expenditures across the entire sector
Arbitrage value	**Higher** prices **Increased** volatility of prices
Environmental value	**Higher** total greenhouse gas emissions
Insurance value	**Increased** third party energy **dependence** and **weakened security of supply**
Kick start value	**Slowed down** decarbonisation of the energy sector, less renewable energy available

Targeted policies to enable underground hydrogen storage would foster a cost-efficient, integrated, secure and decarbonised European energy system

Timing	Measure	Vehicle
Address immediately	1. Set an explicit 2030 target of 45 TWh for available UHS capacity	***"The EU 2030 Underground Hydrogen Storage Plan for a decarbonised energy system"***
	2. Address administrative and complex approval processes	***Decomplexify, digitalise and deliver***
Address within a year	3. Define signalling support mechanisms	***"Important European UHS project (EUH_2SP)"***
	4. Define a portfolio of financial support mechanisms	***Funding via ETS revenues, guaranteed loans, CEF EUH_2SP, etc.***
Address within three years	5. Monitor the market regularly via EU-wide KPIs	***"The EU long-term H2 (storage) strategy"***

Ongoing integration with wider EU H2 and energy policy (REPower EU 2.0, Green Deal, Gas Package, …)

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What is the scale of the benefits from reaching 45 TWh of UHS by 2030?

- We have compared the **total cost of the energy system** if the 45 TWh of UHS is deployed, vs if only 9 TWh is rolled out by 2030

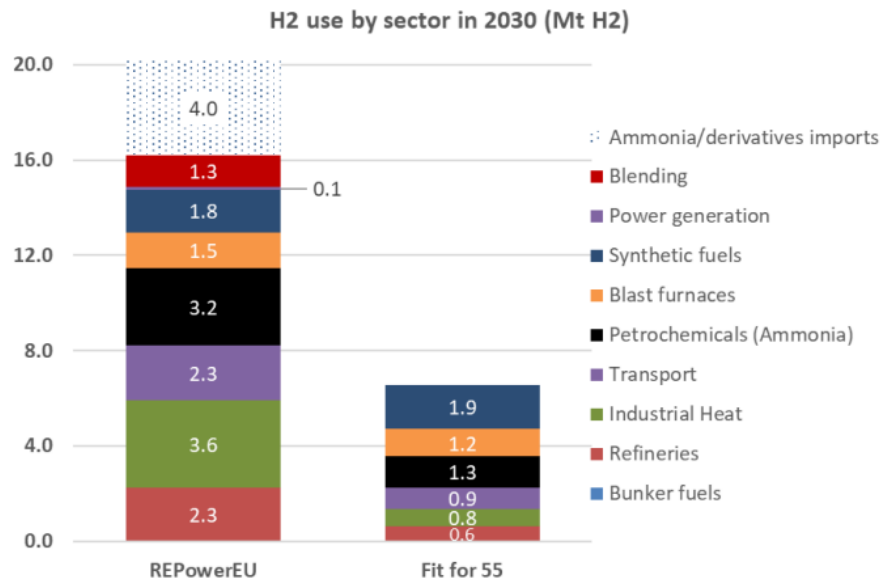
- The results are consistent with expectations
  - **Avoided investment in infrastructure**: avoiding investment in alternative, more costly infrastructure elements
  - **Reduced operational costs of serving energy demands**
    - higher deployment of electrolysis and more flexible operational management of electrolysers
    - lower cost of hydrogen by avoiding RES-E curtailment and instead running additional electrolysers during RES-E production episodes
    - avoiding running electrolysers during high electricity price episodes
  - **Reduced GHG emissions** by enabling electrolysers to stop during high electricity price episodes where electricity has a higher carbon content, and instead using UHS to ensure deliverability of H2 to end-users

2.3 euros saved in investment, operational and carbon costs of the energy system, for every 1 euro invested in underground hydrogen storage

Back-up – Key assumptions for the 2030 modelling exercise
The REPowerEU context

The 2030 modelling exercise is conducted **in a context aligned with REPowerEU**, which means that:

- Demand is allocated to end-uses with **flat** demand profiles in 2030.
- There is **no SMR/ATR** in the system in 2030.
- Out of the **20 MtH2** of hydrogen demand:
  - **10 MtH2** will be delivered via electrolysis in the EU,
  - **6 MtH2** will be delivered via imports of H2, and
  - **4 MtH2** will be delivered via imports of derivatives.



REPowerEU ambitions - European Commission

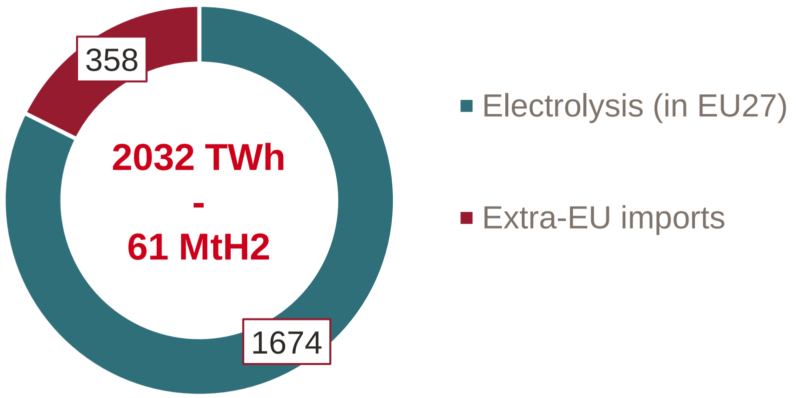
Back-up – Key assumptions for the 2050 modelling exercise

The Fit-for-55 context

The 2050 modelling exercise is conducted **in a context aligned with reaching a net-zero EU economy**, which means that:

- Hydrogen demand strongly progresses to reach **61 MtH2,** including thermosensitive end-uses and H2-fired power generation.
- **Domestic electrolysis and extra-EU imports** combine to deliver these volumes (underlying assumptions inspired by TYNDP 2022).
- The structure of the electricity generation mix is aligned with the 2050 vision provided in the Fit-for-55 documents, notably in terms of **RES development** and **nuclear generation**.

2050 hydrogen supply in EU27 (TWh LHV)



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