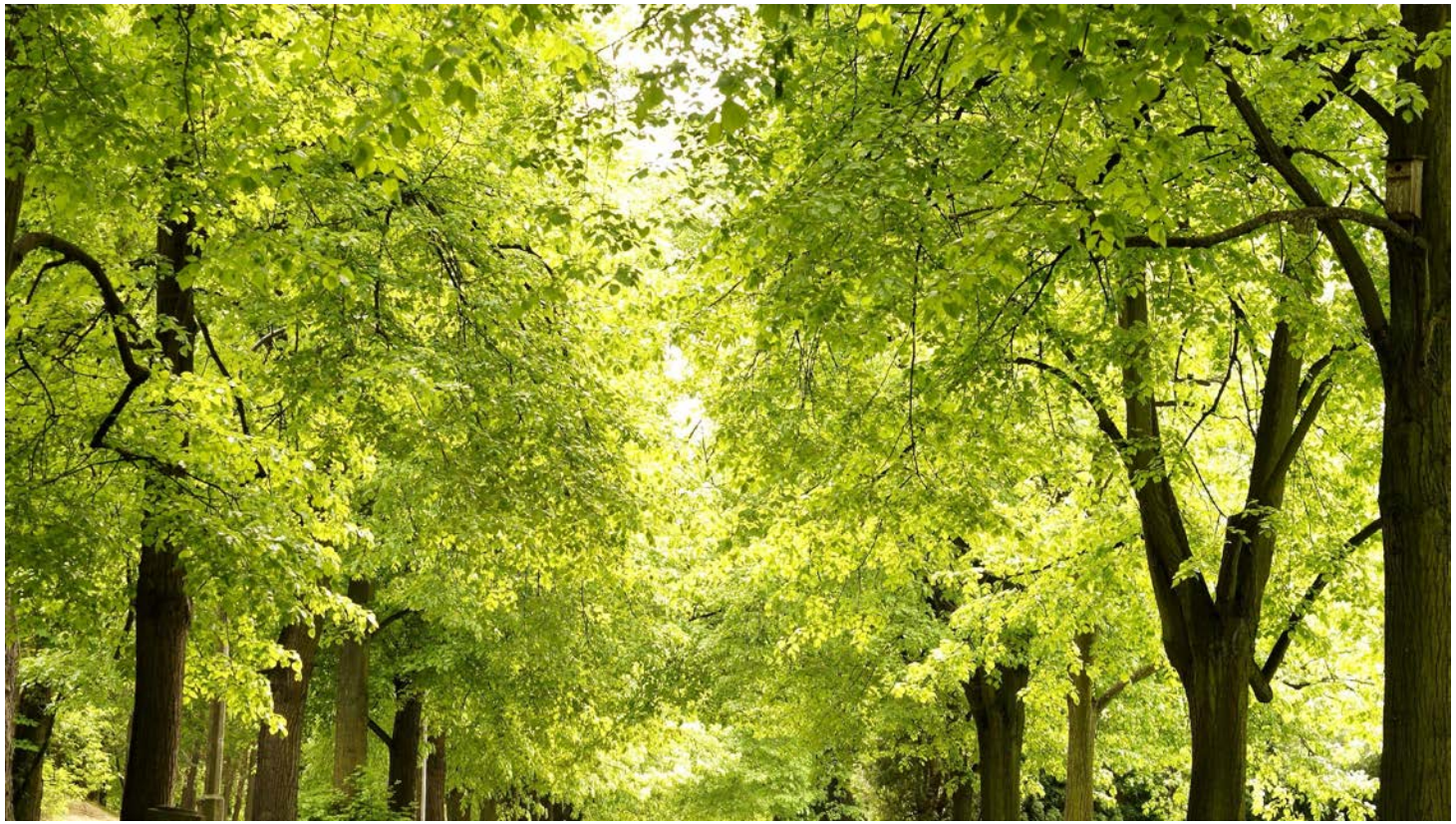

A POSSIBLE STEP FORWARD TO GREEN HYDROGEN USE EXPANSION

A BUSINESS-CENTRIC APPROACH

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10° HAEE Energy Transition Symposium

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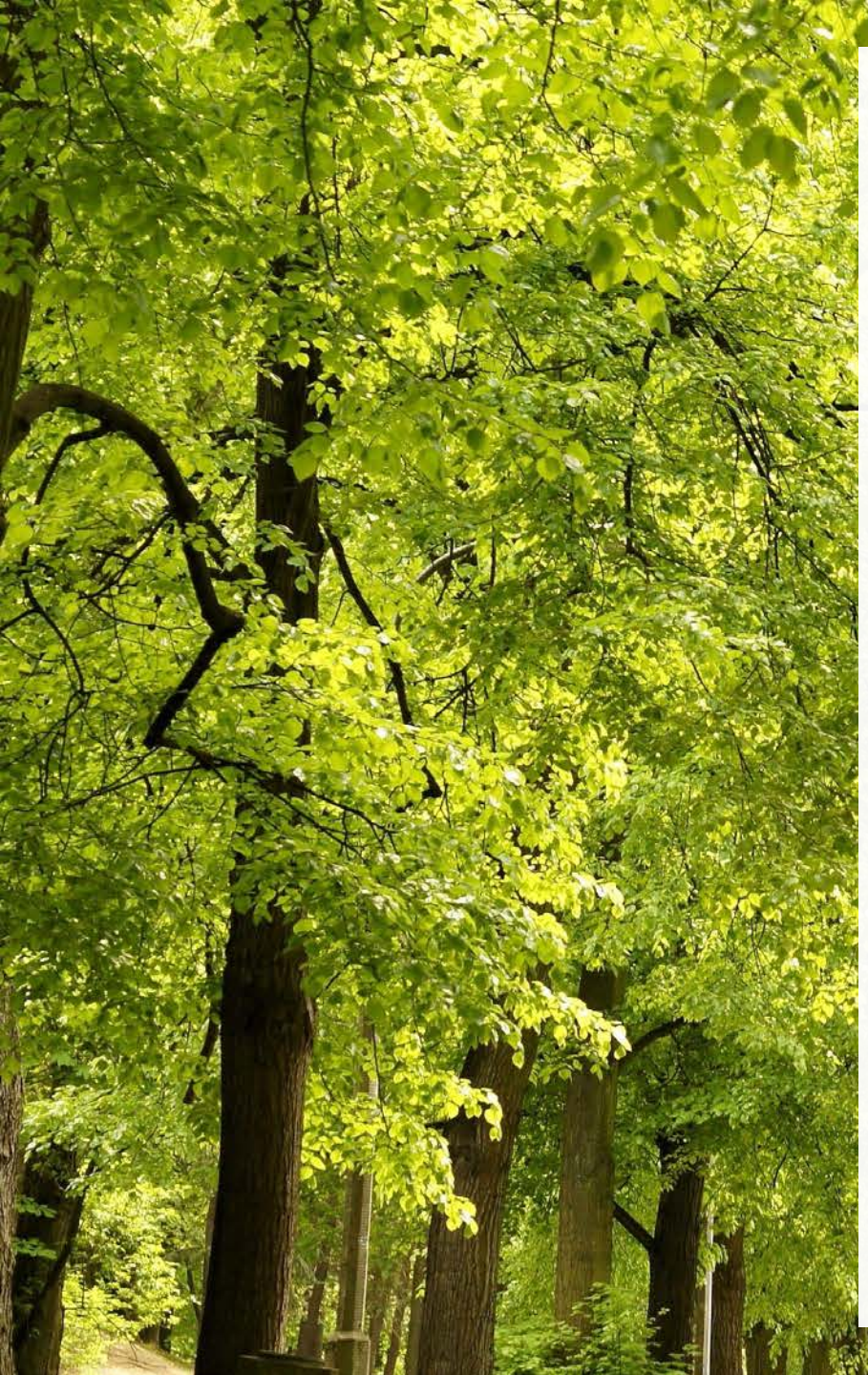
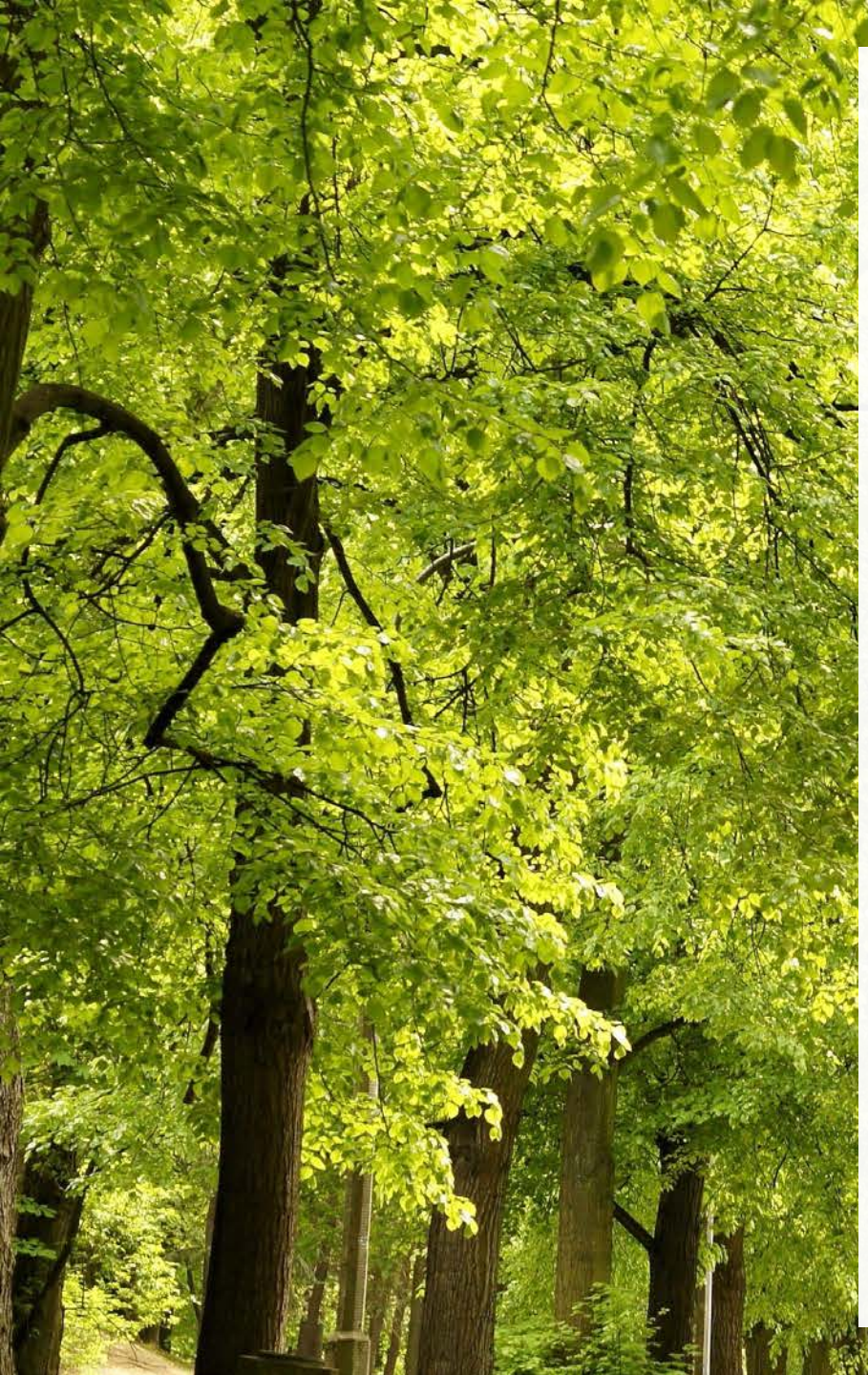


PRESENTATION SUMMARY

- ✓ The global push towards net-zero emissions by 2050 necessitates a significant shift in energy sources, with green hydrogen emerging as a key, albeit costly, component.
- ✓ This presentation advocates for a pragmatic, industry-led approach to scale up green hydrogen production, specifically targeting "hard-to-abate" sectors, like steel manufacturing.
- ✓ By empowering individual industrial players to develop their own green hydrogen projects, supported by streamlined regulatory processes and targeted financial incentives, we can foster market expansion for electrolyzers, drive down costs through economies of scale, and ultimately reduce the need for extensive public subsidies for end-uses.
- ✓ This presentation summarizes the content of a paper, elaborated by Tiemes srl (www.tiemes.it), and includes:
  - Background and current challenges
  - A business-centric proposal
  - Targeting Hard-To-Abate sectors: a steel industry case study (2 slides)
  - Conclusions and policy implications

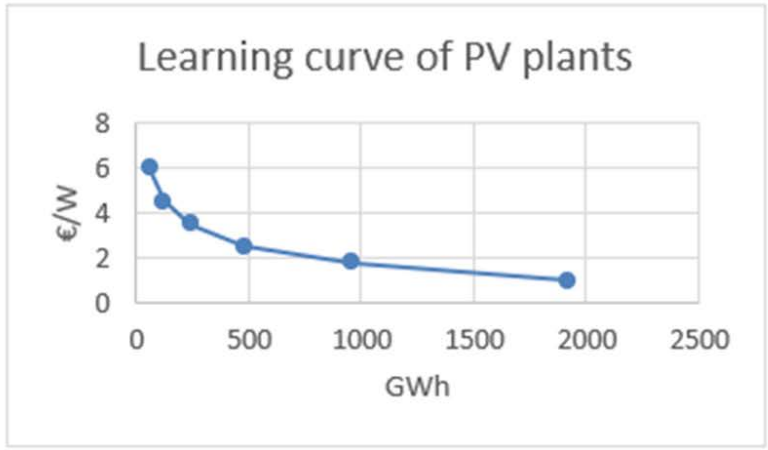


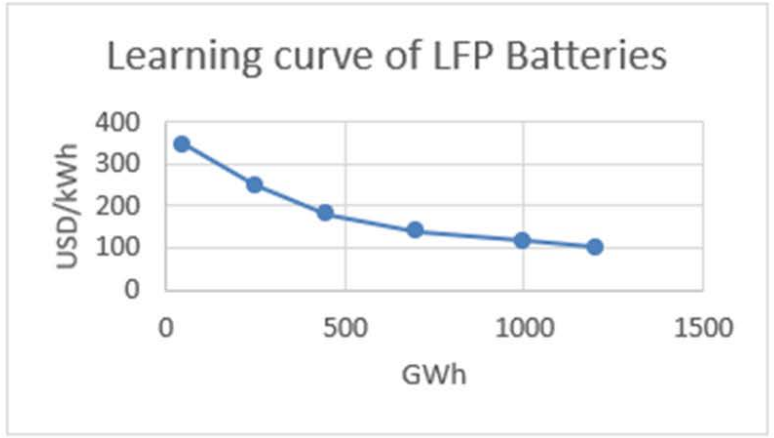
BACKGROUND and CURRENT CHALLENGES

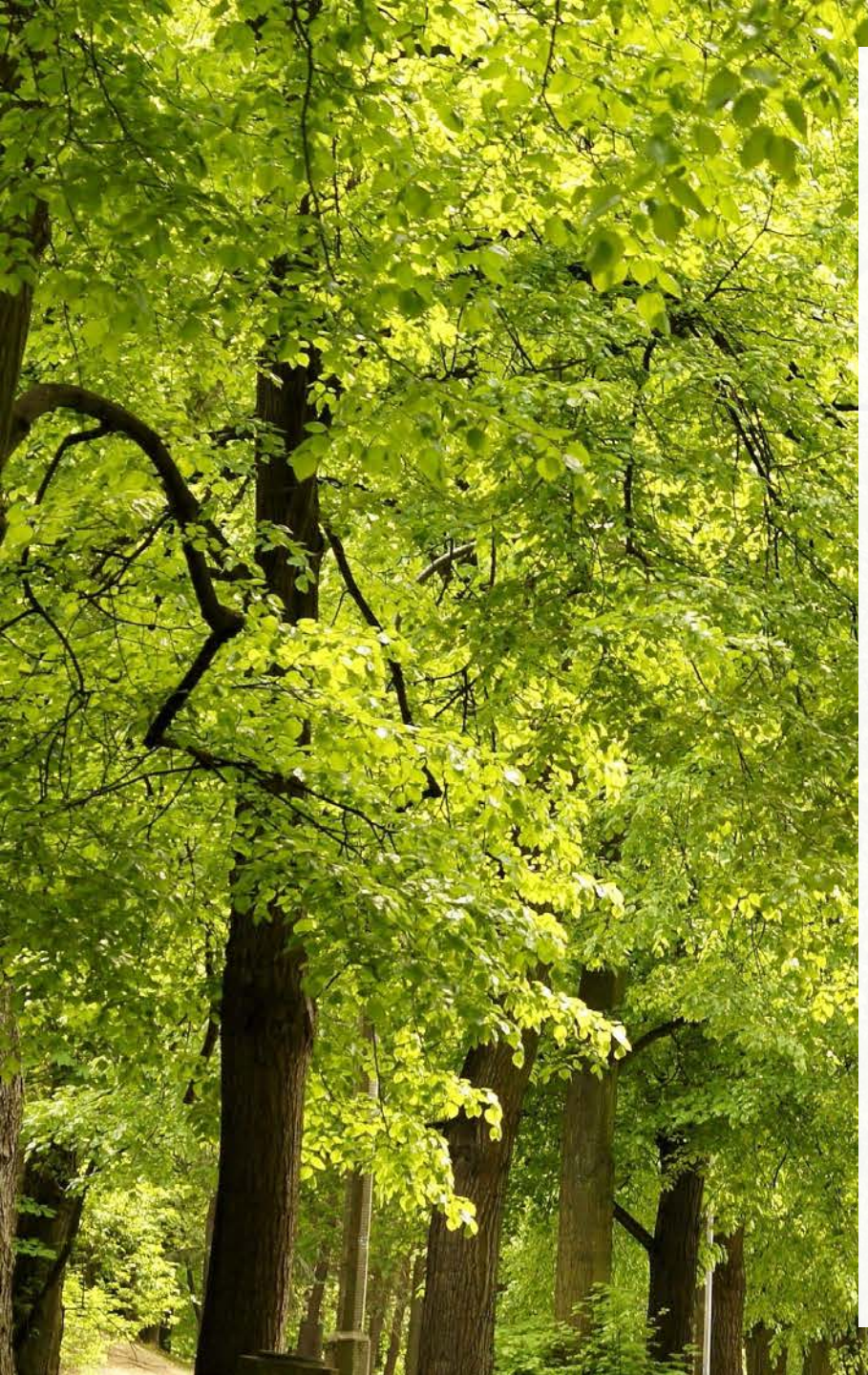
- ✓IEA roadmap to fight climate change includes by 2050 renewables, electrification, efficiency, hydrogen and CCUS
- ✓Hydrogen is currently made («gray») mainly by Steam Methane Reforming (SMR): to avoid relevant emissions:
  - carbon dioxide from SMR can be captured, but other uses or storage must be found (CCUS), to make «blue» hydrogen, or
  - «green» hydrogen can be produced by water electrolysis with Renewable Energy (RE)
- ✓Despite past fluctuations in interest, the significant growth of RE (40% of global power in 2024) suggests a ripe opportunity to expand the electrolyzer market and make green hydrogen more cost-competitive
- ✓Currently numerous announced green hydrogen projects are lagging to reach a final investment decision, primarily due to the high price of hydrogen. The prevalent approach of focusing on broad policies and global production/trade patterns may be hindering, rather than accelerating, tangible progress.

A BUSINESS-CENTRIC PROPOSAL

- ✓ Instead of a top-down, harmonized global plan, this proposal suggests empowering individual industrialists to develop their own green hydrogen business plans, encompassing asset design and power supply decisions.
- ✓ This approach mirrors the successful "learning curve" observed in the Photovoltaic (PV) and Battery industries, where economies of scale significantly reduced costs (see charts below) and allow to win customers to justify final investment decision.







TARGETING HARD-TO-ABATE SECTORS: A STEEL INDUSTRY CASE STUDY (1)

- ✓ The steel industry presents a compelling case for early adoption of green hydrogen due to its economic and environmental weight, and its need for high-temperature heat that cannot be directly supplied by RE.
- ✓ Electric Arc Furnace (EAF) technology, which can integrate Direct Iron Reduction to supplement limited scrap-steel availability, allows for hydrogen application. To ease the transition, hydrogen can be initially used in suitable blends with natural gas.
- ✓ Project proposals may be made by each steelmaker, including:
  - Proton Exchange Membrane ELectrolyzers (PEMEL) with RE supply, water and gas purification (currently at 5 M€ per 5 MW package),
  - Hydrogen storage,

  which, if authorized by competent Authority, access to subsidies.
- ✓ Crucially, these projects, once authorized by Authorities, should be eligible for subsidies, such as "per green kWh used" incentives.
- ✓ Addressing the challenge of providing for the entire RE needs of these projects may require waivers to EU RED II additionality rules or a phasing of investments aligned with Power Purchase Agreement (PPA) availability.

TARGETING HARD-TO-ABATE SECTORS: A STEEL INDUSTRY CASE STUDY (2)

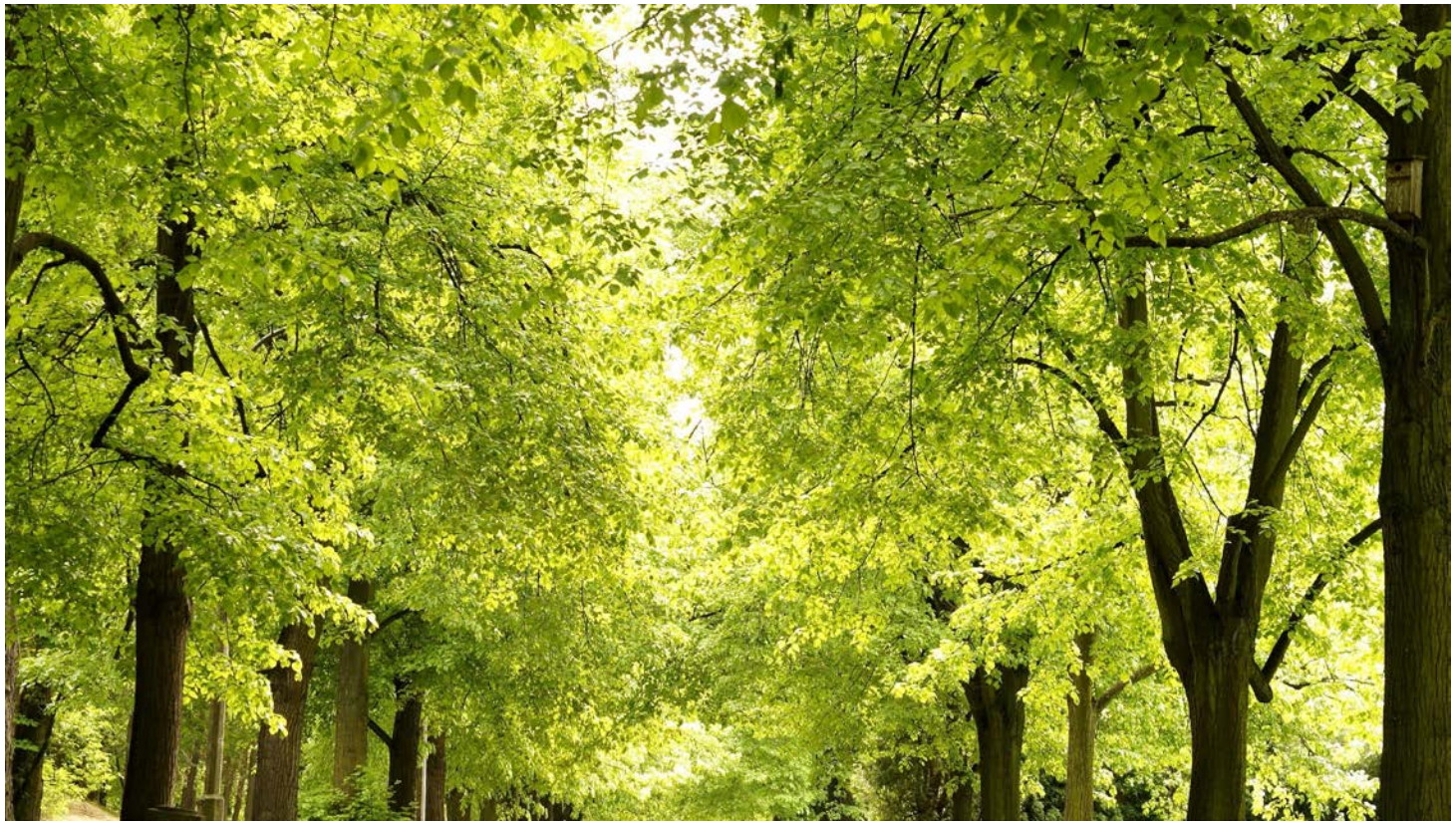
- ✓ An analysis of hydrogen production economics (see table below) highlights the potential for significant cost reductions by 2035 through lower PEMEL and PV investment costs and reduced RE PPA power prices.

Metric	2025 (Own RE Supply)	2025 (External RE Supply)	2035 (Own RE Supply)	2035 (External RE Supply)
Hydrogen production (kt/y)	1.6	1.6	1.6	1.6
PEMEL investment (Eur/W)	1	1	0.3	0.3
PV investment (Eur/Wp)	0.7	-	0.2	-
RE PPA power price (Eur/kWh)	-	0.06	-	0.02
Total Investment 45°N (Meur)	71	25	24	10
Hydrogen cost (Eur/kg)	6.1	6.3	1.9	2.8
Eur/kWh from Hydrogen	0.18	0.19	0.06	0.08

- ✓ Assumptions and sensitivities:
  - EAF/PEMEL std used: lifetime PEMEL 10 y, BOP 20 y; if 3y-lower, last column H_2 cost € 2,9/kg
  - 2035 ROI 6%, if 10%, H_2 cost € 3,1/kg
  - 2035 RE PPA: 0.02 €/kWh (+0,02 transport & overhead), if 0,03 €/kWh H_2 cost € 3,3/kg
- ✓ Risks mitigation:
  - Incentives should compensate extra cost of H2-kWh vs. fossil-kWh for power price volatility
  - EPC contracts should include performance guarantees to mitigate technical problems
  - social acceptance should justify extra cost with lower pollution and higher security
- ✓ Life Cycle Analysis (LCA) suggests that continuous improvement is crucial in:
  - PEMEL technology, e.g. extending lifetime, reducing weight and critical materials,
  - safety standards (e.g. from petrochemical industry) adaptation to new users

CONCLUSIONS and POLICY IMPLICATIONS

- ✓ Overcoming the hurdles in green hydrogen introduction requires a shift from broad, harmonized plans to empowering industrialists to pursue their own business cases, including asset design and power supply decisions, even if subject to standard permitting procedures.
- ✓ Once authorized, public Authorities should provide financial support and simplify RE supply regulations (e.g., PPA phasing, additionality waivers).
- ✓ This decentralized approach will drive electrolyzer market expansion, leading to cost reductions for electrolyzers, along with expected cheaper PV power, and allow more projects to accelerate final investment decision.
- ✓ Consequently, the need for public support for hydrogen end-uses will diminish, focusing instead on cases requiring specific investments for adoption, such as modifying industrial processes for 100% hydrogen use.
- ✓ This strategy seems to offer a more agile and market-driven path to scaling green hydrogen to effectively contribute to net-zero goals.



THANKS FOR YOUR ATTENTION

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