Study on development of water electrolysis in the EU

Joint NOW / FCH JU Water Electrolysis Day

FCH JU, Brussels

3 April 2014

Outline

- Objectives of the study
- Study approach
- Main messages
- Electrolyser status and technical trends
- Techno-economic analysis approach and sample results
- Summary of key study insights

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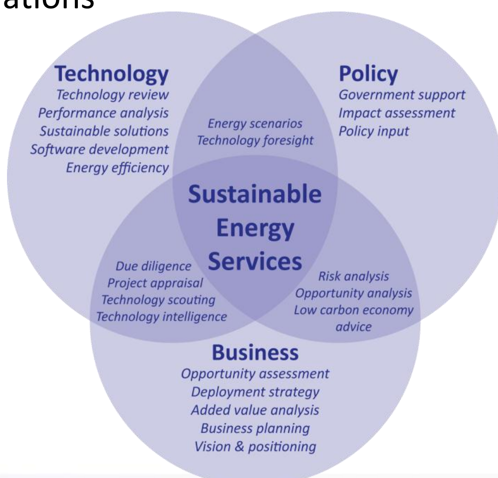
Objectives of the study

- Document the stakeholder expectations on the status and development of water electrolysis technology
- Provide insight into the conditions necessary for the commercial viability of water electrolysis in emerging energy applications
- Identify technology development priorities to support progress towards commercial viability
- Provide an evidence base to inform the FCH2 JU research priorities

Who we are

E4tech

- International consulting firm, offices in UK and Switzerland
- Established 1997, always independent
- Focus on sustainable energy
- Deep expertise in technology, business and strategy, market assessment, techno-economic modelling, policy support…
- A spectrum of clients from start-ups to global corporations



elementenergy

- Specialist energy consultancy with an excellent reputation for rigorous and insightful analysis
- Services offered across a wide range of low carbon energy sectors, around Strategy and Policy, Market Analysis and Engineering Solutions.
- We consult on both technical and strategic issues – our technical and engineering understanding of the real-world challenges support the strategic work and vice versa.

Low Carbon Transport
- Electric vehicles
- H_2 vehicles
- Market uptake
- Infrastructure modelling
- Business planning
- Project delivery

Built Environment
- Financial viability
- Master planning
- Building design
- Policy advice
- Regional strategy

Power Generation & storage
- Renewables
- Micro-generation
- CCS
- Techno-economics
- Feasibility studies
- Geographic analysis

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The study carefully compared water electrolysis options with their competing alternatives to examine viability

Steering Committee

Technical Advisory Group (TAG)

New Energy World JU – fuel cells & hydrogen for sustainability

New Energy World IG – fuel cells & hydrogen for sustainability

N.ERGHY

Electrolyser technology status and expected trends

↓

Techno-economic analysis

↓

Recommendations for RD&D

Stakeholders / data

- Industry
- Research organisations
- Literature

Task lead

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Water electrolysis can be commercially viable in transport applications – and some others – by 2030

- Water electrolysis (WE) can be a commercially viable element of the future energy system
  - Hydrogen for transport
  - Industrial hydrogen uses
- Gigawatt scale cumulative deployment is plausible by 2030
  - In line with stakeholder expectations
  - Coherent with emerging hydrogen infrastructure plans
- But this is hard to achieve and requires:
  - Continued technology development and cost reduction
  - Supportive regulatory and policy framework conditions
  - Clear requirements for emerging WE energy applications

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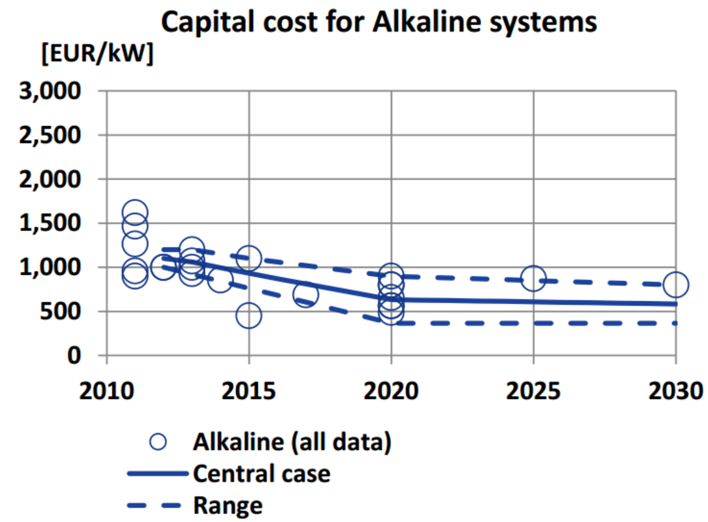
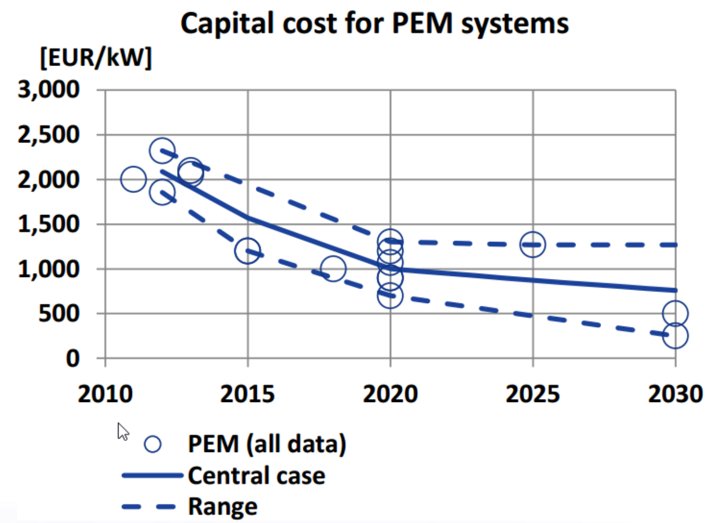
Data from literature and stakeholders allowed us to put together KPI* trends to underpin the analysis

- Data sources included literature and interviews with stakeholders
- KPIs were validated with the project TAG
- KPIs include:
  - specific capex
  - efficiency
  - system and stack size
  - lifetime
  - dynamic characteristics
  - system pressure
  - opex
  - availability
  - current density

* Key Performance Indicator





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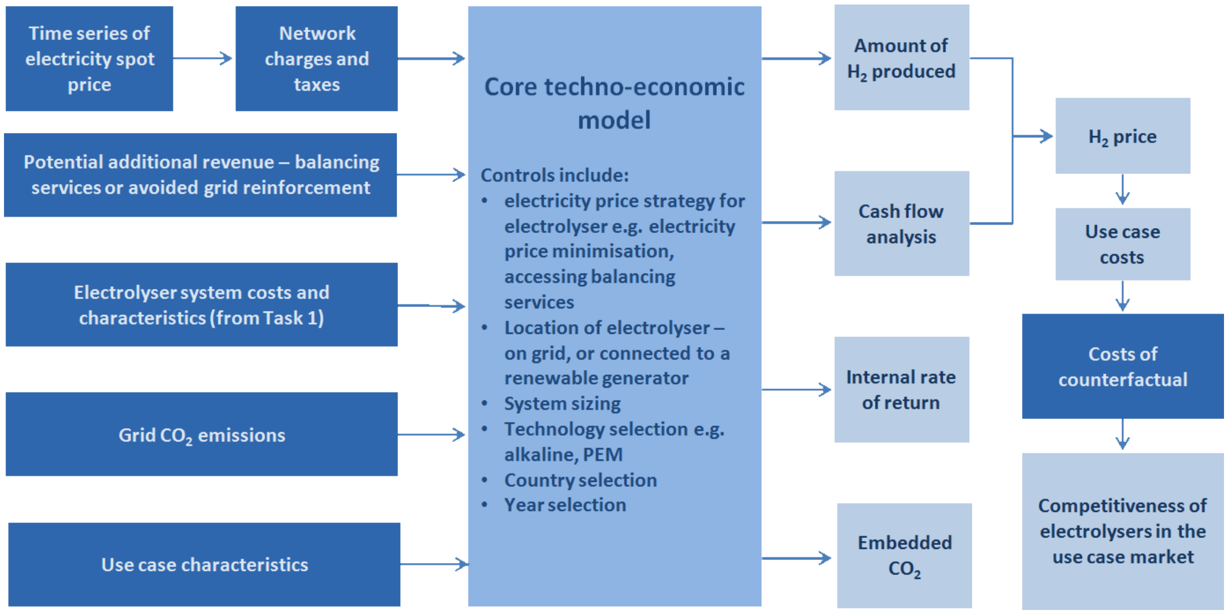
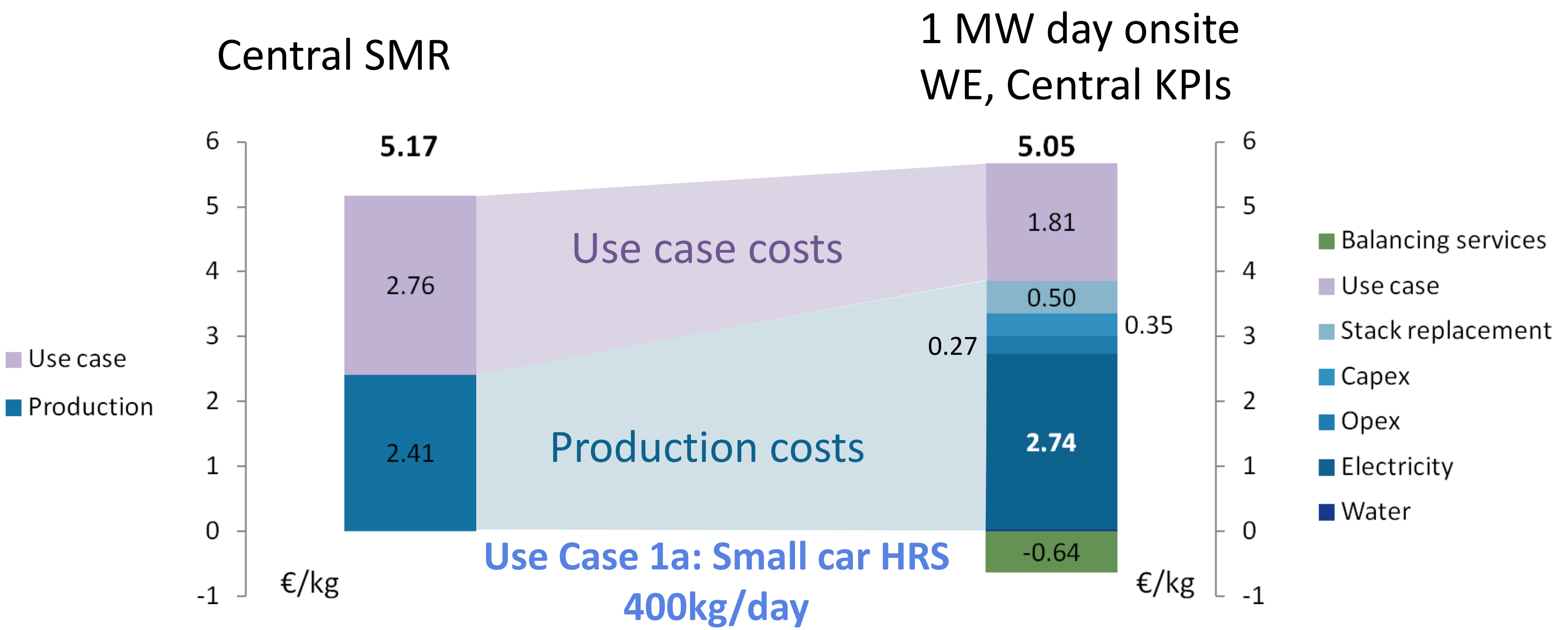
Techno-economic analysis was based on time-resolved demand and price data and primarily compared to SMR*

- TEA uses time-resolved demand and price data to estimate the specific cost of produced hydrogen over the lifetime of the installation
- Primary counterfactual is hydrogen produced by large SMR
- Use cases considered include:
  - Vehicle refuelling
  - Industrial applications
  - Gas grid injection
  - Re-electrification



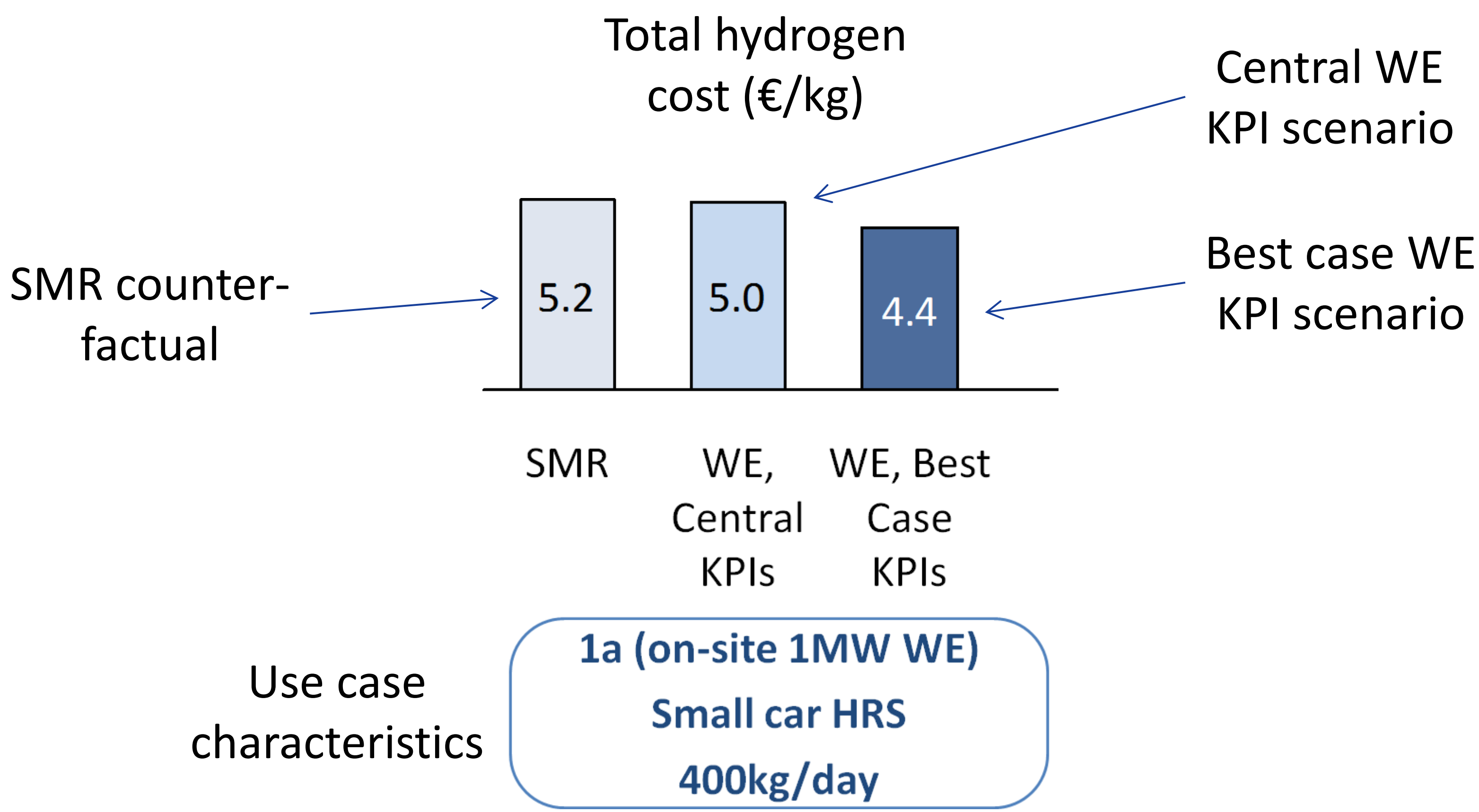
* Steam Methane Reforming

The TEA calculated the total point-of-use hydrogen cost for a range of use cases and counterfactuals



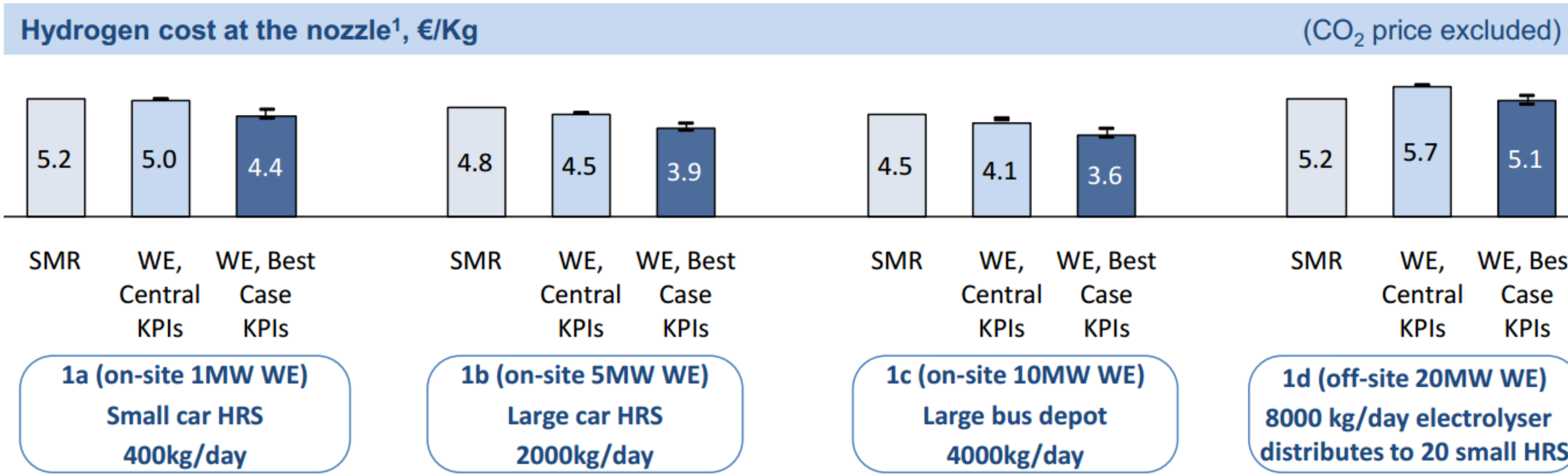
- Here, WE production cost is *higher* but final cost of hydrogen is *lower* at the refuelling station – due in part to revenues from balancing services
- Use case costs include refuelling station costs, compression, storage, and distribution as appropriate

Summary plots compare WE with central and best case KPIs to the relevant counterfactual, in a given country



- This sample shows the layout of plots that follow and that are in the report

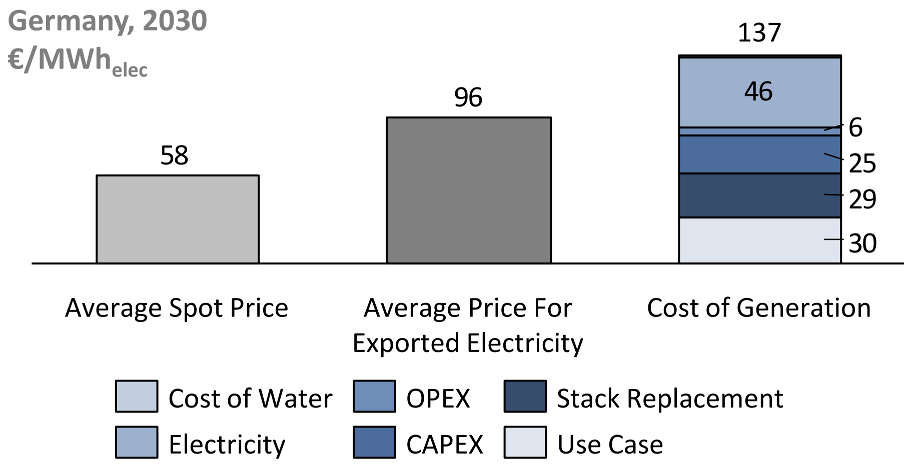
Sample TEA results: WE for vehicle refuelling in Germany in 2030 is generally competitive with SMR



- Example results are for Germany using forecast utility prices and electrolyser KPIs for 2030
- Analysis suggests that even with the *central* KPIs, electrolysers should be competitive with SMR in vehicle refuelling applications in the *currently favourable* German regulatory environment

Industrial and energy storage use cases would require stronger policy support to reach commercial viability

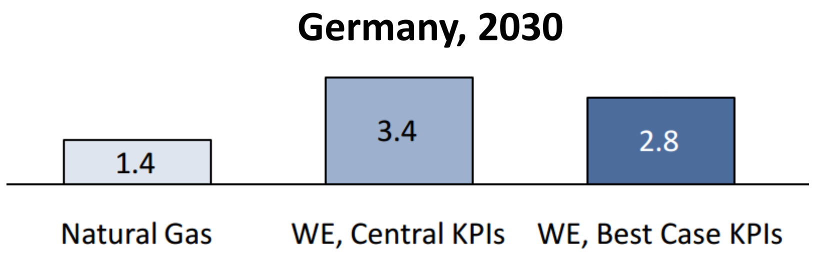
Electricity Price/Cost, €/MWh



3a
100 MW re-electrification

Cases such as re-electrification or hydrogen injection into the natural gas grid are likely to remain far from commercial viability, even with high volatility in electricity prices

Hydrogen cost , €/Kg



3b
10 MW gas grid injection

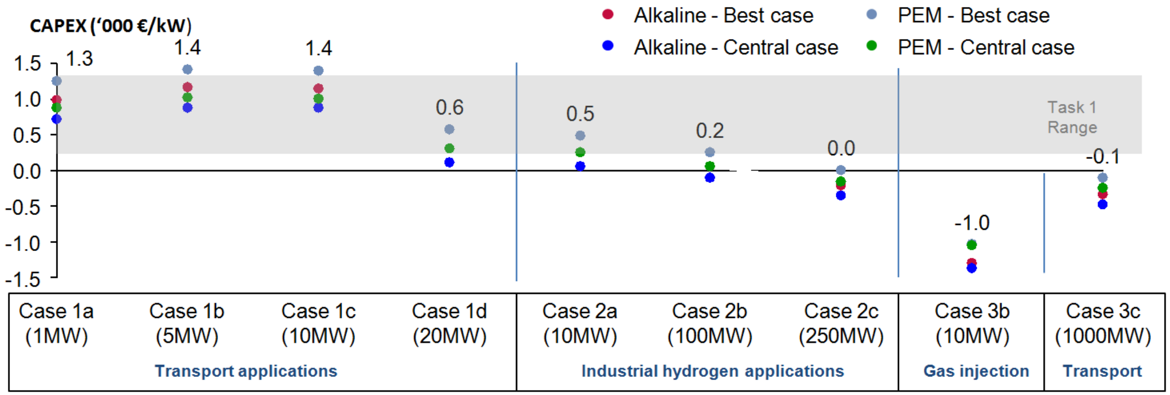
Counterfactual is wholesale natural gas

Natural gas grid injection would require a carbon price of about 200–300 €/tCO_2 to reach cost parity – assuming the WE is run on renewable electricity

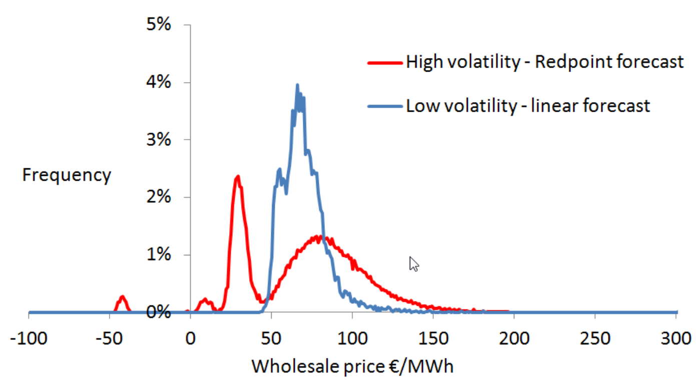
Full details of the analyses conducted are in the project report

Sensitivity analysis

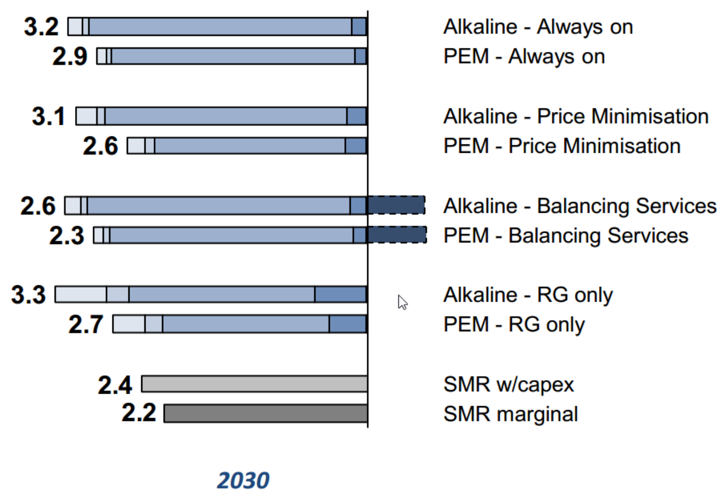
- Capex
- Efficiency
- CO_2 price



Electricity price volatility



WE operational strategy



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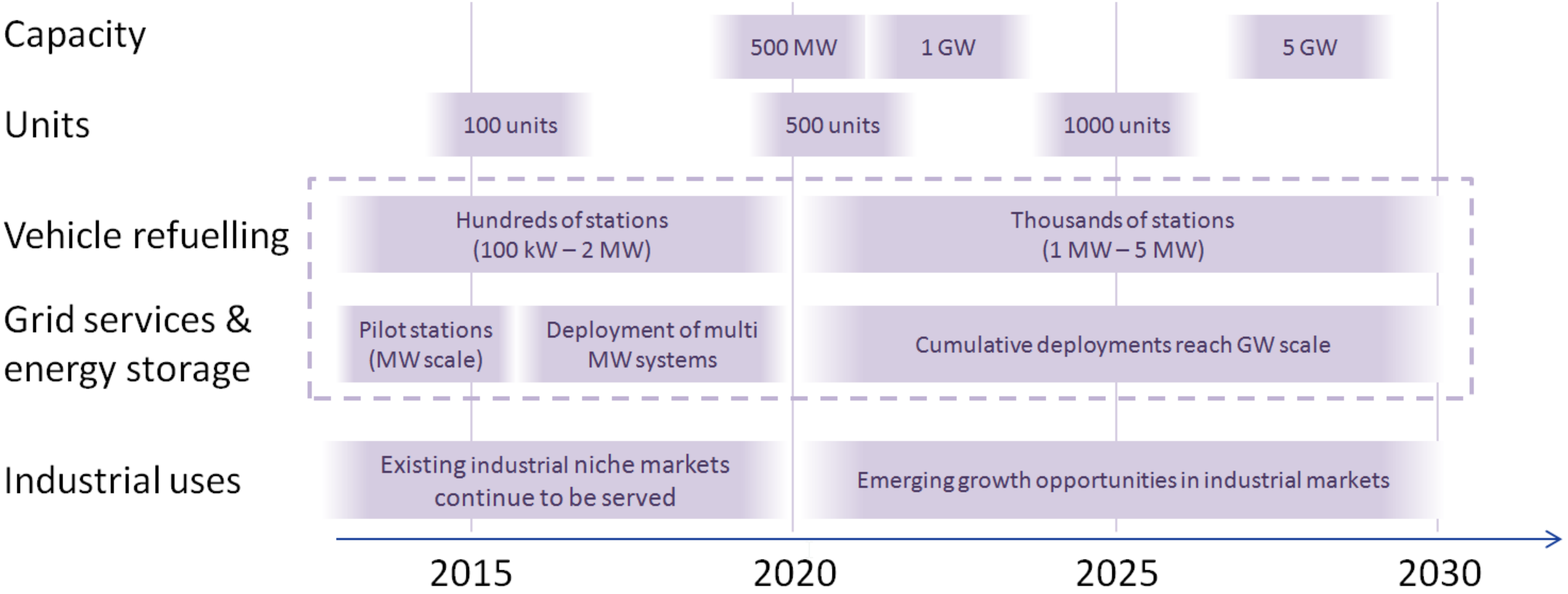
Insights from the study included several conditions that affect WE commercial viability

- The **cost** of electrolytic hydrogen is **dominated by the cost of electricity** (in high electrolyser utilisation use cases)
- Electrolyser capex is sufficiently high that **high utilisation is necessary** to amortise the system cost sufficiently
- **Distributed applications**, such as onsite production for vehicle refuelling, avoid high distribution costs
- A **favourable regulatory framework** can greatly reduce the effective cost of electrolytic hydrogen
- Continued or accelerated **technology development** pushes electrolyser KPIs towards the "better" edge of expectations
- A **high carbon price** increases the value of low carbon electrolytic hydrogen
- **Increased electricity price volatility** *could* provide meaningful quantities of low cost electricity

In markets with favourable conditions, WE could compete in vehicle refuelling applications by 2030

- Where favourable conditions already exist, such as in Germany, water electrolysis (WE) should reach competitiveness with large SMR by 2030 – for vehicle refuelling
- Broader adoption of such favourable conditions could extend the commercially viable markets for water electrolysis
- Maturation and rationalisation of the electrolyser manufacturing base and supply chain could:
  - bring down specific costs
  - broaden the range of viable use cases to include some industrial applications
- Hydrogen injection into the gas grid and re-electrification are likely to require significant policy support to be competitive

Gigawatt scale WE deployments by 2030 are coherent with stated hydrogen infrastructure plans



- Although vehicle refuelling seems the most viable application, the concurrent provision of grid services will be necessary to support this deployment
- GW scale cumulative deployments seem realisable by 2030, in line with stakeholder expectations

Specific areas require further research, and the electrolyser industry must evolve

- Stakeholder engagement highlighted areas that need further research
  - Detailed requirements for emerging electrolyser applications
  - Definition of standard test and duty cycles, particularly for dynamic operation
  - Demonstration of – and data on – dynamic operation and impact on system life
  - Clarification of novel use cases for emerging technology like SOEC
- The electrolyser industry will need to evolve significantly to capture emerging opportunities
  - Current commercial electrolysers are essentially mature, but system designs may not be well suited for new applications
  - Industry and supply chain are fragmented and will need to be rationalised to drive down costs

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  - Klaus Dieter Scheffer, Siemens
  - Ulrich Stimming, TUM
  - Daniel Hustadt, Vattenfall

- All interviewees

Thank you

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