Policy design for green hydrogen

Niall Farrell,

Economic and Social Research Institute

Objective

- Review the cost of hydrogen technologies for Climate Change Advisory Council
- Structured literature review according to cost competitiveness and required policy response
- General framework that can be applied to other technologies

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- Techno-economic projections tell us when various solutions should be introduced

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- **What is the role for policy?**
  - Remove barriers/correct for market failures
    - When and to what extent should there be intervention?

Approach

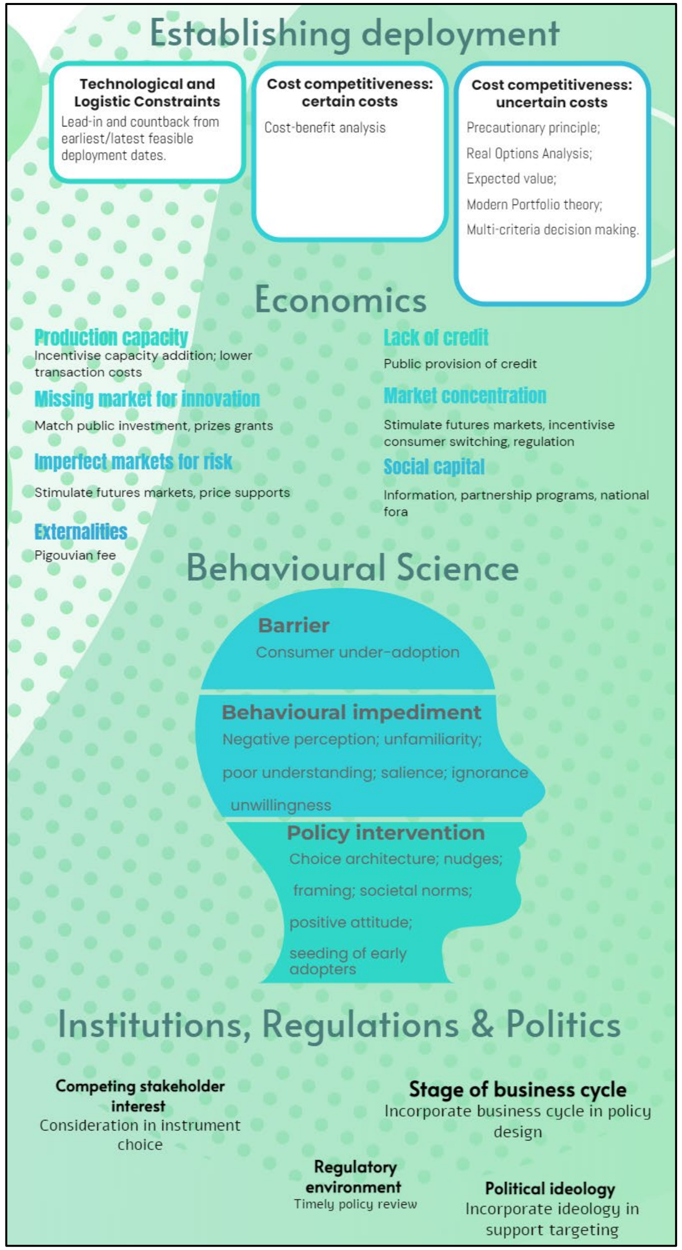
- **A number of constituent steps**

  1) When does hydrogen appear in a low-cost transition

  2) What are the barriers prohibiting this

  3) What can policy do to overcome these barriers

  4) When must these actions be taken


Establishing deployment
Technological and Logistic Constraints
Lead-in and countback from earliest/latest feasible deployment dates.
Cost competitiveness: certain costs
Cost-benefit analysis
Cost competitiveness: uncertain costs
Precautionary principle;
Real Options Analysis;
Expected value;
Modern Portfolio theory;
Multi-criteria decision making.
Economics
Production capacity
Incentivise capacity addition; lower transaction costs
Missing market for innovation
Match public investment, prizes grants
Imperfect markets for risk
Stimulate futures markets, price supports
Externalities
Pigouvian fee
Lack of credit
Public provision of credit
Market concentration
Stimulate futures markets, incentivise consumer switching, regulation
Social capital
Information, partnership programs, national fora
Behavioural Science
Barrier
Consumer under-adoption
Behavioural impediment
Negative perception; unfamiliarity;
poor understanding; salience; ignorance
unwillingness
Policy intervention
Choice architecture; nudges;
framing; societal norms;
positive attitude;
seeding of early adopters
Institutions, Regulations & Politics
Competing stakeholder interest
Consideration in instrument choice
Stage of business cycle
Incorporate business cycle in policy design
Regulatory environment
Timely policy review
Political ideology
Incorporate ideology in support targeting

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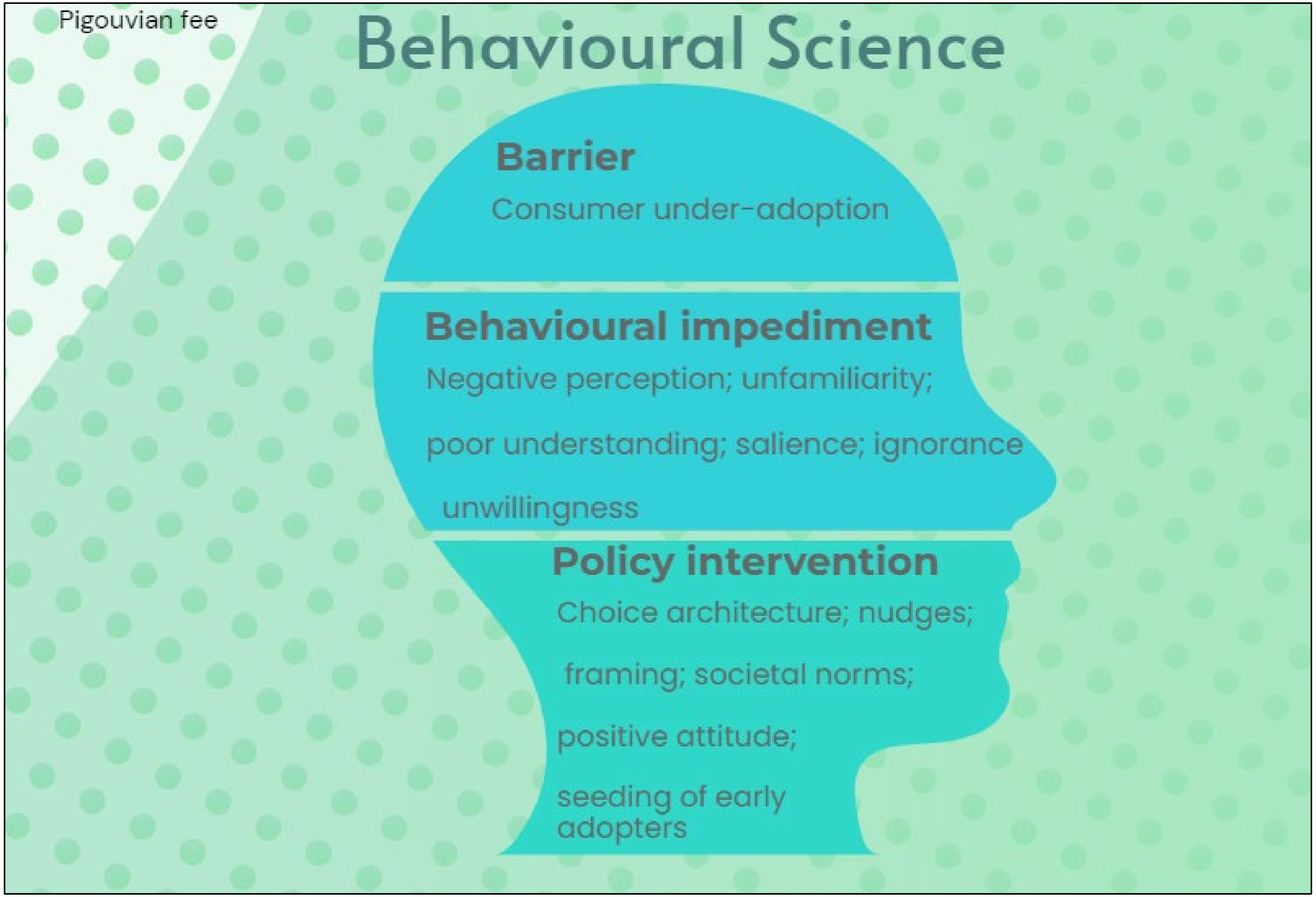
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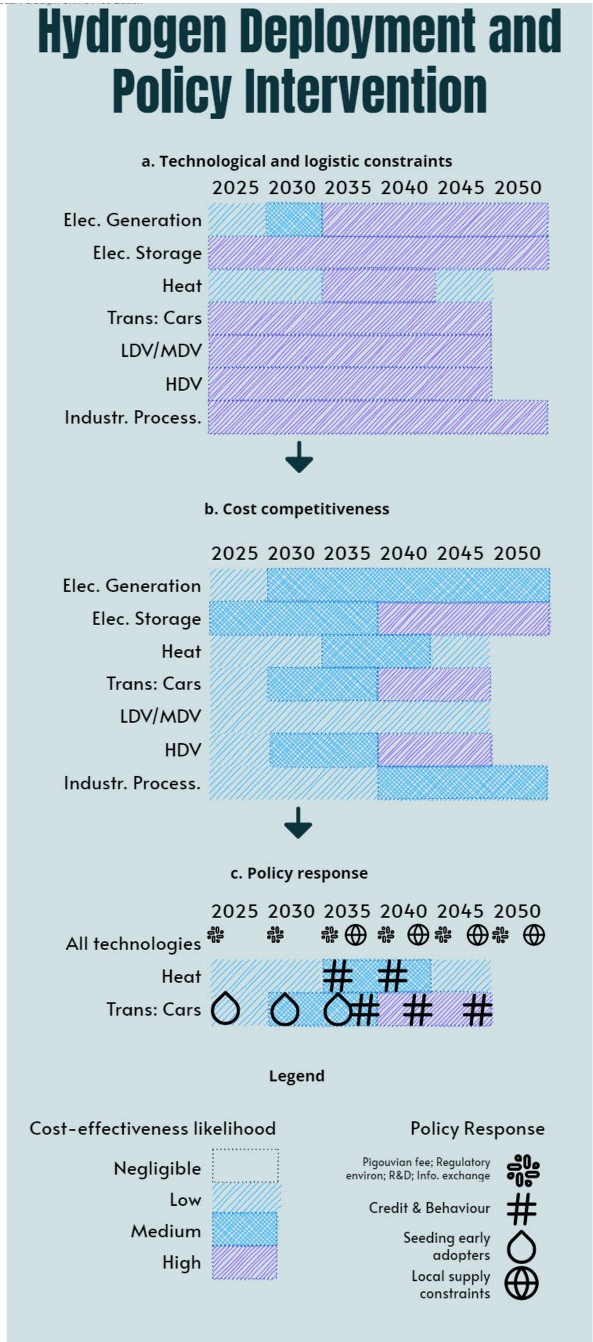

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Technological and logistical constraints

Technological and logistical constraints

- Vary by application
- **Transport** Infrastructure is important but not prohibitive
  - Evidence suggests modest infrastructure required for early-mid adopters (Staffel, et al.)
- **Heating** infrastructure requires much foresight
  - The UK, for instance, replaced 40 million appliances over an 11-year conversion programme from ‘town’ gas to natural gas
  - Different technology and different times, but a not-insignificant lead-in time to be expected.

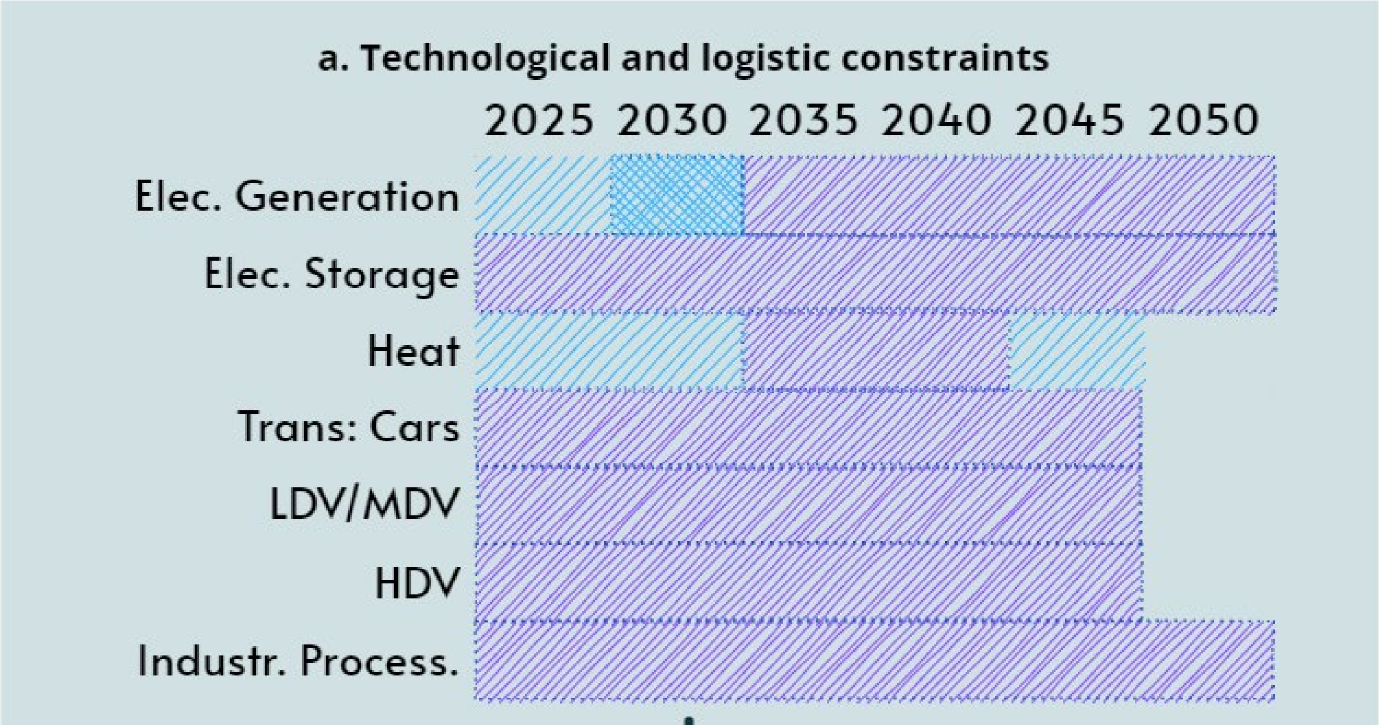
Technological and logistical constraints

- **Electricity generation/storage**
    - Hydrogen burned as a fuel, on its own, in early stages of development
        - Possible to convert CCGT gas turbines to co-fire with hydrogen
        - Mixed reports on when 100% hydrogen-firing technology likely to be widespread
        - The Mitsubishi Hydrogen-to-Magnum Project, aims to convert one gas turbine unit to run on 100% hydrogen by 2027.
    - Storage
        - Certain technology exists

Technological and logistical constraints

- **Transport & Industrial processes**
  - Technology exists in most cases
    - Cost-competitiveness will guide deployment

Technological and logistical constraints



Step 2: Cost competitiveness

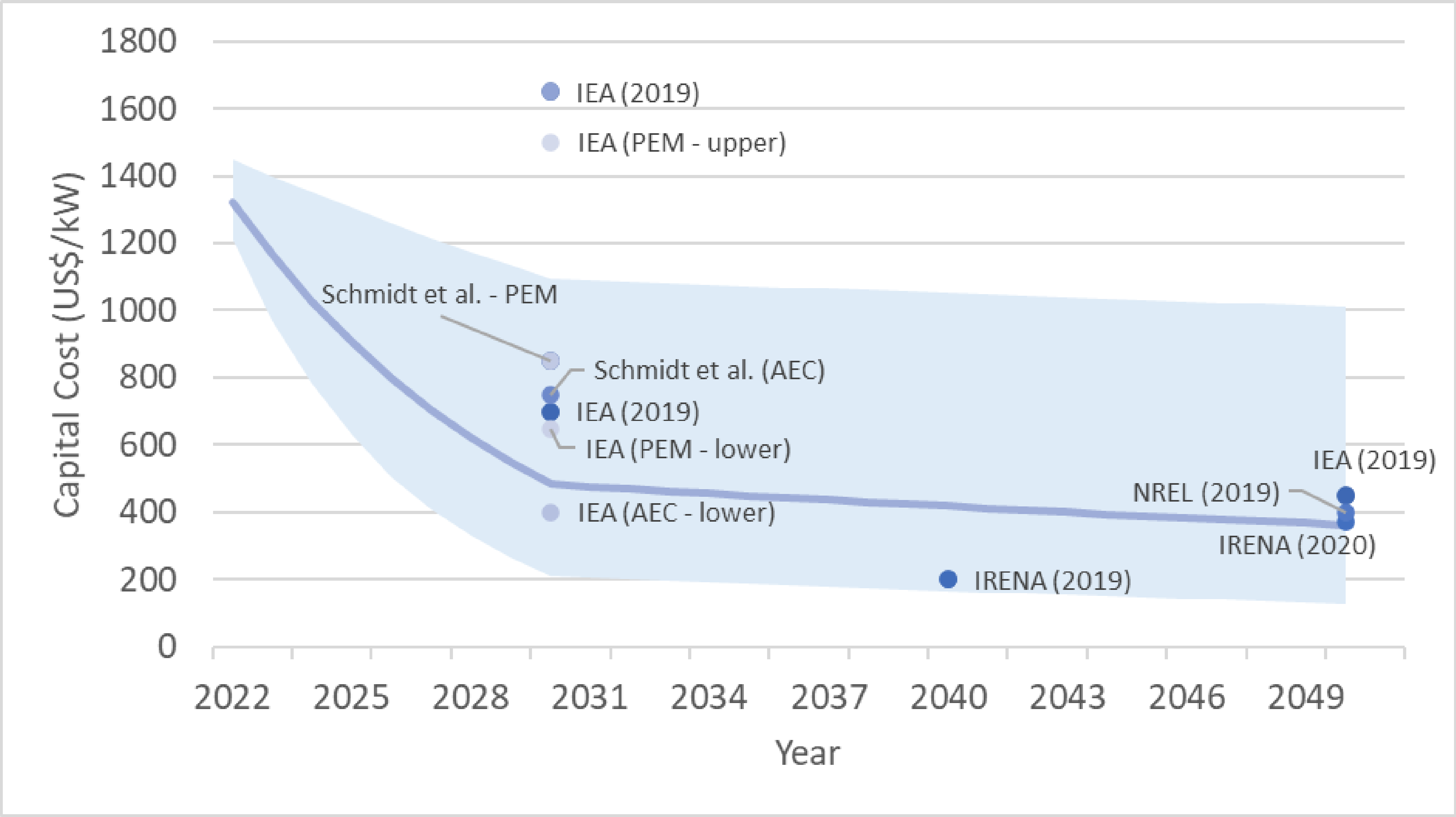
Cost of production

Step 2: Cost-competitiveness

- Following procedure
  - 1) Benchmark of costs
    - What Levelised Cost of Hydrogen (LCOH) likely at low, medium and high likelihood in 2030 and 2040
  - 2) Conditional on these cost projections, what does cost-effective deployment look like?

Drivers of LCOH

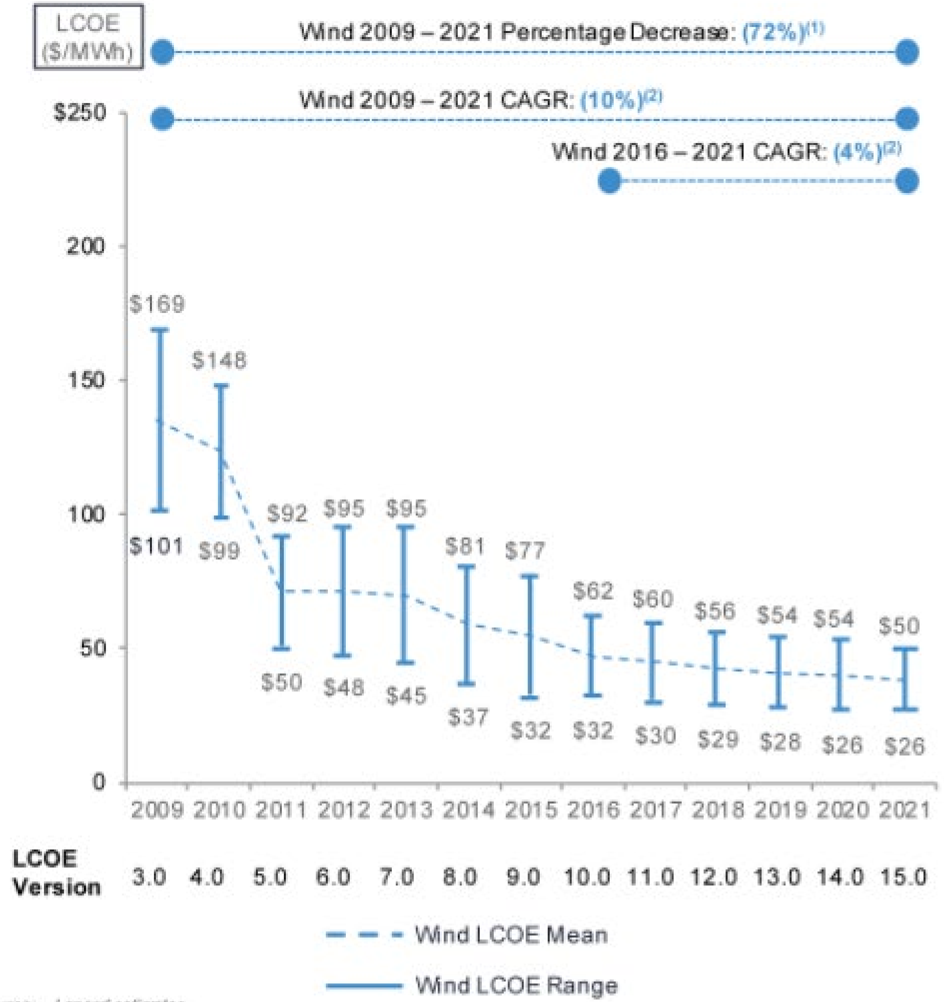
- Primarily
  - Capital cost
  - Cost of electricity


1800
1600
1400
1200
1000
800
600
400
200
0
Capital Cost (US$/kW)
IEA (2019)
IEA (PEM - upper)
Schmidt et al. - PEM
Schmidt et al. (AEC)
IEA (2019)
IEA (PEM - lower)
IEA (AEC - lower)
IRENA (2019)
IEA (2019)
NREL (2019)
IRENA (2020)
2022
2025
2028
2031
2034
2037
2040
2043
2046
2049
Year

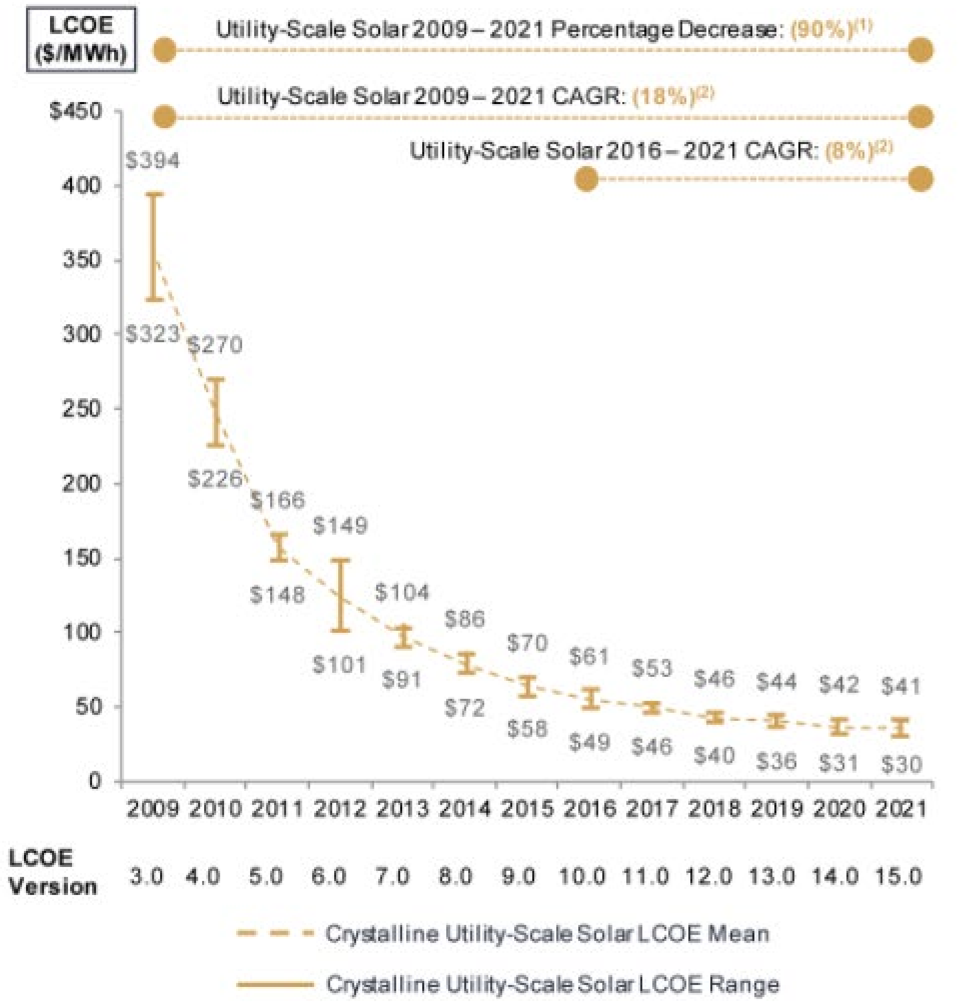
Levelized Cost of Energy Comparison—Historical Renewable Energy LCOE Declines

In light of material declines in the pricing of system components and improvements in efficiency, among other factors, wind and utility-scale solar PV have exhibited dramatic LCOE declines; however, as these industries have matured, the rates of decline have diminished

Unsubsidized Wind LCOE



Unsubsidized Solar PV LCOE



Source: *Lazard estimates.*
(1) Represents the average percentage decrease of the high end and low end of the LCOE range.
(2) Represents the average compounded annual rate of decline of the high end and low end of the LCOE range.

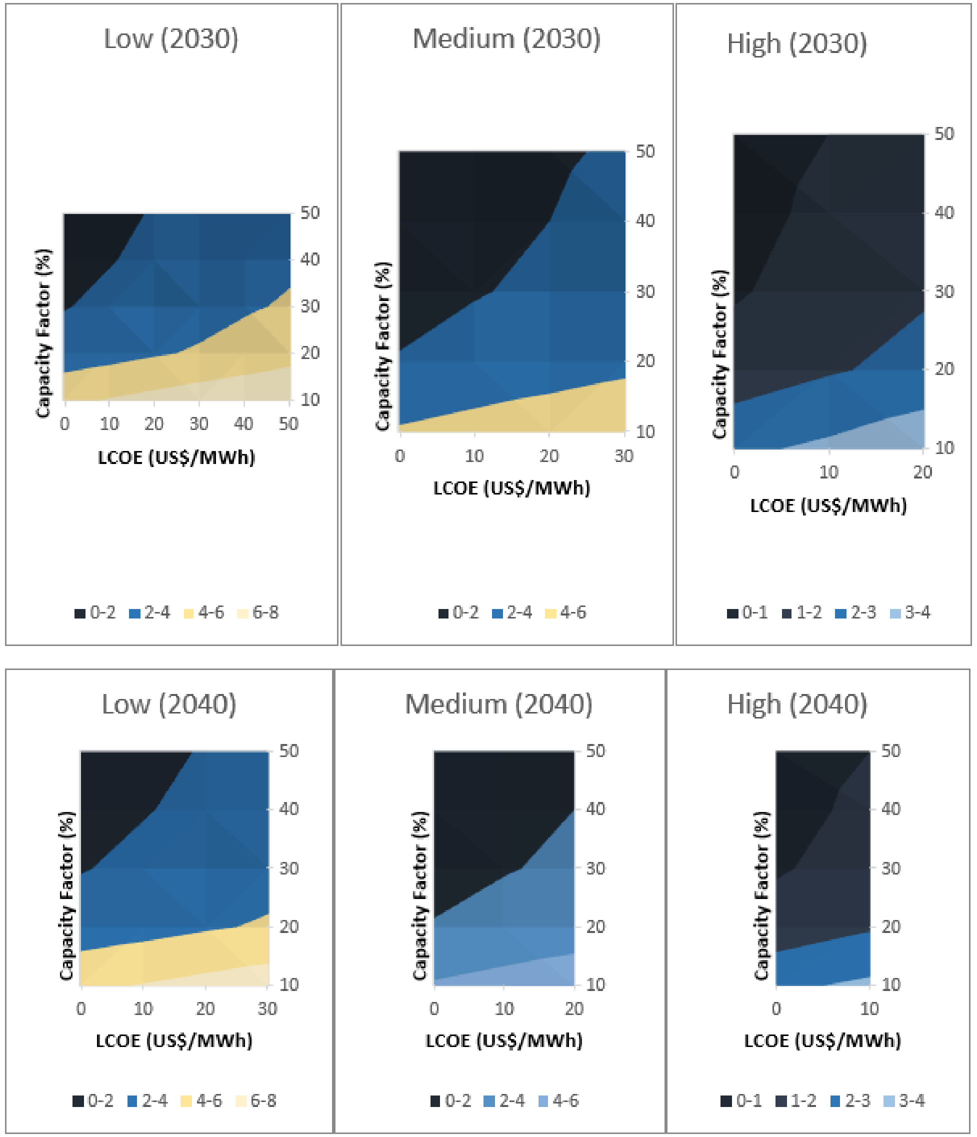


Figure 4: LCOH (USD/kg) by low, medium and high rates of cost reduction: 2030 and 2040 milestones

Notes: Data source The Hydrogen Council [40], Aurora Energy Research [41], Hydrogen Council [55]. The cost-reduction trajectory is estimated conditional on expected capital cost and electricity price changes.

Key insights – cost of production

- If Levelised Cost of Electricity of c.$20/MWh is achieved, alongside utilisation rates of 40% or more, there is a reasonable chance of achieving an LCOH of $2/kg by 2030.

- Lower renewable electricity cost can (partially) compensate for pessimistic rates of capital cost reduction
    - Added spill over effect of further driving down the cost of renewable electricity generation.

Cost competitiveness

Cost of Application

Cost competitiveness

- **Space heating**
  - C. $2/kg is the LCOH benchmark for competitiveness with heat pumps
  - Requires optimistic rates of electricity cost reduction and electrolyser rollout, more likely 2040 +, if at all
- **Industrial use**
- c.$1.5-2/kg. Depends on carbon price and gas price trajectory, most likely post-2040

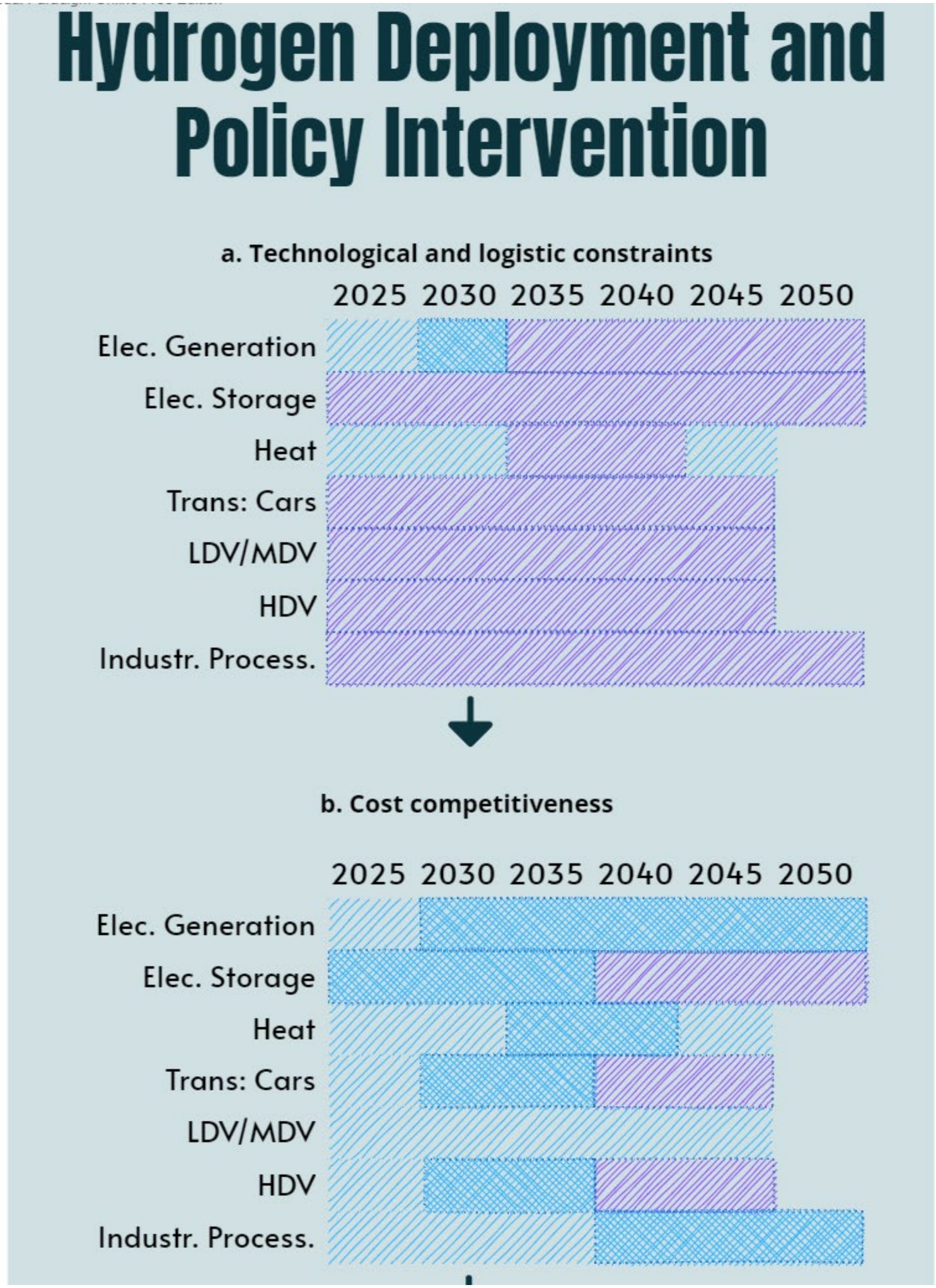
Cost competitiveness

- **Private cars**
  - McKinsey and Co. suggest that hydrogen for private car transport becomes cost competitive with electric alternatives at around $2/kg.
  - Medium-low likelihood by 2030, conditional on the assumed deployment trajectory.
- **Light-duty vehicles**
  - Struggle to reach cost competitiveness with electric alternatives.
- **Medium-heavy duty vehicles**
  - $3/kg is benchmark set by McKinsey. Medium likelihood 2030
  - Vehicle capital cost reductions primary driver for early cost competitiveness

Cost of application

- **Electricity storage**
  - Hydrogen suitable for longer-term storage at high degrees of renewable penetration
  - Likely this most suitable during 2030-2040 window for Ireland
  - Policy response: technology-neutral incentives for flexible capacity. A portfolio of flexibility options will be required and ideally this balance should be guided by market signals.
- **Electricity generation**
  - Feasible c.2030, at unknown cost.

Cost competitiveness



Step 3: Policy response

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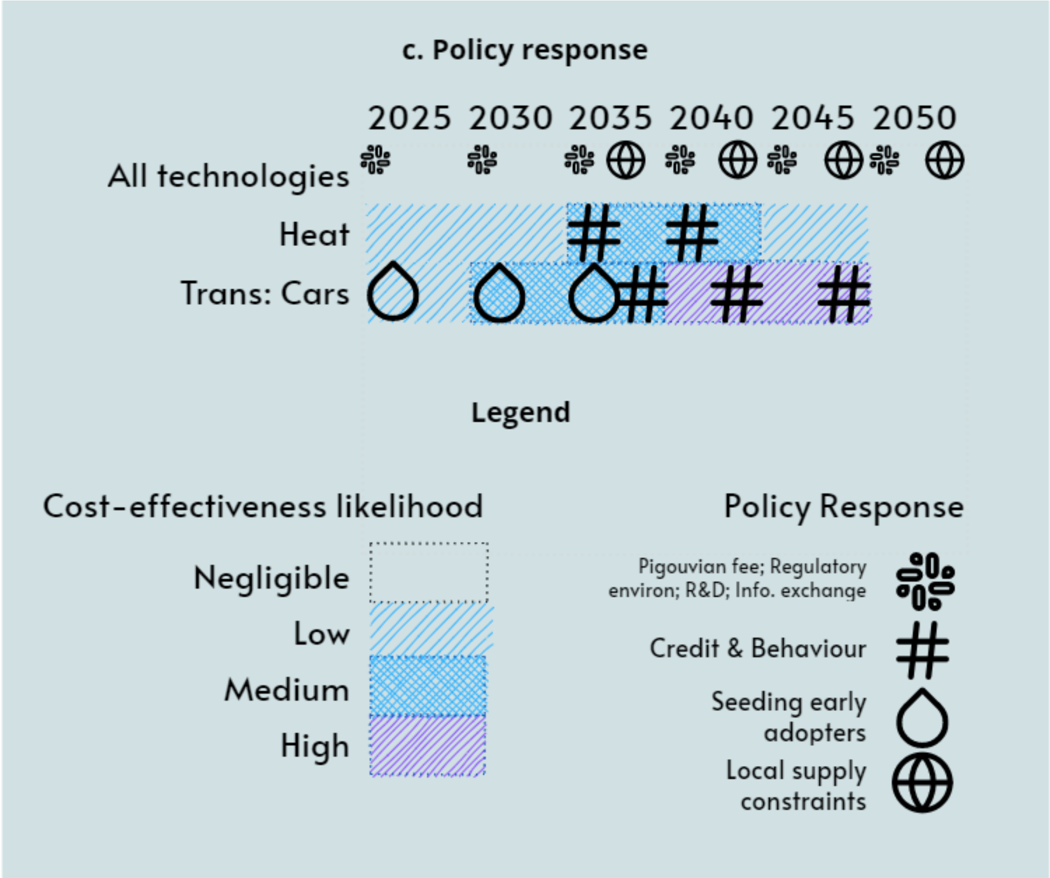
- **Adoption in many contexts will be driven by firms**
  - International prices and domestic carbon prices will guide adoption. Policy required to ensure that transactions are smooth.
- **Electricity Generation/storage**
  - Adequate incentives for storage and flexible generation.
  - Well-working, technology-neutral capacity procurement mechanisms
- **Industrial processes**
  - Policy response: Market driven. Likely unnecessary, possible impediments could be regulatory (e.g. planning electrolyser capacity) and/or related to information diffusion, supply chain establishment, etc.

Step 3: Policy response

- **Heat**
- Long lead-in time and high cost
  - Very narrow window for action. Decision needs to be made sooner than expected if feasible.
  - Credit constraints
  - Behavioural constraints
- **Transport**
  - Tech neutral price supports if implemented – let consumers decide between electric and hydrogen
  - Credit constraints
  - Behavioural constraints
  - Seeding of early adoption

When do we need to start thinking about policy intervention?



In addition, policy response for production

- Given what is known about drivers of cost competitiveness:
  - Deployment-related R&D > lab-based
  - This is a global public good – ideally should be supported at an international level.
- Global production not envisaged as problematic, local bottlenecks may be an issue

Thank you!

niall.farrell@esri.ie

@farrellniall

@niallfarrell@mastodon.ie