Can we use hydrogen as a storage vector to reduce the cost of intermittent renewables?

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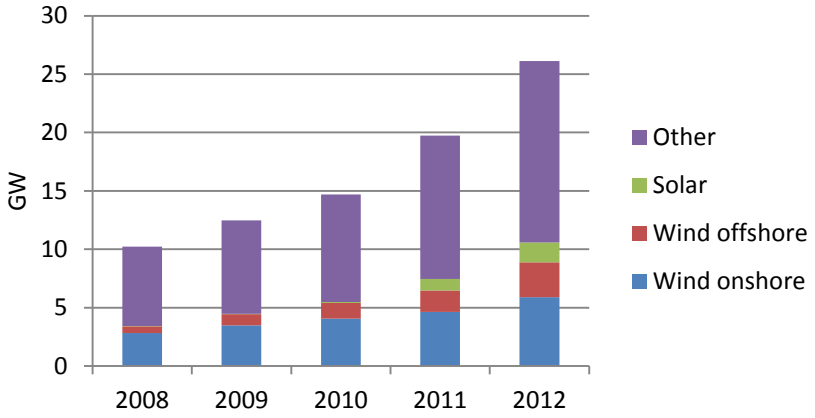
Introduction

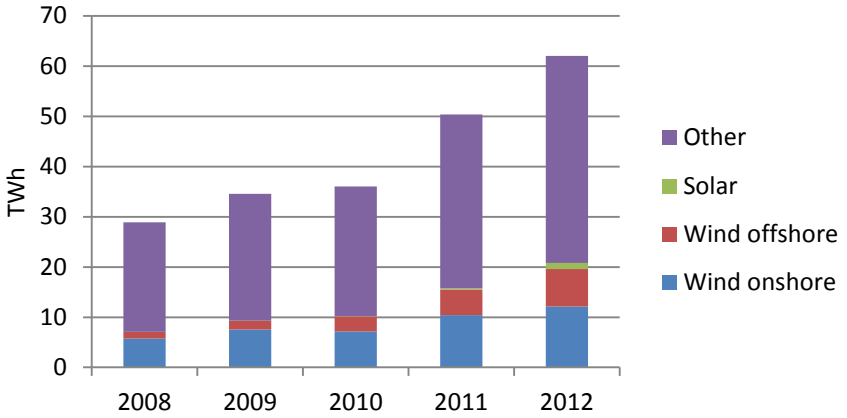
1. UK energy system – electricity and storage
2. Potential roles of hydrogen
3. Important factors in the economics of hydrogen
4. Hydrogen valuation

UK energy system

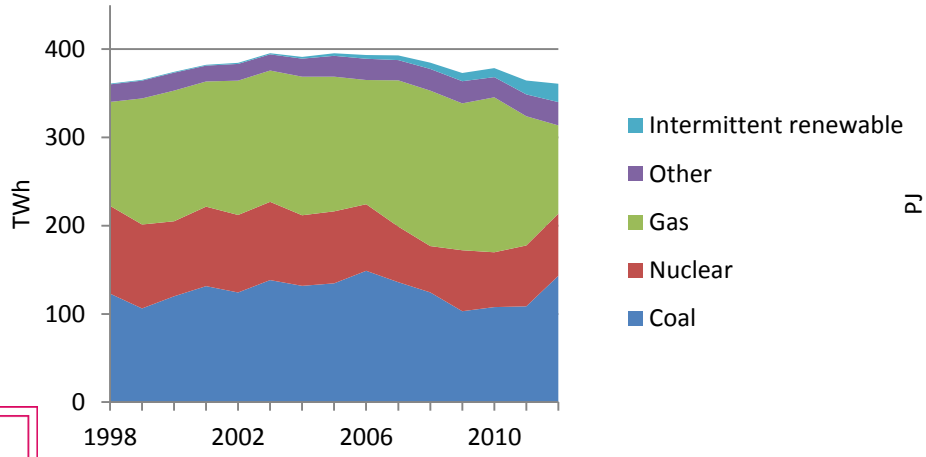
UK renewable capacity



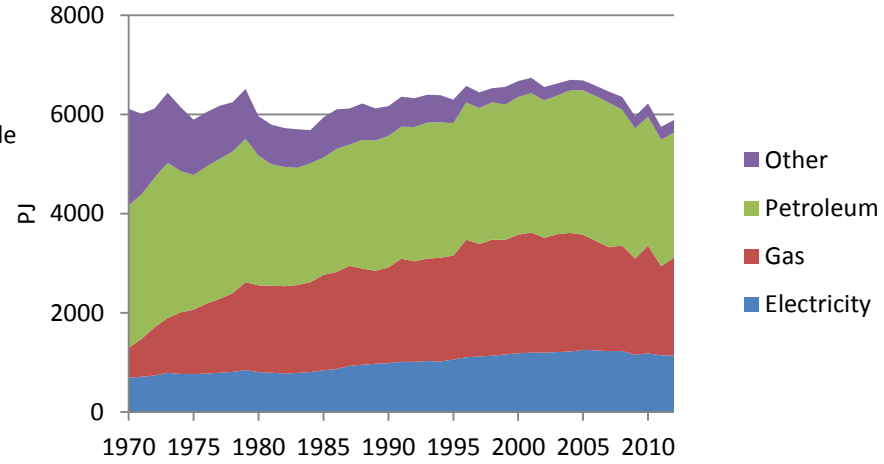
UK renewable generation



UK electricity generation



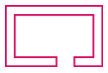
Final energy consumption in the UK



Dealing with renewable intermittency

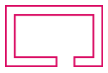
Low demand, high supply periods:

- Curtailment of renewable generation
- Building extra electricity network capacity
- Building electricity storage
- Demand side management



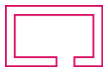
UK energy storage

		Capacity (PJ)	Max flow rate (PJ/day)
Gas	Rough field	117	1.5
	Other depleted field	14	0.3
	Salt cavern	30	3.2
Oil products in 2012		324	
Hydrogen salt cavern		0.01	
Electricity pumped storage			
	Dinorwig	0.004	1.7 GW
	Other		1.0 GW



Hydrogen as a storage vector

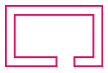
- Electricity storage (underground or gas network)
- Heat decarbonisation (gas network mix)
- Industrial feedstock
- Transport fuel



Can we use hydrogen as a storage vector?

- Yes – from a technical perspective. When regulatory obstacles are overcome.

- Would it reduce the cost of intermittent renewables? Debatable.

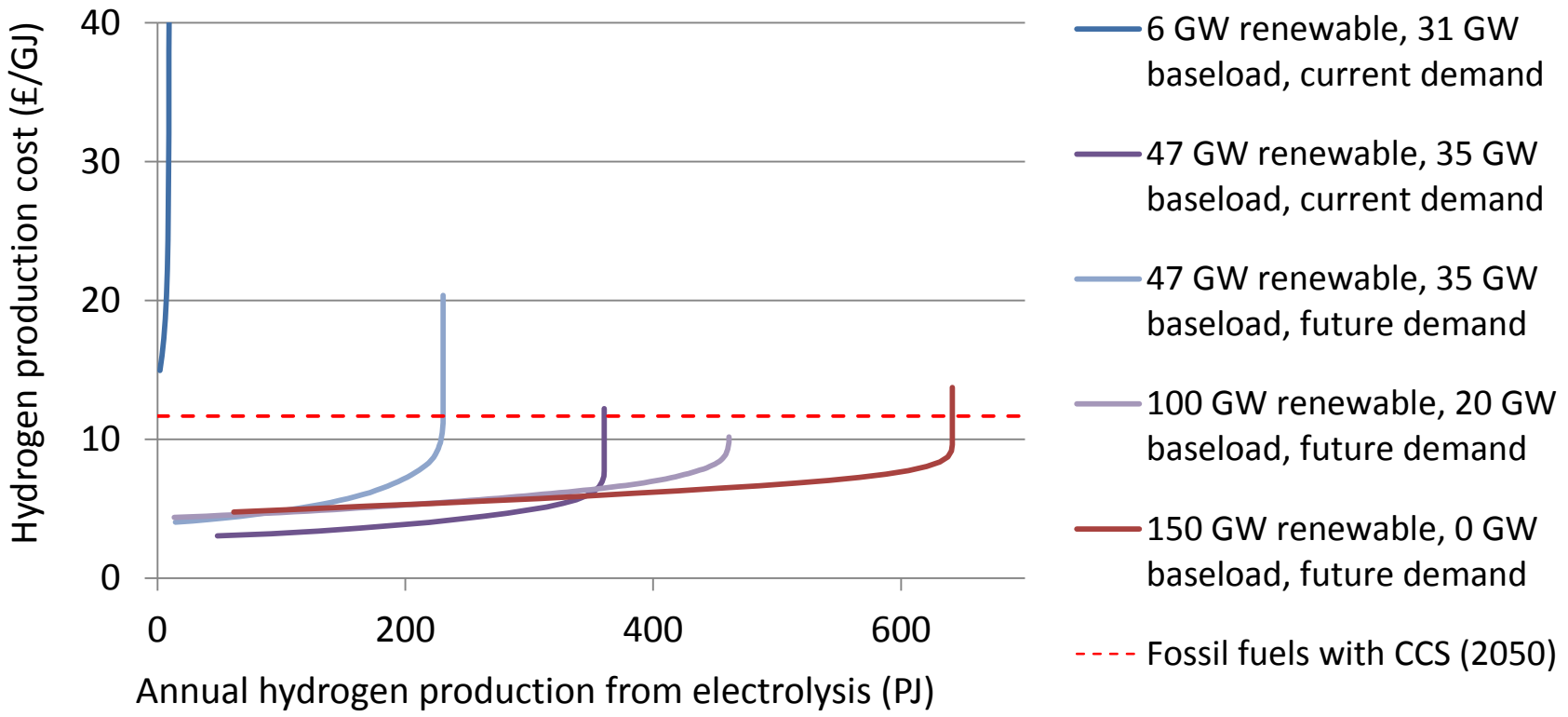


What is the value of hydrogen?

- Cost – electrolysers
- Real options cost – risk of electrolysers being underused

- Direct value – for end uses
- Indirect value – avoiding network reinforcement and storage

Electrolyser cost



Equivalent cost of hydrogen production from additional offshore wind: 25 £/GJ

Indirect value for networks

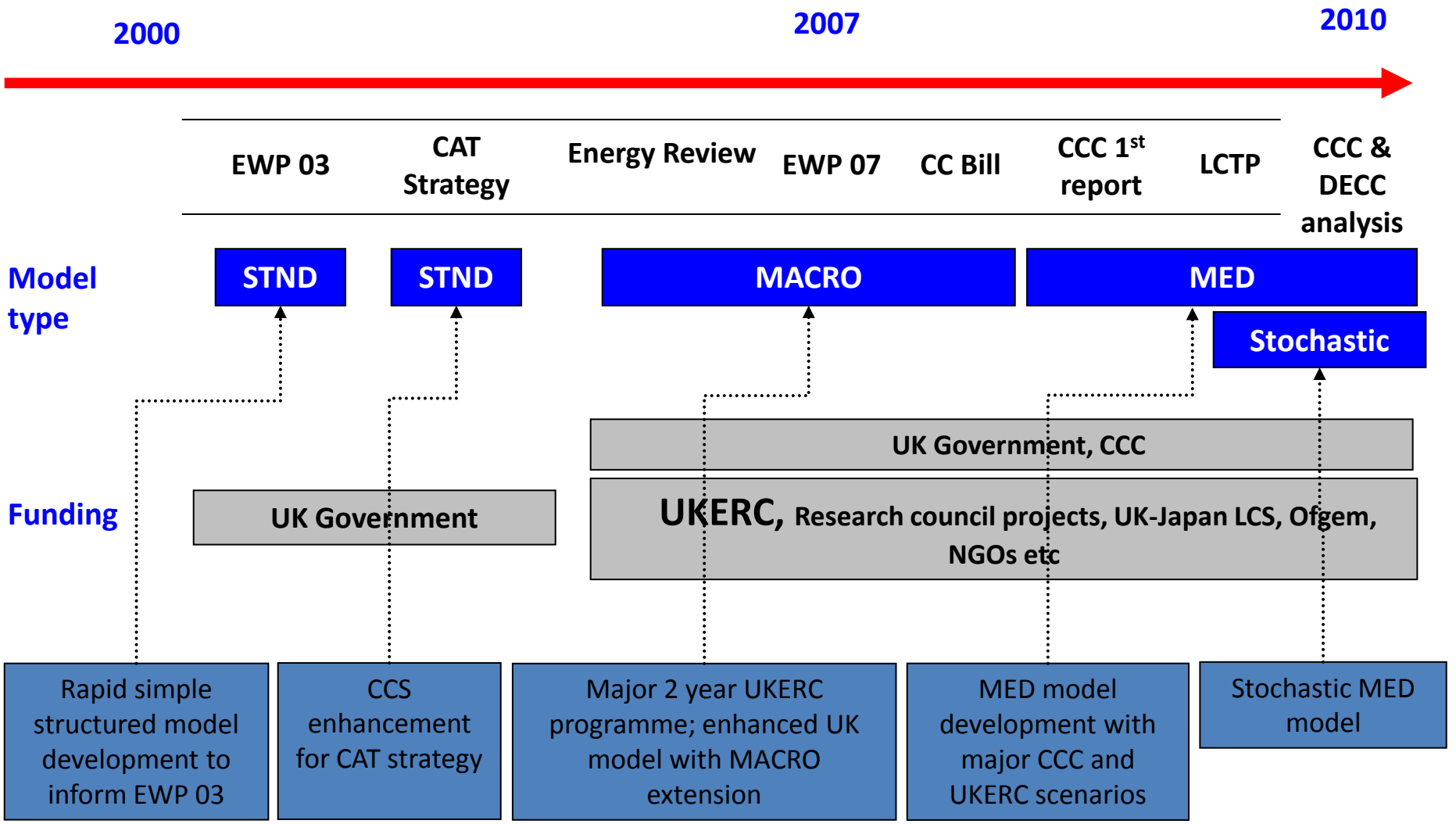
- Where is the future renewable supply?
- Where are the network pinch points?
- Where are the best locations for electrolysers?

UK MARKAL and UK TIMES

- Bottom-up
- Perfect foresight
- Cost-optimisation
- Elastic demands

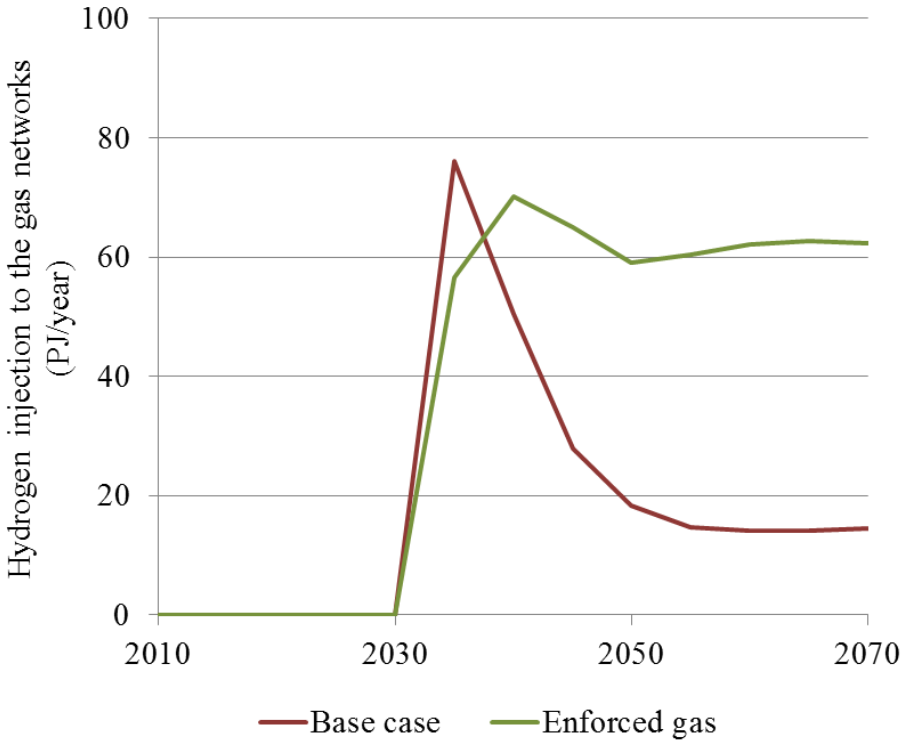
- Energy flows
- Environmental constraints, economic and policy focus

UK MARKAL

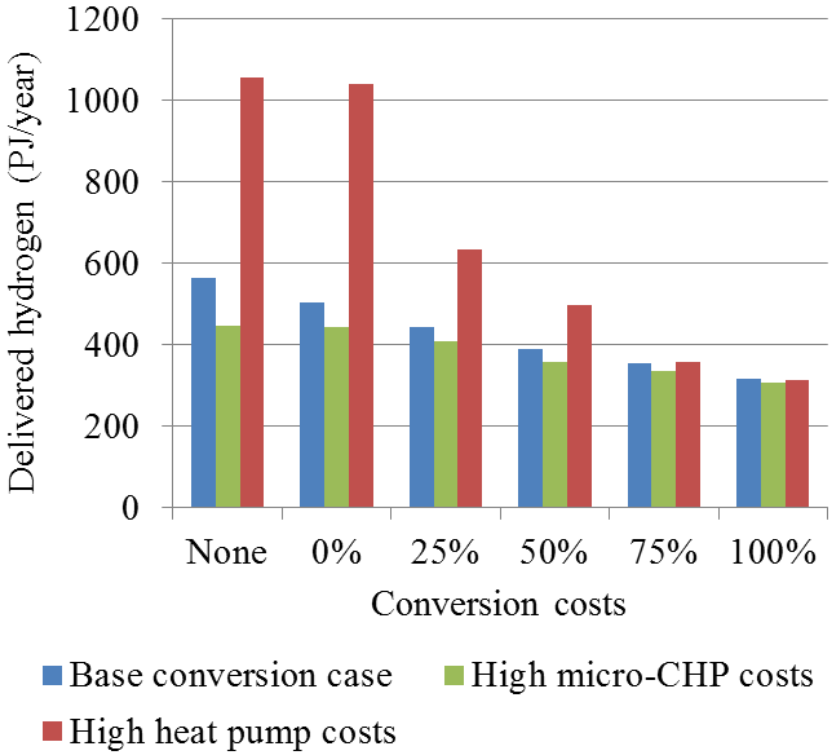

2000
2007
2010
EWP 03
CAT Strategy
Energy Review
EWP 07
CC Bill
CCC 1st report
LCTP
CCC & DECC analysis
Model type
STND
STND
MACRO
MED
Stochastic
Funding
UK Government, CCC
UK Government
UKERC, Research council projects, UK-Japan LCS, Ofgem, NGOs etc
Rapid simple structured model development to inform EWP 03
CCS enhancement for CAT strategy
Major 2 year UKERC programme; enhanced UK model with MACRO extension
MED model development with major CCC and UKERC scenarios
Stochastic MED model

Value of hydrogen as a commodity

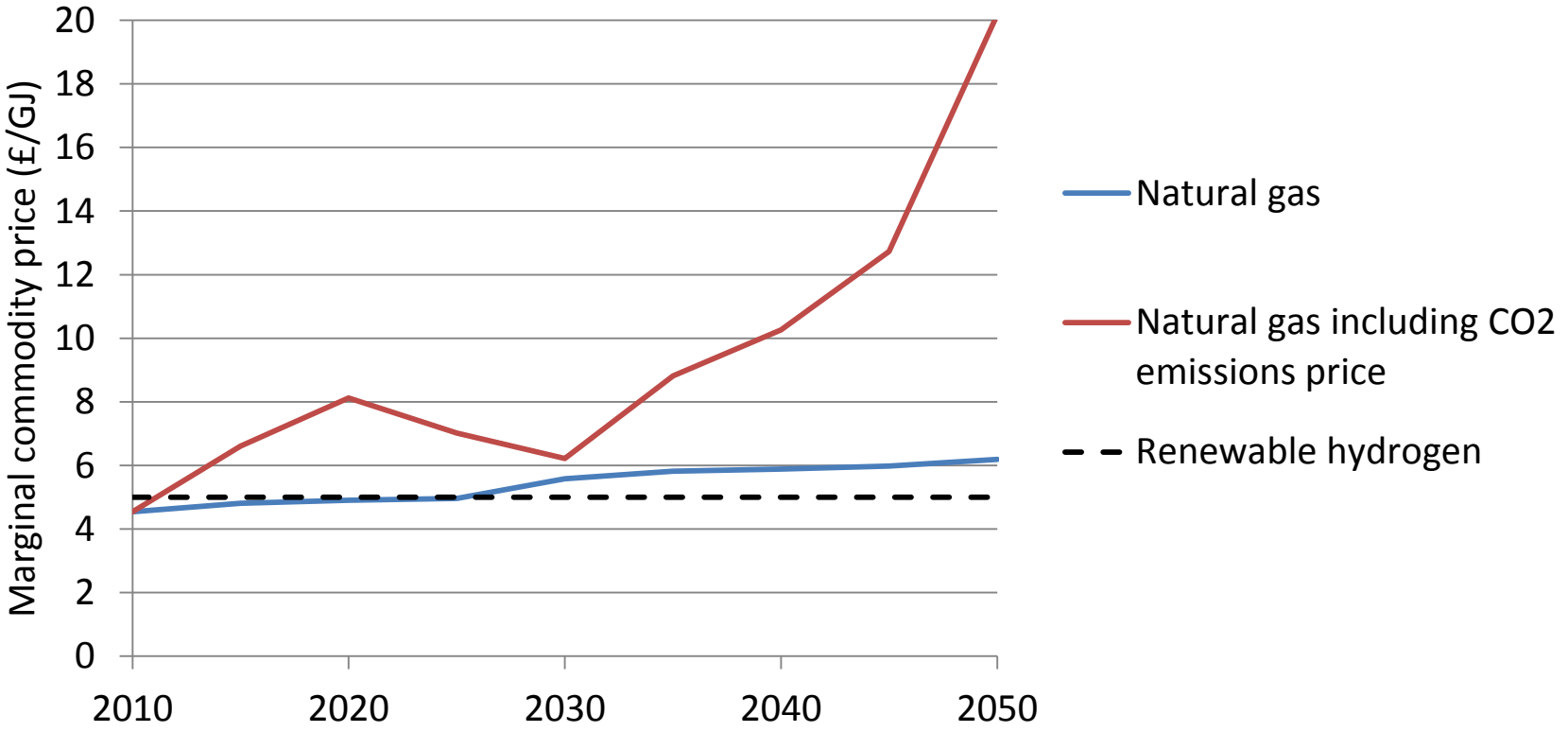
Hydrogen injection to the gas network



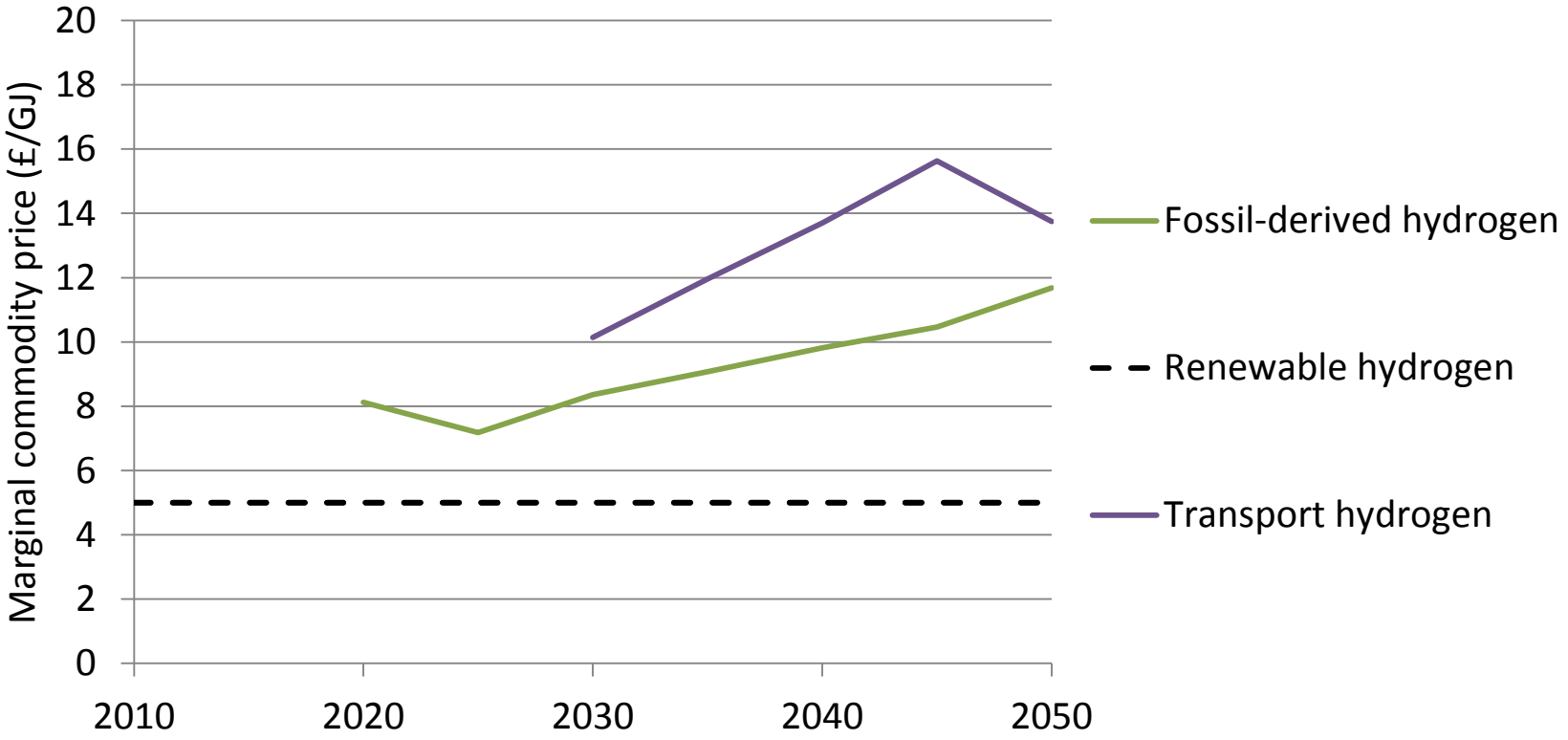
Hydrogen gas network conversion



Value of hydrogen as a commodity

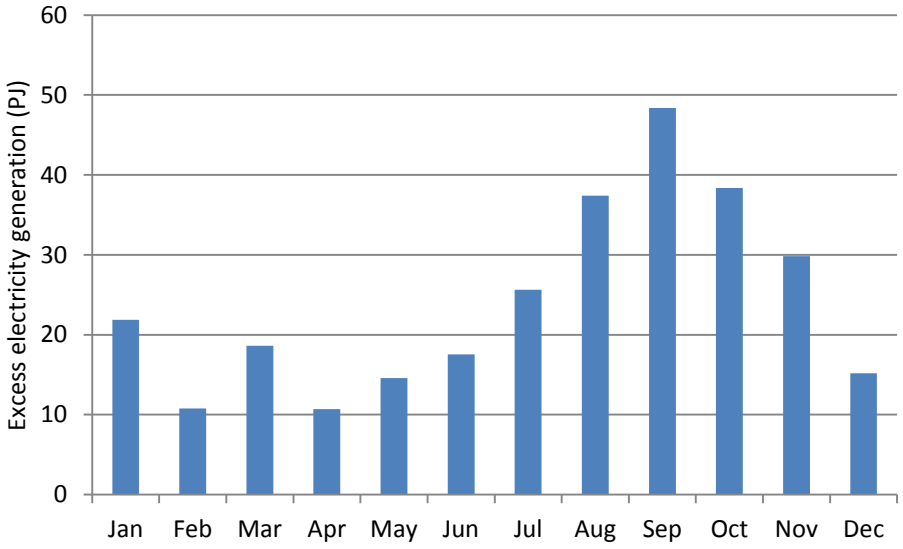


Value of hydrogen as a commodity



Value of hydrogen for storage

- Developing new UK TIMES energy system model to examine inter-seasonal storage of electricity, gas, hydrogen and heat.
- Large-scale hydrogen storage: high cost, eff ≈ 40%
- Modelling issues:
  - Storage needed anyway?
  - How do we represent hydrogen production from excess electricity in energy system models?
  - Demand side management?



Conclusions

- Valuing hydrogen requires us to cross disciplinary boundaries – climate scientists, power engineers, energy economists
- Hydrogen is only an option if the electricity is essentially free or very low-cost – but is an additional market for renewable operators.
- Use in gas pipes or for transport is more economic than large-scale hydrogen storage.
- Future work: real options costs and indirect benefits.

Thank you for listening

Questions?

Thanks: Ed Sharp, Hannah Daly, UCL Energy Systems team

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