Hydrogen and Fuel Cell Foresighting Project

Economic opportunities from Scottish Government Energy Strategy

25th October 2017

[REDACTED]

Overview

- Relevance of the sector to SE
- Hydrogen and Fuel cell Foresighting
- Conclusions and next steps
- Questions/discussion

Relevance of Hydrogen and Fuel cells to SE

- **It could be a major contributor to decarbonisation of multiple sectors**
  - Could address the hard to solve issues like seasonal variation in demand for zero emission heat, over-dependence on renewable electricity to decarbonise heat and transport
- **It could be a new high/skill high employment sector**
  - Tremendous pressures for change especially in the transport sector is creating massive new market opportunities
- **Activity in the sector ties into a number of SE focuses**
  - eg diversification of Oil and Gas and Life Sciences sectors into alternative fuel production
- **High profile of Scotland**
  - Number of projects underway or in development ~19 across Scotland

SE Hydrogen Foresighting 2017

Study Objectives

- Evidence based assessment looking ahead ten years (E4Tech and TNEI input plus other sources eg ETP, Carbon Trust, LCITP)
- Help SE and stakeholders understand the challenges and opportunities (eg jobs) for HFC and how they can best play a role to maximise Scottish economic benefit, both locally and internationally.
- Exploring how the UK HFC roadmap applies to Scotland.
- Identifying the best options for support in the Scottish context

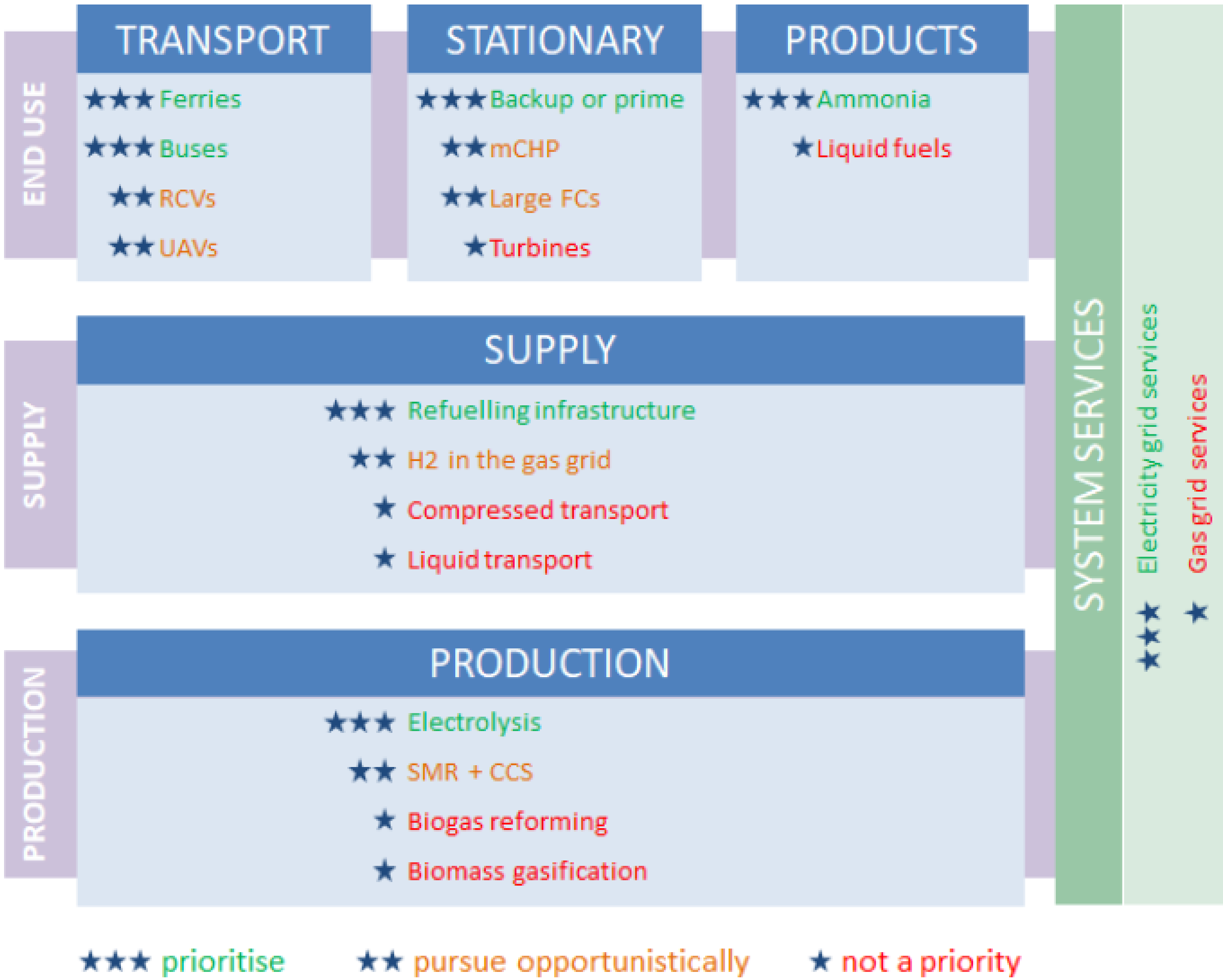
SE Hydrogen Foresighting

Review Criteria

- Technology and markets – maturity, costing of tech versus alternatives etc
- Scottish relevance - company capability, projects etc.
- Role in ‘energy system’
- Role for Scottish Enterprise (inc collaborations)

Steering Group – ETP, Scottish Cities Alliance, Scottish Government

Recommendations from E4Tech review



Technology & Markets a broad perspective

Technology

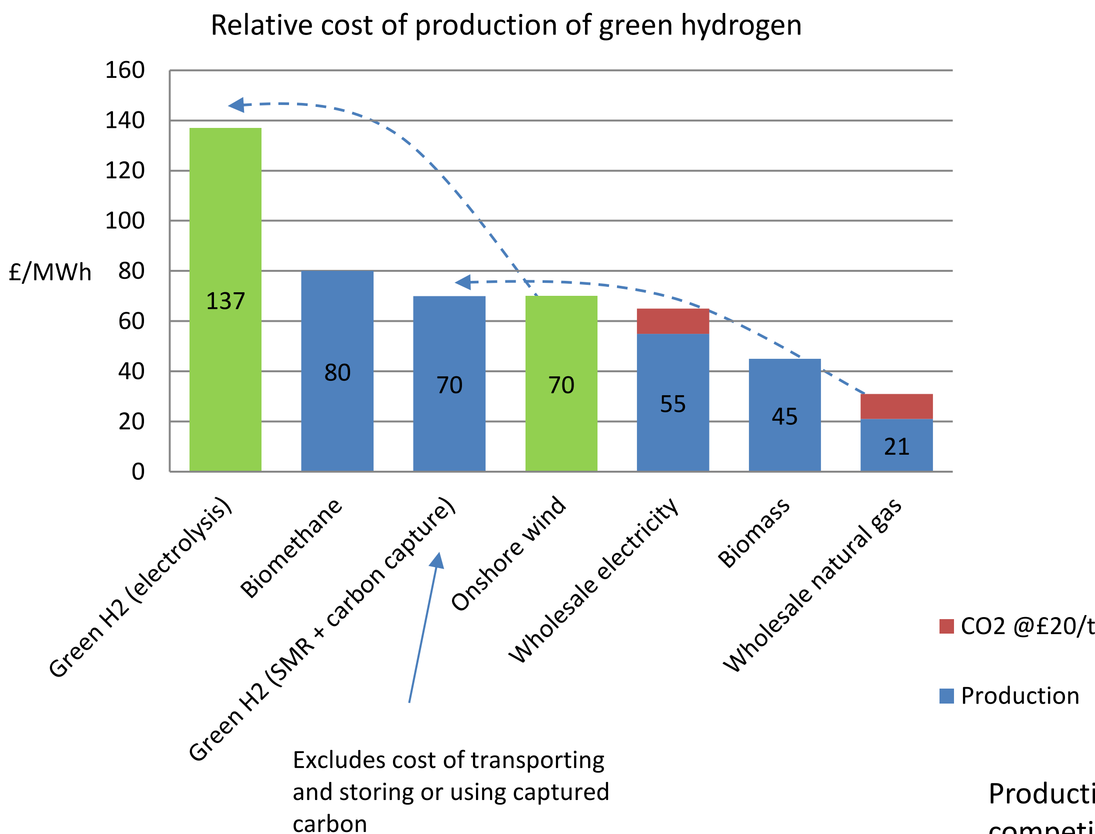
- Electrolysis and Fuel cells are mature
- Carbon Capture and Storage is not mature
- Using hydrogen generally requires a couple more steps than alternatives (cost and efficiency impact)
- Major progress (falling costs, rising sales etc) generally expected
- Some choices block off others eg Fuel cells need pure H2. Stops partial conversion of gas network

Markets

- There are low carbon alternatives for every hydrogen and Fuel cell application
- Market entry price varies significantly by sector
- Huge sunk investment in existing infrastructure
- Policy is a significant driver of change

H2 Production

- Its a vector – produce it from water or natural gas, first step before using it
- Two very different processes – one can be very distributed, the other can leverage industrial economies of scale
- Can then use it multiple ways many of which appear less challenging than in a Fuel Cell eg in a gas turbine, in a boiler

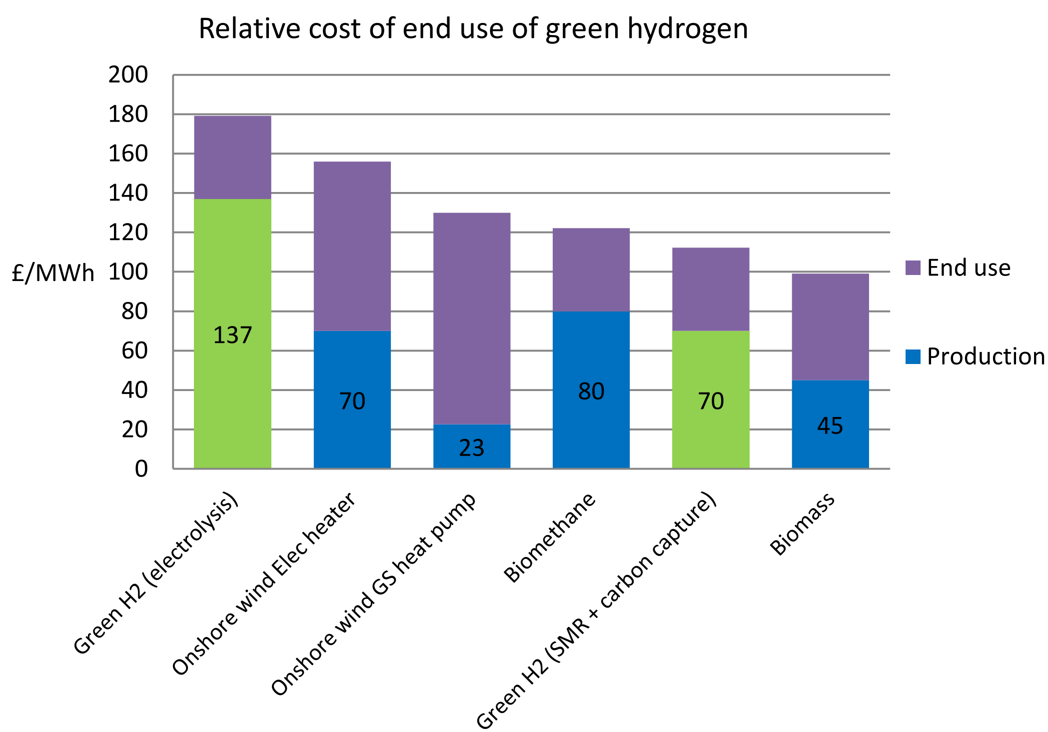


Production conclusion – SMR+CC looks competitive but uncertainties eg cost of transport and storage

End use - Low carbon heating

Context

- Largest energy needs are heating. Lowest price. Big seasonal swings. Making progress decarbonising mainly via biomass. Expectations of significant reductions in demand because of energy efficiency

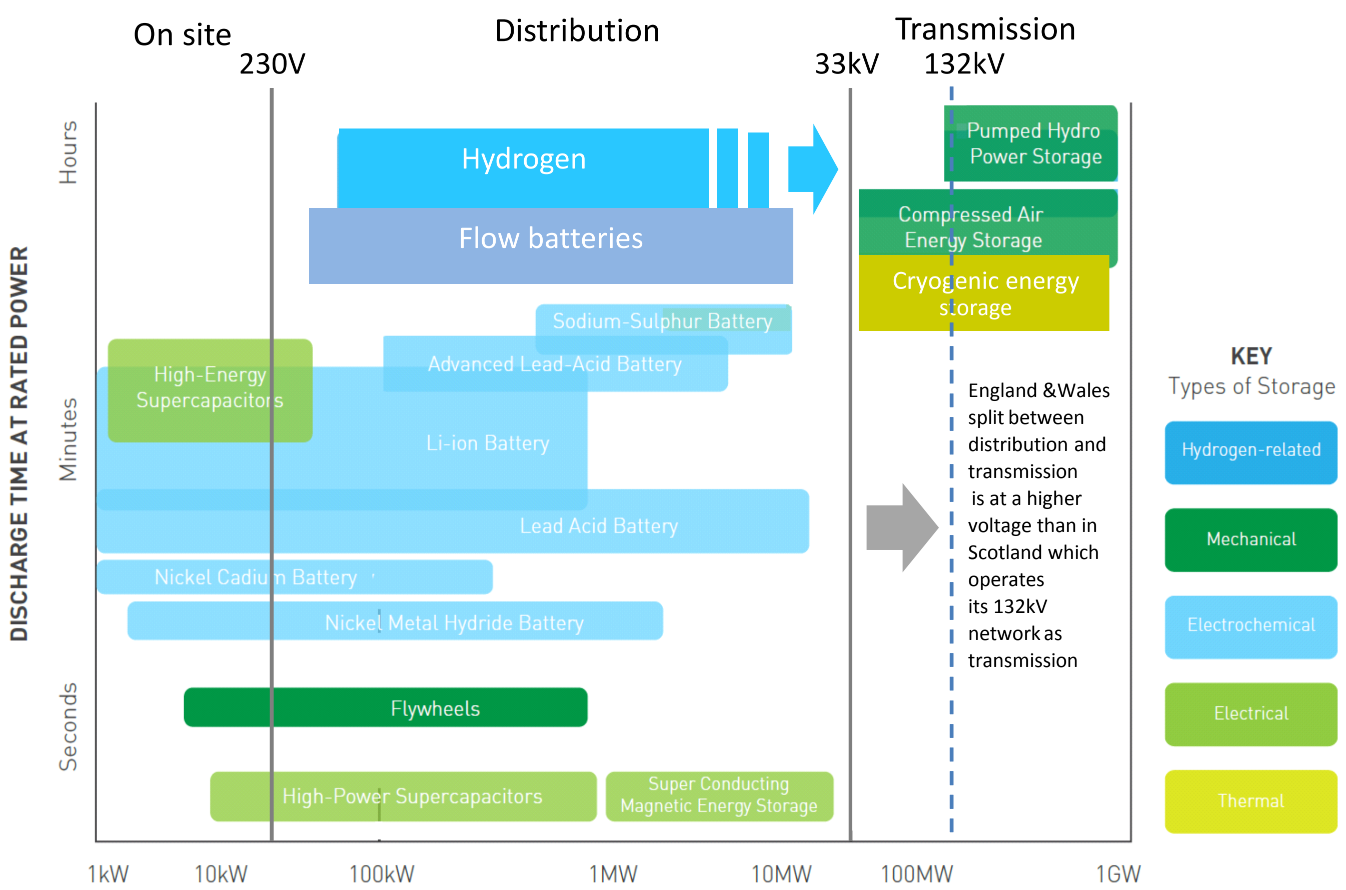


Low carbon heat conclusion – SMR+CC looks competitive and can scale (but uncertainties)

End use - Electricity

Context

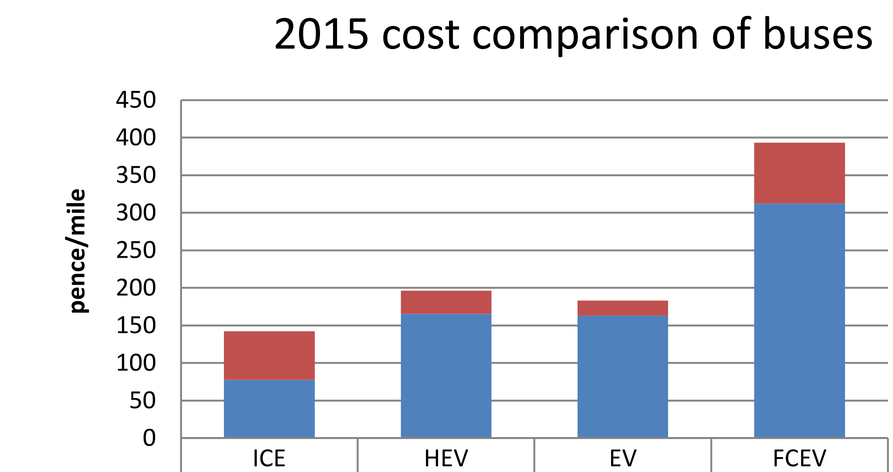
- Significant progress decarbonising electricity being made – half CO2 content per MWh what it was in 90s.
- System focus on electricity as the answer to decarbonising electricity, transport and heat – can the network cope



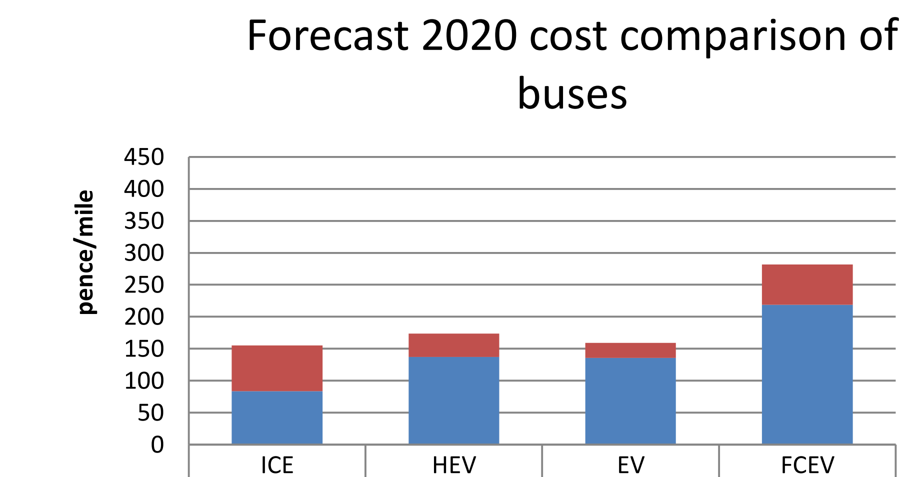
End use - Transport

- Element Energy predict significant price reductions for hydrogen fuel cell vehicles if/when global production numbers rise to the order of 200,000 vehicles p.a.
  - Significant announcements in China, Korea and Japan suggest >100,000 vehicles p.a. by 2020-25
  - SE/Scotland should keep a watching brief on fuel cell vehicle price trends in the light road sector

- SE/Scotland should consider supporting appropriate pilot demonstrator projects to develop Scottish expertise in hydrogen transport, particularly in niche transport sectors such as ferries and buses
  - Constrained routes greatly simplify refuelling for these applications



	ICE	HEV	EV	FCEV
Fuel	65	31	20	81
Capital Costs	78	165	163	313



	ICE	HEV	EV	FCEV
Fuel	72	36	24	63
Capital Costs	84	137	136	219

Scottish company base

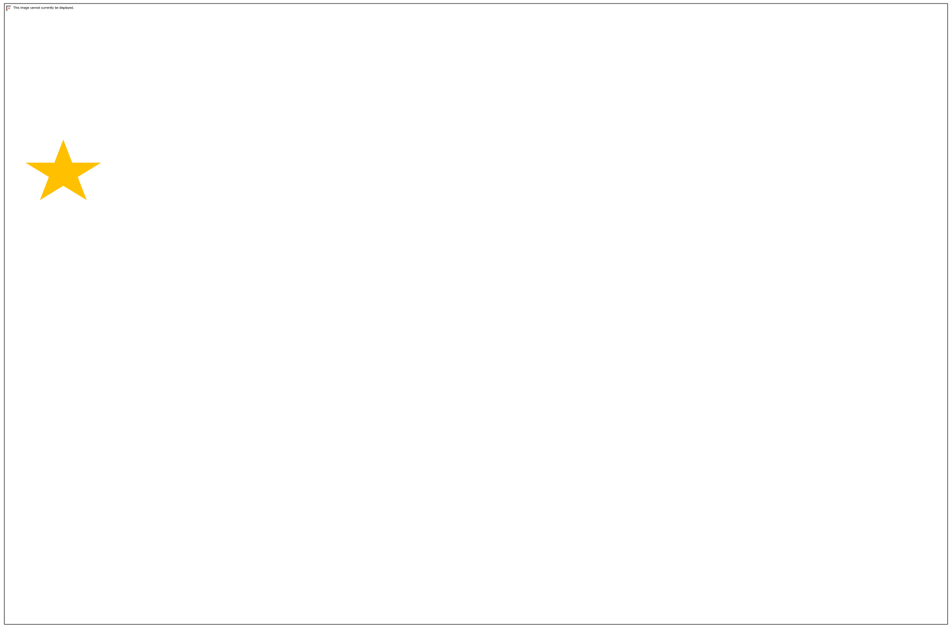
Manufacturing	Ferguson Marine (ships); Alexander Dennis Limited (buses); Farid Hillend Engineering (RCV); Raptor UAS (FC UAVs); Enocell & iPower (FC suppliers); Turbine Services ; Ethos Energy (turbine overhaul); Wyman-Gordon (forged turbine blades) Latent: Cyberhawk Innovations; Aeropair Ltd
H2 Storage	Pure Energy Centre Latent: Pure Energy Centre (for transport applications) ;GL carbon fibre facility (not currently H2 grade, but could be developed);BOC Linde; Calor; SIG Industrial Gas Supplies
Gas management and supply equipment	Latent: Speck & Burke; Express Gas & Cryogenic Systems
Fuel Cell supply chain	Ceimig (develops catalyst for PEM fuel cells); Enocell (system stack and BoP); Logan Power (system integrator); Linnet Technology (UPS systems); Pure Energy Centre (Installation and maintenance) Latent: Doosan Babcock (system integrator); Harpers (CHP providers); Motive Renewables (CHP providers)
Turbine supply chain	Doosan Babcock Energy (pipework, pressure parts, and heat recovery steam generators); Incamet (precision casting for tube attachments.)

Scotland has a manufacturer within each area of interest who is actively engaged with hydrogen projects; potential scope to enter the FC market through the supply chain

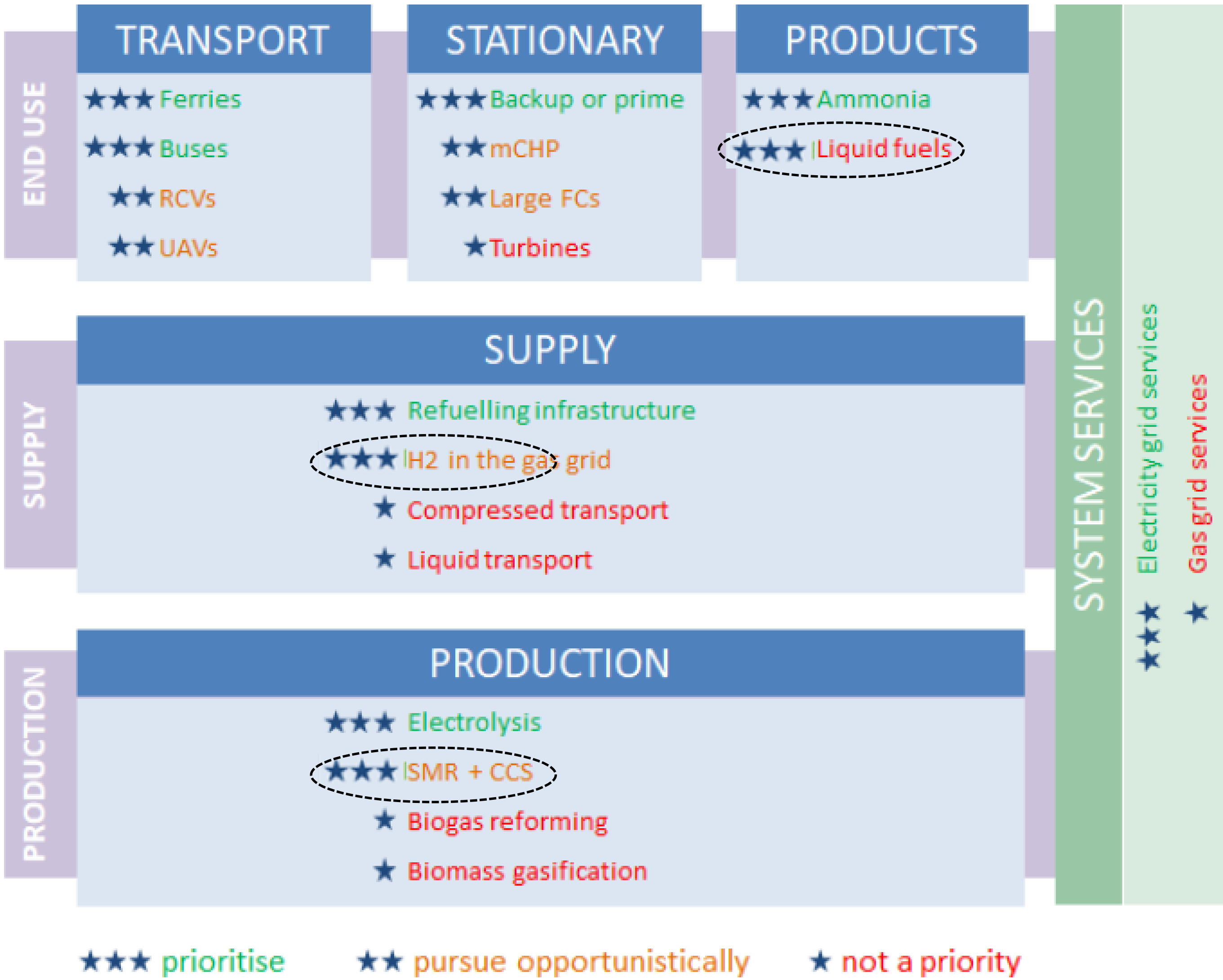
Scottish company base

Hydrogen refuelling supply chain	Haskel (H2 equipment manufacturing); Tokheim (Fuel dispenser manufacture) Latent: The Weir Group (control and safety valves); Auld Valves (control and safety valves); KVC UK (valves); Schoolhill Engineering (valves); Pfaudler (fuel processing); Combined Pumps (pumps); Ferrier Pumps Limited (pumps); Ritchie MacKenzie & Co Ltd (pumps); SPX Flow (pumps)
Hydrogen refuelling infrastructure	Logan Energy (design, integration, installation, commissioning and maintenance of hydrogen production and refuelling stations solutions); latent potential in Scotland comes from smaller gas equipment companies
H2 in gas grid supply chain	Latent: Cochran (industrial boiler manufacturer, preparation for 100% H2 use)
Electrolyser installation and operators:	Pure Energy Centre; Logan Energy (system integration services)
SMR + CCS supply chain	Latent: Doosan Babcock, SGN (natural gas distributer); Shell, INEOS Grangemouth (see below)

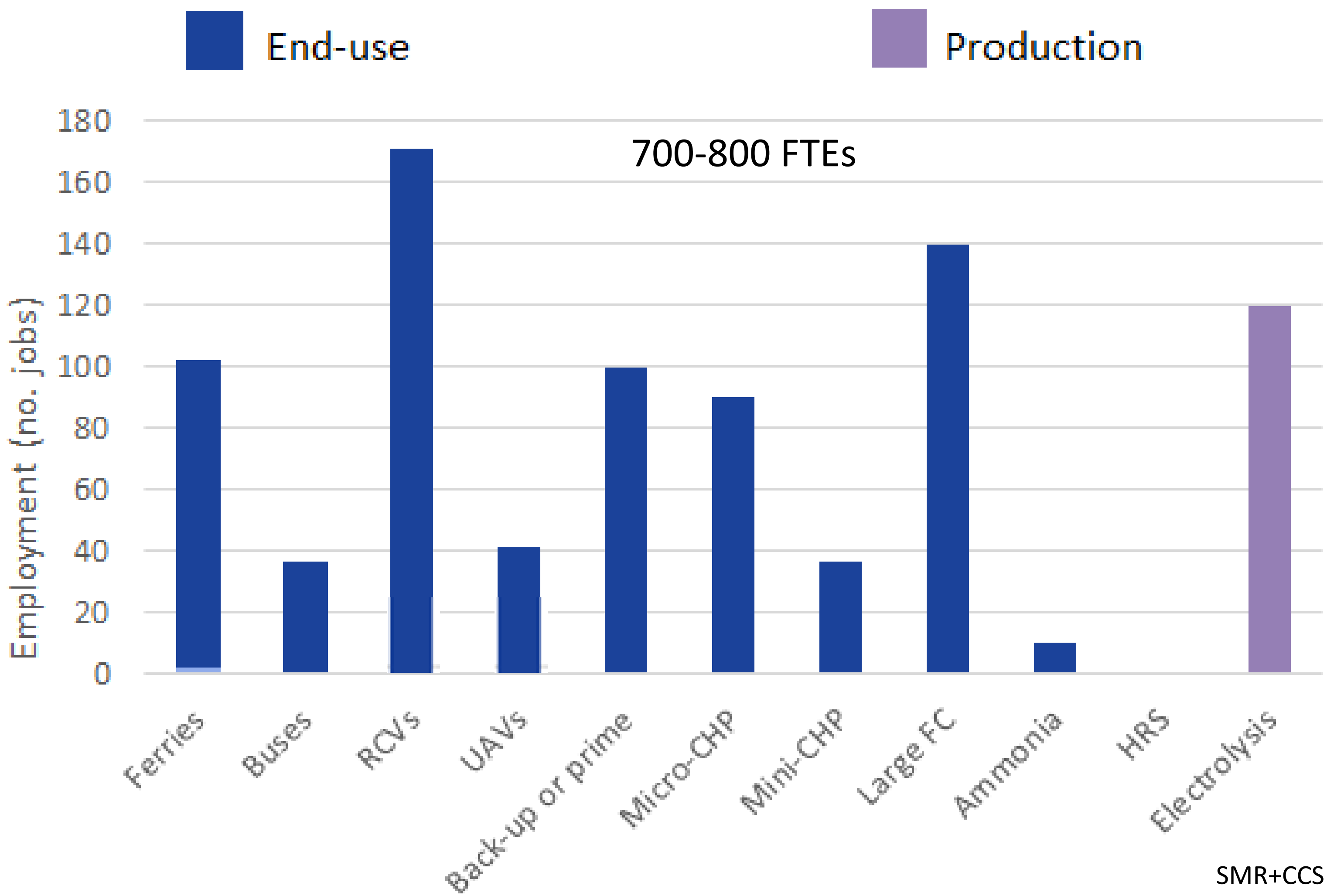
Opportunities for oil and gas diversification



Modification of Results



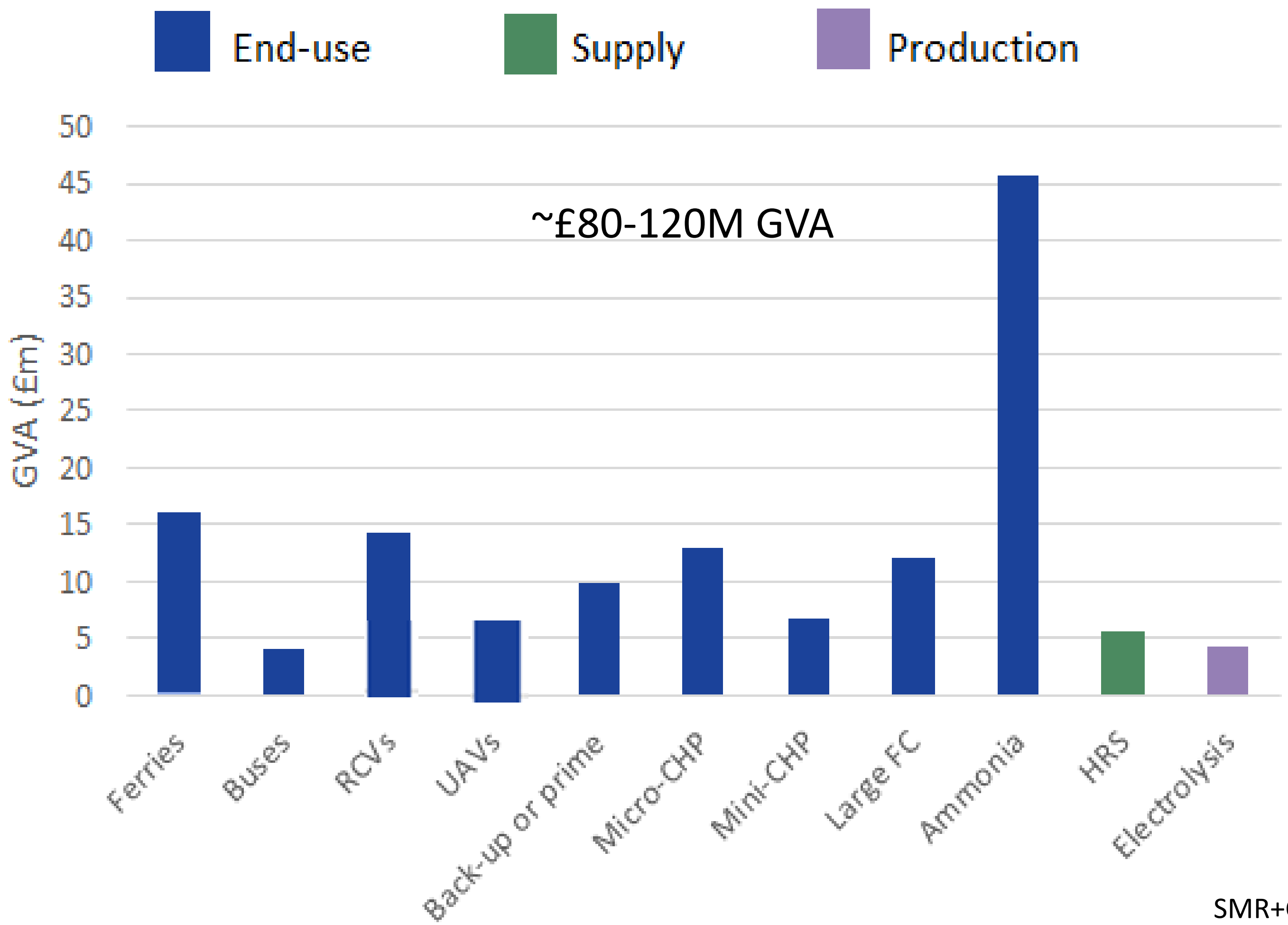
Scottish employment forecast 2015-25



SMR+CCS – several hundred FTE

Review impact of SMR+CCS, liquid fuels, H2 in gas grid and ammonia

Scottish GVA forecast 2015-25



SMR+CCS – several hundred million GVA

Review impact of SMR+CCS, liquid fuels, H2 in gas grid and ammonia

Conclusions

Broadly concur with E4Tech focus areas -

- Transport – high duty niche (ferries, busses)
- Stationary back-up power - remote areas, offshore, Aggreko
- H2 refuelling infrastructure - strong Scottish capability
- Products - ammonia - market, Scottish projects and inward investment interest
- H2 production via electrolysis - growing demand, offsetting grid upgrade, Scottish capability
- System services for electricity - existing market, possible use of electrolysis, H2 for storage

Suggest add -

- Transport - rail
- H2 Refuelling infrastructure - H2 into the gas grid
- Products - liquid fuels - assess impact of new RTFO
- H2 production via SMR + CCS – appears a low cost, large scale route for H2 & ties into Scottish downstream oil and gas strengths
- But cost and technical issues (eg conversion losses) mean alternatives will challenge uptake of hydrogen and Fuel cells (eg storage)

Follow-on work

Additional work

- Fast review of suggested additional areas (eg RTFO)
- Integrate costing of environmental impact of local air pollution

Process

- Finalise SE Hydrogen and Fuel cell Foresighting (adding feedback from SHFCA and this ScotGov event)
- Run stakeholder workshops to build up consensus/detail on how to integrate recommendations into SE/ScotGov strategy (eg innovation support) and identify new projects (including international opportunities)
- Promote ongoing review/agreement of costs and other key aspects of technologies – publish to assist wider community (eg like Riiso Denmark for wind cost and performance data)

Questions

- Given uncertainties around cost of CCS and therefore SMR is this a serious pathway for hydrogen?
- Does production of green hydrogen via electrolysis have a viable future?
- In which circumstances would hydrogen and Fuel cells use in energy systems be a serious option?
- Are there any other applications we should be thinking about?