SCIENCE POLICY RESEARCH UNIT

A hydrogen transition through a sociotechnical lens

United Kingdom Unconventional Hydrocarbons (UKUK) Summer Seminar Series on "Debating the Future of Hydrogen Energy," October 28, 2020

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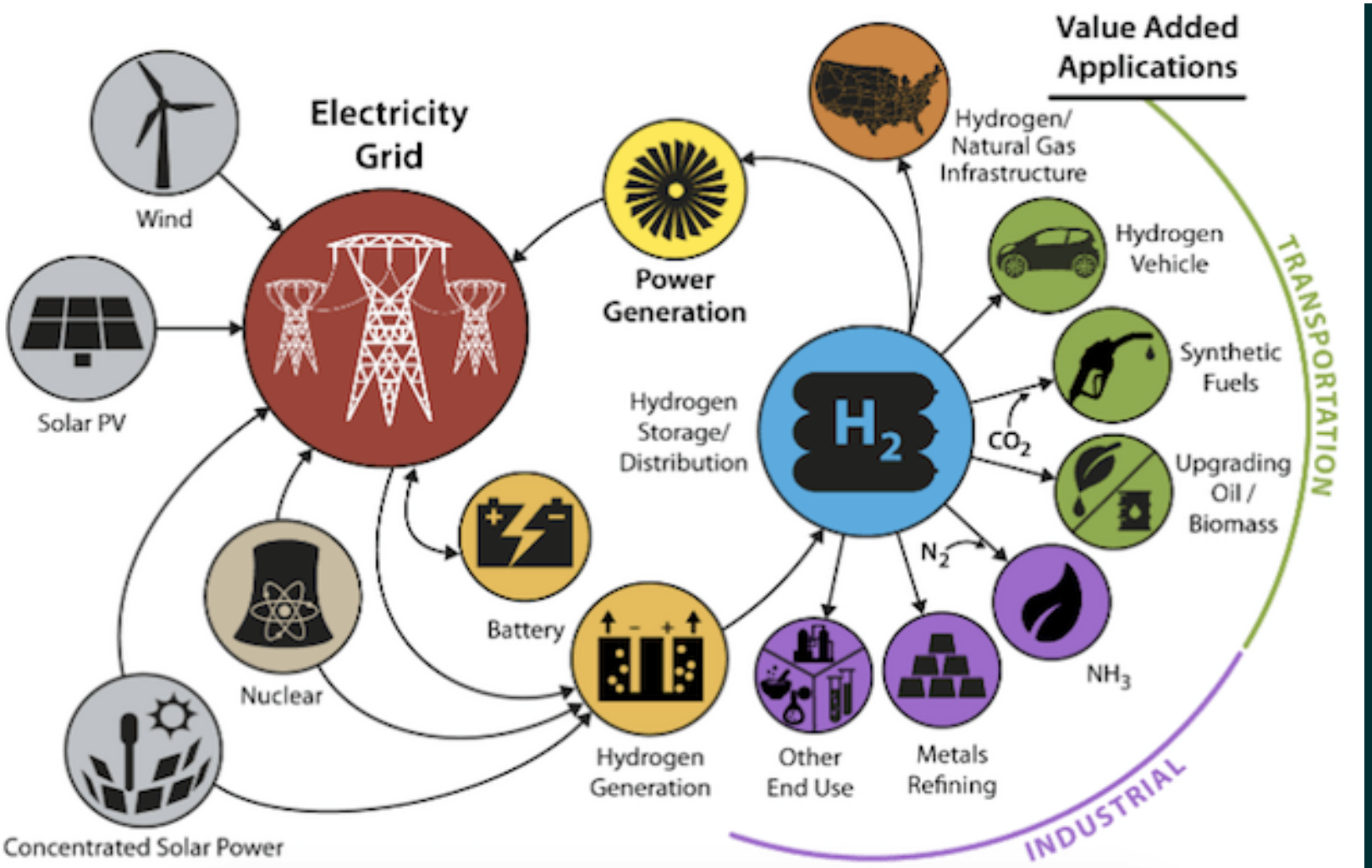
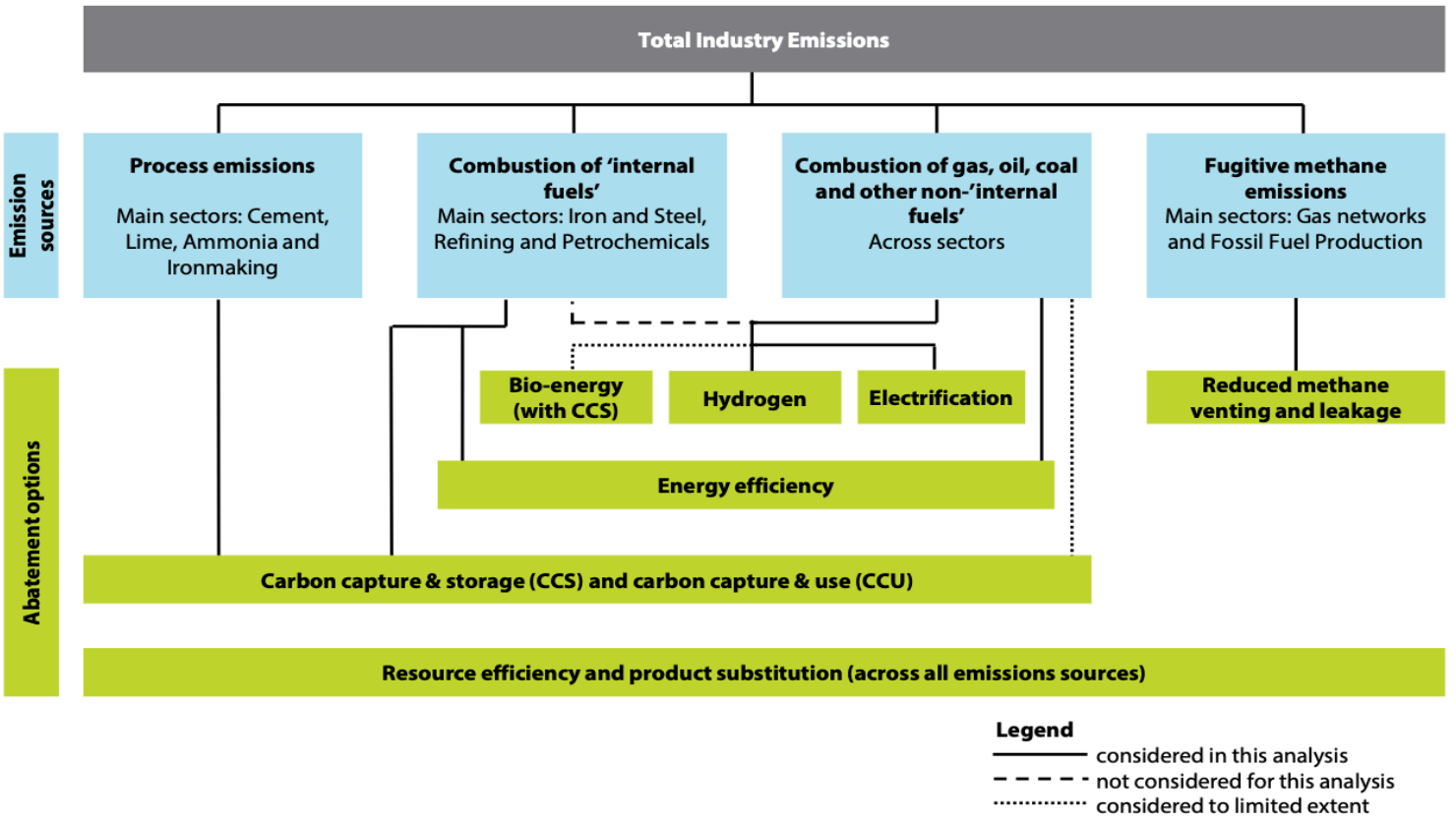
Hydrogen has immense *potential*



Hydrogen has immense *potential*

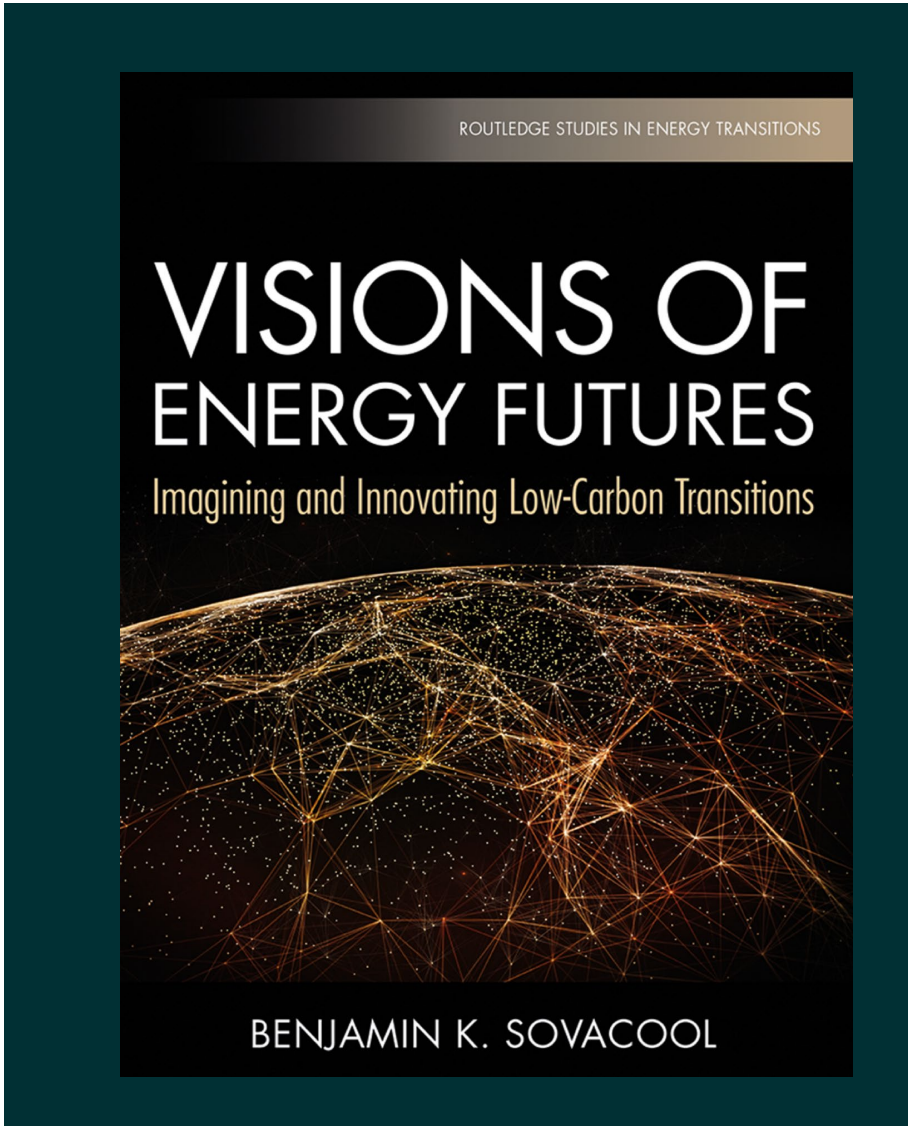
Figure 4.4. Schematic of abatement options for industry emissions and scope of CCC report analysis



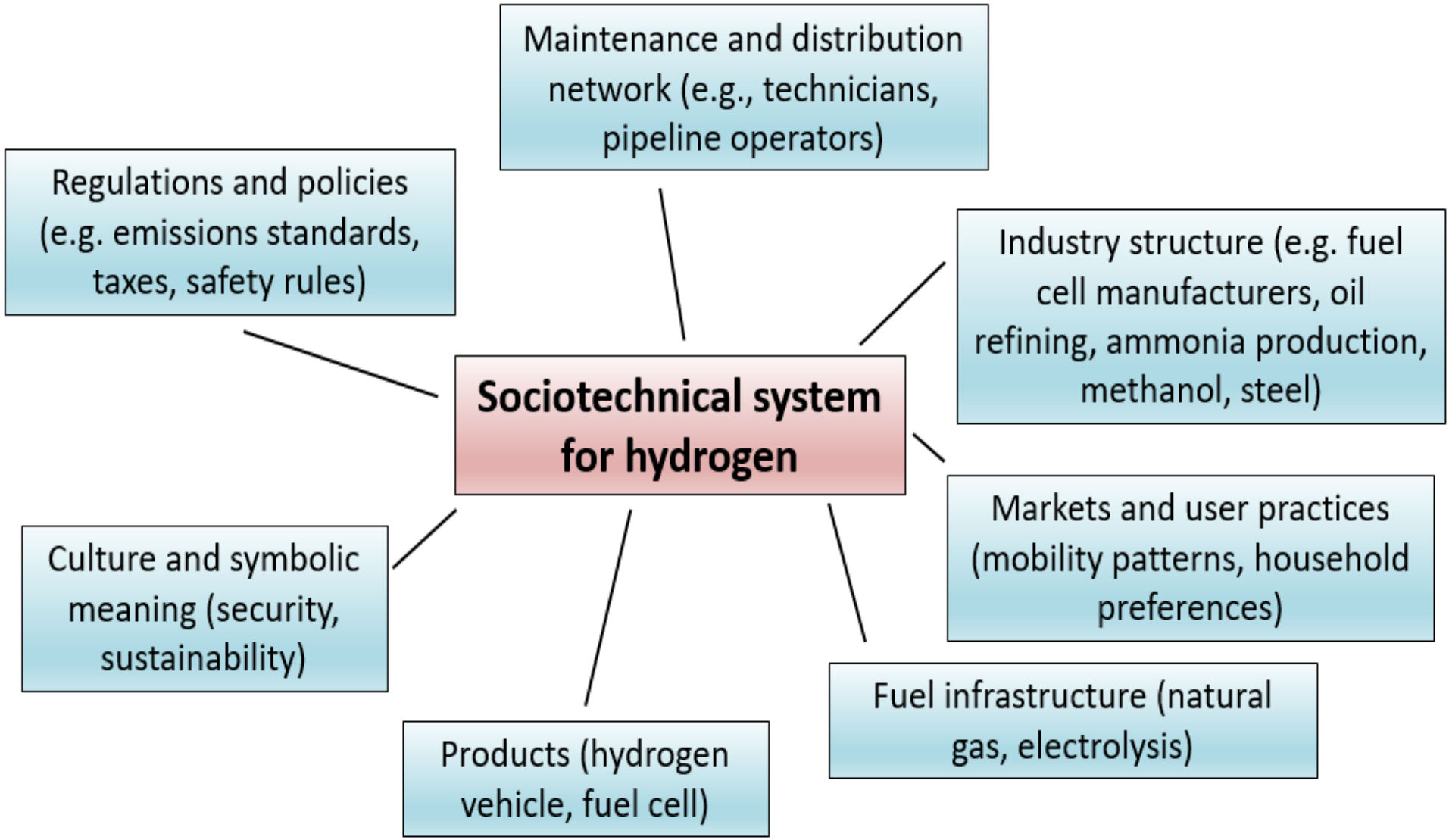
Notes: Combustion of gas, oil and coal includes off-road mobile machinery which can be abated with the fuel switching options. Fugitive CO_2 emissions are considered within process emissions above. The lines for CCS and CCU indicate the consideration of CCS; CCU has not been considered in this analysis. 'Internal fuels' are fuels. produced by industry feedstock (blast furnace gas and coke oven gas in the iron-making sector, and some less valuable hydrocarbons in the refining and petrochemicals sectors).

Hydrogen has a compelling *vision* or story

1) A theme of inevitable destiny that depicts hydrogen as the inescapable and unavoidable result of socio-technical development
2) A theme energy independence where advocates see hydrogen technologies as offering countries a robust, domestically insulated energy infrastructure immune from the vagaries of the global energy marketplace
3) A theme of patriotism that paints hydrogen as a way to achieve national leadership, competitiveness, strength, and vitality
4) A theme of unlimited progressive growth that views hydrogen as a mechanism to achieve endless economic expansion fueled by pollution-free and limitless supplies of energy
5) A theme of energy democratization that sees hydrogen as ushering in a wave of decentralized energy production and use



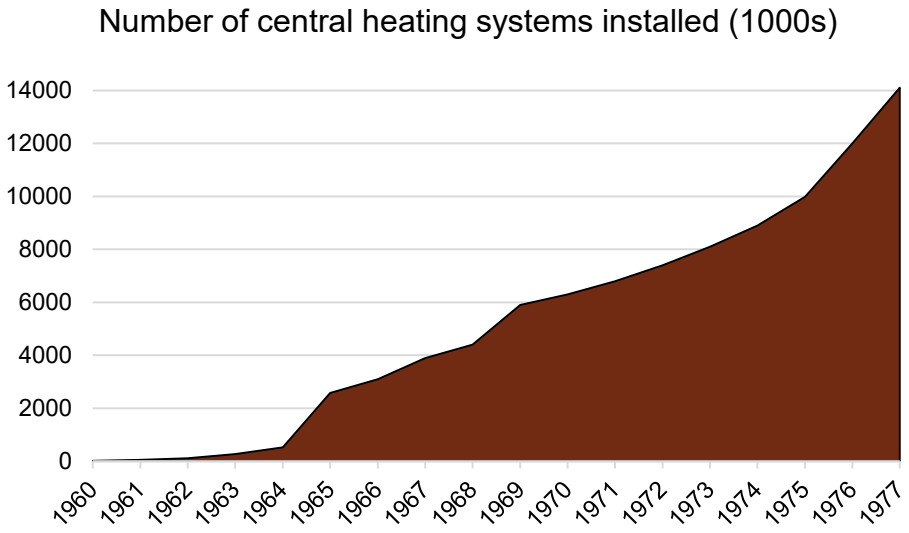
Hydrogen is a *sociotechnical system*

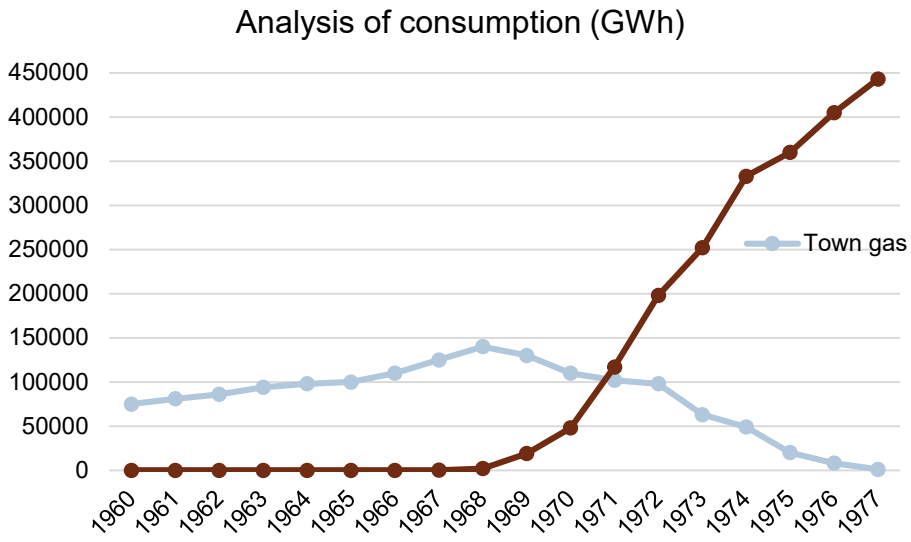


Future hydrogen *pathways* range from easy to difficult in the UK

	Easy	Easy + high public willingness or political capital needed	Difficult	Difficult + high public willingness or political capital needed	Branching
Degree of difficulty	Incremental, beneficial all round; any increases in cost will disappear after early adopter stage	Requires high willingness to participate, which delays or stops diffusion; political capital may be needed to persuade public.	Partially novel; requires more RD&D but can become easy eventually; needs government support at first	Difficult and requires much higher public willingness and political capital. Implementation can be stopped despite being economic	Highly novel, decades of RD&D; high political capital to support early TRLs. Branching to new supply-demand configurations; new infrastructure
Example	Highly efficient light bulbs	Behavioral change to reduce energy use	Onshore wind	Offshore wind	Nuclear power in the 1960s
H2 related measures	• H2 (through gas grid) in buildings (heat, cooking), existing equipment; • Direct electrificati on of small vehicles	• Direct electrification of heat and cooking in buildings (new equipment); • Electrification of train lines (expensive)	• H2 replacing fossil fuels in industrial processes; • green H2 production at scale; • H2 distribution through the gas grid	• H2 in large commercial vehicles, esp. trains; • new low carbon generation for H2 (compared to electrification); • direct electrification of industrial processes	• H2 in small vehicles; • Direct electrification of HGVs, ships; • management of the grid after high electrification of demand sectors

The rapid transition to gas central heating offers a *blueprint* for a possible transition





- Converted 40 million appliances and 14 million homes (almost half of all homes at that time) to run on natural gas from the North Sea, rather than town gas
- A majority of these conversions happen in just 10 years' time;
- By 1977; 92% of the population of the UK had a gas grid connection
- Involved nationalized and state affiliated entities such as the Gas Council and Area
- These worked with local municipalities and also civil society or industry groups

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Social acceptance of hydrogen may be low

What is the main way you currently provide heat in your home?

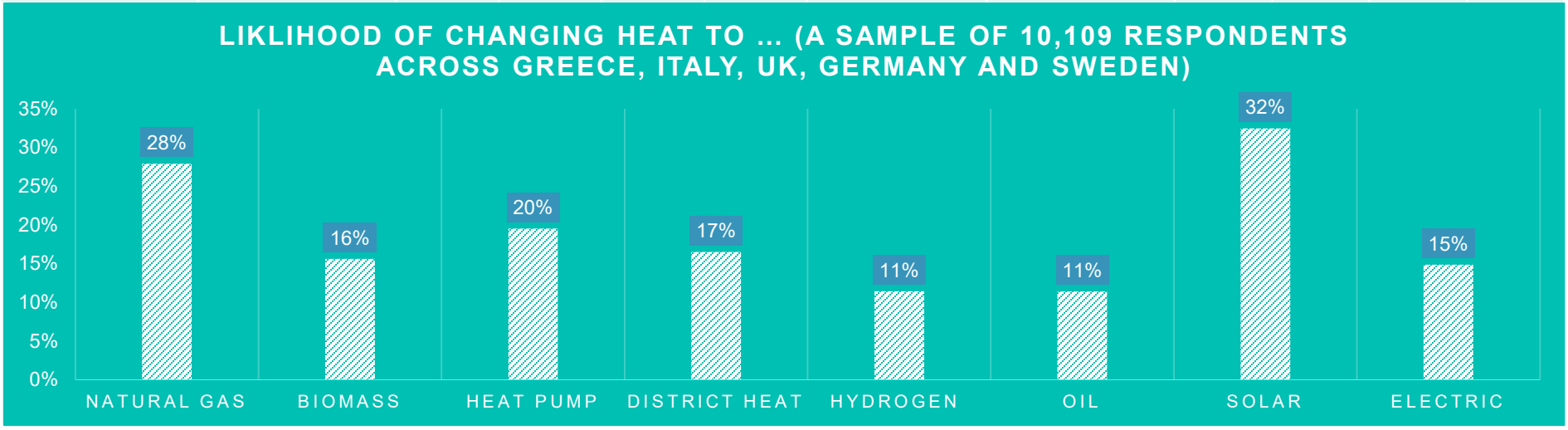
UK respondents only (n=2000), a nationally representative survey of 2,000 people with data collected in early 2020

	Total		completes	
	Count	Column N %	Count	Column N %
Total	2000	100.0%	2000	100.0%
Natural gas / condensing boiler	1475	73.8%	1475	73.8%
Biomass boiler / bioenergy / wood	32	1.6%	32	1.6%
Heat pump	82	4.1%	82	4.1%
District heating / heat network	54	2.7%	54	2.7%
Hydrogen / fuel cell	15	0.8%	15	0.8%
Oil / fuel oil / LPG	111	5.6%	111	5.6%
Solar thermal / solar energy	16	0.8%	16	0.8%
Resistive / electric heating	153	7.7%	153	7.7%
Other	62	3.1%	62	3.1%

How likely do you think you will be to change your heat to hydrogen, if you were given the opportunity, in the next few years?

UK respondents only (n=2000), a nationally representative survey of 2,000 people with data collected in early 2020

	Total		completes	
	Count	Column N %	Count	Column N %
Total	2000	100.0%	2000	100.0%
Very likely	73	3.7%	73	3.7%
Somewhat likely	127	6.4%	127	6.4%
Neither likely nor unlikely	366	18.3%	366	18.3%
Somewhat unlike.ly	283	14.2%	283	14.2%
Very unlikely	771	38.6%	771	38.6%
Don't know	380	19.0%	380	19.0%



Consumers often *overestimate* their own knowledge

Question	% Answering Correctly	Sample included
How is most electricity in Denmark generated?	88.1	Both groups
How much electricity does the average Danish house use?	34.2	Household
How much electricity does the average Danish business use?	15	Industry
How much do you pay per household kilowatt-hour (kWh) for electricity (including tax and distribution)?	37.6	Household
How much do you pay per industry kilowatt-hour (kWh) for electricity (including tax and distribution)?	14.8	Industry
The last time you checked, how much did a liter of petrol/gasoline/diesel cost at the local station?	88.6	Both groups
Which of the following uses more energy in the average home?	70.5	Household

- When a Danish survey asked "In general, how much do you feel you yourself know about energy issues and problems— would you say you know a lot, a fair amount, only a little, or practically nothing?," two thirds of respondents—67%—indicated they knew "a lot" or "a fair amount."
- The questions also had a "I don't know" option that not a single one chose

	USA (n=1503)	Denmark (n=231)
% That can pass literacy test	12	14
% get an "A" on literacy test	1	4
% properly identifying sources of electricity	13	88

Conclusion

- Hydrogen legitimately has potential as a promising sociotechnical option for decarbonization
- Social and scientific discourses often serve to buttress this potential rhetorically
- A hydrogen transition would require major technical but also social, economic, and political shifts
- The exact shape of a hydrogen transition in the UK is yet to be determined, and could take very different (and even divergent) pathways
- The previous town gas to natural gas transition in the UK gives insight into the required scale and scope of major household transitions in the UK
- Social acceptance and literacy/knowledge of hydrogen remains low, which may be both a barrier or an opportunity, and it also creates a large degree of uncertainty

References

Sovacool, BK, J Axsen, and W Kempton. “The Future Promise of Vehicle-to-Grid (V2G) Integration: A Sociotechnical Review and Research Agenda,” *Annual Review of Environment and Resources* 42 (October, 2017), pp. 377-406.

O-STET (Operationalising socio-technical energy transitions) led by UCL and Sussex, with input from Rachael Freeman and Neil Strachan. The link is here.

Sovacool, BK and M Martiskainen. “Hot transformations: Governing rapid and deep household heating transitions in China, Denmark, Finland and the United Kingdom,” *Energy Policy* 139 (April, 2020), 111330, pp. 1-16.

SWS-Heat Project (which undertook the national surveys on hydrogen and heat) led by Benjamin Sovacool at Sussex. The project link is here.

Sovacool, BK and PL Blyth. “Energy and Environmental Attitudes in the Green State of Denmark: Implications for Energy Democracy, Low Carbon Transitions, and Energy Literacy,” *Environmental Science & Policy* 54 (December, 2015), pp. 304-315.

Sovacool, BK. “Differing Cultures of Energy Security: An International Comparison of Public Perceptions,” *Renewable and Sustainable Energy Reviews* 55 (March, 2016), pp. 811-822.

Sovacool, BK and B Brossmann. “Symbolic Convergence and the Hydrogen Economy,” *Energy Policy* 38(4) (April, 2010), pp. 1999-2012.

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