Decarbonising a Country:
H_2 and Electricity
UK Scenarios & Considerations

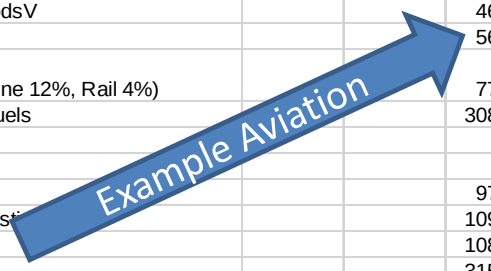
Sustainability = Environment + Economy
Current Energy Use
Some Replacement Scenarios

Trilema
Day 1 – 26 May 2022
Use of H_2 in airports

Prof. Pericles Pilidis - presenting a team effort
Cranfield University - Propulsion & Thermal Power

Holistic Use & Capacity on a National Basis (2019)

			Energy TJ
Coal - electr			78300
Coal - Ind			78300
Other			51300
Total Coal			207900
			0
Petrol			578100
Diesel - Cars			699200
Diesel-GoodsV			469200
JetFuel			565800
Other (Marine 12%, Rail 4%)			777000
Total Liq Fuels			3089300
			0
			0
Gas-electr			972000
Gas-Domesti			1094400
Gas-Other			1087200
Total Gas			3153600
			0
	Capacity GW		0
Wind-land	13.99		115920
Wind-sea	9.89		114840
Hydro	1.61		21600
Solar PV	13.22		45720
BioEnergy	7.84		131760
Total Renewables	46.55		429840
Coal Electricity	6.82		24840
Gas Electricity	34.58		477000
Nuclear Electricity	9.26		202320
Other electricity	0.00		31320
Total Electricity Gen Capacity	97.21		1165320
Av gen Capacity	36.95		0
Total Primary E			7114280



Demand:
Heat + Electricity + Transport

Decarbonise avoiding socio-economic damage same demand scenario

Replace all items:
supply Heat + Electricity + H_2

Source = DUKES (UK govt) + researcher's estimates

Example: Jet Fuel Replacement
In Zero Carbon World
Carry Out Air Traffic Analysis

85% H_2
15% Electricity
0% Heat

					Decarbonised Demand Calculation				
Item	2019 Energy demand in TJ from pg 1	Replace Factors	Need to Replace	Replace with	Gas TJ	Electr - TJ	Hydrogen TJ	H2 000 tonnes p.a	Heat TJ
JetFuel	565800	0.15	84870	Electr	0	36373			
			480930	Hydrogen	0	961860	529023	4408.5	

Repeat & integrate for other energy sectors to obtain

zero carbon UK energy demand

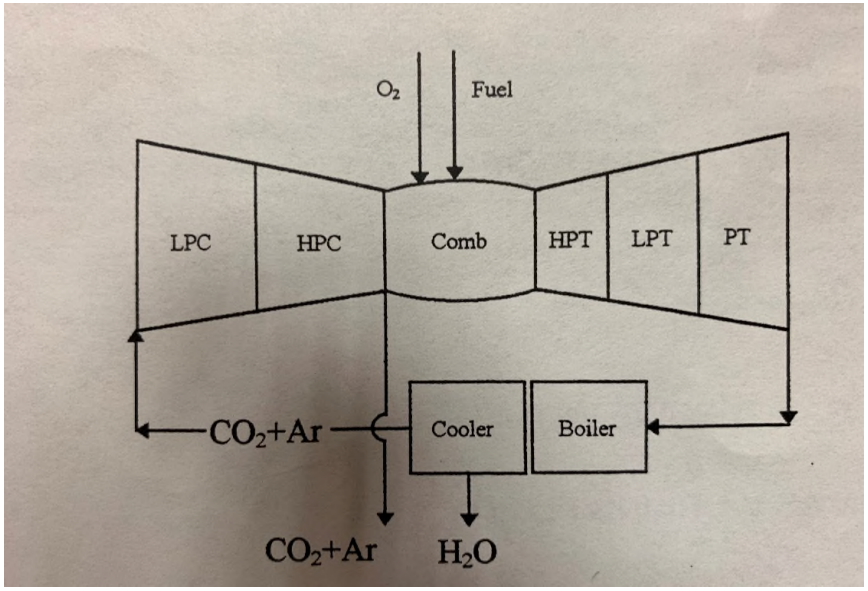
6 Replacement Scenarios examined - combinations of:

Expand RES (primarily wind)
Decommission coal
Convert & Expand Gas to CCS or Semiclosed CO_2 Oxyfuel CCGT
Expand Nuclear
Use District Heat + Cogeneration + Solar Heat

Semiclosed Cycle

From Ulizar,I; Pilidis' P;
A Semiclosed-Cycle Gas Turbine with Carbon Dioxide–Argon as Working Fluid; J. Eng. Gas Turbines Power. Jul 1997, 119(3): 612-616 https://doi.org/10.1115/1.2817028

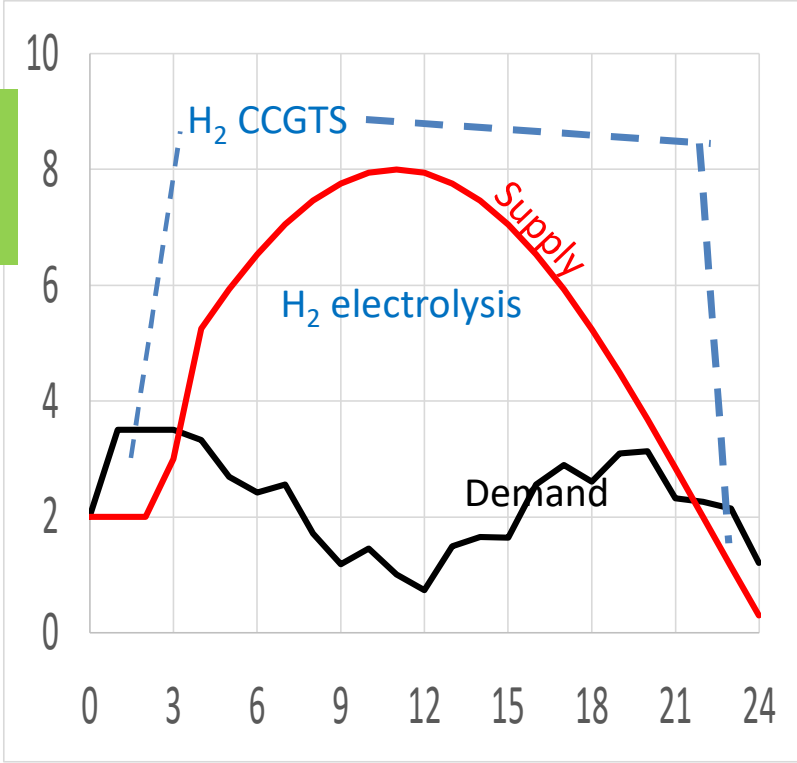
η_{th} – 0.45 (inc ASP)
η_{th} – 0.55 (exc ASP)
Capture Ready CO_2
Zero NOX



Greening a Country

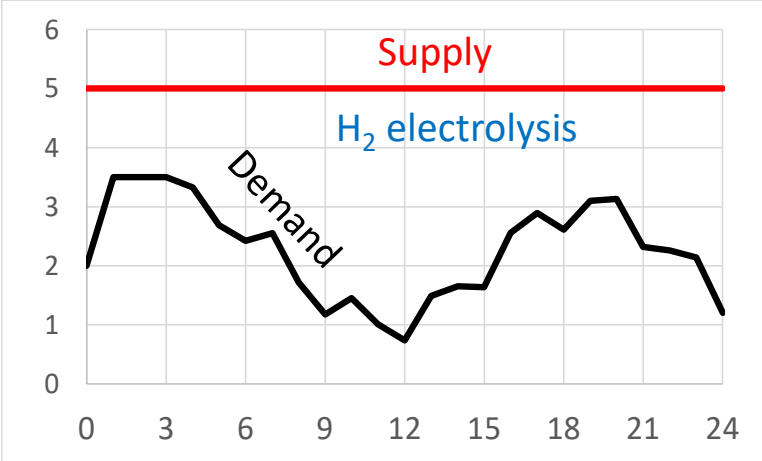
extreme scenarios

Scenario 1 - RES



Time of Day

Scenarios 2 Nuclear
6 CCGTS
or a mix



Time of Day

Decarbonising the UK – H2 & Electricity

Hydrogen: 35-40 % of electricity supply (use seawater electrolysis)
Aviation > 50% of Hydrogen supply
International trade

Mainly CCGT and/or Nuclear offer nearly constant power grid scenario
Benefits of thermal plant and better heat use in colder countries (like UK)
Scenario 4 (Short Term) and progress to 1 (LT) with international grids?
Cost ~ 2% of GDP-

Scenario	Electricity Supply	Installed Capacity
2019 Baseline	1	1
S1 - Emphasis on Renewable	4.4	4.0
S2 - Emphasis on Nuclear	3.6	1.8
S3 - Emphasis on Nuclear and RES	3.6	2.2
S4 - Emphasis on Gas Turbines and RES	3.6	2.2
S5 - Similar to 4 low heat	4.1	2.4
S6 - Emphasis on Gas Turbines	3.6	1.8

Decarbonising the UK – H2 & Electricity

Hydrogen: 35-40 % of electricity supply (use seawater electrolysis)
Aviation > 50% of Hydrogen supply
International trade

Mainly CCGT and/or Nuclear offer nearly constant power grid scenario
Benefits of thermal plant and better heat use in colder countries (like UK)
Scenario 4 (Short Term) and progress to 1 (LT) with international grids?
Cost ~ 2% of GDP-

Scenario	Electricity Supply	Installed Capacity
2019 Baseline	1	1
S1 - Emphasis on Renewable	4.4	4.0
S2 - Emphasis on Nuclear	3.6	1.8
S3 - Emphasis on Nuclear and RES	3.6	2.2
S4 - Emphasis on Gas Turbines and RES	3.6	2.2
S5 - Similar to 4 low heat	4.1	2.4
S6 - Emphasis on Gas Turbines	3.6	1.8

NEEDED!

20 years:
details & implement

2% of GDP

1000s of talented
Engineers & Scientists

Thank you for your attention