Energy Systems Scenarios - latest ETI analysis

ETI10 TEN YEARS OF INNOVATION 2007 – 2017

#ETI10

Welcome and Introduction

Jo Coleman
Director, Strategy Development

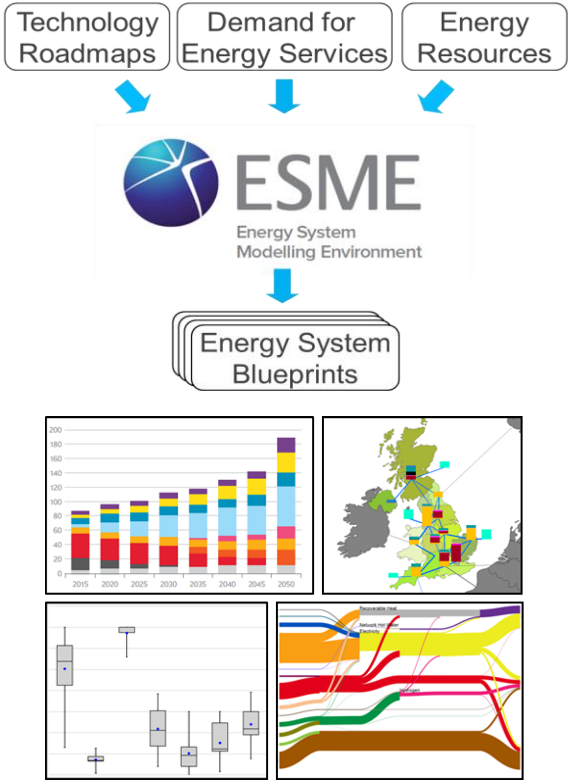
Agenda

- Recap of ETI modelling approach & 2015 scenarios
- What has changed since 2015?
  - CCS cancellation, big nuclear & SMRs
  - Success of renewables, falling cost of batteries
  - Hydrogen for heating?
  - At or nearing a tipping point for EV's?
- Key areas of technology and resource uncertainty as illustrated in the Clean Growth Strategy & potential topics to be explored in a 2018 scenarios update
  - Electrification
  - Hydrogen
  - Emissions Removal
- Conclusions

RECAP OF ETI MODELLING APPROACH & 2015 SCENARIOS

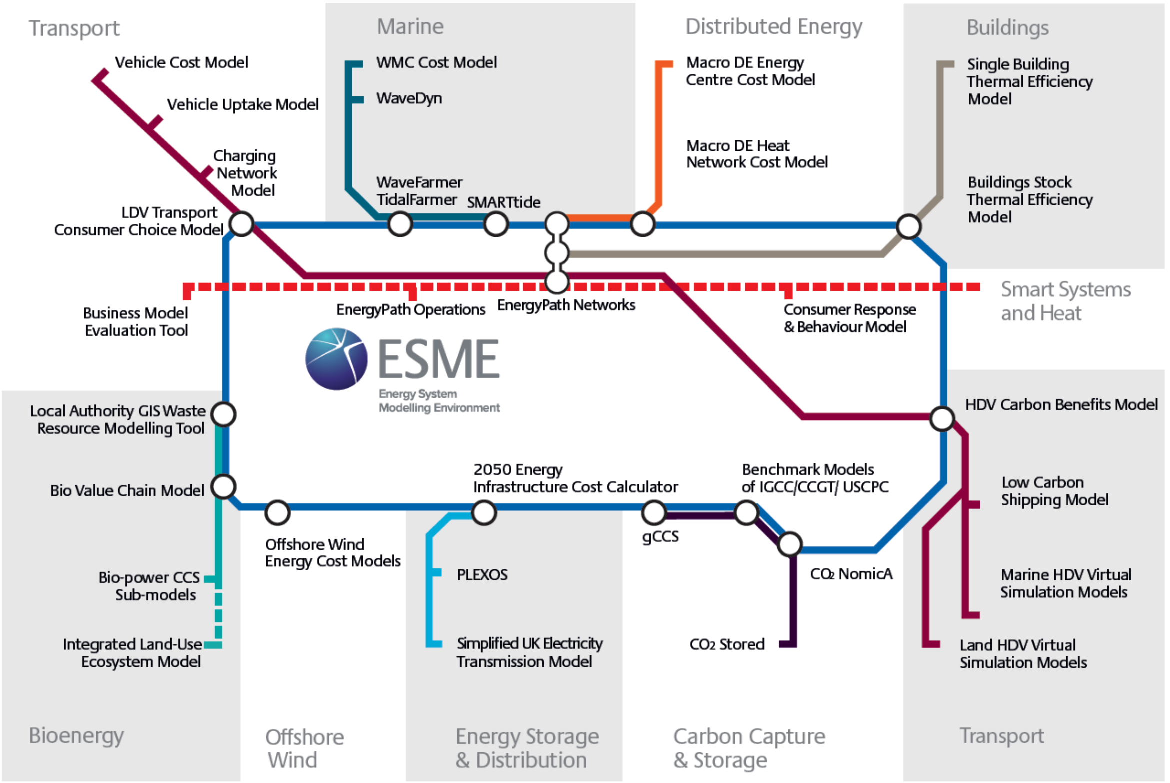
Energy Systems Modelling Environment

- Whole-system approach: power, heat, transport, industry and energy infrastructure
- Least cost optimisation, policy neutral
- Deployment & utilisation of 300+ technologies
- Probabilistic treatment of key uncertainties
- Pathway and supply chain constraints to 2050
- Spatial and temporal resolution sufficient for system engineering



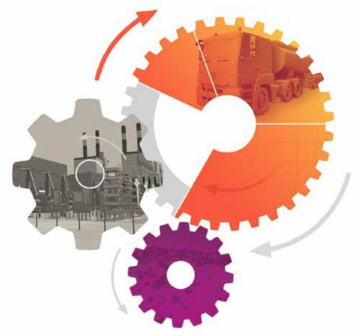
More details in *Modelling Low-Carbon Energy System Designs with the ETI ESME Model* available on the website: http://www.eti.co.uk/programmes/strategy/esme

ESME and the wider ETI modelling suite



Recap of the 2015 Scenarios

CLOCKWORK



- Carbon Offsetting
- Institutional Mandate
- National scale infrastructure
- Phased decarbonisation

PATCHWORK

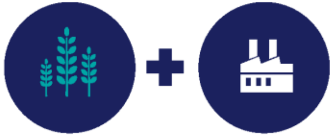
- Extensive renewables
- Societal Engagement
- Multiscale Infrastructure
- Parallel decarbonisation

ENERGY TRANSITION ANALYSIS - KEY LESSONS LEARNT

The UK can afford a 35 year transition to a low carbon economy - the cost of transition is in the range of

1-2% GDP in 2050

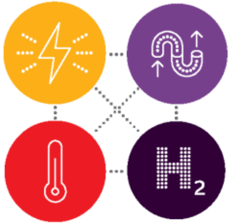
CCS and Bioenergy are especially valuable



Negative emissions create headroom for difficult to abate sectors

High levels of intermittent renewables requires flexibility across entire system

Energy infrastructure has to be adapted and enhanced, new networks created and integrated

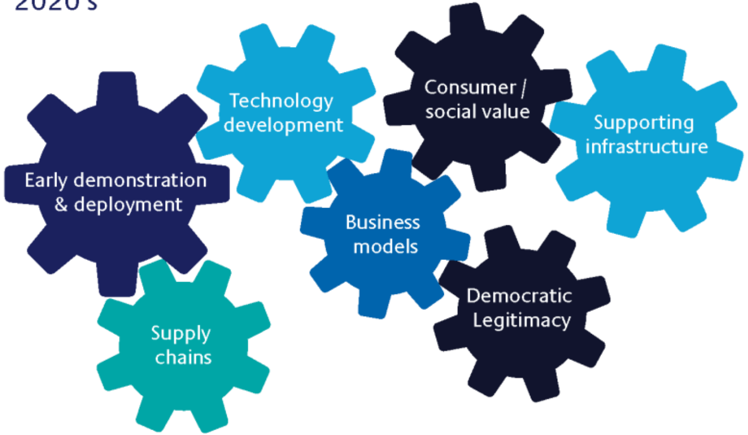


Develop and prove a basket of promising solutions

Key Technology Priorities

- Bioenergy
- New nuclear
- Offshore wind
- Gaseous systems
- Low carbon heating
- Efficiency of vehicles & EVs
- Carbon Capture and Storage
- Efficiency in buildings

Preparing for scale up and wide scale deployment by mid 2020's

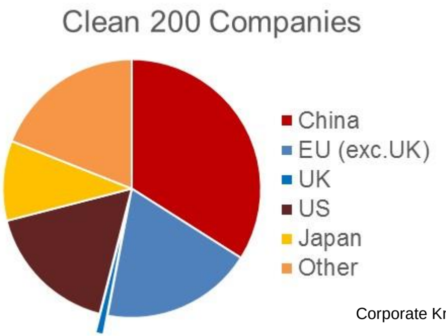


WHAT HAS CHANGED SINCE 2015?

A world of political dichotomy yields new risks & opportunities

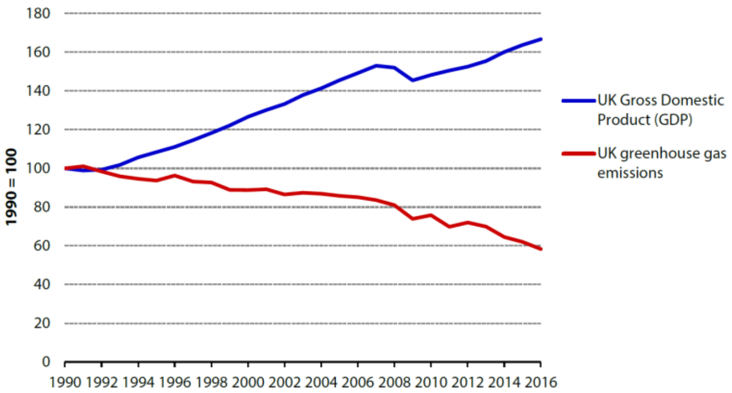
- COP21, Trump, China, EU & Brexit, the role of states and cities
- Decarbonisation has decoupled from economic growth
- 2015, 2016 and 2017 likely to be warmest years on record
- 71% of UK public concerned or very concerned about climate change

- Increasing risk of litigation related to extreme events and health issues
- G20 Task Force develops climate-related financial disclosure framework
- Global progress with carbon pricing/policies
- Sector adjacency eg Shell, Dyson, Google



Corporate Knights, February 2017

Euronews, 15th August 2017



The CCC, June 2017

Nuclear project delays and CCS struggling to gain momentum

energy technologies institute

Nuclear

- 4 AP1000 reactors in China expected to start commercial operation in 2018 (delay of 3 years)
- Westinghouse bankruptcy, Toshiba bail-out
- Construction halted at VC Summer in South Carolina, 67% complete
- Hinkley Point C £1.5bn cost increase & risk of 15 month delay
- Small Modular Reactors competition

CCS

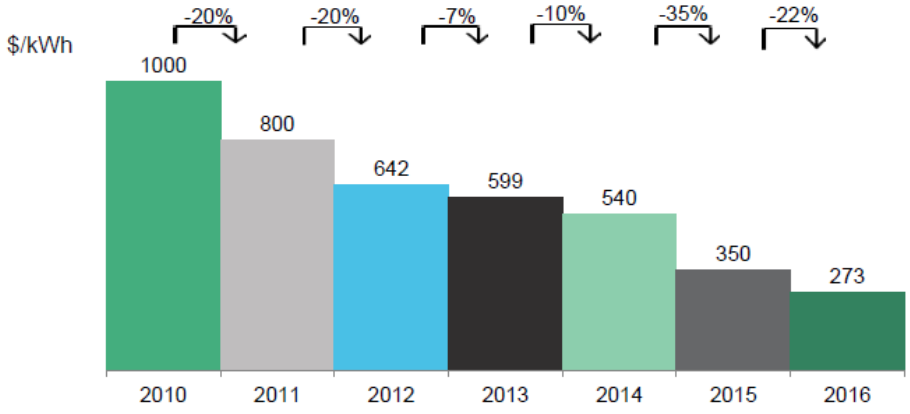
- 17 large scale CCS plants in operation, 5 in construction
- Many more projects in development but few reaching commercial close & start of construction

- Clean Growth Strategy: up to £100m in innovation and new CCUS Council, to develop option of deploying CCUS at scale in the UK
- OGCi (OIL AND GAS CLIMATE INITIATIVE) Climate Investments announces the Clean Gas Project

Global surge in wind and solar but fossil fuels continue to dominate

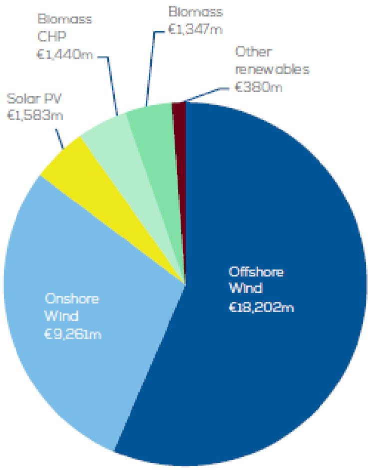
- Globally, 80% of energy from fossil fuels, 11% from biomass and 9% electricity
- Estimated global solar capacity of 390GW by end 2017 (same as nuclear)
- Solar and wind each generate 1.8% of total global electricity vs 11% for nuclear and 40% for coal
- Wind accounts for 10% of EU generation & 12% in UK, from 10GW of onshore and 5GW of offshore
- 46% new EU wind investments announced in 2016 in the UK

- Battery costs continue to fall



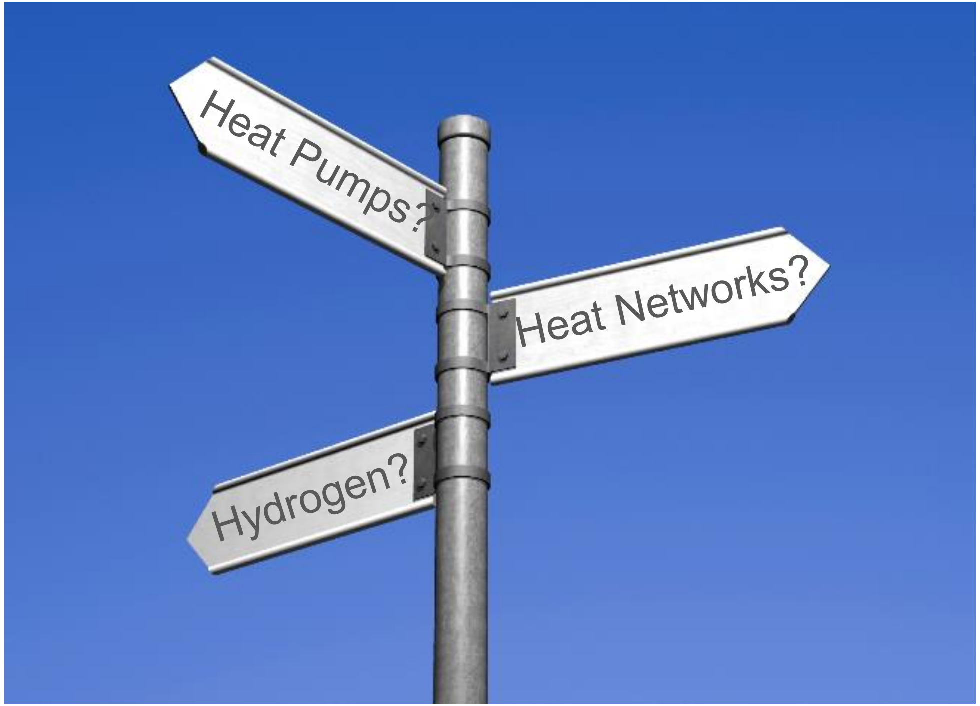
Bloomberg New Energy Finance, June 2017

2016 Clean Energy Investment, EU



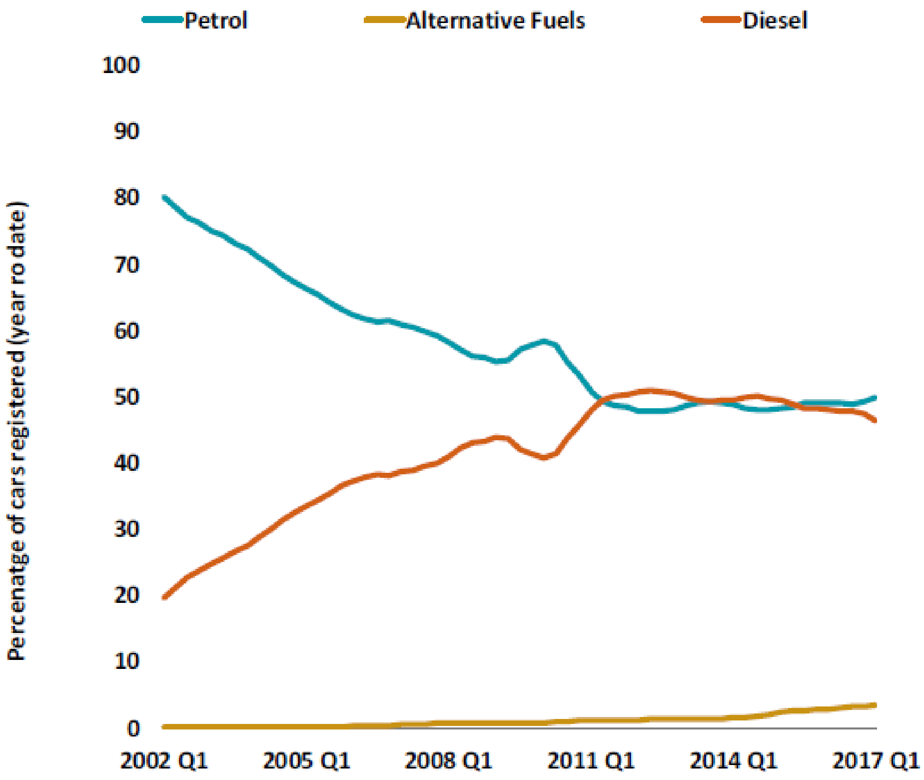
Source: WindEurope

Hydrogen for heating?



EV's poised to take off – but how quickly?

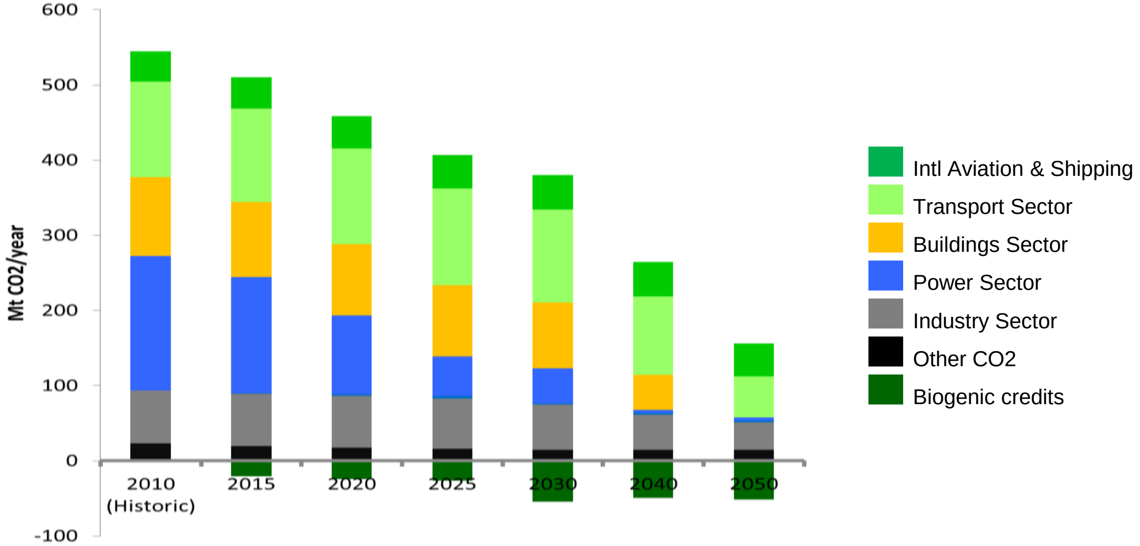
- Air pollution a more urgent concern than climate change
- EV's have become a status symbol
- Range 'doubling' with each new release (likely to overshoot need in order to reduce anxiety)
- Volvo – all new cars **electric** by 2019, Toyota already 40% hybrid in UK (Lexus 99%)
- HMG – announcement to end the sale of new **conventional** petrol and diesel cars by 2040
- VWs diesel scandal & scrappage schemes appear to be nudging consumers



1.5º has elevated interest in net zero & hard to abate sectors

- Afforestation, BECCS and negative emissions
  - Controversy around their role & the reliance on BECCS in modelling
  - CCC, Scottish & Welsh Governments developing strategy/policies

- Attention turning to industrial processes & long distance transport

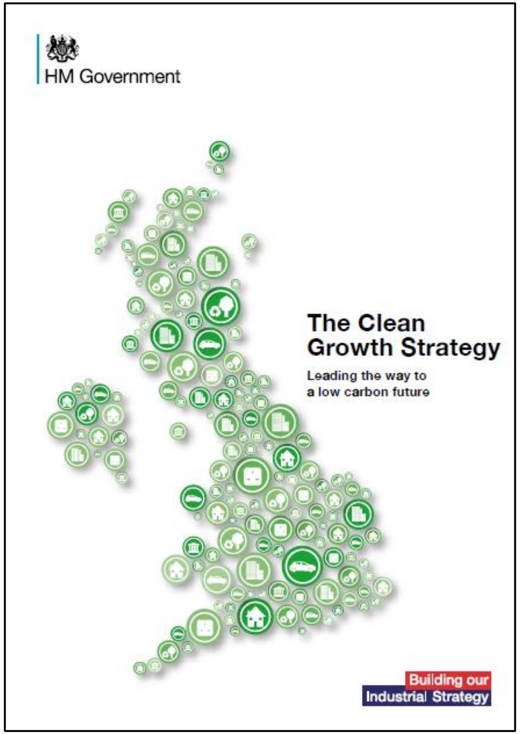


A more complicated and dynamic world

Fossil fuel reigns	→	1.5ºC, 2ºC……or 4ºC
National	→	Interconnected, regional and local
Single sector	→	Multi sector & integrated
Centralised	→	Decentralised
Commodity	→	Services
Single revenue stream	→	Multiple fragmented revenue streams

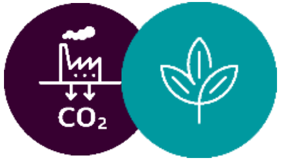
CLEAN GROWTH STRATEGY

3 Illustrative Pathways



- 83% of buildings use electric heating
- 100% of car and van km are electric
- 55% of HGV km are zero emission
- No CCS

- Majority of buildings use a hydrogen grid
- 100% of car and van km are hydrogen
- Steam methane reforming & CCS

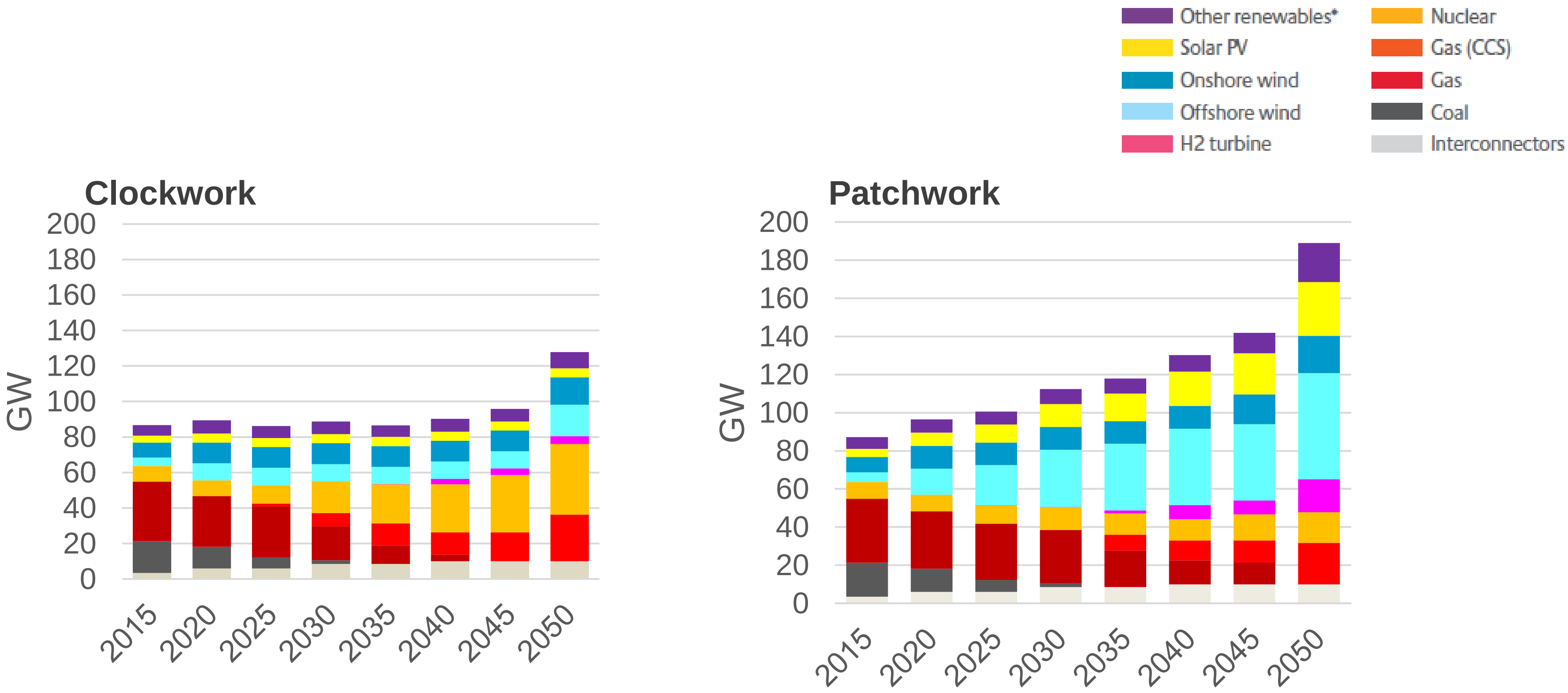


- Bioenergy with CCS creates 20Mtpa negative emissions

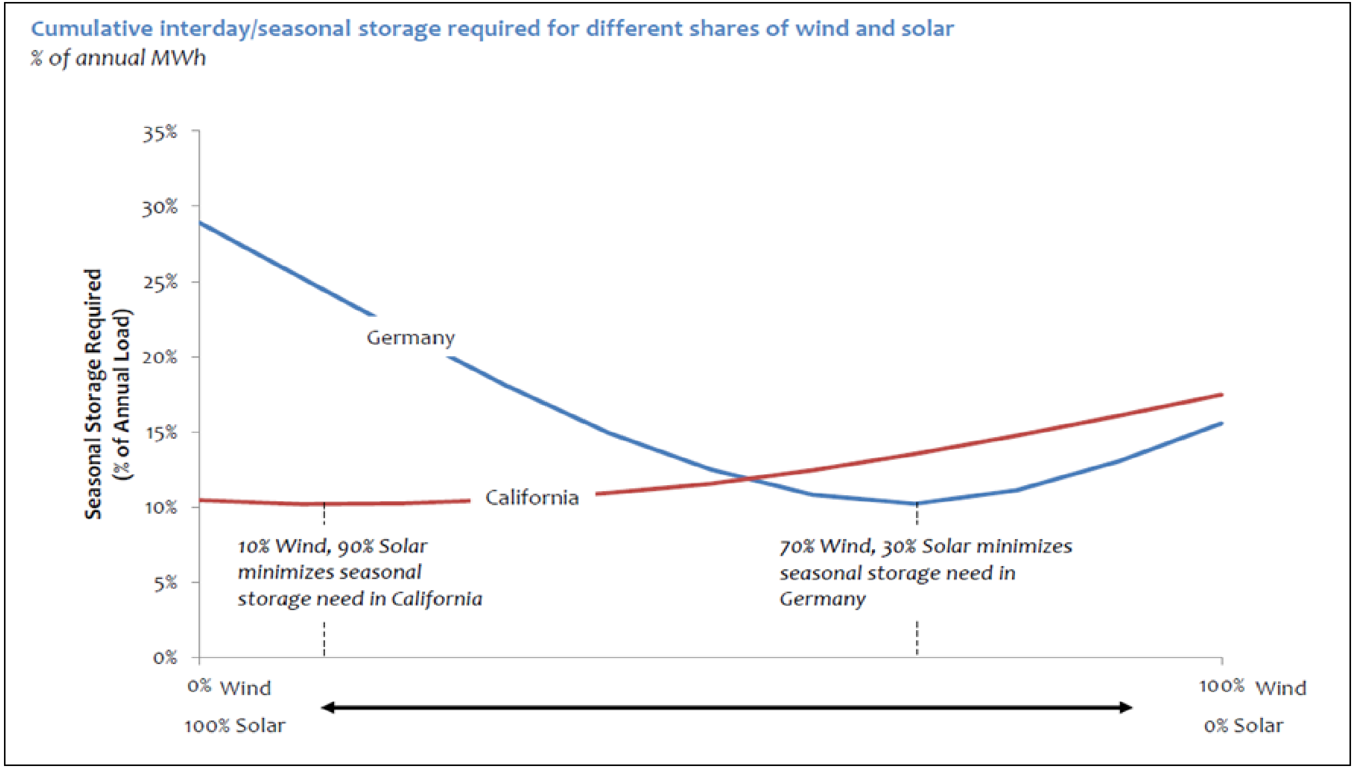
How far can intermittent renewables take us?

ELECTRIFICATION

Electricity Capacity

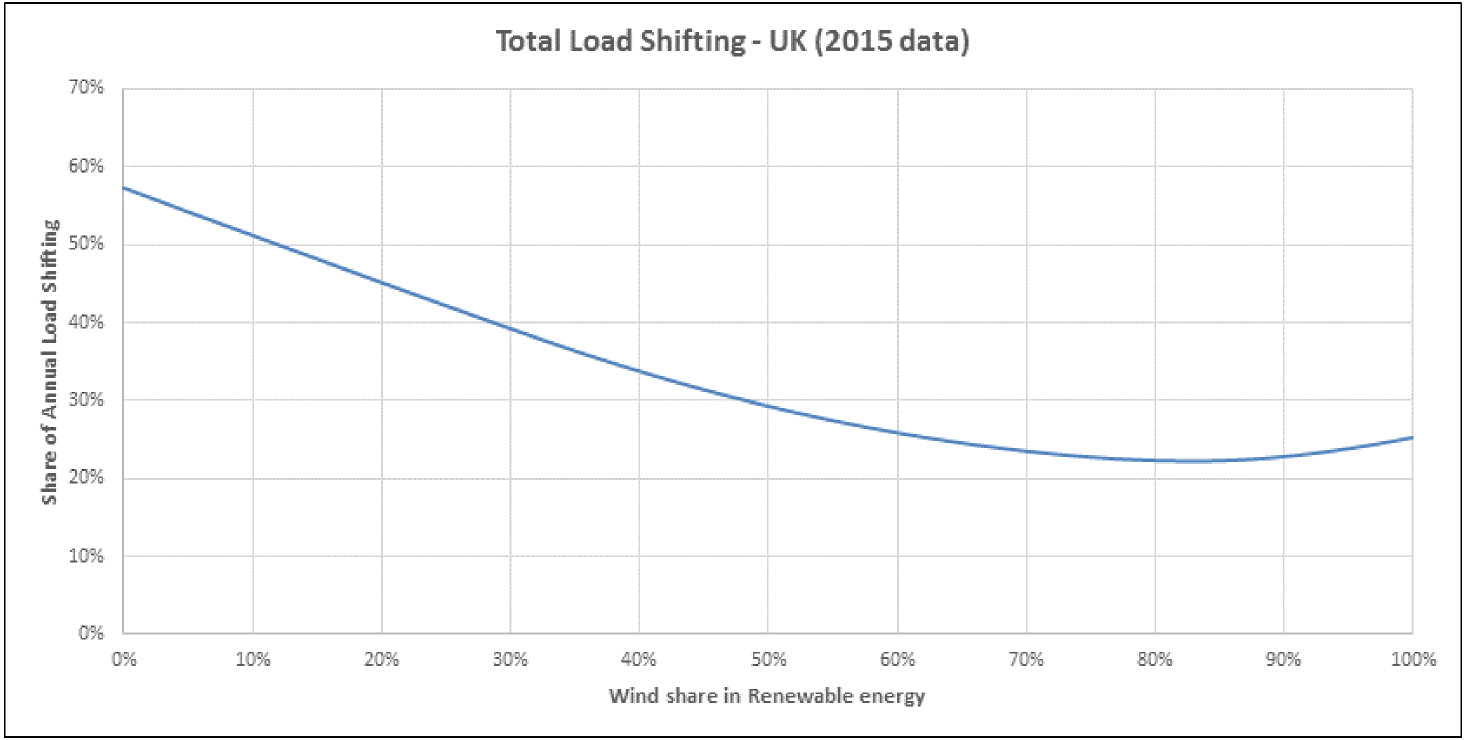


Optimal mix of wind/solar to minimise storage in Germany & California

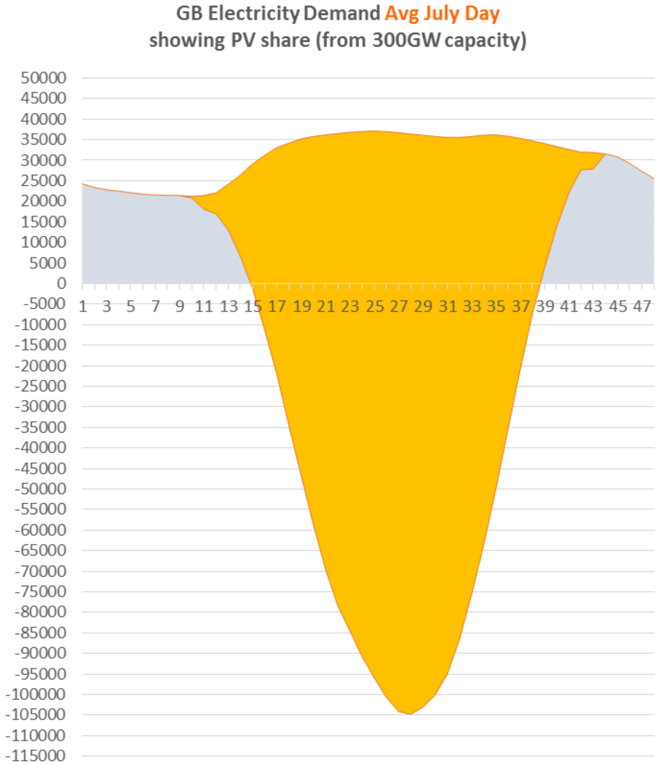


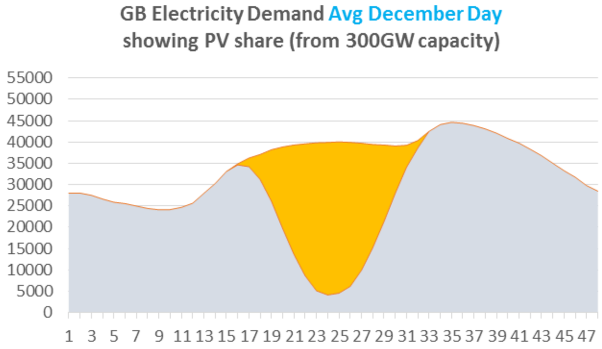
Source: Energy Transitions Commission

Optimal mix of wind/solar to minimise storage in the UK



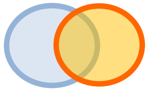
300GW where total PV output = total demand





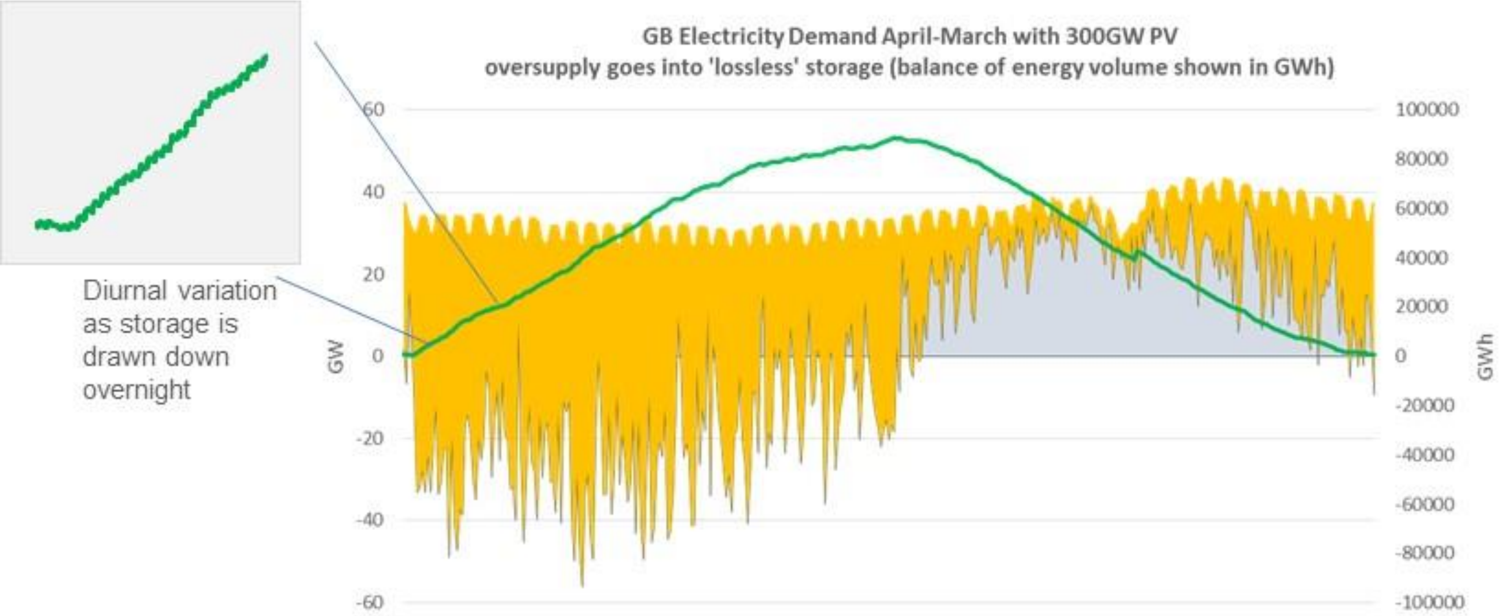
~300GW Annual Summary

Demand
300 TWh



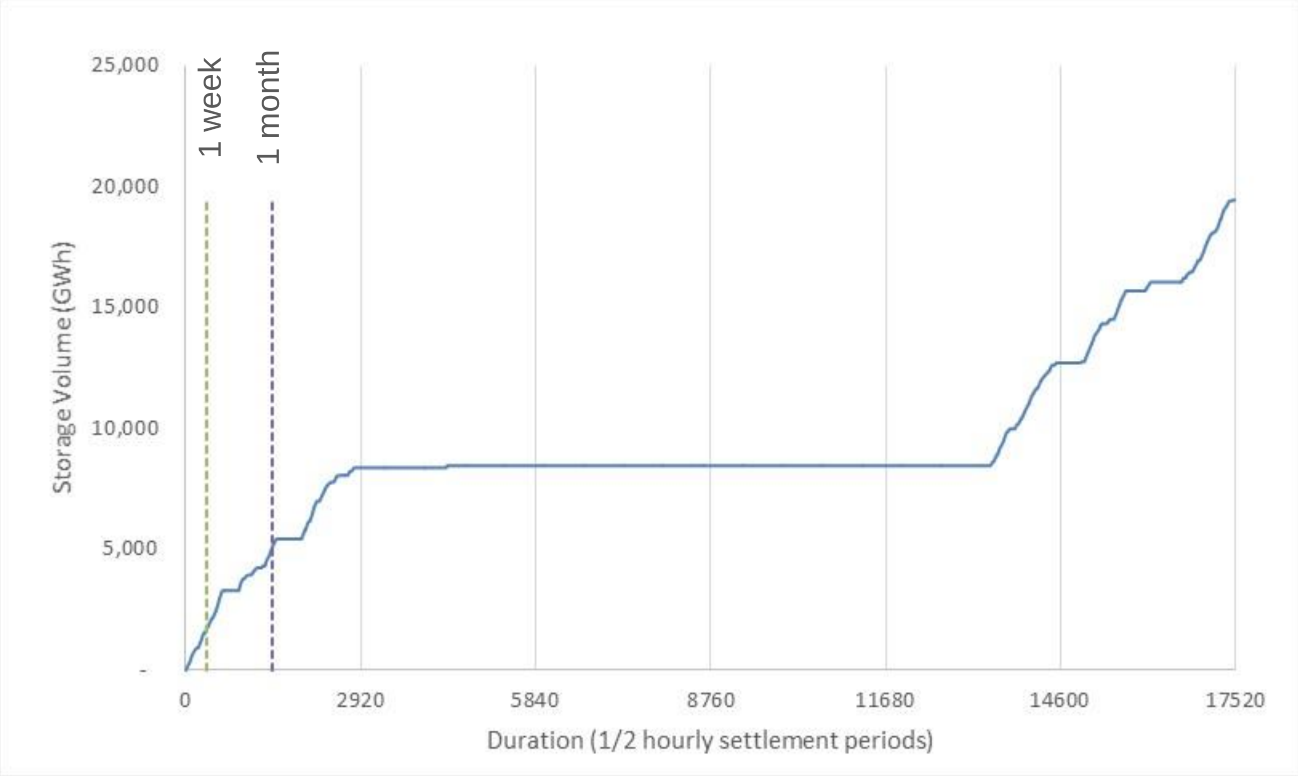
PV Output
300 TWh
(>50% spill)

‘Pure PV+storage’ seasonal balancing



Pure PV + storage scenario would require energy volume capacity of almost 90TWh not accounting for losses. (Compared to current 10TWh natural gas storage)

Storage Volume Duration Curve (2015)
83%:17% Wind:Solar

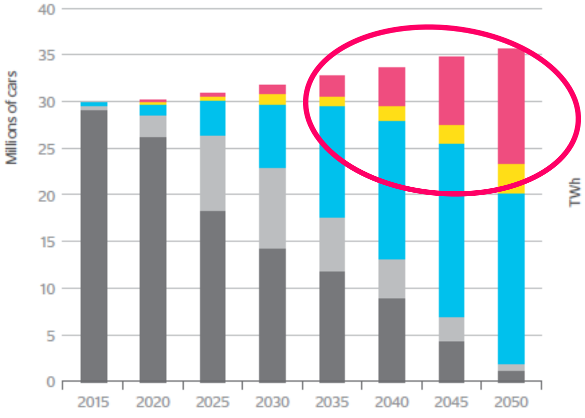


HYDROGEN

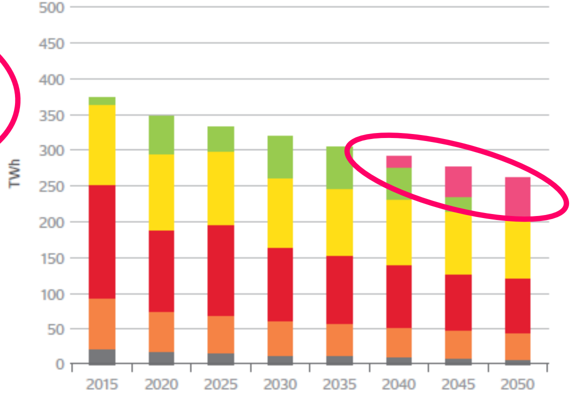
The role for hydrogen in the energy system

- ETI historical analysis highlights potential roles for hydrogen in peaking power plant, in industry and in transport, iIllustrated below through ‘Patchwork’ scenario

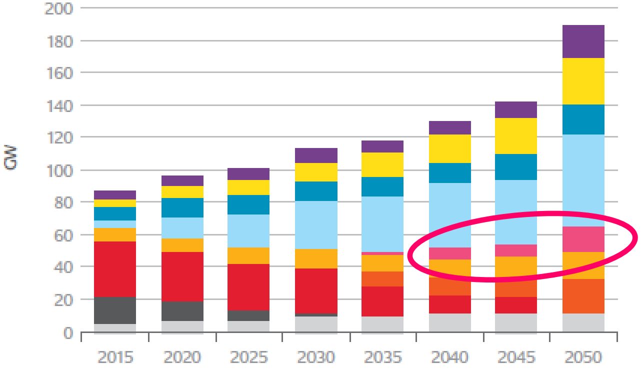
Vehicles



Industry consumption



Power generation capacity



ETI’s hydrogen projects and analysis

Programmes:

Insights:

Model:

Projects :

Heat…Hydrogen…and Hype

- No single solution for low carbon heating

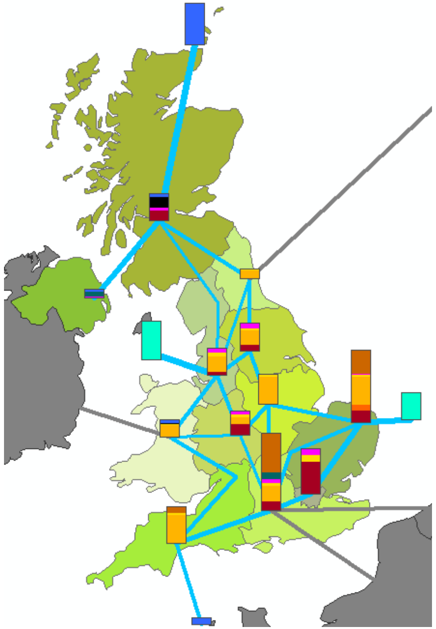
Urban and suburban properties	Repurposed gas grids (hydrogen)	Electrification (heat pump)	District heating
Cost/impact of decarbonised heat supply			
Cost/impact of network activities			
Cost/impact of activities in customer premises			
Need for new regulation			

CCC: UK must act now to secure zero-carbon heat by 2050, Oct.2016

ESME gas network representation

Actual UK gas transmission network
(from nationalgrid.com)

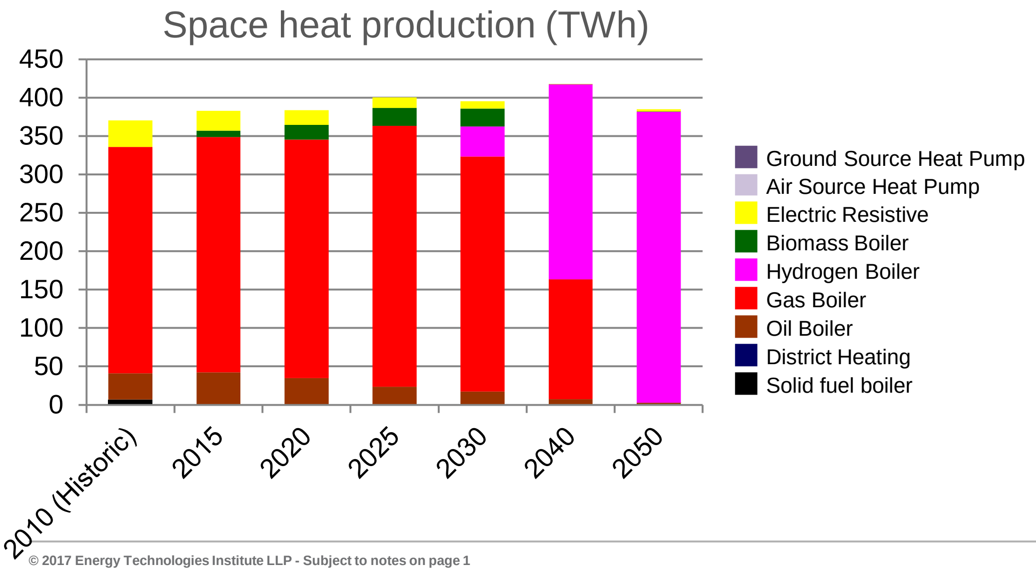
Network is represented using the regional resolution used for everything in ESME

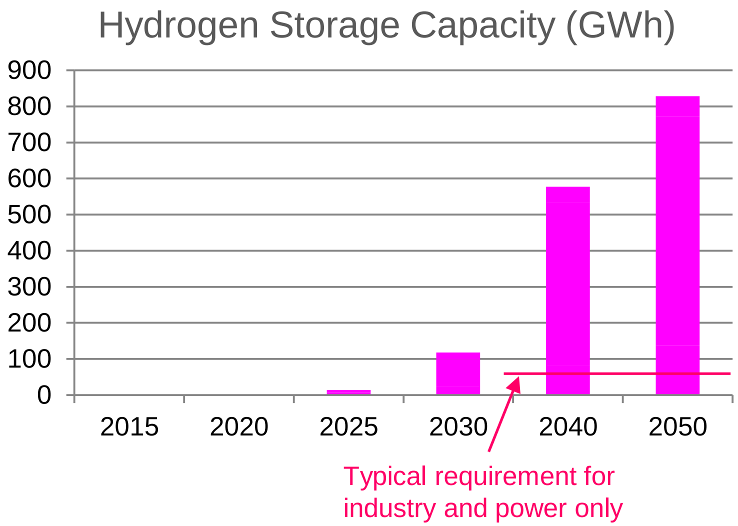


Power sector above shows approach:

Significant system challenges with an enforced 100% conversion

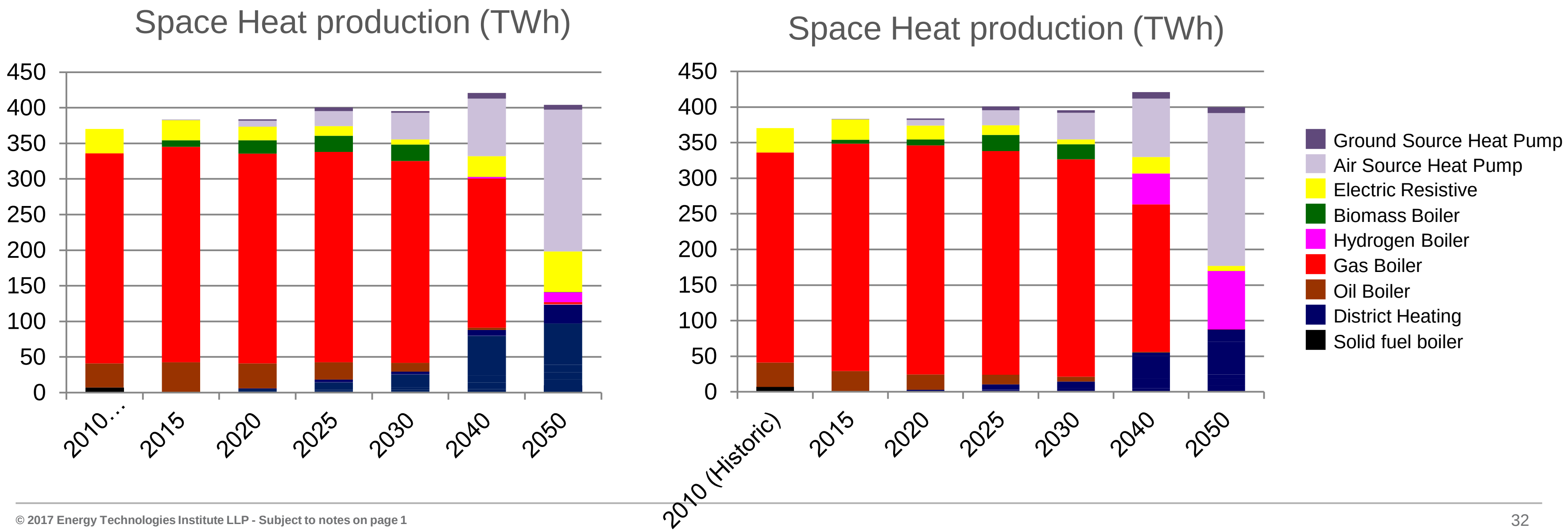
- 60-200GW of hydrogen plant producing upto 600TWh in 2050 (including industry & power demand)
- CO_2 sequestration over 200 Mtpa in 2050
- 800GWh/200GW hydrogen storage capacity in salt caverns



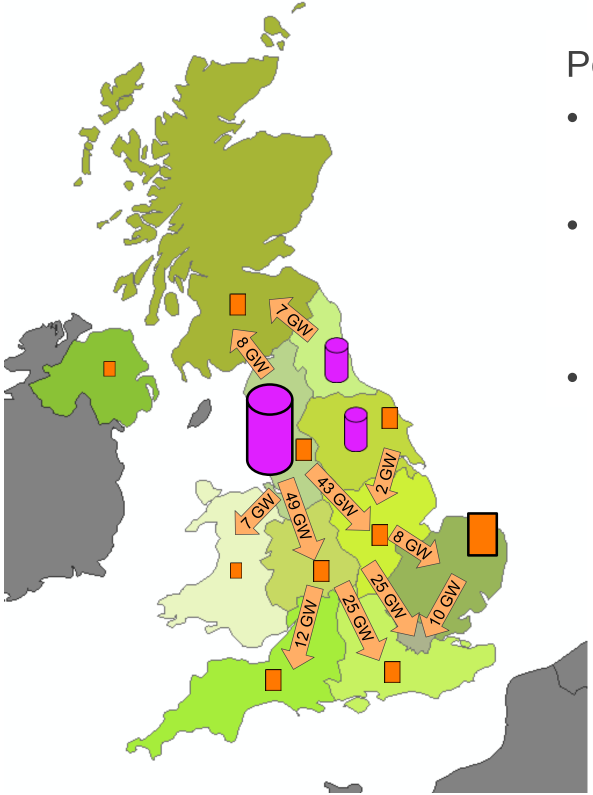


But some hydrogen for heating is selected

- Using H21 cost assumptions, conversion of 8-54% of homes to hydrogen in optimised runs
- Hydrogen capacity mainly used as heat boost to nominally sized heat pumps in hybrid systems
- Operation of hydrogen stores to meet peak day demand impacts optimum deployment



Optimising production, storage & transmission is a complex problem



Peak Day, Morning 6-10am

- Hydrogen stores (salt caverns) emptying in Northern England
- Hydrogen production plants (main CCS clusters on east coast) running hard
- Significant transmission flows towards major demand centres. Similar magnitude to current gas transmission

Hydrogen stores in NW, NE, YH (salt caverns)

Hydrogen production plants

Preliminary conclusions about the potential role for hydrogen in heating

- Very significant whole system challenges to UK wide roll-out of hydrogen for heating
- Further evidence required to underpin modelling assumptions eg:
  - Siting constraints for >100GW of CCS plant
  - Offshore storage sites for 200mtpa CO_2 injection
  - Ability of hydrogen stores to deliver peak day demand as well as seasonal and diurnal storage
  - Salt cavern sites in NW/NE, combined with transmission and distributed storage
- Cost reduction required across supply chain, but particularly in hydrogen production & storage sub-systems
- Analysis to date suggest that hydrogen may be best used in combination with baseload heat pumps
- No apparent reason to hold off transition to heat pumps and/or gas hybrid solutions

Bioenergy with CCS

EMISSIONS REMOVAL

A route to meeting - 80% GHG for the UK

Power now, heat next, transport gradual – cost optimal

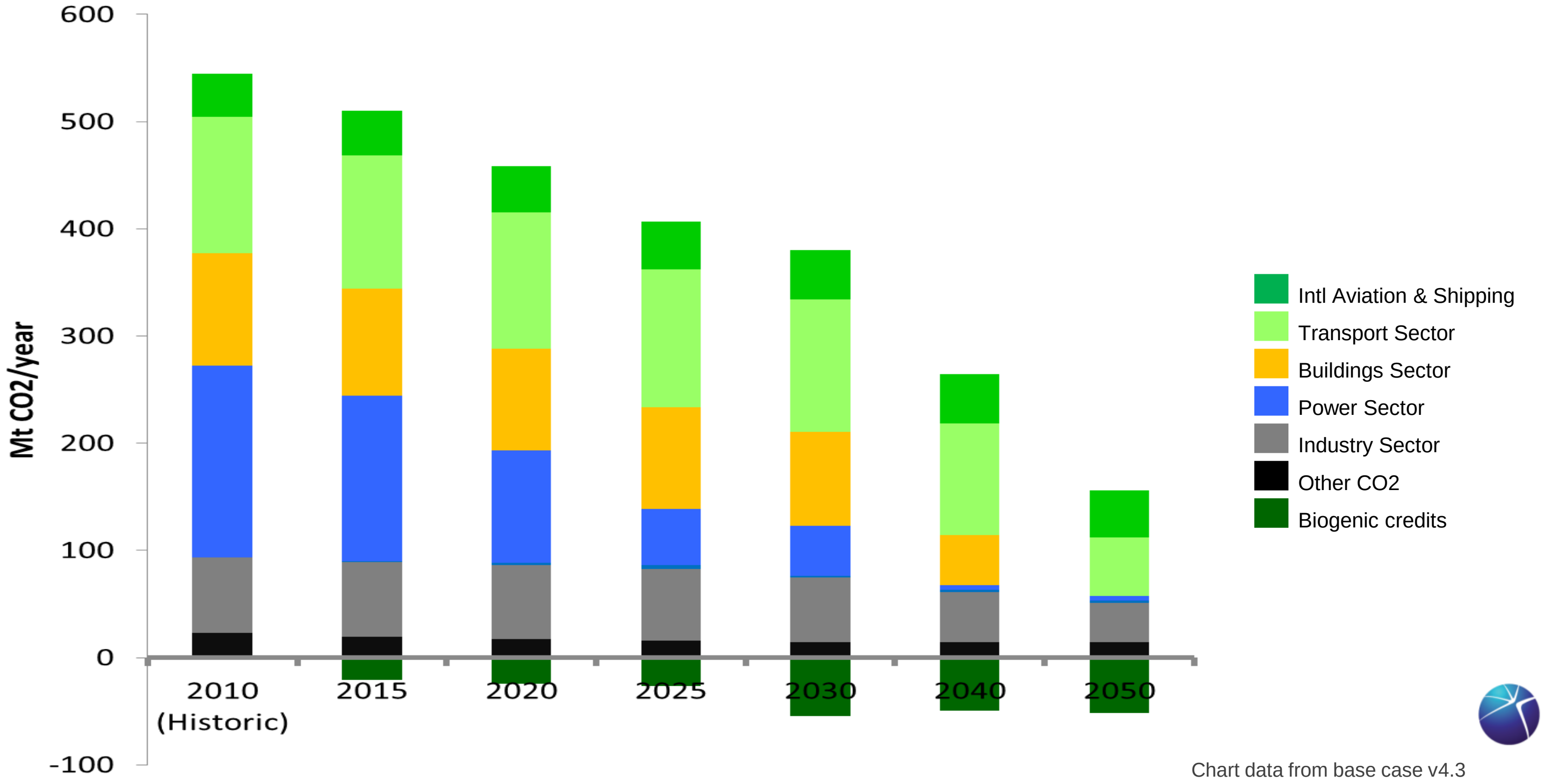


Chart data from base case v4.3

ETI Bioenergy Programme – key questions

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How much negative emissions could be realised through bioenergy deployment in the UK?

What would be the best ways to use this bioenergy in the future UK energy system?

What are the right combinations of feedstock, pre-processing, and conversion technologies?

elum
BIOENERGY DIRECT LAND-USE CHANGE

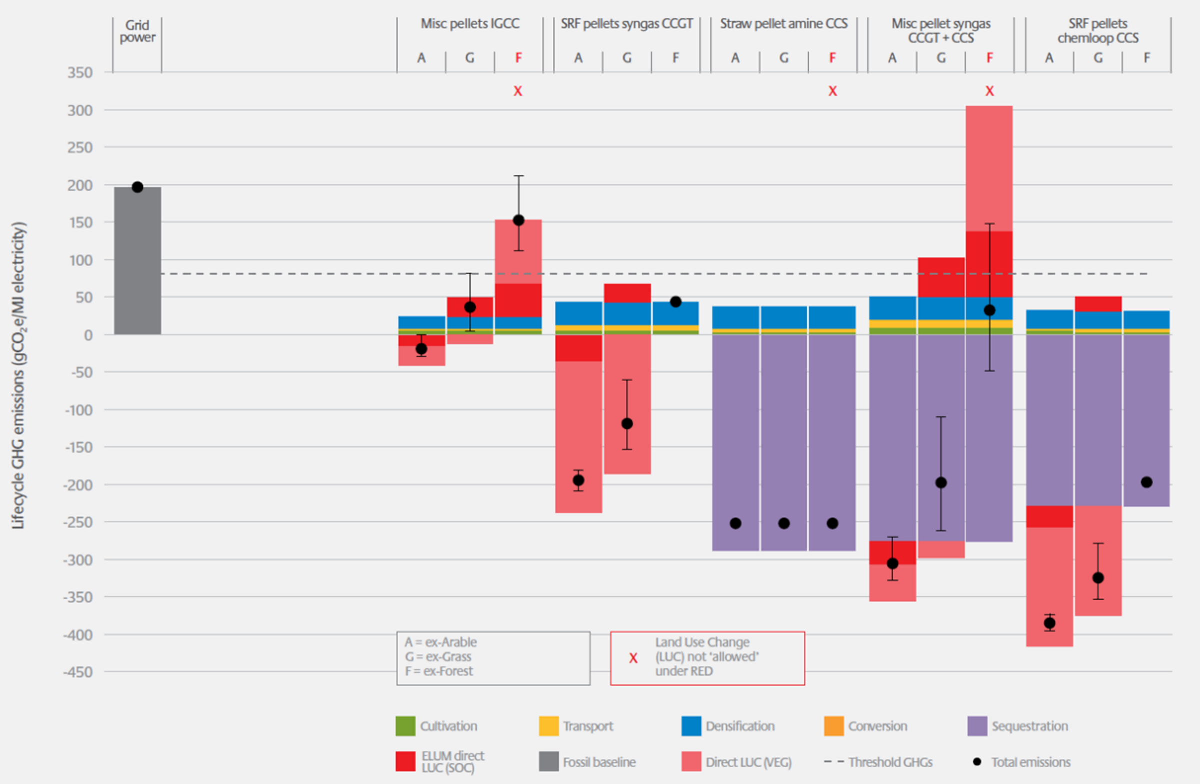
BVCM
Bioenergy Value Chain Model
Optimising Bioenergy

BioFIP
Biomass Feedstock Improvement Process

Advanced Waste Gasification

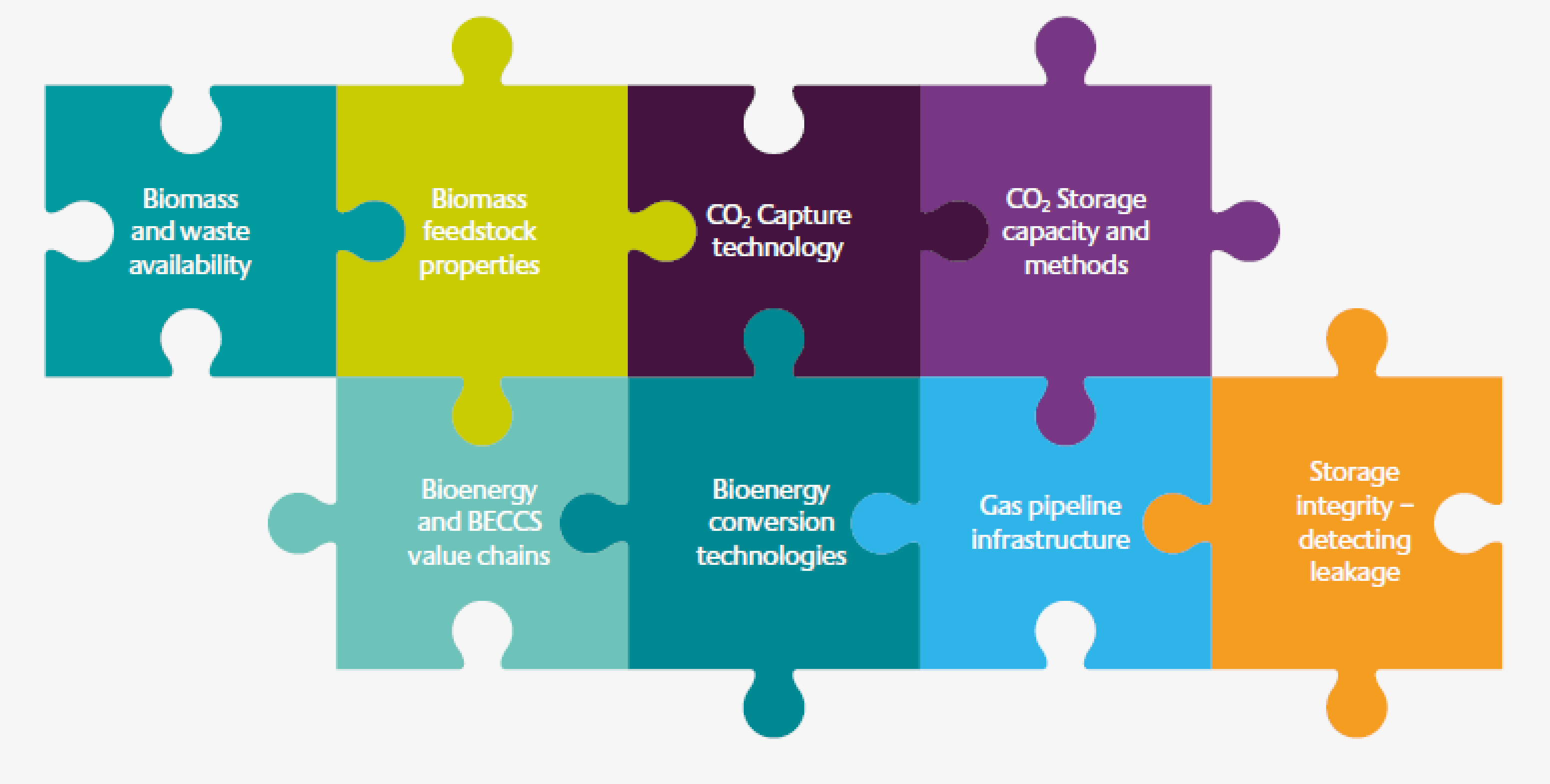
Enabling policy, regulatory and market frameworks. Understanding public perception

Bioenergy value chains can deliver genuine carbon savings



- dLUC emissions can be material, but are of second order importance in chains with CCS
- In grassland transitions, SOC change is somewhat offset by increased above ground biomass
- Existing sustainability criteria prevent the most damaging land use transitions

Critical evidence has been collated across the BECCS value chain



Significant advances have been made in de-risking BECCS deployment

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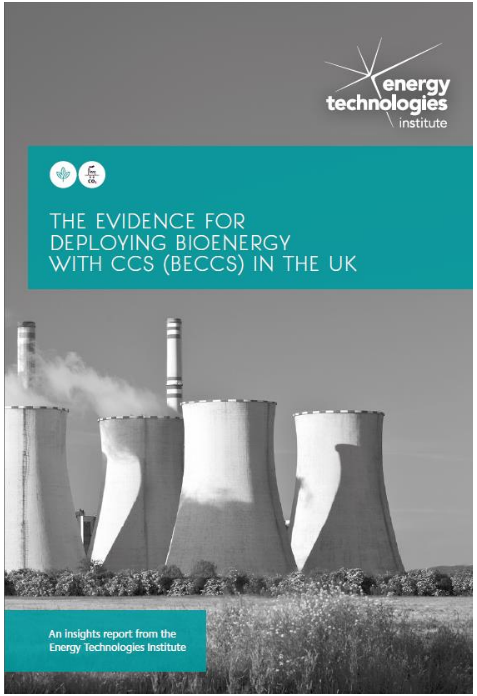

- BECCS is critical to deploy in order for the UK to meet its 2050 emissions target cost effectively
- The evidence base suggests that BECCS value chains can deliver genuine sizeable negative emissions
- The UK is well-placed to exploit the benefits of BECCS, given the storage opportunities offshore, our experience in bioenergy deployments and our strength in bioenergy and CCS research and development

CONCLUSION

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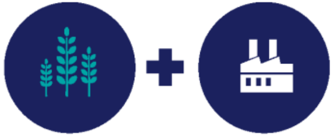

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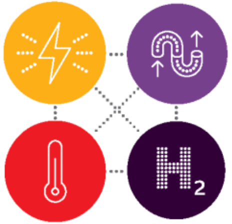

Develop and prove a basket of promising solutions

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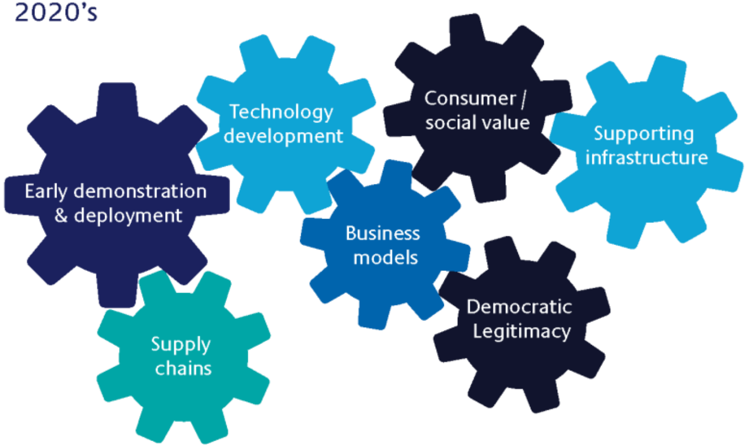
Gaseous systems
Low carbon heating
Efficiency of vehicles & EVs
Carbon Capture and Storage
Efficiency in buildings

Preparing for scale up and wide scale deployment by mid 2020's



Still to come… 30 projects, 10 insights…

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WASTE HEAT RECOVERY PHASE 3

FEBRUARY 2017

A project which aims to develop and demonstrate a Waste Heat Recovery System for ships that could deliver fuel efficiency savings of at least 8%

3

ETI INVESTMENT £3.6m

HIGH EFFICIENCY PROPULSION SYSTEM FOR SHIPS PHASE 3

FEBRUARY 2017

A project to develop and demonstrate a High Efficiency Propulsion System for ships which aims to reduce fuel consumption by around 8%

3

ETI INVESTMENT £3m

FLETTNER ROTOR SAILS PHASE 3

FEBRUARY 2017

The project will be the first installation of wind-powered energy technology on a product tanker vessel, and will provide insights into fuel savings and operational experience

3

ETI INVESTMENT £3.5m

ON-HIGHWAY SIMULATION SUPPORT PHASE 3

APRIL 2017

This project will build and develop on-highway heavy goods vehicle models using an industry recognised platform to verify the integrated system concepts developed in the Land Phase 1 project

3

ETI INVESTMENT £140k

NATURAL HAZARDS REVIEW PHASE 3

MAY 2017

Preparation of guideline document to describe the characterisation of natural hazards relevant in the UK. Case studies at 5 locations to be used to demonstrate methodologies

3

ETI INVESTMENT £500k

WASTE GASIFICATION PHASE 2 – COMMERCIAL PLANT DEVELOPMENT

APRIL 2017

A 1.5 MWe waste gasification power plant capable of high efficiencies and reliability

2

ETI INVESTMENT £5m

BIOMASS FEEDSTOCK IMPROVEMENT PROCESS

MARCH 2017

A demonstration project which aims to show how the removal of impurities and contaminated material from sustainable biomass could make bioenergy cheaper, more efficient, and deliver greenhouse gas savings

ETI INVESTMENT £2.2m

CATAPULT Energy Systems

Questions?

Jo Coleman
Director, Strategy Development