British Institute of Energy Economics

Informed thinking, productive debate

NERA ECONOMIC CONSULTING

BIEE Parker Seminars 2014
Seminar 5
Technology and Innovation Issues for a Low Carbon Economy

November 19th 2014

energy technologies institute

www.eti.co.uk

Technology and innovation issues for a low carbon economy: perspectives from the ETI experience

George Day & Andrew Haslett

BIEE Parker Seminar, 19 November 2014

Overview

Brief context

- UK innovation ‘report card’ (BIS)
- Innovation literature ‘through the ages’

Energy systems and innovation

ETI’s role in this space

- How ETI has built its portfolio

Key insights from ETI’s work on the energy system transition

Engineering & scientific analysis in targeting innovation investment

- Examples from ETI programmes

Final thoughts

- Practicalities - institutions & ‘balance’ in policy

Is the UK any good at innovation?

World class strengths in many aspects of the system, such as research excellence, higher education institutions and the business environment

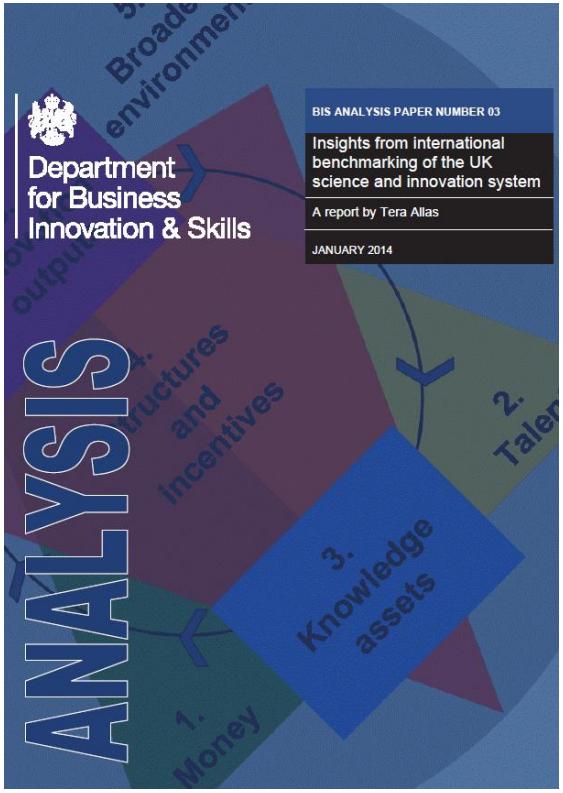
- Highly productive research nation in terms of articles and citation impact, high proportion of downloads and most cited academic articles

Concerning weaknesses in the talent base, especially in terms of basic skills, science, technology, engineering and maths (STEM) skills and management skills

Sustained long term pattern of under-investment in public and private R&D and publicly funded innovation

- R&D investment broadly static at 1.8% of GDP since early 90s (US 2.8%, China 1.8% but rising rapidly, France and Germany consistently >2%, S Korea 4%)

More broadly UK exhibits low levels of productivity and low business investment



Innovation literature: bluffers guide *(apologies to Greenacre, Gross & Speirs)*

Linear models

- Technology push and demand pull

Understanding technological change

- Induced innovation – changes in relative prices
- Evolutionary – uncertainty and bounded rationality – favour incremental innovations
- Path dependency – increasing returns to adoption, technological and institutional lock in

Emerging 'system perspective'

- Technological innovation systems – overall structure of institutions and actors, & dynamic interactions

Transition dynamics

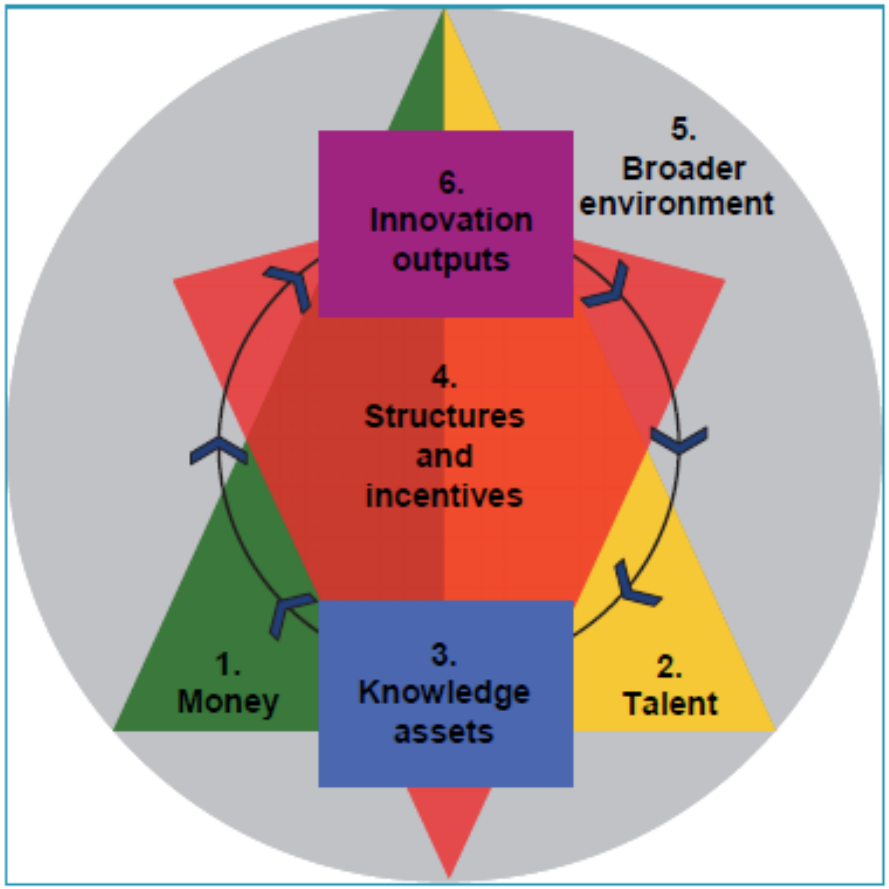
- Energy system transitions, notion of 'lock in', importance of infrastructure

Policy implications

- Not just about public funding of technological R&D
- Need to correct for 'systems failures' – institutional frameworks, interactions/exchange, challenge to 'lock in' (esp wrt to decarbonisation)

Source: *Innovation theory: a review of the literature*, Imperial College Centre for Energy Policy & Technology working paper, May 2012

‘Innovation system’ & UK report card



Category	Assessment
Money	Medium/Low
Talent	Medium/Low
Knowledge assets	Medium/High
Structures and incentives	Medium/High
Broader environment	Medium/High
Innovation outputs	Medium (mixed)

‘Market failures’ perspective on innovation *(as per Oxera)*

Technological or knowledge spillovers

- positive knowledge externalities not reflected in private decision making

Public goods and appropriability

- knowledge and ideas are often non-excludable
- esp when knowledge is problematic to ‘codify’

Co-ordination or network failures

- innovation is a social activity, but exchange or co-ordination problems (e.g. inadequate access by smaller firms to innovation system) may inhibit – esp radical innovations

Imperfect and asymmetric information

- particularly affects financial markets which may be unwilling to fund high tech innovative projects with good prospects

Source: *Innovation market failures and state aid: developing critieria,,* Oxera report for DG for Enterprise and Industry, November 2005

Characteristics of a national energy system

… or some reasons why (a) innovation might be particularly challenging and (b) a system approach may be particularly valuable

Energy sources and vectors both compete and interact in complex ways

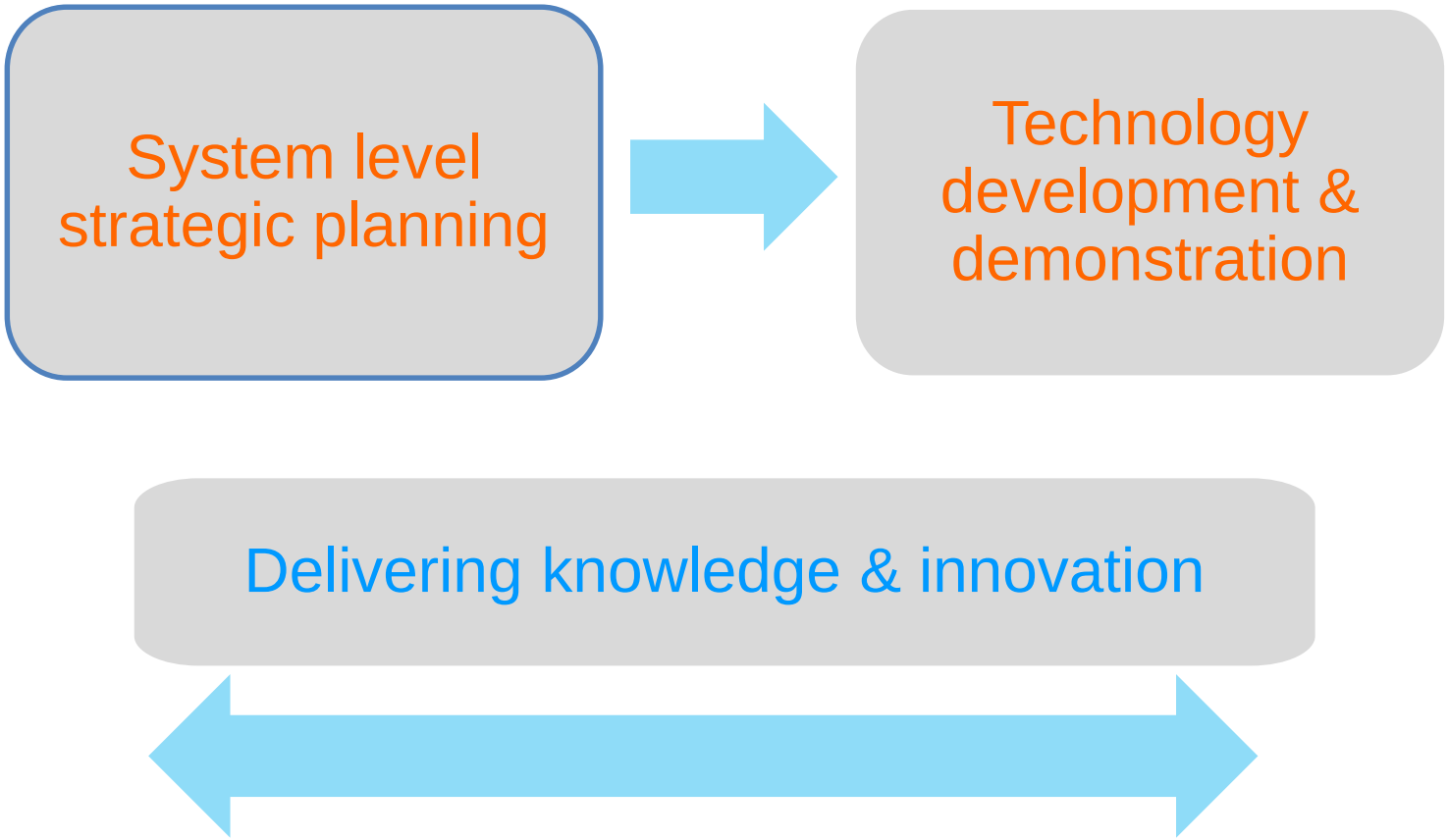
- But behave according to well-understood physical laws

Exhibits network effects and path-dependency (to some extent)

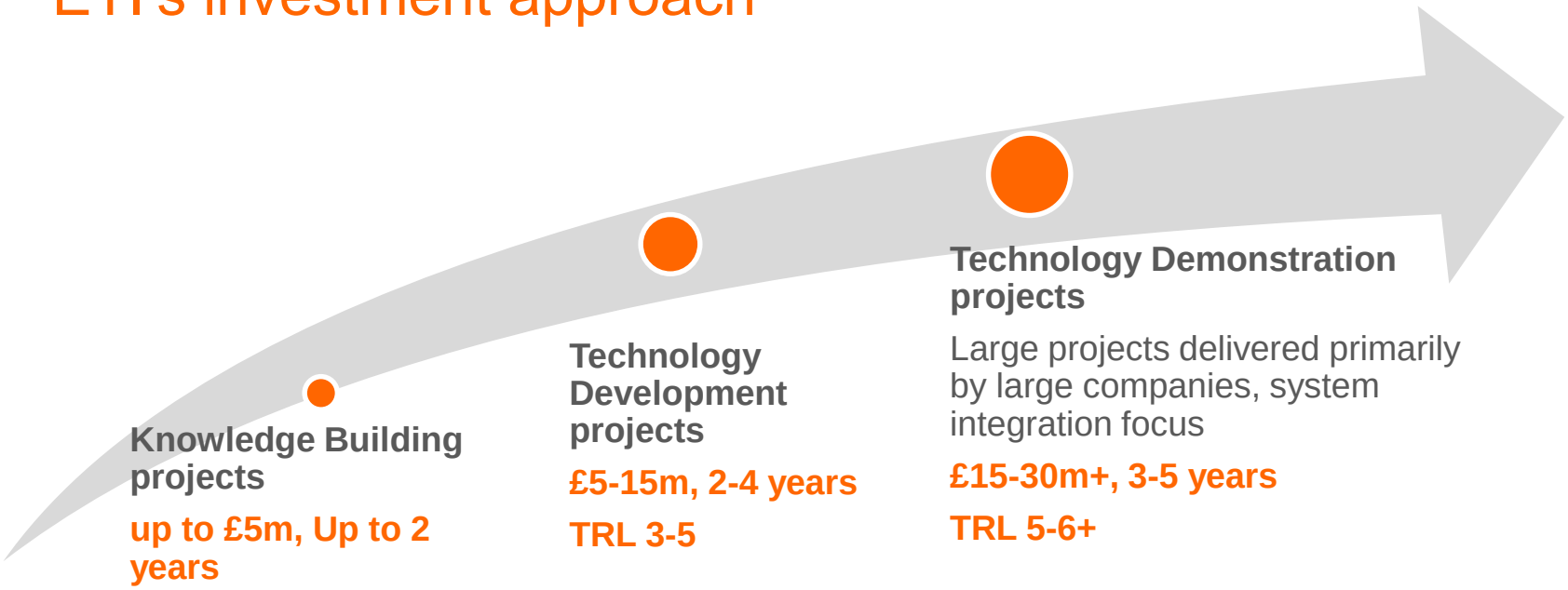
Importance of externalities and (hence) policy intervention in shaping the market

Scale of investment required

ETI approach to its portfolio



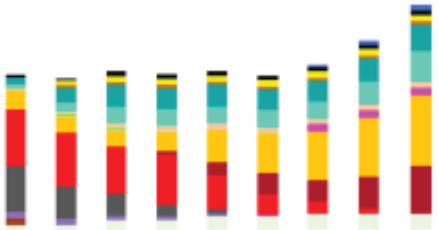
ETI's investment approach

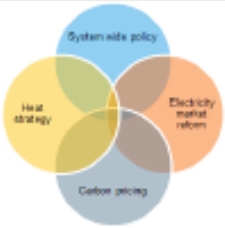


Meeting UK energy and climate change targets cost effectively	Additionality & impact of ETI investment (finance and capability)	Impact and inter-relationship with policy development	Value Return to ETI & its Members	Impact on UK economic development (& energy prices)	Acceptability of project risk

Energy transition scenarios demonstrate the importance of preparedness

ESME
Energy System Modelling Environment





Context

- ETI has developed illustrative scenarios for the UK's energy transition to 2050, combining ESME analysis with accessible narratives
- The focus is on key dimensions of transitions highlighted in the 2014 Technology Strategy: the rate of transition and the balance of popular vs economic technology solutions

Key Insights

- Critically important to take a systems approach – sectors and their infrastructure cannot be developed in isolation
- Infrastructure planning will be sequential: national strategies for biomass and CCS will impact key choices elsewhere in the system
- There is a critical need to invest in the development and proving of a portfolio of the most valuable technology options

Implications

- Preparedness is key: near-term action is necessary so that by the mid-2020s the UK is ready to make critical choices
- Consumers must adopt new technologies for heat and transport in any scenario; leadership, policy incentives and attractive offerings will be essential
- Technical and regulatory details need to be worked out. Verifying final practicality and developing supply chains requires large systems demonstrations
- A combination of public and private, shared and individual, investments will be required. Investment decisions will be national, local and individual

ETI experience: three key learnings

System-wide perspective is of overriding importance

Importance of underlying engineering analysis

- To targeting investment in technology development and innovation
- Identifying technology options which have ‘strategic value’ to the system

‘Preparedness’ is key: developing and testing new ways of assembling known (rather than novel) technologies

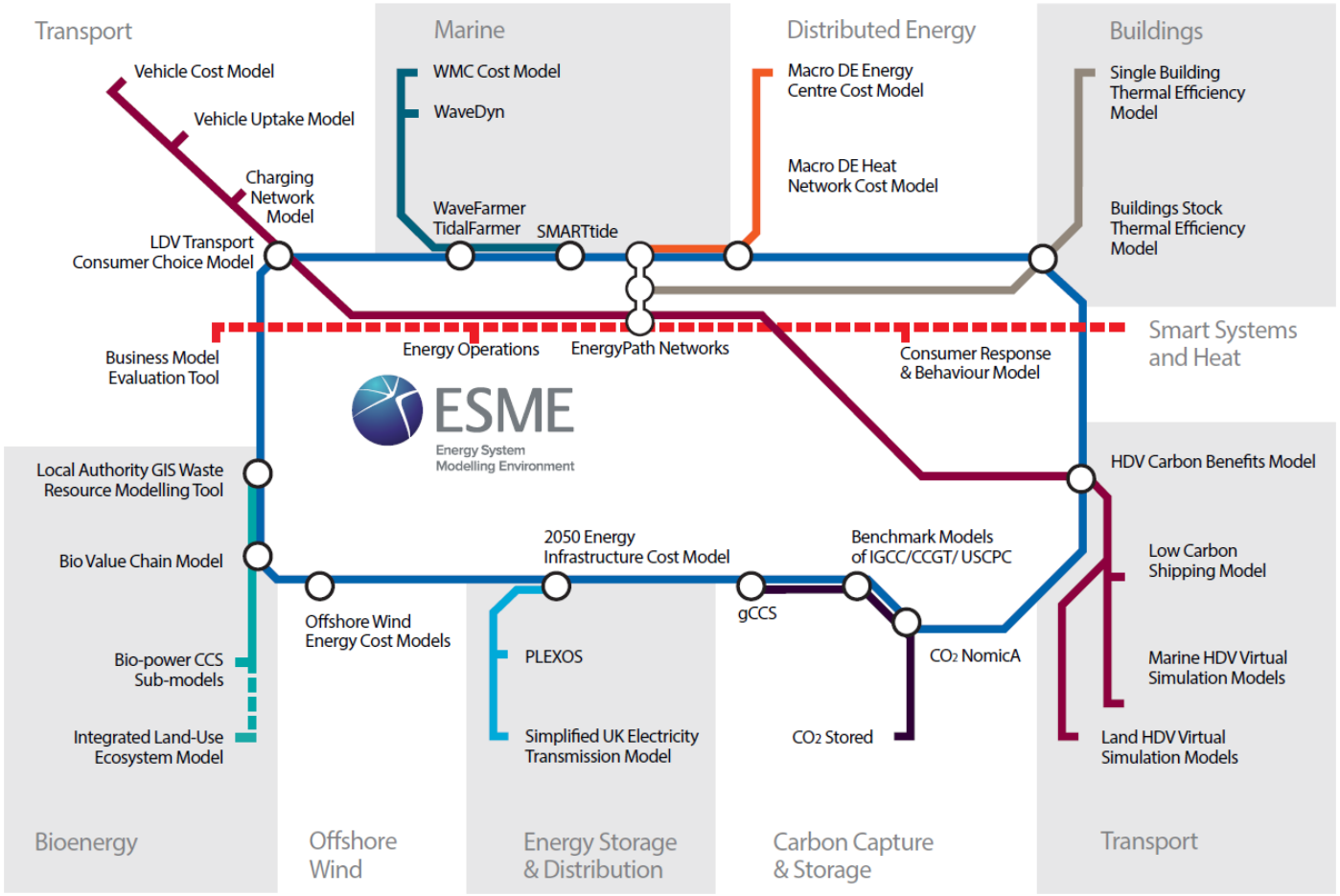
- Technology assembly, development and proving
- Early demonstration and deployment (learning and cost reduction / demonstration at scale ie. activity required to get onto a NOAK cost curve)
- Business model development (public / private, risk sharing, contracting, value chain)
- Testing consumer / social acceptability
- Creating enabling market, policy & regulatory frameworks

CV

- Chemical Engineer, worked 30 years at largest UK chemical company
- Experience in design, capital projects, technology sales & technical service, manufacturing, R&D
- Twenty years becoming head of process technology for heavy chemicals (0.5MTe/year asset), another ten to responsibility for corporate technology strategy and business innovation capability for specialties (paint, flavours, fragrances, functional ingredients, electronic materials…)
- Joined ETI in April 2008 as Strategy Director, responsible for recommending to Board what projects we should undertake and gradually added Chief Engineer, responsible for technical quality and capability

ESME integrates knowledge from across ETI programme areas

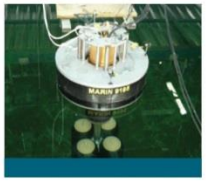
ESME - On track to 2050



Delivering innovation from strategic planning to technology demonstration

Knowledge building

Bioenergy
Multi-site field trial to study impact of bioenergy crops on soil carbonisation and greenhouse gas emissions
– Reporting in 2014



Marine
Optimising wave and tidal array yields
– Industry use from 2013
– Reporting in 2014

Carbon Capture and Storage
First comprehensive UK CO_2 Storage database
– Delivered in 2013

Developing technology

Energy Storage and Distribution
New approach to storing electricity at scale
– Testing up to 2017

Marine
3 phase 11KV Wet-mate connector with integrated communications
– Delivered in 2012

Transport
Increasing efficiencies of HDV land and marine vehicles by up to 30%
– Testing up to 2017

Demonstrating technology and system solutions

Offshore Wind
New designs for Floating turbine platforms – reducing generation costs
– Tank testing and design completing in 2013

Offshore Wind
World leading facility to increase reliability of new turbines
– Operational in 2013

Marine
1MW tidal generator providing environmental impact and performance
– Operational in 2013

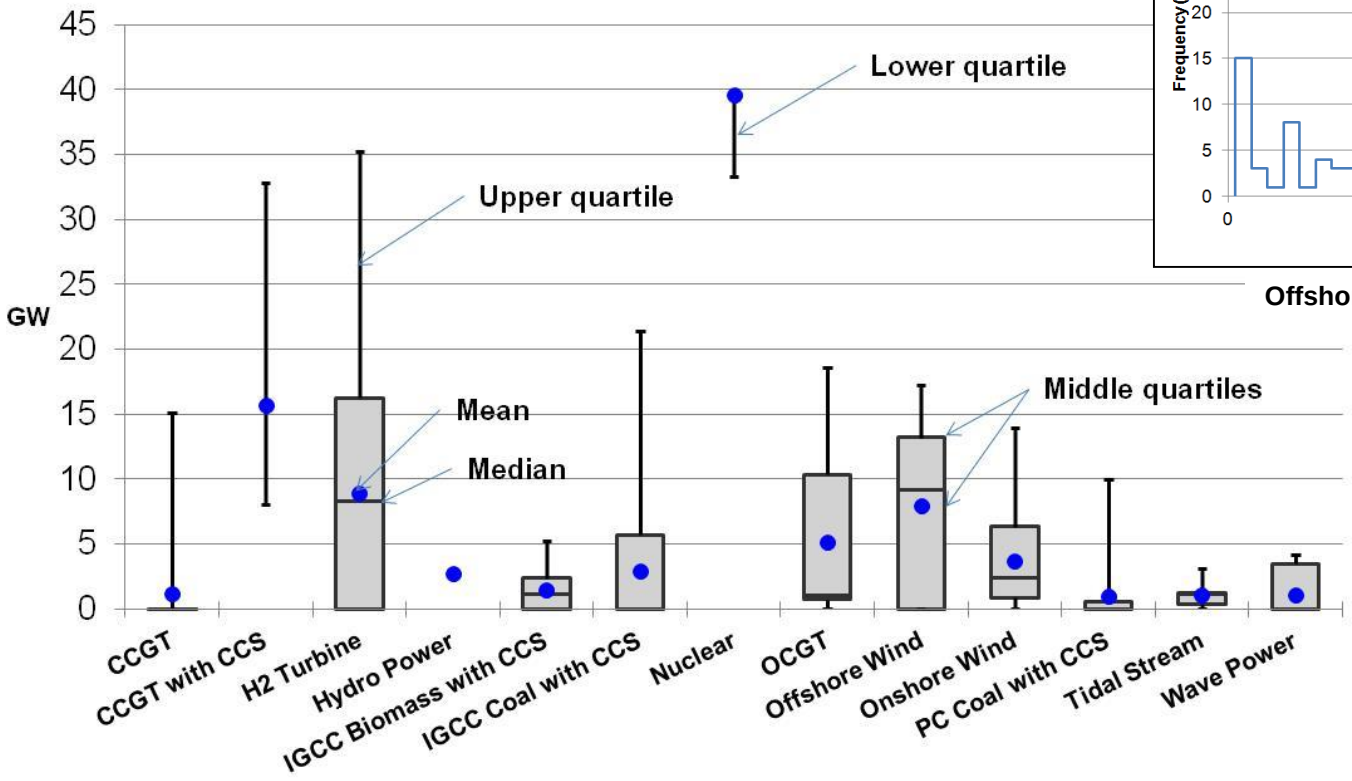
Summary of key cost reduction areas

- Bigger, better turbines
- With bigger, more efficient blades
- Installed more cheaply
- With improved, system, cost of energy
- Accessing better wind resource
- Benefitting from volume economics
- With clear returns for stakeholders
- Ability to test new innovation quickly

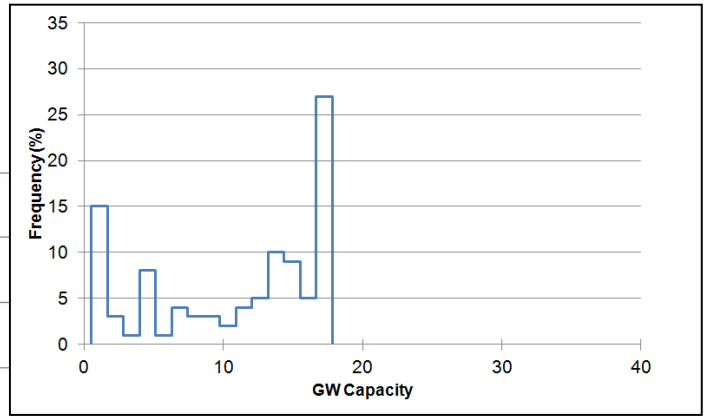
What are the disruptive technologies going to be?

Optimised world – UK 2050

All technologies deliver expected cost reduction & performance improvement to cost & schedule



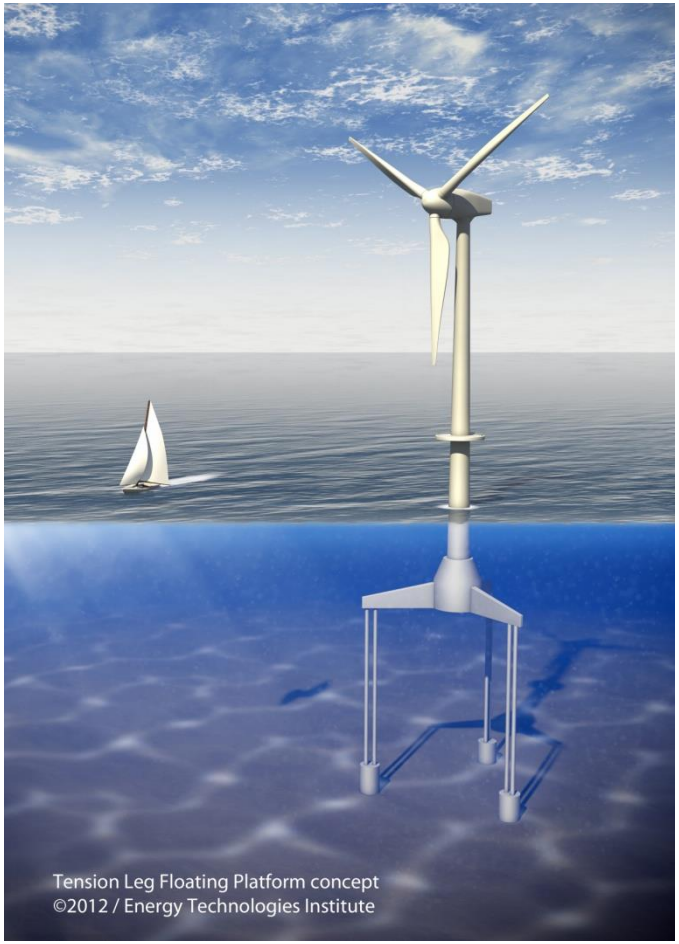
Generation Capacity probability distribution in 2050

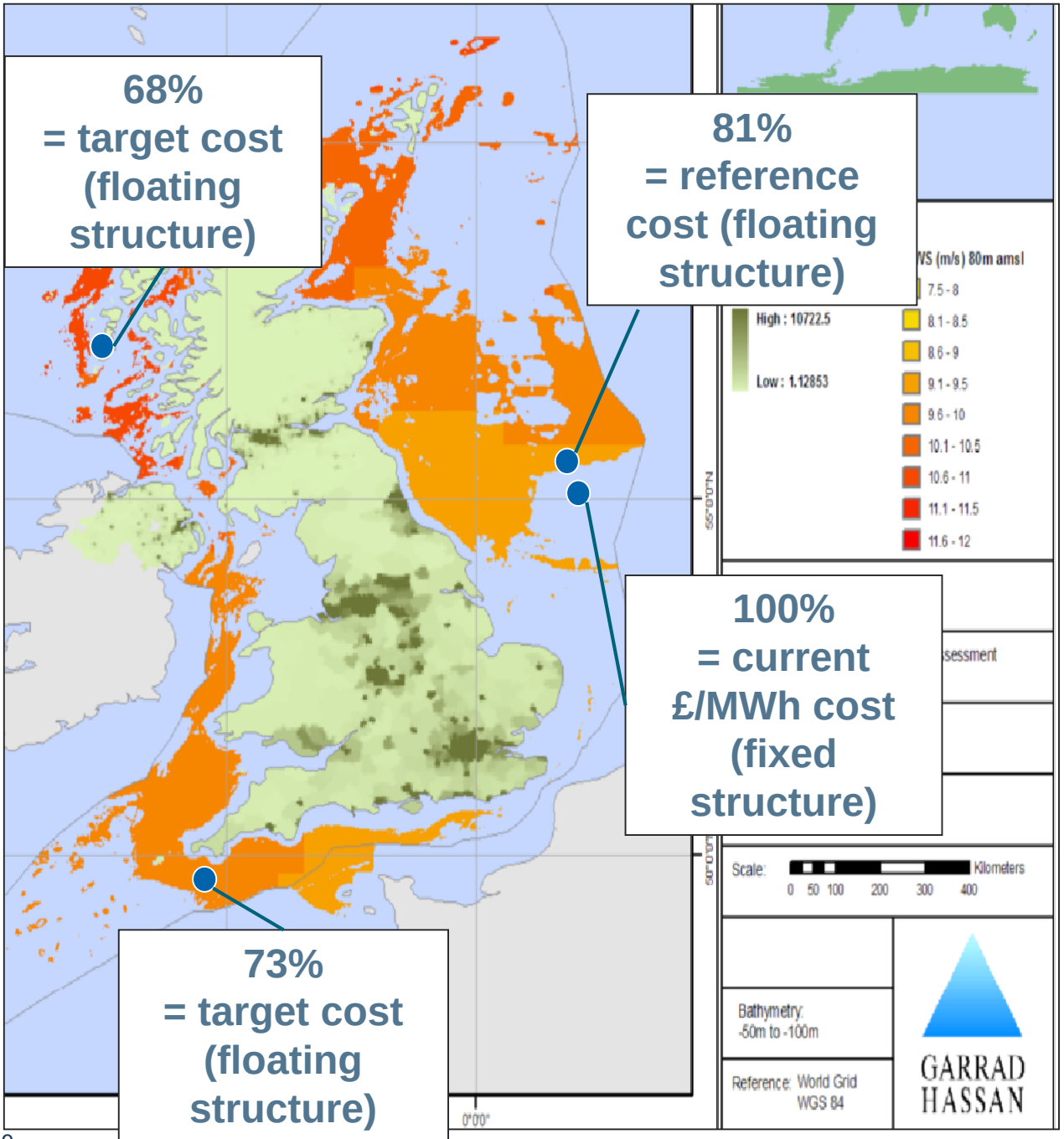


Offshore Wind Probability Distribution

ESME V3.0 “Director’s Cut”

Floating Offshore Wind System Demonstrator – ballpark £80M project





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Average wind speeds over UK waters which are 50-100m deep range from 9-12 m/s

Cost figures from ETI design and cost modelling projects

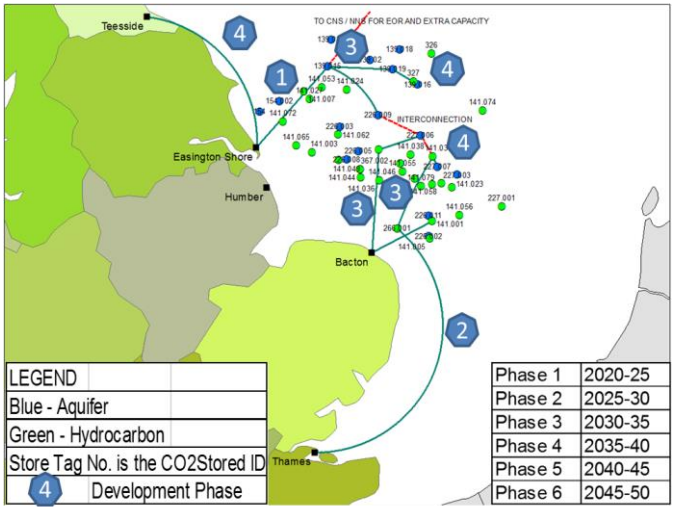
Opportunities

- Energy yield proportional to (wind speed)^3
- 11 m/s wind (Western Isles) offers >180% of the energy of 9 m/s wind (Dogger Bank)
- Highest mean wind speeds are around West of Scotland and off the South West coast
- Good grid connection and short distances to shore in North Devon

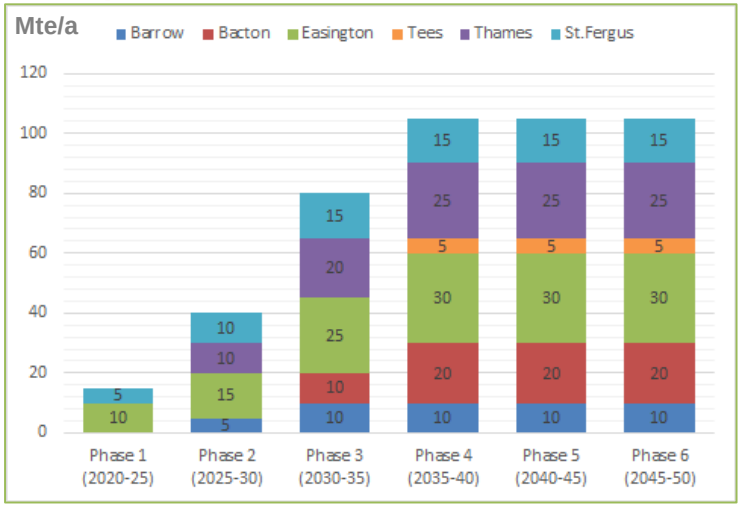
CCS – offshore storage planning

- 2GTe to be appraised by 2025 (7 aquifers)
- Clustering of emitters, limiting the number of shoreline hubs (6) and planning of networks reduces infrastructure costs, by as much as 30-50%

SNS Example Network

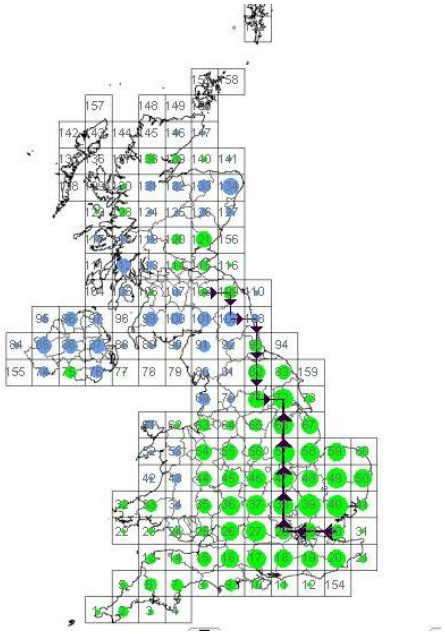


Build Up of Flows from Shoreline Hubs

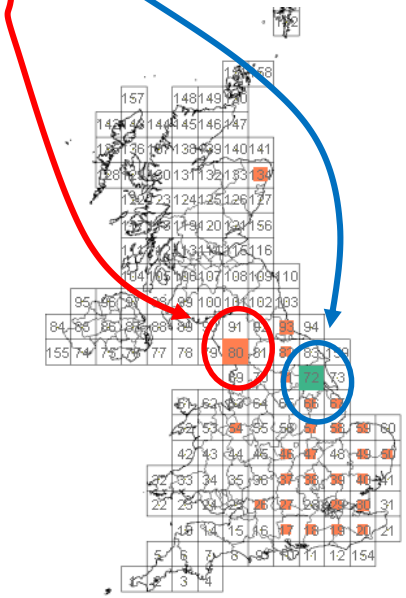


Exploring potential most economic bio-energy chains – first impressions

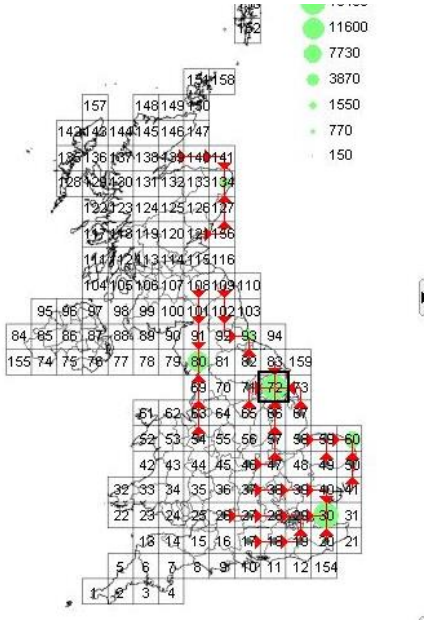
Moderate syngas piping – trunk down Eastern UK

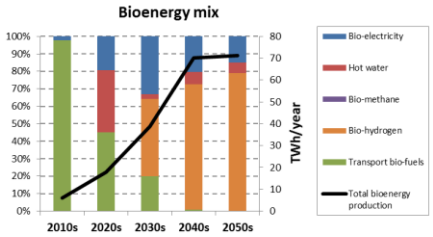


Geographic centres:
Gas+H2+CCS at Barrow (and distributed)
Bio-CCGT at Easington

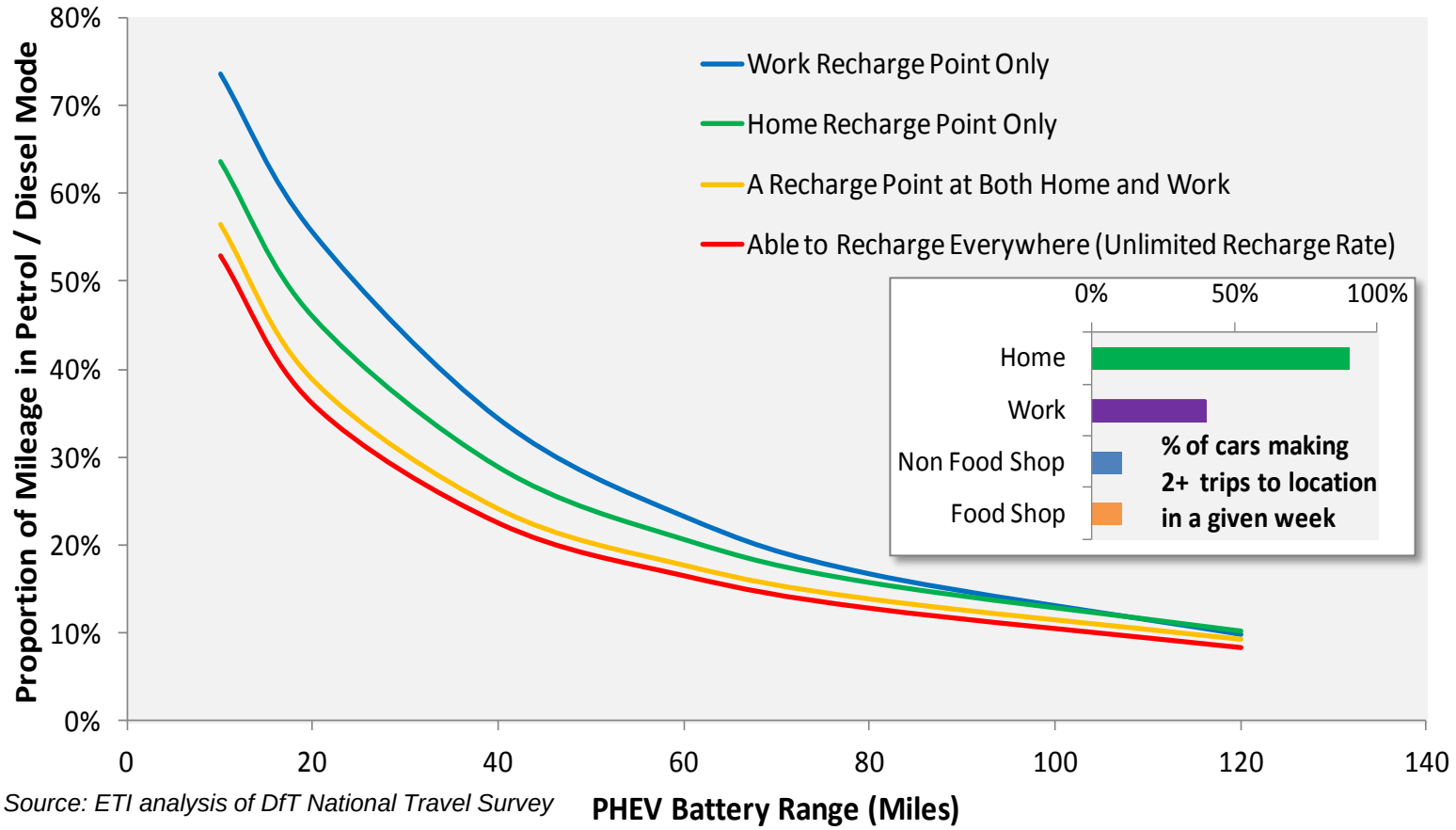


Significant CCS piping



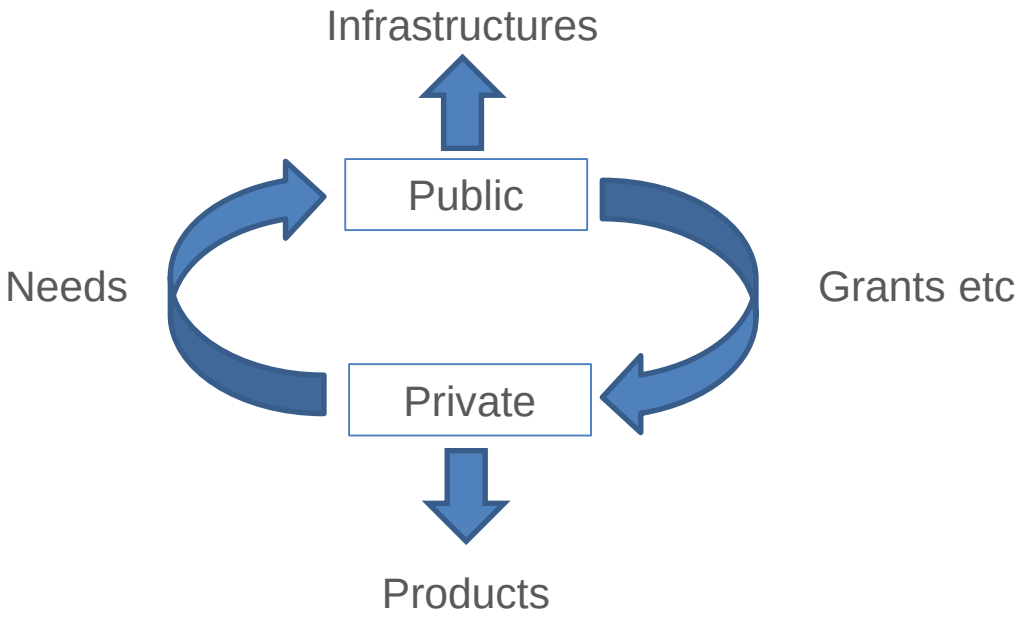


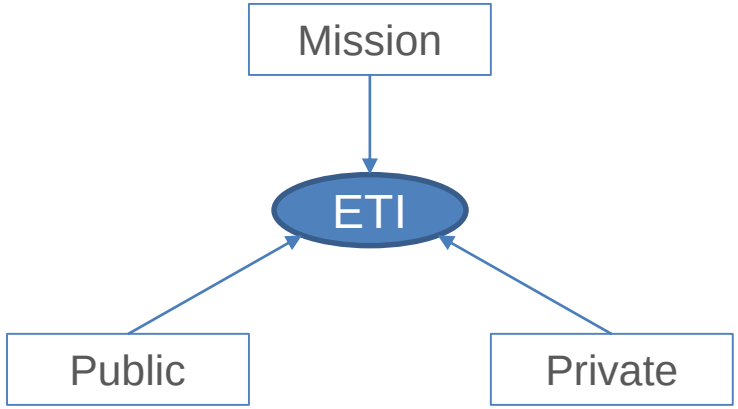
Using NTS data to model vehicle technology patterns of use



Source: ETI analysis of DfT National Travel Survey

Public – Private innovation engagement models





Final thoughts (1): *institutional practicalities in the space between public and private sectors*

- Many attempts at creating institutions & a history of instability
  - ETI is no exception, Catapults are the latest incarnation

- Importance of people with commercial and industrial skills & experience (ie not civil servants, not academics) to work on priorities driven by policy, but at some remove from the constraints of government itself
  - Working in this environment is difficult – reconciling commercial & policy objectives

- Added value of 'strategic collaboration' between public and private sectors: not just public sector 'grant giving', or free-standing projects
  - Need continued institutional innovation to create environment for public-private-academic strategic interactions & collaboration

Final thoughts (2): *low carbon innovation policy – getting the balance right?*

- Demand pull (market interventions, RO, FITs, Standards etc) v supply push (public funding, capex grants, prizes, matched equity)
- Shaping of incentives to innovate – ‘one size fits all’ v tailored?
- Strategy vs markets (EMR v Wood Review)?

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