energy technologies institute

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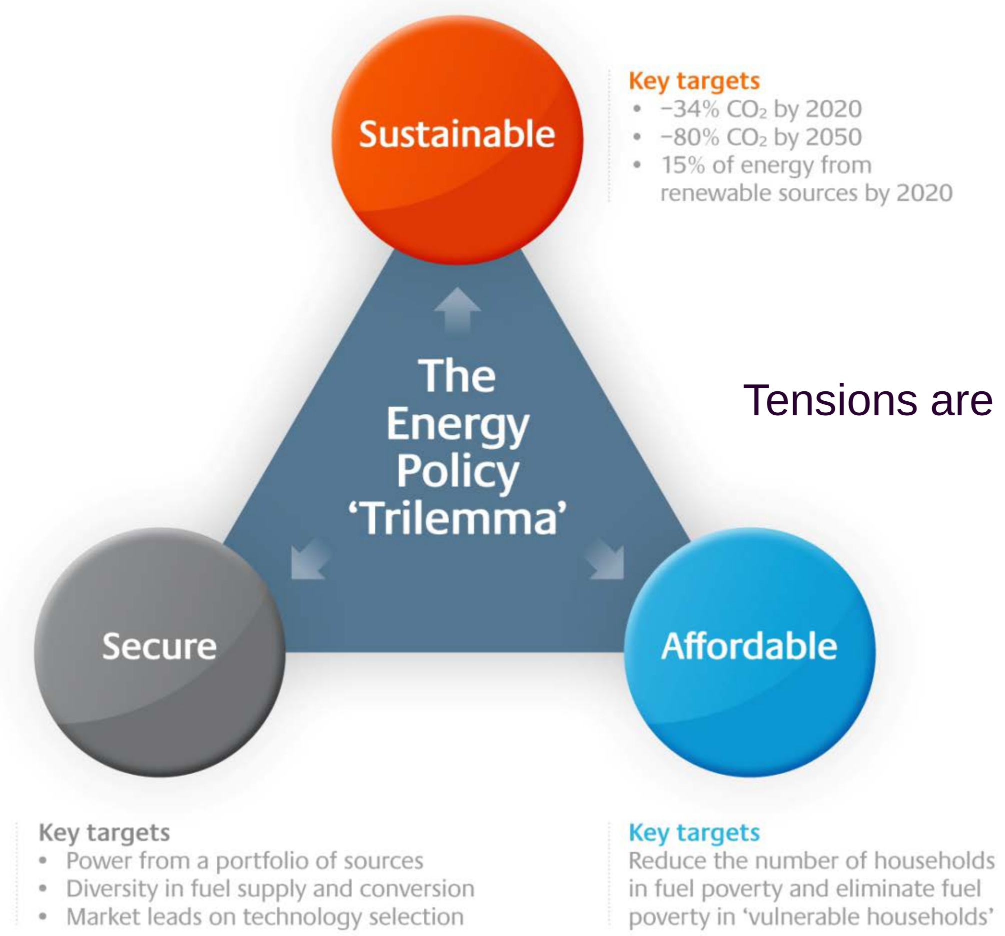
Transitioning to a Low Carbon Energy System

Mike Colechin

ETI10 TEN YEARS OF INNOVATION 2007 — 2017

The UK energy challenge...



Tensions are increasing...

Preparing for the Energy Transition: Context

- **Increasing demand to 2050**
  - Population: 65 to 77-79 million
  - Vehicles: 24 to 35-43 million cars
  - Housing: 24 to 38 million houses,
    (80% of current stock still in use in 2050)

- **Action to date**
  - Beginning to decarbonise power sector
  - Increasing energy efficiencies (especially in cars)

- **UK energy system is a unique and complex set of interlinked assets and infrastructure**
  - Ageing power plants need replacing
  - Significant wind (and marine) energy potential
  - Significant offshore CO2 storage potential
  - Significant opportunity for UK biomass
  - Reasonable public support for all low carbon options
  - But, poor housing stock and a very significant heating challenge

Energy Technologies Institute (ETI)

The ETI is a public-private partnership between global energy and environment companies and the UK Government

Targeted development, demonstration and de-risking of new technologies for affordable and secure energy

Shared risk

ETI members

bp

CATERPILLAR®

EDF ENERGY

Rolls-Royce

Department for Business, Energy & Industrial Strategy

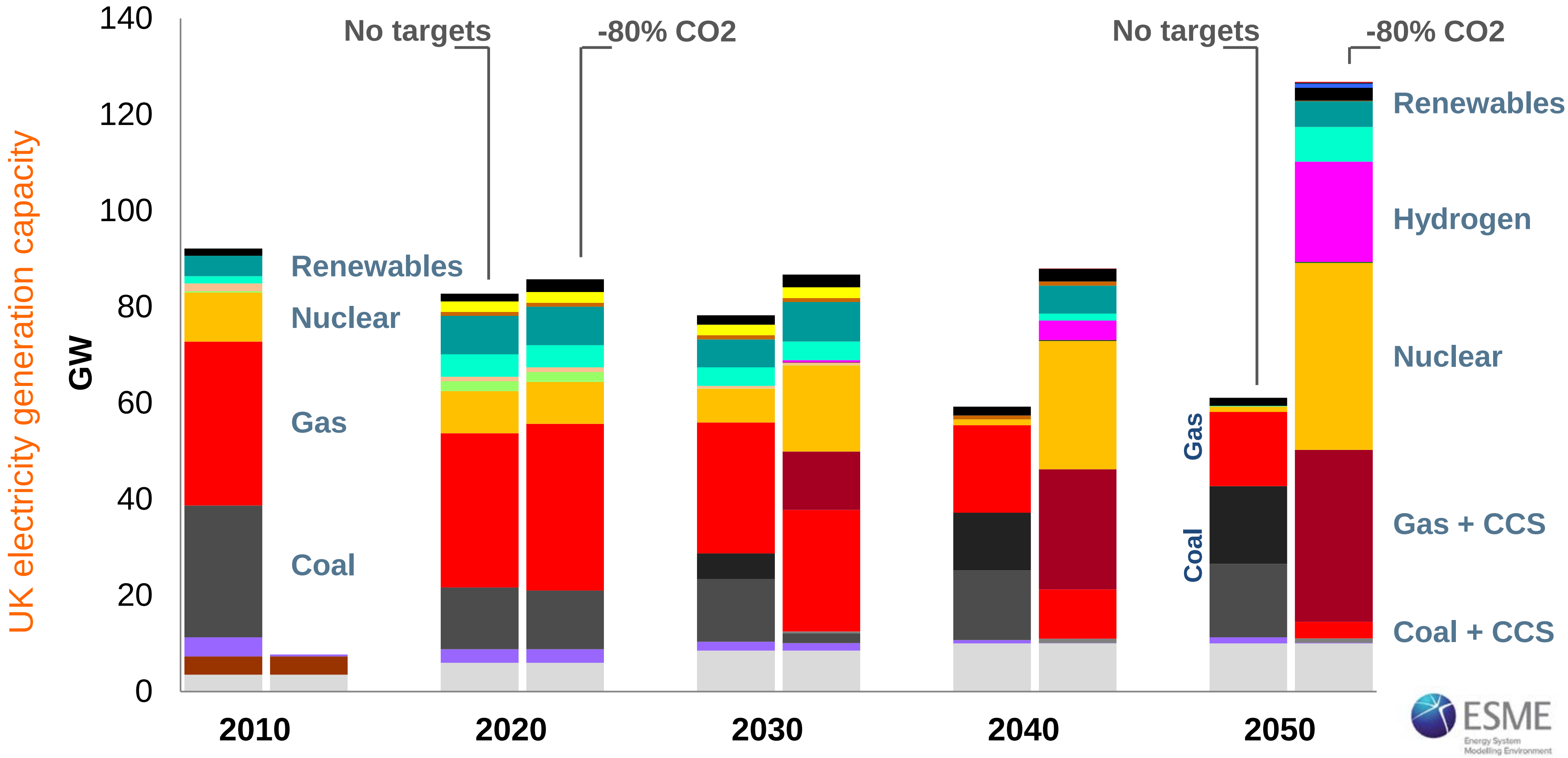
EPSRC Pioneering research and skills

Innovate UK

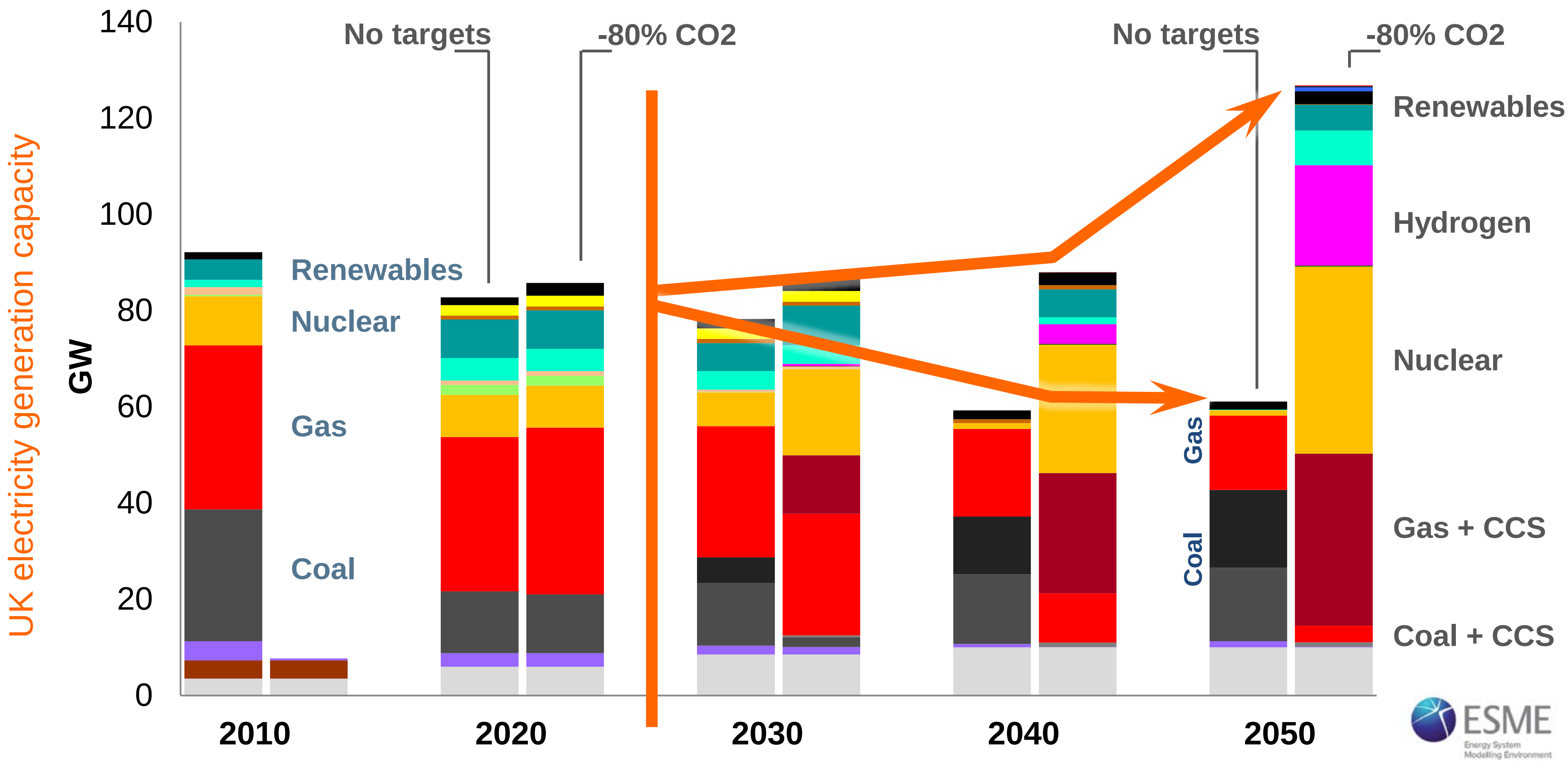
ETI programme associate

HITACHI Inspire the Next

"No emissions targets" and "-80% CO_2 in 2050" are very different worlds…



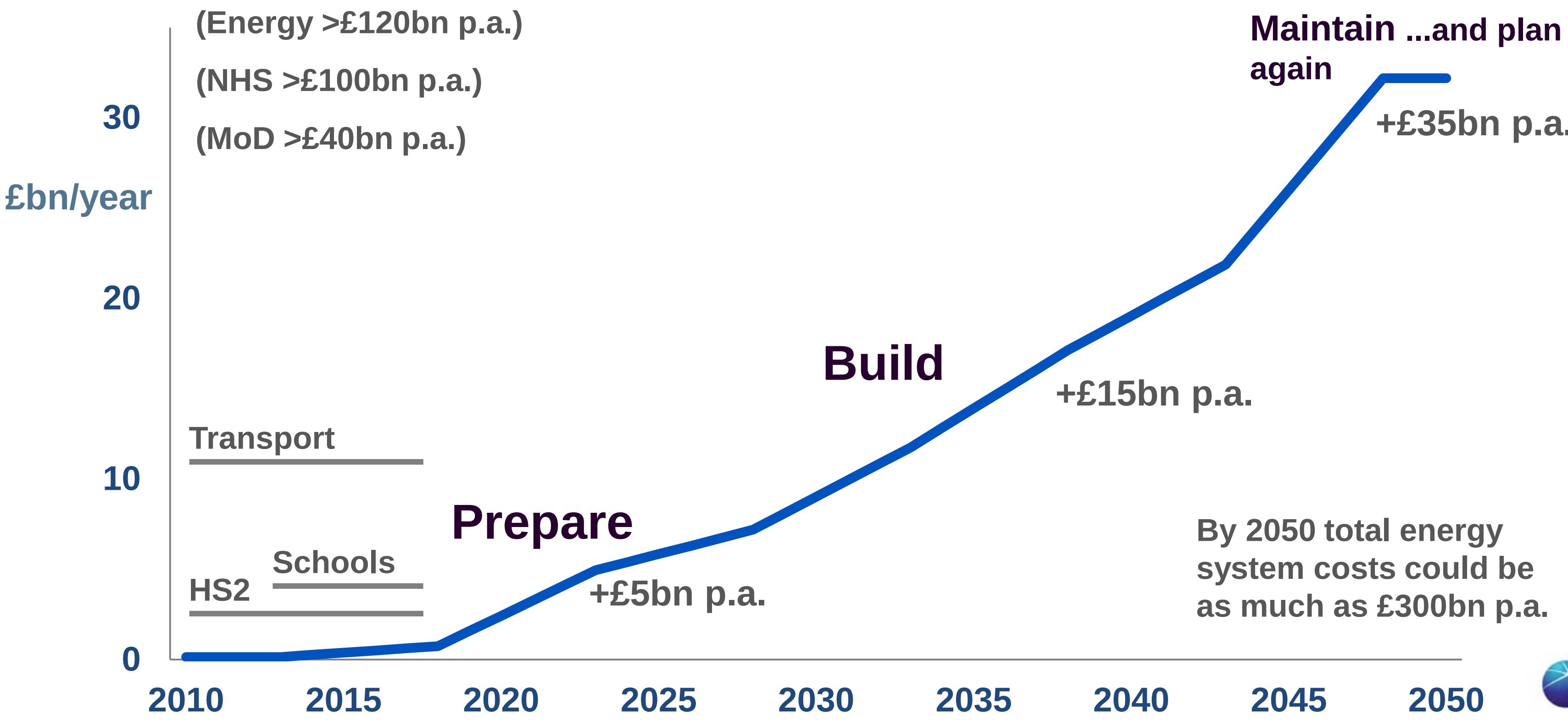
As long as we prepare NOW, decisions on 2050 can wait… but not for long



Prepare over next 10 years

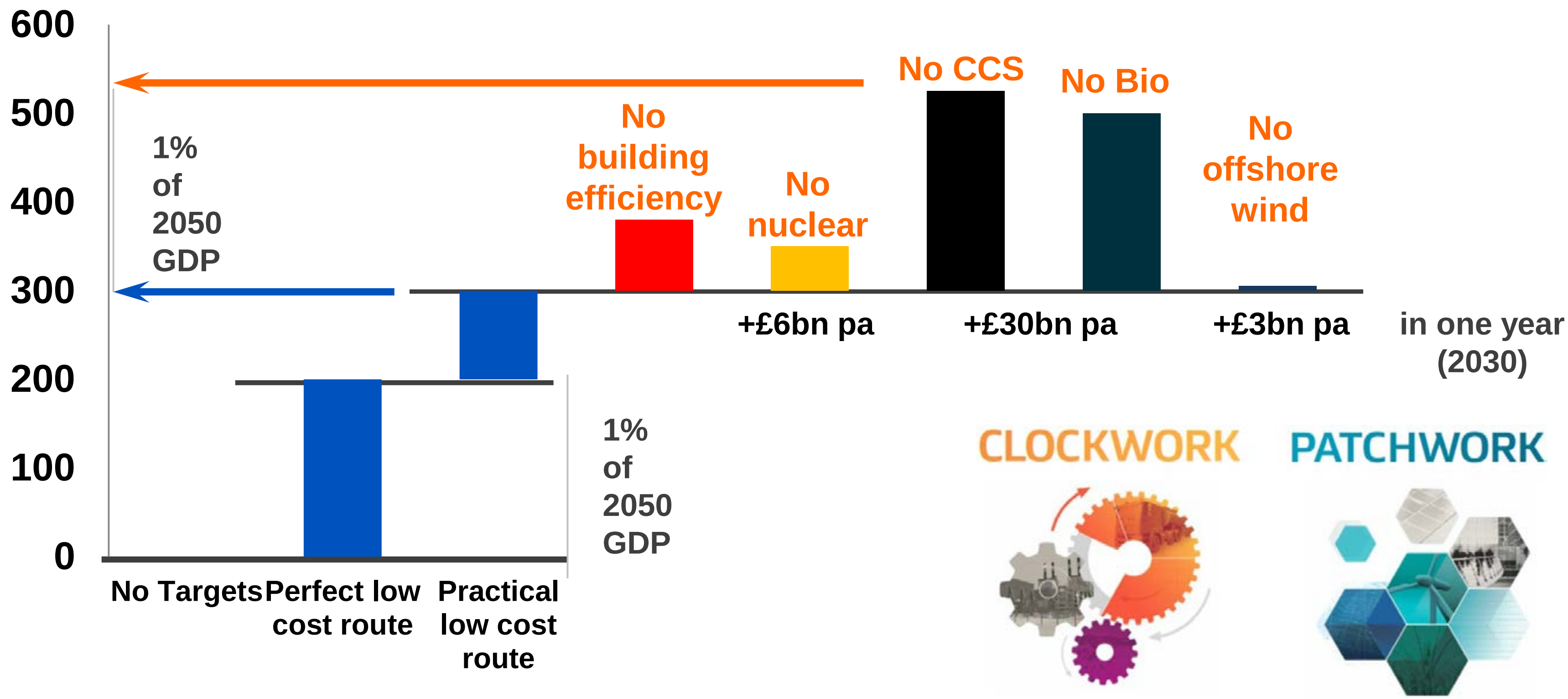
creating platform for infrastructure roll-out and growth

Incremental capital investment in a 'low-carbon' energy infrastructure

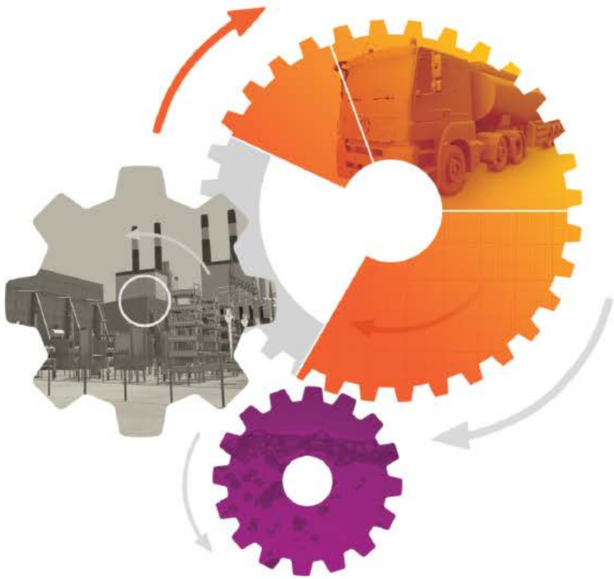


The UK can achieve an affordable transition (1-2% of GDP) - system optimisation is key

Additional cost of delivering -80% GHG energy system
NPV £ bn 2010-2050

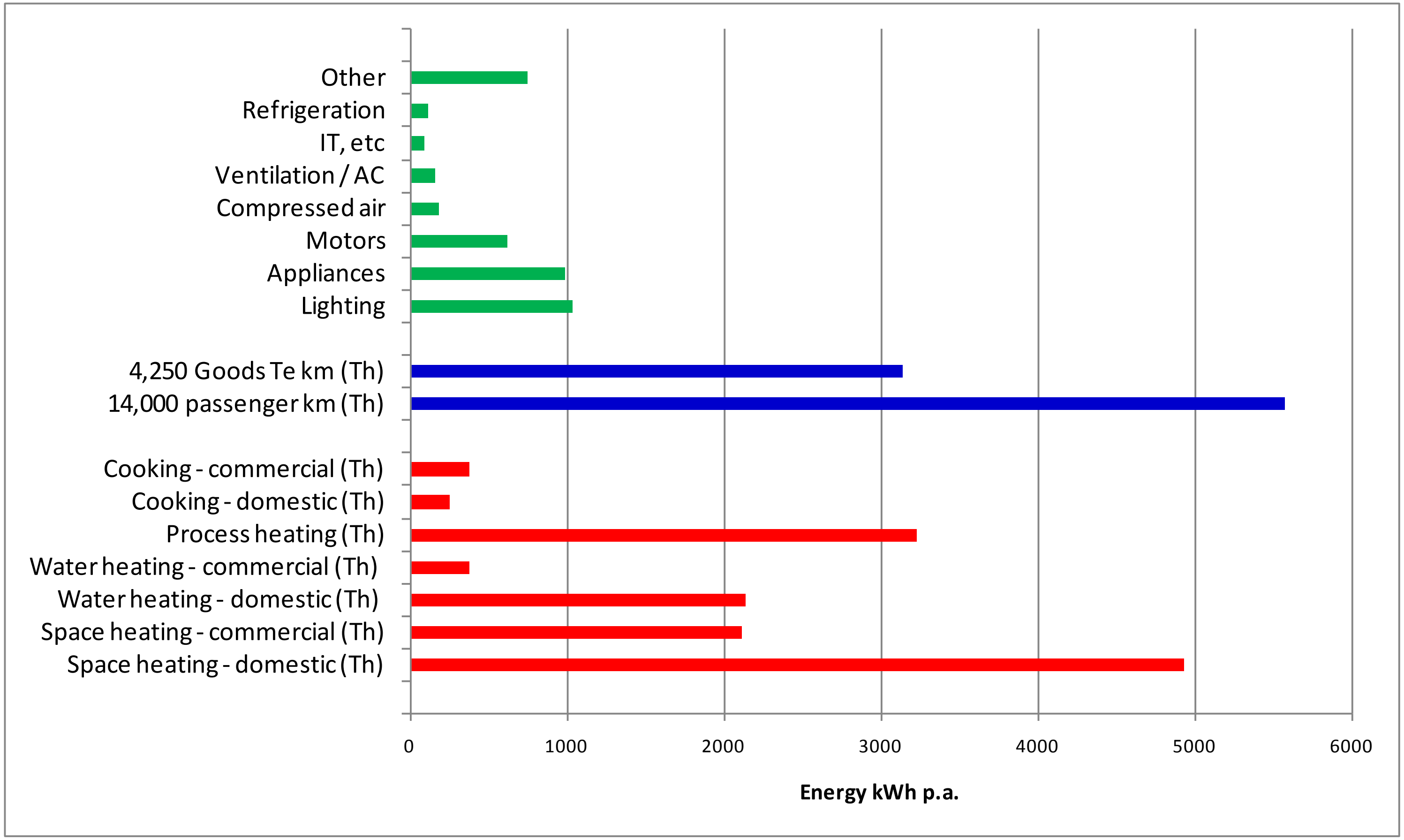


ETI's Clockwork and Patchwork Scenarios



are representative of the challenges the UK faces in a move to low carbon – displaying the scale of the challenge

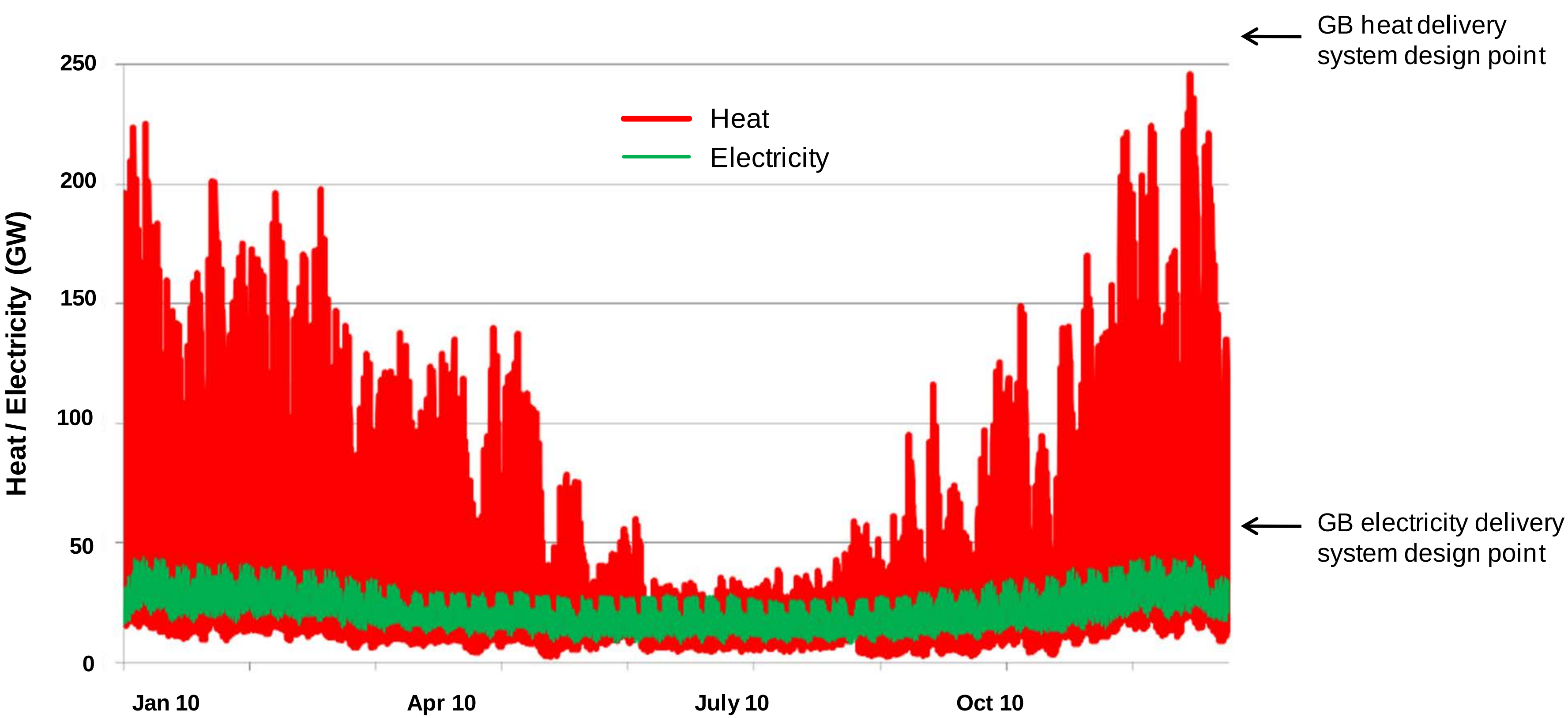
Individual energy consumption in the UK*...



* 2010 UK consumption divided by 60M (people in the UK)

Notes: 1. Passenger transport figure excludes international air travel
2. Data excludes heavy industry

GB heat and electricity demand variability (commercial & domestic - 2010)



Source: UKERC (2011)

90%

of the UK’s housing stock will still be in use in 2050

20%

contribution of household heating to national carbon emissions

Today fewer than

4%

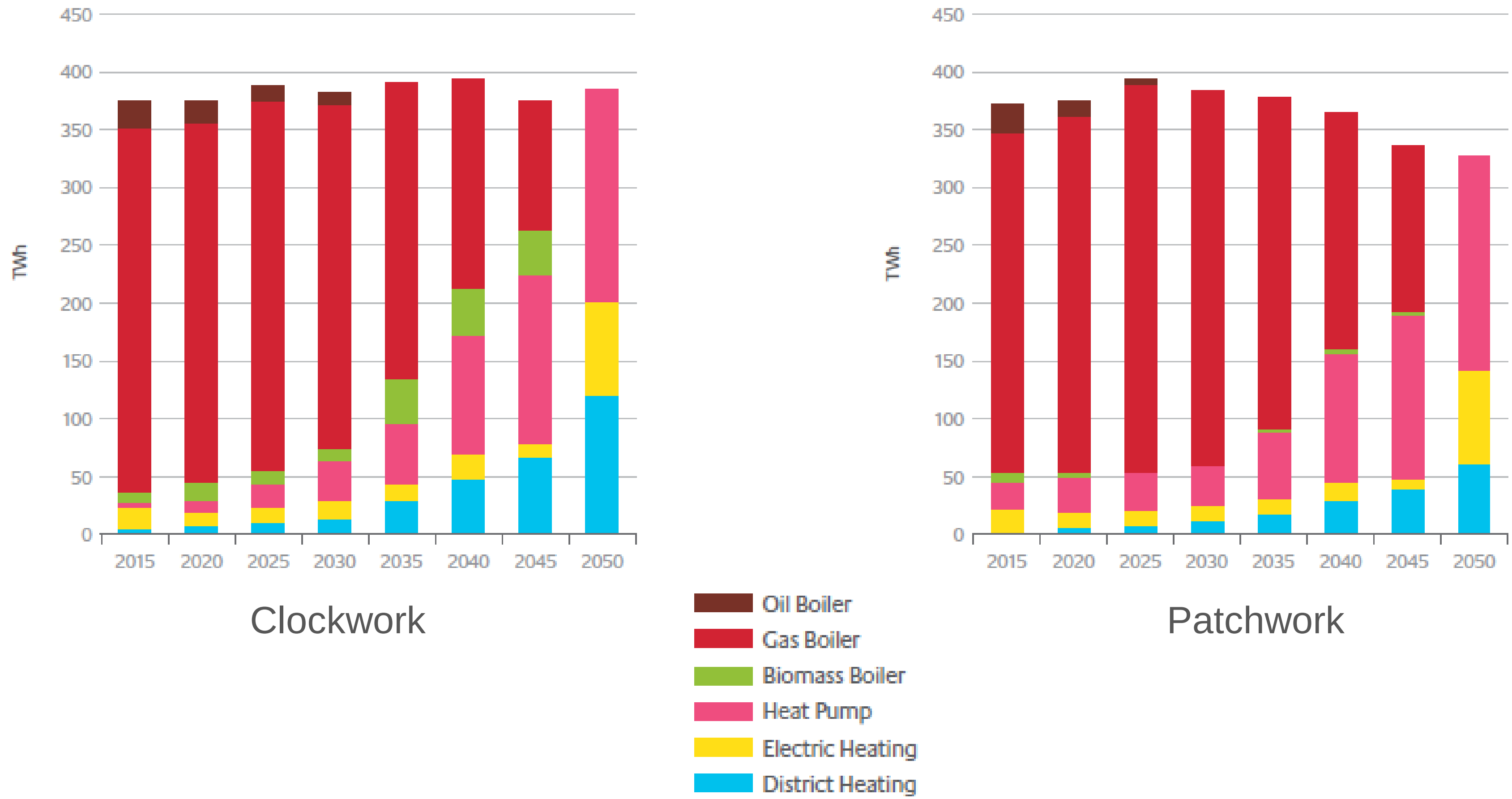
have low carbon heating

and

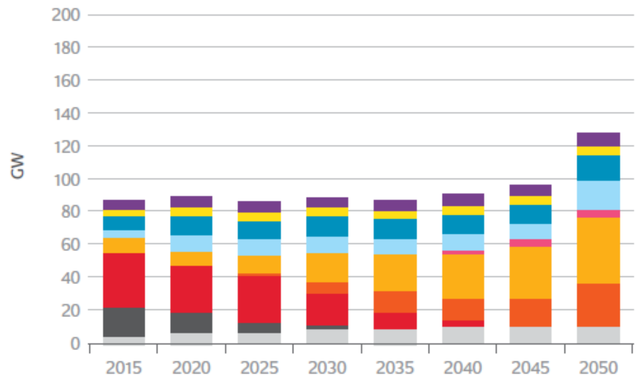
90%

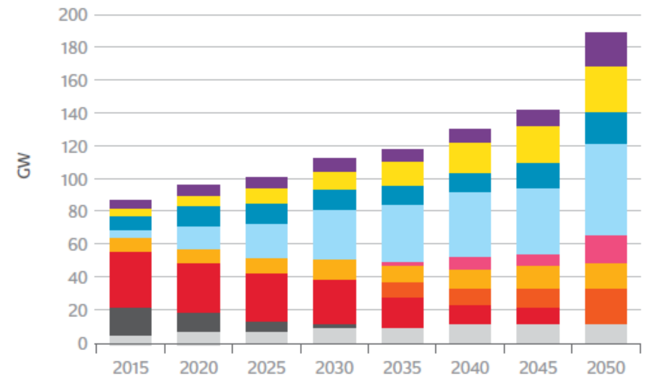
prefer gas central heating given the choice

Space Heat Generation



ELECTRICITY CAPACITY





CLOCKWORK

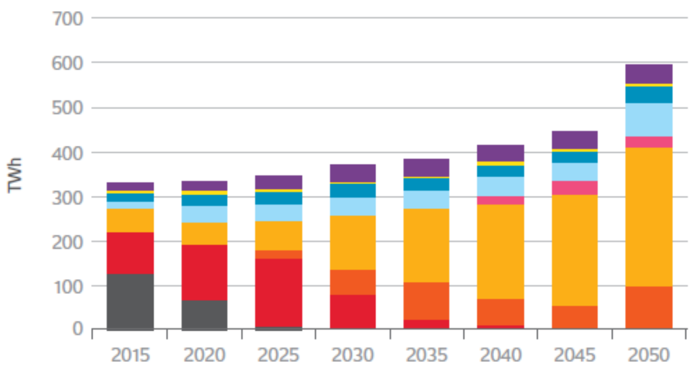
- Nuclear provides 40GW of capacity by 2050
- Existing pipeline of renewables built out to 2020, then maintained, with some further uptake of wind in 2040s
- Gas plants retrofitted/replaced with CCS from 2020s
- Hydrogen takes over from gas for peaking capacity from 2030s
- Total capacity of ~130GW by 2050. Balance between nuclear, CCS and renewables

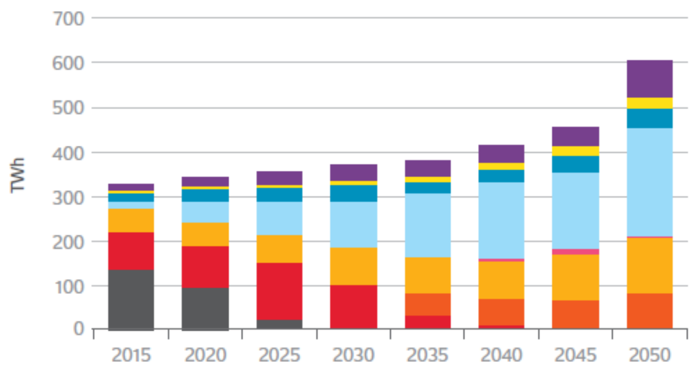
PATCHWORK

- Nuclear replacement of existing capacity only (16GW)
- CCS delayed until 2030s before replacing unabated gas plants
- Wind power capacity reaches 75GW by 2050, mostly from offshore
- Significant capacity of hydrogen turbines (17GW) required to balance intermittent supply
- Solar provides 28GW, Tidal 10GW and Wave 4GW of capacity by 2050
- Total capacity of ~190GW by 2050, dominated by renewables

ELECTRICITY GENERATION

Other renewables*
Solar PV
Onshore wind
Offshore wind
H2 turbine
Nuclear
Gas (CCS)
Gas
Coal
Interconnectors





CLOCKWORK

» Nuclear has the highest load factor of all supply technologies, making the largest contribution to total generation by 2050

» Gas with CCS has a seasonal role, providing baseload through winter and more backup through summer

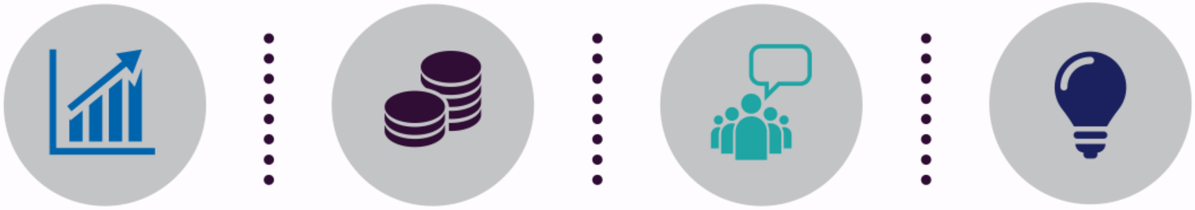
» Improvements to technology means new offshore wind turbines have a load factor of 50% by 2050, meaning a larger share of generation compared to onshore

PATCHWORK

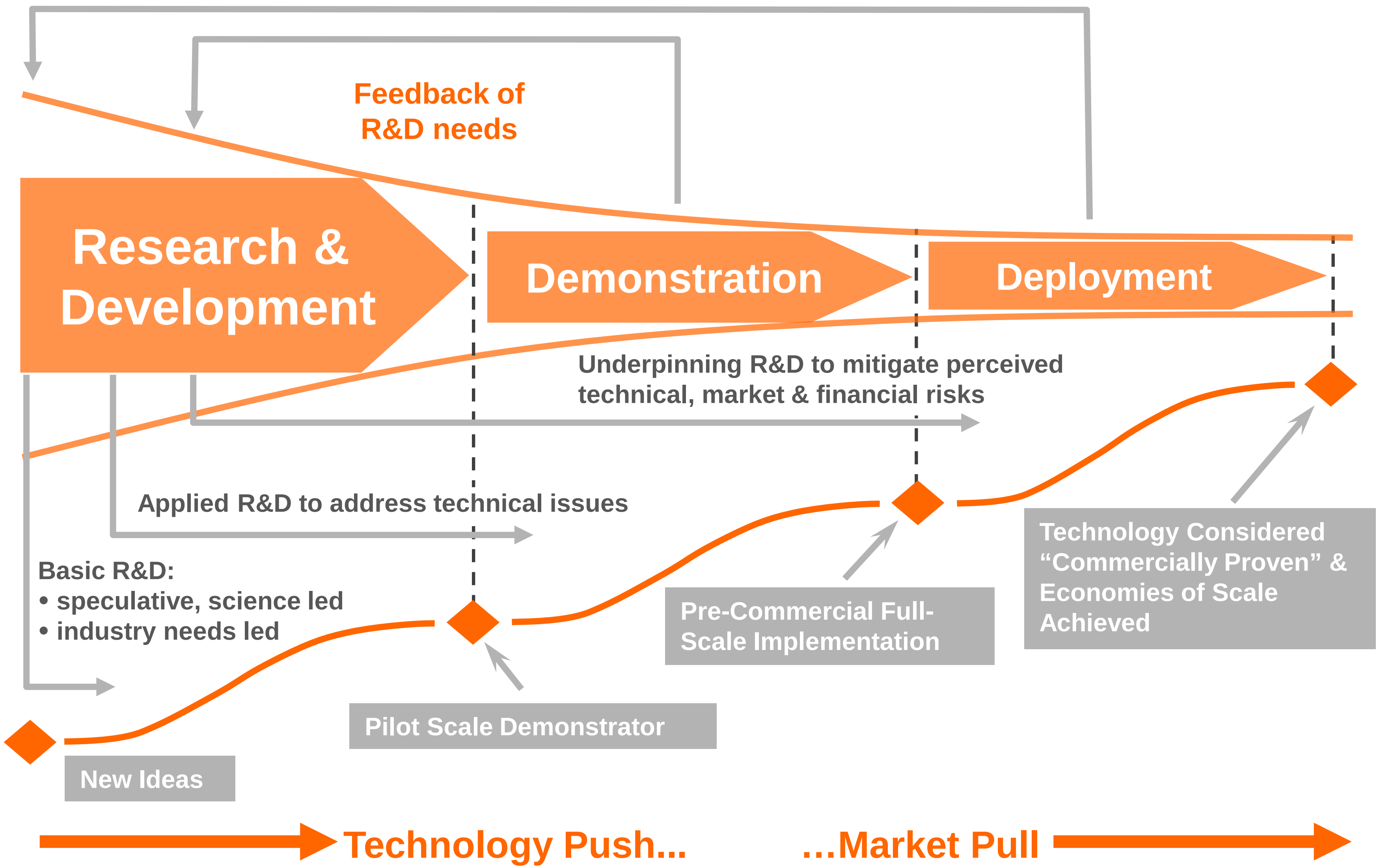
» Despite its limited capacity, the high load factor of nuclear means it contributes ~20% of electricity generation in 2050

» Of the renewables, offshore wind makes the largest contribution of all technologies, while generation from solar is very modest, given its low load factor of 11% in the UK

The UK needs innovation to help it meet its carbon targets



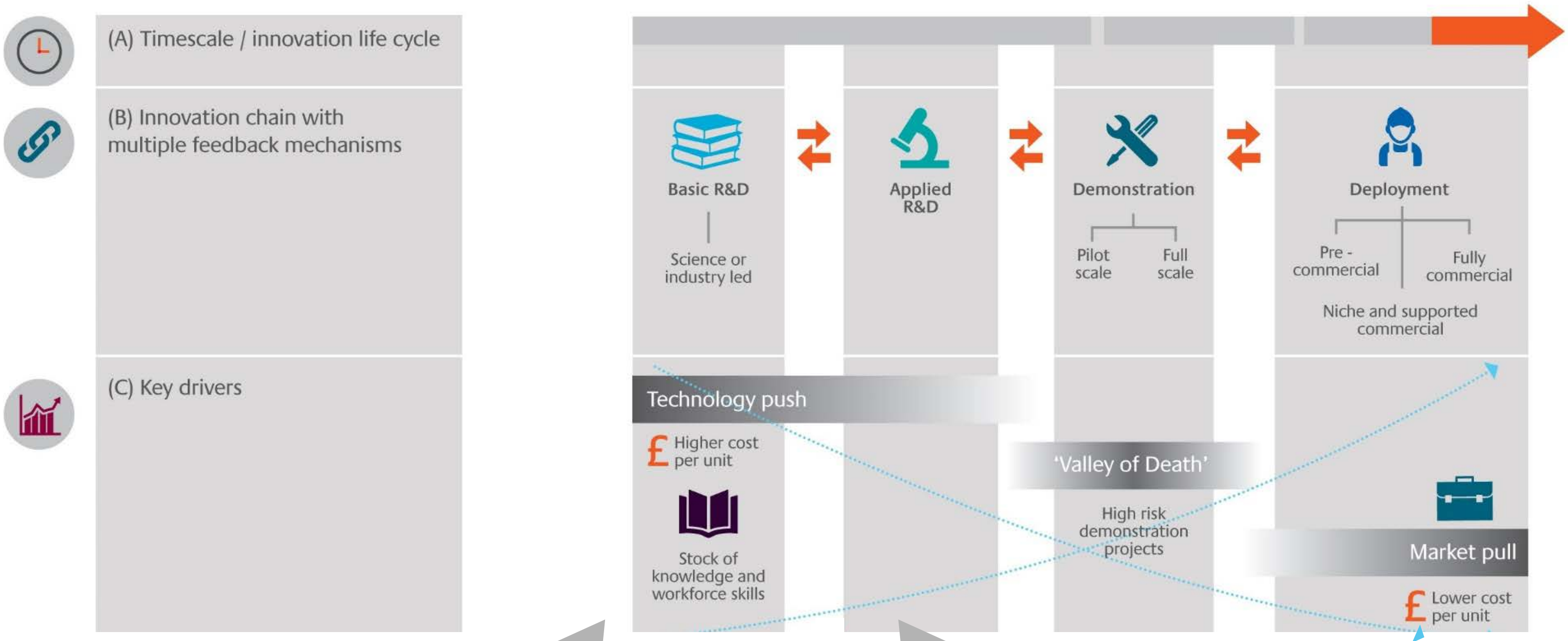
Successful innovation has several critical components: market confidence, finance, public policy and the capability to innovate


Feedback of
R&D needs
Research &
Development
Demonstration
Deployment
Underpinning R&D to mitigate perceived
technical, market & financial risks
Applied R&D to address technical issues
Basic R&D:
• speculative, science led
• industry needs led
Technology Considered
"Commercially Proven" &
Economies of Scale
Achieved
Pre-Commercial Full-
Scale Implementation
Pilot Scale Demonstrator
New Ideas
Technology Push...
...Market Pull

It takes time for innovation systems, networks, relationships and expectations to form, evolve and mature.

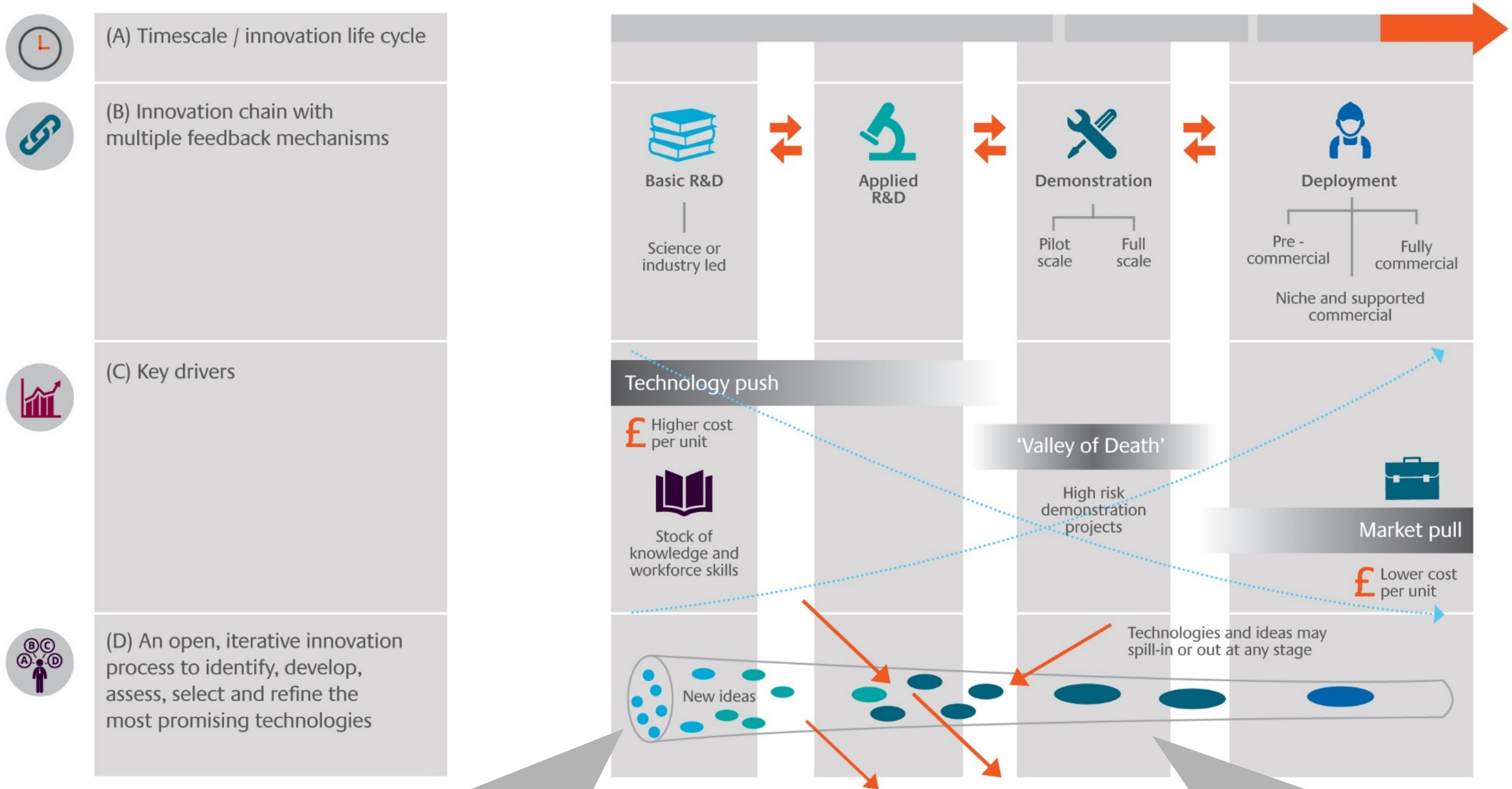
Weak or immature innovation systems may delay progress and decrease the likelihood of success.

A new technology will pass through distinct stages in its evolution but the process is seldom linear.



Innovations may be idea-led and/or demand-led. The forces of technology-push and market-pull combine to provide continuous challenge to develop cost-effective technologies.

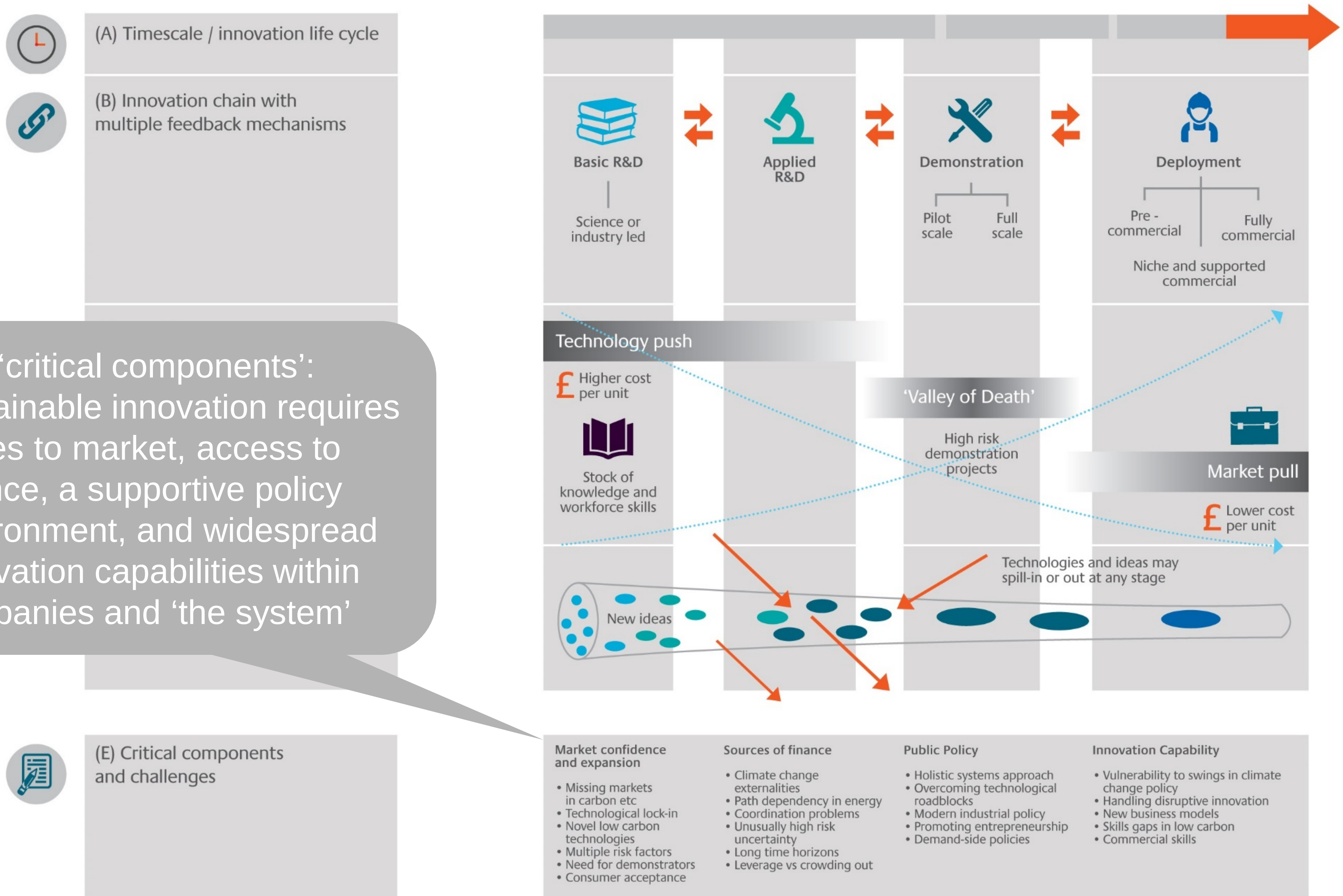
Promising technologies may fail to attract sufficient risk capital and/or the resources needed to support demonstration due to significant market uncertainty.



Useful technologies and ideas are exchanged and may be spun in or out at any stage

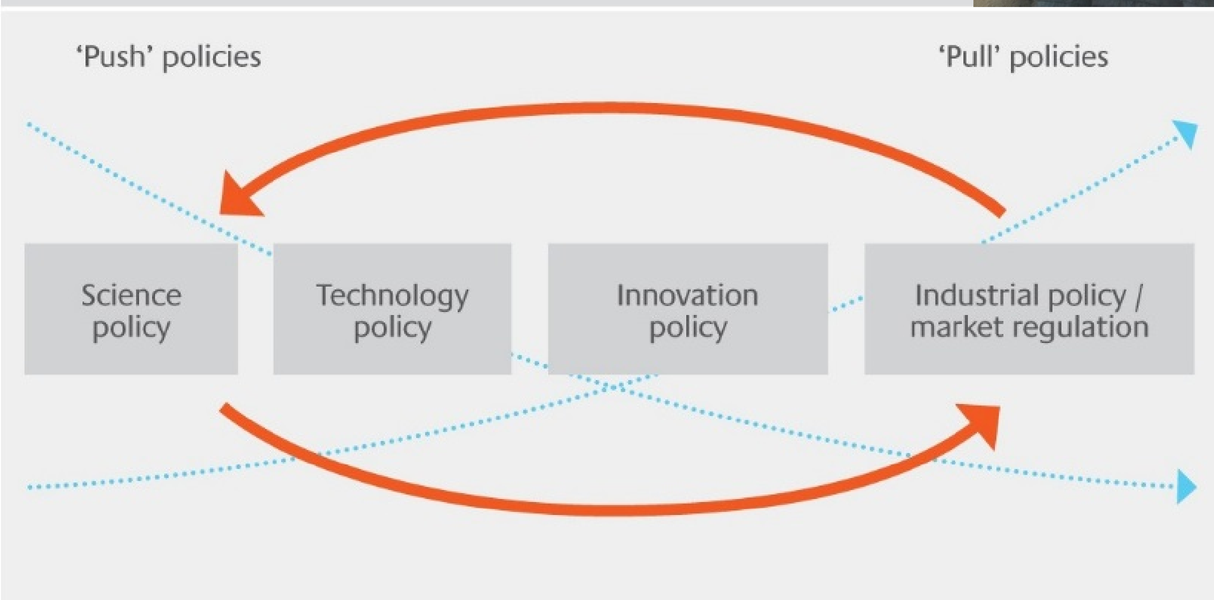
Organisations pursue multiple pathways to advance their ideas

The ‘critical components’: sustainable innovation requires routes to market, access to finance, a supportive policy environment, and widespread innovation capabilities within companies and ‘the system’



Policy journey...

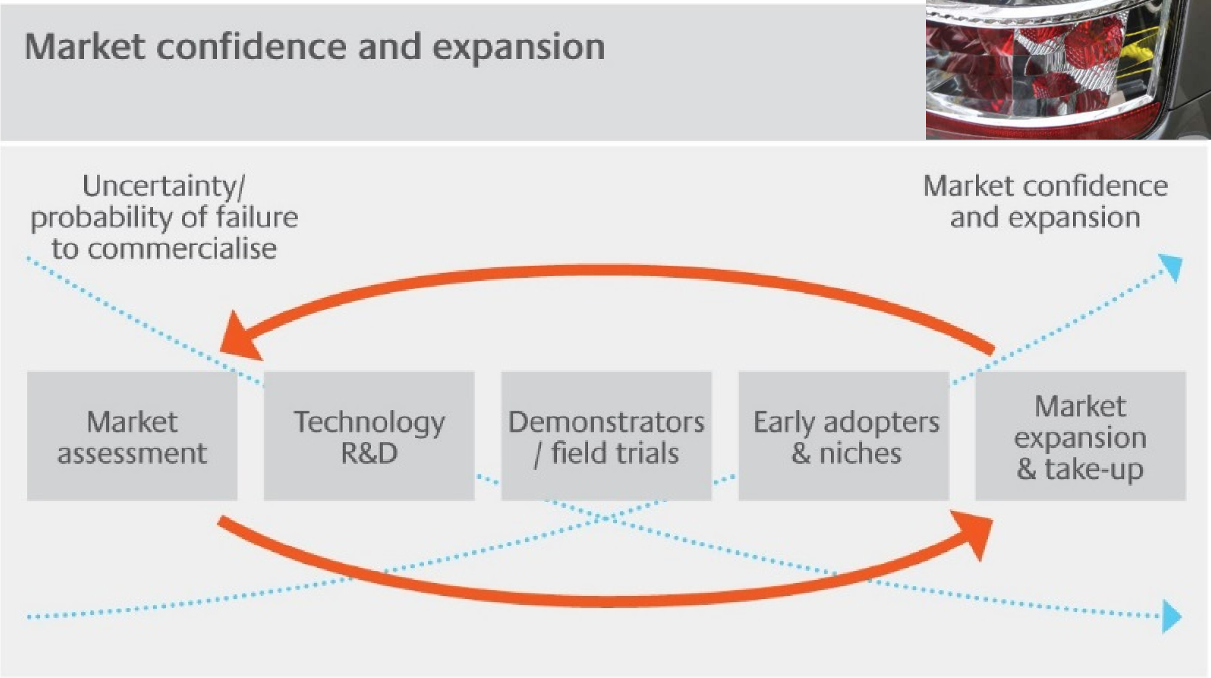
Public policy



Key Issues:

- Systems approach
- Overcoming technological roadblocks
- Building innovation capability
- Strategic collaboration
- Promoting entrepreneurship
- Demand-side policies

Market journey...

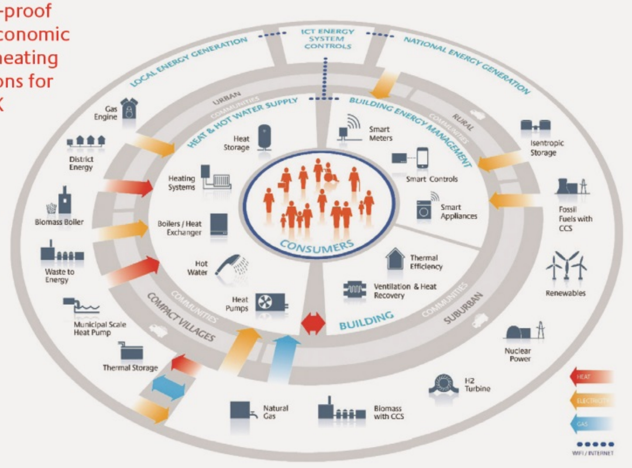


Key Issues:
- Missing markets
- Multiple risk factors
- Novel technologies
- Finance to support demonstrators
- Consumer acceptance

Capability journey...

Smart Systems and Heat

– Creating future-proof and economic local heating solutions for the UK



Innovation capability

Capability requirement

Business driven capabilities

Operational   Management   Transactional

Technology driven capabilities

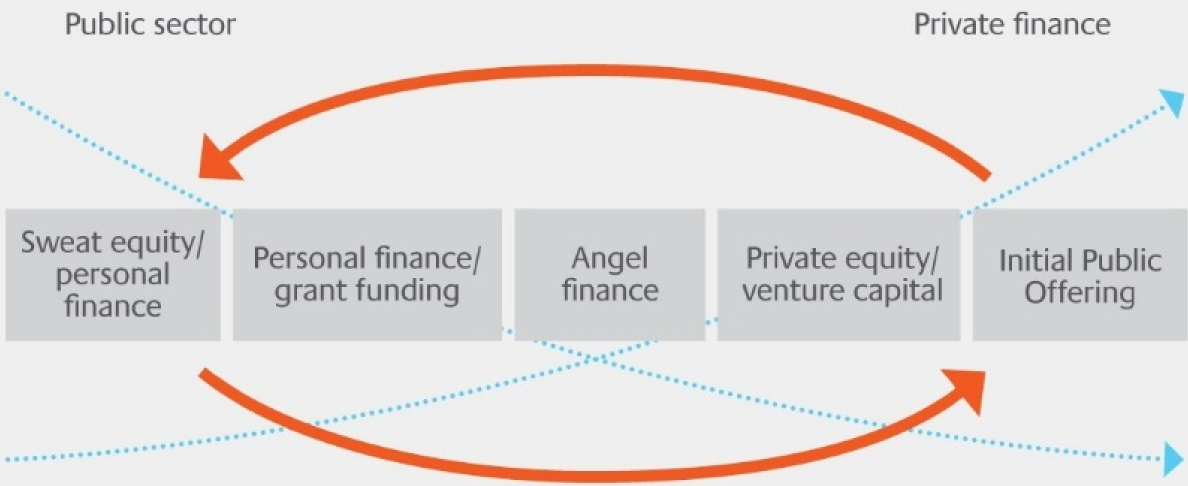
Based on Zawislak et al [13]

Key Issues:

- Disruptive innovation
- New business models
- Skills gap
- Dependence on environmental policy
- Commercialisation skills

Company journey...

Sources of finance

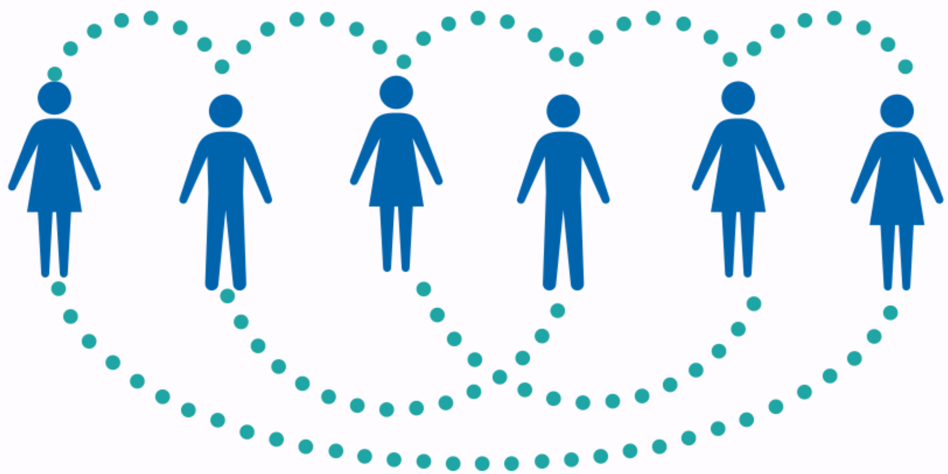


Financial/company journeys may differ, often depending on the type of technology. The journey shown is stylised to illustrate potential sources of finance available.

Key Issues:

- Externalities
- Path dependency
- Coordination failures
- Risk and uncertainty
- Long time horizons
- Leverage vs crowding in

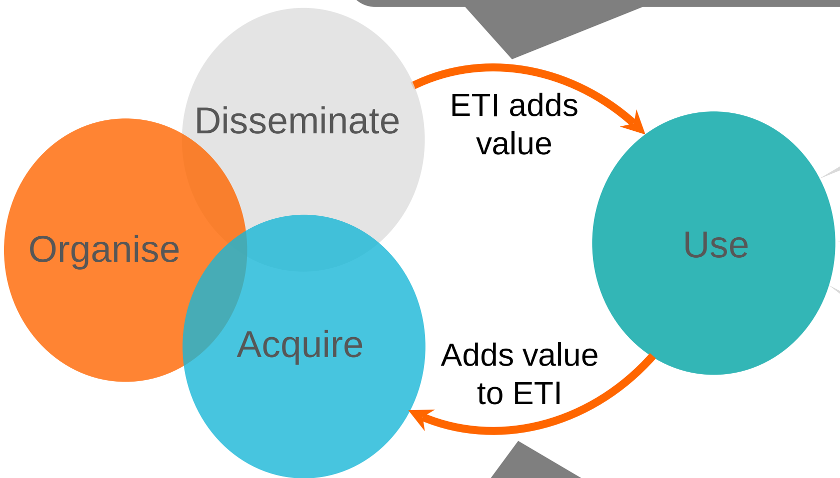
Successful innovation systems often involve open and iterative processes, which are complex



They depend on multiple interactions between different actors

Priority is ‘closing the loop’ to deliver the ETI’s outcomes

ETI Communication
delivers tailored views of knowledge for defined audiences



Feedback
- more knowledge created
- allows ETI to target areas for further work

...used by the ETI to deliver impact on the UK’s energy system
through capability and credibility
by driving technologies to commercialisation

...used by ETI Members to further the development of their individual business strategies and policy aims, delivering value

...used by the broader stakeholder community to
- inform policy,
- support and develop supply chain
- build investor and industry confidence

Delivering Impact

Delivery
Activity that creates project 'outputs'

Action
Delivery of project 'benefits' to relevant stakeholders (beneficiaries)

Impact
Defined project 'outcomes' have been achieved

Delivering:

- knowledge for stakeholders
- knowledge about stakeholders
- knowledge from stakeholders

Collaboration and shared understanding is required to help the innovation process

involving interactions across science, business and government to facilitate knowledge transfer and learning

it is easier to achieve a transition with a shared understanding of the drivers of new low carbon energy technologies

Registered Office
Energy Technologies Institute
Holywell Building
Holywell Park
Loughborough
LE11 3UZ

For all general enquiries telephone the ETI on 01509 202020

For the latest ETI news and announcements email info@eti.co.uk

For more information about the ETI visit www.eti.co.uk

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