www.eti.co.uk

A perspective on (whole systems) energy modelling

Scott Milne
Strategy Analyst

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Overview

- About the ETI

- Our Modelling and Analysis
  - **Energy System Modelling Environment (ESME)**
  - Wider suite of modelling tools
  - Low carbon scenarios
  - Key insights

- Modelling and policymaking
  - Direct and indirect uses of ESME
  - UK MARKAL/TIMES

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About the ETI

- The Energy Technologies Institute (ETI) is a public-private partnership between global industries and UK Government

Delivering...

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

- Shared risk

ETI members

bp

CATERPILLAR®

EDF ENERGY

Rolls-Royce

Shell

EPSRC Pioneering research and skills

Department of Energy & Climate Change

Department for Business Innovation & Skills

Innovate UK Technology Strategy Board

ETI programme associate

HITACHI Inspire the Next

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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 completed in 2013

Offshore Wind
World leading facility to increase reliability of new turbines – Operational from 2014

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

Supported by Market, Policy & Regulatory Analysis & Consumer Behaviour Research

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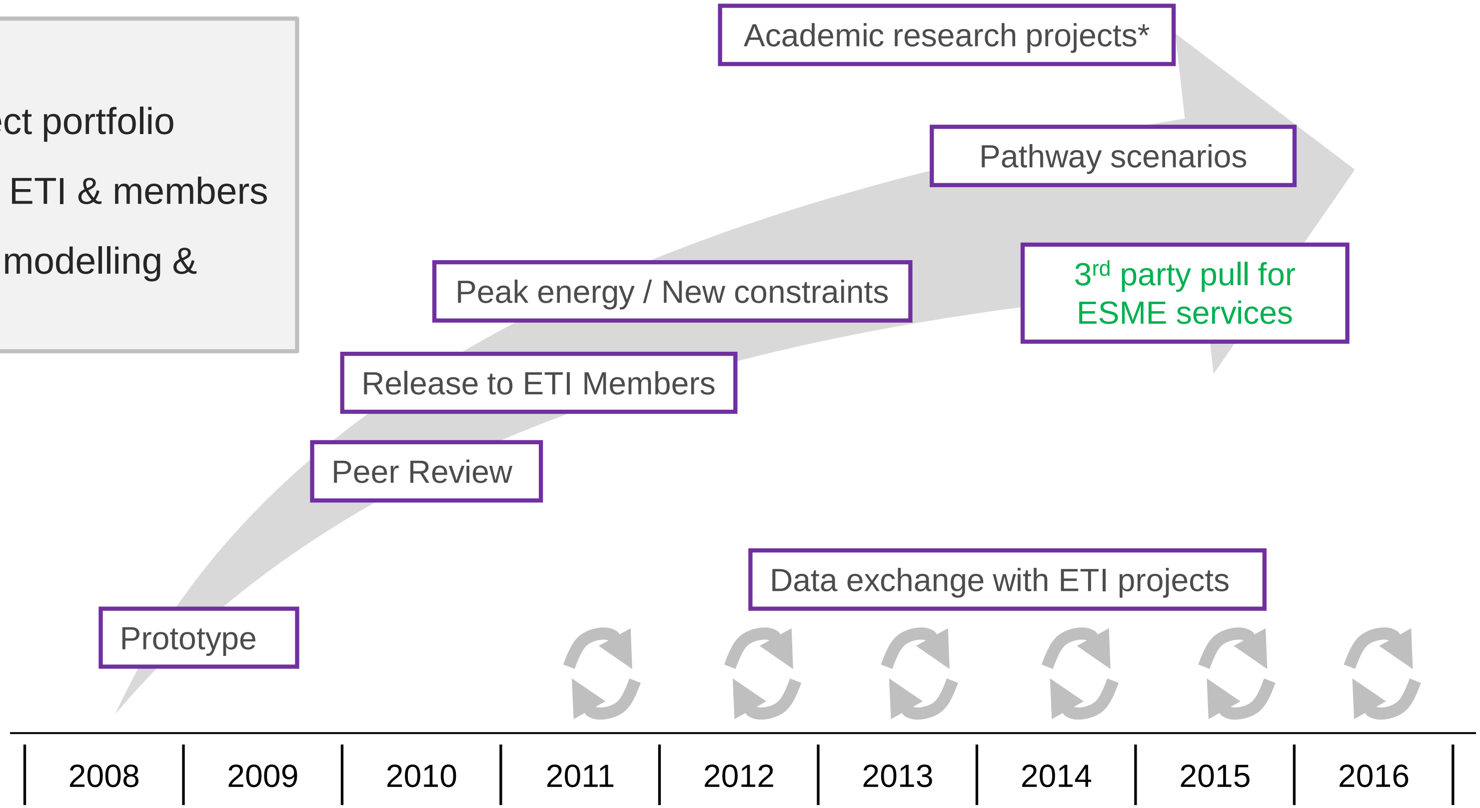
Energy System Modelling Environment

Objectives:

- Inform the ETI project portfolio
- Strategic insights to ETI & members
- Enable dialogue on modelling & strategy with HMG

ESME
Energy System Modelling Environment



* Academic projects on: Demand Response, Equity issues, Modelling under Uncertainty (UKERC), WholeSEM (EPSRC), Realising Transition Pathways (RCUK) and Energy Infrastructure Modelling (CASE)

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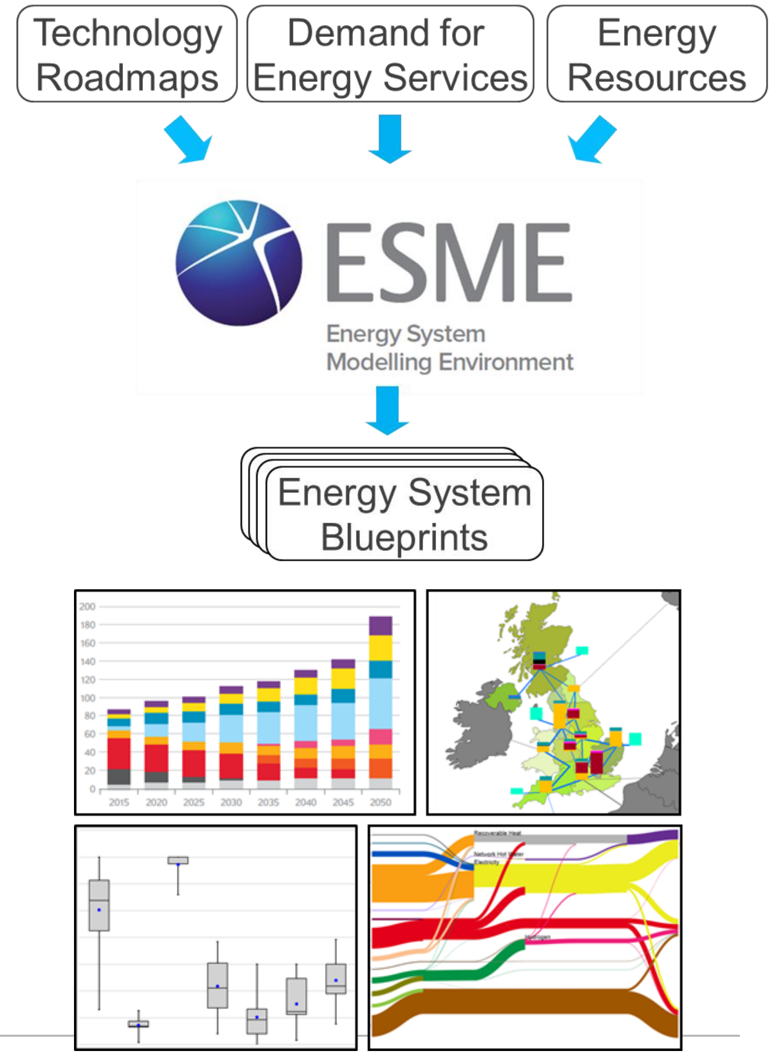
The ESME model



- 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

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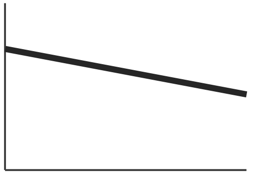
Probabilistic analysis

Deterministic mode

- All parameters have a deterministic profile 2010-2050.

- ESME can conduct a single deterministic run using these values.



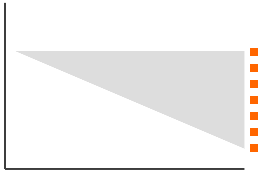
Monte Carlo mode

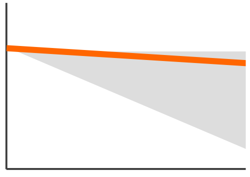
- Some parameters have a 2050 distribution (mostly technology costs, but can include resource availability, build rate limits etc).

- In Monte Carlo mode, multiple simulations are conducted.

- In each simulation, these parameters are assigned a 2050 value from distribution.

- Allows a statistical analysis of the energy system design space.





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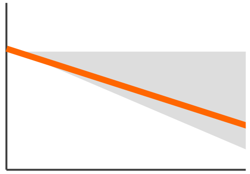

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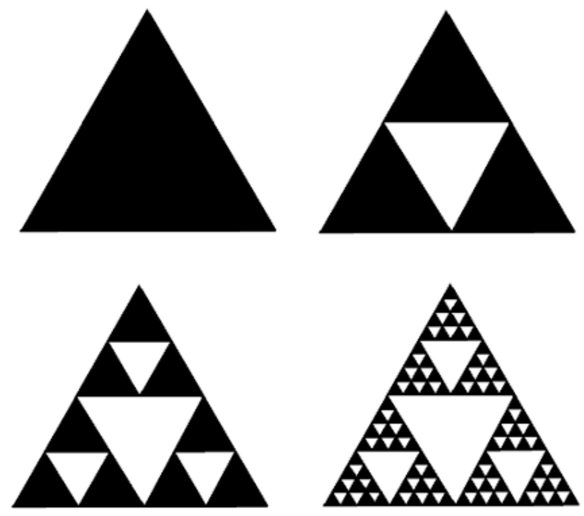
Model resolution

- Perils of aggregation!



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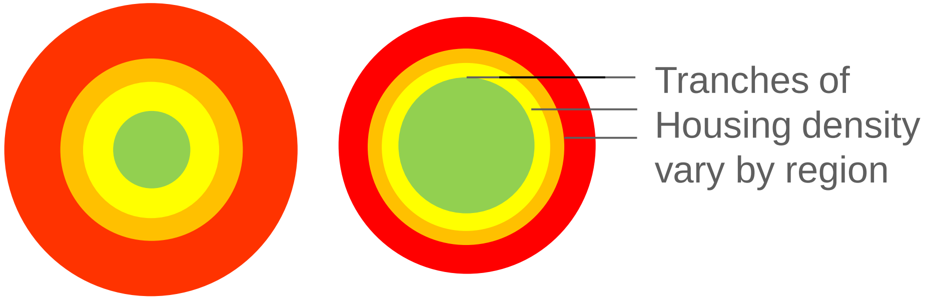
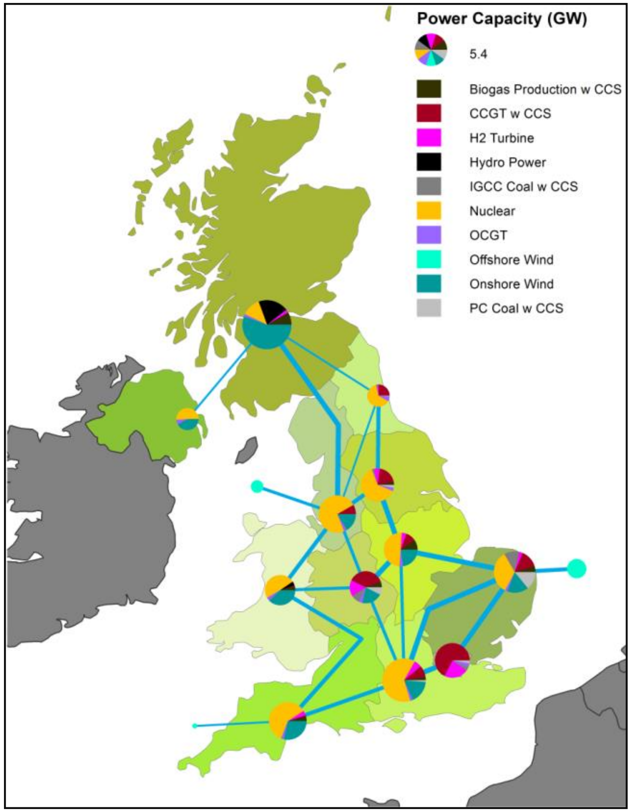
Spatial resolution

- Co-location of supply and demand
- Transmission distances and costs
- Siting requirements for e.g. Nuclear / CCS plant (safety/water abstraction)
- Density of built environment for District Heating uptake: ESME, we





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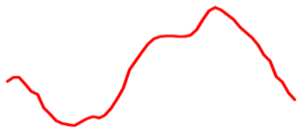
Temporal resolution

- A Day in the Life of ‘Levelised Cost of Energy’:

…and in the Real World:



Daily peaks, troughs, swings

- A Year:

Seasonal variation

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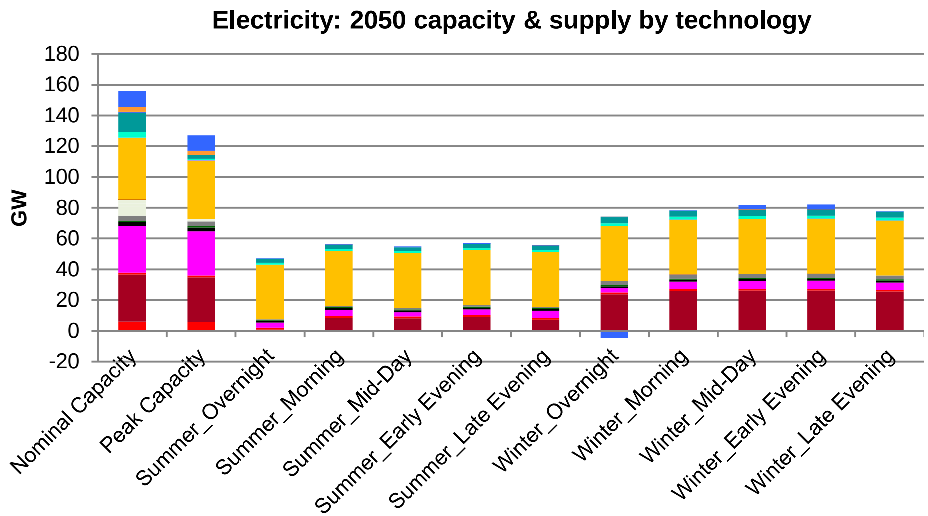
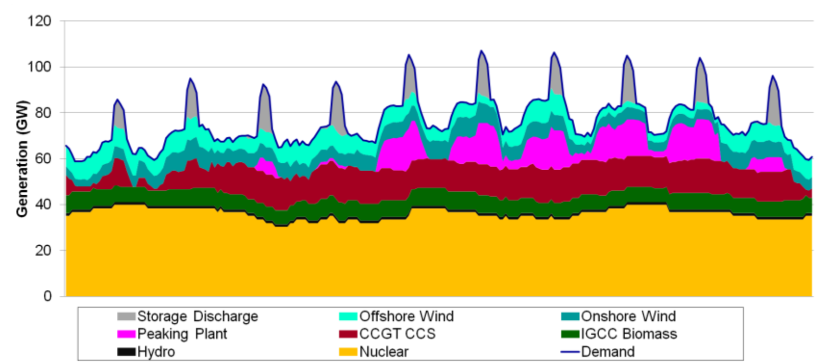
Temporal resolution

- ESME
  - Two seasons
  - Five diurnal time slices



- ESME solution then tested in a more finely grained dispatch model (PLEXOS)



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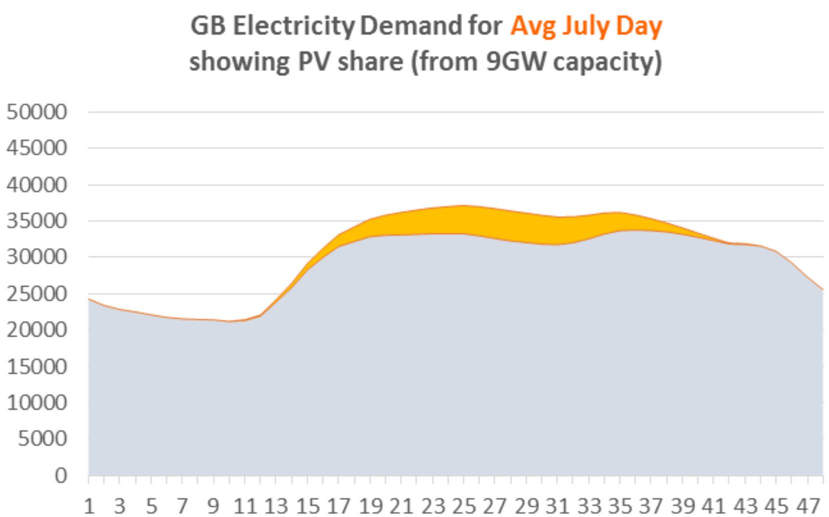
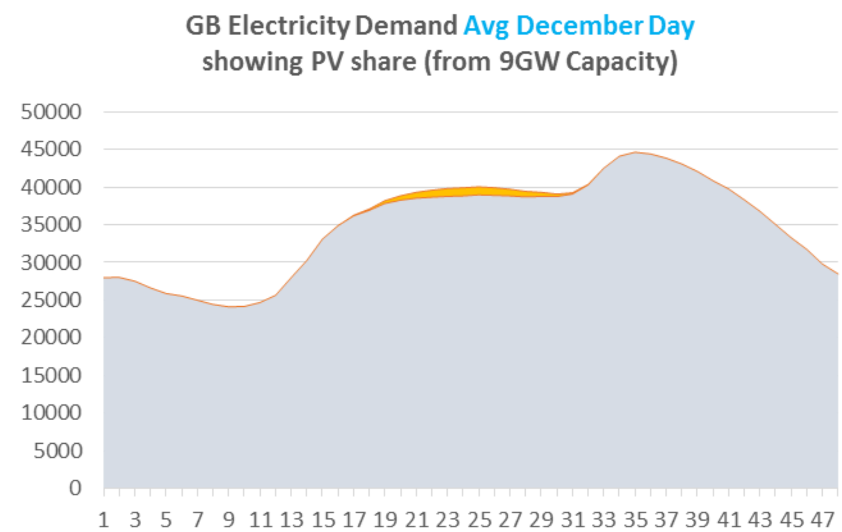
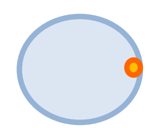




~9GW Annual Summary

Demand
300 TWh



PV Output
8 TWh

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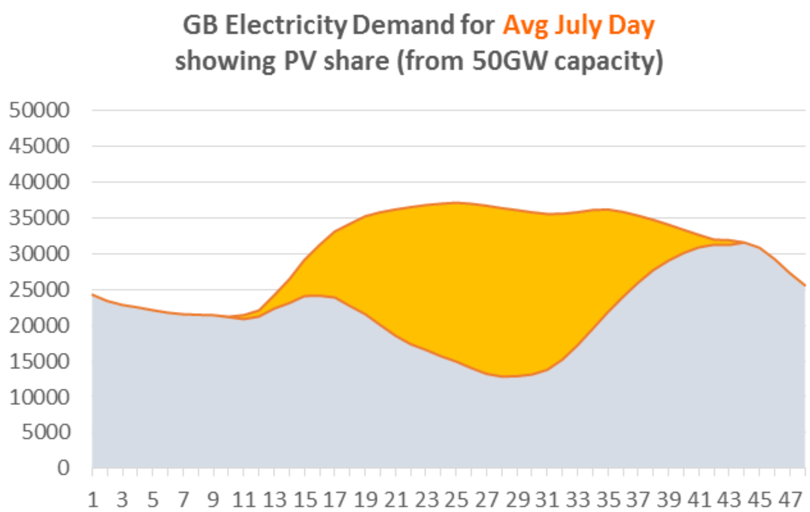
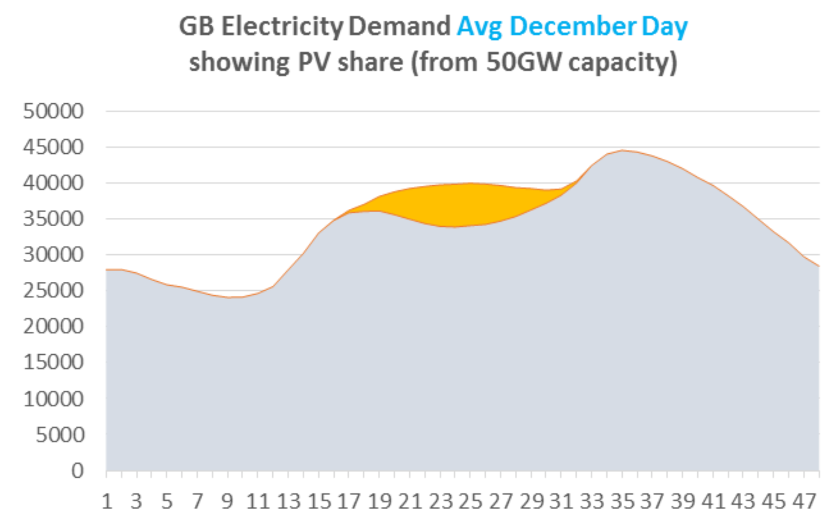
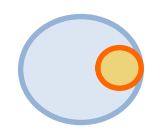
PV scenarios – 50GW





50GW Annual Summary

Demand
300 TWh



PV Output
49 TWh
(<1% spill)

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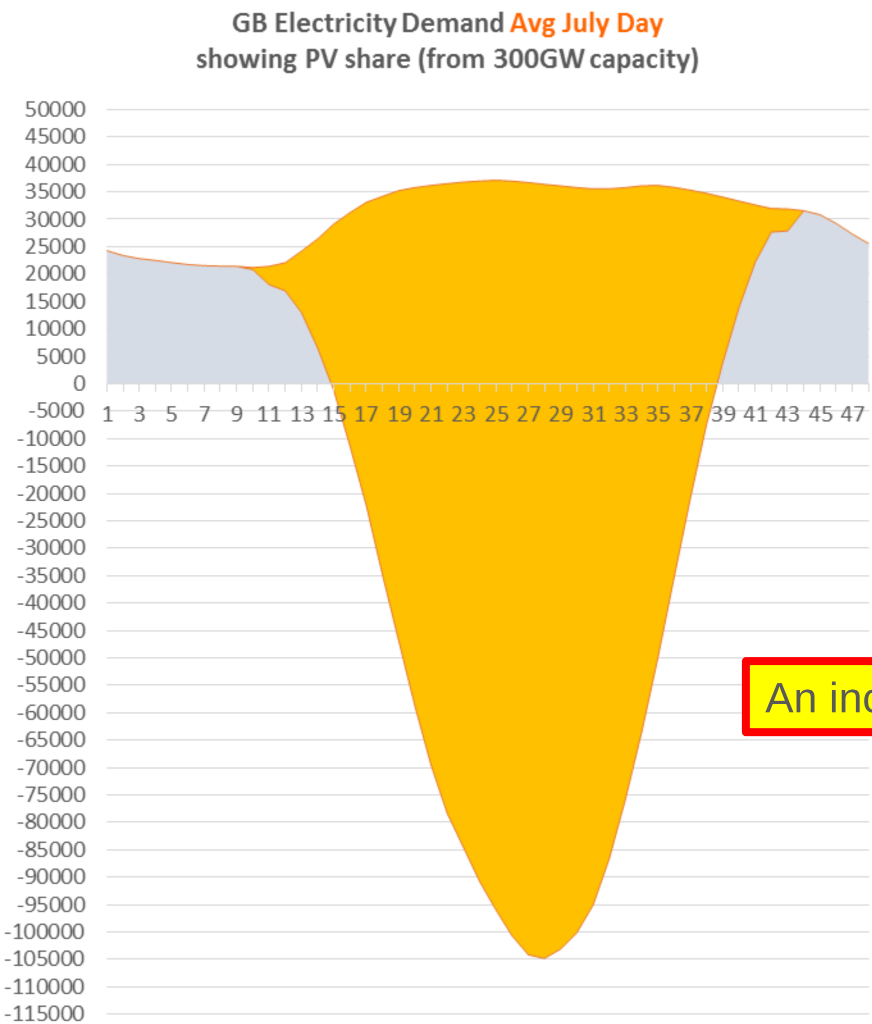
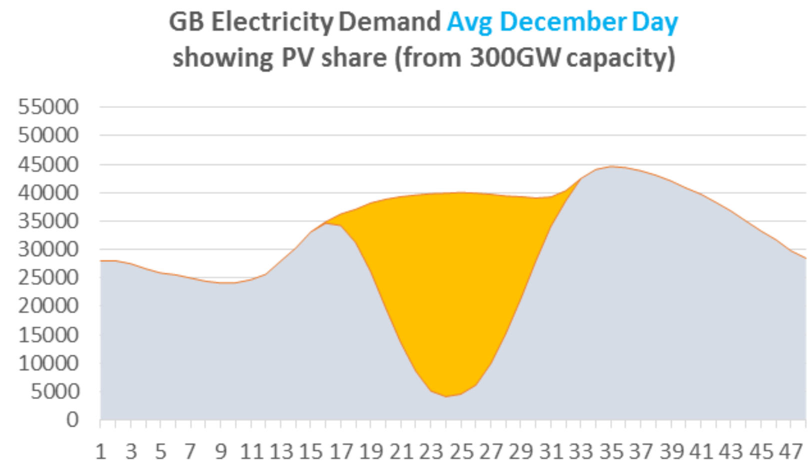
300GW where total PV output = total demand

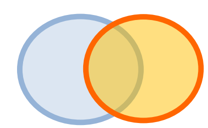




An inconvenient tooth?!

~300GW Annual Summary

Demand
300 TWh



PV Output
300 TWh
(57% spill)

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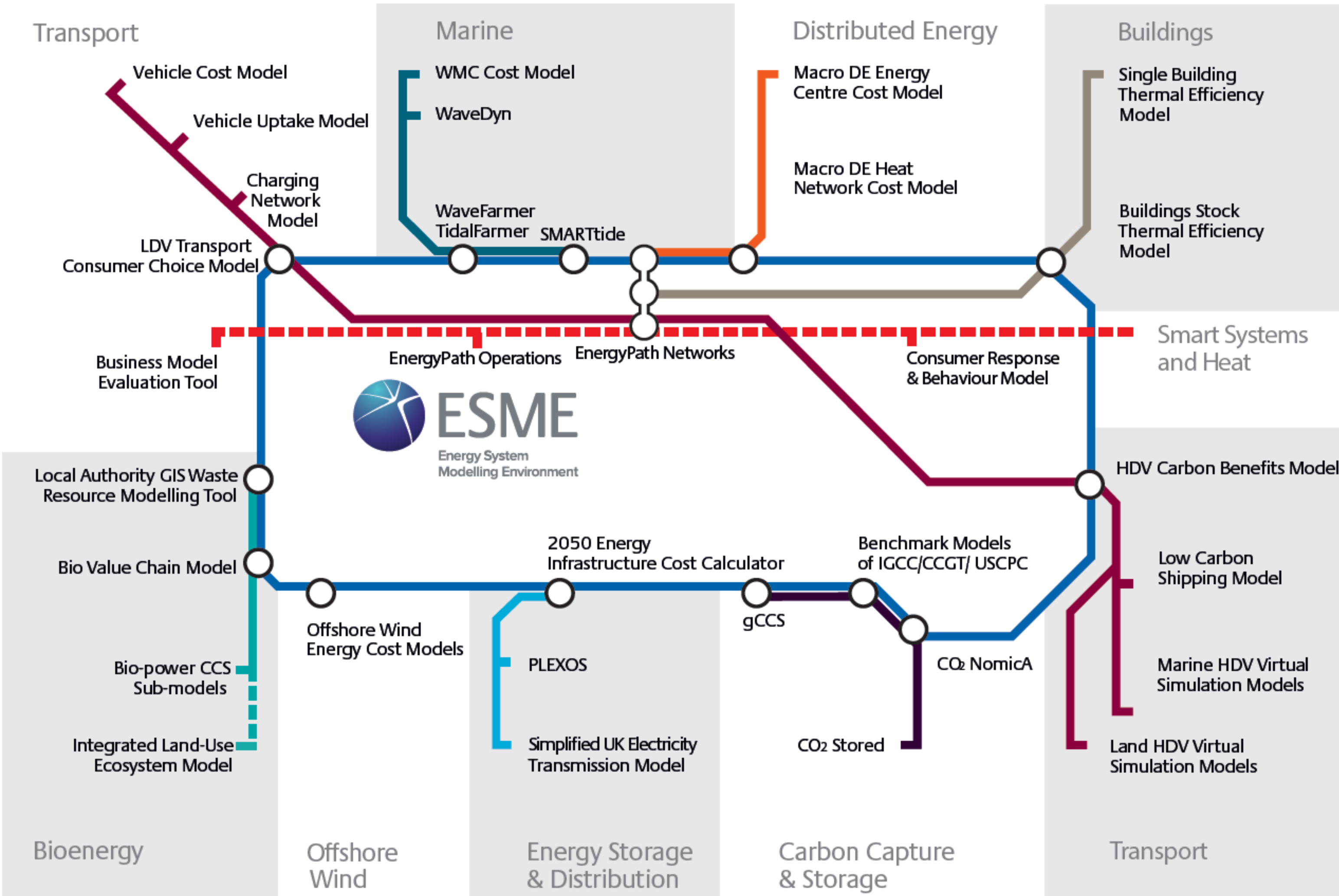
ESME and the wider ETI modelling suite



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SCENARIOS AND INSIGHTS

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ETI Scenarios

- UK energy system – power, heating, transport, industry & infrastructure
- Bound by Climate Change Act – 80% emissions reduction by 2050
- Building on several years of modelling, analysis and scenario development using ESME
- Devised in consultation with ETI members and stakeholders
- Launched on 4th March 2015

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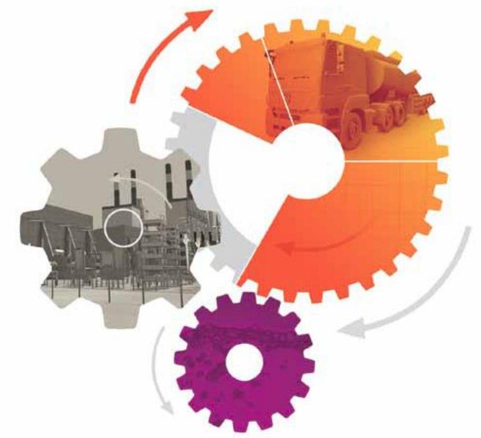
CLOCKWORK



PATCHWORK

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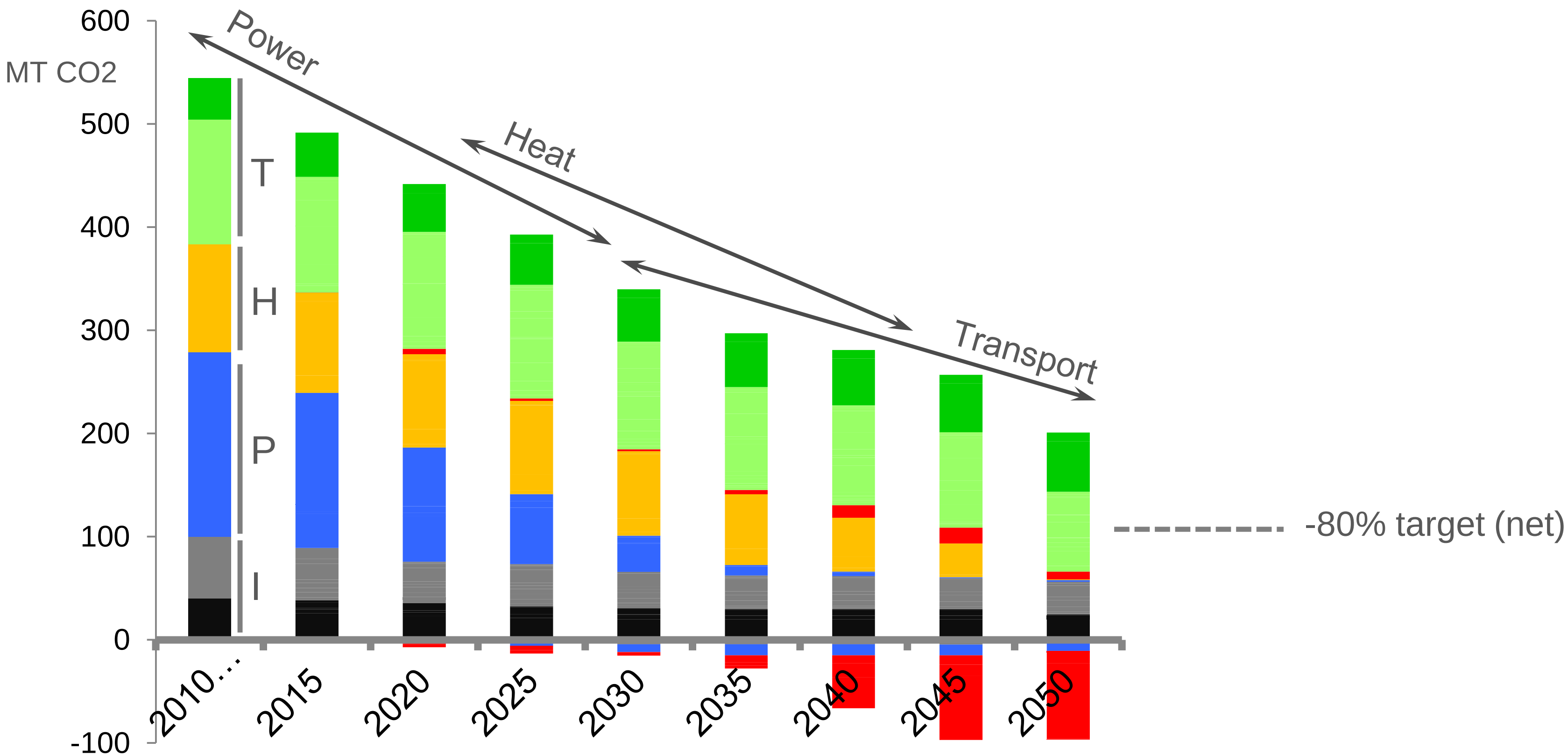
One route to meeting - 80% CO_2 for the UK

Power now, heat next, transport gradual – cost optimal



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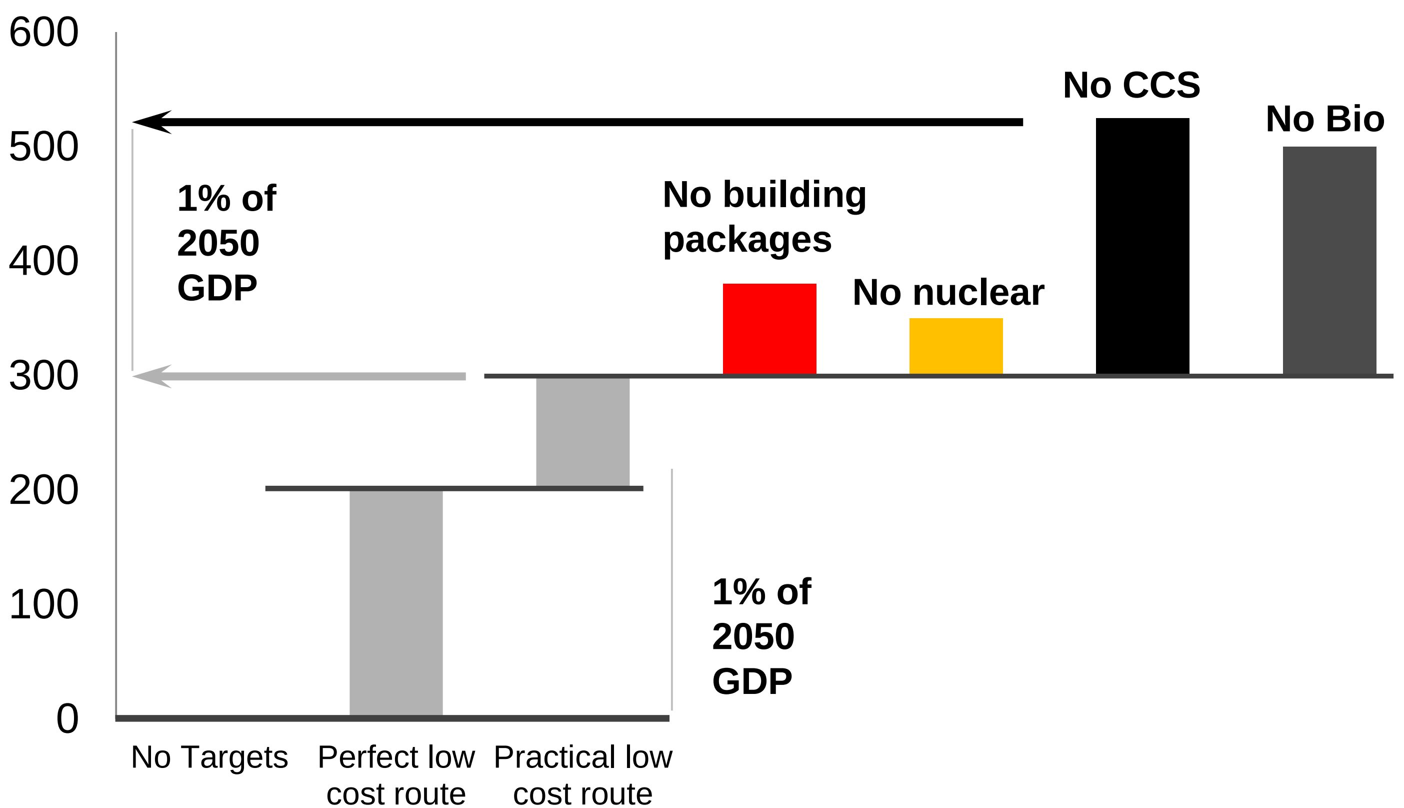
Abatement Cost

Additional cost of delivering 2050 -80% CO2 energy system

NPV £ bn 2010-2050



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Key Messages

1

The UK can achieve an affordable transition to a low carbon energy system over the next 35 years. Our modelling shows abatement costs ranging from 1-2% of GDP by 2050, with potential to achieve the lower end of this range through effective planning

2

The UK must focus on developing and proving a basket of the most promising supply and demand technology options. Developing a basket of options (rather than a single system blueprint) will help to limit inevitable implementation risks

3

Key technology priorities for the UK energy system include: bioenergy, carbon capture and storage, new nuclear, offshore wind, gaseous systems, efficiency of vehicles and efficiency/heat provision for buildings

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Key Messages

4

It is critical to focus resources in the next decade on preparing these options for wide-scale deployment. By the mid-2020s crucial decisions must be made regarding infrastructure design for the long-term

5

CCS and bioenergy are especially valuable. The most cost-effective system designs require zero or even “negative” emissions in sectors where decarbonisation is easiest, alleviating pressure in more difficult sectors

6

High levels of intermittent renewables in the power sector and large swings in energy demand can be accommodated at a cost, but this requires a systems level approach to storage technologies, including heat, hydrogen and natural gas in addition to electricity

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ENERGY MODELLING AND POLICY

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Energy modelling and policy

Beyond ETI

- UCL Energy Institute – ESME one of many models including UK MARKAL, UK TIMES and global models used to inform low carbon policy by demonstrating:
  - value of an energy systems approach, need for all sectors to play a role
  - The enabling role of early decarbonisation of the electricity sector
  - Range of potential system costs and implications for carbon pricing
  - Value of energy service demand reductions, hedging against high costs of decarbonisation as well as security of supply issues

- See UCL REF2014 submission ‘Energy-economic modelling of long term decarbonisation pathways: The policy impacts of the MARKAL-TIMES model family’
  - http://impact.ref.ac.uk/CaseStudies/CaseStudy.aspx?Id=36988

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Energy modelling and policy

Selected citations of ESME

The Renewable Energy Review (CCC, May 2011)

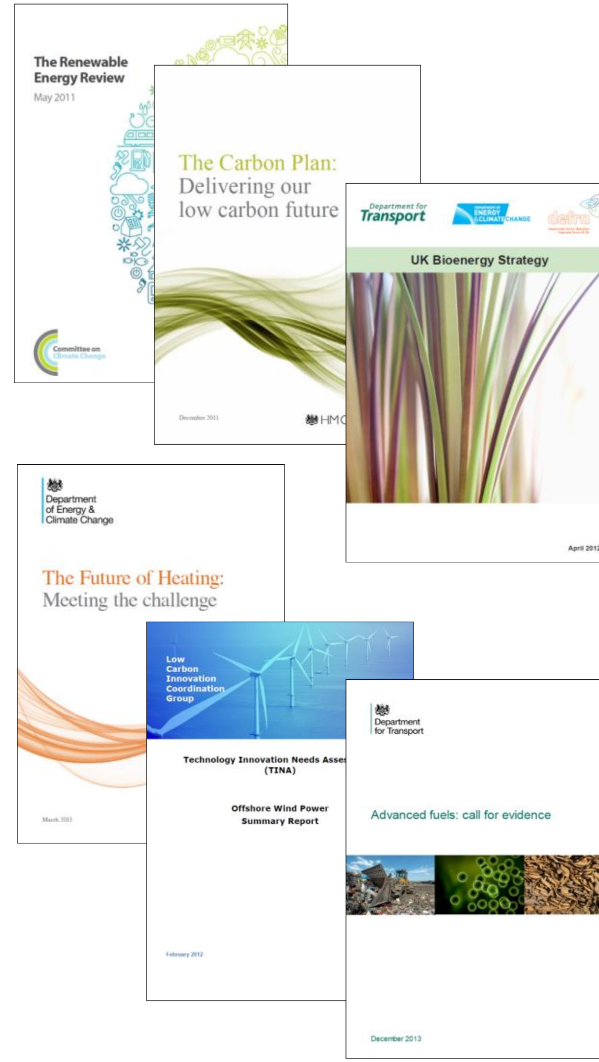
The Carbon Plan (HMG, Dec 2011)

UK Bioenergy Strategy (DfT, DECC, DEFRA, April 2012)

The Future of Heating (DECC, Mar 2013)

LCICG TINAs (2012: Bioenergy, CCS, Electricity Networks & Storage, Heat, Marine, Offshore Wind. More to follow in 2016)

Advanced fuels: call for evidence (Department for Transport, Dec 2013)



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Energy modelling and policy

Wider impact of ETI

- Role on advisory boards (for CCC, EU H2020, EPSRC WholeSEM)
  - ETI's whole systems strategy helping inform the low carbon agenda

- Support for DECC Technology Strategy (Summer 2015)

- Craig Lucas, Acting Director of Science and Innovation, DECC:
  - "Analysis work undertaken by the ETI has played a key role in helping to inform our innovation strategy, technology priorities and options across a broad range of energy policy areas. The ETI's approach combines analytical rigour with a very practical approach based on their broad industrial experience and strong links to industry. This provides a robust evidence base for DECC's analysts to use to support policy makers"

- Amber Rudd, Secretary of State:
  - "The environmental and economic arguments [for CCS] have been made so well by so many people in so many ways. For example the **Energy Technologies Institute** said, 'no other technology has such a dramatic impact in lowering the cost of the low carbon economy as CCS. Deploying CCS would keep electricity bills as low as possible, 15 percent lower than without CCS"

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Evidence of action?

UK cancels pioneering £1bn carbon capture and storage competition

theguardian website of the year

Nov 2015

- ETI assessment of impact: additional £1bn <u>per year</u> throughout 2020s as a result of reconfiguring the system to adopt second-best solutions

- Policy reset - focus on affordability and security.
  - Affordability through (limited) innovation funding

- False economy?
  - Often no substitute for learning by doing (de-risking)

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Summary

- Energy System Modelling Environment ESME
  - One part of the strategy toolkit
  - Employed in context of wider engineering, economic and policy expertise
  - From probabilistic analysis through to specific scenarios

- (Whole system) Modelling and Policy
  - Provides systematic basis for articulating assumptions, and testing their interaction under uncertainty
  - Identification of no regrets technologies, option values, ‘world without x’ etc
  - Starting point for detailed analysis of suitable policy mechanisms

  - ‘Whole system’ mind set not necessarily shared by all decision makers

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

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