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# Exploring low carbon scenarios with the ETI's Energy System Modelling Environment (ESME)

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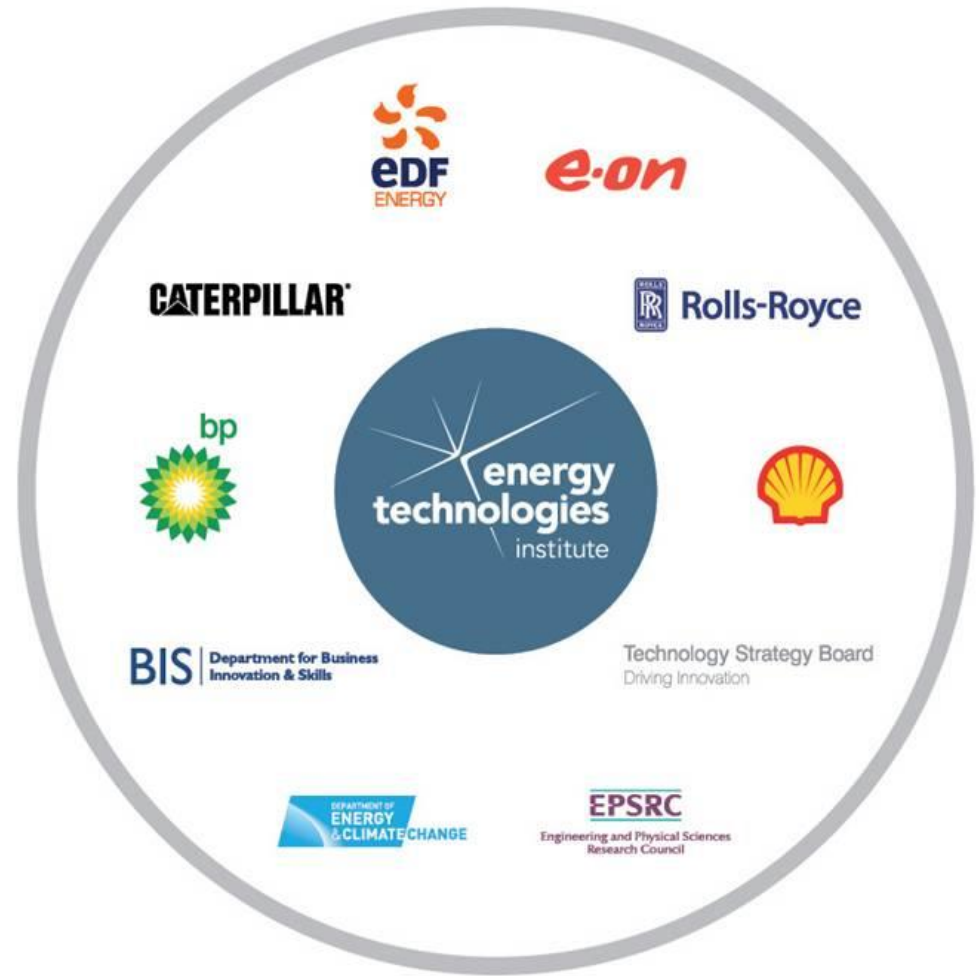
# Overview



- Energy Technologies Institute
- ESME Model
- Spatial and temporal resolution
- Demand cases
- Uncertainty analysis
- The 'Director's Cut' core variants and sensitivity runs
- 2014 ETI scenarios

# Energy Technologies Institute (ETI)

- A public-private partnership between global industries and UK Government
- Enabling deployment of affordable, secure, low carbon energy systems
  - **Developing knowledge**, skills and supply-chains
  - **Demonstrating systems** and technologies
  - **Informing development of policy**, regulation and standards



# Energy System Modelling Environment (ESME)



- Developed by ETI as a central part of its energy system analysis
- Design and build of ESME:
  - Informed by ETI members throughout
  - Engaging leading academics and consultants
  - v1.0 internationally peer reviewed in 2010
- Ongoing development:
  - Incremental updates supported by strategic advisory group
  - ESME is established in the ETI's business processes
  - Used by ETI members & partners

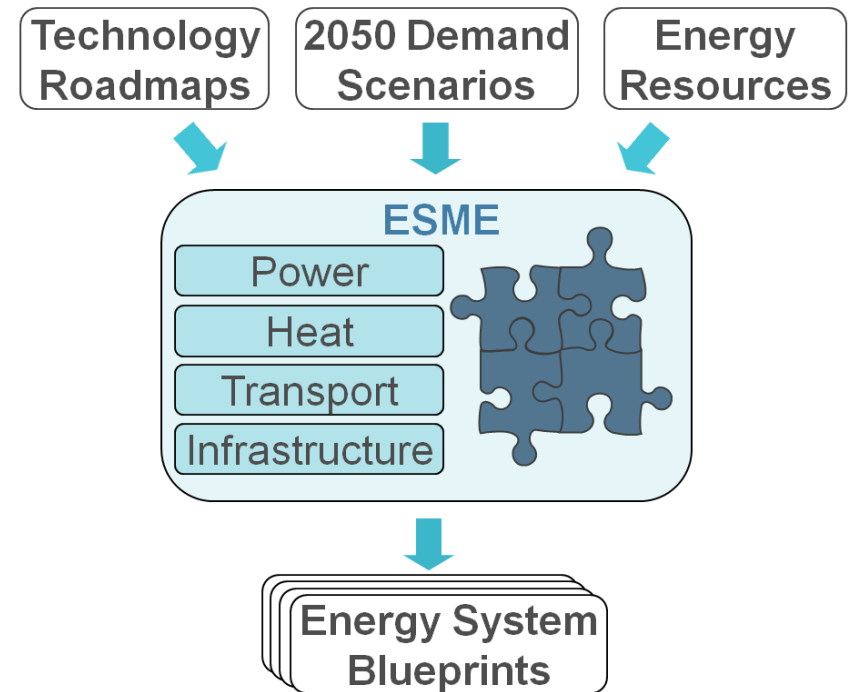


# ESME

A national energy system design tool

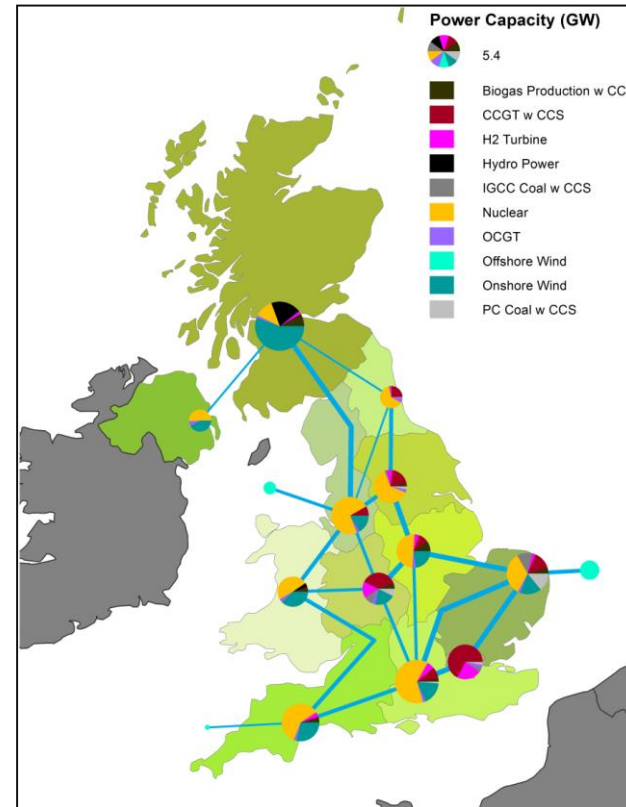


- Least cost optimisation, policy neutral
- Deployment & utilisation of >250 technologies
- Pathway and supply chain constraints to 2050
- Spatial and temporal resolution sufficient for system engineering
- Probabilistic treatment of key uncertainties



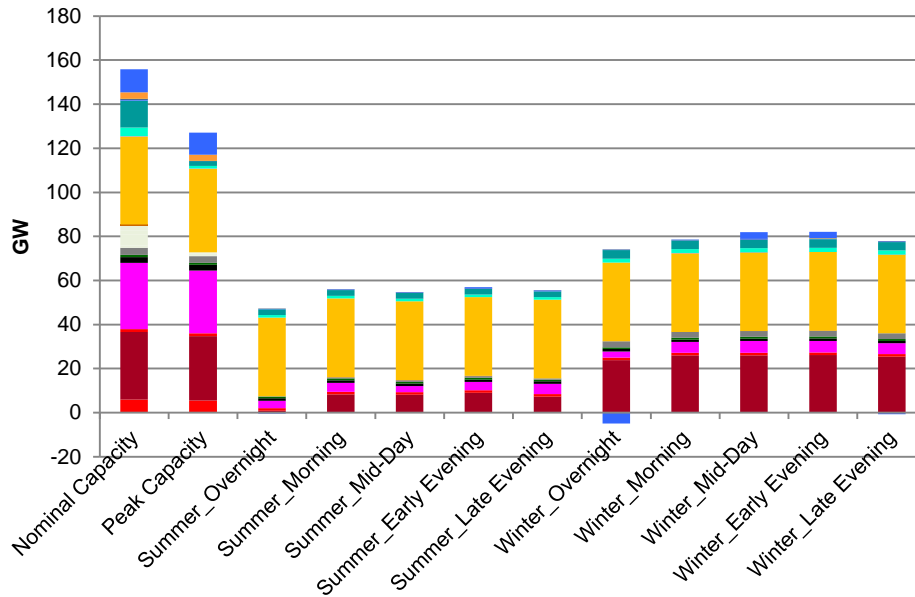
# Spatial resolution

- 12 onshore regions
- 12 offshore regions
  - 9 resource and 3 storage
- Supply and demand balanced in each onshore region



# Temporal resolution

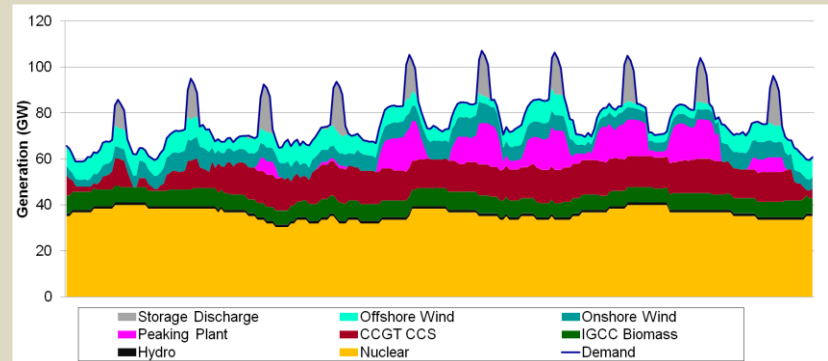
Electricity: 2050 capacity & supply by technology



- 2 seasonal x 5 diurnal time slices
- 'Average' supply and demand balanced in each time slice
- Peak capacity requirement – a given multiple of the highest average demand

Tested against PLEXOS:

- Power sector dispatch model
- Full year demand profile at 30min (or finer) time step



# Three demand cases

Each case informed by overarching narrative to derive assumptions for the 28 energy services



## “Back to the Future” (Reference Case)

The economic slowdown leads to a lost decade, but strong economic growth resumes after 2017... Individual prosperity remains linked to asset ownership, in particular homes and cars.

## “The Great Stagnation” (Low Case)

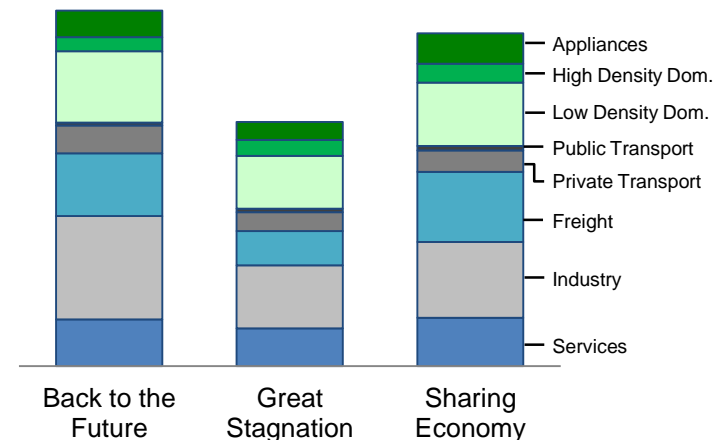
Slow economic growth becomes the norm... aging population and slow deleveraging weigh on the economy, and consumption remains weak.

## “The Sharing Economy” (Alternative High Case)

Robust growth... sharing of resources & services, resulting in lower demand for “shareable” physical goods (e.g. cars) and increased demand for services... Urbanisation is high... economy more focused on several regional hubs

	“Back to the Future”	“The Great Stagnation”	“The Sharing Economy”
Population 2050 (mn)	75.6	70.2	77.3
Average GDP Growth	2.4% p.a.	1.3 % p.a.	2.5% p.a.
Pathway	Recovery in 2017	Slow Growth as the norm	Recovery in 2016
Growth Mix	Balanced	Services led	Services led
Regional Variation	Existing trend (focus on London & East Midlands)	Strong shift to London	Concentrated in several large cities

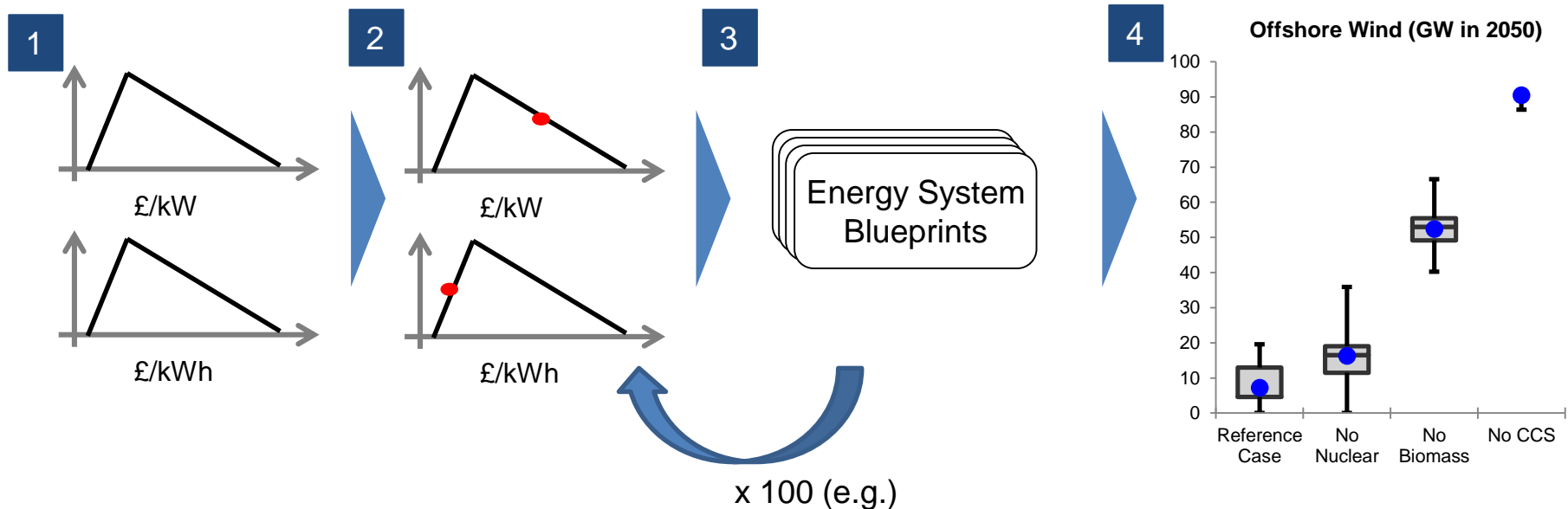
**Demand Mix by Case (Indicative) in 2050**





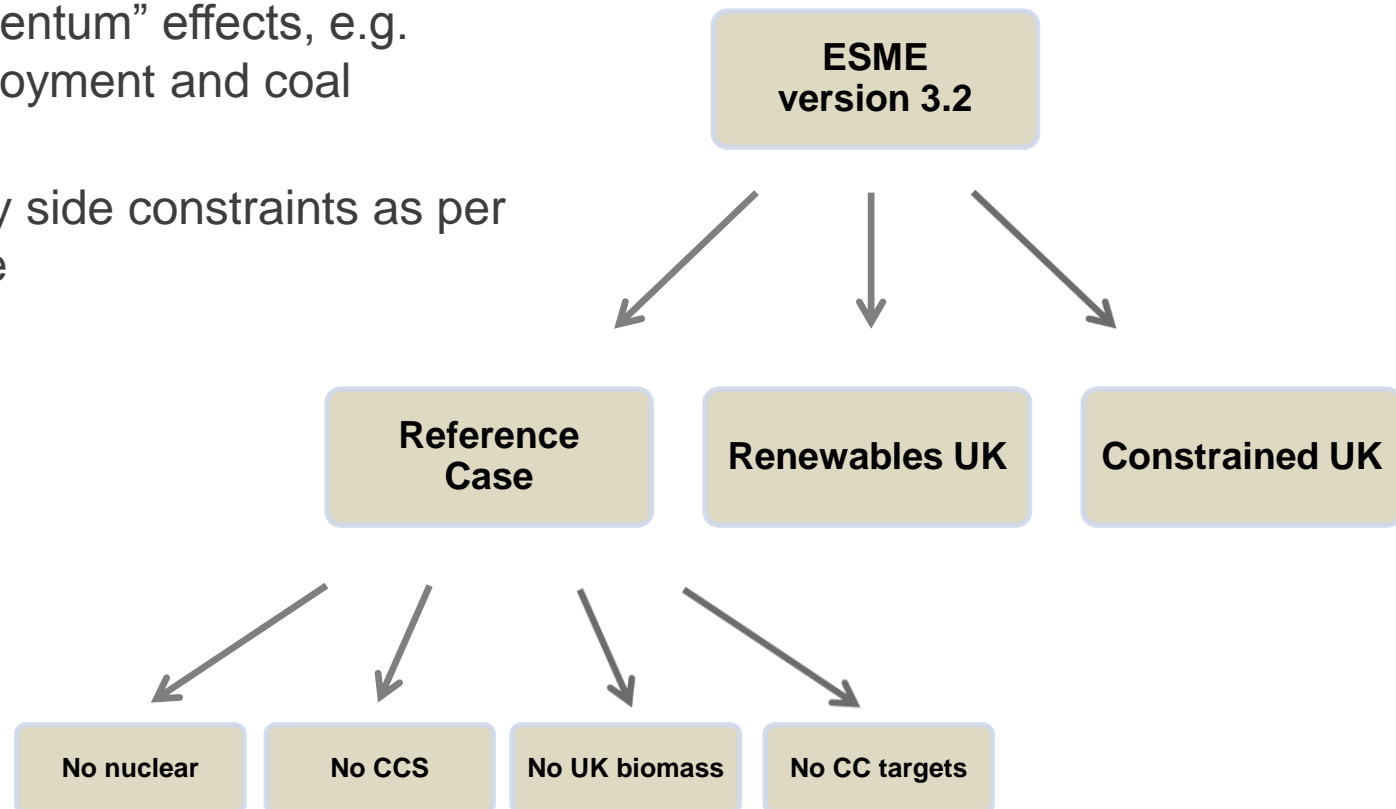
# Uncertainty analysis

- ESME Monte Carlo runs:
  1. Ranges and distributions on uncertain inputs
  2. In a given simulation, each parameter assigned a value from its range
  3. ESME finds least cost energy system for that configuration of values
  4. Distribution over e.g. 100 simulations can then be investigated



# Internal scenarios from 2013

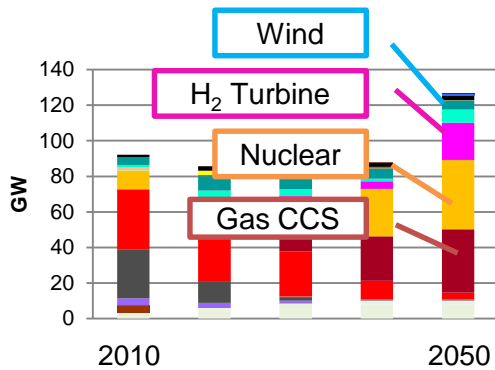
- Demand case selected for each scenario
- Latest data from ETI projects
- Near term “momentum” effects, e.g. renewables deployment and coal retirement
- Additional supply side constraints as per desired narrative



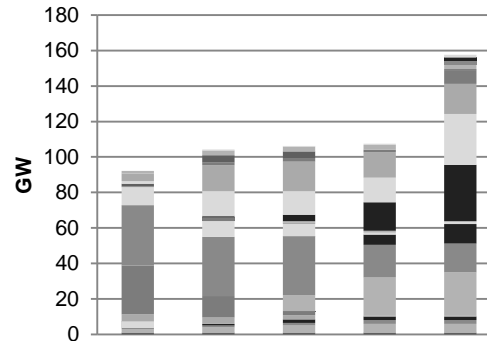
# 2013 Director's Cut core runs

## Electricity Capacity 2010-2050

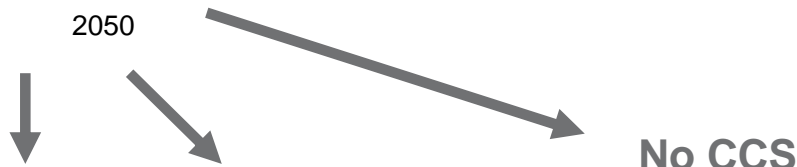
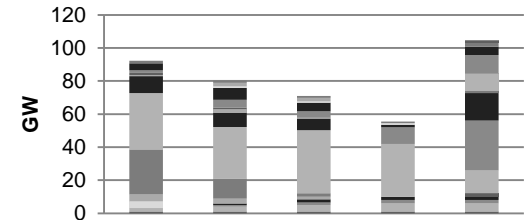
### Director's Cut



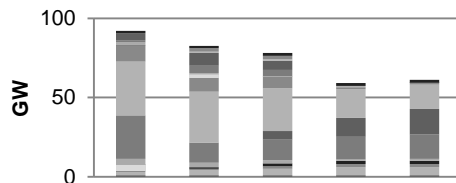
### Renewables UK



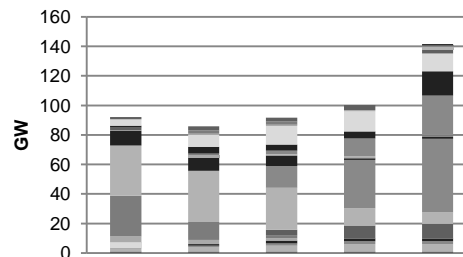
### Constrained UK



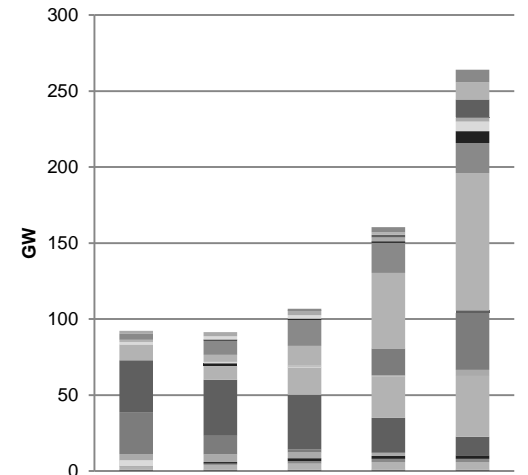
### No CO2 Target



### No Nuclear



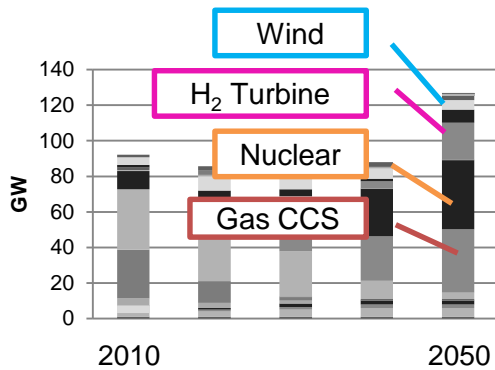
### No CCS



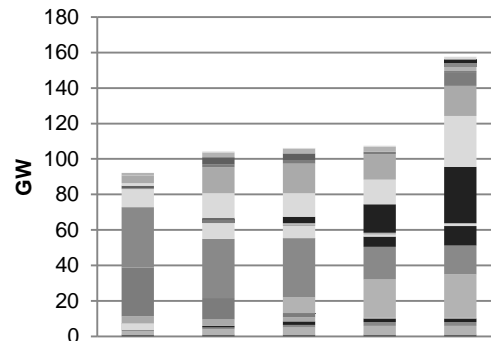
# 2013 Director's Cut sensitivity runs

## Electricity Capacity 2010-2050

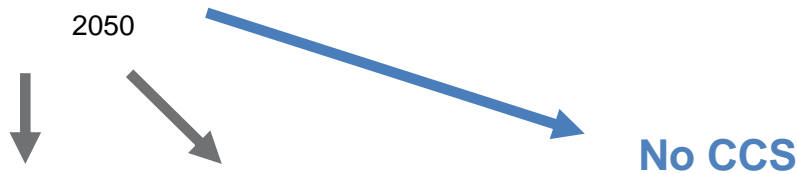
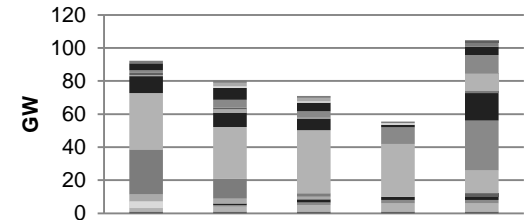
### Director's Cut



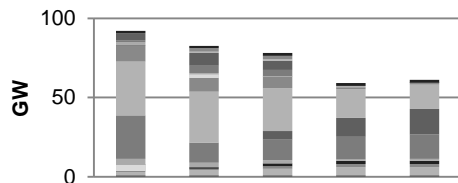
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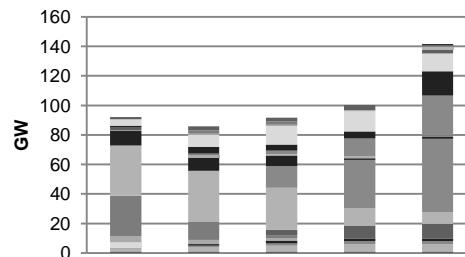
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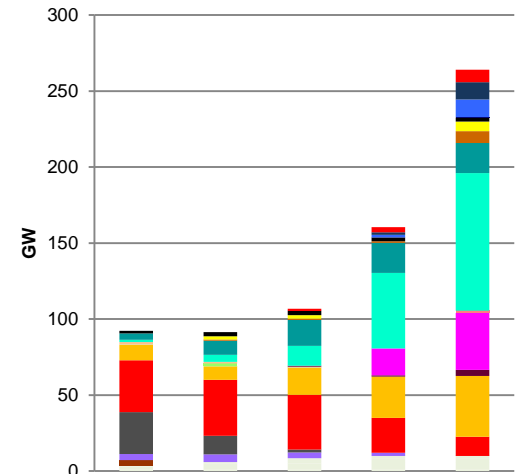
### No CO2 Target



### No Nuclear



No CCS



# 2014 ETI Scenarios

## Aims and Outputs



Rounded scenarios with more detailed consideration for factors such as:

- **policy** and political developments
- **social** impacts e.g. household heating transition, fuel poverty
- **economic** realism e.g. exploring FOAK costs, winners and losers
- more specifics on **technology** characteristics, i.e. the detail that ESME leaves out

Exploring:

***co-evolution*** of these factors

***path dependency*** of system components

***role of different actors*** in the energy system

End products:

**Scenario booklet** - narratives and modelling summary

**Supporting analysis** – detailed modelling and sensitivity analyses

# 2014 ETI Scenarios

## Development Process



Improving on 2013 scenarios:

- Identify problematic aspects of scenarios as they stand
- **Revise scenarios in ESME**
- **Develop social, economic, political aspects of scenario narratives**
- Enrich technological perspective with vignettes around ETI programme areas
- Synthesise key messages (including from sensitivity runs)



# Summary



- ESME – ETI’s UK energy system modelling environment
  - Spatial and temporal disaggregation
  - Variety of demand cases along with probabilistic analysis
  - Used to explore a multitude of energy system designs
  - Internal scenarios developed in 2013 as a trial
- 2014 – development and publication of rounded ETI scenarios
  - Storyline narrative
  - ESME energy system design
  - Technology vignettes
  - Supported by ESME sensitivity analysis
- **ESME available on licence for academic research**
- [scott.milne@eti.co.uk](mailto:scott.milne@eti.co.uk)



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