ENERGY INNOVATION MILESTONES TO 2050

By

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Presentation to a meeting of the International Research Network For Low-Carbon Societies (LCS-RNet)

Berlin, September 20-21, 2010

Philosophy of models

- Human understanding of any complex system is derived from implicit or explicit models
- Making models explicit forces clarity about underlying assumptions and specification of relationships; complex interactions can produce new insights and counter-intuitive outcomes
- Models answer questions – need to be clear about the question and ensure that the model is fit to answer it
- Difference between models for
  - Forecasting (what the future will be): need clear understanding of causation/interactions; mainly natural science models, some short-term economic models
  - Scenario analysis (what the future might be): more speculative/uncertain, different plausible assumptions, sensitivity analysis, longer term

Modelling low-carbon futures with models of

- The climate system (forecasts with different emission scenarios and assumptions about climate sensitivity): how will anthropogenic GHG emissions affect the climate?
- The energy system (scenarios of different developments in technology and behaviour on the supply and demand side): what will GHG emissions and energy system costs from the energy system be?
- The economic system (impacts on the economy of different developments in the energy system): how will different developments in the energy system affect the economy?
- The financial system (models of carbon markets, e.g. GLOCAF): how might global carbon trading develop under different scenarios of climate change mitigation, and what are the prices of carbon and North-South financial flows under these scenarios?
- Combining some or all of these gives Integrated Assessment Modelling (IPCC). For the future, a major question for modelling is: how will climate change affect the energy system (e.g. water for nuclear power stations) and the economy (can we assume continuing economic growth?)

Energy policy objectives

The objectives of energy policy for European and many other countries are basically three:

- Transition to a low-carbon energy system (involving cuts of at least 80% in greenhouse gas (GHG) emissions by 2050, which will require the almost complete decarbonisation of the electricity system)
- Increased security and resilience of the energy system (involving reduced dependence on imported fossil fuels and system robustness against a range of possible economic, social and geo-political shocks)
- Cost efficiency (ensuring that investments, which will be large, are timely and appropriate and, above all, are not stranded by unforeseen developments)

Major possible, but uncertain, developments (1)

- **Decarbonisation of electricity** (and its use for personal transport and residential heat). This depends on the development and deployment of four potentially important low-carbon options:
  - *Large-scale renewables*: issues of incentives, deployment, supply chain, storage technologies
  - *Small-scale renewables*: issues of planning, institutions, storage
  - *Nuclear power*: issues of demonstration, cost, risk (accident, attack, proliferation, waste, safety, decommissioning), public acceptability
  - *Carbon capture and storage (CCS)*: issues of demonstration, feasibility, cost, risk (storage, liability)

Major possible, but uncertain, developments (2)

Demand

- **Demand reduction:** efficiency (rebound effect), lifestyles
- **Demand response:** smart meters/grids, load smoothing, peak/back-up reduction, storage, leading to implications for
- **Network design:** transmission grid reinforcement, distribution networks
- **Key demand technologies:** most importantly likely be *electric vehicles* (with or without *fuel cells*), which could also be used for electricity storage/load smoothing, and *heat pumps*, both of which would use the decarbonised electricity. However, both technologies are in substantial need of further development and their mass deployment raises important consumer/public acceptability, as well as infrastructure, issues.

Major possible, but uncertain, developments (3)

Bioenergy. Thorny issues related to**:**

- *Carbon reduction*: how biomass is produced
- *Environmental sustainability*: issues of land use, biodiversity
- *Different uses of biomass*: competition between bioenergy and food
- *Social issues*: issues of power, livelihoods, ownership and control

Major possible, but uncertain, developments (4)

Internationalisation in relation to:

- *Technology*: e.g. global research, innovation, technology transfer. Balance between competition and co-operation
- *Trade*: e.g. bioenergy, electricity, carbon, border taxes
- *European integration*: grids (electricity, gas), markets (Roadmap 2050)

Options and choices

- Different countries have different options and are likely to make different choices across all these dimensions, depending on their energy history, culture, resource endowments and international relations.
- Choices are essentially political (though industry will be inclined to argue that the country concerned ‘needs’ their favoured option).
- The options will play out differently in terms of energy security, national industrial interests, and cost
- The economic and political consequences of making the wrong choices are potentially enormous
- Balance between developing portfolios (diversity) and going to scale (picking winners – economic as well as energy).
- Importance of demand side

Possible timeline, 2010-2050 (1)

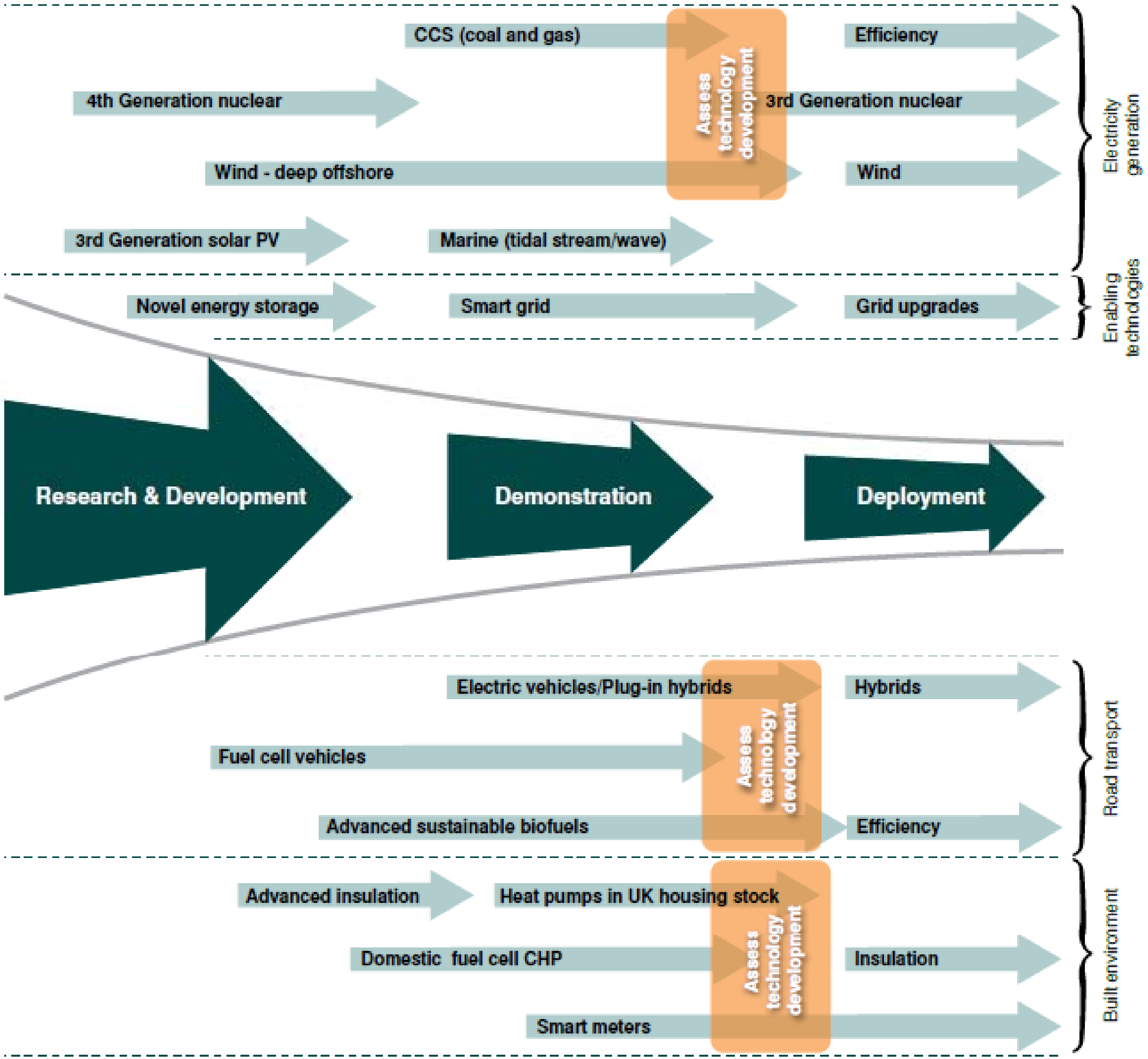
2010-2020:

- Actual UK response to the EU Renewables Directive
- Supply-side options are clarified (In EU how much beyond 20% renewables? Does CCS work? Which countries will go for nuclear? How much distributed generation?)
- Trajectory of demand reduction is clarified
- Trajectory of electrification of personal mobility and residential heat is clarified
- Demand response technologies are installed
- Requisite institutional reforms are put in place
- Internationalisation agreements are put in place

Pipeline of selected energy technologies showing progress required by 2020

Source: Energy Research Partnership 2010 *Energy innovation milestones to 2050*, March, ERP, London

www.energyresearchpartnership.org.uk/tiki-download_file.php?fileId=233



CCS (coal and gas)
Efficiency
4th Generation nuclear
Assess technology development
3rd Generation nuclear
Wind - deep offshore
Wind
3rd Generation solar PV
Marine (tidal stream/wave)
Electricity generation
Novel energy storage
Smart grid
Grid upgrades
Enabling technologies
Research & Development
Demonstration
Deployment
Electric vehicles/Plug-in hybrids
Hybrids
Fuel cell vehicles
Assess technology development
Advanced sustainable biofuels
Efficiency
Road transport
Advanced insulation
Heat pumps in UK housing stock
Domestic fuel cell CHP
Assess technology development
Insulation
Smart meters
Built environment

Possible timeline, 2010-2050 (2)

2020-2030:

- Large-scale roll out of different supply technologies
- Establishment of new demand patterns
- Roll out of grid redesign
- Re-think/re-orientation where possible/desired to take account of new technologies and options

2030-2050:

- Large-scale deployment of chosen options
- Limited scope for trajectory change without large costs

Thank You

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