UCL Institute for Sustainable Resources

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CECILIA 2050

OPTIMAL EU CLIMATE POLICY

Presentation to the CECILIA2050 Mid-term Conference:
"EU Climate Policy Beyond 2020 –
taking stock and looking forward"

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Key Challenges for the Energy Sector: Insights from CECILIA2050

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SEVENTH FRAMEWORK PROGRAMME

Energy policy objectives (low carbon +)

The objectives of energy policy for European 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), and a wider 'green economy'
- 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)
- Competitiveness (some sectors will decline as others grow – allow time for the transition); cost efficiency (ensuring that investments, which will be large, are timely and appropriate and, above all, are not stranded by unforeseen developments); and affordability for vulnerable households (special arrangements if prices continue to rise)

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 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 (historically supply needs have been substantially over-estimated)

The demand side

- Buildings (residential, commercial)
- Transport (road vehicles, rail, aviation, shipping)
- Industry (energy, process)
- Agriculture

The supply side

- Vectors: electricity, heat, liquid fuels, hydrogen
- Fossil sources: coal, oil, gas (last two conventional and unconventional)
- Low-carbon sources: ambient renewables (wind, solar, wave), bioenergy, nuclear
- Low-carbon technologies: CCS, geo-engineering

Major possible, but uncertain, developments (1)

Energy Demand: determines *how much* supply, and *what kind of* supply, is required

- **Demand reduction:** efficiency (rebound effect), lifestyles
- **Demand response:** smart meters/grids, load smoothing, peak/back-up reduction, storage, leading to implications for
- **Network design**
- **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 (2)

- **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
  - *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)
- **Market redesign** for intermittency, inflexibility and zero marginal cost renewables (e.g. payments for capacity, storage)

Major possible, but uncertain, developments (3)

Bioenergy - thorny issues related to:

- *Carbon reduction*: how is biomass 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
- *International integration*: grids (e.g.high-voltage DC electricity), markets (European Roadmap 2050)

Possible timeline, 2010-2050 (1)

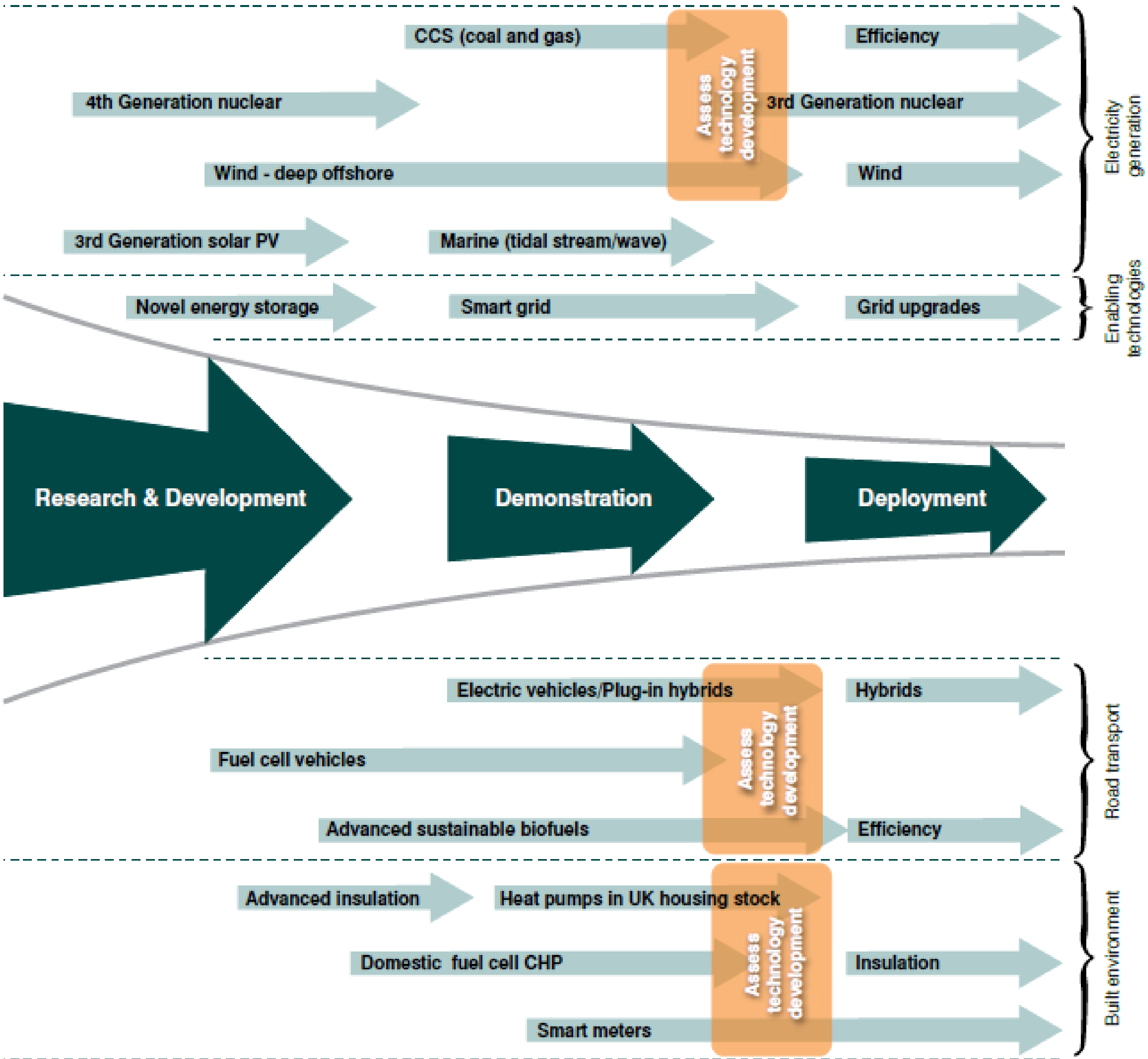
2010-2020:

- Results relating to the EU Renewables Directive
- European 2030 package and associated target(s)
- 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 (e.g. Energy Market Reform in UK) 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

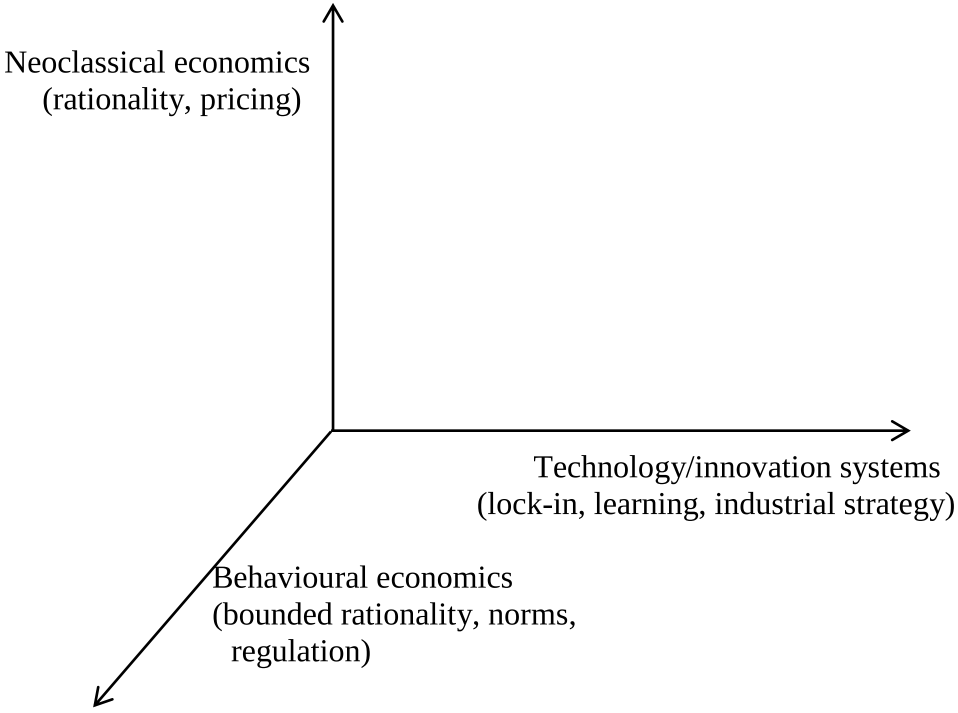
Climate change: an unprecedented policy challenge

The Stern Review Policy Prescription

- Carbon pricing: carbon taxes; emission trading
- Technology policy: low-carbon energy sources; high-efficiency end-use appliances/buildings; incentivisation of a huge investment programme
- Remove other barriers and promote behaviour change: take-up of new technologies and high-efficiency end-use options; low-energy (carbon) behaviours (i.e. less driving/flying/meat-eating/living space/lower building temperatures in winter, higher in summer)
- Carbon pricing will both stimulate investment in low-carbon energy sources and promote behaviour change. But in the presence of market barriers and innovation failure, either prices will need to be infeasibly high, or they will need to be supported by complementary policy

Three domains of change

Acknowledgement: Michael Grubb, *Planetary Economics*, forthcoming



CECILIA2050 structure of climate policies

- Carbon pricing
- Energy efficiency and energy consumption
- Promotion of renewable energy
- Non-CO2 GHGs

Landscape of UK climate policies

	Policy Landscapes			
Policy Instrument	Carbon Pricing	Energy Efficiency and Energy Consumption	Promotion of Renewable Sources of Energy	**Non-Carbon Dioxide GHGs**
Climate Change Levy (inc. Carbon Price Floor)	(✓)	✓	✓	
Climate Change Agreements		✓		
EU ETS	✓	✓	✓	✓
Renewables Obligation			✓	
Renewable Energy Feed-In Tariff			✓	
Renewable Heat Incentive			✓	
CRC Energy Efficiency Scheme	✓	✓		
Carbon Trust Standard		✓		
LSE Carbon Reporting Requirements		✓		
Green Deal		✓		
Energy Company Obligation		✓		
Renewable Transport Fuel Obligation			✓	
Vehicle Excise Duty		✓		
Landfill Tax				✓
Greenhouse Gas Action Plan			✓	✓

‘Optimality’ in an n-th best world

- Effectiveness (e.g. extent of emissions reduction)
- Cost efficiency (equalisation of marginal cost; stimulation of innovation/technology; stimulation of behaviour change)
- Feasibility (political economy [international and domestic], complexity)
- Different views:
  - Existential: the existing mix is the best that could have been achieved
  - Optimal: anything less than the neo-classical optimum is unacceptable
  - Opportunistic (shots-in-the-locker): develop alternative policies to be ready for window of opportunity

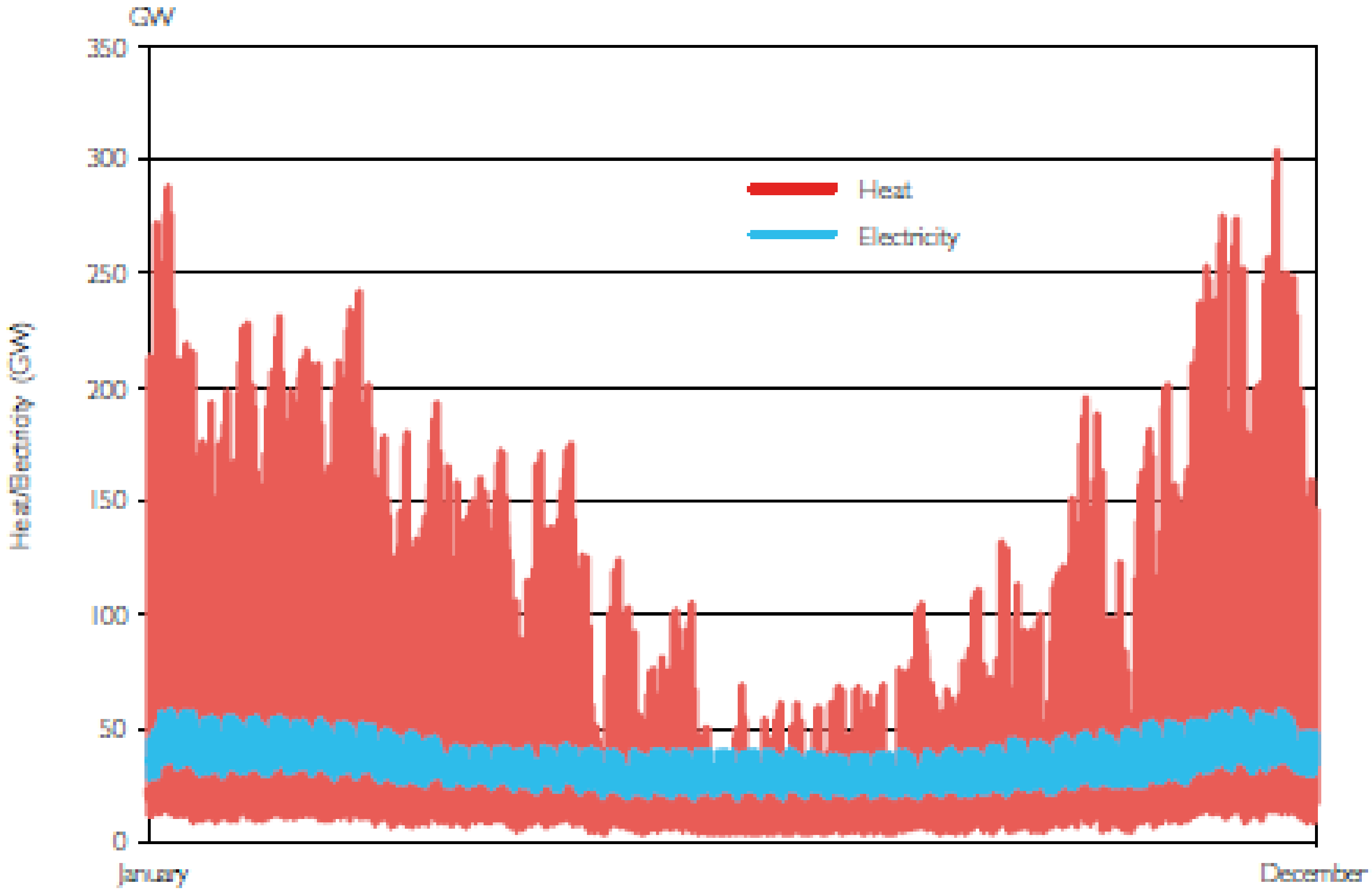
Bottom-up scenario construction

- *Ex ante* estimation of effect of instrument (inc. rebound effect if appropriate)
- Consideration of interaction between instruments, inc. order of implementation (e.g. home insulation, can only save energy once)
- Reality check on energy system implications (e.g. substitution of low-carbon electricity for gas-based heat, see next slide)
- Bottom-up modelling (e.g. MARKAL/TIMES)

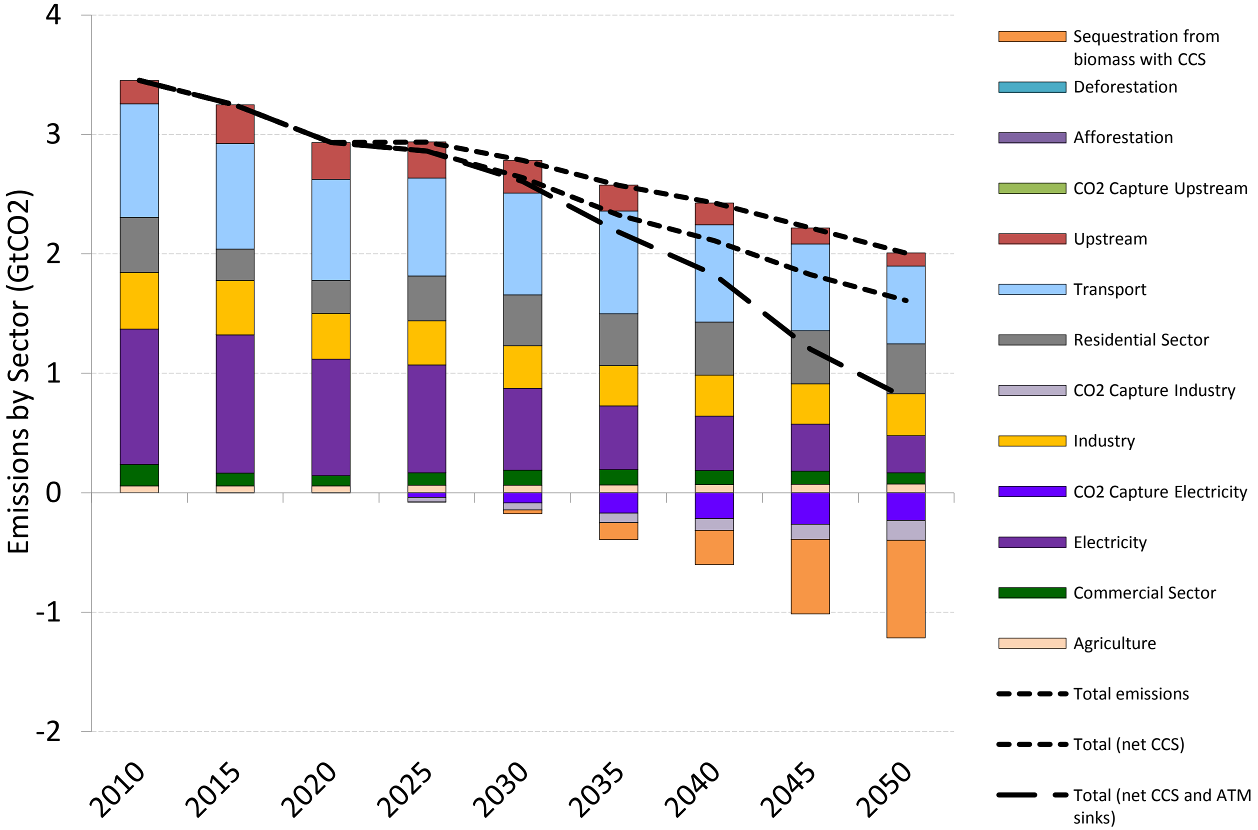
Variability in energy consumption

Source: DECC Heat Strategy, 2012, p.12 (daily consumption also relevant)

Chart 2: Comparison of heat and electricity demand variability across a year (domestic and commercial) – 2010[7]



Results from UCL-ETM (European Times Model)

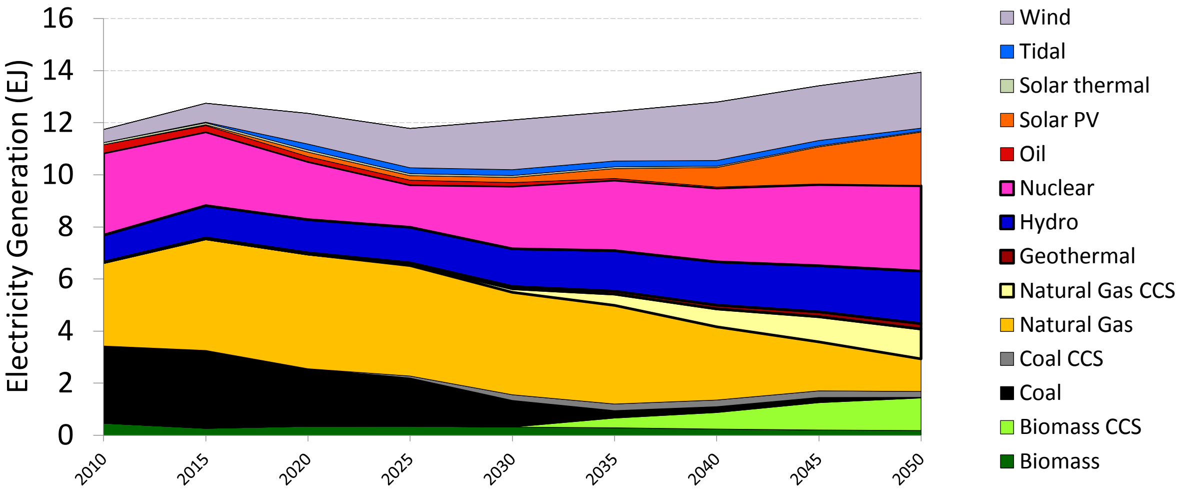


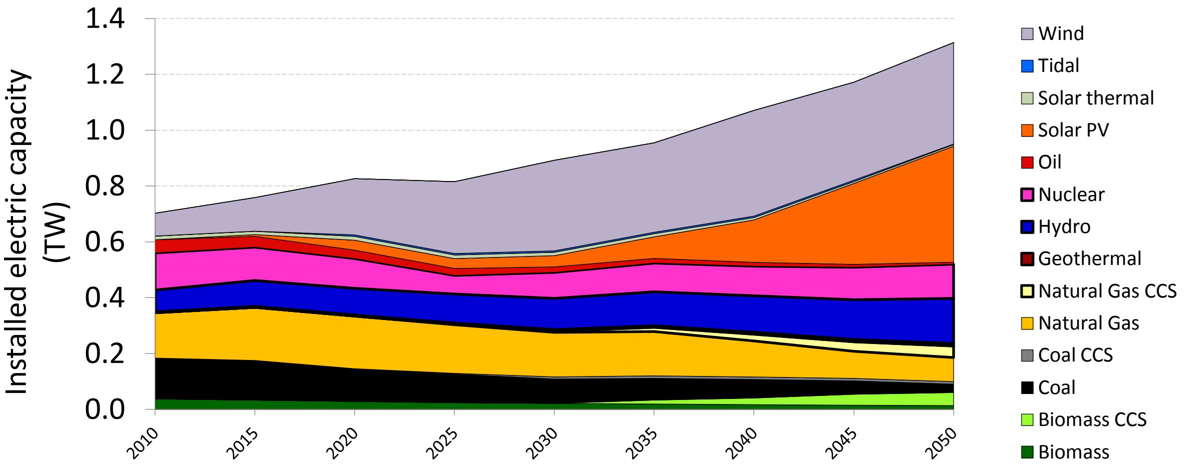
Key Modelling Assumptions for 2DS

- 80% CO_2 reduction by 2050 from 1990 levels (CO_2 only because other GHGs poorly characterised)
- 2020 RES and emission targets met (202020 targets) – but not efficiency
- Nuclear capacity constrained to 2010 levels (at an EU aggregate level)

Energy commodity prices for oil, coal and gas equal to IEA's 2012 2-degree scenario levels (2DS, lower prices than reference scenario – reduced global demand)

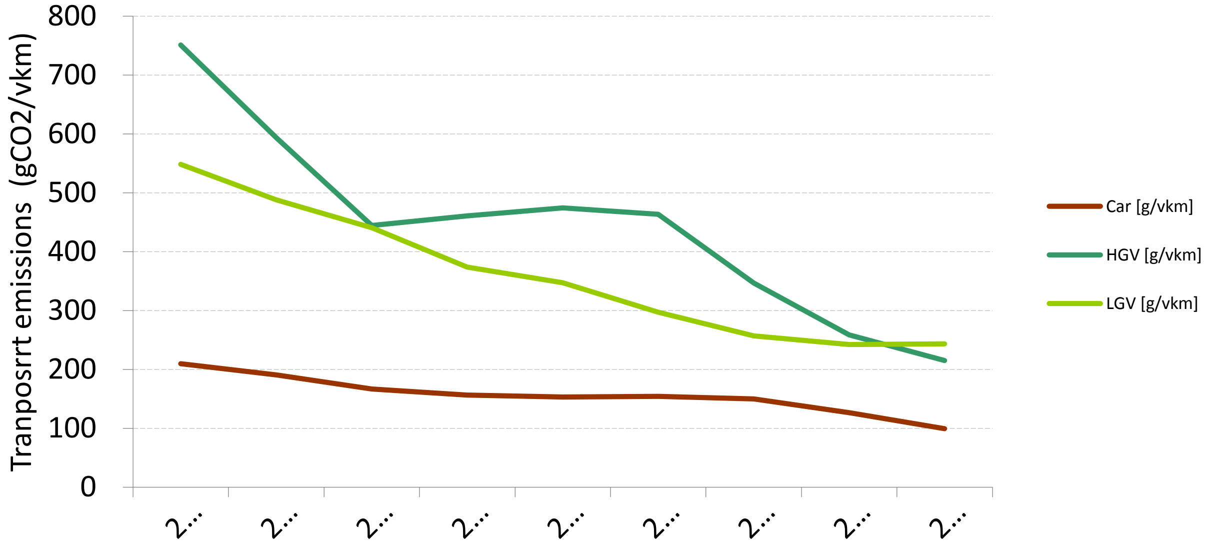
Power Sector





- Negative emissions in electricity generation essential by 2050, and likely after 2040.
- CO_2 intensity of around -190gCO_2/KWh by 2050, with negative emissions delivered by biomass CCS.
- Carbon price of over $5000 by 2050 if no biomass CCS permitted.
- Nuclear new build allowed up to 2010 capacity.
- If no new nuclear capacity permitted, gap is filled with additional wind/PV. Very little investment cost difference.

Transport



- 60% increase in energy service demand (in bvkm) for all vehicle types.
- **Cars** – General shift from gasoline to diesel, with about 25% of journeys satisfied by PHEVs and hybrids, and about 20% biofuel in fuel mix by 2050.
- **LGVs** – Shift to hybrids from 2025, then to PHEVS from 2035 – about 40% LGV vkms are PHEV by 2050.
- **HGV**s – Significant increase in use of biofuel through RED (to consistently around 25% HGV fuel consumption from 2020 onwards – 10% biofuel overall), with hydrogen increasing significantly from 2035 to around 40% all HGV vkms (around half HGV fuel consumption), by 2050.

Buildings

- Overall, total energy demand in both residential and commercial sector remain the same, despite increase in both types of property. Challenges then in deploying significant efficiency measures on both new and existing stock.
- **Household energy** – increasing use of gas (40% to 50%) and electricity (25% to 35%) displaces oil products.
- **Commercial energy** – shifts significantly to use of heat pumps from around 2025 onwards, to around 20% final energy consumption for commercial heating.

- **Key Challenges**
  - Expand gas and electricity grid to new builds and existing buildings to replace other fuels.
  - Encourage efficiency measures in existing building stock.

- **Agriculture** CO_2 emissions small and largely unchanged – obviously cheaper emission abatement elsewhere

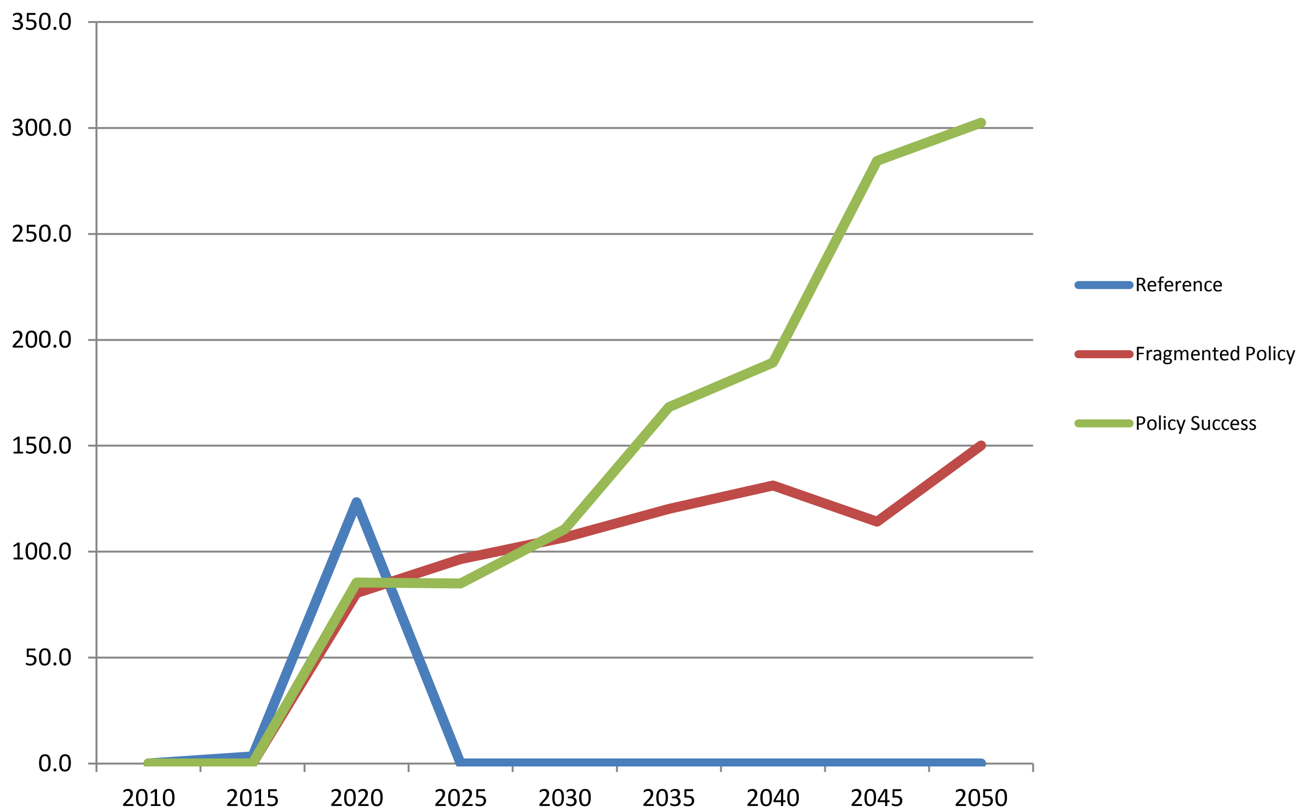
Other Key Sectoral Challenges

- Power sector:
  - Incentivising rapid RES-E increases, balanced with incentive to maintain back-up generation. Improved grid balancing techniques required preventing excessive RES-E curtailment and price volatility (also increased interconnector capacity).
  - Must be achieved without excessive cost to consumer, to maintain affordability and feasibility.
  - Non-financial barriers must also be removed, such as complex administrative procedures and unfavourable planning regimes.
- Transport:
  - Delivering significant electricity and hydrogen infrastructure for HGVs by around 2035/2040.
  - Encouraging development and (rapid) deployment of affordable fuel cell and PHEV vehicles, and vehicles able to accept higher proportions of blended biofuels.
  - Encouraging modal shift to public transport, but this is not considered by the model.
- Industry
  - Development and deployment of CCS on industrial processes (CCS cuts industrial emissions by half, with another 10% or so from efficiency (against increasing output demands)).

General Challenges

- **Long-term planning**
  - Ensure compatibility of existing and new infrastructure to meet demands of the future. E.g. fossil fuel/biomass power plants with CCS retro-fit capability, possibility for gas infrastructure to deliver hydrogen, etc.
- **Innovation policy**
  - Greatly increased R&D budgets
  - Funding for development and deployment of new and immature technology, including PHEVs, fuel cell HGVs, CCS (particularly biomass), storage technologies, etc.
  - Incentives to innovate for vehicle efficiency, to reduce capital costs, etc.
- **System costs**
  - Overall system cost of a 2DS (80% CO_2 reduction by 2050) trajectory is almost identical to a 4DS (60% CO_2 reduction by 2050) and 6DS (no carbon constraint after 2020) trajectory, partly due to different assumed energy costs offsetting decarbonisation costs, which include greatly increased power sector investment.
  - The ‘Reference’ scenario used IEA 6DS prices, and ‘Fragmented Policy’ uses IEA 4DS prices, both of which are higher than 2DS prices (reflecting demand).

Carbon Prices ($)



Thank you

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