2015: a Critical Year for Energy and Climate Policy

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Structure of presentation

- The global challenges of energy and climate change
- Possible developments in the global energy system
- Policy responses
- Economic implications
- Conclusions

The Energy Trilemma

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

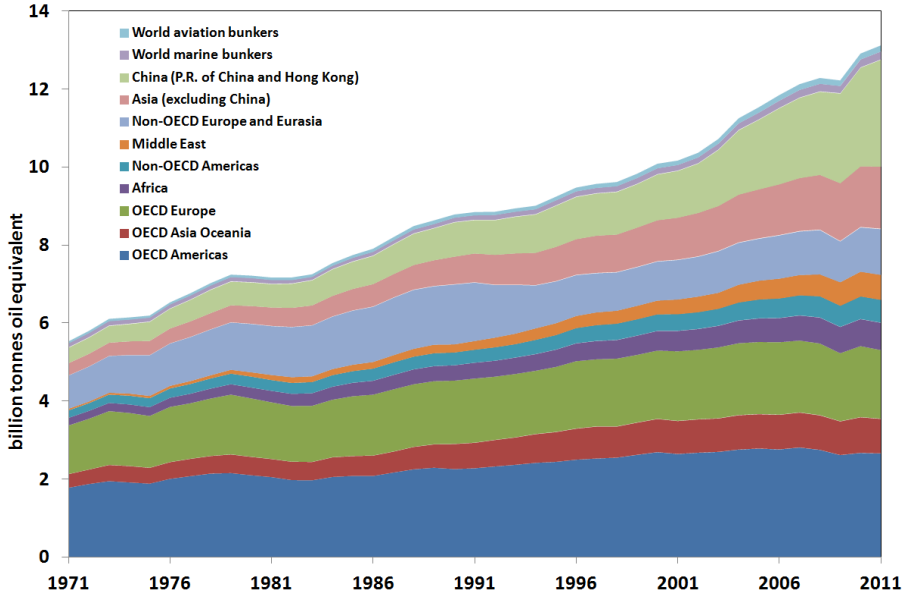
- Transition to a low-carbon energy system (involving cuts of at least 80% in greenhouse gas (GHG) emissions by 2050, which will require the almost complete decarbonisation of the electricity system), and a wider 'green economy'
- Increased security and resilience of the energy system (involving reduced dependence on imported fossil fuels and domestic system robustness against environmental, economic, social and geo-political shocks)
- Affordability
  - For businesses: need for competitiveness (some sectors will decline as others grow – allow time for the transition) and cost efficiency (ensuring that investments, which will be large, are timely and appropriate and, above all, are not stranded by unforeseen developments)
  - For vulnerable households: need to be able to pay energy costs

Energy security – avoiding 'shocks' to the energy system

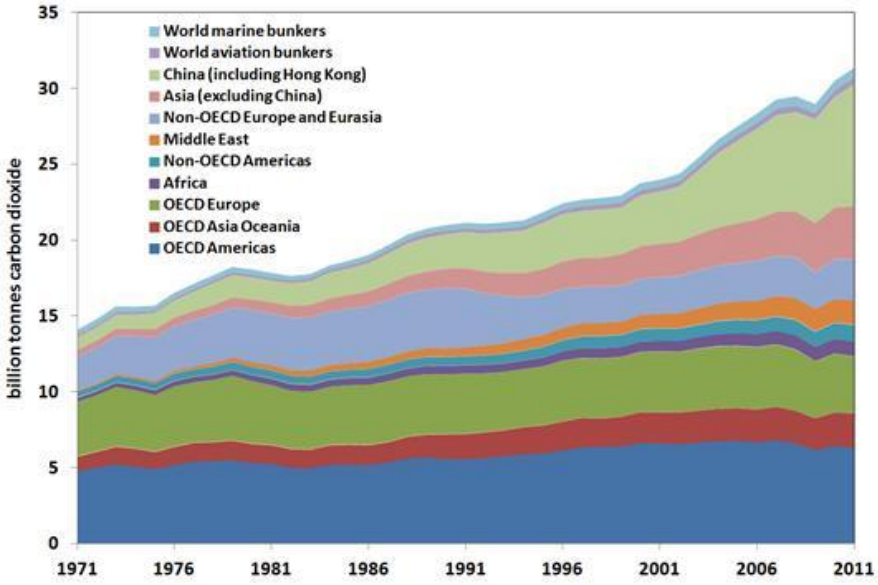
- Concerns:
  - Transformation, conversion, storage and distribution systems that deliver energy services (adequacy of investment in electricity generating capacity - 'keeping the lights on'), intermittency of renewables
  - The availability and cost of primary energy supplies (fears of politically motivated interruptions to supplies of oil and gas), e.g. Russian gas
- Evidence:
  - Many of the "shocks" to the gas and electricity systems relate to equipment failures or weather-related events, rather than politically motivated or other deliberate interventions.
  - The duration of impacts differs according to which part of the energy system is affected. Electricity shocks have tended to last for hours-days, gas shocks for weeks-months, and oil shocks for months-years in some cases.
  - The nature, timing and extent of 'shocks' are characterised by incertitude

The inexorable increase in energy use and CO2 emissions

Global primary energy demand by region

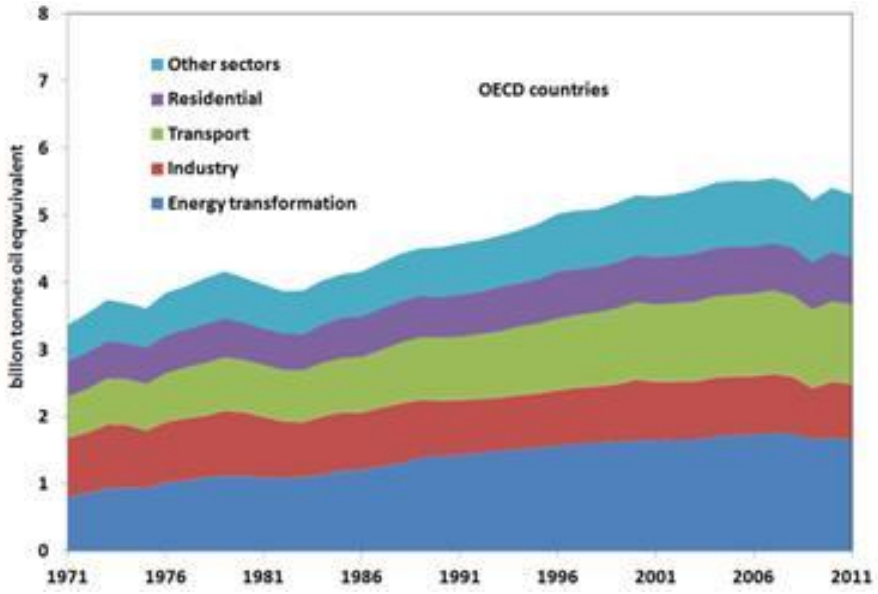


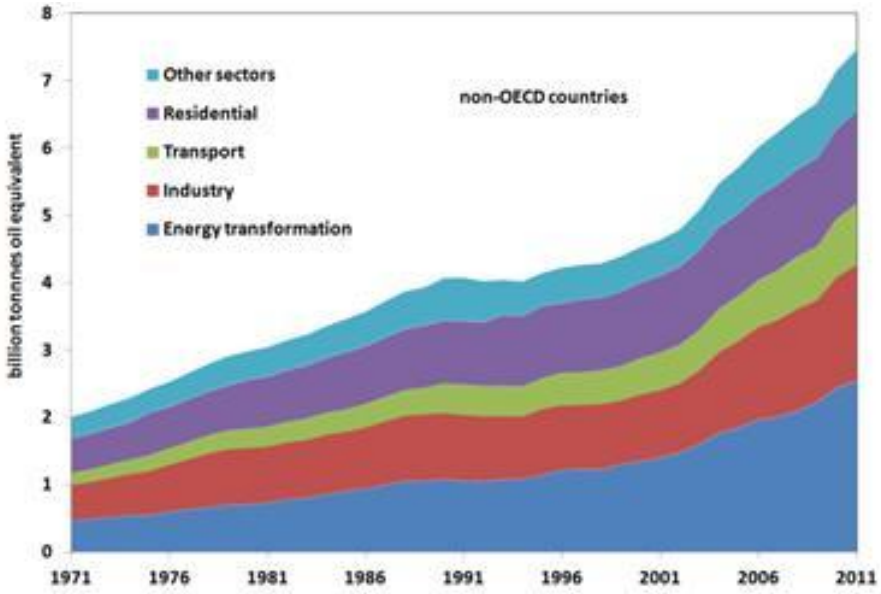
Global CO2 emissions by region



Energy use by sector

OECD and non-OECD countries





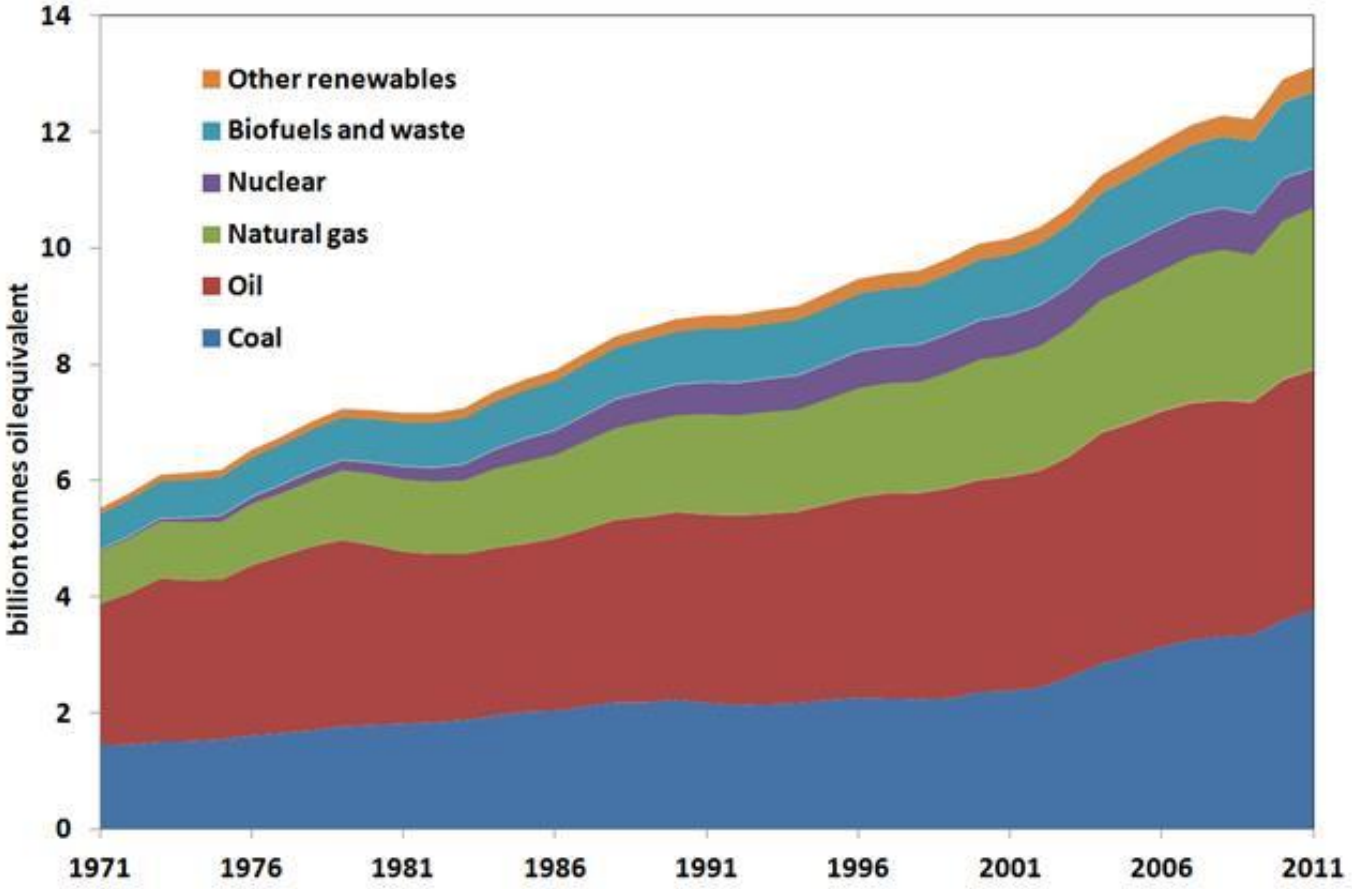
Energy unequally consumed

Primary energy consumption in selected countries in 2011
(tonnes of oil equivalent per capita)

High consuming countries		Major developed economies		Emerging economies		Lower-income countries	
Iceland	17.9	United States	7.0	South Africa	2.8	DR Congo	0.4
Qatar	17.8	Australia	5.4	PR China	2.0	Tajikistan	0.3
Trinidad and Tobago	15.5	Korea	5.2	Argentina	2.0	Nepal	0.3
Kuwait	11.5	Russian Federation	5.2	Thailand	1.7	Cameroon	0.3
Netherlands Antilles	10.9	Netherlands	4.6	Mexico	1.7	Haiti	0.3
Brunei Darussalam	9.3	France	3.9	Turkey	1.5	Yemen	0.3
Oman	8.9	Germany	3.8	Brazil	1.4	Myanmar	0.3
United Arab Emirates	8.4	Japan	3.6	Indonesia	0.9	Senegal	0.3
Luxembourg	8.0	United Kingdom	3.0	Nigeria	0.7	Bangladesh	0.2
Canada	7.3	Italy	2.8	India	0.6	Eritrea	0.1

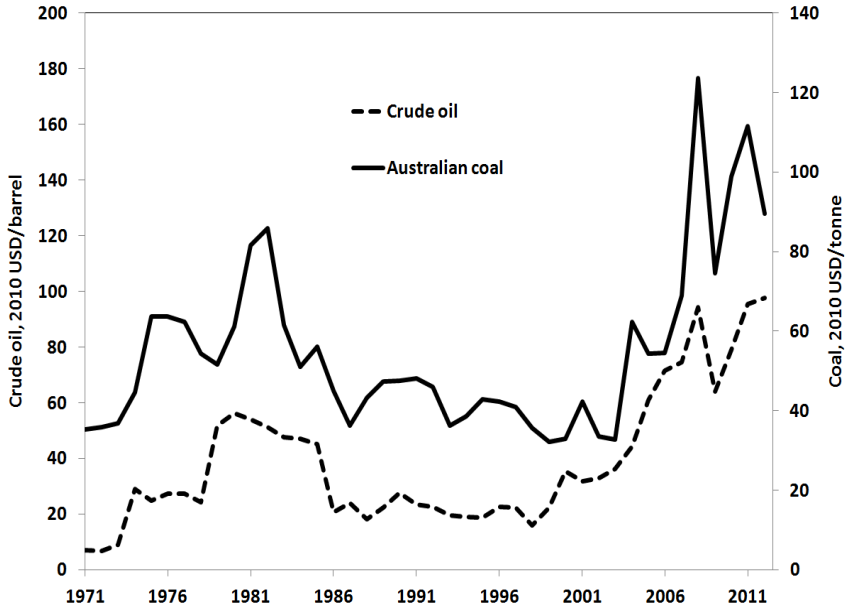
The dominance of fossil fuels

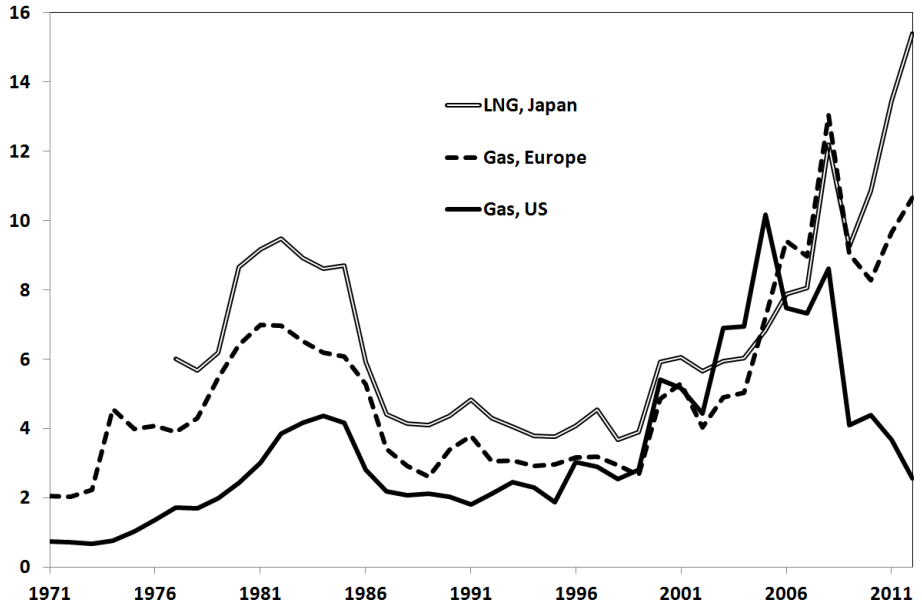
Global primary energy demand by fuel



Oil, coal and gas prices

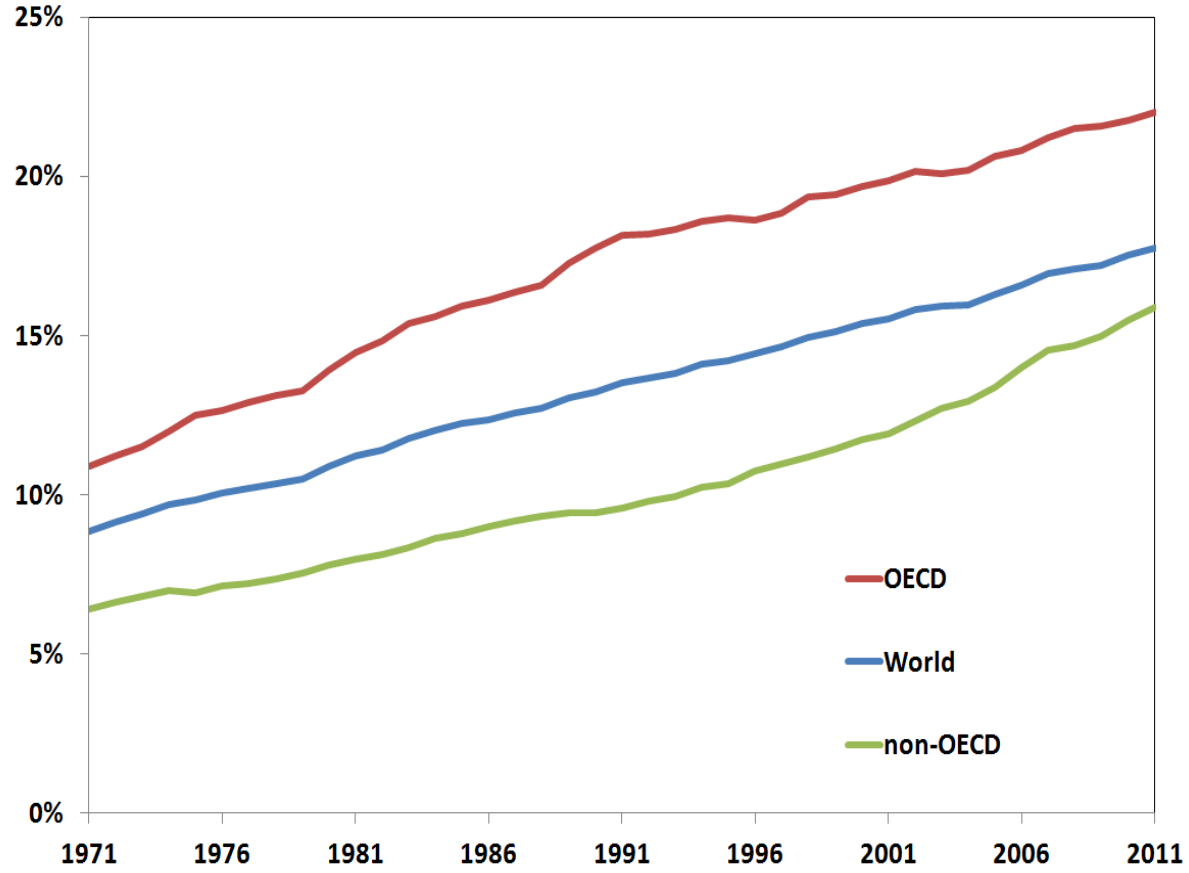
(gas unit 2010 USD/million BTU)





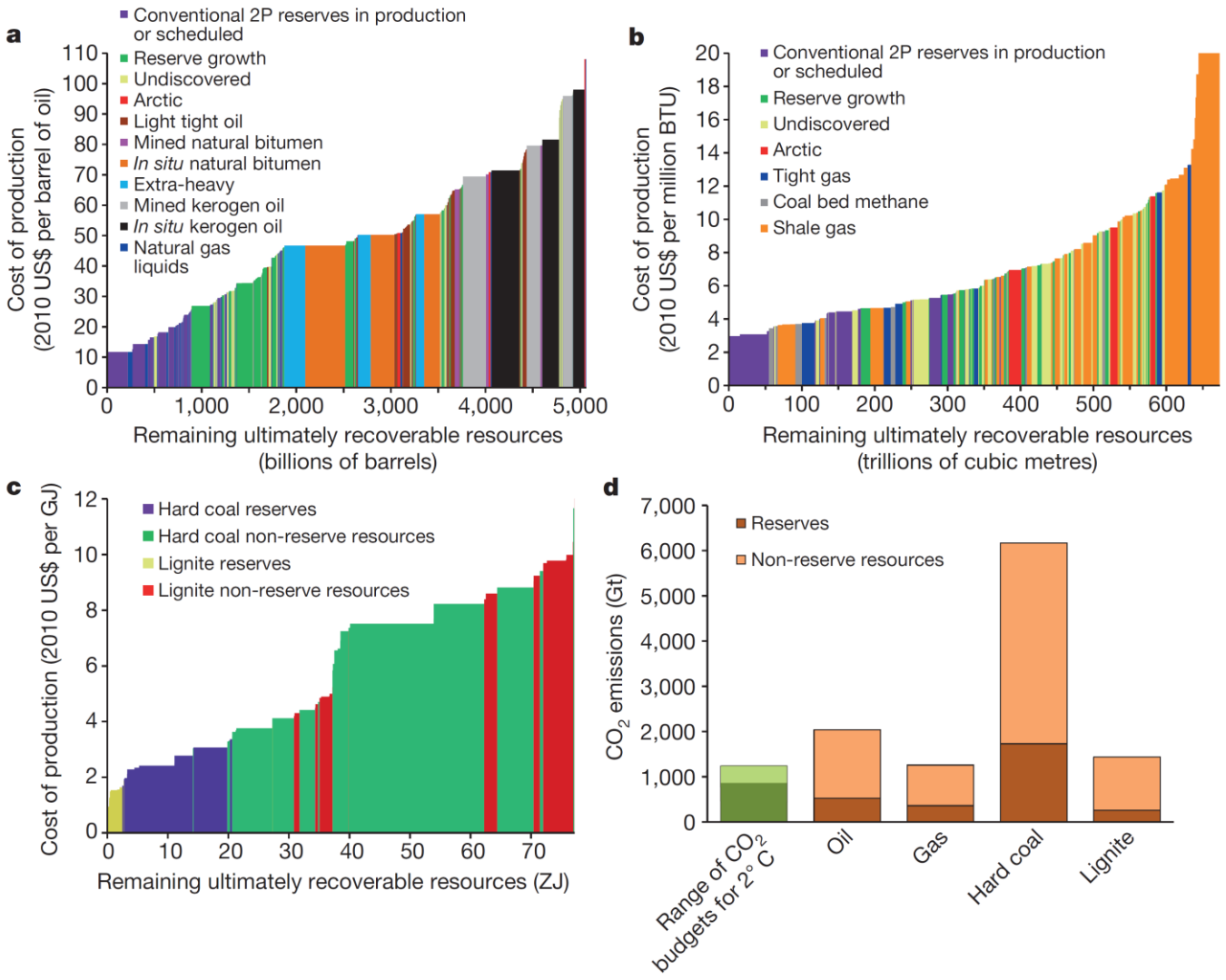
Proportion of demand met by electricity

OECD and non-OECD countries

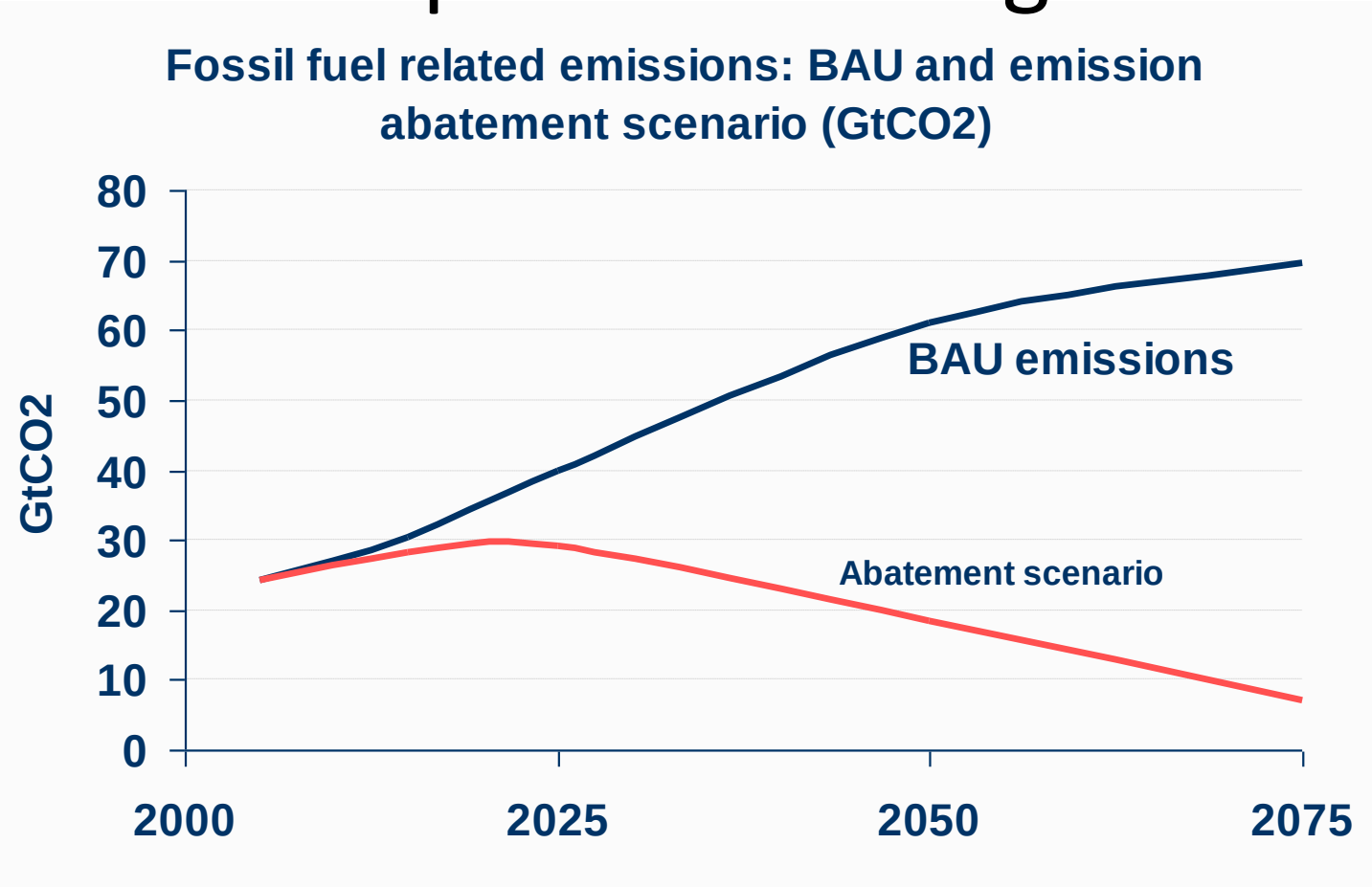


Reserves, resources and carbon budgets

McGlade, C. and Ekins, P. 2015 'The geographical distribution of fossil fuels unused when limiting global warming to 2°C' *Nature*, pp.187-190



Emissions trajectory to limit temperature change



Source: Stern Review, Part III, Chapter 9

The framework of climate policy

- UN Framework Convention on Climate Change (UNFCCC), 1992, Kyoto Protocol, annual COP/MOP meetings, post-Durban process
- G20 processes and discussions
- The EU 20/20/20 by 2020 Programme and associated policies
- National policies and programmes
- State (US)-level policies and programmes
- Regional/city/local roll-out ambitions/ obligations

(global and EU levels discussed here)

The UNFCCC (1)

- The Kyoto Protocol (1997)
  - Entry into force 2005, first commitment period, 2008-2012; 192 signatories, including EU
  - Crucial issue of 'common but differentiated responsibility'
  - Distinction between Annex 1 (industrial, binding targets) and non-Annex 1 countries (no commitments)
  - Flexible mechanisms: emissions trading, Joint Implementation (JI), Clean Development Mechanism
  - Adaptation Fund for developing countries

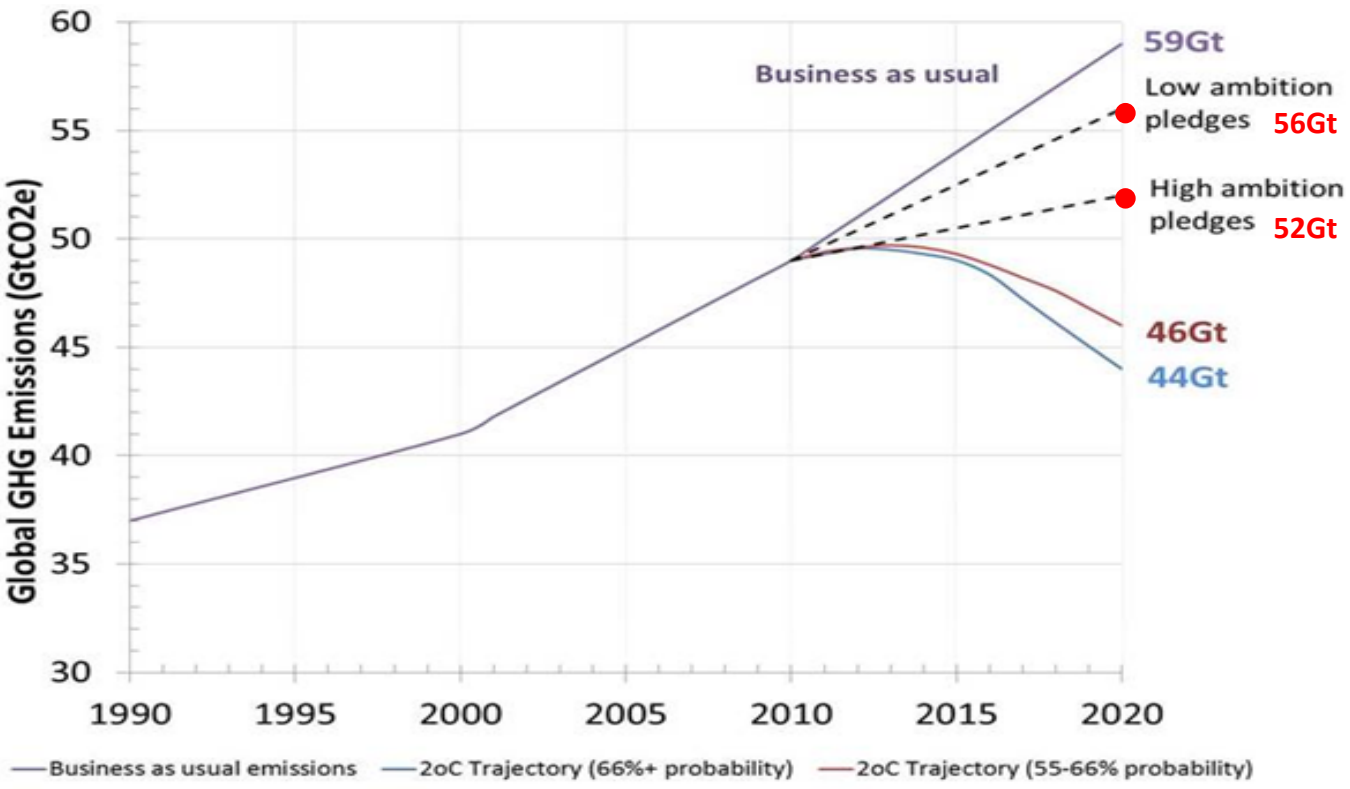
- Copenhagen (2009)
  - The Copenhagen Accord: voluntary commitments to emission reduction by all countries (now called Intended Nationally Determined Contributions – INDCs)
  - Global recognition of the 2^{o}C 'guardrail
  - Commitment to Green Climate Fund ($30 bn 2013; $100 bn 2020)

The UNFCCC (2)

- Cancun (2010)
  - Accord incorporated into Treaty
  - Commitments from all industrial countries and major developing countries (90% global energy-related emissions), but nowhere near enough for 2^{o}C guardrail

- Durban (2011)
  - The launch of an Ad Hoc Working Group on the Durban Platform for Enhanced Action, which will seek to adopt an agreement for long-term emissions reductions by 2015, to come into effect no later than 2020.
  - Agreement will include all countries, which will make commitments to emissions reduction, and will have legal force
  - All countries are now committed to the prospect of legally binding emissions reduction
  - This could provide a major impetus for the development and adoption of low-carbon technologies, but only with prospect of global deal

The 2°C 'emissions gap'



BAU in 2030
68Gt

2°C cost-effective trajectory in 2030

47Gt
(50% chance of 2°C)

42Gt
(66% chance of 2°C)

Objectives for Paris

- **Paris (2015) needs agreement a global, legally binding deal, applicable to all**
  - **Legal Form**: Should be a Protocol, with legally binding elements
  - **Continued commitment** to 2°C 'guardrail' and carbon budget
  - **Mitigation Ambition**: Commitments should
    - Be nationally determined, but subjected to international scrutiny
    - Keep below 2 degrees goal within reach,
    - Be complemented with a regular review process on a five year cycle, and if possible a Long Term Goal
    - Envisage 'Deep Decarbonisation Pathways' and technological explicitness
    - Involve carbon pricing by at least some countries
  - **Differentiation**: All Parties should contribute 'fair' share, along a spectrum
    - Different types of commitment, different levels of ambition. Major and developed economies to lead the way
  - **Rules**: Internationally agreed rules base for MRV and accounting
  - **Adaptation and Finance**: All countries should be responsible for mobilising finance. Adaptation needs to be core part of Agreement

The international state of play in summary

- Curbing global warming requires international cooperation and agreement to reduce emissions of greenhouse gases

BUT

- Developing countries will not accept emission control if they think it will impede their development

SO

- Committed industrial countries (like the UK, Korea) will need to show that deep emissions control is compatible with continued economic growth and development
- Best hope for emission control is the emergence of a ‘green race’ for low-carbon technologies: ‘green economy’
- ‘Green growth’ is now the strategic economic imperative
- What developments in the energy system could drive ‘green growth’?

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, intermittency, market design (zero marginal cost)
  - *Small-scale renewables*: issues of planning, institutions (distribution networks)
  - *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 (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

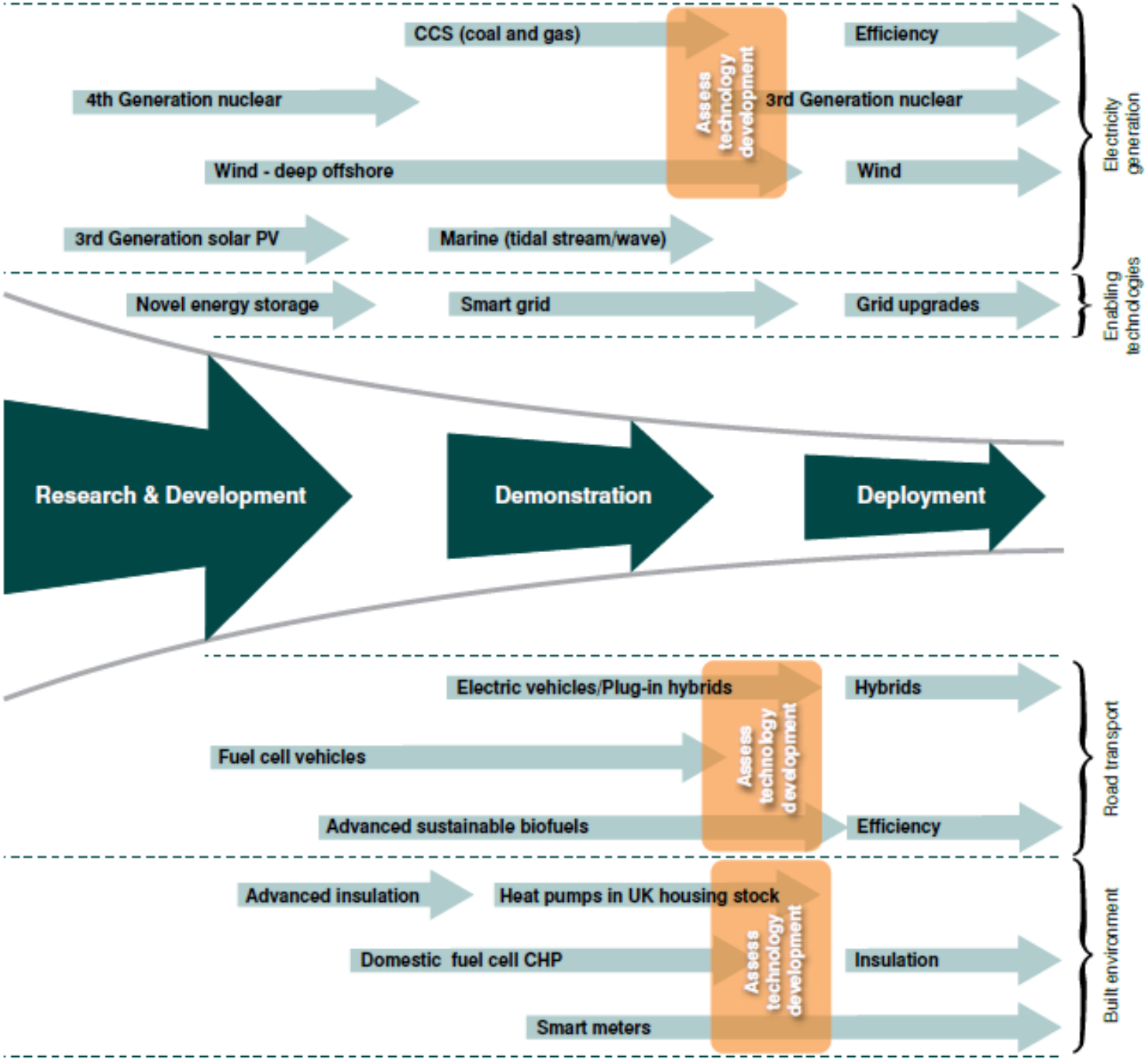
Major possible, but uncertain, developments (4)

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)

Pipeline of selected energy technologies showing progress required by 2020

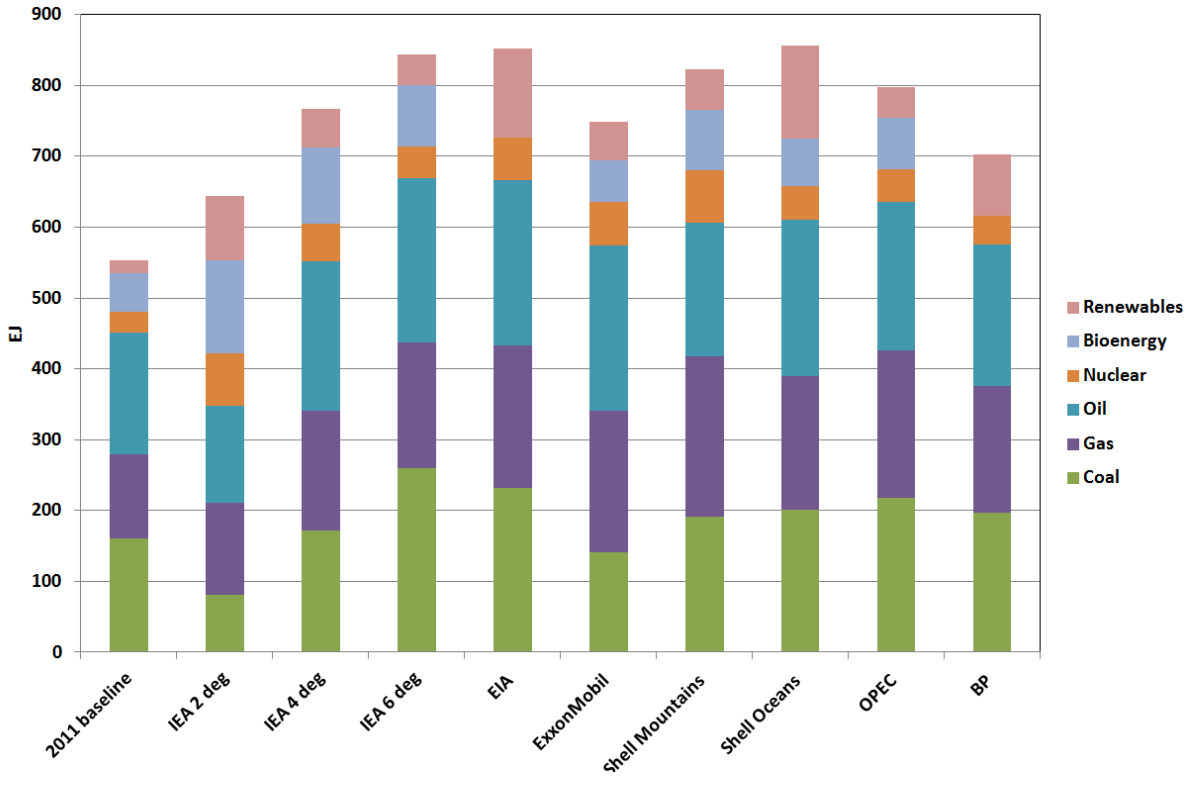
Source: Energy Research Partnership 2010 *Energy innovation milestones to 2050*, March, ERP, London
www.energyresearchpartnership.org.uk/tiki-download_file.php?fileId=233


CCS (coal and gas)
Efficiency
4th Generation nuclear
3rd Generation nuclear
Assess technology development
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

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)
- Need for immediate decarbonisation and avoidance of future carbon lock-in

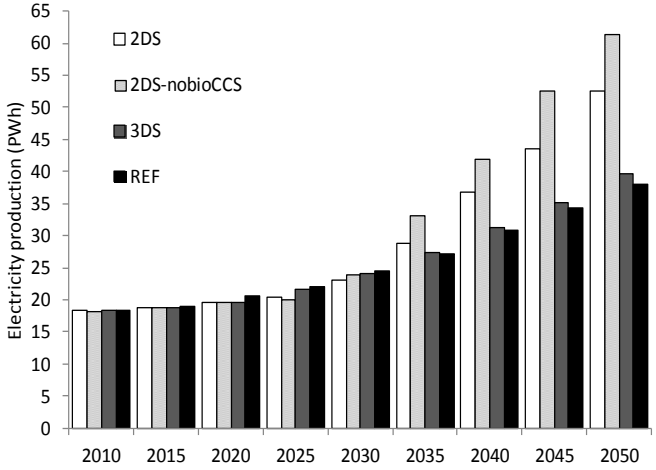
Primary energy demand in different global energy scenarios/projections for 2040

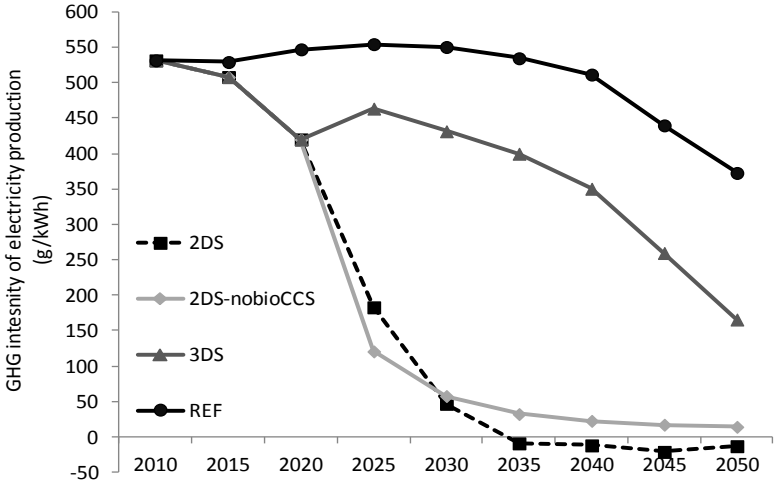


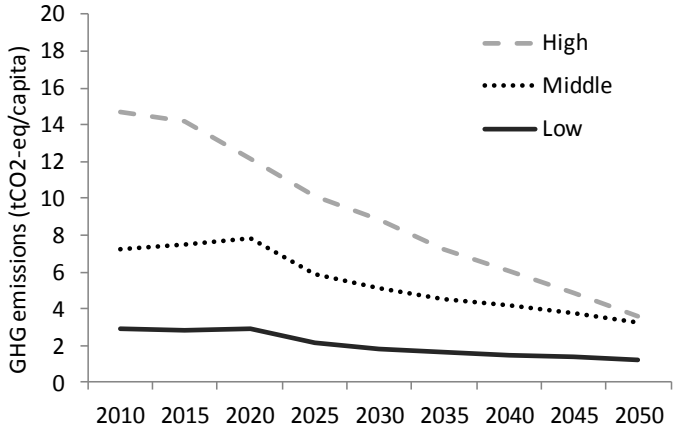
a)

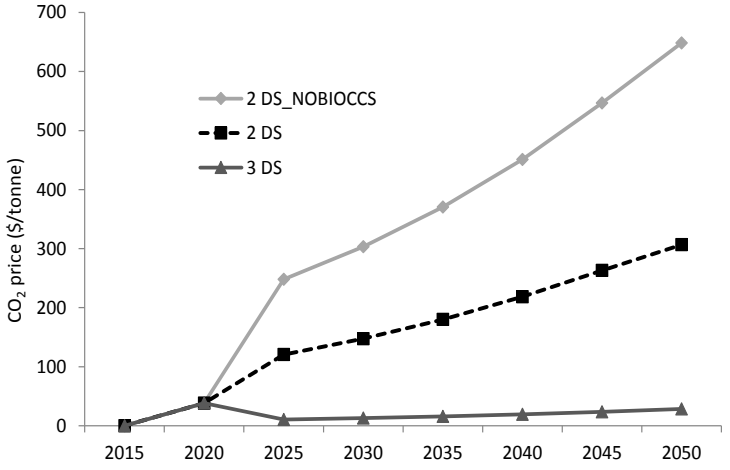
Global electricity generation in four scenarios (left) and its GHG intensity (right), per capita emissions (2DS, bottom left), CO2 prices (bottom right)

Ch.24 in Ekins, P., Bradshaw, M. and Watson, J. 2015 (forthcoming) *Global Energy: Issues, Potentials and Policy Implications*, Oxford University Press, OUP





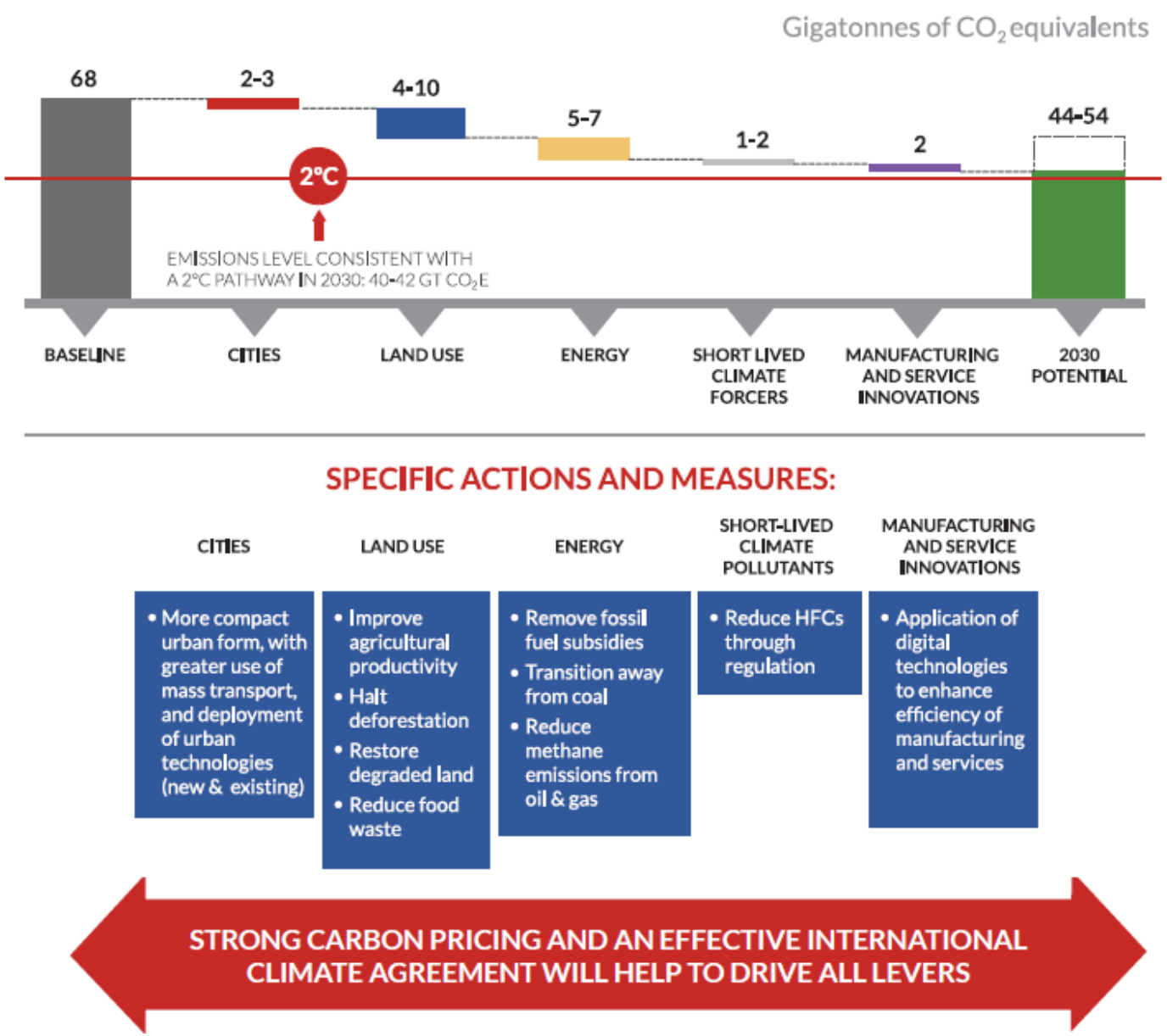




An unprecedented policy challenge

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/lower building temperatures in winter, higher in summer)
- Carbon pricing will both stimulate investment in low-carbon energy sources and promote behaviour change



Carbon abatement policies for different sectors

Source: New Climate Economy Report, p.24

Categorisation of environmental policies

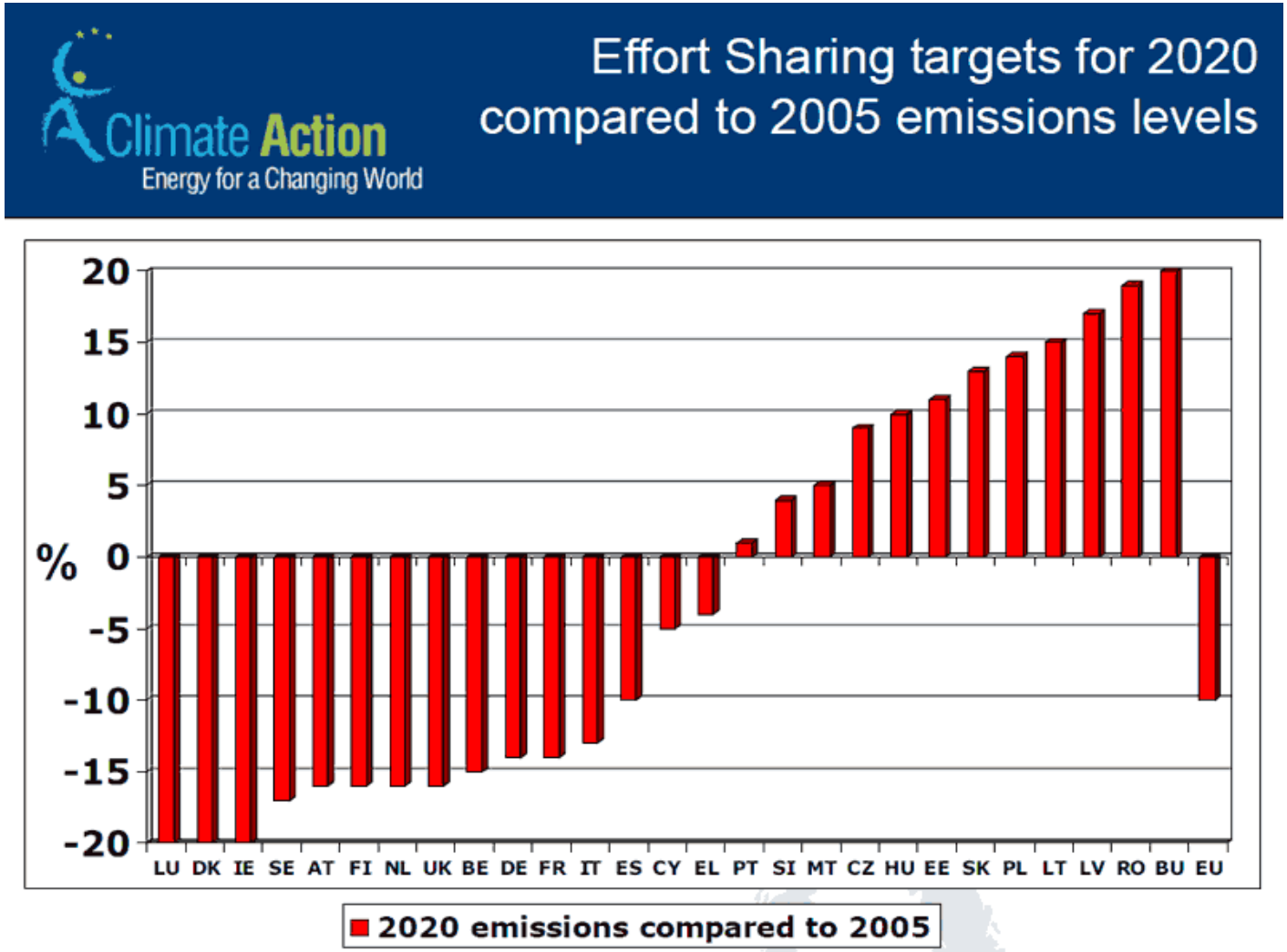
- *Market/incentive-based (also called economic) instruments*: include emissions trading, environmental taxes and charges, deposit-refund systems, subsidies (including the removal of perverse subsidies), green purchasing, and liability and compensation.
- *Regulation instruments*, which seek to define legal standards in relation to technologies, environmental performance, pressures or outcomes. Can also include imposition of obligations, e.g. renewable and energy efficiency obligations in the UK.
- *Voluntary/self-regulation (also called negotiated) agreements* between governments and producing organisations. Economic actors may enter into these in order to forestall the introduction of market-based instruments or regulation.
- *Information/education-based instruments* e.g. Eco-labels, 'smart' meters, may be mandatory or voluntary.
- *Innovation instruments*, R, D and D spending, sectoral industrial strategies (some of the above instruments are also used to support innovation)

The EU 20/20/20 by 2020 Programme

- 20% cuts in carbon emissions (30% with international cooperation)
- 20% of renewable energy in final energy demand
- 20% reduction in energy use (below what it would otherwise be)
- Targets rolled out to Member States
  - E.g. UK 15% renewable energy by 2020; 16% cuts in GHG emissions from 2005 level from non-traded sector

ESD (Effort Sharing Decision on energy efficiency)

Source: http://ec.europa.eu/clima/policies/effort/index_en.htm)



The EU 2030 Proposals

- 40% cuts in carbon emissions (perhaps more with international cooperation)
- 27% of renewable energy in final energy demand EU-wide, 27% target for energy efficiency BUT
- No targets for Member States (so 27% purely aspirational and close to business-as-usual anyway)
- ‘Backloading’ EU ETS emission permits in an attempt to support the EU ETS price; further reform post-2020

EU energy and climate policy instruments

	Policy Landscapes			
Policy Instrument	**Carbon Pricing**	**Energy Efficiency and Energy Consumption**	**Promotion of Renewable Sources of Energy**	**Non-Carbon Dioxide GHGs**
EU ETS	✓	✓	✓	✓
Energy taxation Directive	✓	✓		
Effort Sharing Decision		✓	✓	✓
Energy Performance of Buildings Directive		✓	✓	
Ecodesign Directive		✓		
Energy Labelling Directive		✓		
Energy Efficiency Directive		✓		
Emission Standards for Passenger Cars		✓	✓	
CO2 Labelling for Passenger Cars		✓	✓	
Renewable Energy Directive			✓	
CCS Directive			✓	
F-Gas Regulations				✓
Landfill Directive				✓
Nitrates Directive				✓
LULUCF Accounting Rules				✓

Source: Drummond, P. 2013 'The European Union', report in the CECILIA2050 project ('Choosing efficient combinations of policy instruments for low-carbon development and innovation to achieve Europe's 2050 targets')

IPPC also seeks to promote energy efficiency

The rationale for environmental taxation

- Market failure leading to excessive pollution and environmental destruction
- More efficient than regulation; more effective than voluntary agreements and information
- The tax rate needs be set according to one of three aims:
  - Internalise external costs (Pigouvian tax 1932, need to know damage costs)
  - Achieve standards set on the basis of science and political feasibility (standards and pricing approach, Baumol and Oates, 1978)
  - Need to stimulate investment in desired alternatives (e.g. low-carbon, waste management technologies, cf UK Landfill tax)

The rationale for energy taxation

- Energy demand increases with income (income elasticity +0.5)
- Energy demand decreases with price (industry elasticity -0.6)
- Market failures for some energy efficiency technologies
- Improvements in energy efficiency lead to a rebound effect, and therefore save less energy than anticipated (up to 70%)
- Humans are extremely ingenious at finding new ways to use energy (heating drives, gardens, making artificial snow etc.)

Economic instruments: Green Taxes and Emissions Trading in the EU (1)

- Carbon-energy taxes:
  - Tax is a Member State (MS) competence, unanimity required
  - Efforts to introduce an EU carbon/energy tax in 1990s were unsuccessful
  - Differences in MS environmental taxation undoubtedly distort the single market
  - Energy Taxation Directive (2003) – low minimum energy taxes – was ultimately agreed
  - Unanimity on further EU stand-alone green tax initiatives in EU28 seems unlikely
  - Might be a case for more limited agreement, or for relaxing the unanimity requirement, if there is a case for EU-wide green taxes
  - Revision of Energy Taxation Directive – carbon and energy components

Economic instruments: Green Taxes and Emissions Trading in the EU (2)

- **EU Emissions Trading Scheme (EU ETS)**
  - Phase 1: 2005-2007
  - Phase 2: 2008-2012
  - Phase 3: 2013-2020
  - Speedy introduction of EU ETS a remarkable achievement; widely regarded as path-breaking, essential foundation for global emissions trading for climate change mitigation
  - Nevertheless, not without problems
  - Emissions reduction policies affect the permit price, not emissions, once the cap has been set

Economic instruments: Green Taxes and Emissions Trading in the EU (3)

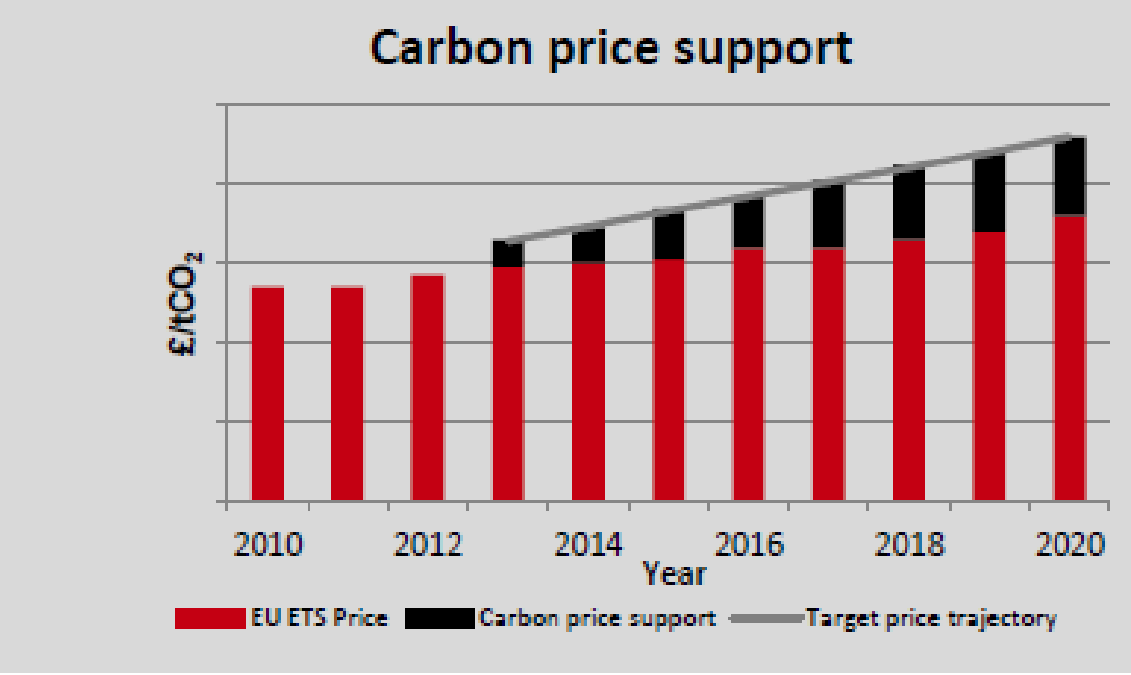
- Emissions trading – issues and problems:
  - New sectors (aviation)
  - Interactions with other schemes
  - Different MS National Allocation Plans distort competition in EU markets
  - Volatile allowance market gives little assurance for low-carbon investment
  - Calls from business for 'predictable carbon price' (although full predictability incompatible with trading)
  - Permit price pass through - evidence of 'windfall profits', especially in power generation
  - Widespread agreement that more allowances need to be auctioned
- Could an EU-wide carbon tax help?

The price of CO_2 under the EU ETS

Source: Environment Agency and Intercontinental Exchange, http://daily.sightline.org/2014/07/02/four-carbon-pricing-pitfalls-to-avoid/eu-carbon-prices-have-been-low-since-2008-chart-courtesy-of-european-environment-agency-and-intercontinental-exchange-used-with-permission/

Carbon price policy (UK)

- Commitment to increase proportion of tax revenue from environmental taxes (little progress so far)
- Carbon price support (£16/tCO2 in 2013, £30/tCO2 in 2020)
- Why not at EU level? Energy Tax Directive



How much will it cost?:

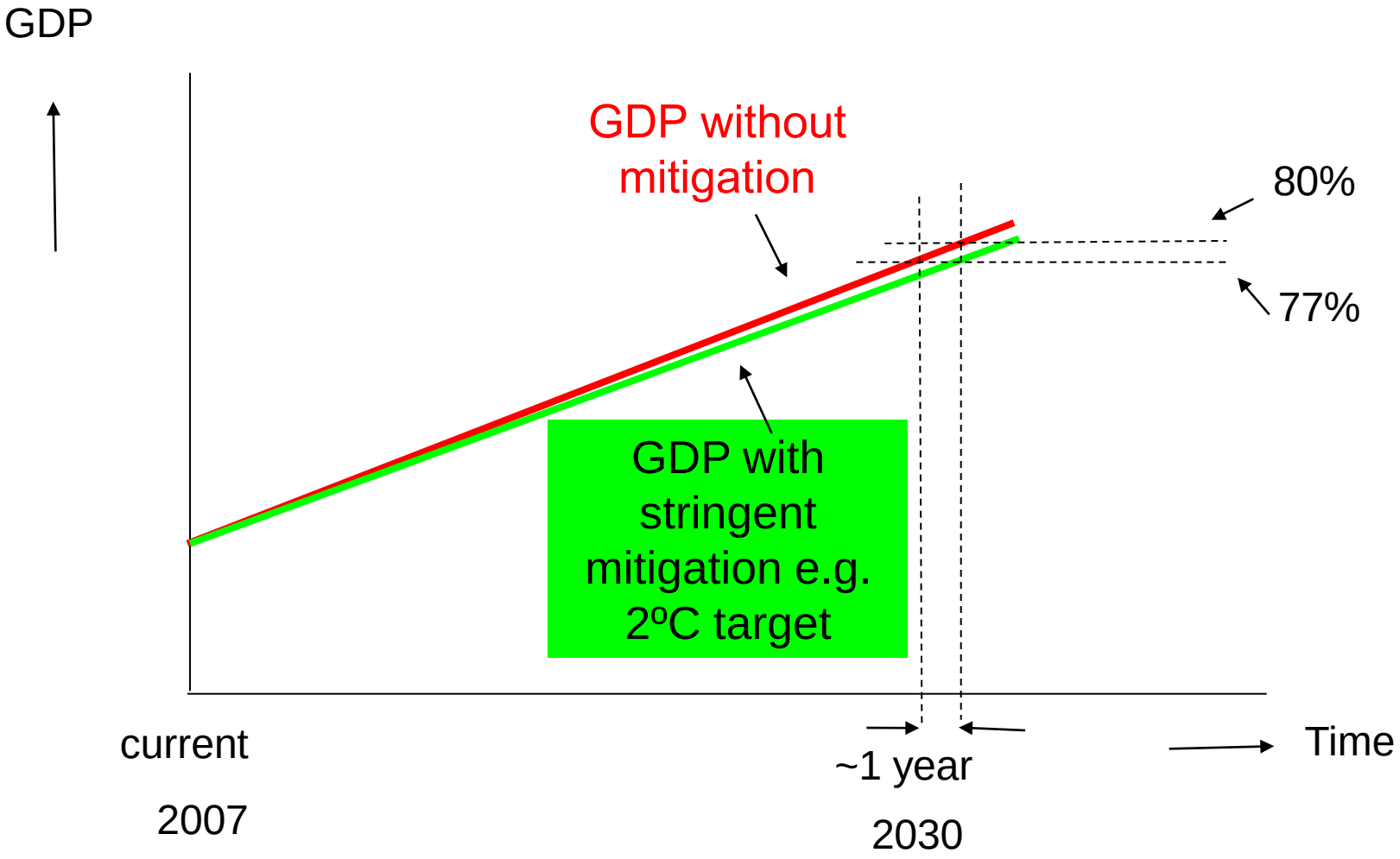
The (macro-economic) costs of climate change mitigation

- Pessimists:
  - Alternative energy sources are more expensive, are bound to constrain growth
  - Cheap, concentrated energy sources are fundamental to industrial development
- Optimists (broadly the Stern Review arguments):
  - 'Costs' are really investments, can contribute to GDP growth
  - Considerable opportunity for zero-cost mitigation
  - A number of low-carbon technologies are (nearly) available at low incremental cost over the huge investments in the energy system that need to be made anyway
  - 'Learning curve' experience suggests that the costs of new technologies will fall dramatically
  - Climate change policies can spur innovation, new industries, exports and growth

Estimating the macro-economic cost of carbon reduction

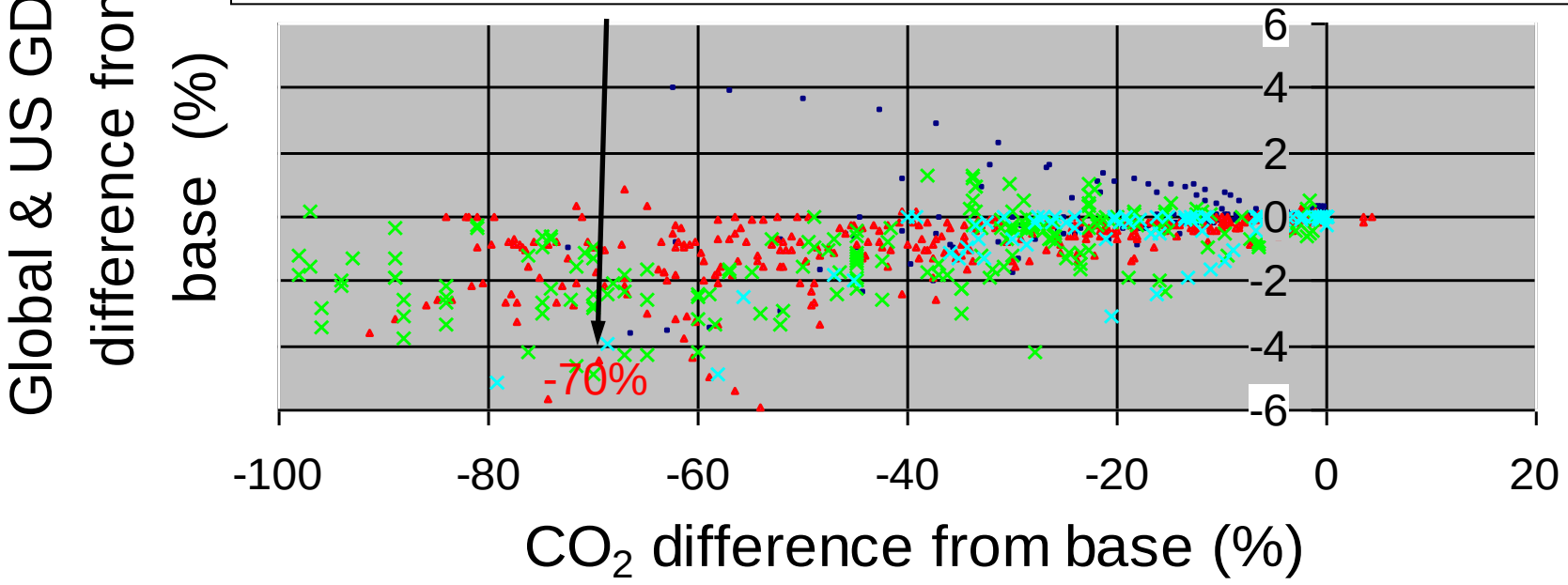
- Models are essential to integrate cost data in a representation of
  - The energy system (MARKAL): energy system cost, welfare cost, GDP cost
  - The economy : macro-econometric/general equilibrium models
  - Good models are 'garbage in – garbage out'; getting the inputs right
- Model results depend on three crucial factors:
  - The robustness of the model structure.
  - The plausibility of the input assumptions.
  - The quality of the data
- Stern's conclusion (p.267)
  - "Overall, the expected annual cost of achieving emissions reductions, consistent with an emissions trajectory leading to stabilisation at around 500-550 ppm CO_2e, is likely to be around 1% GDP by 2050, with a range of +/-3%, reflecting uncertainties over the scale of mitigation required, the pace of technological innovation and the degree of policy flexibility."
  - BUT costs depend on baseline used for comparison

Illustration of a 3% GDP cost number with 3% GDP growth per annum



Scatter plot of model cost projections, 2000-2050

Each point refers to one year's observation from a particular model for changes from reference case for CO2 and the associated change in GDP (from four sources, for periods over 2000-2050)



Projections from the 2011 UNEP Green Economy Report

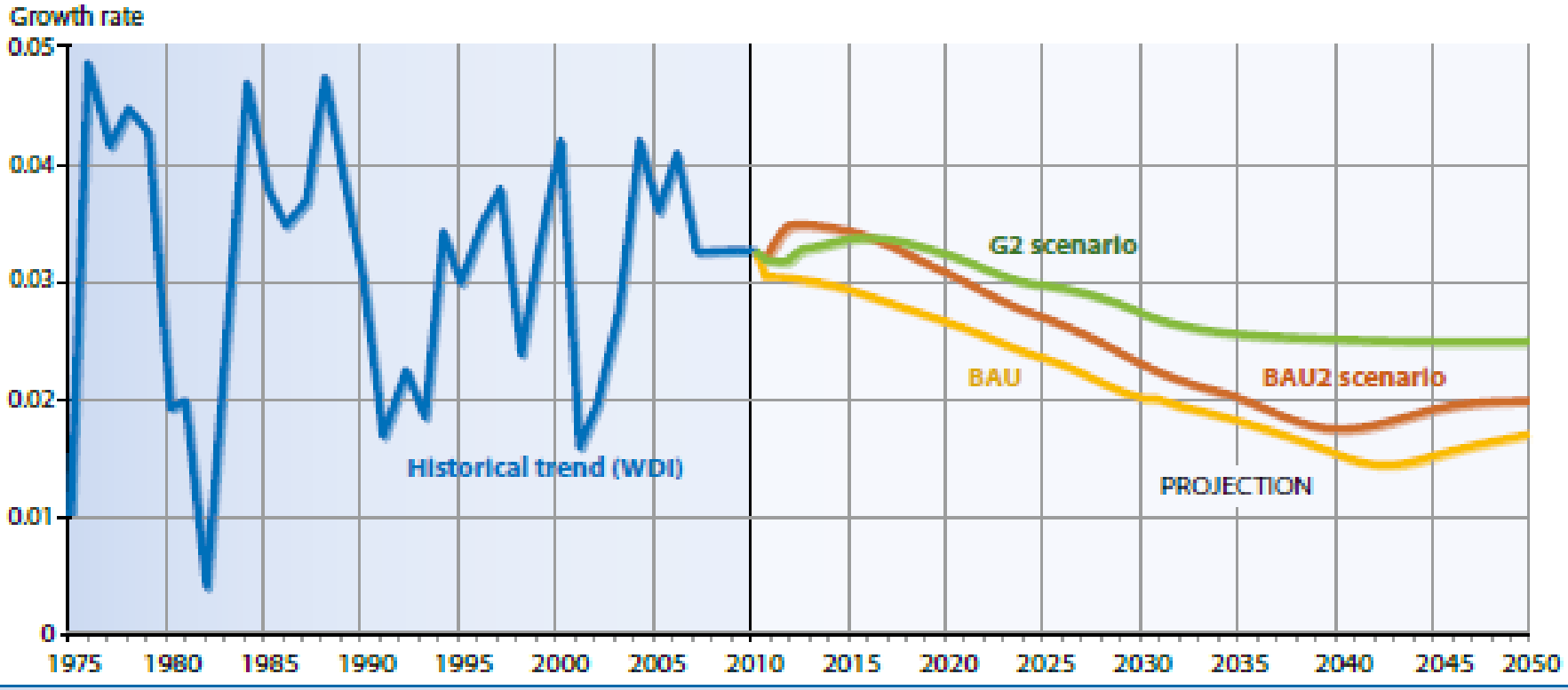


Figure 13: Trends in annual GDP growth rate, historical data (WDI, 2009) and projections in BAU, BAU2 and G2 scenarios

Conclusions on the economics of GHG abatement

- GDP costs of mitigation are relatively low (1-4% GDP) compared with possible climate damages
- These costs are also low compared to expenditures on health and insurance against risk
- With health co-benefits, there are net benefits from mitigation in many countries
- Fossil fuel importing countries with abundant renewables could experience net GDP and employment benefits by 2030
- The development of renewables technologies promises essentially limitless zero marginal cost electricity for the future
- Fossil fuel importing countries experience energy security benefits
- Investment in clean energy could be a major driver of development
- **Why then is decarbonisation so difficult politically?**

The cost/political feasibility paradox

- Need for active government policy:
  - Government funding of R,D&D will need to increase dramatically, but deployment and diffusion can only be driven at scale by markets.
- Need for large-scale investments:
  - Developing and deploying the technologies will require huge investments in low-carbon technologies right along the innovation chain (research, development, demonstration, diffusion).
- Need for shift to investment from consumption:
  - Financing this investment will require a substantial shift from the UK's consumption-oriented economy of today to an investment economy that builds up low-carbon infrastructure and industries.
- Need for higher savings and lower consumption rates
  - This need not have a major negative impact on GDP (incomes) and employment but may not be politically popular in a consumer society.
- Need for rising carbon prices
  - Stimulating the required investment will require high (now) and rising carbon prices over the next half century, to choke off investment in high-carbon technologies and incentivise low-carbon investments. These high carbon prices will also greatly change lifestyles and consumption patterns. This too is not proving politically popular.

Conclusion

- It is not technology or cost, that are the main constraining factors to moves towards environmental sustainability, but politics – people's attachment to consumption rather than savings/investment, and to high-carbon lifestyles causes them to resist the necessary sustained, radical policy interventions required to bring about technological revolution.
- Changing this political reality is the necessary condition for the adequate mitigation of climate change, and promotion of environmental sustainability more generally, which will alone avoid the potentially enormous, but still very uncertain, costs of global environmental change.

This is the challenge for 2015 (and beyond)

Thank you

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