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The Engineering Response to Climate Change: The International Dimension

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June 2007

Outline



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- Introduction
- Context: The Future Landscape
- The Economics of Transformation
- Issues in Technology Deployment
 - IPR, Public Goods and Competitiveness
 - Technical Standards
 - Regulation and System Change
- Role of Engineering Professions

Introduction: My Background (Abridged)



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- **UK Prime Minister's Strategy Unit:** Energy Policy; Climate Policy; Innovation and Wealth Creation; International Policy.
- **UK Foreign Office:** WSSD: G8 Renewable Energy Task Force; REEEP
- **MIT Energy Lab:** Energy Systems and Technology Policy
- **PowerGen:** Energy markets
- **GEC Energy Systems:** Power Station Engineering
- **Bristol University:** Mechanical Engineering (Energy Systems)

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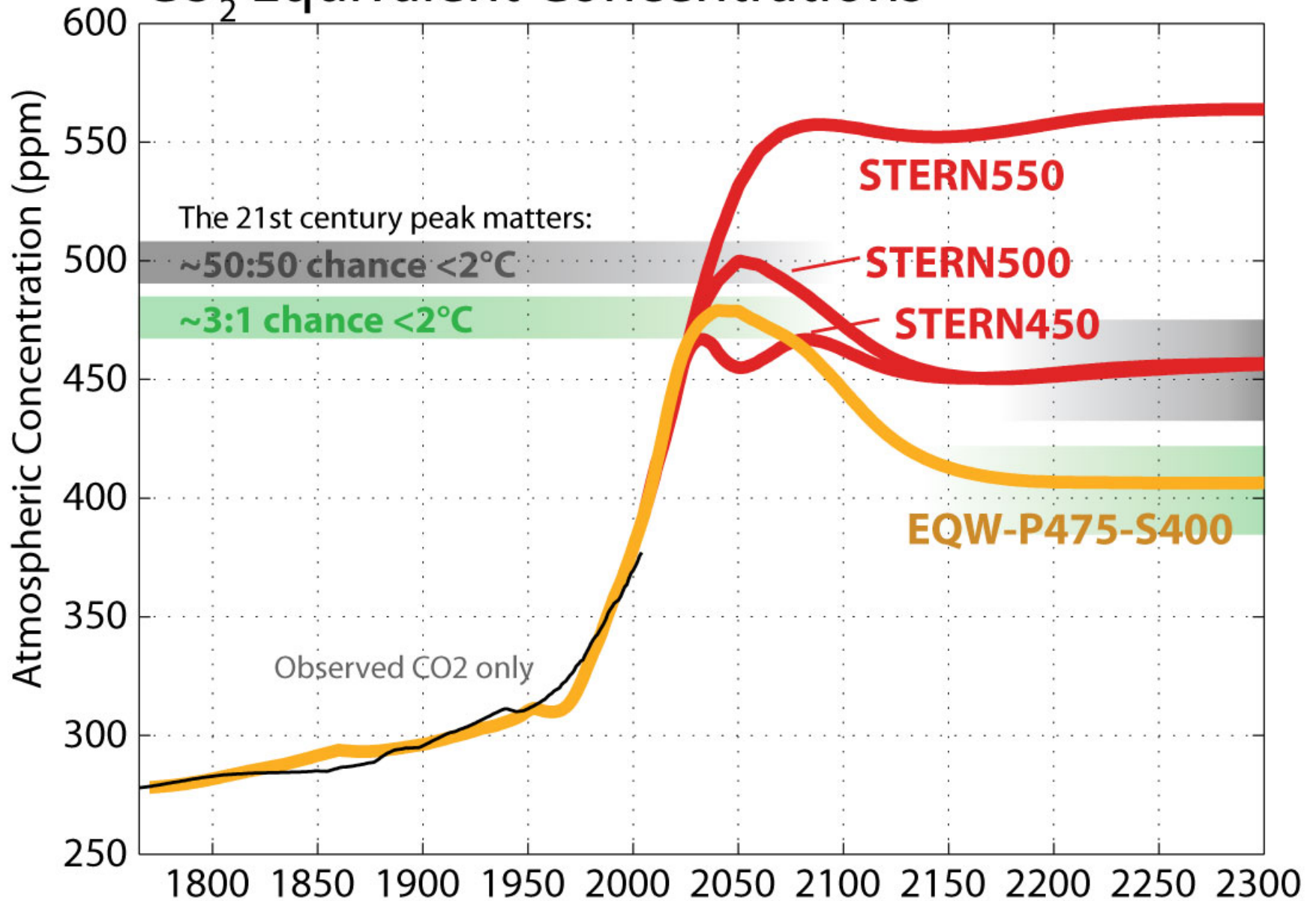
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What does the Climate need need from technology and engineering?



- **Rapid global diffusion of near-to-market low carbon technology:** “best-case” 2 degrees target depends on large scale renewables, CCS and critically efficiency deployment (60-70% of CO2 reductions).
- **New adaptation options:** 30 years before climate change slows-need new ways of designing robust, resilient and flexible infrastructure – in both developed and developing countries
- **A new generation of solutions:** need more radical technology – especially in bio-fuels, cars, planes, ships, and solar – to deliver from 2030 onwards (and help solve the hard politics of climate change).
- **Credible international collaboration mechanisms:** to lower the cost/risk of technology investment and to buy in major developing countries to a global deal.

CO₂ Equivalent Concentrations

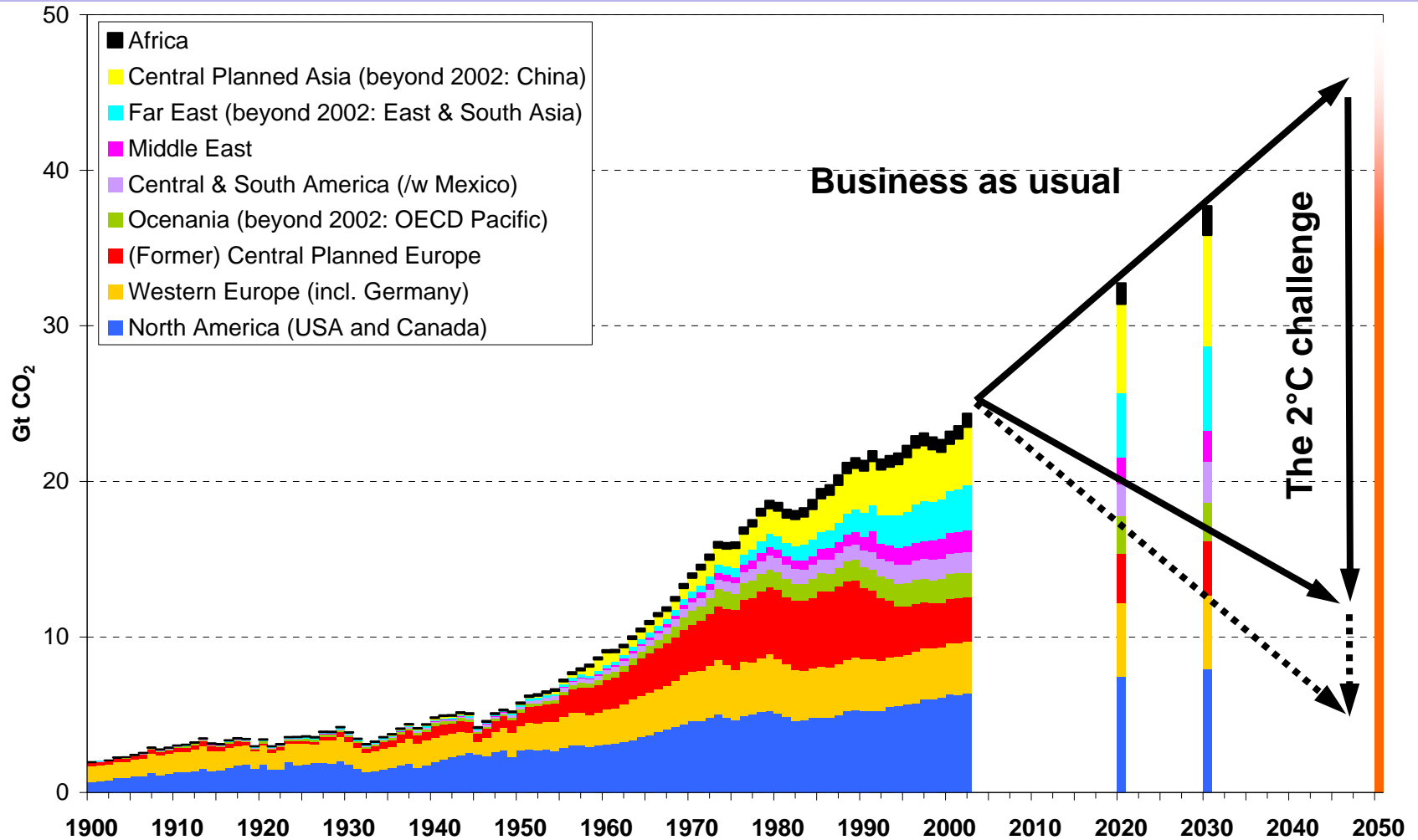


Source: M. Meinshausen (2006)

Emissions trends



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Next 20-30 Years will be different to the Past

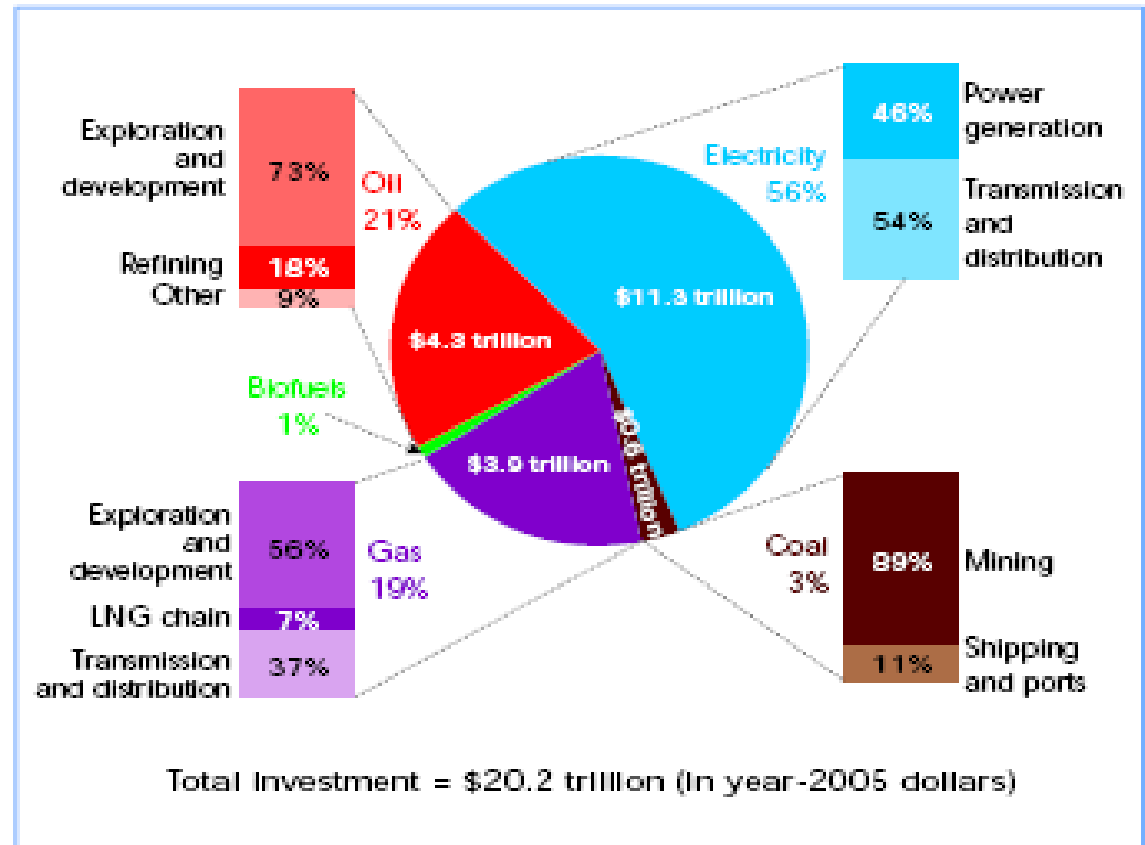


- **Changing global economic balance:** new carbon intensive investment is as much in Middle Income Countries as the OECD
- **Global Innovation Space:** Developing countries are producers not just a consumer of advanced technology
- **Global talent market:** high mobility of technical talent – 75% of Chinese students remain in western countries
- **Energy Security:** political priorities of energy security are driving investment into high carbon solutions using direct policy tools (spending, subsidy, regulation)

Power Generation dominates next 25 years of energy investment

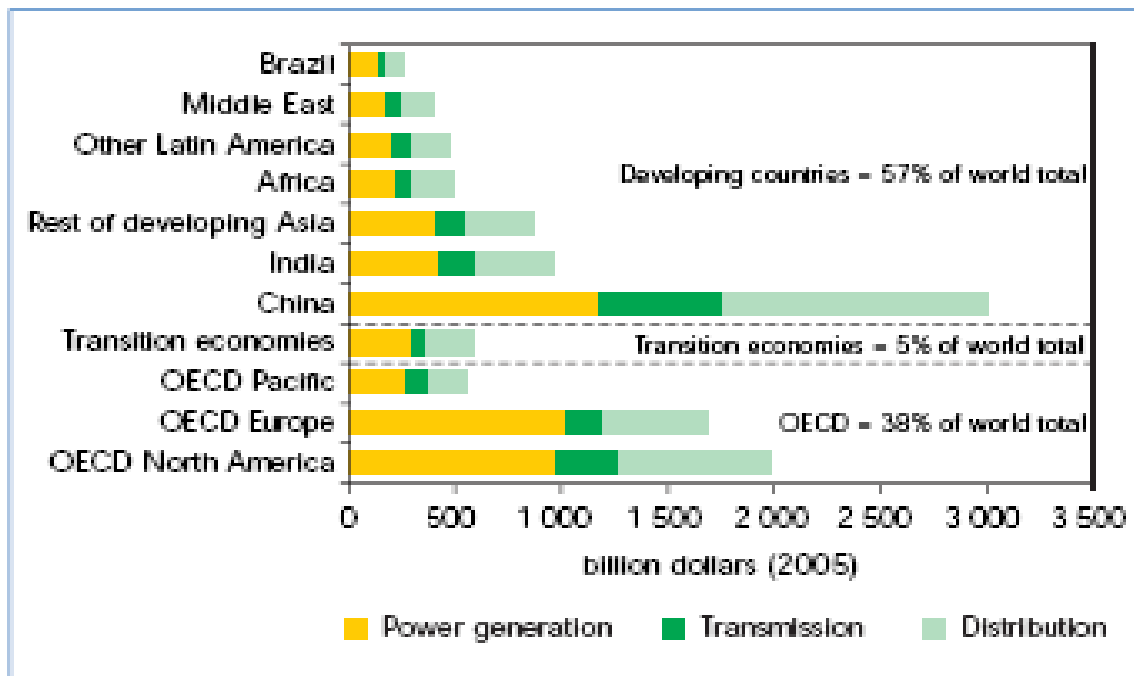
- IEA estimates that moderate climate change scenario (2040 peak):
 - reduces energy investment from \$19-21 trillion to \$9-11 trillion. \$2 trillion lost from power sector.
- Power sector:
 - \$1 trillion shift to efficiency
 - \$1 trillion to lower carbon supply options.

Cumulative Investment in Energy Infrastructure in the Reference Scenario by Fuel and Activity, 2005-2030 (in year-2005 dollars)



Investments focused on middle-income countries

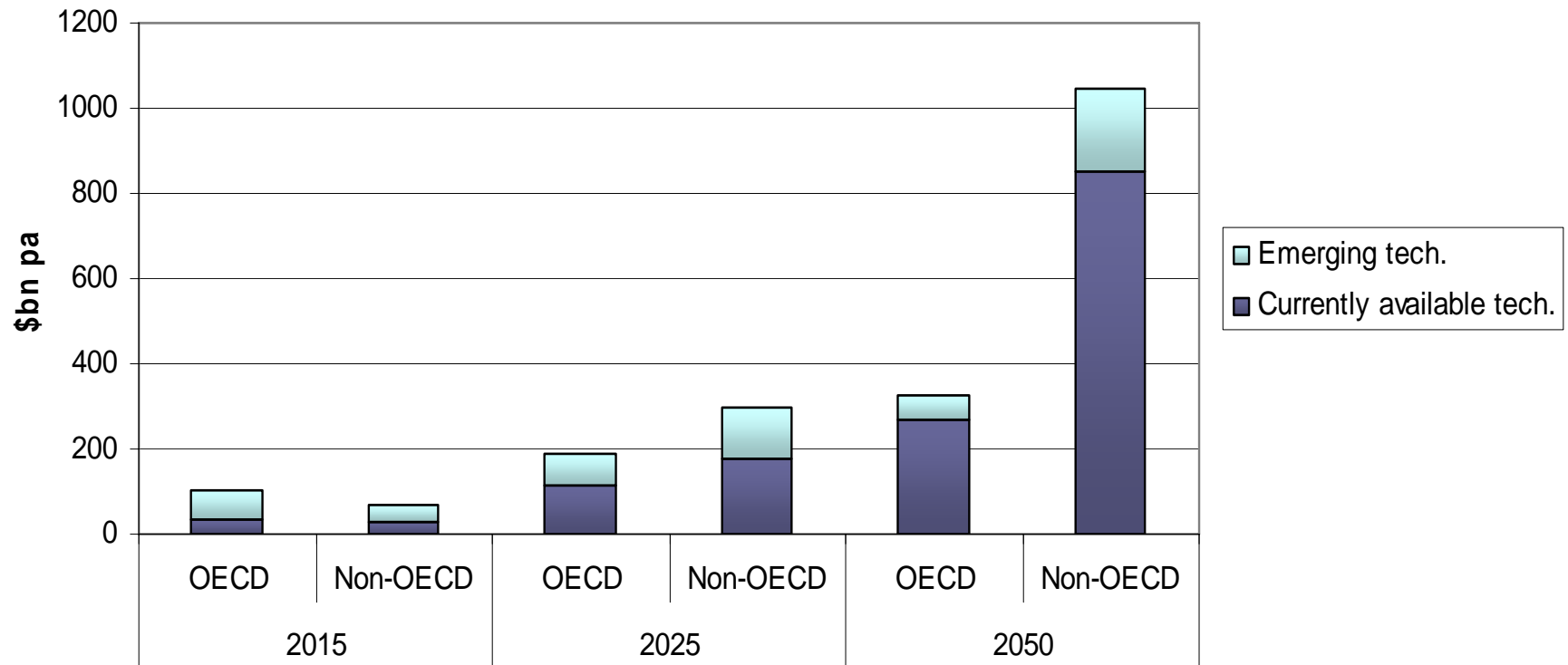
Cumulative Power-Sector Investment by Region in the Reference Scenario, 2005-2030



- A large part of all the energy investment needed worldwide is in middle-income countries, where demand and production increase most quickly.
- China alone needs to invest about \$3.7 trillion – 18% of the world total. Russia and other transition economies account for 9% of total world

Source: IEA, WEO 2006

Stern Report: Implied Low Carbon Technology Investments



Global Innovation and Talent Space



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Innovation is not confined to OECD countries – strong R,D&D policies in all major developing countries

- China: space; aircraft; nanotechnology; energy
- India: space; IT; nuclear energy
- South Africa: nuclear energy; coal-to-liquids
- Brazil: biofuels

GE has research hubs in US, Germany, India and China – but is still perceived as a US technology company!

Energy and Climate Security are public goods; markets will not automatically give right signals to shift major investment



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- Recent fossil fuel price increases dwarf equilibrium carbon price in Stern Review but are not leading to carbon-free economy
- Price rises and energy security are driving investment in climate instability:
 - rapid rise in coal power investment
 - coal to liquids investment in US and China
 - Large increase in carbon inefficient biofuels
- Impact on energy efficiency of high energy prices has been very slow, even in transport sector

Need coherent, clear and effective policy signals to drive investment to deliver energy and climate security together

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Economics of Transformation: From “What” to “How?”



Climate Change is unique challenge to drive global change in markets and technology towards a public good goal inside a specific timescale (outside WWII and Cold War).

Post 2012 framework needs to target three core activities:

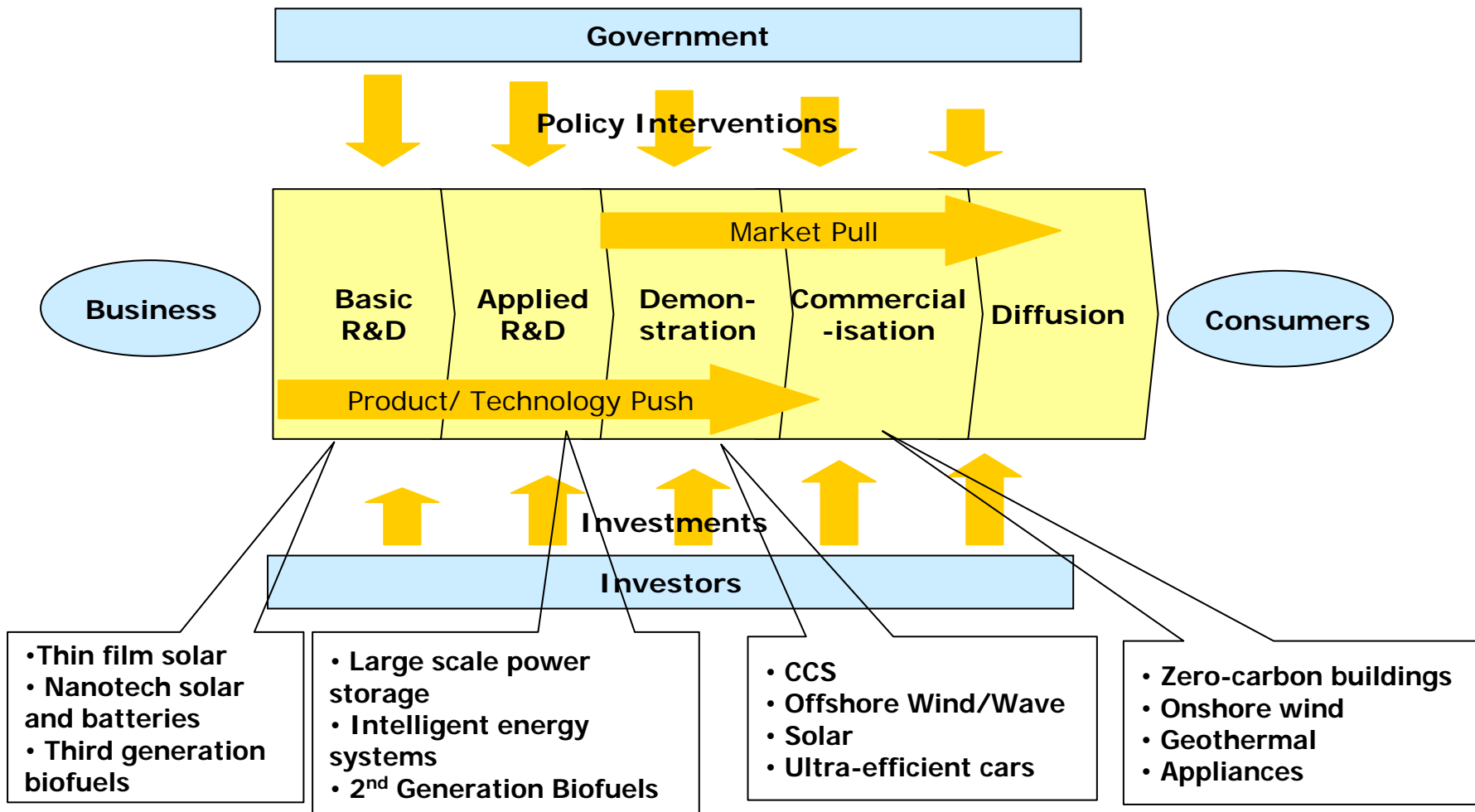
- **Investment:** consistent signals to investors to move on-going energy system investment towards low carbon alternatives.
- **Innovation:** produce sufficient “market pull” to generate radical investment in innovation in the next generation of low carbon technologies, services and businesses.
- **Institutions:** redesign the market, regulatory and business models currently shaping the energy system so they efficiently and effectively drive low carbon investment, and are increasingly sensitive to carbon price signals.

Very weak understanding of what is a robust system of incentives and institutions to drive the transition to a low carbon economy.

Innovation Chain is different for every Technology



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Technology: Pathways to deployment at scale are uncertain



Uncertainty around technological solutions under development....

Wind Energy	rate of cost reductions as global markets grow
Solar Energy	rate of cost reductions as global markets grow
Biomass Energy	cost-effectiveness of next generation technology
Nuclear Energy	cost-effectiveness and safety/proliferation characteristics of next generation technology
Carbon Sequestration	cost effectiveness and environmental integrity

and potential surprises.....

Solar Technology	appearance of ultra-cheap solar technology
Biotechnology	development of high efficiency cellulose conversion
Nanotechnology	development of ultra-efficient energy use technologies

Carbon Catch 22: balance of public and private investment depends on expectations and risk



- Decision makers are uncertain about the economic and technical feasibility of meeting ambitious cuts in CO₂, so set “fuzzy” carbon reduction goals;
- Many technologies will only be developed with immediate market pull rather than technology push. Companies will only invest if future markets are certain enough;
- Some options require investment in radical system transformation but new innovations could appear which make these redundant;
- Fear of being seen to “pick technological winners” and desire to put risk onto private sector is stalling more radical technological options.

Need to create a virtuous circle of demonstrating feasibility of emissions cuts so decision makers commit to credible targets for market pull

In medium term cannot eliminate core market risks



Markets will continue to discount future carbon price and “top-down” targets because:

- Political risks surrounding global carbon commitments
- Market risk due to immaturity in the sector – no understanding of market robustness
- Transaction risks due to lack of track record with purchasing and selling entities
- Technology risks in many sectors



Conclusion: What is needed?

Policy makers need credible ways to move technology development and diffusion which complements carbon markets and:

- Focuses on outcomes – not reliant on “magic of price mechanism”
- Leverages on-going investment in MICs
- Maximises use of global innovation networks
- Fits with energy security priorities in Middle income Countries
- Gives bespoke instruments in each sector balancing push and pull factors – there is no technology neutral solution
- Engages private sector as collaborators and competitors – understanding investor risk-reward balance

Engineering professionals need to be at the heart of designing technology pathways for critical technologies

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IPR, Public Goods and Competitiveness



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- Developing countries see technology transfer as a key objective in climate deal- for industrial policy reasons
- EU has sold “clean industrial revolution” on domestic competitiveness and climate grounds
- Large public investment in renewables, CCS etc producing IPR for private firms
- But this conflicts with strategic imperative of technology diffusion
- Need to develop a public technology licensing agreement with technology developers operating in developed countries?

Technical standards are key component to agreements



- Innovation and diffusion in buildings and transport will be driven by technical standards not price (and some parts of power sector?)
- Trade and investment driven deals with dynamic developing countries can lower costs and drive diffusion
- Need to link tariff barrier reduction, investment policy, mutual standards recognition and joint efficiency standard policies
- Need to design innovation into international and national standard setting policies

Industry regulation and system innovation



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- “Market pull” through carbon price excludes system innovation and is diluted by poor regulatory environment
- Waste of public money if technology pull instruments not linked to regulatory reform in energy and power sector. Need sectoral “Energy Charter Treaty Analogues” with reciprocal agreements on 3rd party system entry, energy subsidies, price transparency, unbundling, system incentives, investor treatment etc.
- Need focus on system innovation which will not be delivered by incremental investment: power sector – smart grids; urban design and infrastructure; transport systems; water systems etc.

Areas for Technology Cooperation?



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- Joint investment vehicles for power sector demonstrations: CCS; offshore wind; solar thermal
- Joint public sector fund for adaptation technology development; collaboration on remote sensing, mapping and response
- Low carbon free trade zone – EU-China?
- Low emission vehicles agreement – EU, China, California...?
- Public equity share vehicles in subsidised technology: CCS, offshore wind etc
- Regulatory protocols for clean power system investment: India; Brazil?
- Clean aircraft partnership: Airbus and China?

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A Unique Opportunity?



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Solving climate change requires replacing energy and materials use with intelligence and design

It will benefit all companies and sectors which depend on knowledge for their competitive advantage

Critical Areas for Engineering Professionals



- Project management of carbon policies
- Making innovation and investment considerations central to policy design
- Building technological and management capacity to drive new business models, system changes and public investment
- Developing adaptation capacity and response models

Project management of Carbon Policies



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- Managing national carbon budgets – especially on demand and efficiency side-is a massive project management task
- Current systems fail to integrate risk, investment cycles and production/capacity cycles. Critical reason that UK (and others) are “off-target”.
- Critical role at national and sub-national level to improve project management of complex infrastructure and investment challenges e.g. zero-carbon homes by 2017; 20% renewables; CHP roll-out.

Innovation and Investment in Low Carbon Policies



- Climate change requires step-change in innovation in mitigation and adaptation
- Need to ensure all climate change policies give strong incentives for new solutions:
 - Surprise technologies
 - New entrants from different sectors
 - New solutions – video conferences vs air travel
- Need to avoid investment lock-in to redundant technologies and systems – and justify investment in flexibility and resilience

Need much better innovation and deployment routemaps for critical technologies and sectors

Increasing technological and management capacity



- Will be a demand for increased and new technological capacity in many areas:
 - Basic R&D capacity: very high efficiency materials and systems;
 - To drive new business models: energy services versus supply provision; building energy system optimisation – supply and demand;
 - System changes – massive increase in embedded control in power network; building; transportation and appliances
 - Public investment – need for higher information and design content to ensure optimal development of critical public infrastructure

Developing Adaptation Capacity



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- Adaptation capacity will need to be increased to ensure resilience in critical public infrastructure:
 - Energy system design: hydro; fossil fuel extraction;
 - Water systems;
 - Sea defences;
 - Urban heat wave/flood resilience.
- Increasing capacity in urban areas in developing countries will be a key challenge.