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1530

Managing climate change and promoting growth, development and equity.

Nicholas Stern

Chaire Développement Durable au Collège de France
2009-2010 and IG Patel Professor of Economics and Government at LSE

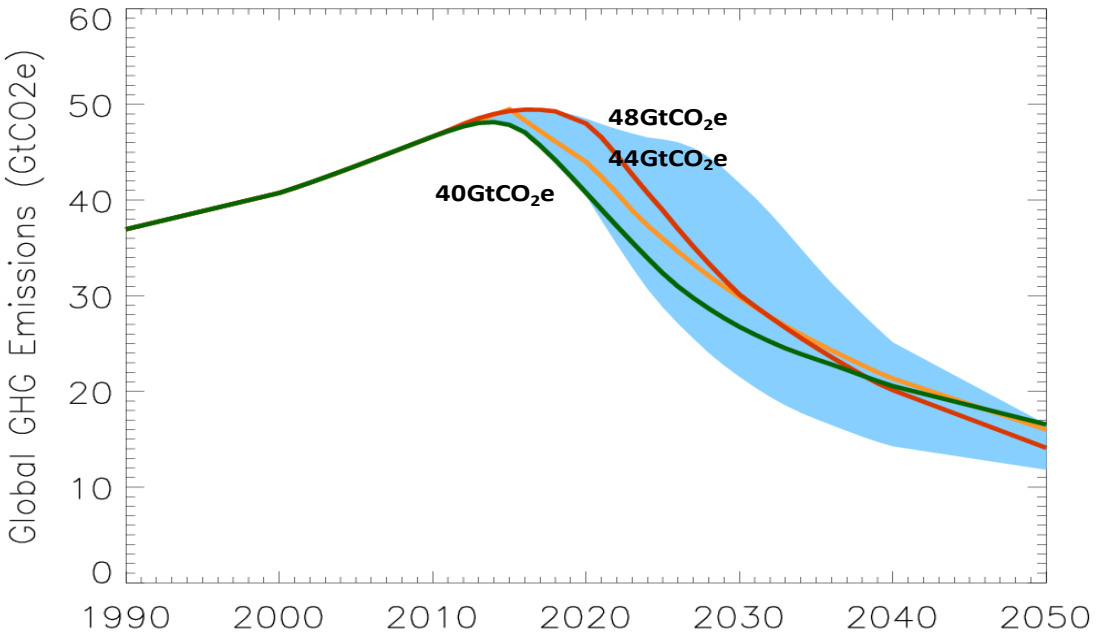
Lecture 3: Opportunities and policies for low-carbon growth in the developed and developing world.

Paris, 5 March 2010

Six Part Structure

- Part 1: Areas and instruments for action
- Part 2: Policy on the greenhouse gas externality
- Part 3: Technology
- Part 4: Combating deforestation
- Part 5: Costs of action
- Part 6: Low-carbon growth

Scale of action



- Holding below 500ppm CO_2e, and reducing from there, is necessary to give a reasonable (say 50-50) chance of staying below 2 degrees. This requires bringing emissions down from 47Gt CO_2e today to below **20Gt CO_2e** (approx. 50% of 1990 levels) by 2050.

- A plausible emissions path is around **47Gt** CO_2e in 2010 (reduced by economic slowdown – might have been 50), **44Gt** in 2020, **under 35Gt** in 2030 and **under 20Gt** in 2050. Likely to have to go **'well under'.** Clearly necessary to 'peak' before 2020.

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*These results are based on the Hadley Centre climate model MAGICC
Thanks to Jason Lowe and Laila Gohar for running these trajectories through the model.

Scale of action

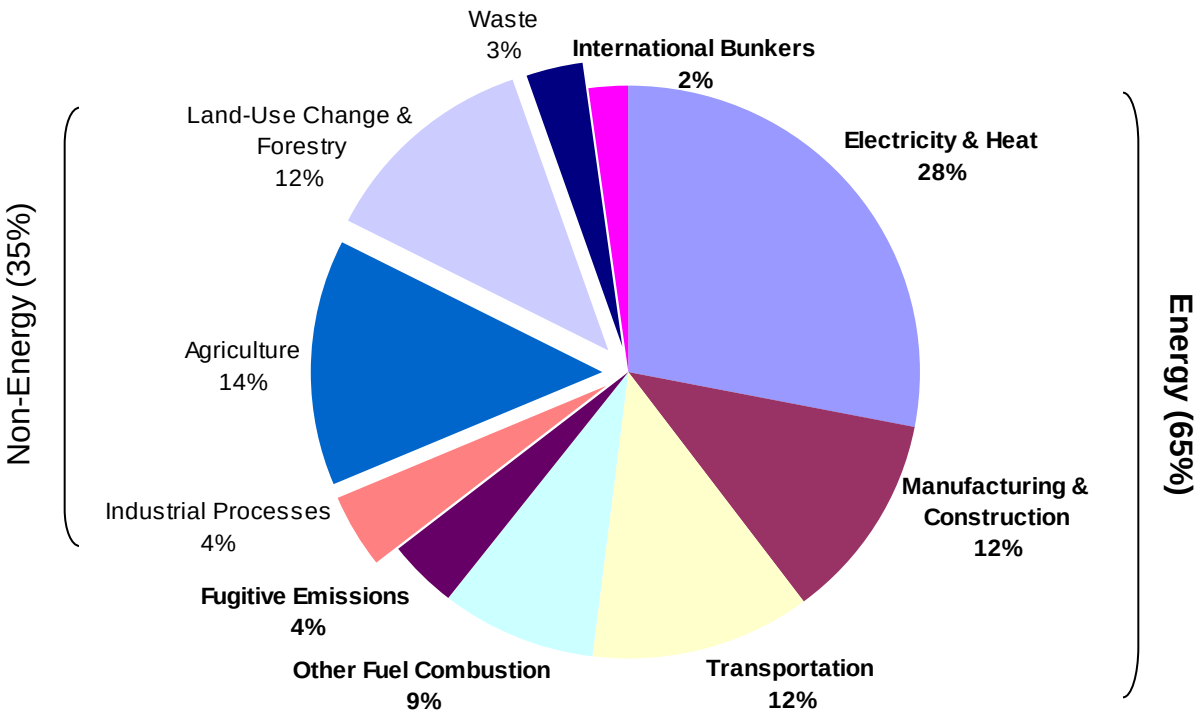
- A range of trajectories is possible – later peak years require stronger action later on: the total emissions over the next few decades will be key.

- As global population likely to be around 9 billion in 2050, these simple headline numbers imply average *actual* emissions around 2 tonnes per person p.a. in 2050. Since it is unlikely that there will be major blocks of population much below 2, there cannot be major blocks much above 2. *Actual* emissions clustered around 2 does not mean equal per capita permits to emit.

- Cannot afford any delays: a delay of 10 years in initiating action would be likely to increase the 'starting concentration' from around 435ppm CO_2e to over 460ppm CO_2e, making required reductions more costly or impossible, in achieving 2^{o}C.

- Emissions reductions for Europe involve 80% cuts 1990-2050 since average per capita in 1990 was 10-12 tonnes. Larger percentage cuts necessary for USA.

Sources of emissions



Based on 2005 global emissions (CO_2e).

Source: Climate Analysis Indicators Tool (CAIT) Version 7.0. (Washington, DC: World Resources Institute, 2010).

- Reductions on scale will require progress in: energy efficiency, new low-carbon technologies, halting deforestation. And action necessary in all sectors.

Areas of action: how to cut

- **Energy efficiency:** need to seek out ways of improving energy efficiency much more vigorously. Strong policy will increase incentives and reduce obstacles to improve energy efficiency.

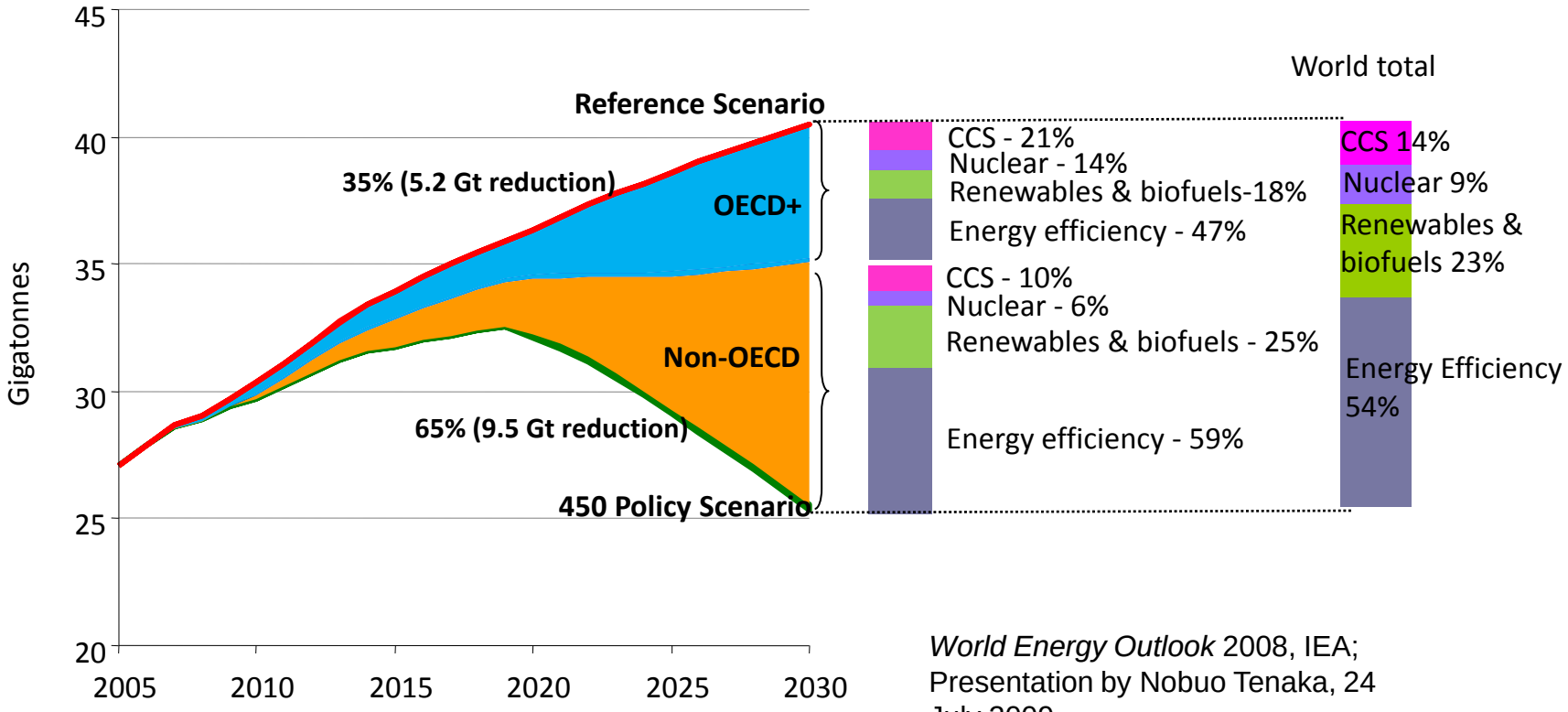
- Energy efficiency opportunities are available in most areas. Some are already acting strongly, e.g., Wal-Mart have achieved a 70% saving on energy in supermarket aisles by putting doors on refrigerated cases.

- **New technologies:** widespread advance in the development and diffusion of new technologies is required. Well developed carbon markets, taxation, regulatory and other policies will create a powerful stimulus.

- **Deforestation:** strong initiatives required, with public funding, to halt deforestation. Need to be incorporated into development programmes and preparations made to include avoided deforestation in trading (see Part 4).

Areas of action: how to cut

- Reductions in energy-related CO_2 to 2030.



World Energy Outlook 2008, IEA; Presentation by Nobuo Tenaka, 24 July 2009.

- Energy efficiency is the largest contributor.
- Renewables, nuclear and CCS also play key roles. OECD and non-OECD countries must both work towards reducing CO2 emissions.

Areas of action: incentives to cut

- Pricing the externality - carbon pricing via tax or trading, or implicitly through regulation.
- Bringing forward lower carbon technology - research, development, demonstration and deployment.
- Overcoming information barriers and transaction costs to promote energy efficiency – regulation, standards.
- Promoting a shared understanding of responsible behaviour – beyond sticks and carrots.
- Combating deforestation.

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The greatest externality the world has ever seen

- An externality arises when the actions of one person directly affects the prospects of another, e.g., discharging toxic waste into a river system.
- When we emit greenhouse gases we damage the prospects of others. Unless appropriate policy is in place we do not bear the costs of the damage.
- Markets therefore “fail” in that prices give the wrong signals; they do not reflect the true cost to society of producing and using goods and services.
- The biggest externality the world has ever seen: all are involved; the potential effects are global and very large.

An externality with a difference

- It is **global** in its origins and impacts;
- It involves major **uncertainty** in most steps of the scientific chain;
- It is **long-term** and governed by a **stock-flow** process;
- Effects are potentially on a **huge scale** and **irreversible**.
- The implications of these crucial features for policy action and analysis must take us way beyond standard microeconomic theories for externalities. But the standard theories are a starting point (see lectures 4/5 for global issues).

Standard policies for externalities

- **Taxes** (Pigou) – traditional policy to correct negative externalities: tax according to marginal damage.

- **Rights** (Coase) – if no transaction costs and well defined property rights, bargaining between agents will correct a negative externality. Agents are willing to pay other agents to reduce emissions if the others have property rights to emit; or if there are rights to be free of pollution then those who wish to pollute must pay others.

- **Internalising** (Meade) – the apple orchard could take over the bee-keeper and then take full account of the externalities. The residents could take over a polluting factory.

- Each of these has its advantages and difficulties depending on the circumstances of the externality. In general, information, administration and negotiation costs will be important.

- Optimum is where marginal social cost (MSC) of the damage. i.e., social cost of an extra unit of emissions, is equal to marginal abatement cost (MAC), i.e., cost of reducing emissions by an extra unit.

Pricing the externality

- **Tax:** the price of greenhouse gases is determined by the level of the tax. Tax is set according to marginal social damage associated with emissions level at which MSC and MAC are balanced.

- **Trading:** a fixed number of emissions permits is issued, the initial allocation of which is set by the government, and the market price is set through trading. With full information the total quota corresponds to the same amount of emissions as with the tax.

- **Regulation:** explicit rules or standards which may require changes to process or equipment. The implicit price is the additional cost divided by emissions saved.

How to set tax?

- Set tax rate where MAC and MSC are equal: requires estimating 'optimum' emissions levels – both MAC and MSC may vary sharply with emissions levels.

- MAC requires assumptions about ranges of technologies and their development which are very uncertain. And costs will depend on how well abatement is organised.

- MSC is calculated by estimating the damages created by an extra unit of emissions which will be present in stocks of greenhouse gases over very long periods: **very large possible range**.

- MSC depends very sensitively on a range of assumptions:
  - Future path of the economy and emissions (both highly endogenous);
  - Distributional and intertemporal values;
  - Assumptions on nature and magnitude of risk and uncertainty: strength of the carbon cycle, climate sensitivity, etc.

How to set quotas?

- Emissions permits to emit greenhouse gases are allocated as a basis for trading: if want to emit more must buy extra permits; if emit less can sell.

- Allocation of allowances must add up to the target post reductions or overall quota, which should be strongly influenced by the science and international agreements.

- How to allocate emissions permits? Auctioning or free-allocation? 100% auctioning should be objective. A permit is a financial asset. Why give it away to the shareholders of certain firms?

- Free allocation of permits based on previous years emissions is attractive to firms. It allows ‘no change’ as a policy and possible additional profits from trading. Potential problems: ‘special pleading’ leading to over-allocation; gaming whereby firms overstate past emissions, future plans or difficulties of adjustment, and gain substantial profits from selling their large ‘excess’ allowances.

Experience of EU-ETS

- Phase I (2005-2007): initial allocations of allowances almost free of charge. Based on historical emissions and existing plans (National Allocation Plans) and approved by the European Commission.

- A lack of transparency led to over-allocation and price volatility. Prices dropped sharply in April 2006 when markets realised the number of permits issued was more than expected. Total allocations and cuts they embody should be transparent.

- Phase II (2008-2012): allowance allocations much stricter and more transparent.

- Prices in 2008 were around €25 a tonne CO_2. Current prices are around €12-14 a tonne. The economic downturn has had a large impact on prices.

- EU-15 collective Kyoto target of 8% below 1990 levels for 2008-2012. Latest European Environment Agency projections - 13% below.

Comparing taxes and quotas

- **Administration:** In principle all 3 policies for pricing the externality involve measurement of emissions. But there may be short-cuts or proxies. For example, could have specific taxes on coal, gas and oil. Or could regulate to disallow any coal-fired power station without CCS.

- **Speed:** Cap and trade gives immediate quantity adjustment. Tax effects on quantities may take longer to come through.

- **Uncertainty:** Caps give quantity certainty but price uncertainty. Tax gives price certainty.

Comparing taxes and quotas

- Revenue: taxes give immediate revenue. Quotas provide revenue only when auctioned. But there is no medium-long-term argument for giving quotas away.

- Adjustment costs/options: quotas can be introduced initially with little auctioning with a move over time to auctioning. Eases costs of adjustment and political acceptability.

- Quotas allow international trading of emissions between rich and poor countries. Increases efficiency; provides private financing for emissions reductions in poor countries; and allows for wealth transfers through permit allocation.

- Tax and quantity (with full auctioning) approaches look similar if learn and review.

- As information arrives about the marginal abatement cost curve, policy can do better by adjusting the tax/quota than by keeping either tax or quantity fixed. Similarly as information arrives on dangers.

Uncertainty and volatility

- If MAC curve is fairly flat then a small ‘error’ in tax could lead to a big change in emissions; if MSC curve is steep then large changes could have severe consequences. Similarly if are setting quotas and MAC curve is steep and MSC curve is flat then an ‘error’ in quotas could be costly.

- Over medium term, MSC curve likely to be steep – damages rise rapidly with emissions; points to quota approach.

- Volatility of prices in trading can be managed by deeper, broader and more transparent markets. International trading valuable here. Also by ceilings and floors.

Pros and cons of regulation

- Avoids uncertainty for investors and enables scale economics: example of unleaded petrol.

- Industry often overstate costs:
  - US auto manufacturers estimated the cost of complying with 1995 low-emissions vehicle standards would be in excess of $1,500 above the cost of a comparable model. One year later Honda released a car with half the emissions of the 1995 standard. It cost $100 more than a comparable model (King Review, Part II, 2008).

  - Industry cost estimates for sulphur dioxide reductions, mandated under the US Clean Air Act Amendments (1990), were as high as $1,500 per tonne. Allowance prices were around $150 per tonne in 1999 (RFF, 1999). The average spot price paid in the 2009 auction of allowances was $89 per tonne (EPA).

- *"When Industry is required to lower pollution output it usually doesn't just slap a new filter on an existing process; it often invests in new technology."* (Goodstein and Hodges, 1997).

- New technology brings down costs. Hence initial cost estimates are often overestimated.

How is the combination of tax, quota and regulation likely to be settled?

- Given the different kinds of relative merits, there is likely to be a combination of tax, quota-cum-trading, and regulation. Should manage and reduce unnecessary overlapping to keep signals clear and coherent.

- For example, in Europe we see taxes on petrol, the EU emissions trading scheme covering approximately 40% of emissions, and regulations on cars and buildings.

- Criteria driving these combinations derive from the issues discussed above, with their different relevance for different sectors.

- Important to involve all sectors.

- Different countries have different politics: US seems to find regulation easier politically than taxation?

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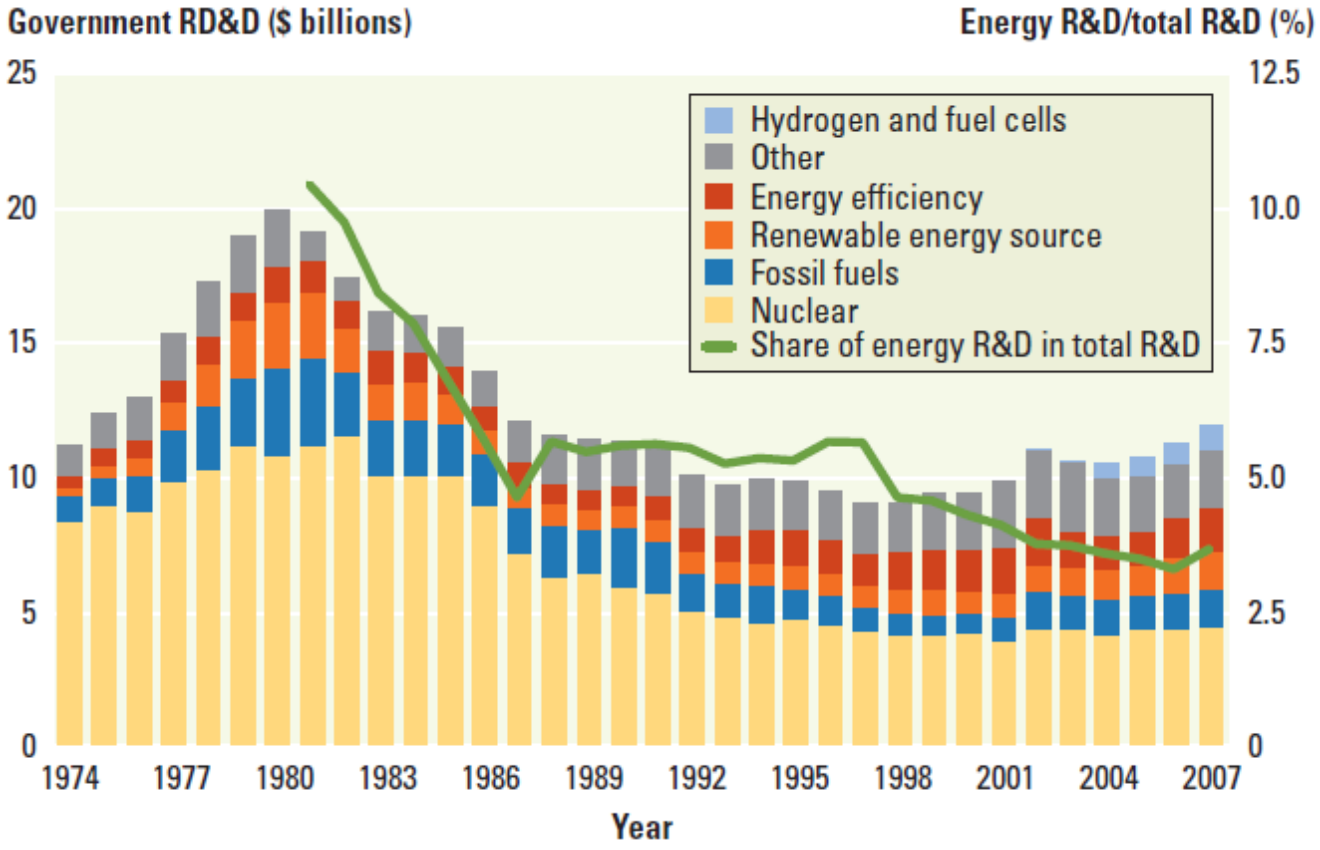
Ideas are public goods

- If I produce a new technology or demonstrate what is possible then many can use the knowledge and understanding. This is a positive externality.
- Thus large literature on role of public promotion of R&D. Includes theories of patents, etc.
- Global public energy R&D has declined significantly since the 1980s (see next slide). Private sector R&D has also declined.
- Evidence from the energy sector indicates that patents track public R&D closely, which suggests that public R&D spurs innovation.
- Arguments for public support for climate change technologies are still stronger than for supporting R&D generally because of scale of risks and urgency of action/costs of delay.

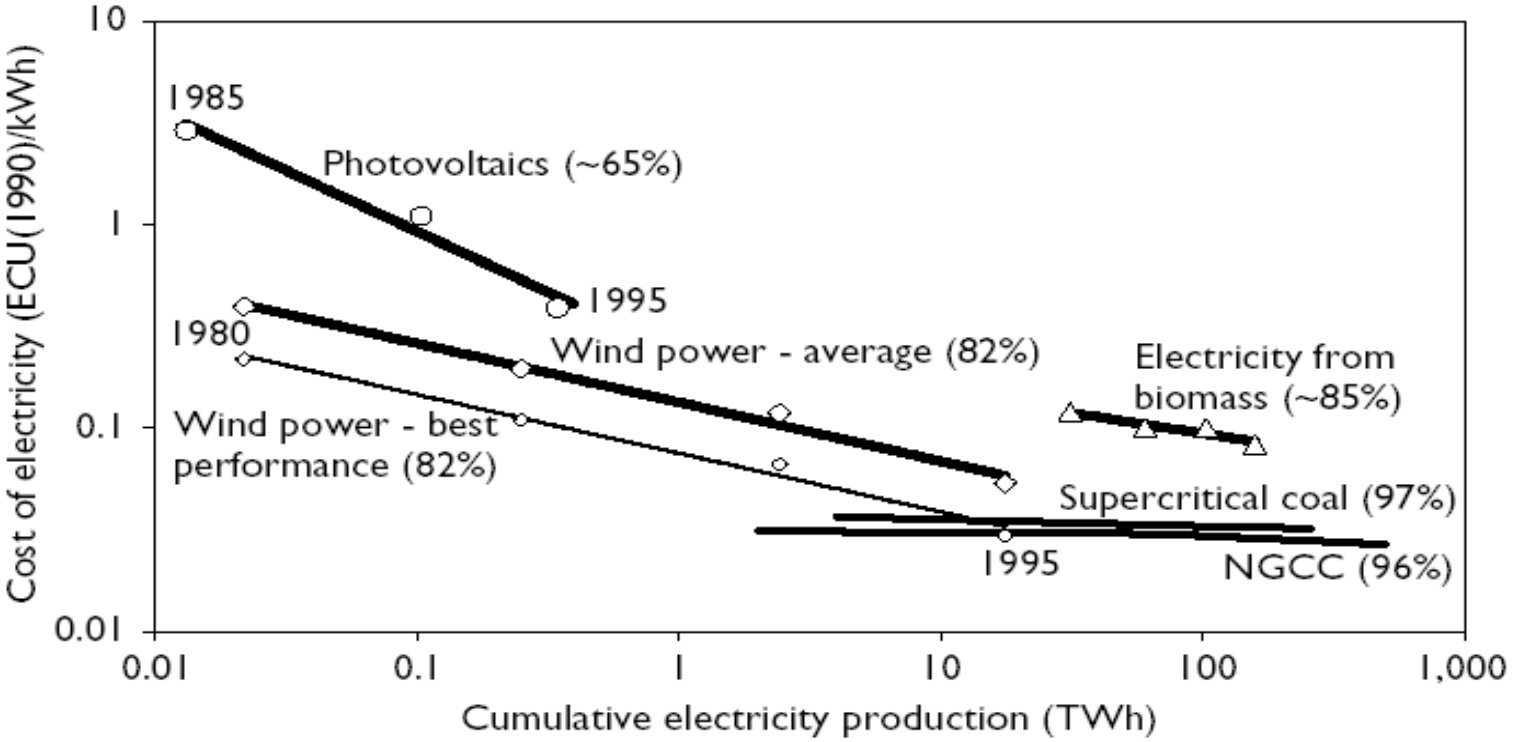
Public budgets for energy R&D



Source: World Development Report 2010, p 292. Note: RD&D calculated at 2007 prices and exchange rates.

Deployment and learning

- Not just R&D.



- One element of technology policy is public funding to support innovation and deployment of new technologies because learning depends on overall experience.

Searching and Finding

- DuPont, the major international chemical company based in the USA, has found savings of $2 billion per annum from careful scrutiny and action on waste, particularly concerning energy.

- The Carbon Disclosure Project (CDP) writes to the world's largest companies and challenges them to measure and disclose their carbon emissions.

  – Cisco Systems has reported through the CDP for 6 years. They have now produced software to measure energy usage across the organisation and have developed an emissions reduction goal, a 25% reduction on 2007 levels by 2012.

  – Logica plc has also reported under the CDP. They have reduced emissions across a number of business units, including a cut of over 11% in the last 18 months in their Indian operations. Logica have set an ambitious goal of a 50% cut in emissions across the global organisation by 2020.

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Extent of the deforestation problem

- Deforestation accounts for up to 20% of global emissions (much uncertainty – need for more reliable data). Similar to total emissions from US or China.

- Brazil, Indonesia, Malaysia and Congo account for 60% of emissions from deforestation.

- 13m ha forest cover lost in tropics every year (size of England) and produces 5.8 Gt CO_2 per year.

Deforestation and development inextricably linked

- Agriculture is the leading driver of deforestation emissions.
- Many agricultural activities very land intensive, e.g., Brazil has around one head of cattle per hectare. Some parts of Africa and Indonesia still close to slash-and-burn. In many parts of world forests are important source of fuel.
- Must increase the productivity and sustainability of agriculture. Increases in output/hectare essential to avoid additional pressure on forests.
- But much broader than this: policies for development are required that empower and protect the rights and livelihoods of those who depend on forests.
- Need to provide opportunities outside agriculture (education and health); need better governance for observation and enforcement; clearer and more effective property rights; monitoring of forests; effective forest authorities; legal structures; police; national parks.
- And stopping deforestation has many other benefits beyond climate change: biodiversity; water and soil erosion…

Policy and institutional reform required

- Need a price/reward for protection of forests.
- Need planning and conservation departments/institutions that are effective, together with effective monitoring and measurement.
- Important to operate on global scale to avoid international leakage. In other words must avoid simply moving deforestation from place A to place B.

Cost estimates

- The Eliasch Review (2008) estimates:
  - Including forestry in a global carbon market could reduce costs of mitigation globally by up to 50% in 2030.
  - Total of $4 billion over 5 years required to prepare the 40 forest nations for participation in forest market schemes – but the capacity story and rewards to capacity much broader than this.
  - The costs of not addressing deforestation at $1trillion/yr by the end of the century – probably underestimated.
- Cost estimates of halving deforestation globally:
  - $15 billion/yr (Stern) broadly consistent with estimates of Eliasch Review.
  - This would give CO_2 reductions of around 3-4 Gt at around $5 per tonne.

Ideas and planning

- Innovative ideas are emerging. Ecuadorian government prepared to avoid oil extraction in sensitive rainforest areas if developed countries pay $350m compensation for 10 yrs.

- Indonesia's National Climate Change Action Plan – rehabilitate 35m ha of degraded forest by 2025. Aim to prevent deforestation or degradation of 40m ha by 2025. Aim to reduce forest fires by 95% on 2006 levels by 2025. Need to support Indonesia further develop this plan – unable to achieve without international assistance and funding.

- Brazil aims to reduce deforestation in Amazon by 80% by 2020, saving 4.8 billion tonnes of carbon over this period. Eliminate net loss of forest cover by 2015. This is a key example. Support for the Amazon fund (Norway $1bn, UK also, see Waxman–Markey Bill passed in the House of Representatives).

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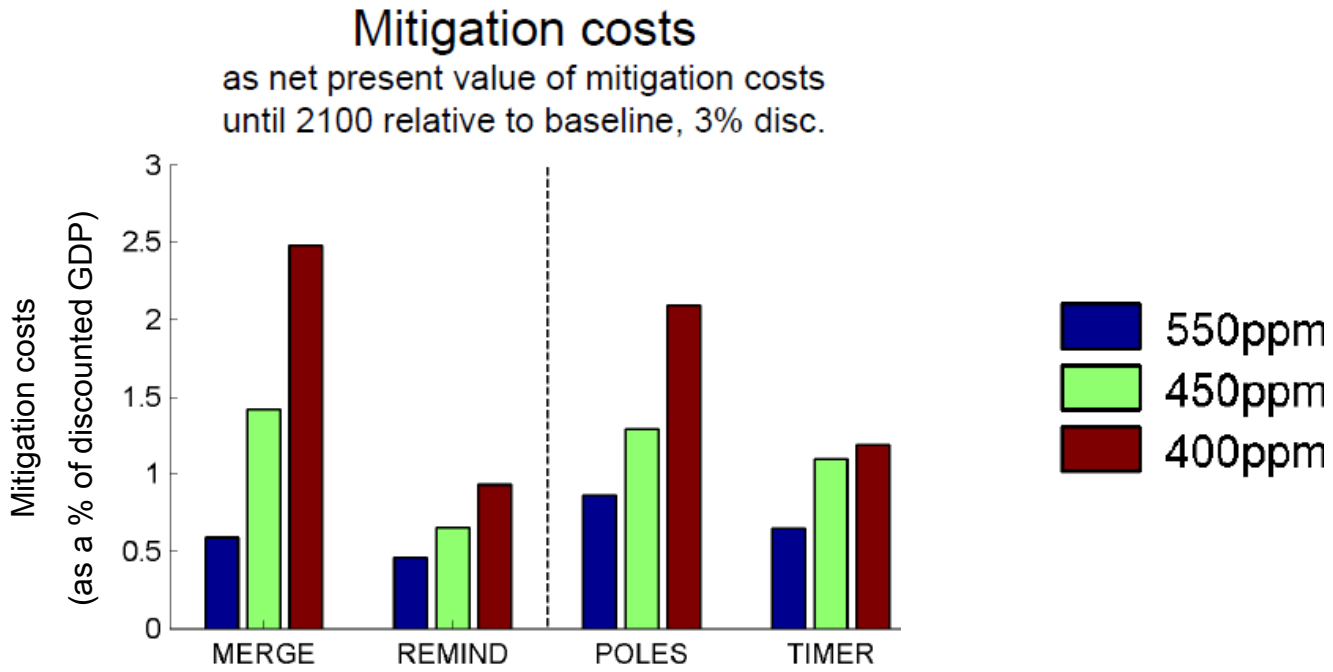
Costs: top-down

- Scale of reductions:
  - 30 Gt CO_2e p.a. in 2030
  - 60 Gt CO_2e p.a. in 2050
  - 60 x $30 per tonne = $1.8 trn; around 2% of likely 2050 global GDP.

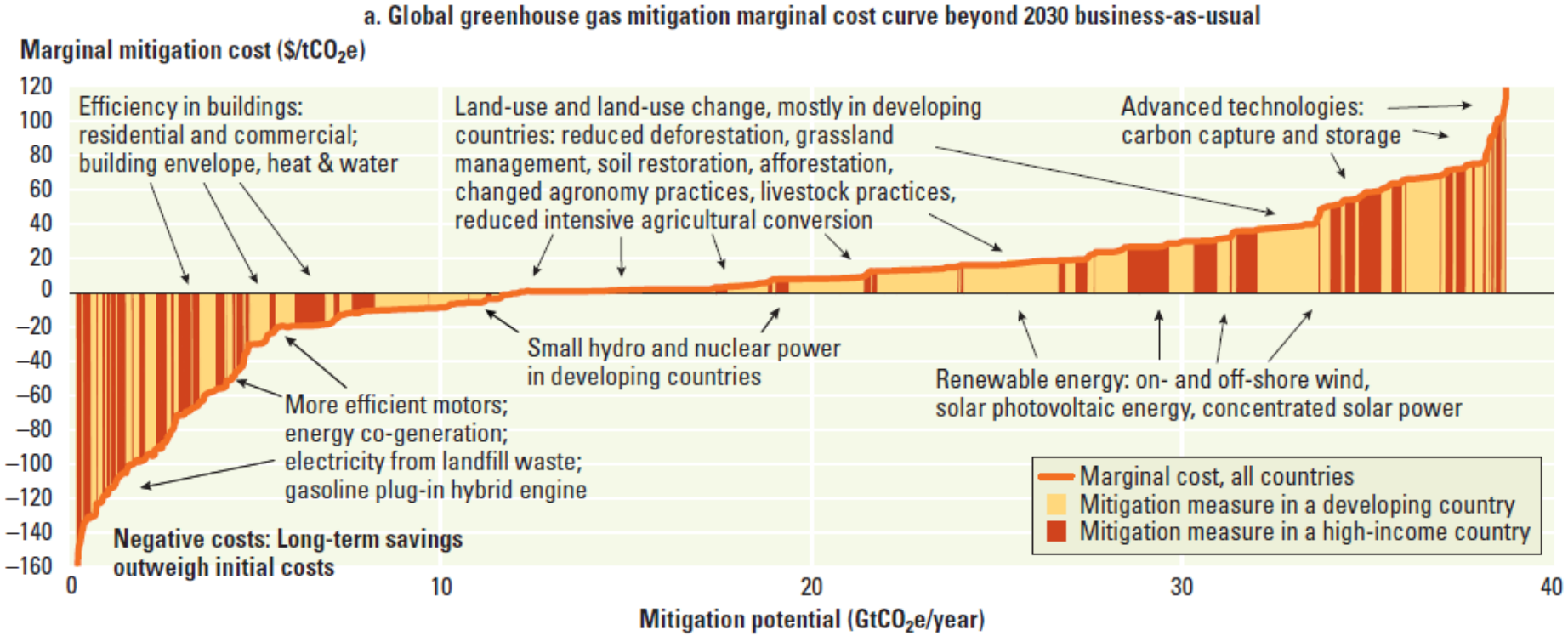


Source: Edenhofer et al., 2010, The Economics of Low Stabilisation: Model Comparison and Mitigation Strategies and Cost, The Energy Journal 31, 11-49.

Costs and ambition

- 1% of GDP Stern Review hold concentrations in the range 500-550 ppm CO_2e.
- 2% of GDP if 450-500 ppm CO_2e: since publication of Stern Review, the risks now look greater and we should, in my view, see 500 ppm CO_2e as a maximum and then attempt to reduce from there towards 450 or below.
- Policy is cheaper if it utilises otherwise unused resources (unemployed, underemployed, etc.).
- With strong technical progress costs could be reduced sharply.
- Many co-benefits from cleaner, safer, more energy-secure and more bio-diverse world.

Cost: bottom-up



Source: World Development Report 2010, p. 57 (Prepared by McKinsey & Company).

Costs and support to developing countries

- Clear financial commitments required to support action on mitigation and adaptation. Rich countries to provide US$50bn p.a. by 2015 to developing countries. This should rise to US$100bn p.a. in 2020 and US$200bn p.a. in the 2020s.

- Progress in developing countries over the next decade would be conditional on evidence of strong examples of action and sharing of technologies and substantial finance by developed countries. Many existing developing country plans are already conditional on developed country support.

- Immediate priorities – around US$15bn p.a. for adaptation in Africa and other vulnerable countries, a similar sum for both deforestation and technology (focus on R&D, demonstration and deployment).

- Developed countries should not articulate the immensity of the issue and the ‘crucial role’ of developing countries, and then claim support is unaffordable. US$50bn p.a. represents around 0.1% of likely rich country GDP in 2015. This is insignificant compared to the costs we will face if we fail to act strongly. Support must be additional to existing commitments on ODA.

- Progress made prior to and at Copenhagen on funding.

Costs and learning

- But is this ‘burden’ or ‘cost’ the right way to look at the issue of finding a new path?

- Think of investment and opportunity:

  – Huge opportunity for private investment. Many large long-term funds seeking opportunities.

  – Low-carbon economy will be one of the most exciting and dynamic periods in history; innovation, discovery, investment.

  – Low-carbon growth will be more energy secure, cleaner, quieter, safer, more bio-diverse.

  – High-carbon growth will kill itself, first on high hydrocarbon prices and, more fundamentally, on the hostile environment it will create.

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Growth theory: 20th century models

- Does going ‘green’ lower growth rates?
- Harrod-Domar g = s/v
- Feldman–Mahalanobis model. India’s 2nd 5 year plan (1956-61). Leontief input-output (I-O) models.
- Alternatively, marginal/incremental capital-output ratios (v) rise as a result of ‘extra’ costs of green technologies.
- v ↑ → s/v ↓ → g ↓
- Similarly, if in Leontief I-O structure, a higher input or capital coefficient is required: growth rates fall.
- This is the green as ‘burden’ or ‘anti-growth’ story.

Growth and learning: growth models of late 20th and 21st century.

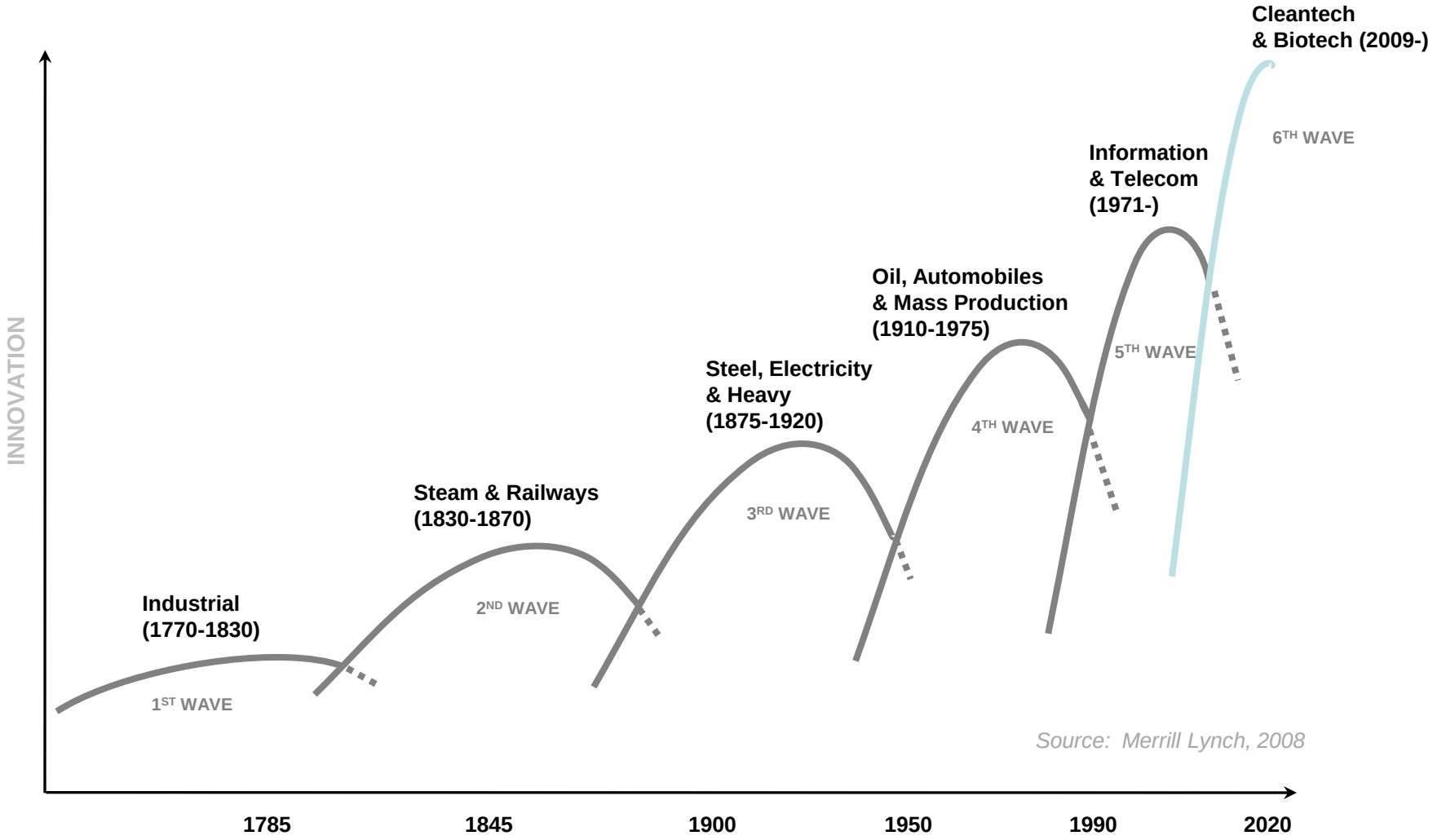
- Schumpeterian models of ‘endogenous growth’ and creative destruction; new firms and methods drive out old.

- Endogeneity of technological progress: learning from experience; trial and error; direct investment in R&D.

- Acemoglu et al. (2009) and Aghion et al. (2009): support for green technologies can accelerate learning.

- Will be many new goods and quality improvements.

Waves of innovation



Source: Merrill Lynch, 2008

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Pace of new technologies

- Solar energy (photovoltaic) prices have declined, on average, 4% p.a. over the past 15 years. Demand has grown by 30% p.a.

- The solar energy industry typically uses **price per watt peak (Wp)** as its primary unit of measurement (a watt peak is the direct current watts output of a solar module). The prices for high power band (>125 watts) solar modules has dropped from around $27/Wp in 1982 to around $4/Wp today.

- A solar module represents around 40-60% of the installed cost of a solar system. Total installed costs depend on type and size of installation.

- Must compare costs of delivered or local energy: generally generation costs in grid-based systems are around 1/3 of delivered costs.

(Source: www.solarbuzz.com)

Range of new ideas

- Buildings: solar, heat pumps, reflective roofing, ‘green’ roofing, smart meters.

- Agriculture: low-till, enhanced high-yield and disease resistance crop varieties, advanced irrigation systems.

- Transport: hybrid and electric vehicles, e.g., powered by new generation lithium-ion batteries and hydrogen fuel cells, next-generation bio-fuels (e.g., algae).

- Electricity: thin-film solar, wind, tidal, geothermal, nuclear fission.

Scale of markets

- In 2008, globally, a total of USD 155 billion was invested in 'green' companies and projects.
  - 'Green' financial investment in developing countries increased to USD 36.6 billion in 2008, a 27% increase on 2007.
  - China led 'green' investment in Asia, with USD 15.6 billion of new investment (mostly in new wind projects, and some biomass plants), an 18% increase on 2007.
  - China became the world's largest PV manufacturing base in 2008, with 95% of its production for the export market.
  - 'Green' Investment in India grew 12% in 2008 to USD 3.7 billion.

- HSBC's latest research on global 'climate revenues':
  - Global climate revenues rose 75% in 2008 to USD 530 billion;
  - Five countries account for 76% of global climate revenues: US and Japan around 20% each; France 17%; Germany 15%; and Spain 4%.

- The IEA suggests that an annual average of USD 1.3 trillion in clean energy investments will be required between 2005 and 2050 (over 80% will come from the private sector according to the UNFCCC).

Innovation and competition

- Competitiveness: little evidence of movement to ‘dirty’ places; climate policies only one determinant of plant and production location decisions (See Stern Review Chapter 11).

- Global or sectoral agreements can significantly reduce any loss in competitive advantage from climate policy.

- Risks of losing ground if stay ‘dirty’ or being ‘shut out’. Both for firms and countries.

  – Climate change is becoming a key dimension of competition in a low-carbon economy.

  – Increased risks of stranded assets - either as a result of climate change or rising carbon prices.

  – Increased reputational risks - changing attitudes of investors & customers.

Action plans in developing countries

- India:
  - 8 missions: Solar; Enhanced Energy Efficiency; Sustainable Habitat; Water; Sustaining the Himalayan Ecosystem; Forestry; Sustainable Agriculture; Strategic Knowledge for Climate Change.

- China:
  - 40-45% reduction in carbon intensity 2005-2020;
  - Significant progress in transformation to a low-carbon economy through low-carbon vehicles, energy efficiency, renewables and low-carbon buildings;
  - Increase share of non-fossil fuels in primary energy to 15% by 2020;
  - Increase forest coverage by 40 million hectares;

- Brazil:
  - 80% reduction in deforestation by 2020; eliminate net loss of forest coverage by 2015.
  - Efficiency improvements, e.g., National Policy for Energy Efficiency, replacing old refrigeration units, solar hot water heating, phasing out the use of fire for clearing and cutting sugarcane, etc.
  - Preserving the high share of renewables (48.5%) in energy generation.
  - Encourage sustainable increase in biofuels.

Ethiopia: MERET project

- The MERET project is a joint venture between the Ethiopian government and the World Food Programme to assist communities rehabilitate land and ensure food security.

- *"…millions of hectares have been rehabilitated, half a billion trees planted and, since the project went operational, over two million people have ensured food security in areas that had for long been severely degraded ."* Dr Aberra, State Minister of Agriculture and Rural Development, December 2009.

- Development/Adaptation/Mitigation intertwined.

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