Facts & Trends to 2050

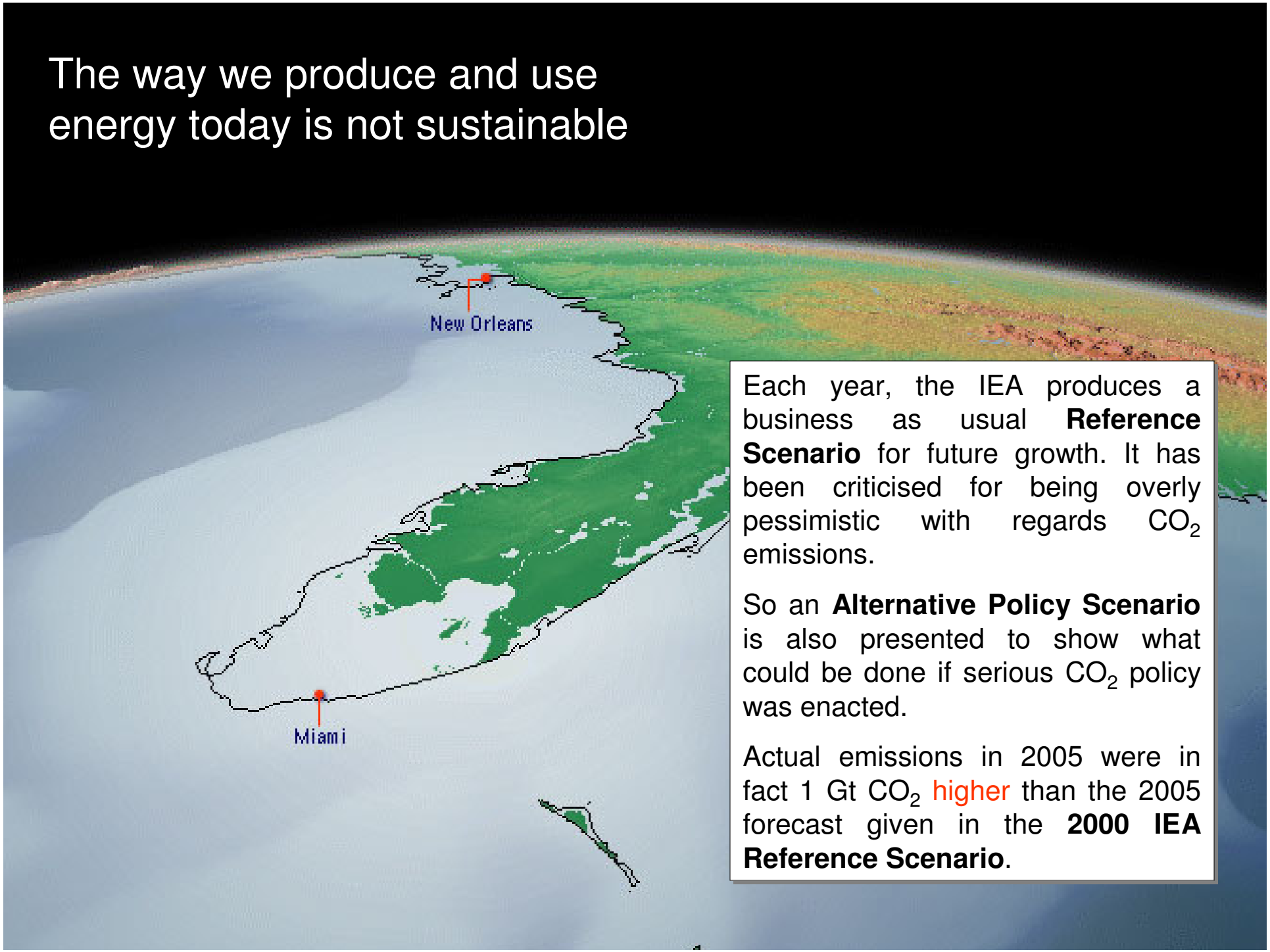
An overview of the WBCSD trilogy of publications

- Facts and Trends to 2050
- Pathways to 2050
- Policy Directions to 2050

World Business Council for Sustainable Development
Energy and Climate

World Business Council for
Sustainable Development

The way we produce and use energy today is not sustainable



Each year, the IEA produces a business as usual **Reference Scenario** for future growth. It has been criticised for being overly pessimistic with regards CO_2 emissions.

So an **Alternative Policy Scenario** is also presented to show what could be done if serious CO_2 policy was enacted.

Actual emissions in 2005 were in fact 1 Gt CO_2 higher than the 2005 forecast given in the **2000 IEA Reference Scenario**.

A new direction
is needed

This presentation . . . .

This presentation discusses future energy options in the context of a long term atmospheric concentration of CO_2 of no more than 550 ppm.

The options discussed are not a scenario, but an illustrative hypothesis to gauge the extent of change needed in our energy infrastructure and the impact that might have on industry.

The presentation is not an endorsement of any particular pathway, technology or specific atmospheric concentration target, nor is it meant to lay out a set of 'must do' policy approaches.

Our energy system

Primary Energy

Liquids

Direct combustion
Industry and
Manufacturing

Energy

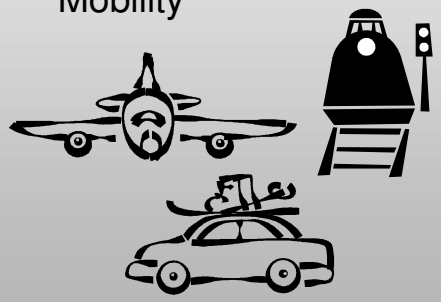
Power
Generation

Energy

Energy

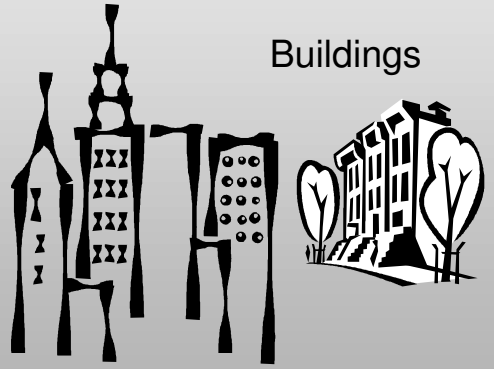
Final Energy

Mobility

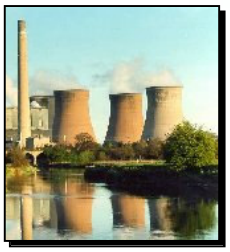


Consumer
Choices

Buildings



What is one Giga-Tonne per year of Carbon?



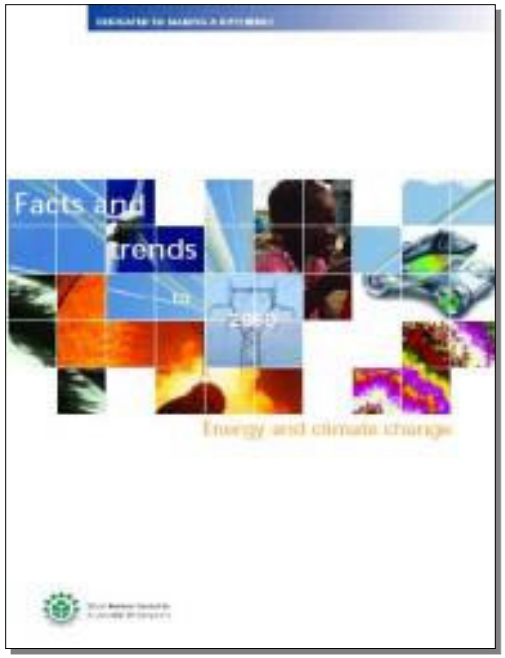
. . . about 700 modern 1 GW coal fired power stations

. . . about 1400 1 GW CCGT power stations

. . . about 600 million of these

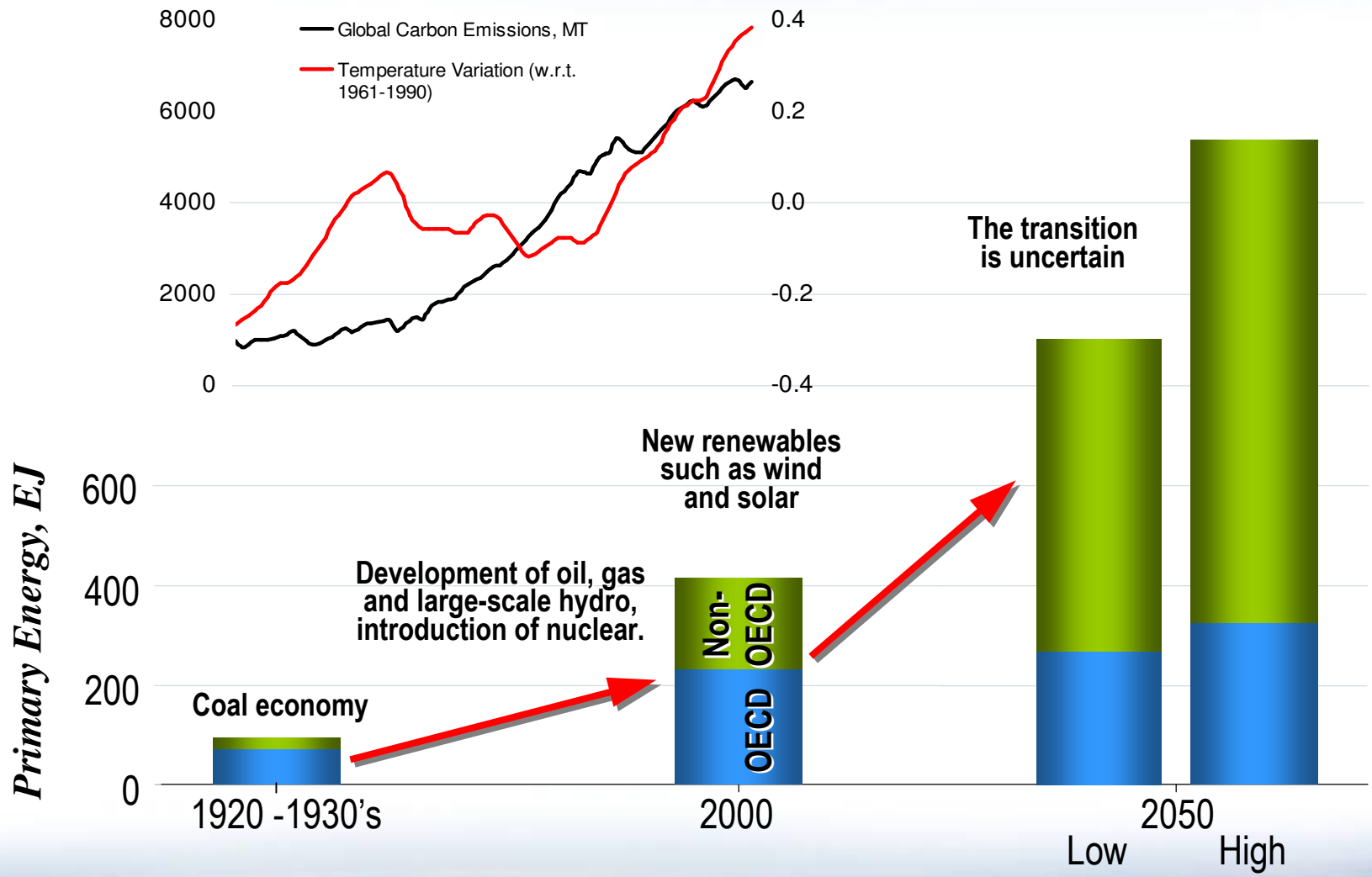
. . . or more than one and a half billion of these

Facts and Trends to 2050



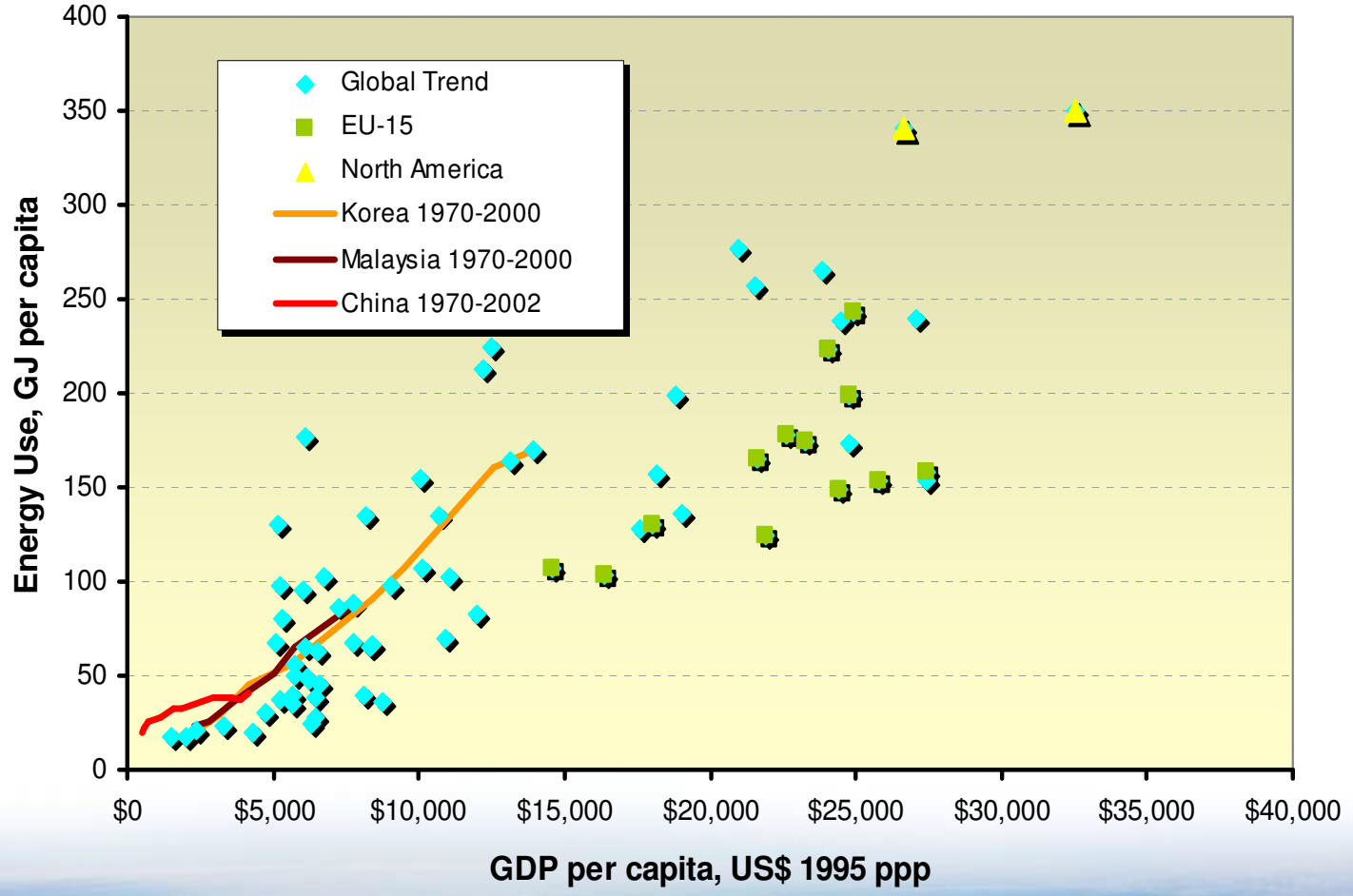
Published in September 2004, *Facts and Trends to 2050* examines the relationship between energy and climate change.

How will our Energy Infrastructure Develop?



Growth, Development and Energy Demand

- Basic premise – energy use and growth are strongly linked



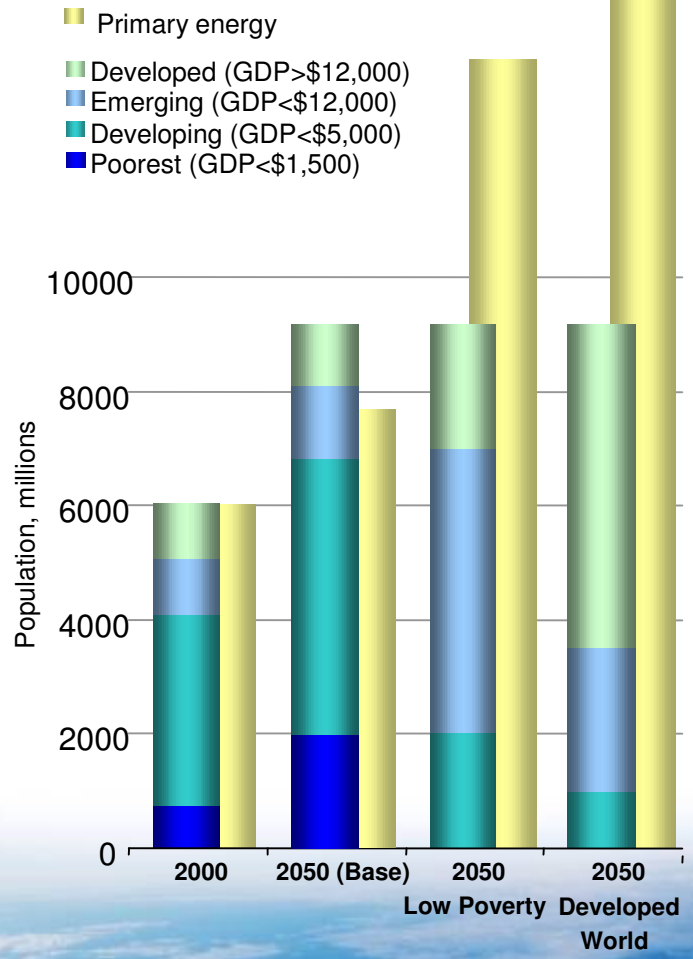
Growth, Development and Energy Demand

Global population divided into income groups;
- Poorest (GDP < $1,500)
- Developing (GDP < $5,000)
- Emerging (GDP < $12,000)
- Developed (GDP > $12,000)

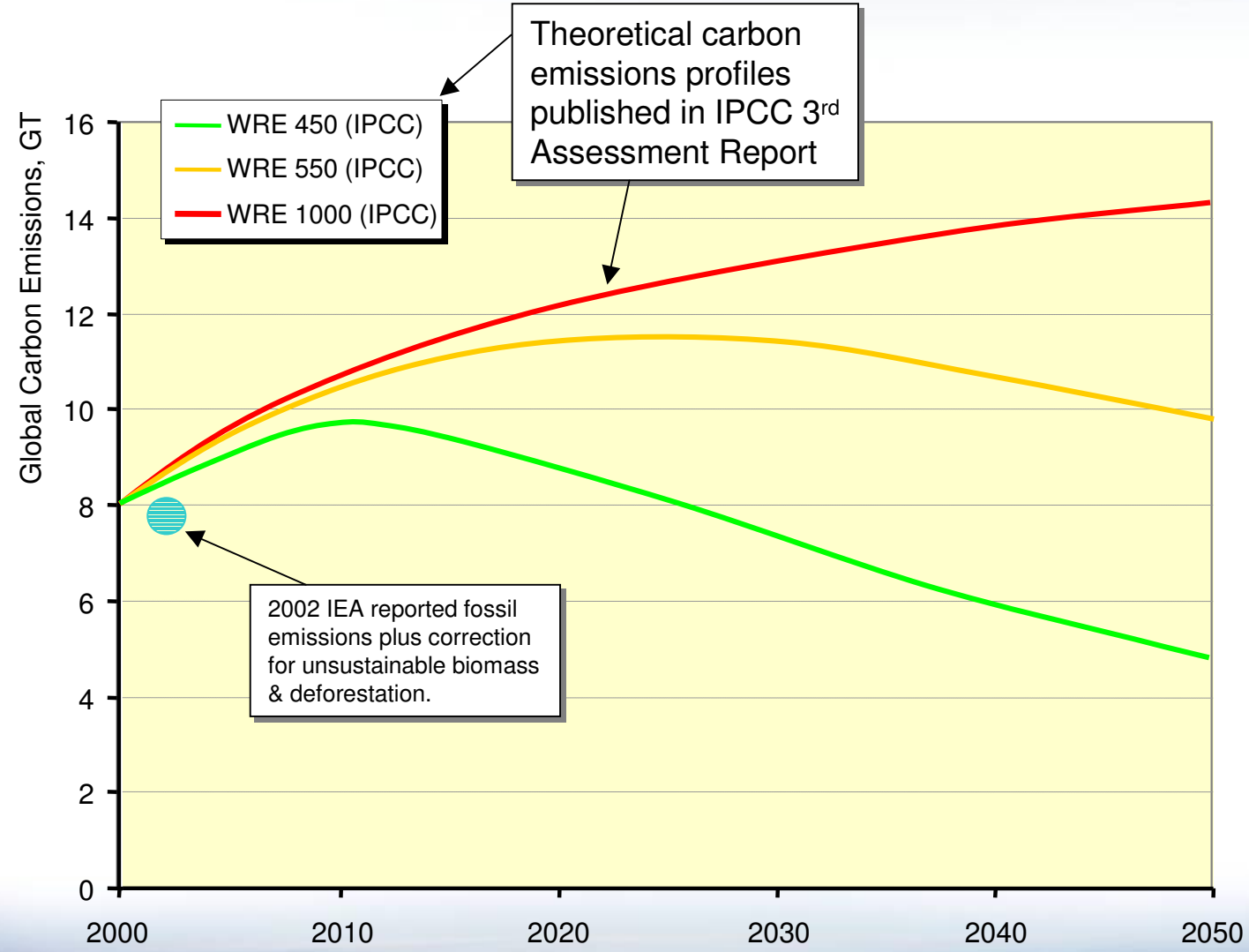
Population expected to rise to 9 billion by 2050, mainly in poorest and developing countries.

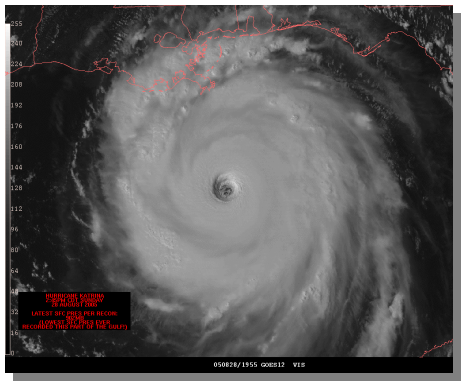
Shifting the development profile to a "low poverty" world means energy needs double by 2050

Shifting the development profile further to a "developed" world means energy needs triple by 2050

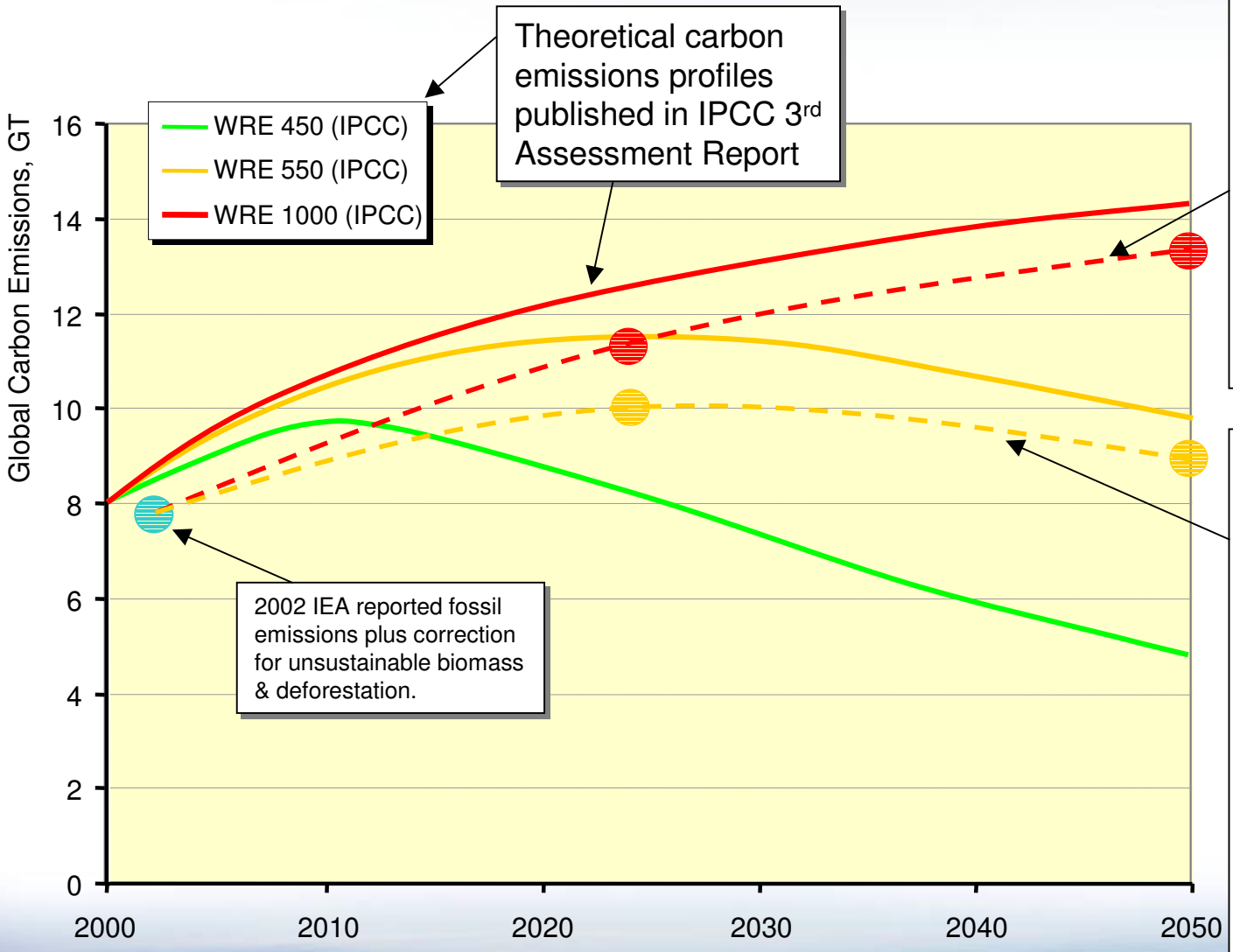


High and low carbon pathways





High and low carbon pathways



>900 ppm Trajectory Energy by 2050:

- Coal over 2x, no Carbon Capture & Storage (CCS), some coal to liquids.
- Oil up 50%
- Gas over 2x
- Biofuels make up 10% of vehicle fuel mix.
- Electricity 1/3 of final energy.
- Modest increase in nuclear.
- Renewables provide 1/3 of electricity generation.
- Vehicle efficiency up 50%.

<550 ppm Trajectory Energy by 2050:

- Coal up 50%, but half of power stations use CCS.
- Oil down 10-15%.
- Gas nearly 2-3x
- Biofuels make up 20% of vehicle fuel mix.
- Hydrogen has arrived.
- Strong shift to electricity as final energy (~50% final energy).
- Strong increase in nuclear.
- Renewables provide half of electricity generation.
- Vehicle efficiency up 100%
- Sustainable biomass practices

The Kaya Identity

The *Kaya Identity* breaks down the main emissions driving forces as multiplicative factors on one side of an equation, against CO_2 emissions on the other, such that:

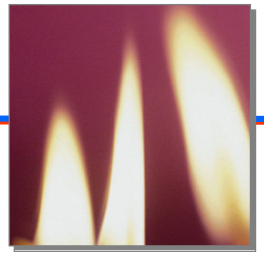
CO_2 emissions = people X GDP/person X energy/unit GDP X CO_2/unit energy

Only four factors govern the outcome, being:

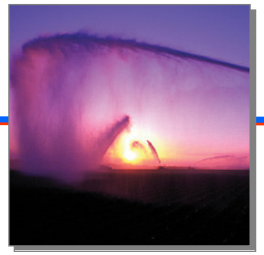
- Population — Number of people
- Standard of Living — GDP per person
- Energy Intensity — Energy per unit of GDP (efficiency of the economy)
- Carbon Intensity — CO2 per unit of energy (reflects the energy source)

Options for change – enabling technologies

Emission reduction (CO_2 / unit energy)


A further shift to natural gas

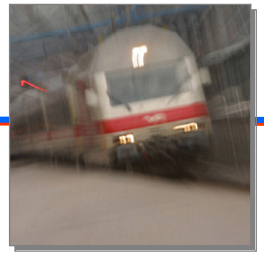

Nuclear power


Renewables

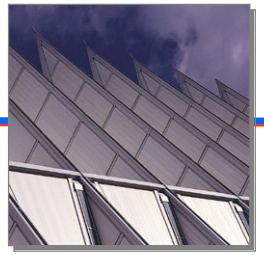

Bio-products


Carbon capture and storage

Energy conservation and efficiency (energy / unit GDP)


Mass transportation

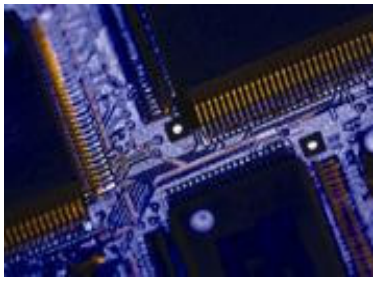

Road transport


Buildings


Low energy appliances

Doing things differently

All change tomorrow??

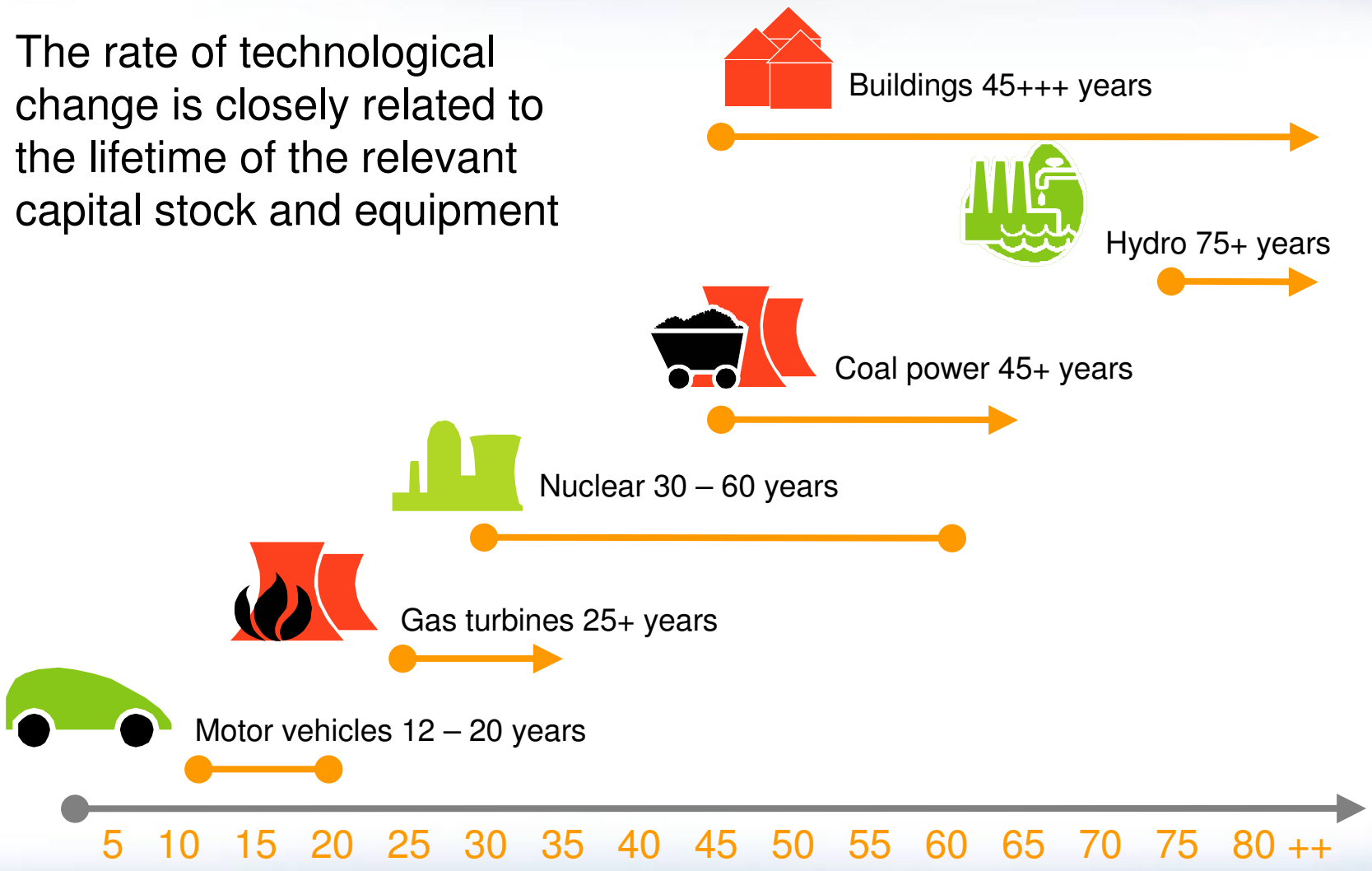


Many advocate that a much more rapid change in our energy infrastructure is the only solution to the threat of climate change. However:

- Major transitions at the global level will take time to implement
- The speed with which new technologies diffuse depends on many factors.

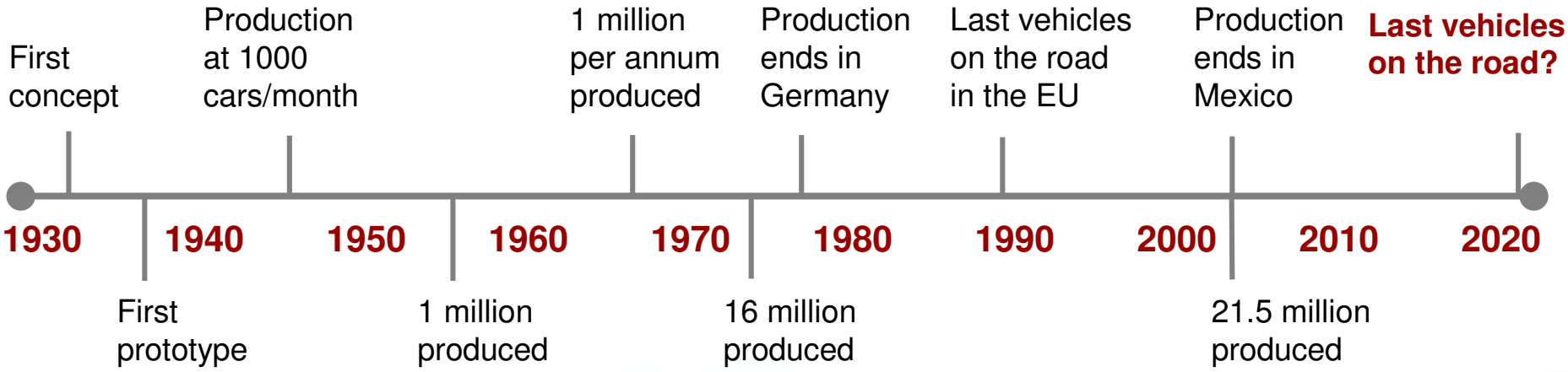
Size and lifetime matter !!

The rate of technological change is closely related to the lifetime of the relevant capital stock and equipment

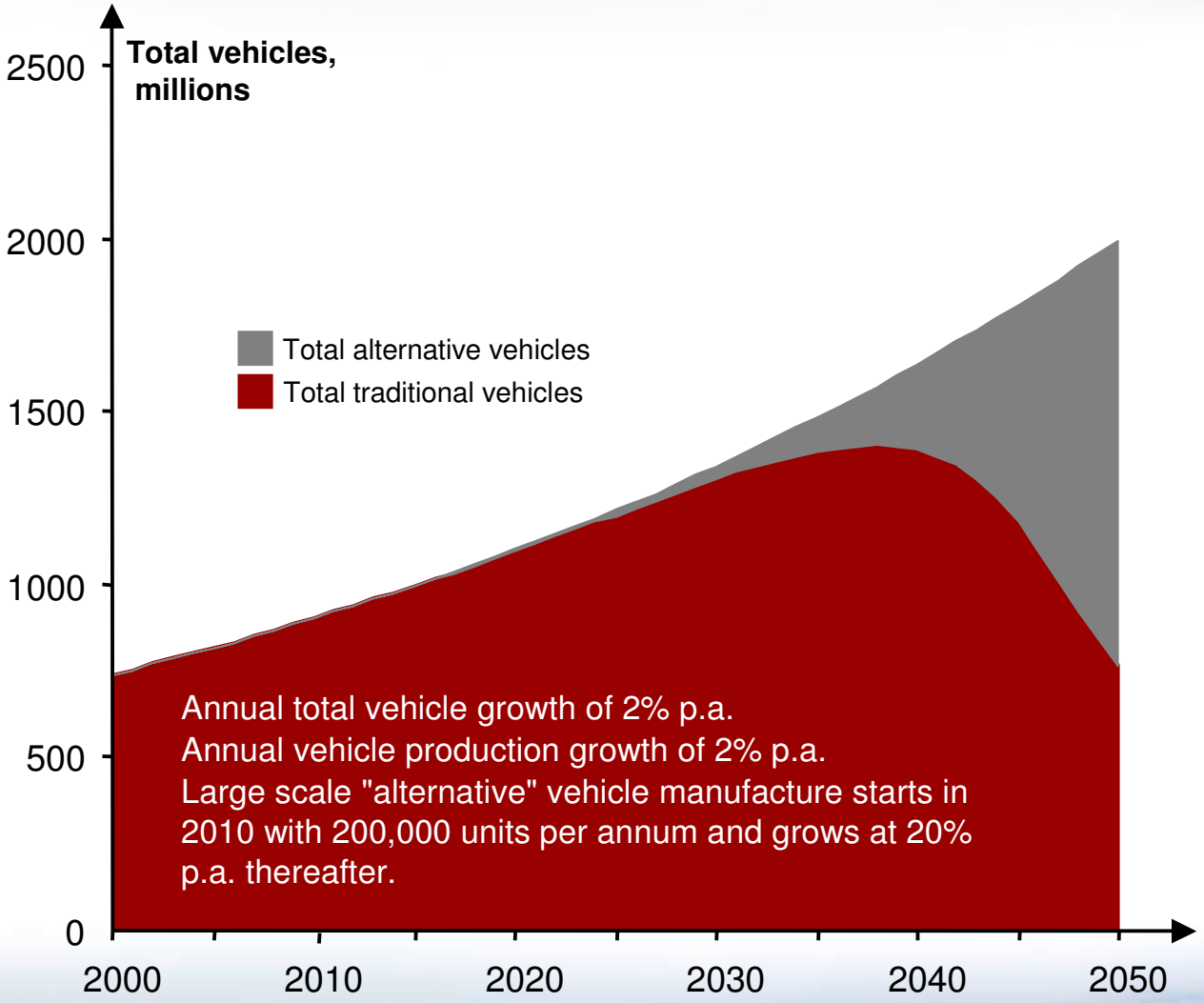


Regional boundaries may limit change

New technologies in developed countries may arrive, mature and even decline before their widespread adoption in developing regions.



Even very rapid change can appear slow!

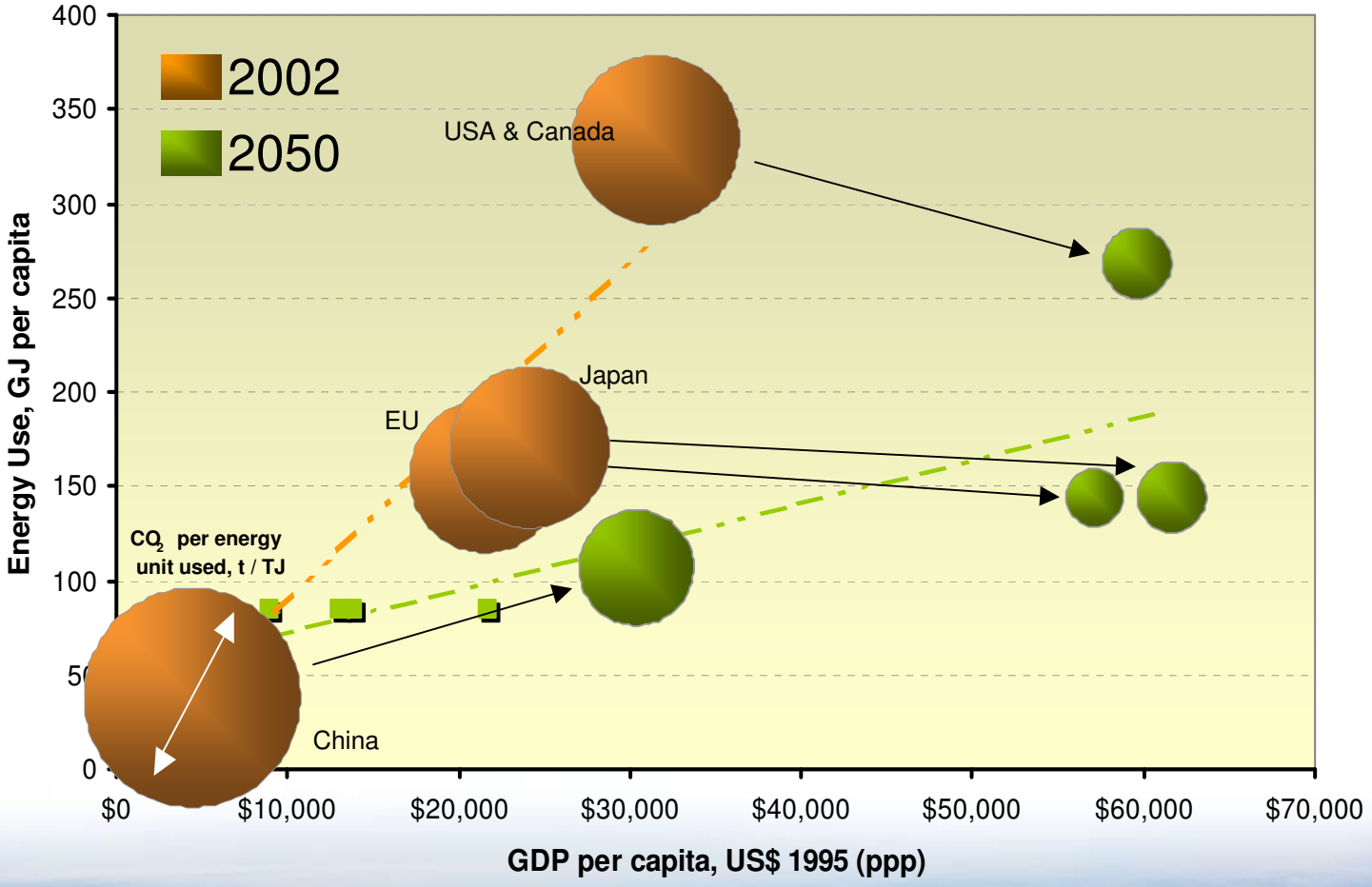


Pathways to 2050

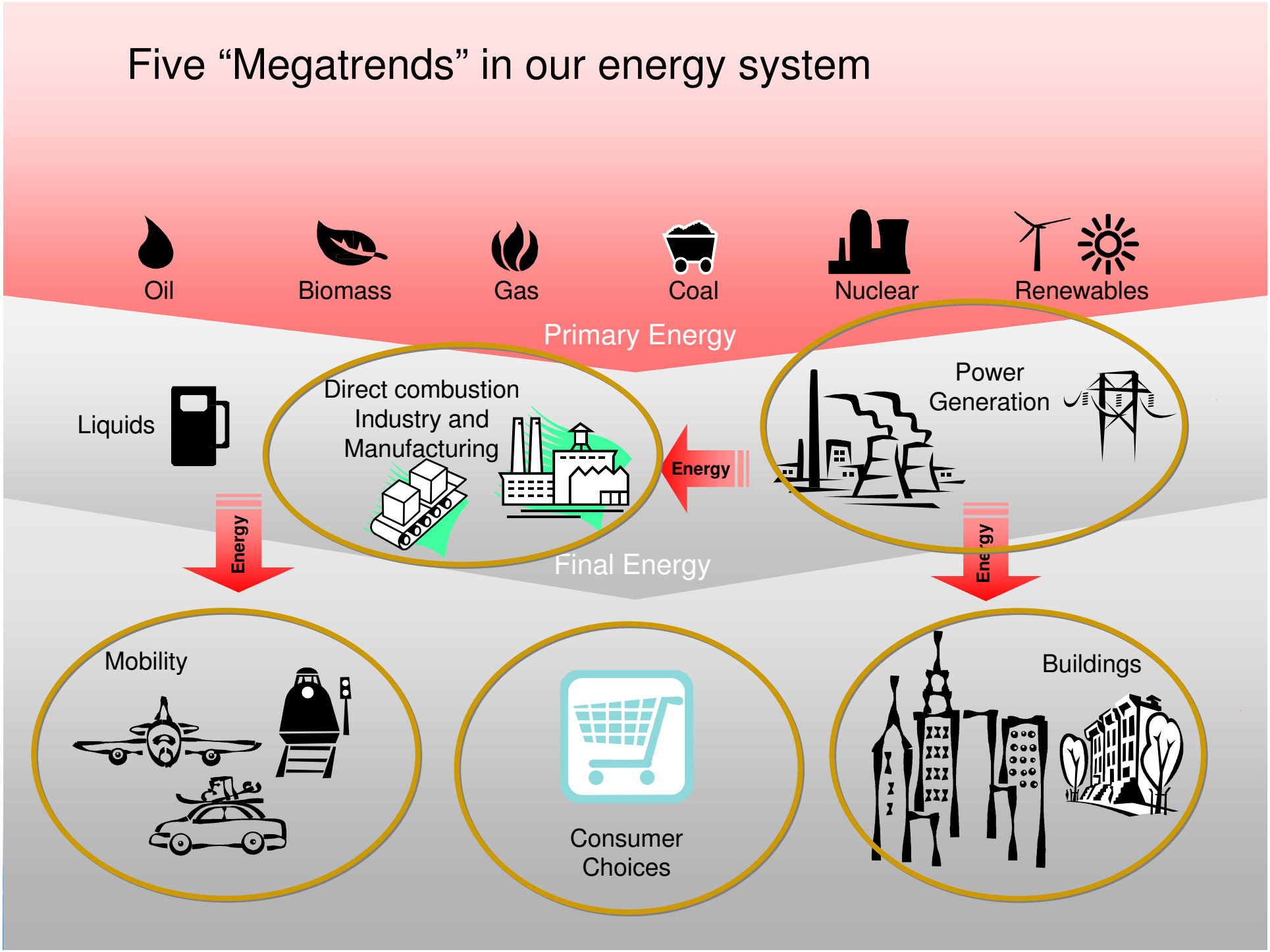
Published in December 2005, *Pathways to 2050* illustrates the scale of change needed in our energy systems to meet a 550 ppm stabilization target.

Pathways to 2050

A significant shift required in both "energy per GDP" and "CO_2 per unit of energy used"

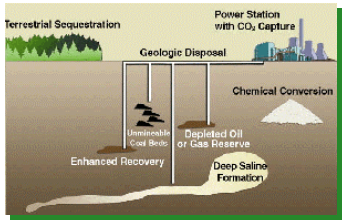


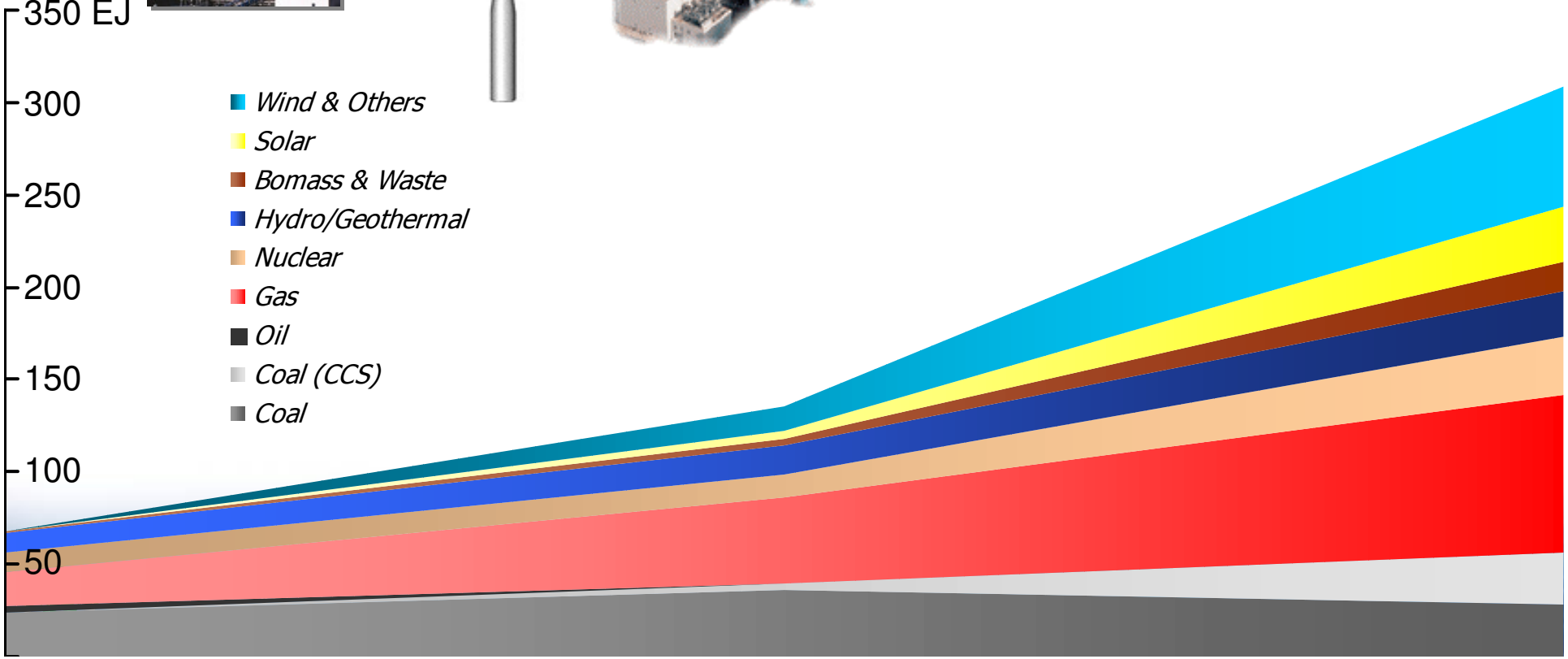
Five “Megatrends” in our energy system



Power Generation – Growing in importance

2002 **2025** **2050**





Using electricity to deliver major reductions

- Electricity increases as a % of final energy, driving emissions management upstream and away from the consumer.
- Upstream carbon management becomes a key goal.
- Electricity mix shifts to;
  - ✓ Renewables (wind / wave / solar / biomass / hydro / geo)
  - ✓ Natural gas
  - ✓ Nuclear
  - ✓ Coal with carbon capture and storage
- Technologies such as distributed generation (using renewables) become important

Mobility – Doing much more with less

2002 13.9

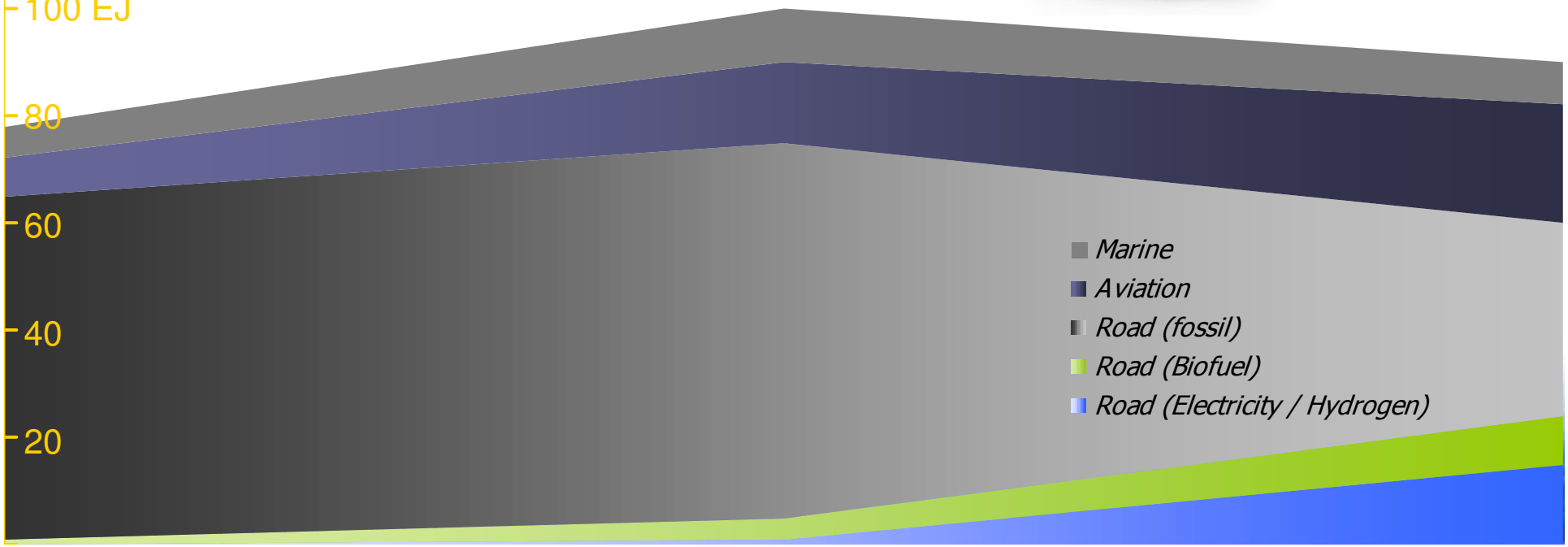
0 5 10 15 20 25 trillion-kms

2025 22.5

0 5 10 15 20 25 trillion-kms

2050 28

0 5 10 15 20 25 trillion-kms



Industry & Manufacturing

2002

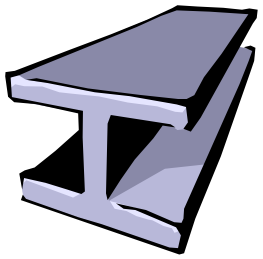
1.11 GtC

Carbon emissions in 2002, GtC

94 EJ

Energy Use in 2002, EJ

2025



2050

171 EJ

Energy Use in 2050, EJ

1.51 GtC

Carbon emissions in 2050, GtC

Energy use and emisson levels are rising in industry and manufacturing due to:

- Rising population levels;
- Continuing economic growth (e.g. GDP per capita in China increases by more than a factor of 7).

Emission reduction measures:

- Increase the deployment of currently best available technologies (BATs) especially to developing countries;
- Improve energy efficiency and fuel conservation;
- Develop new low energy and low carbon emission manufacturing technologies;
- Shift towards electricity.

Buildings

2002

0.78 GtC

Carbon emissions in 2002, GtC

104 EJ

Energy Use in 2002, EJ

Rising living standards

Growing service sector

Information economy

Rural to urban living

2025

2050

237 EJ

Energy Use in 2050, EJ

0.75 GtC

Carbon emissions in 2050, GtC

Radical design

Placement

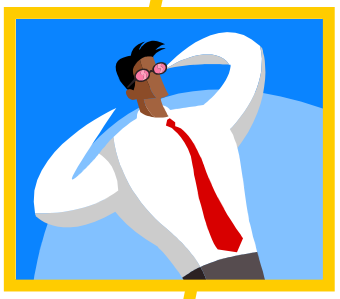
Efficient appliances

New materials

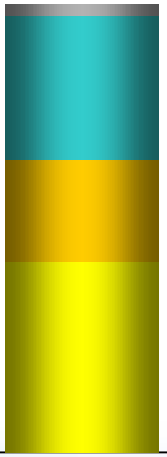
In-situ energy generation

Consumer Choices

	Tonnes **Carbon** p.a.
A family of four:	
Semi-detached house	1.57
And has installed:	
Insulation & double glazing	-0.22
Efficient lighting	-0.09
Solar heating & electricity	-0.26
A ground-sourced heat pump	-0.59
And also:	
Uses A* appliances	-0.11
Adjusts the thermostat	-0.04
Switches off lights/appliances	-0.06
Drives one car:	
A hybrid, 5,000 miles	0.23
And makes extensive use of alternative transport	
Travels regionally by air on vacation:	
~8 short-haul trips	0.32
Also produces waste	0.25
but recycles where possible	-0.15
	0.85 tonnes p.a.



	Tonnes **Carbon** p.a.
A family of four:	
Large detached house	2.57
+ Extra air-conditioning	0.04
+ Heated swimming pool	1.48
But could install:	
Insulation & double glazing	-0.9
Efficient lighting	-0.13
Solar heating & electricity	-0.34
And could also:	
Use A* appliances	-0.16
Adjust the thermostat	-0.18
Switch off lights	-0.31
Drives two cars:	
A large SUV, 15,000 miles	1.42
A regular sedan, 10,000 miles	0.78
And travels by air regularly:	
~15 short-haul trips	0.73
~ 8 long-haul trips	2.38
Also produces waste	0.25
But could recycle some	-0.15
	9.65 tonnes p.a.

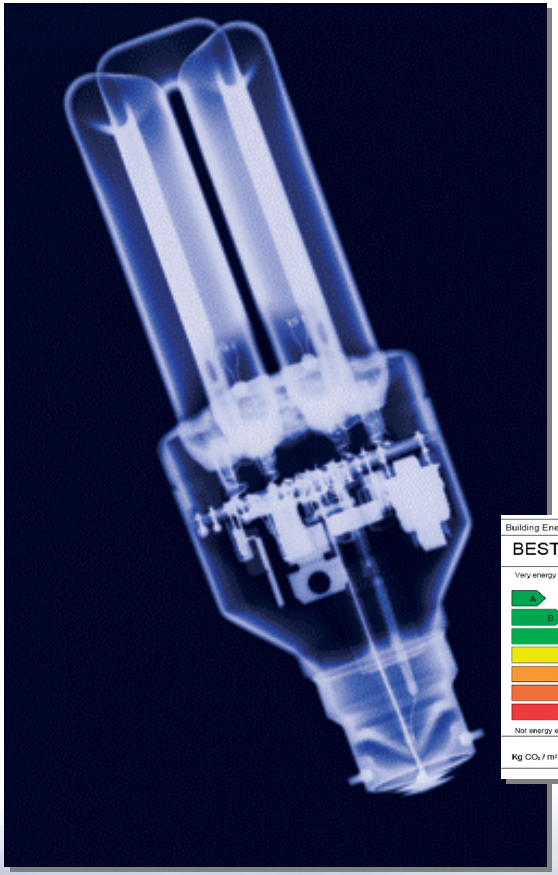


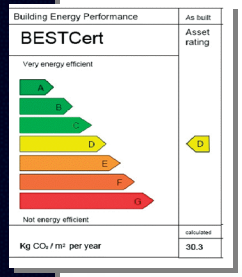
Waste
Air travel
Car travel
Household

Source: www.bp.com/carbonfootprint

Global Milestones – Energy Efficiency

2025 2050





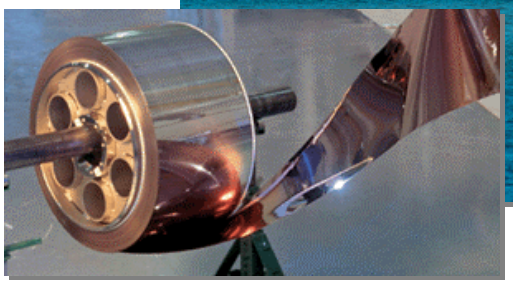
Achieved **significant efficiency gains**, with developed countries improving by more than 2% annually.

Continue to achieve significant **energy efficiency** gains in all countries.

Global Milestones – Renewables

2025 2050

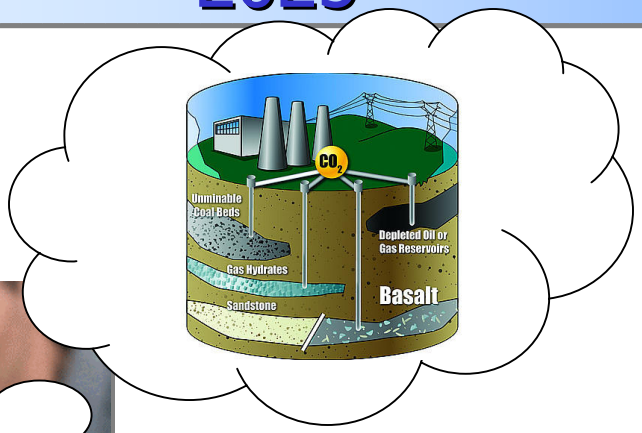
Introduced **wind and solar power** on a significant scale globally, with over 1 TW of installed wind capacity.

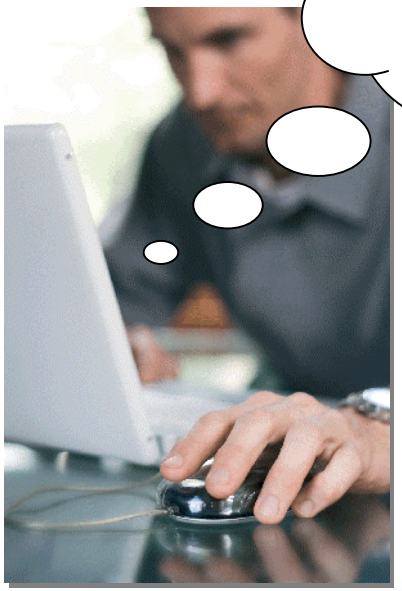


Deployed **wind, wave, tidal and solar power** on a large scale globally, with renewables (including hydro & biomass) contributing contributing about half to the power sector.

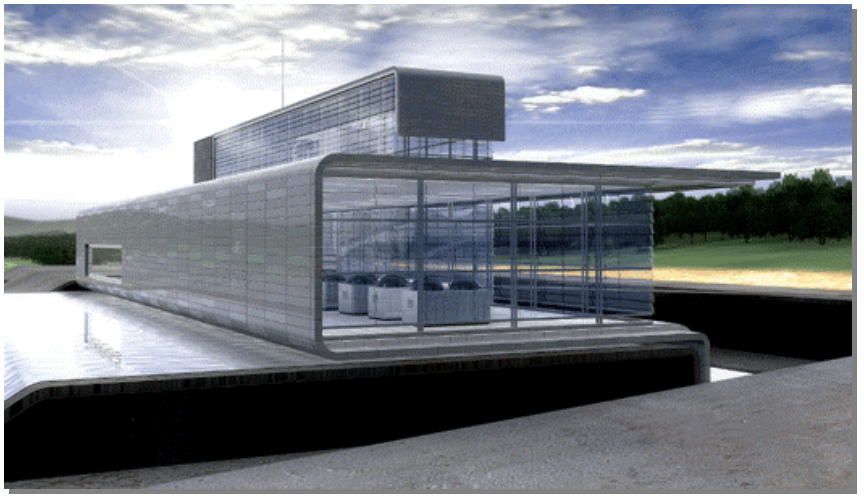
Global Milestones – Carbon Capture and Storage

2025 2050





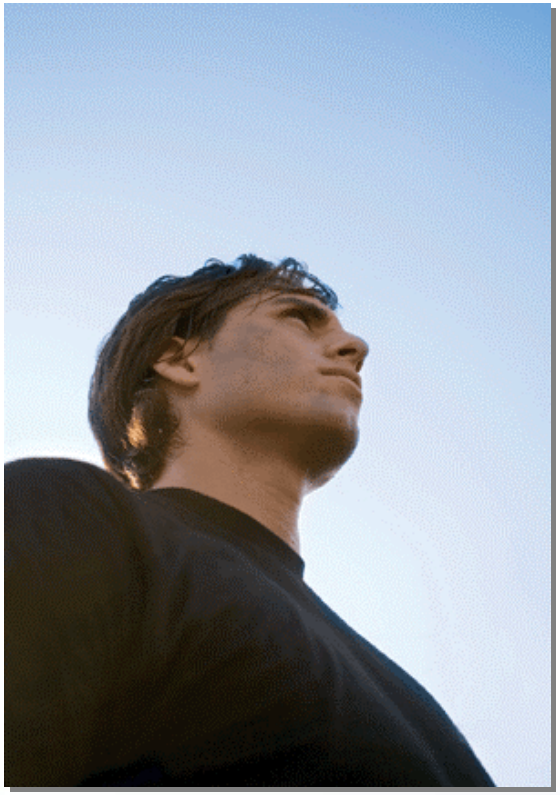
Commercialised coal power generation with **carbon capture and storage** and have some 100 or more plants in operation globally.



Deployed coal power generation with **carbon capture and storage** and have some 1000 or more plants in operation globally.

Global Milestones – Nuclear

2025 2050



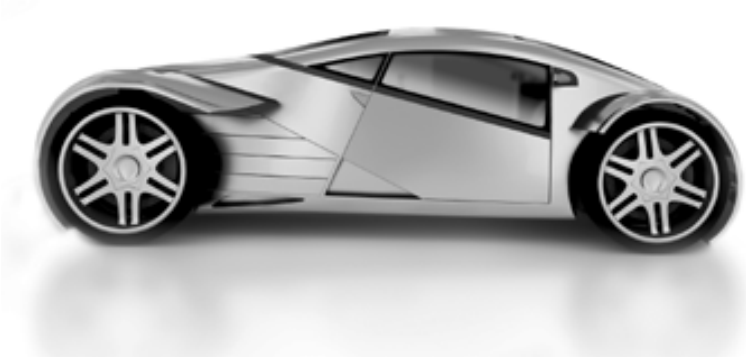
Gained full public acceptance of **nuclear power** as a viable zero-carbon power generation option and restarted long term growth in this industry.

Expanded the role of **nuclear** in power generation, reaching some 10% globally.

Global Milestones – Vehicles

2025 2050

Achieved wide deployment of **high efficiency vehicles** (e.g. hybrid diesel) in developed countries, with developing countries following, and started deployment of (near) zero emission vehicles.



Deployed **high efficiency vehicles** globally, with overall efficiency doubling (20 => 40 mpg) through the period.

Global Milestones – Automotive Fuels

2025 2050

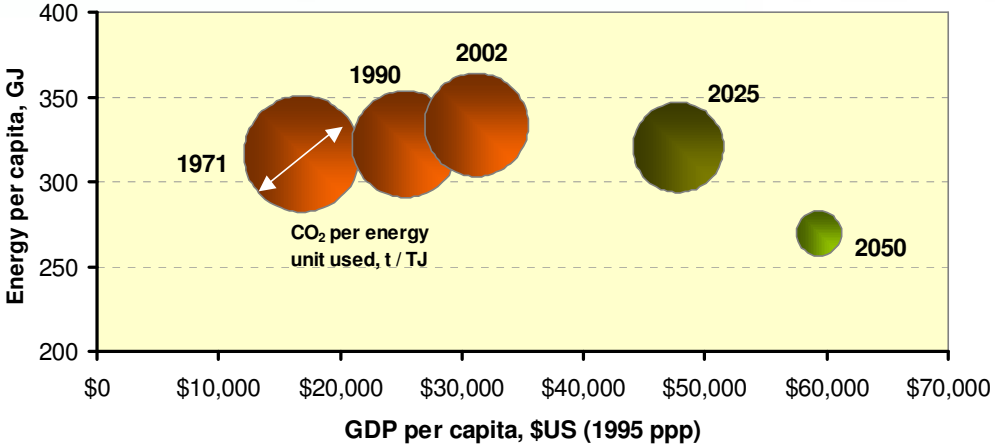
Recognised the potential of **advanced bio-fuels** and reached a level of more than 5% bio-fuels in transport fuels globally.

A range of alternative vehicle fuels such as **advanced bio-fuels, electricity** and **hydrogen** in everyday use and making up some 40% of road transport fuel.

USA and Canada – Efficient and growing

In 2050:

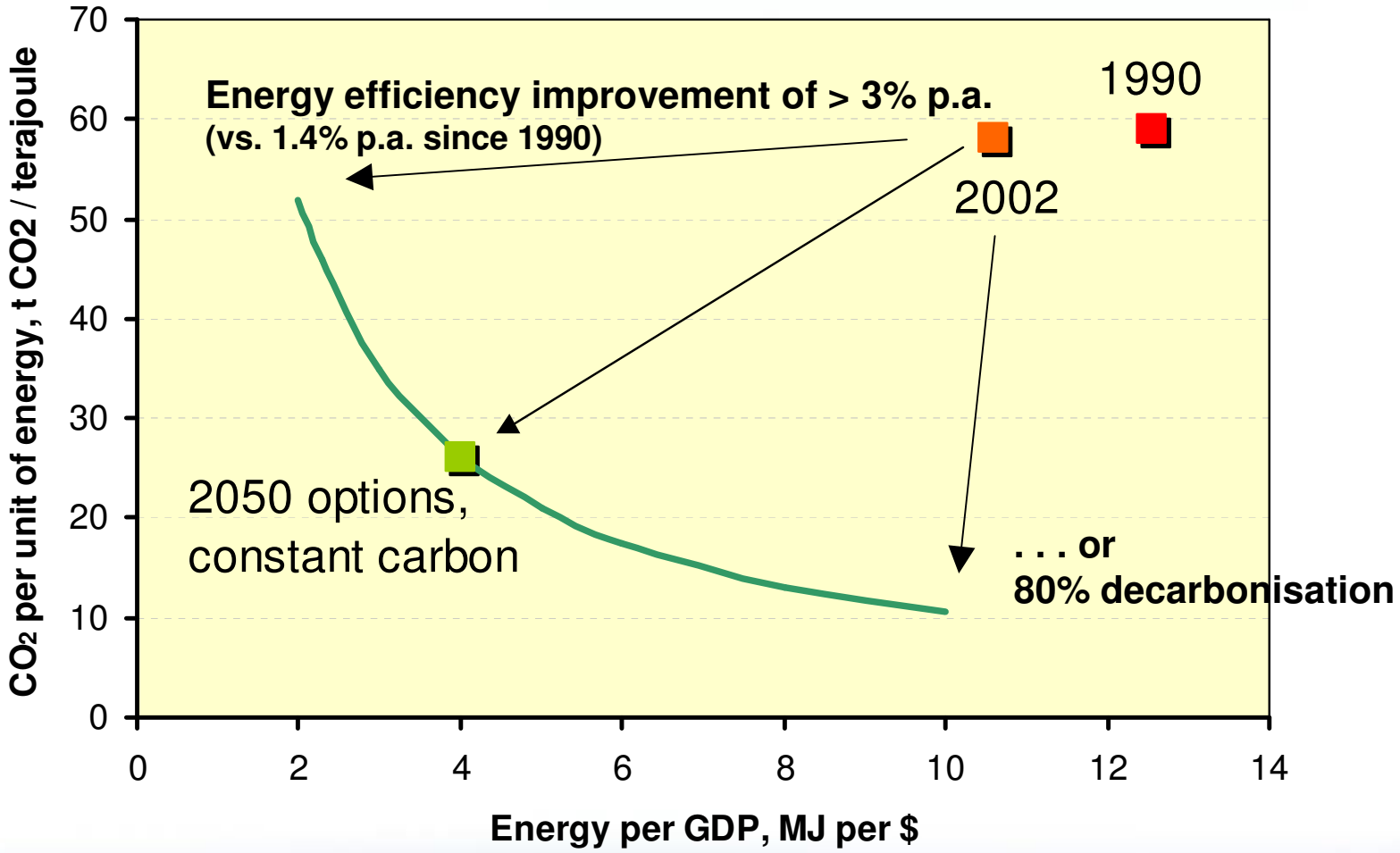
- Robust growth with little increase in energy demand;
- A transformation in the transport sector;
- Coal fired power generation based largely on CCS;
- Nuclear power use up 40%;
- Large scale use of renewables.



Milestones by 2025:

- Much improved public awareness of the impact of energy use;
- Carbon emissions in decline particularly from the transport sector;
- Nuclear power capacity maintained at 2000 levels;
- Over 70 coal-fired power stations with CCS;
- 50% improvement in vehicle efficiency and two million hydrogen powered vehicles on the road;
- Bio-fuel use well established and meeting 10+% of the vehicle fuel mix.

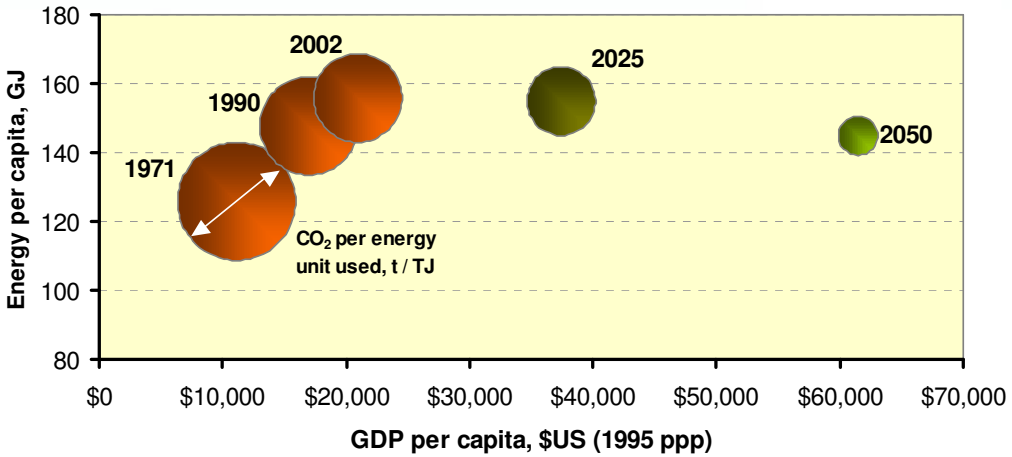
Exploring Economic Trade-Offs



EU-25 – Broad based energy infrastructure

In 2050:

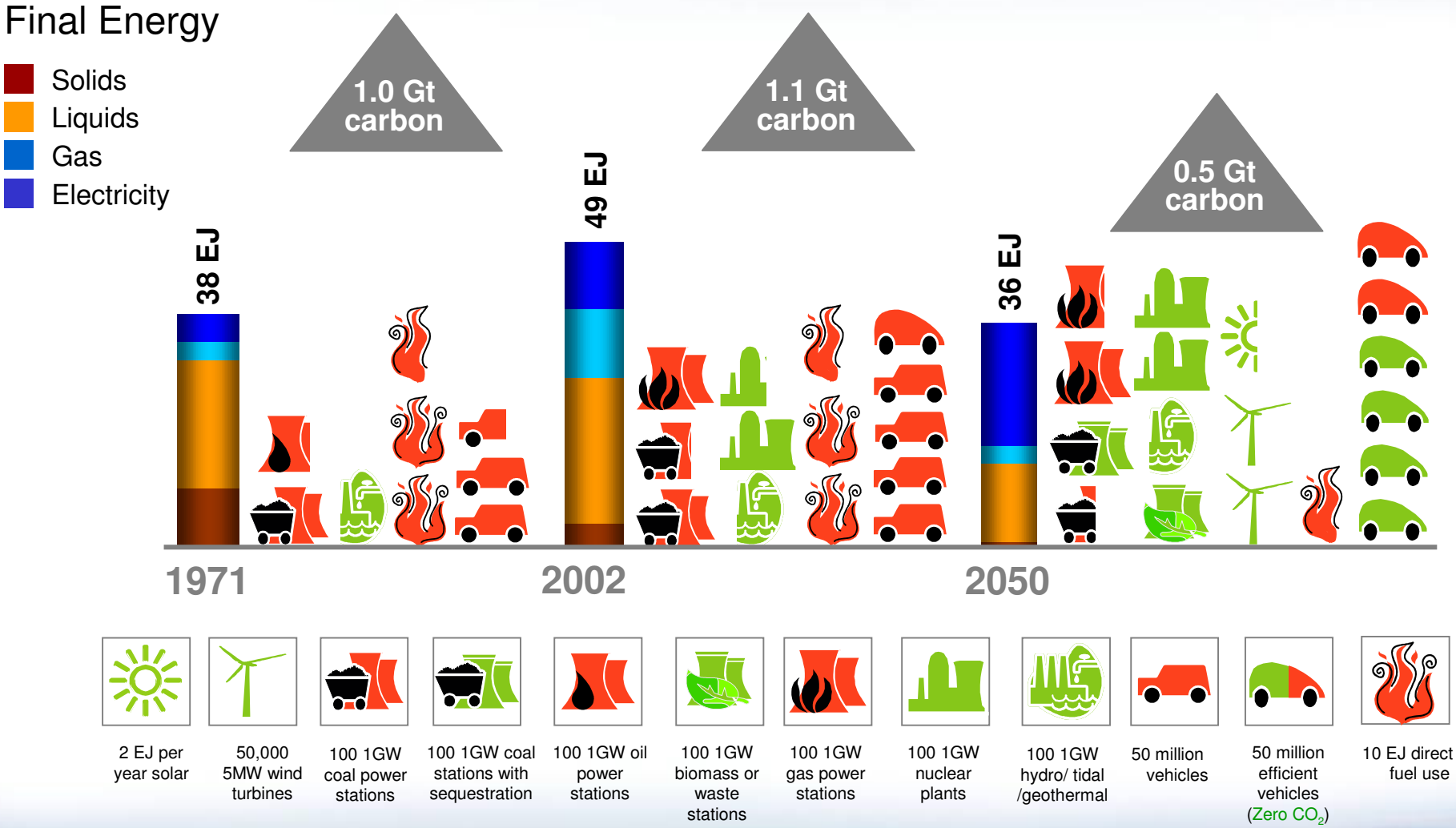
- Overall reduction in primary energy demand;
- Electricity becomes the main end-use energy source;
- A broad based energy mix, including nuclear;
- Petroleum / Bio-fuel / Hydrogen mix in the transport sector
- Large scale use of renewables.



Milestones by 2025:

- Some 30+ large generating stations using CCS;
- Natural gas use up 35% from 2002, mainly for power generation;
- A restart in nuclear power growth;
- Rapid growth in renewable energy: wind power some 10-15 times the 2002 level;
- Vehicle efficiency improves by nearly 50% with bio-fuels and / or hydrogen having a strong foothold (10% on-the-road).

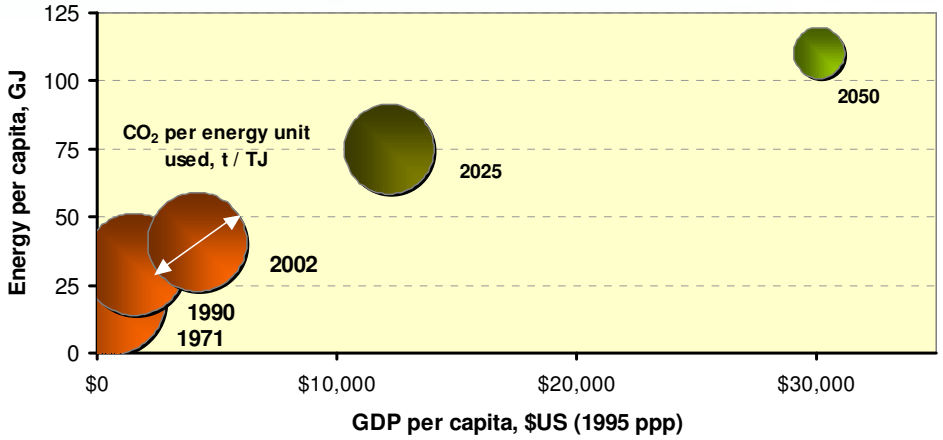
Even bigger changes to come for the EU



China – A low-carbon, coal-based economy

In 2050:

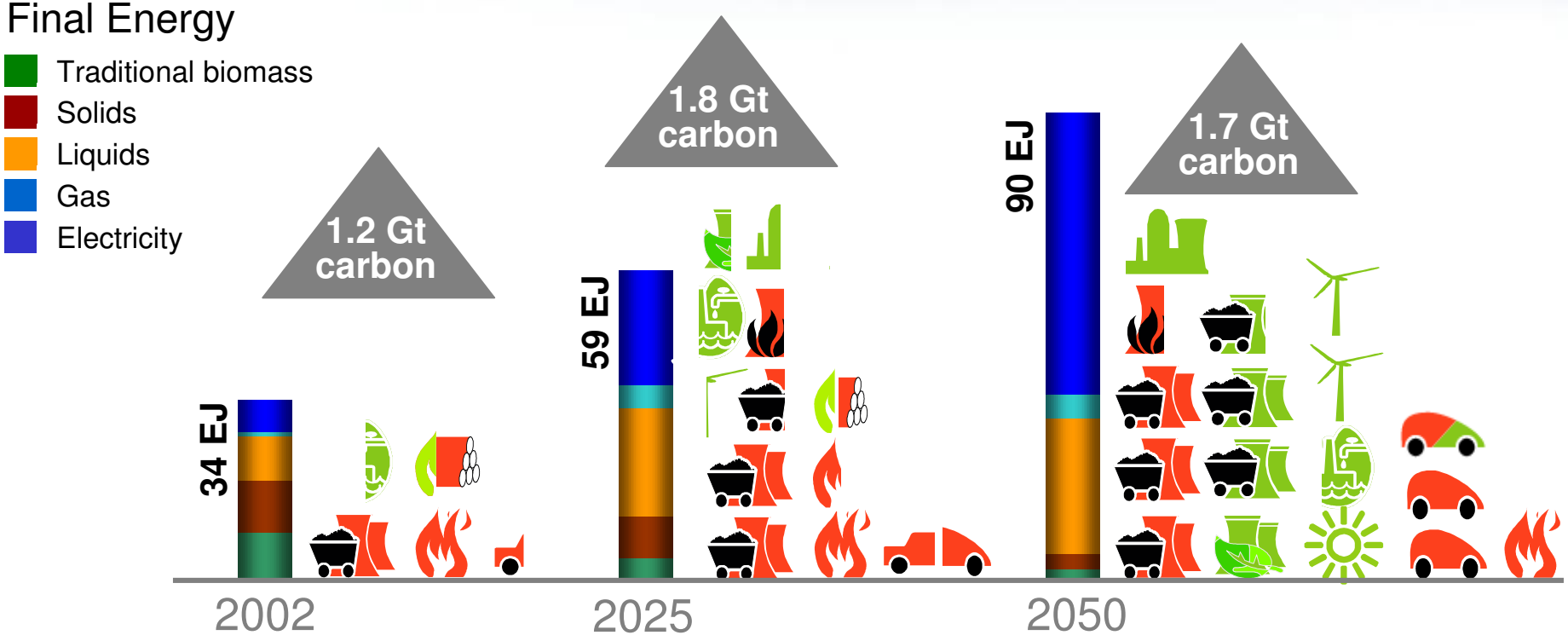
- Heavy reliance on coal for power, but 50% using CCS;
- Large scale use of renewables, dominated by wind;
- Nuclear as a mainstream source of power;
- High efficiency vehicle fleet (~350 million) - 6 litres/100 km.
- Sustainable biomass practices.



Milestones by 2025:

- Gasification as the standard for coal based power generation (with CCS starting);
- Tough energy efficiency standards in place for all buildings;
- 10 fold expansion in nuclear power generation vs. 2002;
- Wind and solar deployment becoming significiant;
- Continued tightening of vehicle efficiency standards and hydrogen infrastructure starting development.

China's developing energy infrastructure

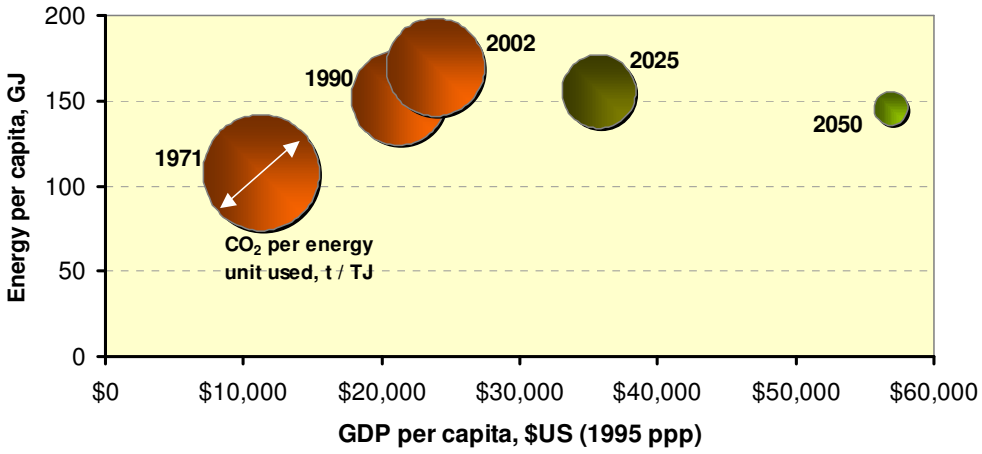


5 EJ per year solar | 100,000 5MW wind turbines | 200 1GW coal power stations | 200 1GW coal stations with sequestration | 200 1GW oil power stations | 200 1GW biomass or waste stations | 200 1GW gas power stations | 200 1GW nuclear plants | 200 1GW hydro/ tidal /geothermal | 100 million vehicles (Zero CO_2) | 100 million efficient vehicles (Zero CO_2) | 10 EJ non-commercial fuel | 20 EJ direct fuel use (Biomass)

Japan – A sustainable energy showcase economy

In 2050:

- Coal fired power generation phased out and natural gas generation reduced;
- Nuclear at double 2002 levels;
- Distributed solar generation;
- A rapid shift to hydrogen for transport;
- A further step change in efficiency of the economy.



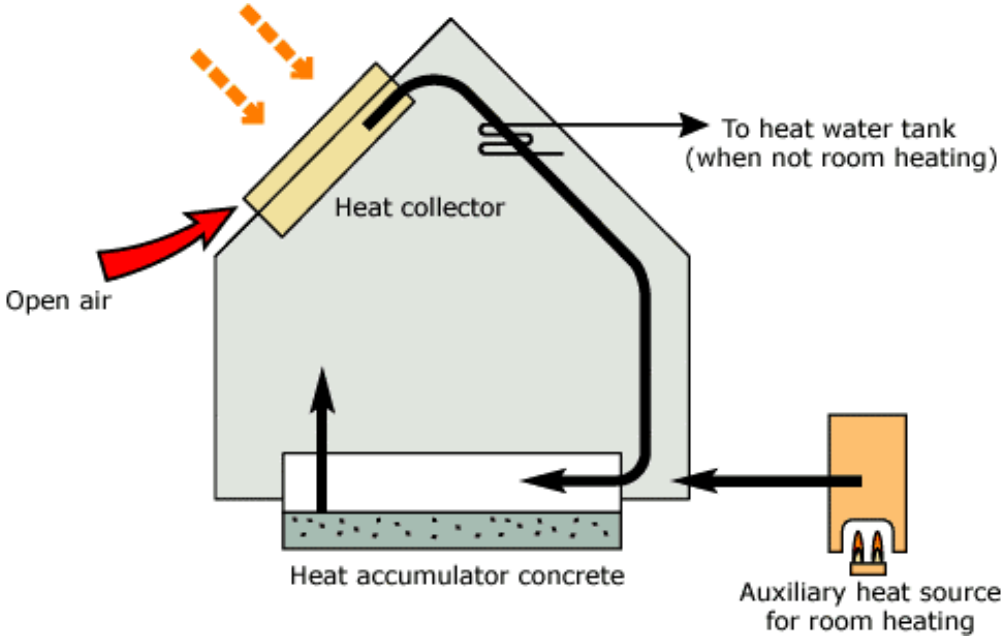
Milestones by 2025:

- A 50+% reduction in coal fired power generation;
- Sustained growth re-established in the nuclear sector;
- Thin-film solar commercialised in building use (roofing / cladding);
- Commercial hydrogen generation and use in transport with ~20% market share;
- 50% improvement in vehicle efficiency and two million hydrogen

Solar could become a key energy technology

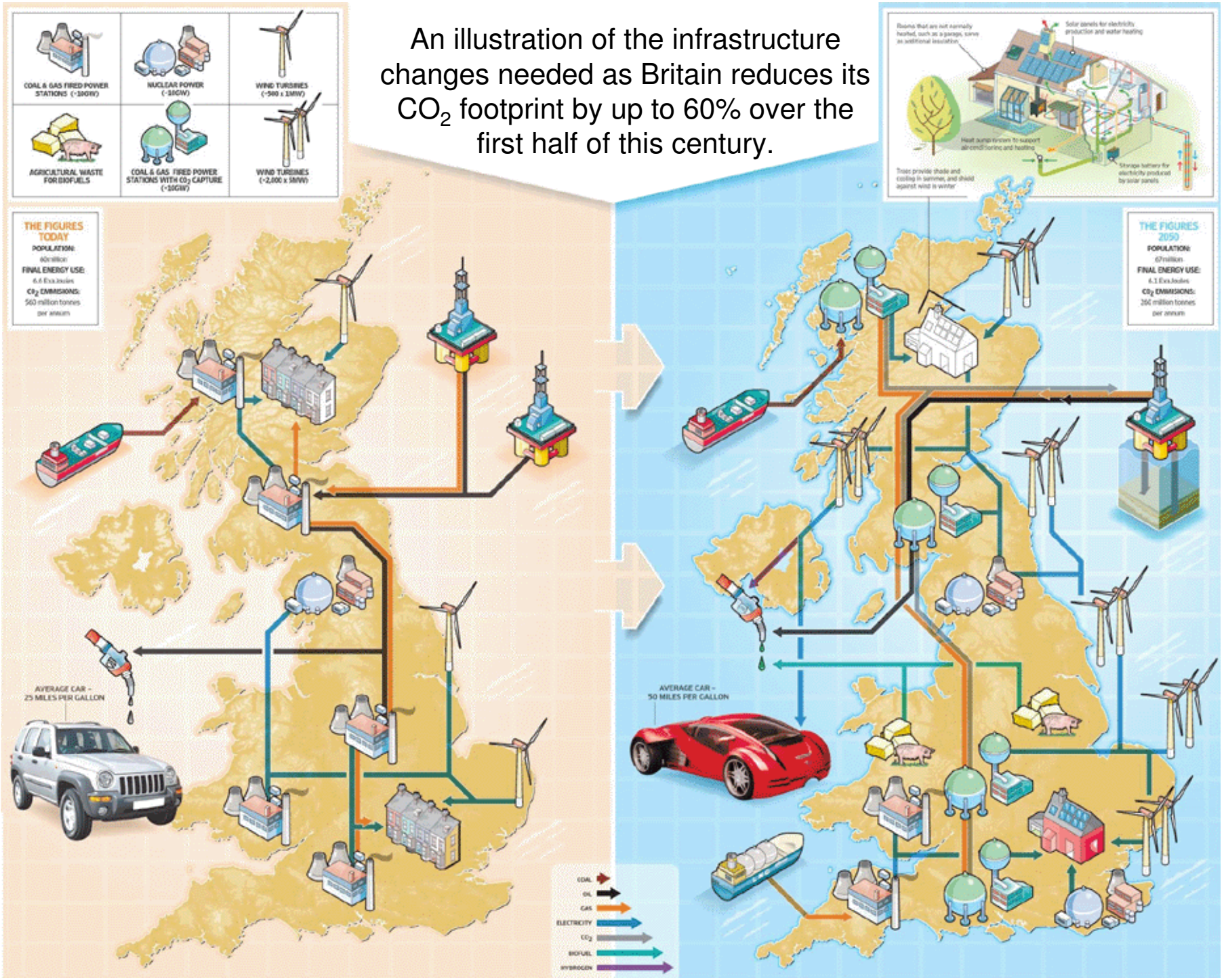
Thin film technology

. . . and solar thermal

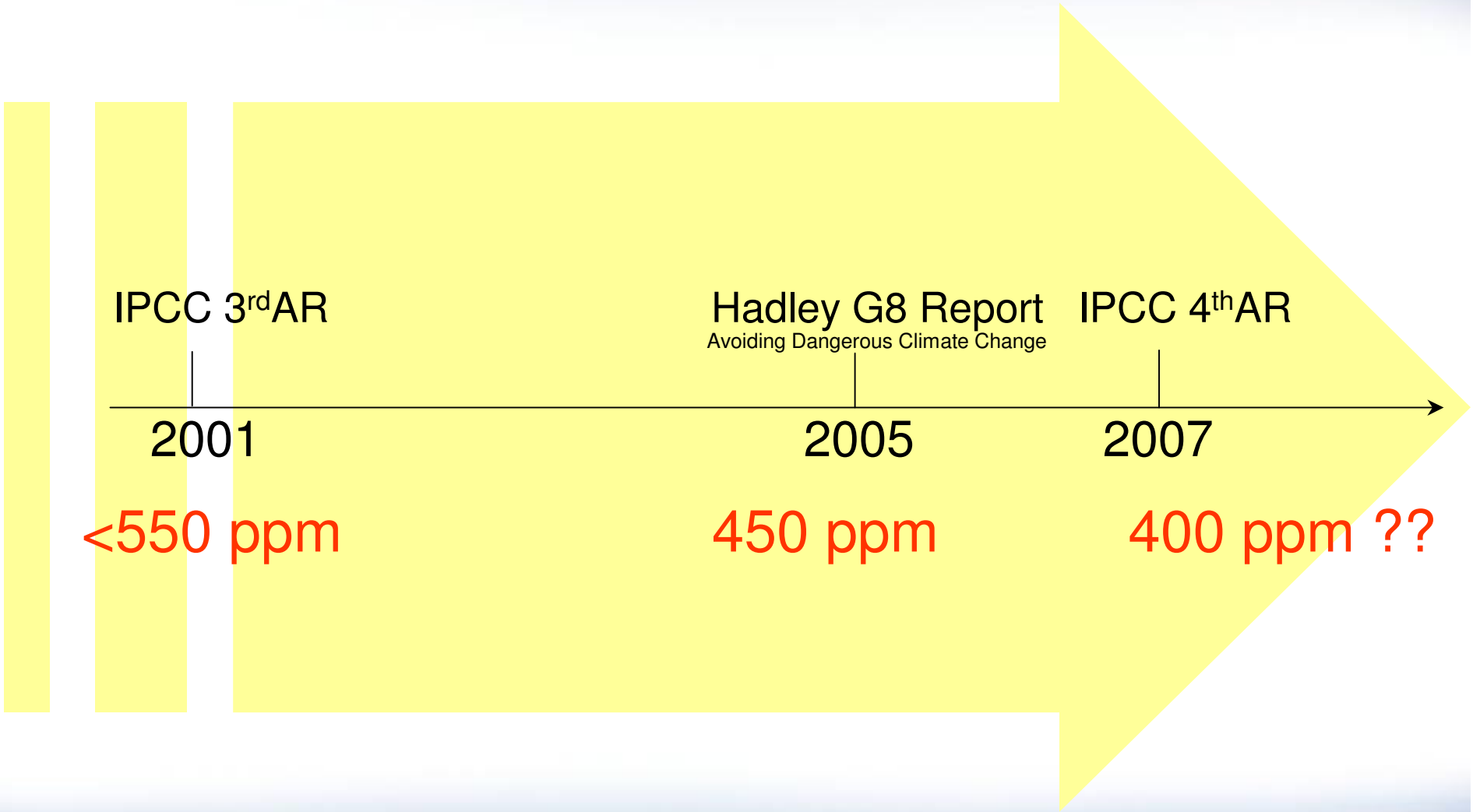


Energy for Britain – Today to 2050

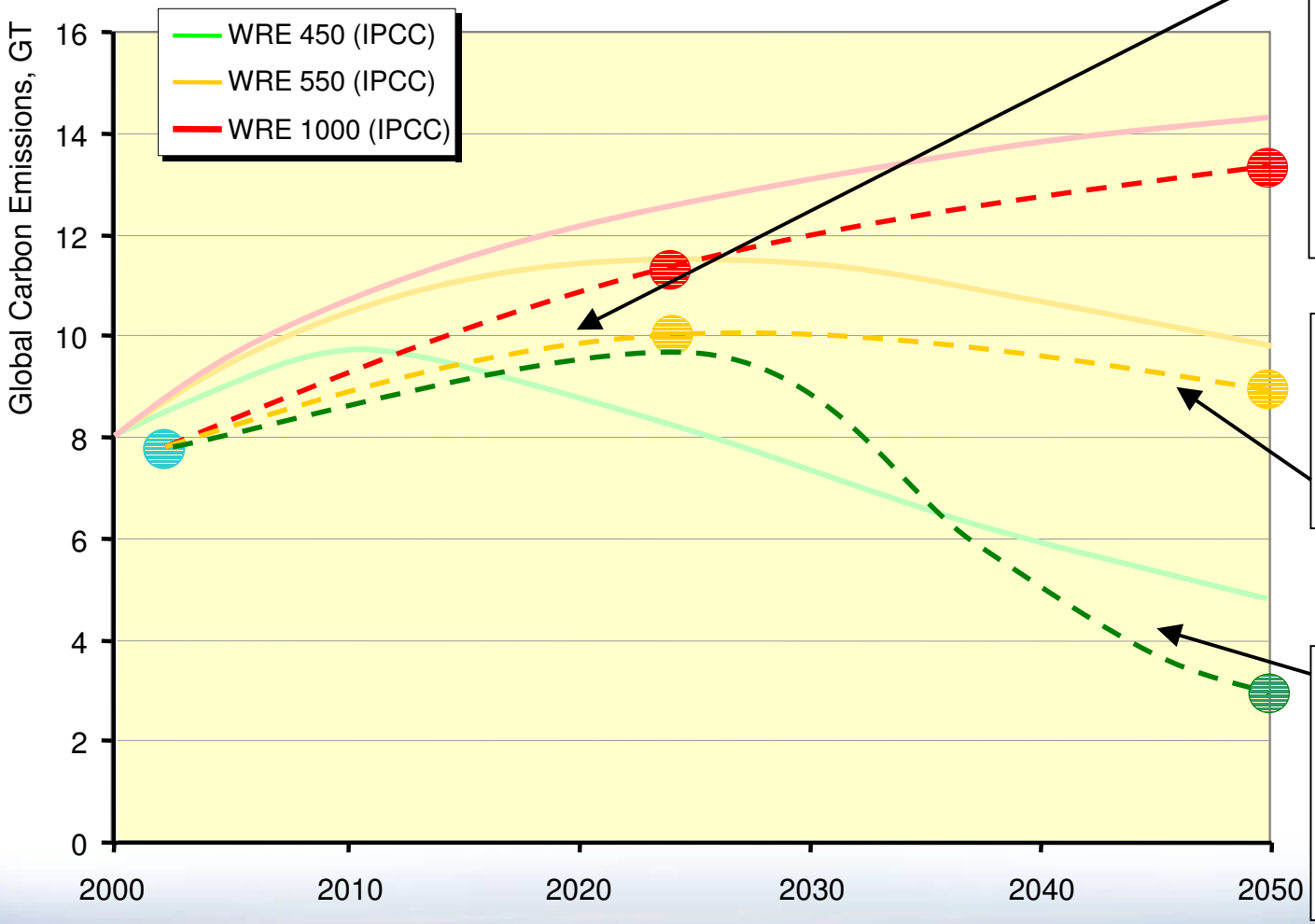
An illustration of the infrastructure changes needed as Britain reduces its CO_2 footprint by up to 60% over the first half of this century.



. . . but the debate is shifting rapidly



Even deeper cuts for <450 ppm



Pre-2025 Trajectory

- Similar trajectory to 550 ppm case for practical reasons.
- Limited by (e.g.):
  - Global agreement on an international framework
  - Development of policy and carbon markets
  - Technology development and early commercialisation constraints
  - Nuclear power dialogue

Post-2025 Trajectory (<550 ppm)

- All new facilities must adopt new technology (e.g. CCS for coal fired power stations).

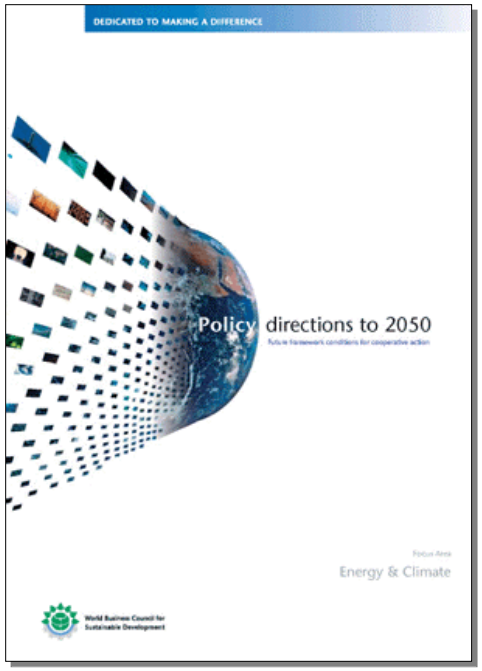
Post-2025 Trajectory (<450 ppm)

- Much faster deployment with many facilities (i.e. pre-2025 coal fired power plants) replaced earlier than normal retirement would dictate.

Global milestones by 2050 for <450 ppm
(if we can't move faster before 2025)

- A zero emissions power generation sector.
  - ✓ Nuclear, renewables and all fossil with CCS
- A very low emissions transport sector, with fossil fuel still used in aviation and other special applications. Some nuclear power in the marine sector.
- Electricity for most domestic and commercial energy needs and in some heavy industry. Some emissions from;
  - ✓ Cement manufacture
  - ✓ Certain heavy industries (e.g. metals)
  - ✓ Domestic and commercial coal and gas in some developing countries.
- Sustainable forestry and agricultural practices globally.

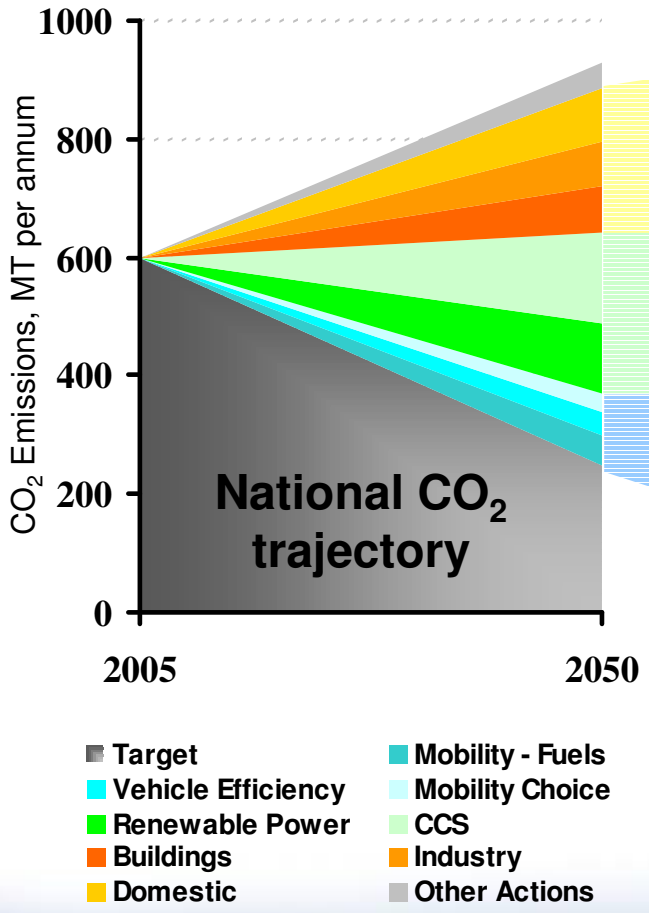
Policy Directions to 2050



Published in March 2007, *Policy Directions to 2050* discusses the policy frameworks needed to deliver the necessary scale of change in our energy systems to begin to address the issue of climate change.

Opportunity starts at the national / sectoral level

A. Opportunity Wedges (National) (Developed Country Example)



B. National/Sectoral Goals & Targets

Efficiency	Buildings Industry Domestic	xx % p.a. through to 20xx
Power Generation	Renewables	xx MW p.a. by 20xx
	CCS	xx tonnes CO_2 p.a.
Mobility	Bio-fuels	xx litres p.a. by 20xx
	Efficiency	xx mpg by 20xx
	Choice	Hybrid / Diesel uptake Mass transit

C. National Policies

Buildings – adopt new country building standards, design awareness

Industry – Sectoral agreements, emissions trading, technology standards

Domestic – carbon labeling, increased product standards (e.g. standby energy)

Renewable Energy – renewables targets.

CCS – funding for infrastructure, tax cuts on capital investments, price signals for carbon via emissions trading

Biofuels – targets, support for manufacturing, CO_2 labeling

Vehicle Efficiency - support technology, incentives, sectoral agreements

Mobility Choice - consumer incentives, promote public/private partnerships for transport networks

The development of energy policy

Energy policy is set at the national level. It is now one of the principal responsibilities of government.

The development of energy policy is responsive to;

- Financial considerations
- Available natural resources
- Security of supply
- Environmental signals

A future framework must recognise the sovereign nature of energy policy decisions, but at the same time provide clarity, context and drive for such decisions.

A future framework – What is needed?

1. A long-term goal

- ✓ Established by 2010
- ✓ Described in terms of CO_2e^* emissions.

2. Technology development and deployment framework

- ✓ Expanded support for R&D
- ✓ Global standards
- ✓ Technology transfer driven by standards
- ✓ Risk management

3. Emissions management at national and sectoral level

- ✓ Bottom-up approach aligned with energy policy
- ✓ Sector by sector
- ✓ Expanded project mechanism
- ✓ Progressive inclusion of all countries

4. Linkage framework to encourage international trading

*All GHGs but as CO_2 equivalent

Clean development partnerships & programs

Clean development partnerships and technology programs based on standards and benchmarking can drive new technology development.

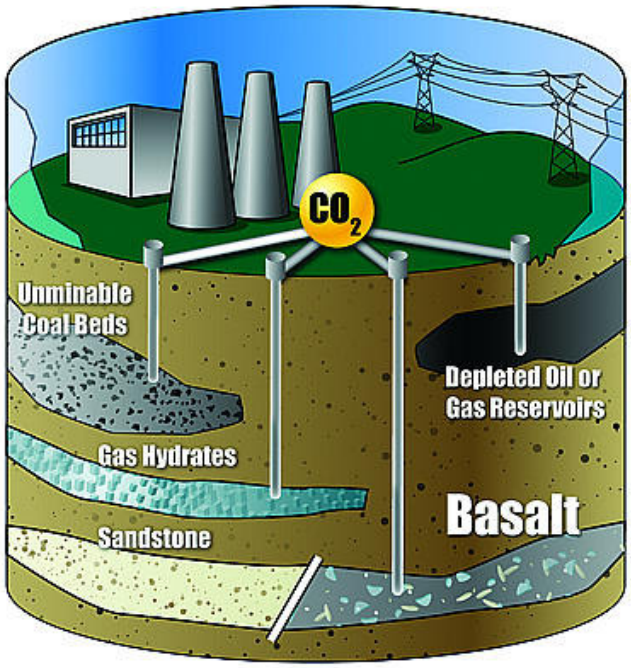
Asia-Pacific Partnership on Clean Development & Climate

FutureGen ALLIANCE

FreedomCAR & Fuel Partnership

H_2 EUROPEAN HYDROGEN AND FUEL CELL TECHNOLOGY PLATFORM

Managing new technology risks



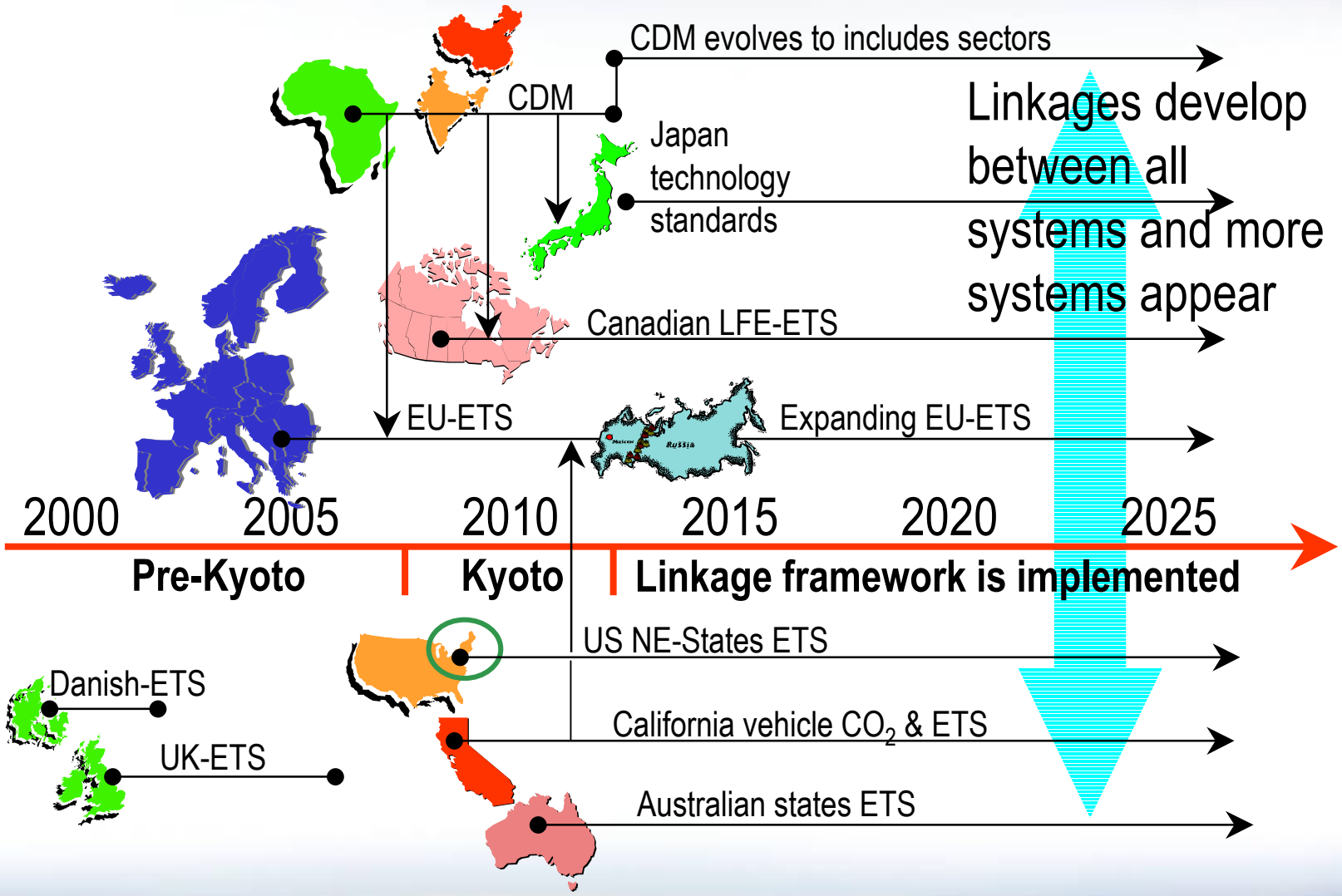
Direct and Indirect Incentives

- Well funded clean development networks with aggressive targets for pilot and near commercial demonstrations.
- R&D incentives
- Infrastructure funding
- CO_2 product labelling

Regulatory Uncertainty

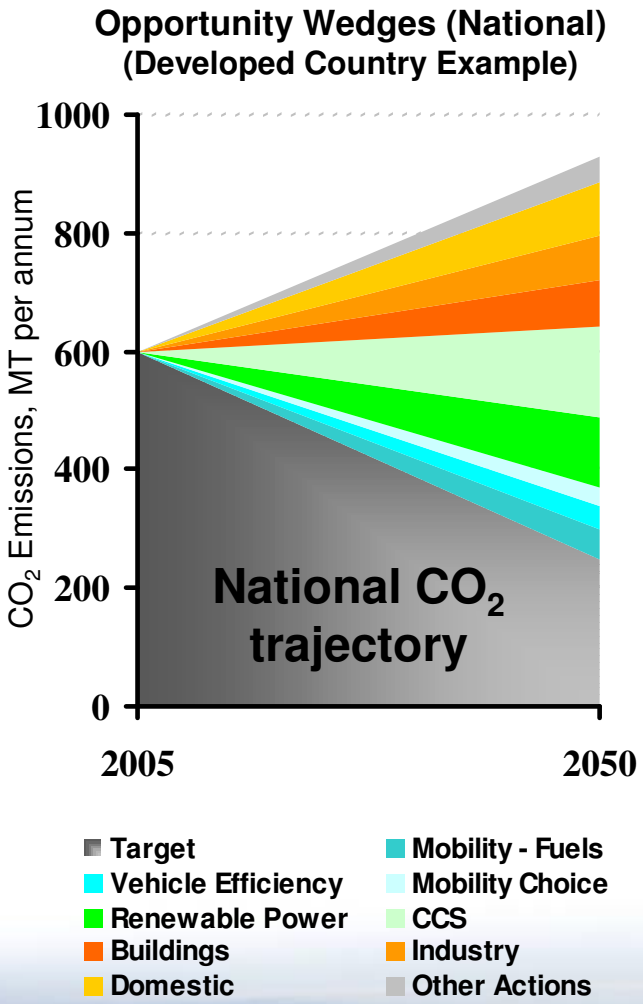
- Multilateral financing mechanisms such as GEF
- Far-out issuance of reduction units as a special case within the project mechanisms.

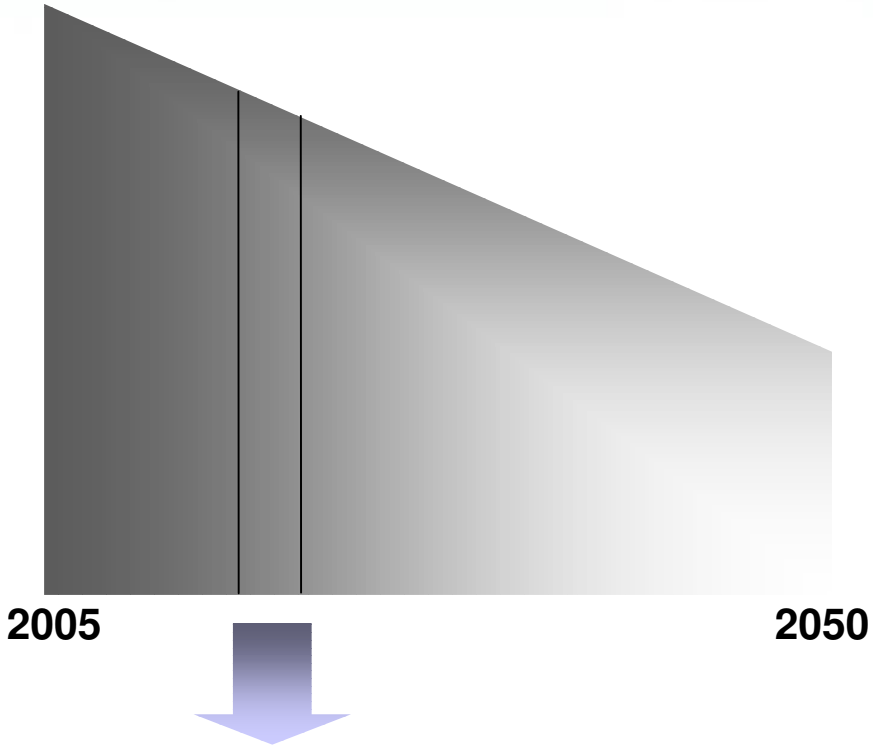
GHG markets are expanding globally



CO_2 targets and trading at national level

At the national level:

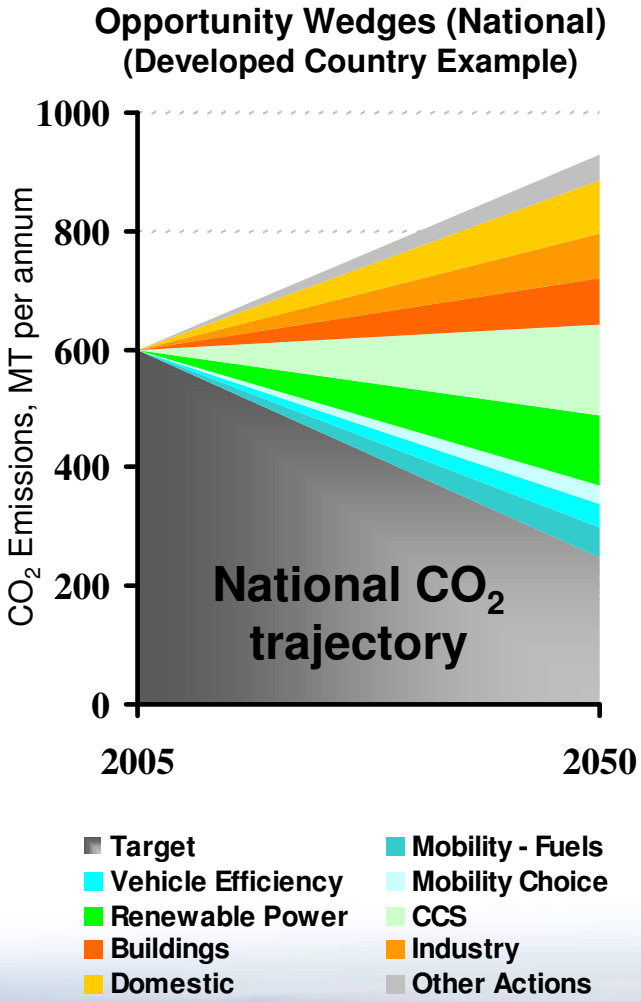


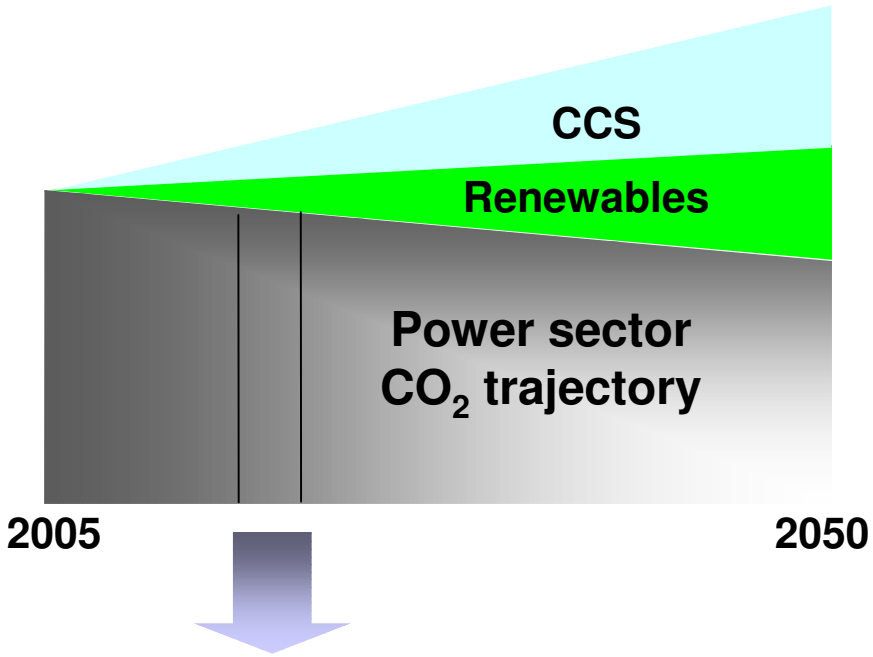


Trajectory for 2013 to 2018 for international allocation purposes.

CO_2 targets and trading derived from sectors

Or at the sector level only:

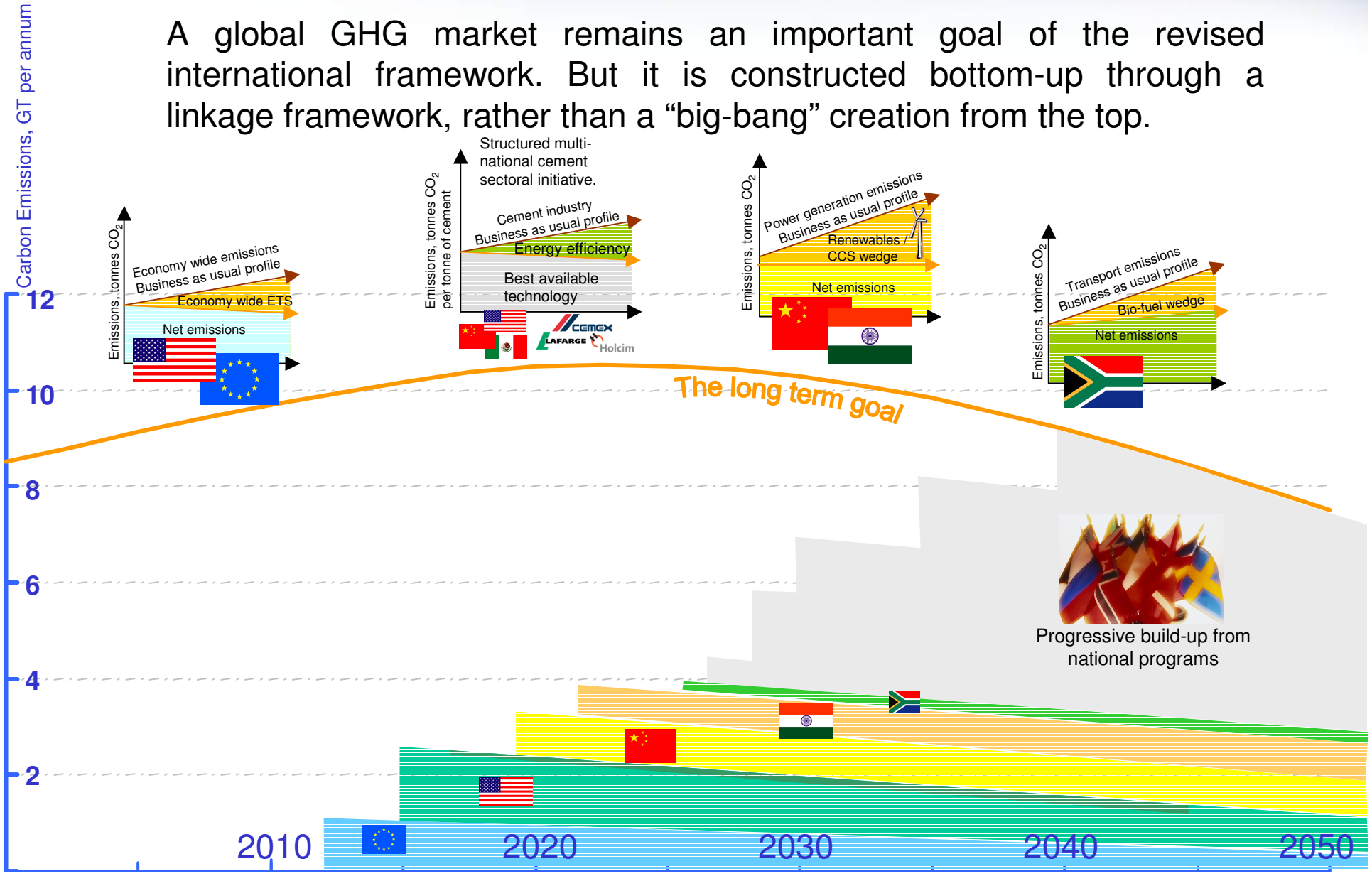




Trajectory for 2013 to 2018 for international allocation purposes.

Progressive Build-Up from National Programs

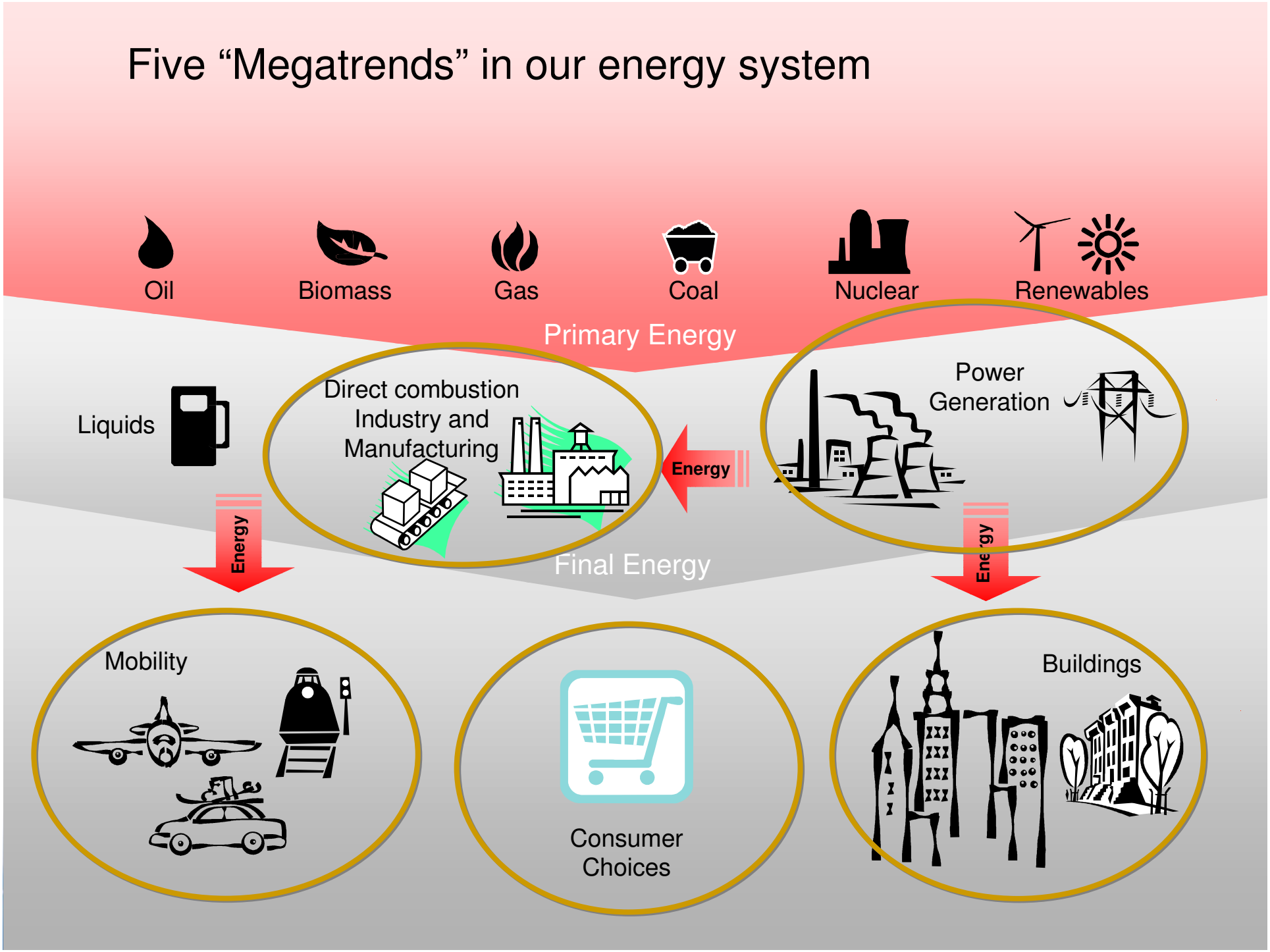
A global GHG market remains an important goal of the revised international framework. But it is constructed bottom-up through a linkage framework, rather than a "big-bang" creation from the top.



Framework Comparison

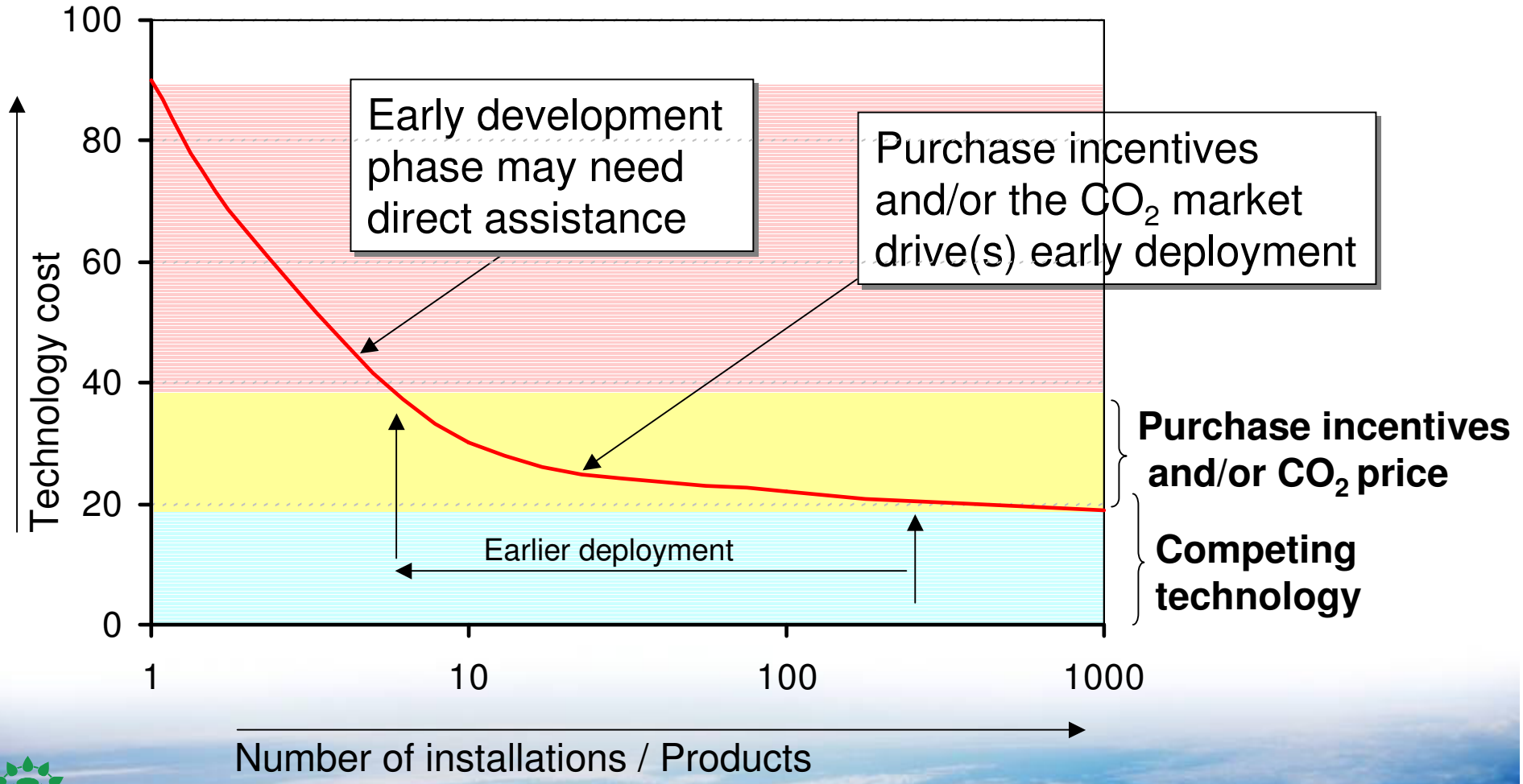
Kyoto – 2008-2012	WBCSD Revised Framework
Top down reduction obligations	Bottom-up – National / sector policies and commitments
Short term (5 year) compliance obligation	Longer term (50 year emissions trajectory)
Allocation of a reduction obligation – equitable allocation difficult to achieve politically	National opportunities and policies aligned with energy security and climate change priorities
Least cost compliance – not enough certainty for large investments in new technologies	Technology development and deployment focus
Emissions market	Deeper engagement of capital markets and greater influence over allocation of capital driven by a wide range of policies and a broad based emissions market.
Targets –tons reduced relative to a baseline	Targets still in terms of carbon reductions – but aligned to specific actions with GHG benefits – e.g. XX MW of wind power by 20XX.

Five “Megatrends” in our energy system



Technology development and deployment

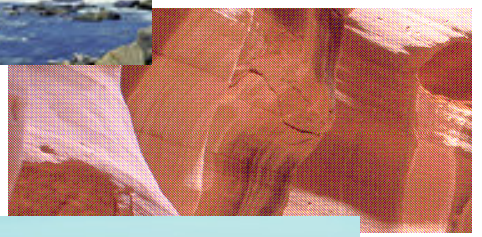
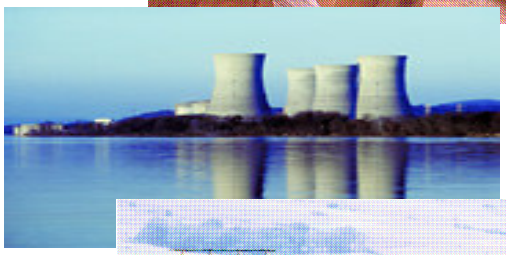
Future policy must focus on both the development of new technology and the rapid deployment of the both new and existing technology



Power Generation – What is needed

Key directions . . .

- Decarbonisation
- GHG emissions management
- Energy efficiency improvements
- Electriticy as a preferred domestic and commercial final energy source

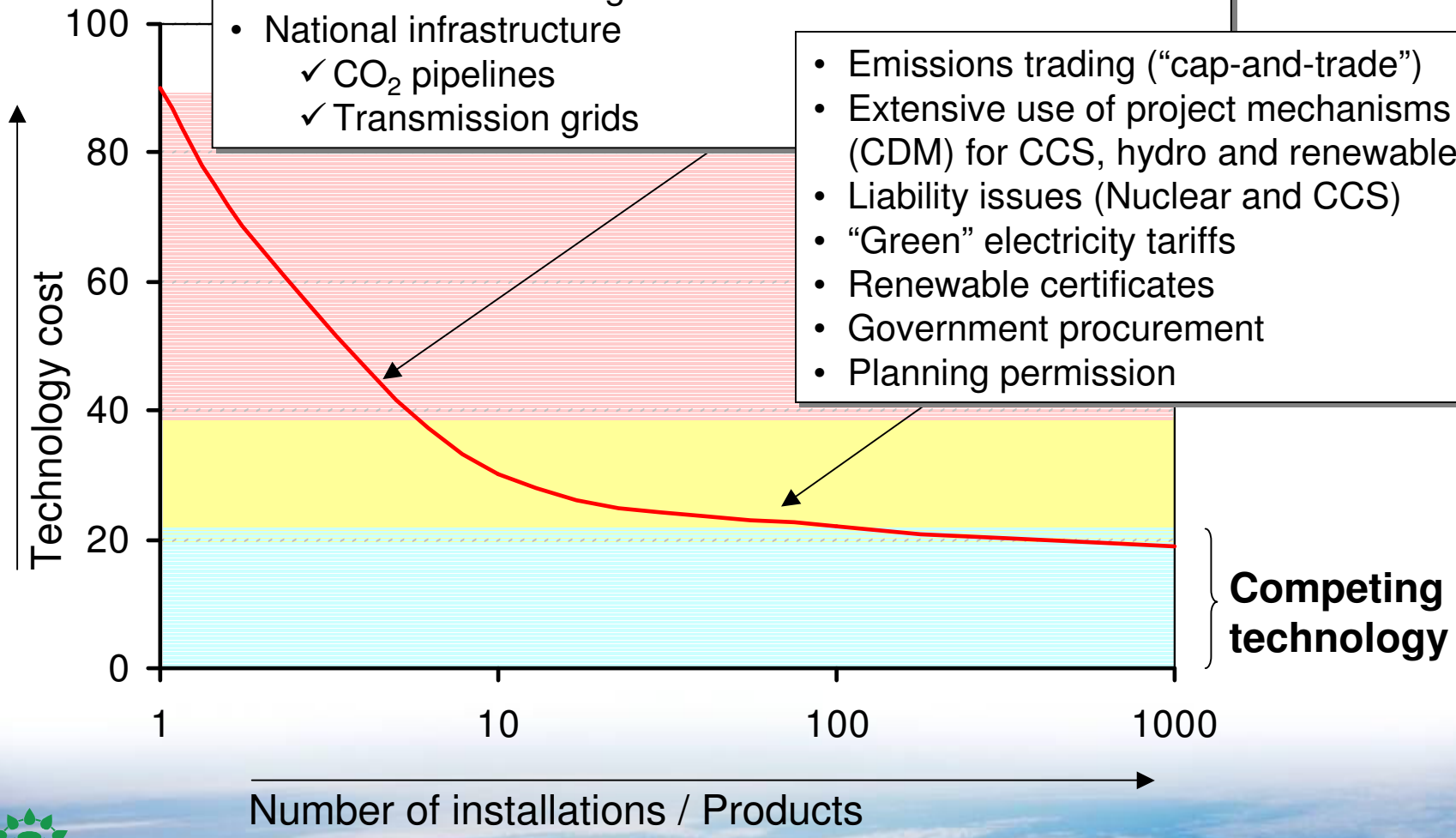
Key technologies…

- Renewables
- Nuclear power
- Clean coal technology - including carbon capture and storage (CCS)
- Natural gas

Power Generation – How it could work

- Financial assistance for large scale CCS demos
- International collaboration for Gen IV nuclear development
- National renewables goal
- National infrastructure
  - ✓ CO_2 pipelines
  - ✓ Transmission grids

- Emissions trading (“cap-and-trade”)
- Extensive use of project mechanisms (CDM) for CCS, hydro and renewables
- Liability issues (Nuclear and CCS)
- “Green” electricity tariffs
- Renewable certificates
- Government procurement
- Planning permission



Mobility – What is needed

Key directions . . .

Involve fuel producers, vehicle makers and the consumer.

- New more efficient vehicles
- Broadening the range and type of fuels
- Changing the way we use mobility

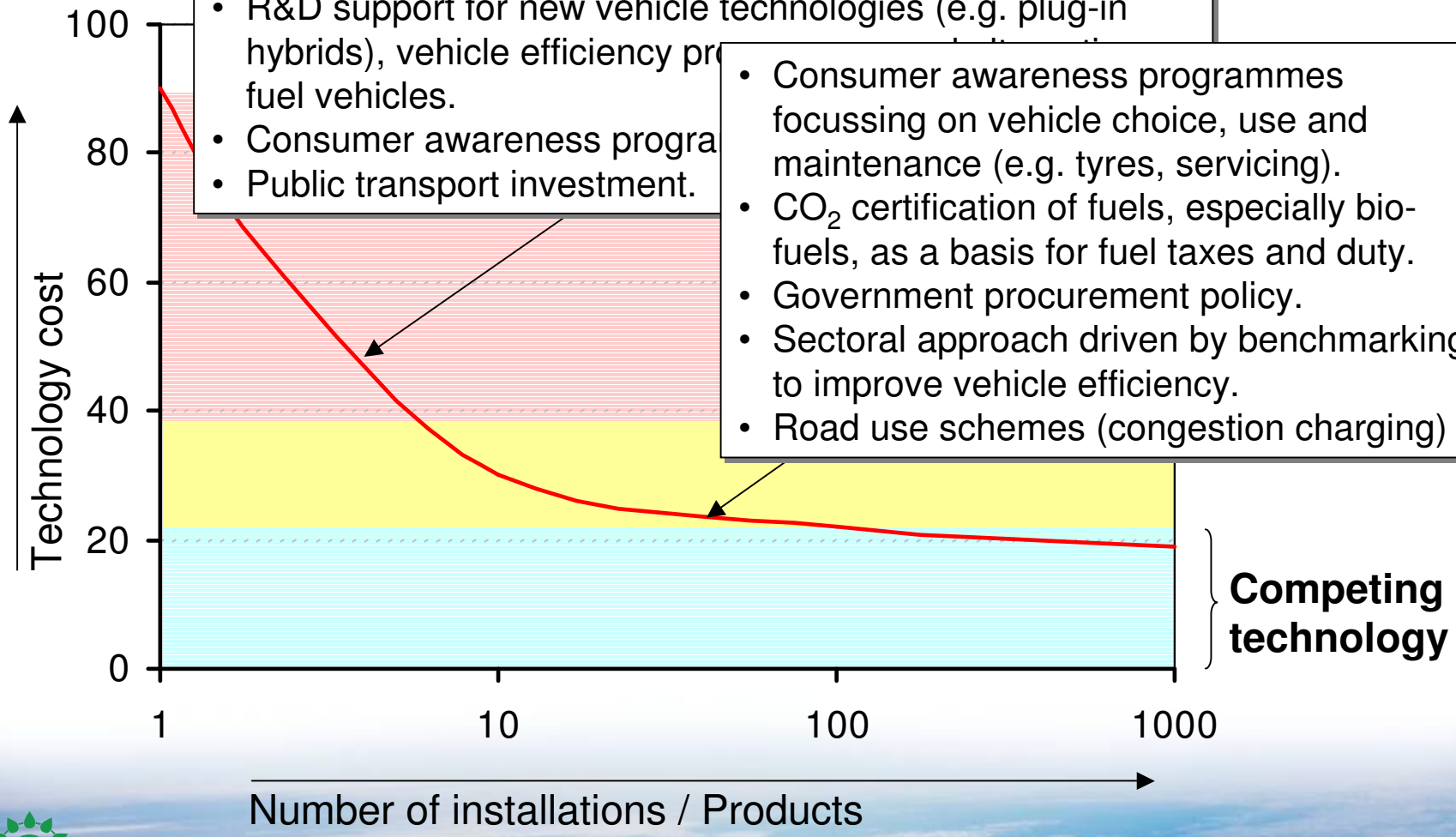
Key technologies . . .

- Hybrids and plug-in hybrids (drive trains and batteries)
- 2nd generation biofuels, synthetic diesels, electricity.
- Integrated public / private transport mechanisms
- Hydrogen

Mobility – How it could work

- Support development of fuel manufacturing technology.
- Demonstration projects for advanced technologies (e.g. hydrogen fuel-cell vehicles).
- R&D support for new vehicle technologies (e.g. plug-in hybrids), vehicle efficiency pr
  fuel vehicles.
- Consumer awareness progra
- Public transport investment.

- Consumer awareness programmes focussing on vehicle choice, use and maintenance (e.g. tyres, servicing).
- CO_2 certification of fuels, especially bio-fuels, as a basis for fuel taxes and duty.
- Government procurement policy.
- Sectoral approach driven by benchmarking to improve vehicle efficiency.
- Road use schemes (congestion charging)



Industry & Manufacturing – What is needed

Key directions . . .

- Energy efficiency measures
- Breakthrough low-GHG manufacturing technologies
- Rapid deployment of best available technology

Sectoral Approach . . .

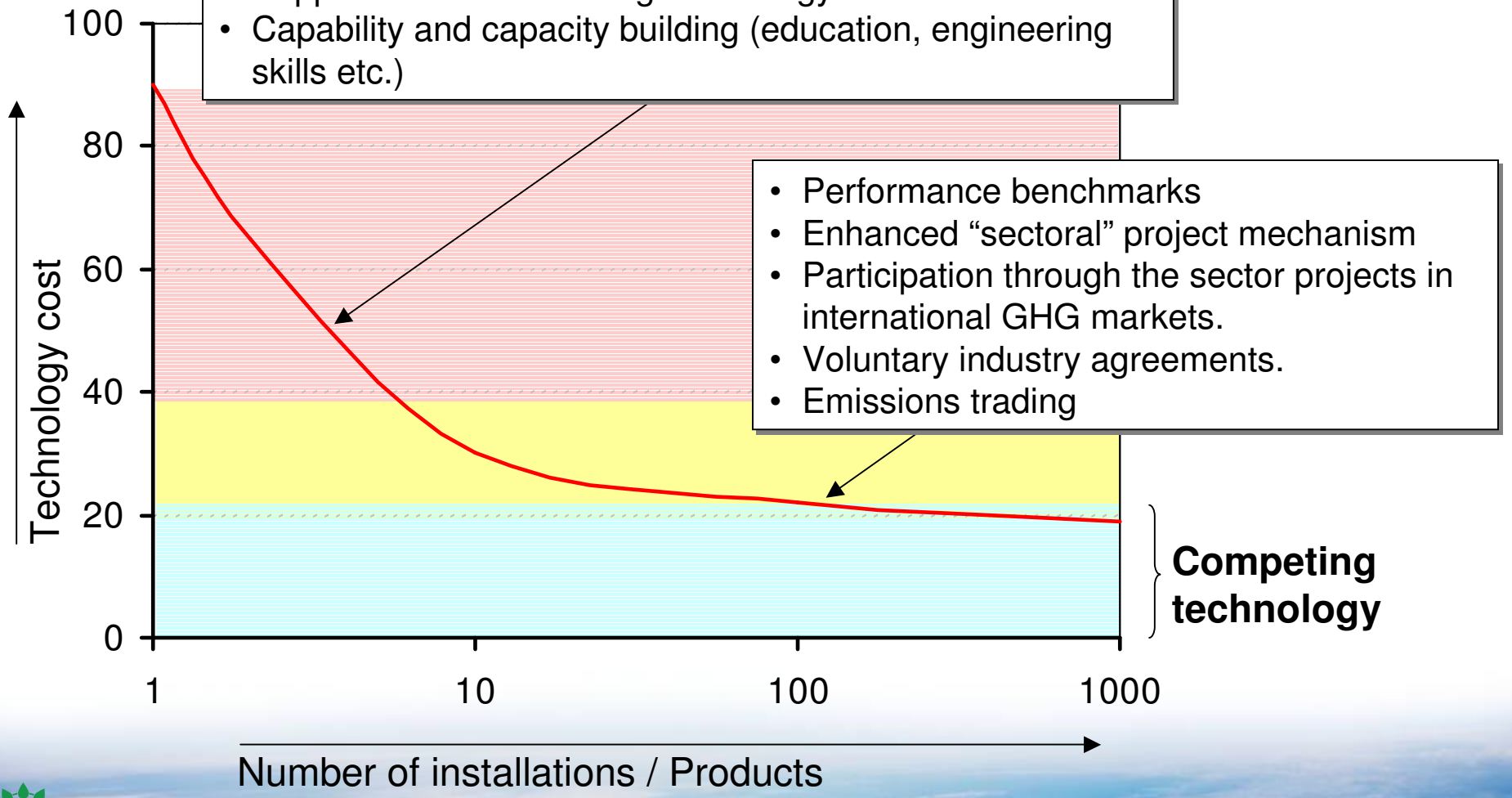
Many different policies already exist, but a sector based initiative offers scope for wide coverage and inclusiveness.

- Creation / Expansion of the international project mechanism to recognise whole sectors as a “project”.

Industry & Manufacturing – How it could work

- Technology development and transfer forums (e.g. Asia-Pacific Clean Development).
- Support for manufacturing technology R&D.
- Capability and capacity building (education, engineering skills etc.)

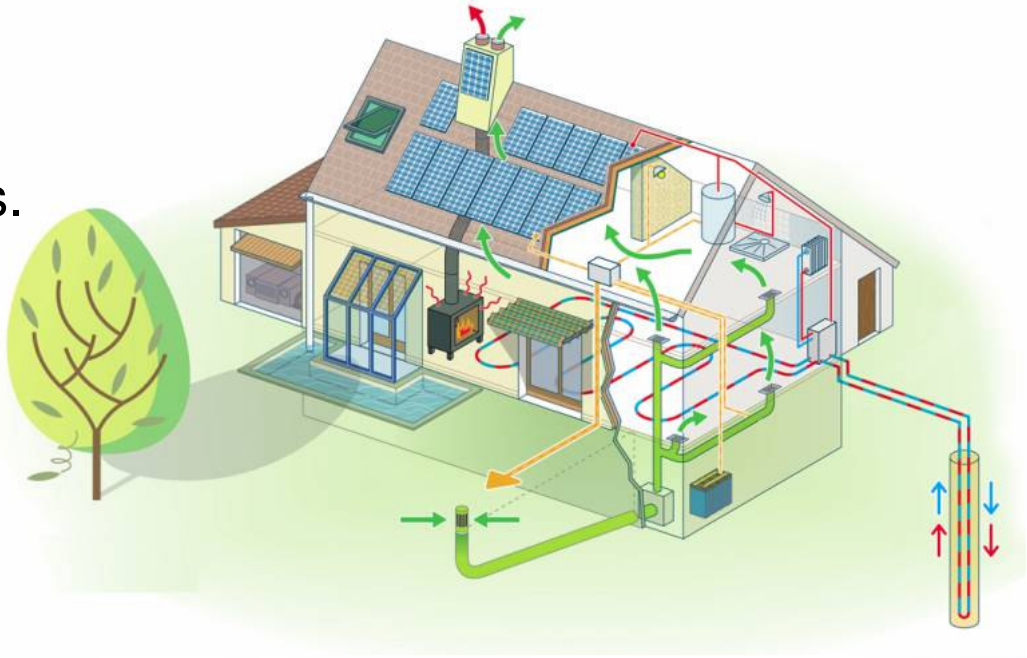
- Performance benchmarks
- Enhanced “sectoral” project mechanism
- Participation through the sector projects in international GHG markets.
- Voluntary industry agreements.
- Emissions trading



Buildings – What is needed

Key directions . . .

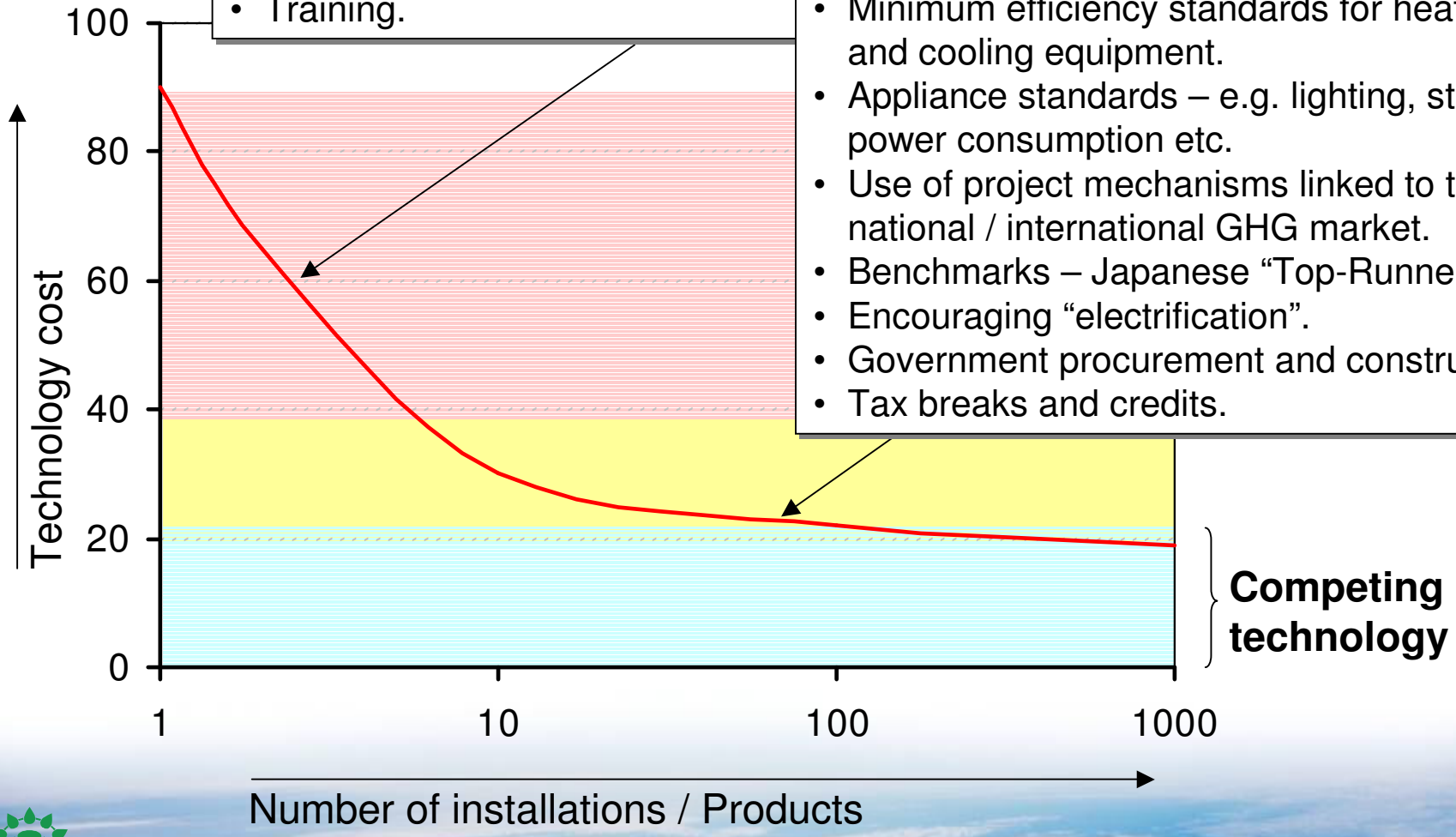
- Energy standards and codes for buildings, appliances and lighting.
- Education programmes for operators and occupiers.
- Transparency and awareness.
- Focus on building materials and their lifecycle emissions.
- Innovation in building design.



Buildings – How it could work

- Urban planning decisions.
- Encouraging radical design – e.g. design prizes.
- Education and awareness programmes.
- Training.

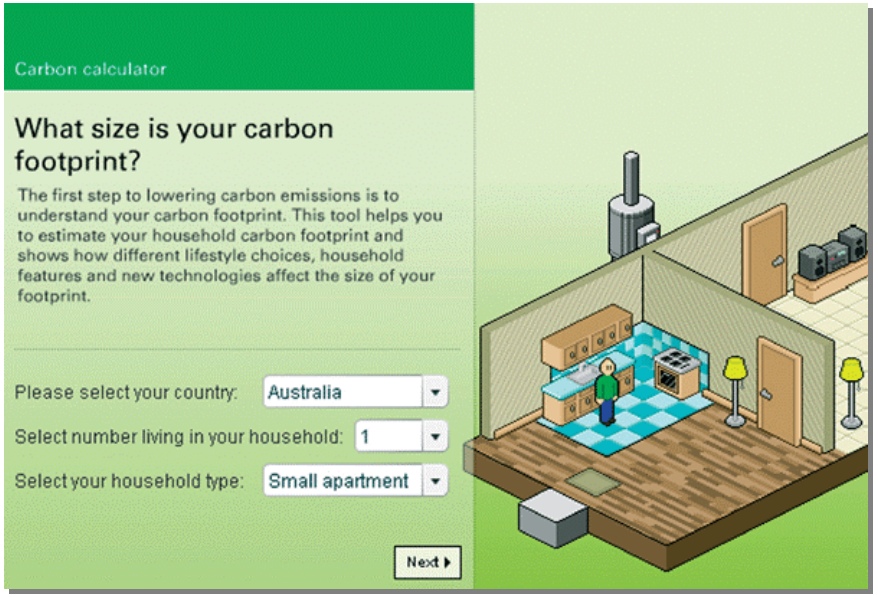
- Minimum efficiency standards for heating and cooling equipment.
- Appliance standards – e.g. lighting, standby power consumption etc.
- Use of project mechanisms linked to the national / international GHG market.
- Benchmarks – Japanese “Top-Runner”.
- Encouraging “electrification”.
- Government procurement and construction.
- Tax breaks and credits.



Consumer choices – What is needed

Key directions

- Increased consumer awareness and understanding of the energy/ carbon issue
- Robust programs to encourage energy efficiency targeted at consumers
- Attribute a value to carbon, which allows consumers to recognize its cost throughout product and service life cycle
- Market conditions that influence the consciousness of consumers



A Sustainable Energy Future

- Understanding the energy challenge
- Recognising the need for a sustainable approach
- Investing in technology
- Using the markets
- Delivering solutions

Doing it now !

An end in sight . . . . .?