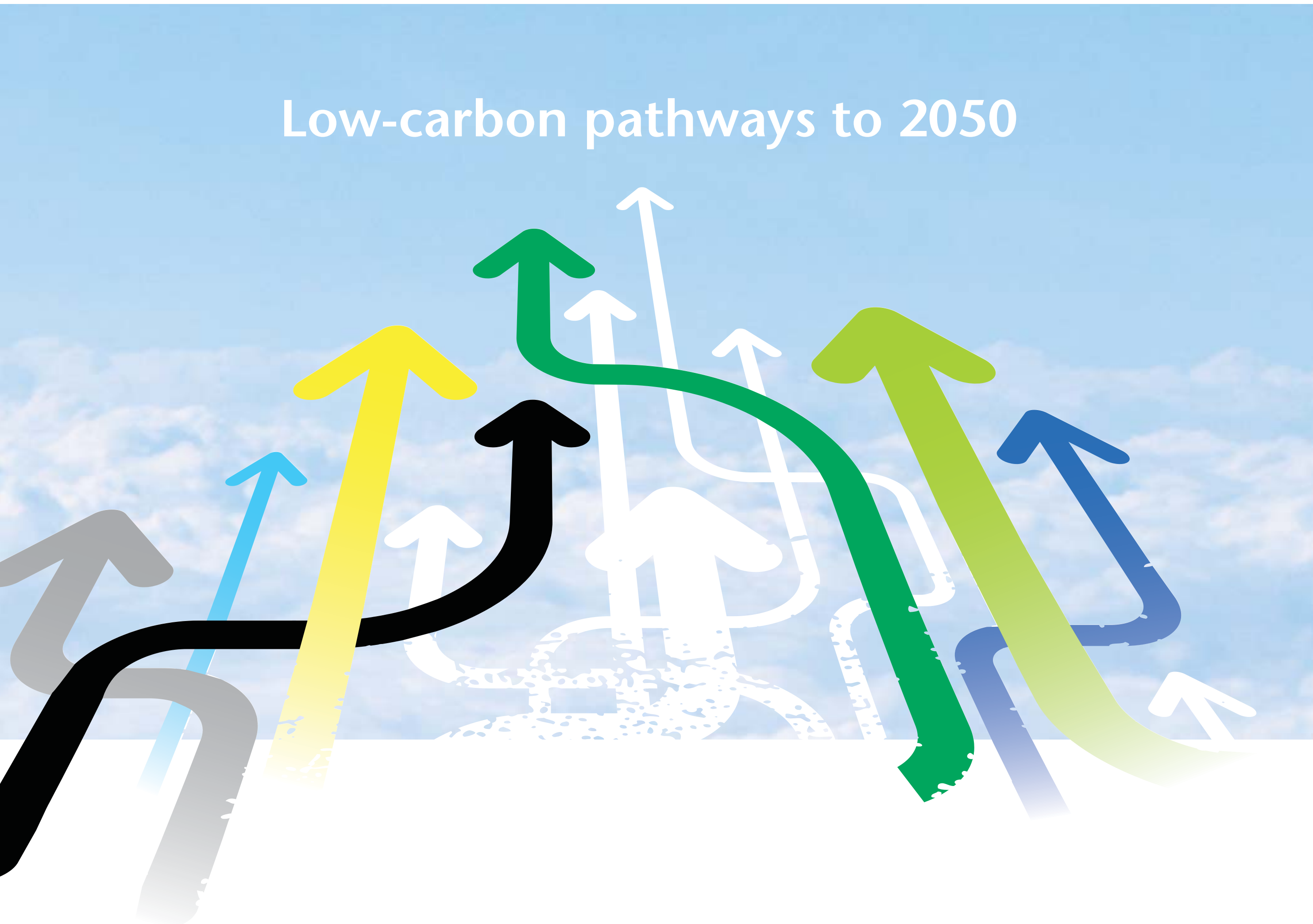
business solutions for a sustainable world

The Energy Mix



Low-carbon pathways to 2050

wbcsd energy & climate

The Energy Mix:

In its Vision 2050 project, the WBCSD envisages a world in 2050 that meets the needs of "9 billion people living well, within the limits of one planet". This will require substantial changes in the global energy system, to meet the expected increase in demand (30% - 50% more than in 2010 depending on the size of energy efficiency improvements) while also reducing global greenhouse gas emissions to half of 2005 levels. These challenges imply a radical departure from historical energy pathways (Box 1) and will require government policy intervention at a level not seen in the past.

This document seeks to explore the development of the global energy system to date and seeks to develop a better understanding of the roles played by markets, technology, and policy in shaping the future.

There is a significant risk of lock-in of the GHG emissions trajectory

Today, the global energy mix is an aggregate of different regional mixes, that have been shaped by local resource availability, security of supply concerns, economic development, and technology (Box 4). Examples of this range from coal dependence in South Africa to high hydro-electricity and biomass use in Brazil (Box 10) and nuclear in France (Box 9).

Carbon dioxide emissions (CO_2) from the energy system are now a major issue. While the technologies to reduce emissions are well known and business is technically able to deploy them, commercial viability remains an obstacle in many instances. Investment in the energy sector is characterized by high capital cost and longevity of assets, which means that the case for deployment of an alternative energy technology set must be very robust in the face of the known status quo. Partly for this reason, large-scale change operates on a generational time scale (Box 7), meaning that the substantive change required to reduce global emissions must be supported by a very clear and long-term business case for action to manage the associated investment risk.

The financial crisis which started in 2008 has reduced the appetite for investment risk and therefore raised barriers to change. This will result in further lock-in of a high-emission energy system and may reduce the chance of meeting future goals.

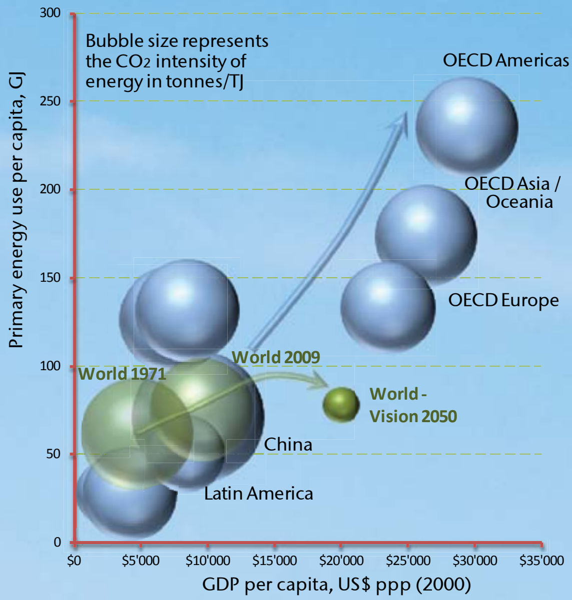
An energy policy framework is required to secure a pathway to vision 2050 outcome

A clear, unambiguous and well structured energy policy framework is required in all countries to shift the energy mix and deliver emission reductions faster than historical energy trends would otherwise dictate. Although governments are attempting to introduce such change, it is occurring slowly on a global level and the efforts are often fragmented and short-lived. More global action is needed and should start now.

Additional features of the current regulatory landscape include short-lived policies and surprise policy changes. These can lead to asset value destruction and stranded assets, thereby deterring future investment. Abrupt policy change can sometimes lead to a disruption of basic energy services, a consequence that no country or company will want.

Box 1

Regional & Global Development Pathways



National and regional energy use and development continues to follow a well worn pathway, albeit with the carbon intensity of the mix varying on the back of local resource availability (hydro in Latin America, coal in China). The pathway to a sustainable 2050 will need to be very different.

Although stability is needed, long-term approaches may still require fine-tuning over time and across geographies depending on progress, effectiveness and exogenous changes. The development of an energy and climate policy framework must:

- Be adequate during the up-coming transition period, while being aligned with the long-term framework objective (and not be for short-term political gain);
- Provide significant financial incentives and regulatory support (ensuring a level playing field) to investments in low-emission energy alternatives which are not currently commercially viable with an early goal of commercial-scale demonstration;
- Allow all technology options on the basis of their economic performance, environmental benefits and other relevant criteria;
- Deliver substantial improvements in energy efficiency (both supply and demand) through standards and incentives ("carrot and stick" combinations) and increase recycling rates of energy intensive materials;
- Balance supply security, affordability and environmental protection;
- Build public support for renewal and replacement of energy infrastructure.

The WBCSD supports actions at local, national, regional and international levels to implement policies to meet the aspirations of Vision 2050. WBCSD members will continue to act and engage pro-actively with continued actions in R&D and deployment, as well as through dialogue with policy-makers at all levels.

Pathways to 2050

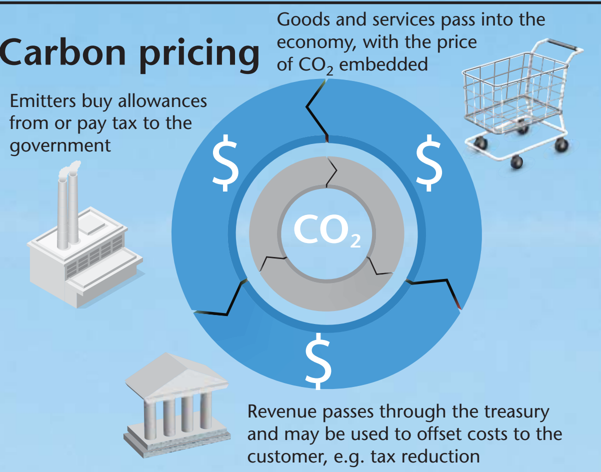
Carbon pricing has a critical role

Among the most powerful mechanisms available to reduce greenhouse gas emissions within an energy policy framework is a carbon price (Box 2). This notion was explored in some depth in the 2011 WBCSD publication Carbon Pricing: the role of a carbon price as a climate change instrument.
The goal of a carbon price is to incentivize behaviors such that the markets begin to differentiate between goods and services on the basis of their carbon footprint, which in turn promotes emission reduction investment opportunities. However, such a mechanism will only function efficiently if market distortions such as direct energy use subsidies (e.g. below-market fossil fuel prices in some countries) are eliminated.

Research shows that, in the absence of technology breakthroughs, in the longer term a global carbon price needs to be in the range US$100 - 200 per ton of CO_2 to have a substantial impact[1] , with the average abatement cost reducing over time as technologies mature and environmental and social externalities are recognised. The route to such a carbon price regime will involve a significant period of transition, avoiding economic disruption and competition distortion. This is a period for nationally tailored capacity building, policy implementation and transitional policies designed to divert expansion of the status quo and therefore lock-in to a long-term high emissions profile. It is also a critical period for the development and subsequent demonstration on a commercial scale of new energy technologies (Box 3) which can then be globally deployed as the carbon price rises.

Box 2

Carbon pricing



With carbon pricing being introduced piecemeal throughout the world, some manufacturers incur the cost of carbon, while others do not, even though they may be competing in the same market. The transition to a carbon price must address such competition issues. For example, if the policy involves the use of an emissions trading system, the interim free allocation of a significant portion of the allowances to certain sectors means that they do not incur the direct cost, but still see the opportunity to reduce emissions. The environmental goal is retained as a fixed number of allowances are in circulation.

1 IEA World Energy Outlook (several years), OECD Environmental Outlook to 2050 (2011), IPCC 4th assessment report (2007), The Stern Review (2007), academic institutions from around the world

The design of the policy framework has to be broad in scope and effective in its application through the economy

An energy policy framework must be both broad in scope and effective in its application throughout the economy. As the response rate to price signals varies from sector to sector due to differences in behavior, the mix of locally available energy sources, infrastructure turnover rate and the utility value of existing assets, the major sectors (power generation, transport etc.) will need specific and different policy approaches to enable the necessary changes. Successful frameworks include a combination of both "sticks" and "carrots" (Box 10 and Box 15). Importantly, carbon price signals should not be undermined through conflicting or overlapping policies; rather policies should be complementary and aligned toward a common goal.

Policy framework operating in each major sector and recognizing technology maturity

	Power generation & Major Industry	Transport	Commercial and Domestic / Buildings
Research & Development	Broad R&D policy framework for energy production and energy use		
Demonstration	Direct support for limited large-scale programs	Early infrastructure networks in key locations	Radical design in buildings-e.g. through competitions
Deployment	Carbon price delivered through a cap, taxes or performance standards, etc.	Carbon price impacts the fuel mix (e.g. fuel standard) Vehicle efficiency standards	Energy efficiency standards for buildings, appliances etc

The support gap

Huge infrastructure investments will be needed to modify the energy mix and lower emissions, requiring public acceptance of new technologies and large installations. Public support for implementation tends to wane when the project has a direct impact on people.

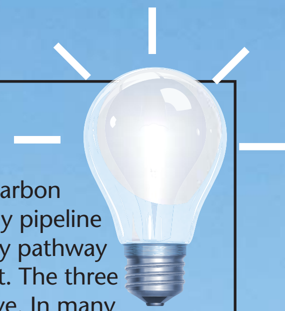
Business, policy-makers and society need to have a clear understanding of why and which technologies are needed in a carbon- constrained world and what the risks and benefits will be. Developing good models for local involvement in the implementation of low-carbon technologies will be essential to pave the way for public acceptance and public support.

The investment gap

According to the 2011 IEA World Energy Outlook, $38 trillion of cumulative investment is needed in energy-supply infrastructure to meet demand between 2011 and 2035. This is the equivalent of 1.6% of global annual GDP. Almost half is in the power sector. A large part will be in Asia, with China and India accounting for $5.8 trillion and $2.2 trillion respectively. To achieve the 450 ppm scenario, $15.2 trillion additional spending will be required in that period: power-sector ($3.1 trillion), transport ($6.3 trillion), and buildings ($4.1 trillion). Financing the 450 ppm scenario will be a significant challenge.

Box 3

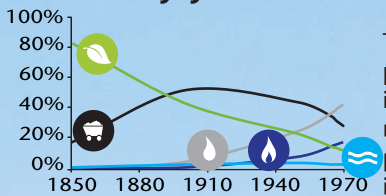
Closing the investment & technology gap



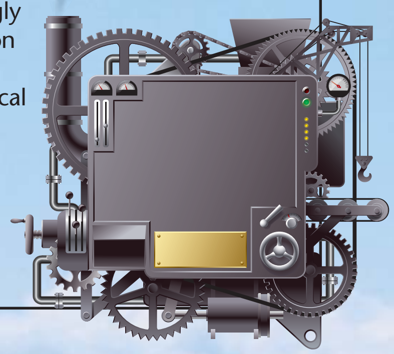
Technology change is critical for a long-term sustainable energy mix. Existing technologies (e.g. carbon capture and storage (CCS), solar, marine) must be rapidly developed to maturity and a technology pipeline established to offer a range of competitive alternatives for future deployment. A typical technology pathway model consists of three phases: Research & Development (R&D), Demonstration and Deployment. The three stages are needed to promote innovation allowing the technology to progress down the cost curve. In many policy frameworks, support for the Demonstration phase is key for learning by doing and delivering essential cost reductions for the deployment phase of large energy infrastructure. For a given technology, funding needs in this phase will be in a higher order of magnitude than the Research & Development phases. When a new technology is still in the upper part of the cost curve, the reach of any deployment incentive, e.g. the carbon market, is typically not sufficient to enable change and other policy measures are needed.

Box 4

The early years of the energy mix

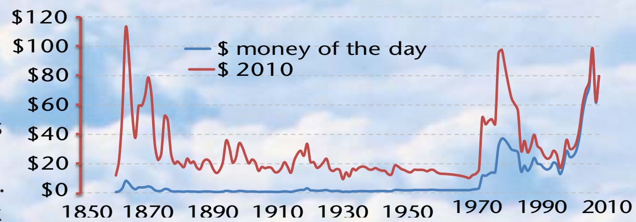


The 19th century Industrial Revolution was increasingly powered by coal, on the back of technological innovation in the form of the steam engine, gas lighting and the replacement of wood-based fuels in various metallurgical processes. In the early part of the 20th century, the internal combustion engine and newfound mobility accelerated the entry of oil (Box 5) into the mix. Global energy demand began rising rapidly during the Industrial Revolution, but most of the growth occurred after World War I and more recently in developing countries. In total, energy demand increased by a factor of 20, over 150 years.

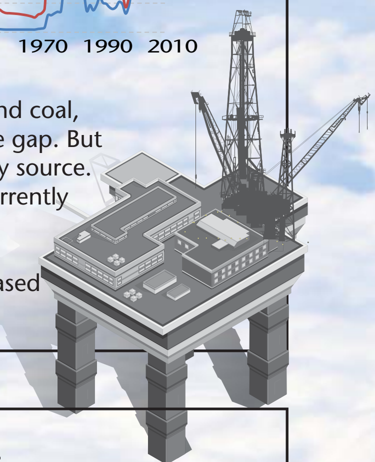


Box 5

The influence of oil prices



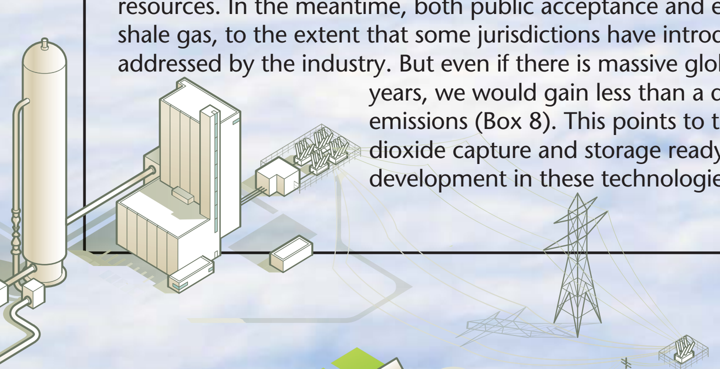
By 1970 oil dominated the global energy system. It had overtaken coal as the principal fuel and was used for power generation, home heating, chemical manufacture and, of course, transportation. But in 1973 OPEC initiated the first oil price shock and the politics of energy changed (Box 9). So did the energy mix. As the price of oil on an energy basis began to separate from gas and coal, demand for oil declined in all uses except transport. Coal, natural gas and nuclear filled the gap. But transportation continued to grow on oil, driven by its ease of handling as a portable energy source. Today, 60% of each barrel of oil goes into the transport system (40% in 1971). There is currently little interaction between the mainly oil-driven transportation sector and the utility sector, which depends on coal, gas, nuclear and renewable energy. There is still a significant price disparity between these two energy systems, but electric vehicle technology and the increased use of biomass in power generation may gradually integrate the two energy systems.



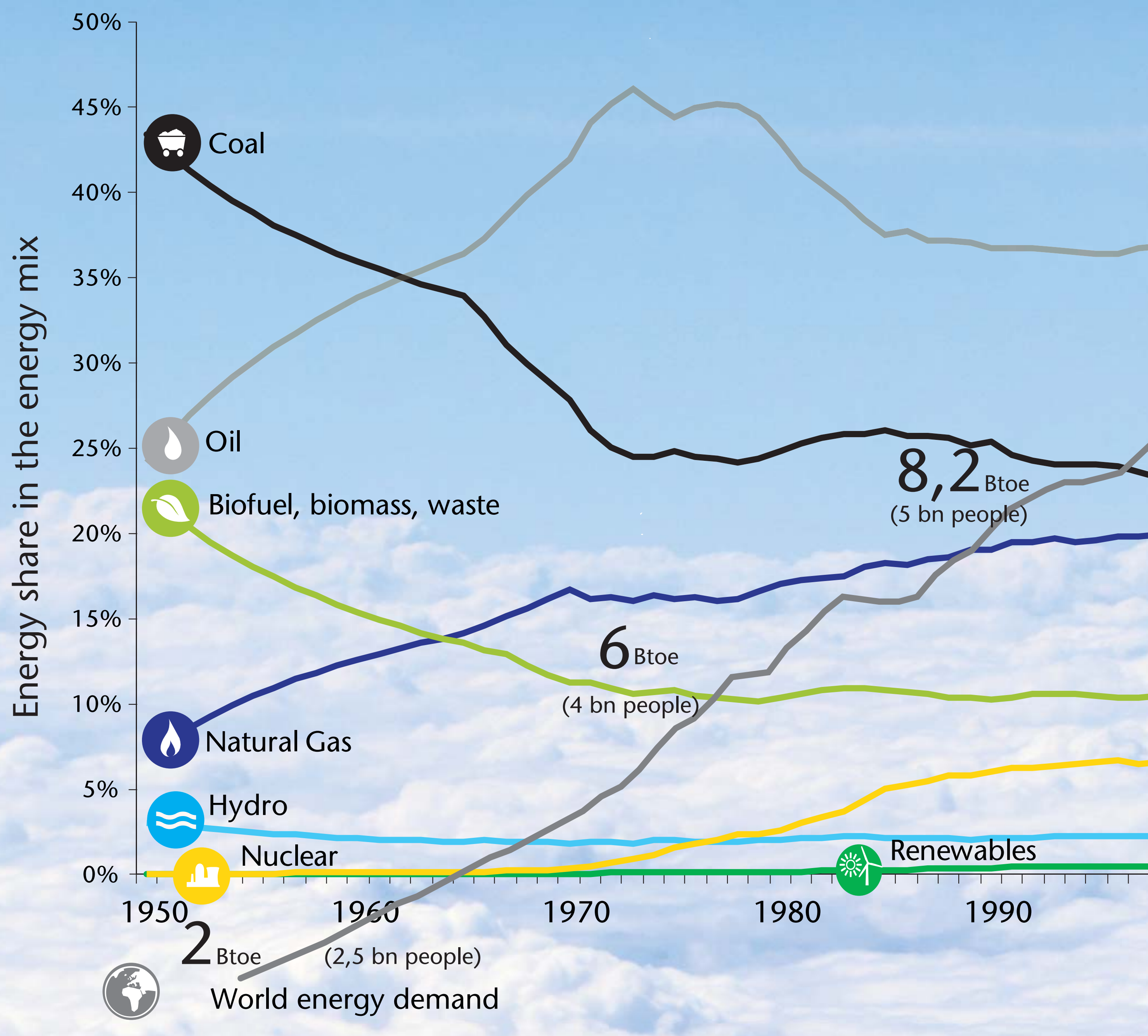
Box 6

Shale gas & the impact of new technology development

Gas technology developments have significantly impacted the energy mix. Firstly, liquefied natural gas (LNG) technology moved the gas market from regional to global. More recently, shale gas production has expanded in the US and changed the global natural gas situation significantly. The Massachusetts Institute of Technology (MIT) Natural Gas Study shows that significant emissions reductions in the US economy can occur on the back of shale gas resources. In the meantime, both public acceptance and environmental impacts are becoming significant issues for shale gas, to the extent that some jurisdictions have introduced drilling moratoriums. These issues will need to be addressed by the industry. But even if there is massive global replacement of coal with natural gas over the next 30 years, we would gain less than a decade before breaching the trillion ton limit for global CO_2 emissions (Box 8). This points to the need for making fossil-fuelled power generation carbon dioxide capture and storage ready (Box 14) and supports the further finding of MIT that development in these technologies must proceed irrespective of the state of gas supply.



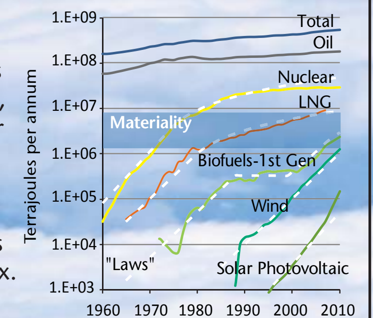
The Energy Mix:

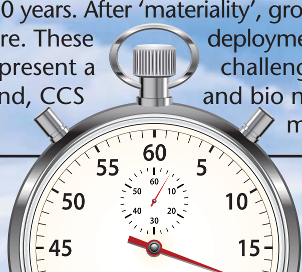


Box 7

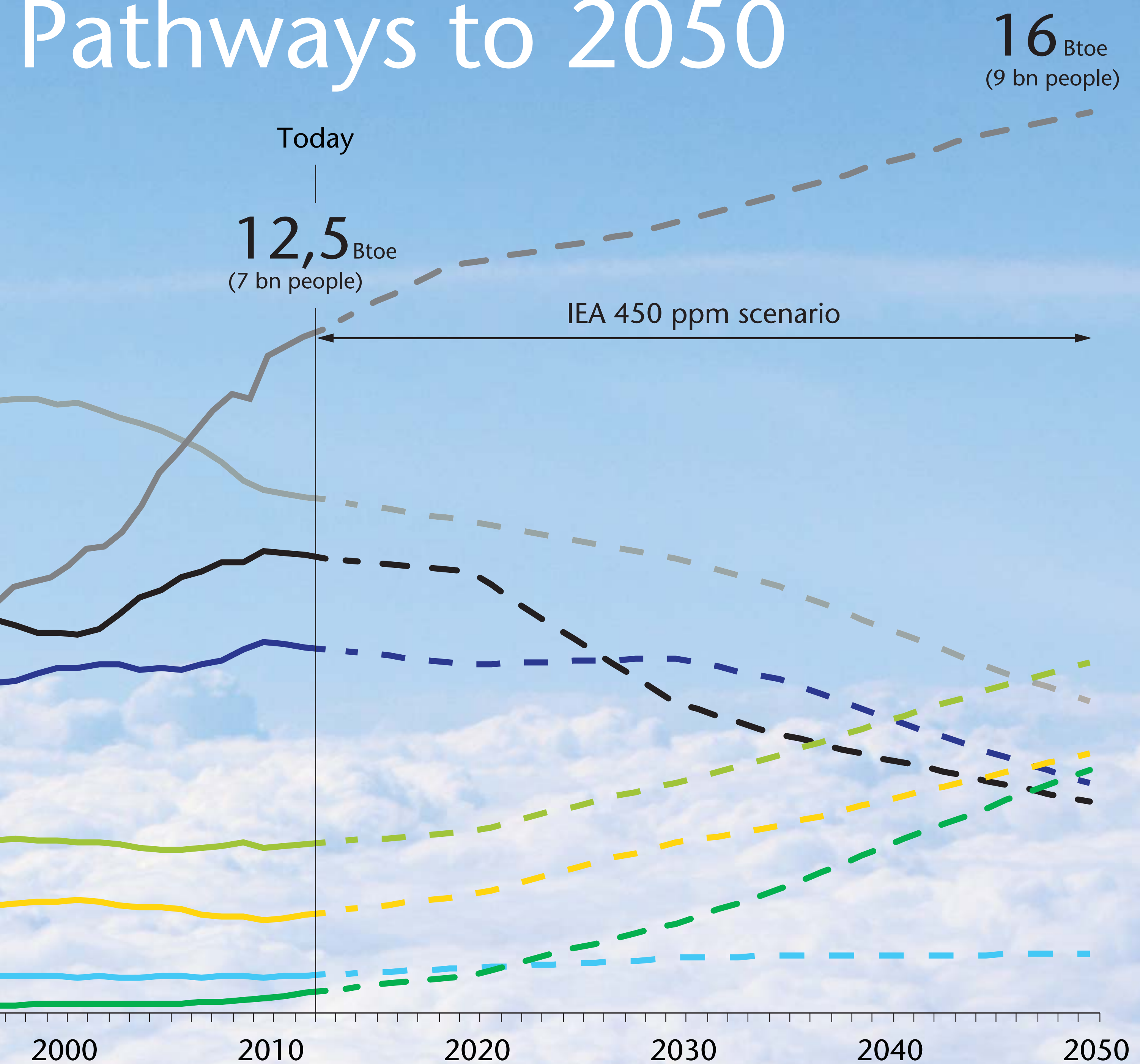
The pace of energy transition

An analysis (Haigh, Kramer – Nature December 2009) of the historical rates of change in the energy system reveals some set "laws". While these are not absolute, the evidence from the past is compelling. When technologies are new, they go through a few decades of exponential growth, which in the 20th century was characterized by scale-up at a rate of one order of magnitude per decade (corresponding to 26% annual growth). Exponential growth proceeds until the energy source becomes 'material' - typically around 1% of world energy. This is change on the scale of a human generation, i.e. 25 to 30 years. After 'materiality', growth becomes linear as the technology settles at a natural market share. These deployment curves are remarkably similar across different technologies and represent a challenge for rapid change in the energy mix. The dilemma is that solar, wind, CCS and bio need to over-perform in the future to have the impact required to meet the 450 ppm climate scenario.

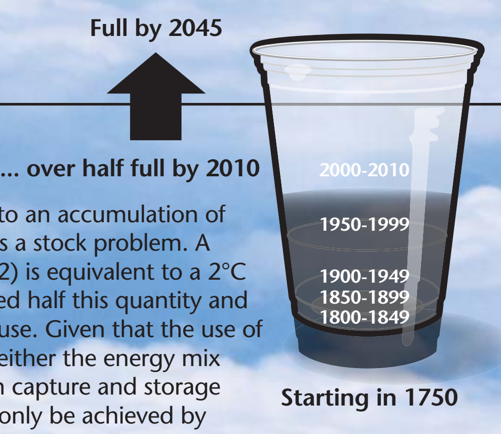




Pathways to 2050



This graph shows the shares of six energy sources in the world energy mix (left axis) and the world energy demand in billion tons of oil equivalent (Btoe) with the related world population (right axis). Estimates to 2050 come from the IEA world energy outlook and the IEA energy technology perspectives

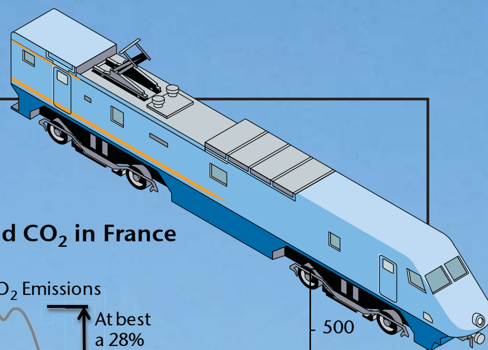


Box 8

URGENCY: A Glass Half Full

Additional carbon dioxide emissions above the normal carbon cycle are leading to an accumulation of this greenhouse gas in the atmosphere, with the effect that this can be treated as a stock problem. A cumulative emission (or stock) of one trillion tons of carbon (2.7 trillion tons CO2) is equivalent to a 2°C rise in temperature (Nature, April 2009). Between 1750 and 2010 we had emitted half this quantity and by circa 2045 the cumulative limit will be exceeded at expected rates of energy use. Given that the use of the remaining fossil reserves will far exceed the remaining "atmospheric stock", either the energy mix must move away from fossil fuels, leaving them unused in the ground, or carbon capture and storage must be rapidly applied on a very substantial scale (Box 14). This latter step can only be achieved by policy intervention, unlike many early shifts in the energy system that were driven largely by technology changes that benefited economic and social development.

Box 9



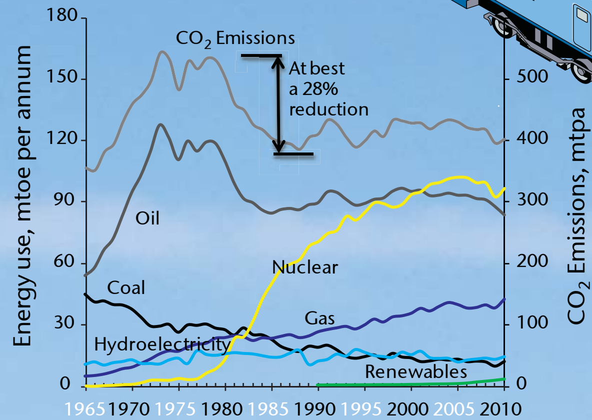
The French challenge of reducing emissions

Although a reduction in CO_2 emissions was not the goal in France in 1970, the policies put in place are largely sympathetic to a CO_2 reduction strategy:

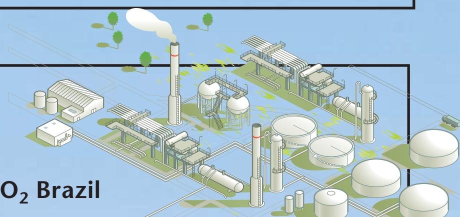
- Strong support for nuclear power;
- High speed nationwide rail transport;
- Significant gasoline / diesel taxes.

As a consequence, emissions were reduced by 28% with nuclear rising to 80% of the electricity generated. French emissions are currently at the level of 1970 and the emissions intensity of the French economy is now almost the lowest in the OECD. However, transportation remains a big challenge in the decarbonization of the French economy. The French energy mix shows that strong policies can be effective in changing the energy mix rapidly.

Energy and CO_2 in France

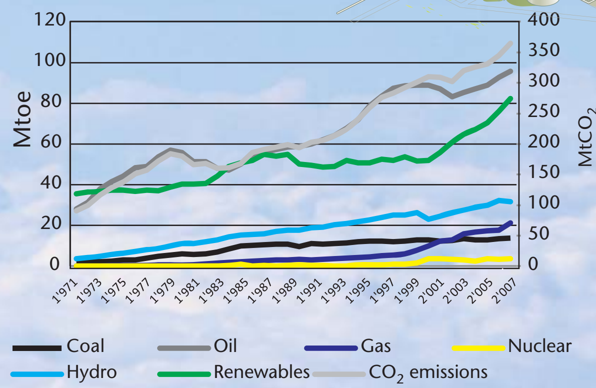


Box 10

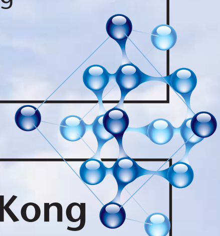


Decoupling growth from emissions: the Brazilian case

Energy use and CO_2 Brazil



In Brazil natural resources and supporting policies have allowed the country to grow while retaining a low-carbon intensity energy mix (35 tCO_2/TJ) and per capita emissions (1,9 tCO_2). Hydro power generates 80% of electricity demand, lowering the carbon footprint of electricity consumption. After the first oil crisis Brazil launched its ethanol program (Poralcool), successfully reducing oil demand, air pollution and GHG emissions. Initially, support measures were subsidies for ethanol production. These were followed by favorable tax treatment in combination with blending mandates. Today 90% of all new cars sold are FlexFuel, representing 43% of the total Brazilian fleet. The success of the program highlights the importance of long-term government efforts and public–private collaboration around ethanol related R&D. However Brazilian CO_2 emissions have still risen, driven by population growth and economic development, but by much less than the business as usual scenario. Brazil also faces the challenge of reducing emissions from current and accelerating land-use change – essentially deforestation and forest degradation associated with expanding agricultural production, large-scale infrastructure projects and extractive industries.

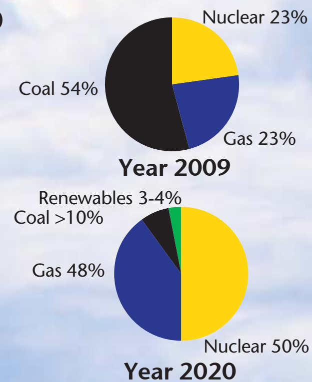


Box 11

Setting a target & developing an energy mix roadmap – Hong Kong

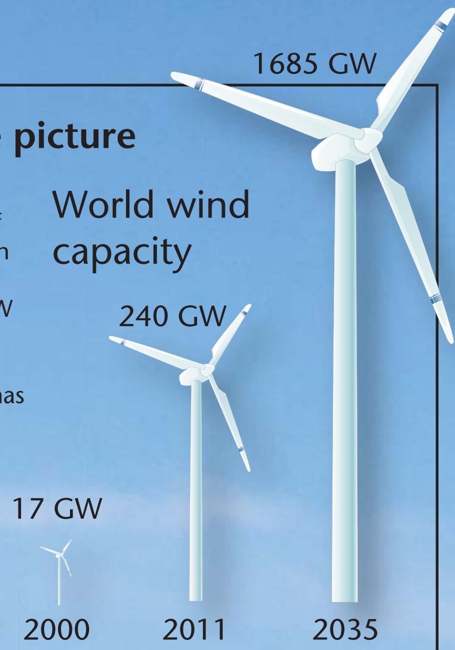
Public processes are required to reduce emissions in the energy sector. In Hong Kong, the Climate Change Strategy and Action Agenda is a step in this direction. The proposal sets a carbon intensity reduction target per unit of GDP (between 50 and 60% by 2020 from 2005 levels), contributing to China's national medium-term targets (between 40 and 45% carbon intensity reduction). One of the key elements for achieving this reduction is an ambitious power mix objective for 2020 where nuclear and gas will replace coal. The dramatic shift in the mix is illustrated. The challenge in terms of timeline is huge and in terms of costs, yet unknown. However, there is confidence in China that with appropriate best practices in geological, climate- adaptive siting and improved designs for safety of currently available nuclear technologies, nuclear power stations can be built, operated and decommissioned safely, efficiently and cost-effectively. From a business perspective, the target and roadmap provides a framework for power sector investment over the next 10 years. On the other hand it still requires more specific policy measures to support the changes proposed, especially for energy end-use efficiency and promoting the use of clean fuels for motor vehicles.

Hong Kong's fuel mix for power generation



Box 12

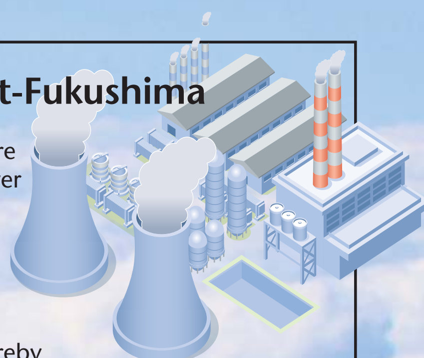
Renewable energy policies can change the picture



Today renewable energy provides 13% of the global energy mix (2% Hydro, 10% biomass and waste, 1% wind/solar etc.) and 19% of the power mix. The expansion of wind and solar in particular has been driven by technological improvements and support policies (such as Feed in Tariffs). As a consequence there is 240 GW of wind and 40 GW of installed solar photovoltaic (PV) capacity worldwide. Experience in several EU countries shows that rapid uptake of renewable energy can happen with support policies. The increased share of wind and solar has led to changes in the price setting mechanisms (and the marginal generation pattern) in some European markets in the past years. The contribution of wind in the electricity systems in some countries has been enormous due to feed-in-tariffs support: Denmark (26%), Germany (8%) and Spain (16%). More than fifty countries, including China, India and Brazil, are following this route. In the case of hydro-power, the worldwide technical potential is estimated at 14,576 TWh/yr, over four times the current worldwide annual generation. The EU has set ambitious targets for 20% renewable energy in the energy mix by 2020. It seems that the EU on average will achieve this goal: some countries will over-perform while others will struggle to increase the renewable share. It is important to recognize that a higher share of renewable leads to an electrification of the energy system requiring new high-voltage transmission capacity, generation back up capacity and development of "smart grid" solutions to manage the high variability and intermittence. Therefore, it is crucial that policies aim at the whole spectrum of renewable technologies. In the face of the huge investments needed, policy-makers need to ensure that these targets are achieved in a cost-efficient way. (i.e. prevent market distorting subsidies becoming permanent).

Box 13

The global nuclear landscape & perspective post-Fukushima

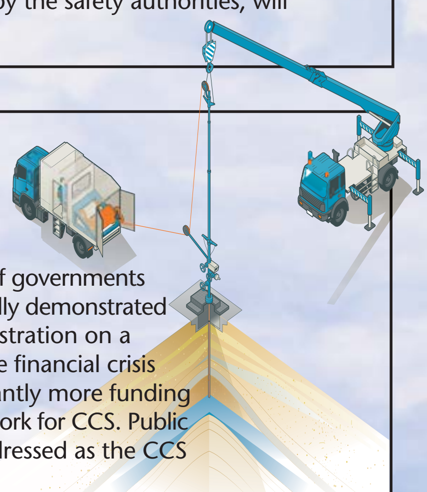


For the nuclear industry, the Fukushima accident has, in particular, led to more demanding conditions to warrant the successful development of nuclear power in the future. The first is a strong emphasis on safety, including the strengthening of the international discipline on this topic. Operators and Safety Authorities worldwide are in the process of integrating lessons and experience from the accident, and the recommendations on safety, stemming from the tests and safety audits, will progressively be implemented. Second, there is a need to significantly enhance dialogue and transparency vis-à-vis all stakeholders, thereby improving acceptability of nuclear energy and ensuring that opinions are expressed, and decisions made, on the basis of sound and factual information. Indeed, the fundamentals underpinning the development of nuclear energy remain unchanged or are even reinforced in today's international context: the forecast of a steep rise in the energy demand over the next decades, the general quest for energy security and affordability at a time of depletion of fossil resources leading to higher prices, and the imperative necessity to reduce greenhouse gas emissions inducing climate change.

Considering this context, and its impacts on society, most of the countries where nuclear power is either in use or under consideration have confirmed their interest for this source of energy as part of their energy mix. The most recent forecasts from authoritative institutions such as the IEA (WEO 2011) anticipate a strong increase (60%) in the world's nuclear generation capacity between now and 2035. Yet, decisions to be made by governments relative to their energy goals and policies, and by the safety authorities, will influence the pace of such evolution and the scheduling of some projects.

Box 14

Carbon capture and storage (CCS)



Fossil fuel makes up around 81% of the global energy mix and projections show that it could still contribute 45% of the energy mix in 2050 (IEA ETP). Reducing emissions in the energy sector will therefore depend on the ability of governments and business to bring CCS technology to the market. CCS has been successfully demonstrated in the US and EU on a small scale and the technology is moving to demonstration on a commercial scale as a result of a policy push in the EU and Australia. But the financial crisis has taken its toll on the efforts now underway. In the coming years significantly more funding will be needed together with the development of a stable regulatory framework for CCS. Public acceptance and water requirements are also issues which will have to be addressed as the CCS development will take place.

Box 15

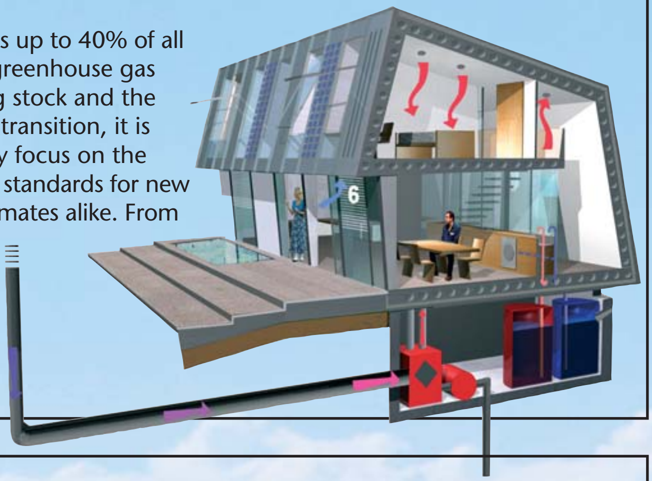
Advances in road transport

Fuel taxation and standards have resulted in the EU vehicle fleet being 40% more efficient than in the USA. Incentives for low-carbon transport and the recent definition of mid- and long-term targets in the EU (130 g CO_2/km by 2015 and tentative 95 g CO_2 km by 2020)and Japan have led to the proliferation of more efficient new cars being sold in the market at an unprecedented speed. Additionally, mitigating the high dependence of fossil fuel in transport (Box 5) have encouraged companies to produce new hybrid and electric vehicles. However, in many countries the increase in activity (passenger-kilometers) has been larger than the improvements in efficiency, and supplemental policies are needed to reduce the impact of the rebound effect created by the economic savings achieved.

Box 16

Energy Efficiency of Buildings

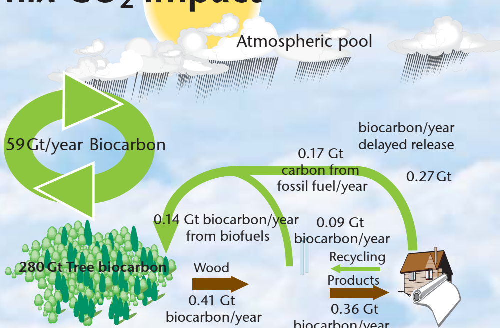
According to UNEP SBCI, the building sector consumes up to 40% of all energy and contributes up to 30% of global annual greenhouse gas emissions. Given the inefficiencies of existing building stock and the massive growth in new construction in economies in transition, it is obvious that future energy policies must include a key focus on the building sector. A basic political requirement is setting standards for new buildings as well as for renovation, for cool and hot climates alike. From 2021 European legislation requires all new houses to be near zero energy houses. Investments in energy efficiency in the building sector are long-term infrastructure investments which also have the potential to boost the local economy, create jobs and improve living conditions.



Box 17

Leveraging natural resource systems and cycles: a contribution to managing the energy mix CO_2 impact

According to the IPCC's 4AR a sustainable forest management strategy – aiming at maintaining or increasing forest carbon stocks, while producing an annual yield of timber, fiber or energy (still an important share of the energy mix) from the forest – will generate the largest sustained mitigation benefit. Bringing more of the world's forests under sustainable management and leveraging the carbon cycle of forests (see illustration) is an important global climate objective which links with the decarbonization of the energy mix towards a low-carbon society. But this is only achievable through effective on-the-ground implementation as proposed, for instance, by the REDD + mechanism.



Forests are ecosystems that when managed sustainably "re-cycle" carbon between trees, the atmosphere and forest products – while also producing many other social, ecological and economic benefits. Note that the carbon removed from the forests by industry represents only about 0.7 % of the carbon that is recycled annually, and less than 0.14 % of the total carbon stored in the world's forests.

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