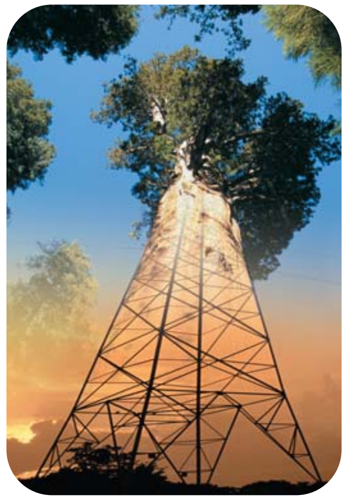

Energy and Sustainable Development

Energy plays a strong role in sustainable development. It contributes to economic activity and higher living standards, but is also costly and the source of considerable environmental degradation.

This series examines six facets – energy security; improving energy efficiency; renewable energy; making markets work; transportation; and environment, health and safety – of sustainable development in the energy sector. It envisages a sustainable energy system as providing ***universal access to adequate supplies (now and for future generations) of affordable, safe and reliable energy produced, distributed and used in a manner that is efficient and environmentally-friendly.***

All countries – developed and developing – will need to design their own policy mix. National circumstances will affect the scope for action and the appropriate policy choices in and between countries.

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Environment, Health & Safety

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Environment, Health & Safety

ENVIRONMENT, HEALTH AND SAFETY

The environmental account of energy is especially heavy. The impacts stem from two sources. The production, transformation and transport of energy cause environmental strain typical of heavy industry. While there have been great strides to reduce the environmental impacts of industrial activities there is still a great deal more to be done.

A more difficult challenge is the environmental consequences of energy use. Proactive efforts to shape society's energy use have been limited by fear of hampering energy's contribution to economic growth and higher living standards. Managing the interactions between energy and the environment is a major sustainability challenge for policy–makers.

The environmental, health and safety impacts are many. In broad terms, they encompass:

- climate change induced by greenhouse gas emissions;
- local and regional air pollution;
- water pollution and ecosystem degradation;
- radiation hazards; and
- risks of accidents and sabotage.

The severity and likelihood of the impacts vary, as does the degree to which the environmental risks have been captured, either by regulatory action or by pricing structures. In many situations especially those involving the local effects of energy production, transformation and transport – the risks have been recognised and subjected to a certain degree of regulatory management and oversight. Other risks – particularly those involving greenhouse gas emissions and ensuing climate change – are less understood and not managed sufficiently.

CLIMATE CHANGE & GREENHOUSE GAS EMISSIONS

Actions to curb climate change will shape the future of the energy sector. There are strong links between fossil fuel combustion, greenhouse gas concentrations, climatic changes and a variety of potentially adverse biophysical and socio-economic shifts (see Box). Consequently, efforts have been made in many political spheres – local, provincial, national and international – to find ways to reduce greenhouse gas emissions from the energy sector.

Patterns and Trends

The energy system is a major emitter of the three most important greenhouse gases – carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) – behind human-induced climate change. Fossil fuel combustion, and to a lesser extent production and transformation, contribute nearly all (97%) of the man-made CO_2 emissions, 28% of CH_4 emissions and 17% of N_2O emissions in OECD countries (Table 1) [1]. With the global warming potentials of the various gases factored in, energy use is the source of 83% of OECD greenhouse gas emissions.

The IEA World Energy Outlook (WEO) projects that global CO_2 emissions will grow by 60% from 1997 to 2020 (Figure 1). The CO_2 emissions of OECD countries, now half the world's total, are expected to grow 25% by 2020. Emissions of developing countries are projected to grow much faster, more

1 Fossil fuel production and transformation release methane through the venting of natural gas in oil operations and coal mining.

Intergovernmental Panel on Climate Change Third Assessment Report

Found that:

"Observations show the Earth's surface is warming, and that most of the observed warming over the last 50 years was likely due to increases in atmospheric greenhouse gas concentrations due to human activities. Global average surface temperature during the 21st century is very likely to rise at rates without precedent in the last 10 000 years. Increases in concentrations of CO_2, the principal anthropogenic greenhouse gas, in the 21st century are virtually certain to be mainly due to fossil-fuel emissions."

Among the projected impacts of climate change are:

- Increased threats to human health, particularly in lower income populations, predominantly within tropical/subtropical countries.
- Altered ecological productivity and biodiversity, with an increased risk of extinction of some vulnerable species.
- Changes in commercial yields of cereal crops, with yields decreasing in most tropical and subtropical regions and either increasing or decreasing depending on the extent of temperature rises in some temperate areas.
- Exacerbated water shortages in many water-scarce areas of the world.

"The impacts of climate change will fall disproportionately upon developing countries and the poor persons within all countries, and thereby exacerbate inequities in health status and access to adequate food, clean water, and other resources."

Populations in developing countries are generally exposed to relatively high risks of adverse impacts from climate change, and because of poverty and other factors, have low adaptive capacity.

Source: IPCC (2001), *Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, N.Y.

than doubling from 1997 to 2020, contributing 50% of global energy-related CO_2 emissions in 2020, in comparison with 39% today. However, in per capita terms, emissions of developing countries remain considerably lower than those of developed countries. Energy use per unit of output is higher in developing countries, so the potential for improved efficiency may somewhat offset the growth in emissions per capita that is likely to result from economic growth. Emissions of transition economies, now 11% of the global total, are projected to grow by almost 50% by 2020.

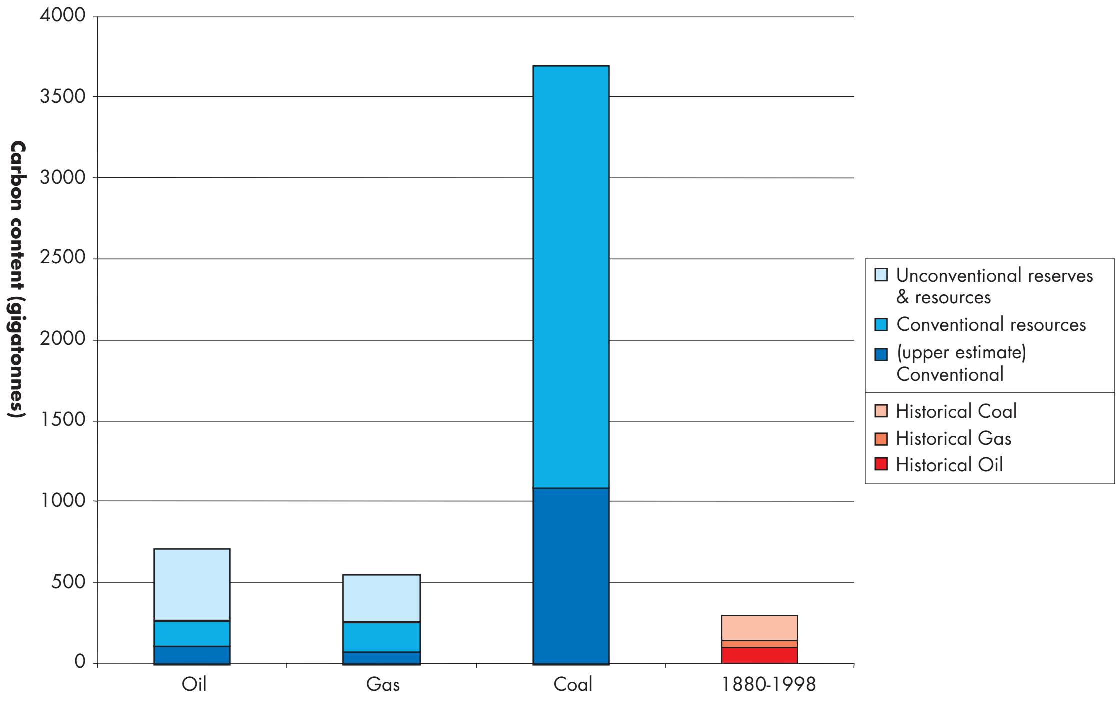
Table 1. Contributions of energy use to human-induced greenhouse gas emissions in OECD Countries, 1998

	CO_2 (81.7%)	CH_4 (9.7%)	N_2O (6.6%)	HFCs, PFCs and SF_6* (2.0%)	Total (100%)
Energy Sector					
- Share of GHG Emissions	79.2%	2.7%	1.1%	0%	83.0%
- Main Sources	Fossil fuel combustion	Fugitive emissions from coal, oil and gas extraction and transport	Fossil fuel combustion	Not applicable	
Non-energy Sector					
- Share of GHG Emissions	2.5%	7.0%	5.5%	2.0%	17.0%
- Main Sources	Industrial processes	Livestock and waste	Agriculture and industrial processes	CFC substitutes*	

* HFCs = hydrofluorocarbons; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride; CFC = chlorofluorocarbons.
Source: UNFCCC (5 September 2000), *National Communications from Parties included in Annex I to the Convention: Greenhouse Gas Inventory Data from 1990 to 1998, FCCC/SBI/2000/11.*

These projections represent "reference case" or "business as usual" scenarios, which assume that past trends continue into the future and that the structure of the energy system remains unchanged. Such short to mid-term projections can have a high probability of actually occurring, because of the inertia inherent in the systems underlying the trends. However, these trends are not likely to continue indefinitely. In the longer term, there is less certainty about technological development, degree of openness of markets, social structures, environmental values held by the people, etc. Furthermore, the increasing evidence that human-induced climate change is occurring, and the recognised unsustainability of current energy trends, is likely to induce major policy interventions to change the outlook for the longer term.

Figure 2. Carbon in Oil, Gas and Coal Reserves and Resources



Source: Intergovernmental Panel on Climate Change (2001), *Third Assessment Report, Report of Working Group III.*

The limits of fossil fuel reserves do not force a viable de-facto solution to the climate change problem, as the prospect of resource exhaustion over the short to medium term is not likely. Over the longer term, constraints on supplies can be expected to contribute to the drive for alternative and environmentally friendlier technologies.

Policies

Confronting the climate change problem is complicated by three important factors: it is global, it is long term and the effects of mitigation and adaptation policies are not fully understood. It is still not even known what concentrations of greenhouse gases in the atmosphere can be considered safe. Despite the many uncertainties involved, it is evident that mitigation and adaptation efforts will need to be intensified. Long-term objectives for emissions reductions, for example, will need to be more stringent than those set out under the Kyoto Protocol.

The technical choices to mitigate climate change include: switching to less carbon-intensive fuels; developing non-fossil energy resources (such as nuclear power and renewable energy); improving end-use efficiency; improving conversion efficiencies of fossil fuel combustion; fostering structural change towards less energy-intensive production and consumption patterns; and removing and storing carbon from the atmosphere. The policies that can bring about these changes include economic instruments (such as taxes and emissions trading), regulations, voluntary initiatives by industry, and specifically targeted government technology R&D policies.

More stringent mitigation goals will require stronger new policies, which will no doubt focus on the energy sector because of its large contribution to the problem. These new policies and measures will profoundly shape the way energy is produced, converted, transported and used.

As part of the Kyoto Protocol, three important new policy mechanisms – Joint Implementation (JI), the Clean Development Mechanism (CDM), and International Emissions Trading (IET) – have been established. Since CO_2 reduction measures are more expensive in some countries than others because of differences in the nature and condition of the public infrastructure and other capital stock, the opportunity to support measures taken over as wide an area as possible lowers the overall costs of meeting targets.

The project-based mechanisms (JI and CDM) provide an accounting system whereby developed countries can meet their mitigation obligations by supporting specific technical measures taken outside their borders. By providing additional incentive for investment in the energy sector in these countries, CDM and JI could provide a valuable source of finance for investment in energy-efficient infrastructure, notably in the power sector.

Similarly, IET provides a market mechanism for channelling funds to CO_2 reduction efforts, both domestic and foreign [2]. The IEA has carried out analysis on the contribution that international emissions trading could make to meeting the Kyoto targets at least cost [3]. Based on energy-related CO_2 emissions, results show that trading emissions between developed countries would considerably reduce the cost of compliance: 63% for North America, 55% for the Pacific region, and 29% for Europe. Annex B countries (those with quantified commitments under the Protocol) would save up to 89% relative to a no-trading scenario. OECD analysis produces similar results.

[2] Besides its anticipated use in the international carbon market, emissions trading has played an important role in the development of domestic trading schemes for carbon, and renewable energy.
[3] IEA (2000), *World Energy Outlook*, Paris.

Evolution of Mitigation Commitments

At present, political negotiations on how to tackle the problem take place under the auspices of the 1992 Convention on Climate Change, which seeks the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The first operational step towards this objective came in the form of the Kyoto Protocol, with its binding emission reductions commitments for industrialised countries in the 2008-2012 timeframe. What comes after Kyoto is not yet clear.

The IEA has examined three possible alternative commitments that might be taken by all countries – developed and developing – to mitigate the climate problem amid the uncertainties about the necessary stringency of emissions reduction levels and the costs of achieving them. Among the options examined are:

price caps – ambitious emissions targets, qualified with a cap on the price of tradable permits,

non-binding targets – non-binding targets, but with the ability to sell credits if the targets are exceeded,

dynamic targets – wherein assigned emissions would be defined ex ante on the basis of some shared expectation about economic growth (though other variables could enter the picture, such as population, exports, etc.). Then, these assigned amounts would be adjusted ex post according to the actual economic growth.

Source: IEA (forthcoming), *Beyond Kyoto*, Paris.

Table 2. Energy-Sector Policy Objectives And Options For Countering Climate Change

Policy Options / Policy Objectives	Economic instruments	Technological development and diffusion	Public infrastructure planning and construction	Legal and regulatory instruments	Voluntary agreements	Information and other instruments
Reduced energy services – lighting, heating, mobility, etc.	– Higher energy prices [1] – Road use taxes – Fiscal incentives [2]			– Road use restrictions		– Campaigns against energy and water wastage
Improved energy end-use efficiency	– Higher energy prices [1] – Motor vehicle registration taxes (based on emissions) – Fiscal incentives – Fair market access/rules for energy service companies (ESCOs) or energy performance contractors – Tradable permits	– More energy-efficient building, industrial and transport technologies	– Road and railway net works, – Mass transit systems – District heating networks	– BAT [3] prescriptions – More stringent: - building codes - appliance and equipment standards - motor vehicle fuel economy standards - Requirements for power plant DSM/IRP [3]	– Voluntary/negotiated commitments for more efficient: - products and buildings - production processes – Voluntary/negotiated commitments for power plant DSM/IRP [3]	– Appliance and equipment labelling – Building efficiency ratings – Auditing, technical assistance and support for EMSs [3] – Driving behaviour modification campaigns – Government facilities leading by example
Improved energy production and conversion efficiency	– Higher energy prices [1] – Power plant emissions charges – Fiscal incentives – Tradable emissions permits	– Cleaner power generation from fossil fuels	– District heating networks	– BAT [3] prescriptions – Power plant minimum efficiency standards	– Voluntary/negotiated commitments to improved power plant efficiency	
Fuel switching	– CO_2 and CH_4 taxes – Emissions charges – Tradable emissions permits – Fiscal incentives	– Greater power generation from renewable, nuclear, and hydrogen sources	– Natural gas, electricity and hydrogen based transport refuelling network	– Power plant fuel portfolio standards – Motor vehicle fleet fuel portfolio standards	– Voluntary/negotiated commitments to fuel portfolio changes in: - power plants - motor vehicles	– Green electricity validation
End-of-pipe emissions treatment/sequestration	– Emissions charges, – Tradable emissions permits	– Chemical and biological sequestration – Deep ocean sequestration		– Emissions restrictions for major point source emitters		

1 Higher energy prices via higher energy taxes, lower energy subsidies, reduced price controls and tradable permits.
2 Fiscal incentives include grants/rebates, loans, loan guarantees and preferential tax treatment.
3 BAT = Best Available Technology; DSM = Demand Side Management; IRP = Integrated Resource Planning; EMSs = Environmental management systems, such as ISO 14001 and EMAS.

Source: Adapted from OECD (2002), *Climate Change and Energy: Trends, Drivers, Outlook and Policy Options*, Paris.

LOCAL AND REGIONAL AIR POLLUTION

Without proper controls, combustion of fossil fuels leads to emissions of particulate matter, sulphur oxides (SO_x), nitrogen oxides (NO_x) and volatile organic compounds (VOCs). Total suspended particulates refer to smoke, soot, dust and liquid droplets from combustion that are in the air. Particulate levels indicate the quality of the air people breath, and emissions are dangerous to human health, causing respiratory problems.

Sulphur dioxide is an air pollutant produced when fossil fuels containing sulpher are burned. It is a precursor to acid rain, which causes acidification of lakes, streams and groundwater (resulting in damage to fish and other aquatic life), damage to forests and to agricultural crops, as well as deterioration of man-made materials (such as buildings, metal structures and fabrics).

The soil deposition of nitrogen from NO_x emissions and nitrogenous fertilisers can lead to nitrogen run-off, which can stimulate the growth of algae and other aquatic plants leading to algal bloom or entrophication of lakes, rivers and streams. Nitrogen oxides and VOCs contribute to the formation of photochemical smog (primarily ozone). In addition, lead pollution from combustion in motor vehicles is still a problem in a few OECD countries and an ongoing problem in many developing countries, causing mental health disorders, particularly in children.

Local and Regional Air Pollution from Energy-related Activities

The majority of airborne emissions from energy result from the use of fossil fuels.

Ambient air pollution and acid deposition (from SO_x, NO_x and VOCs):

- CO from the transport sector.
- NO_x and VOC emissions, and consequent local ozone, from the road transport sector.
- SO_x emissions from coal use in the power sector and certain industries.
- Particulate emissions from fossil fuel combustion.

Hazardous air pollution:

- Fugitive hydrocarbons, such as benzene, emissions from oil and gas extraction and processing industries.
- Hydrocarbon (including polycyclic aromatics), dioxin and toxic air pollutant (such as lead) emissions from the use and combustion of petrol and diesel oil for transport.
- Small quantities of arsenic, mercury, beryllium and trace elements of radionuclides released during the combustion of coal and heavy fuel oil in power plants and industrial boilers.
- Mercury, chlorinated dioxin, furan and other emissions from municipal waste incinerators.

Stratospheric ozone depletion:

- N_2O emissions from fossil fuel and biomass combustion.

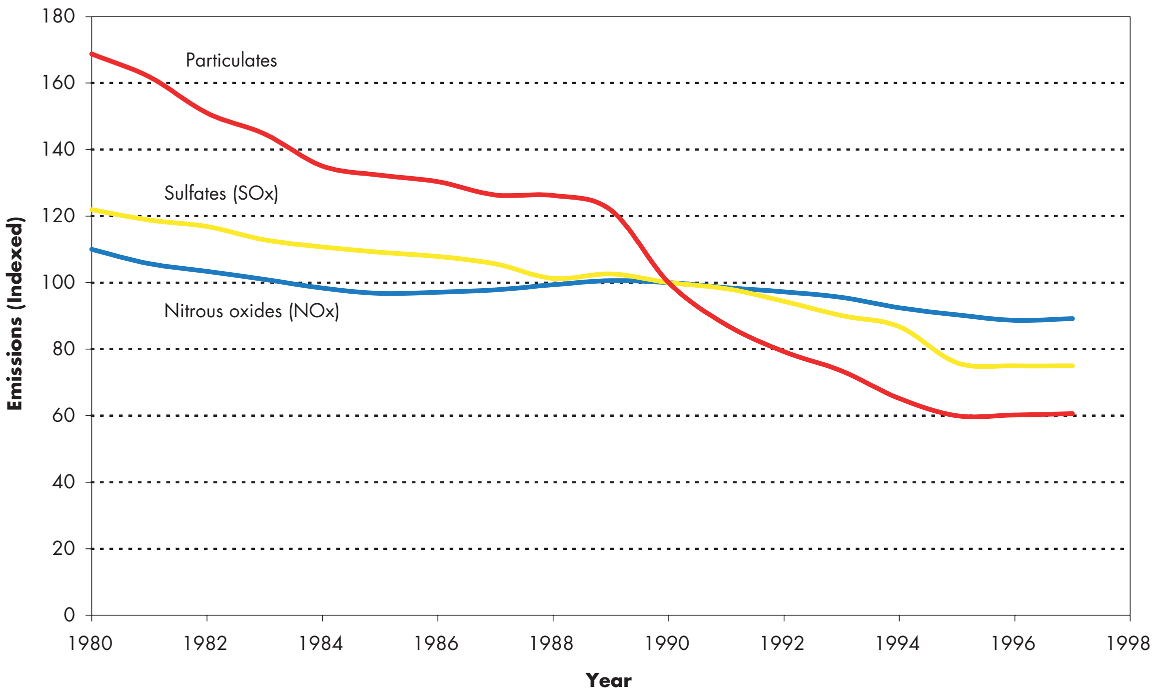
Table 3. Contribution of energy use to air pollutants, mid-1990s
(percentage of total emissions in OECD countries deriving from energy use)

Air Pollutant	Transport	Electricity Production	Other Combustion (industry and residential)	Non-energy
SO_x	7%	55%	25%	13%
NO_x	53%	22%	19%	6%
CO	72%	1%	12%	16%
VOC	39%	0%	6%	54%
Particulates	17%	11%	25%	47%

Source: OECD (1999), *OECD Environmental Data: Compendium 1999*, Paris.

OECD countries have made considerable progress in recent years in reducing emissions of local and regional pollutants. Most of this progress has been through regulatory and permitting procedures – such as the Large Power Plant Directive in the European Union and the Clean Air Act in the United States – but tradable permit approaches have been tried too. The most famous example, the U.S. SO_2 trading scheme, has proved successful in reducing SO_2 emissions significantly below target, and at permit prices lower than originally anticipated.

Figure 3. Progress in Reducing Emissions from Power Generation in OECD Countries (Index 1990 = 100)



Source: Compilation on the basis of OECD (1999), *OECD Environmental Data – Compendium 1999*, Paris.

Unfortunately the same progress has not yet been made in most developing countries, where the effects of energy-related emissions remain dramatic. Table 4 shows the ambient particulates, SO_x and NO_x levels in a number of large cities that in most cases exceed the World Health Organisation air-quality guideline levels. In addition, the poor suffer disproportionately from health damages due to the use of coal, dung and biomass in open furnaces for cooking and heat. The World Energy Assessment estimates that poor indoor air quality due to burning solid fuels is responsible for about 2 million premature deaths a year, mainly among women and children [4].

A case in point is China, which is heavily coal-dependent and where SO_2 and particulates heavily damage human health, agriculture and structures. One study estimates the total costs at US$ 13 billion per year. Sulphur dioxide emissions from Chinese industries and power plants affect 30 per cent of China's territory in the form of acid rain, which reaches as far as Korea and Japan. While the Chinese national average is about two tonnes of SO_2 per square kilometre, comparable to that in the United States, the Chongquing urban area is reported to have 600 tonnes per square kilometre, with the environmental and public health problems to match.

Improving energy efficiency, switching energy bases from coal, biomass and dung to gas and electricity, and introducing basic emissions controls and improvements in coal generating facilities could achieve substantial reductions at limited costs. However, overall costs of remedial or preventive actions could dissuade many of the least-developed countries from taking actions already adopted by OECD countries. The diffusion of more efficient and less polluting energy technologies from OECD countries can play an important role in this context. Under the right circumstances, such transfers could deliver benefits in the economic as well as in the environmental dimension of sustainable development.

Table 4. Annual Average Airborne Emissions of Major Pollutants in Selected Cities in Developing Countries

	Population (2000) (thousands)	Total Suspended Particulates* (micrograms per cubic metre)	Sulphur Dioxide (SO_2)** (micrograms per cubic metre)	Nitrogen Dioxide (NO_2)** (micrograms per cubic metre)
Beijing	10 839	377	90	122
Moscow	9 321	100	109	–
Delhi	11 695	415	24	41
Jakarta	11 018	271	–	–
Tehran	7 225	248	209	–
Capetown	2 993	–	21	72
Caracas	3 151	53	33	57
WHO Guidelines		no threshold given	50	40

* Data are for the most recent year available in 1990-95. Most are for 1995.
** Data are for the most recent year available in 1990-98. Most are for 1995.
– Data not available.
Source: World Bank (2001), *World Development Indicators 2001*.

[4] United Nations Development Programme (UNDP), United Nations Department on Economic and Social Affairs (UNDESA) and World Energy Council (WEC) (2000), *World Energy Assessment*, New York.

OTHER RISKS AND HAZARDS

Many of the issues outlined below are being addressed – or the risk of their occurrence has been reduced. Others remain of concern or represent significant potential risks in terms of the magnitude of damage. The degree to which these risks have been ameliorated also differs greatly between developed and developing countries – the latter seldom have the financial resources to purchase the most up-to-date, environmentally sound and efficient technologies, or the best equipment. But in addition to financial constraints, many developing countries lack the necessary policy and administrative frameworks, and the human, institutional and technological capacities necessary to enable them to take full advantage of cleaner and safer production approaches.

Whereas the air pollution associated with energy is caused mostly by fossil fuel use (combustion), water pollution and ecosystem impacts derive mostly from the production, transformation and transport of energy. Land-use pressure in the energy sector — when energy activities are sited in conflict with agriculture and housing opportunities, or where natural ecosystems could be lost — has focused on mining sites and hydroelectric reservoirs. New efforts to find suitable sites for large-scale wind or solar photovoltaic fields are facing some of the same pressures (see background paper on Renewable Energy).

Other Pollution, Radioactive Hazards and Risks of Accidents from Energy-related Activities

Water pollution:

- Oxygen depletion in freshwater ecosystems from electrical power station cooling systems.
- Water and soil contamination from leaking oil tanks, mine drainage and acidic deposition caused by air emissions of NO_x and SO_x.

Maritime pollution:

- Accidental oil spills.
- Discharge of oil during shipping operations.

Land degradation:

- Large tracts of land made unusable for competing uses by mines, hydroelectric reservoirs and large scale exploitation of wind power, solar power stations or biomass production.

Habitat degradation:

- Disruption to marine life, bird life and flora/fauna by hydropower projects.
- Visual and noise pollution, together with bird kill by wind power.

Solid waste accumulation

- Solid waste (slag and ashes) causing pollution and reduced visual amenities from coal mining and combustion.

Radiation hazards:

- Radon gas, dust, contaminated rainwater streams and mining waste from uranium mining.
- Nuclear waste transport and disposal risks.
- Accidental releases of radioactive material from nuclear power generation facilities.

Accidents

- Blow outs, explosions and fires at oil and gas refineries, production rigs, storage tanks, pipelines, etc.
- Ship, rail and road tanker accidents.
- Hydroelectric dam failures.
- Mine explosions, subsidence and landslides.

Global demands for oil and gas have led to exploration and production in some areas of high environmental vulnerability. Energy extraction activities, such as oil and gas drilling and open-pit coal mining in ecologically sensitive areas, pose problems for local fauna and flora. Acid drainage problems can occur from existing or abandoned coal mines. Uranium mining and milling releases radon and radon compounds, which are potential occupational hazards. The overall scale of their impact is limited though, because of the high energy density of uranium. Process effluent and tailings may cause groundwater contamination.

Fuel transport also presents environmental, health and security concerns (e.g. from leaking oil tankers, and oil and gas pipelines, as well as transport of radioactive materials). Because of the very visible environmental consequences and the number of accidents involving marine-based pollution, much attention has centred on oil discharge and spills. Spills can occur in coastal waters important to fishing, tourism or industry, and cause damage to marine ecosystems. Oil and gas pipelines present additional environmental (e.g. methane leakage and land use implications) and political (e.g. siting and construction of transboundary pipelines) challenges.

Nuclear power has unique environmental and safety issues. The transport and disposal of high-level nuclear waste is an issue of particular public concern. The volumes of wastes produced by nuclear power plants are small compared to those produced by fossil-fuelled electricity plants. However, high-level nuclear wastes have potential health effects much more acute and severe than wastes from fossil fuel plants. They are deadly if not shielded; they cannot be chemically or physically neutralised like many other toxic wastes, and they cannot be dispersed safely. Furthermore, nuclear wastes must be transported (often long distances) to the few sites suitable for their disposal, increasing the opportunities for transportation mishaps. All in all, the costs of properly handling and disposing of high-level wastes, on a unit basis, are very high.

There is a wide agreement among scientists that geological isolation is the best method to dispose of high-level and long-lived wastes [5]. Much technical progress has been made in the past 20 years in identifying suitable sites and procedures for safely isolating radioactive wastes from the environment. Most countries with operating nuclear plants have active programmes to develop disposal facilities for high-level nuclear waste, but actual implementation has been slow. The first disposal facility in the world for high-level civilian wastes is not expected to be operating before 2010, in the United States. Other countries do not expect to put facilities into operation before 2020.

Apart from the scientific or technical aspects of high-level waste disposal are the particularly difficult questions of institutional adequacy and future human behaviour. In the time scale of concern for safe isolation of high-level wastes (e.g. 10 000 years has been used as a design criterion in some repositories), no government or even civilisation could be counted on to actively ensure an undisturbed waste site. A passively safe situation must be sought to ensure waste isolation from the environment.

The energy system, like many industrial activities, is vulnerable to accidents and sabotage. Some of the most important perceived and/or actual risks are:

- on-shore and off-shore blow outs, explosions and fires due to the production, treatment, transport and use of oil and gas, such as fires at refineries, oil rigs, gas storage tanks and explosions of pipelines;

[5] Short-lived wastes pose less of a technical and institutional problem because, by definition, their radioactivity declines within a relatively short period.

- maritime pollution due to oil tanker accidents, as well as soil and water pollution due to spills from rail and road tankers;
- radioactive releases resulting from nuclear accidents in the course of the production of nuclear energy or the transport, treatment or storage of radioactive materials (fuel or waste);
- hydroelectric dam failures causing flooding and landslides;
- land subsidence due to mining activities as well as explosions in mines;
- explosions due to methane build up in refuse dumps and coal mines.

Many energy-related activities, and particularly energy production and transformation activities, are controlled by safety regulations designed to prevent major environmental accidents. The nuclear industry is an example of an energy activity where safety and environmental protection concerns have combined to give rise to a comprehensive set of regulatory controls. The risks of fire and explosion in the oil and gas industry have also led to the development of strict safety regulations. Safety features in most types of direct regulatory instruments, such as licensing for new facilities or monitoring and maintenance procedure requirements for existing facilities.

There are some particular safety issues in developing countries. These involve the physical hazards of energy theft. There have been serious accidents involving people illicitly tapping pipelines and electrical wires. For example, some 700 people were killed in Nigeria in 1998 when a burst oil pipeline resulted in a fire and explosion. Due to chronic shortages of petrol and diesel in Nigeria, thousands of people had been involved in the illegal siphoning of fuel from the burst pipeline, leaving a petrol-soaked area which ignited when a cigarette was lit.

Sensitivity to the environmental and safety risks of malicious attacks on energy facilities has risen in recent years. The oil fires started during the Gulf War were one example. The possibility of terrorist attacks on energy infrastructure highlights the need for heightened security and contingency plans. Some parts of energy systems, such as electricity transformers, are large, require months to build, and are not held in inventory in increasingly competitive industries. Any attack or sabotage can thus cause relatively prolonged supply disruption. The International Atomic Energy Agency (IAEA) warned late last year of the vulnerability of nuclear plants to attacks by terrorists – a message heeded by G-8 leaders who pledged support for a range of measures to combat nuclear and radiological terrorism.

Table 1. Environmental Emissions, Pollutants and Risks

	Coal	Oil	Gas	Nuclear	Renewables
CO_2	X	X	X	✓	✓
SO_2	X	X	✓	✓	✓
NO_x	X	X	X	✓	✓
Particulates	X	X	✓	✓	✓
Radio-isotopes	✓	✓	✓	X	✓
Other*	X	X	X	X	X

* Other includes: chlorine, heavy metals, noise pollution, water quality/flow, visual disturbances, transportation and distribution risks, sabotage risks, etc.
X: fuel gives rise to these emissions or risks
✓: fuel does not pose risks or give rise to emissions

ENERGY AND ENVIRONMENTAL POLICY MAKING

Traditional forms of regulation have often focused on specifying technical solutions to pollution reduction problems, stifling innovation in pollution prevention measures. New approaches focus on specifying emission and energy-efficiency standards while leaving private sector producers flexibility as to how to meet them.

OECD and IEA analysis indicates that the use of economic instruments can help to maximise economic efficiency by making the costs of additional abatement equal between polluters, and by giving polluters a continued incentive to develop low cost abatement options (i.e. an incentive to continue environmentally beneficial technological developments).

At present, energy prices do not fully reflect the environmental and social costs of energy. Imposing an appropriate market (price) signal would encourage environmentally rational energy use – including both reducing consumption and changing its composition in favour of more environmentally friendly goods and services.

Economic instruments are unlikely to be the sole means to fully “internalise” environmental externalities. Consumer resistance to large increases in energy prices, together with concern over the possible loss of international competitiveness, will inevitably limit their use. Policy solutions must thus include ways to mitigate the impact on consumers and the poor in particular (e.g. through compensating decreases in income taxes, or transitional social welfare payments). They should also incorporate the use of new economic instruments such as emissions trading.

Pollution prevention and control regulations, when used, must be complemented by effective enforcement procedures. Enforcement authorities need a clear mandate to inspect firms periodically, rather than merely responding to complaints and alarms, and be given the power to penalise violating firms. One way of linking positive and negative incentives is to channel revenues from non-compliance with environmental regulations to special funds earmarked for investment in cleaner technologies. Regulation requiring disclosure of information on pollutant release and regular audits can play an important role in mobilising public support and facilitating enforcement of environmental regulations.

Different countries will require different policy mixes – integrating fiscal, regulatory and R&D efforts, as well as outreach and consultation processes – to improve the environmental account of the energy system. The domestic actions need to be complemented by international agreements, as many of the issues relating to energy and sustainable development are global in nature.

Society needs to ensure that environmental damage will be prevented or limited to acceptable levels, but economic and energy systems work best when there is adequate flexibility to make choices. Balance can best be achieved if all concerns are represented in the process of policy development and implementation.

MEMBER GOVERNMENTS OF THE IEA AFFIRM

In light of these considerations, Member governments of the IEA affirm:

- **that countries should act to reduce long-term trends in greenhouse gas emissions;**
- **the importance of controlling local pollutants and disposing of waste from energy production and use in order to promote a cleaner environment and protect human health;**
- **the need to ensure high safety standards in the operation and maintenance of energy equipment, plants and infrastructures and the need to put in place appropriate mechanisms to respond to potential accident or failure, including further international co-operation to improve prevention and defence against acts of sabotage and terrorism of the energy infrastructure.**