OECD Contribution to the United Nations Commission on Sustainable Development 15

ENERGY FOR SUSTAINABLE DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Preface

This brochure is a combined contribution to the 15th session of the United Nations Commission on Sustainable Development (UNCSD-15) from the Organisation for Economic Co-operation and Development (OECD) – including the Development Co-operation Directorate, the Environment Directorate, the Directorate for Financial and Enterprise Affairs, the Directorate for Science, Technology and Industry, and the Round Table on Sustainable Development – together with the International Energy Agency (IEA) and the Nuclear Energy Agency (NEA). It has been produced under the auspices of the OECD Horizontal Programme on Sustainable Development and reviewed by the OECD Annual Meeting of Sustainable Development Experts (AMSDE).

Under the theme of "*Energy for Sustainable Development*", this brochure presents policy findings from OECD, IEA and NEA reports relating to energy, climate change and sustainable development. It focuses on four main topics: i) widening energy access in developing countries, ii) increasing energy research and development and dissemination, iii) promoting energy efficiency and diversity, and iv) benefiting from energy-related climate change policies. The report was prepared with the assistance of John Newman, Energy and Environment Consultant.

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Introduction: A Broad Look at Energy Issues

Addressing long-term energy security and sustainability challenges

Current demographic, economic, social, and technological trends – if not counterbalanced by strong new government policies – pose major challenges to the long-term sustainability of the global energy system. If governments do not implement policies beyond those already planned between now and 2030, it is projected that:

- energy consumption will increase by over half (53%);
- the energy mix will remain fairly stable and dominated by fossil fuels (80% share);
- energy-related CO2 emissions will increase by over half (55%); and
- large populations of the world's poor will continue to lack access to electricity (about 1.5 billion) and modern cooking and heating services (about 2.5 billion).

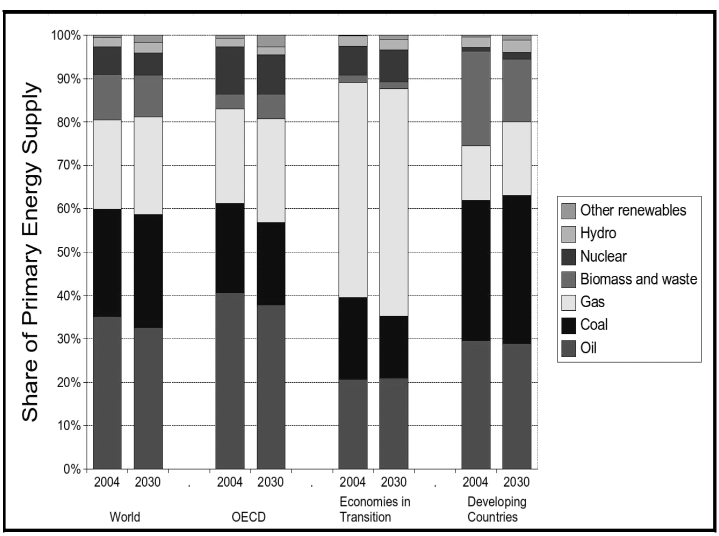
In this scenario, energy consumption increases from 11 200 Mtoe (millions tons of oil equivalent) in 2004 to 17 200 Mtoe in 2030. Over 70% of this growth is expected to come from developing countries, which overtake OECD countries as energy consumers sometime around 2014. Nearly half of the increase in global primary energy use goes to generating electricity and one-fifth of the increase (almost entirely in the form of oil-based fuels) to meeting transport needs.

Growth in energy use and emissions is expected to be particularly marked in some sectors. The sectoral contributors to growth in energy consumption are expected to be power generation (35%), industry (15%), transport (12%) and buildings (6%) in developing countries, followed by power generation (11%) and transport (6%) in OECD countries. Improving efficiency and reducing carbon dioxide (CO_2) emissions should receive early attention in these high growth areas, because these goals are easier and cheaper to attain at the time of new construction than at later retrofit stages.

It is predicted that the global energy mix will remain fairly stable and dominated by fossil fuels to 2030 due to the size and inertia of the energy system and the inability to change it quickly. In this scenario, no fuel's share of the mix changes by more than a few percentage points (**Figure 1**). Fossil fuels remain the largest source of world energy – accounting for about 80% of global demand in 2004 and 81% in 2030. The consumption of each fossil fuel grows at different rates, so their shares of the total shift slightly – oil falls from 35% of the total in 2004 to 33% in 2030; coal rises from 25% to 26%; and gas rises from 21% to 23%. Concerns about continued high consumption of oil and gas raise questions of supply security (**Box 1**).

China and India account for almost four-fifths of the incremental demand for coal. Renewable energy and nuclear power shift to a similarly small degree. Hydropower's share of primary energy use rises slightly. The share of biomass decreases as developing countries switch to modern commercial energy, offsetting the growing use of biomass as feedstock for biofuels production and for power generation. Non-hydro renewables – including wind, solar and geothermal – grow the quickest, but from a small base.

Figure 1. Fuel profile of primary energy use (2004 and 2030)



Note: based on Reference Scenario.

Source: *World Energy Outlook* (IEA, 2006).

Box 1. Energy security and sustainable development

Energy security is a broad concept that focuses on energy availability and pricing. Specifically, it refers to the ability of the energy supply system – suppliers, transporters, distributors and regulatory, financial and R&D institutions – to deliver the amount of competitively-priced energy that customers demand, within accepted standards of reliability, timeliness, quality, safety and environmental impacts, under a wide range of geopolitical, economic, social, technological and weather circumstances.

Traditionally, energy security has been defined in the context of the geopolitical risks to external oil supplies. Today, it is a broader concept, encompassing all energy forms, all the external (foreign) and internal (domestic) links bringing the energy to the final consumer, and all the many ways energy supplies can be disrupted – including equipment malfunctions, system design flaws, operator errors, malicious computer activities, deficient market and regulatory frameworks, corporate financial problems, labour actions, severe weather and natural events, aggressive acts (*e.g.* war, terrorism and sabotage), and geopolitical disruptions.

In practice, the most worrisome disruptions or potential disruptions are those linked to: 1) extreme weather events; 2) mismatched electricity supply and demand; 3) regulatory failures; and 4) concentration of oil and gas resources in certain regions of the world. Insecure energy supplies inhibit development by raising energy costs and imposing expensive (sometimes life threatening) cuts in services when disruptions actually occur.

The energy supply sector can best advance sustainable development by producing and delivering secure and environmentally-friendly sources of energy and by increasing the efficiency of energy use. These overarching qualities are frequently stated in terms of the 3E's – energy security, economic development and environmental protection. The current methods of meeting these criteria involve ensuring fuel diversity, supplier diversity, sound transmission and distribution infrastructure, efficient conversion and delivery technologies, and low- and zero-carbon technologies.

While greenhouse gas (GHG) emissions and the ensuing climate change are not the only environmental problems confronting the energy sector, they are the most universal and most pressing. In the reference scenario, energy-related CO_2 emissions increase from 26.1 Gt CO_2/year in 2004 to 40.4 Gt CO_2/year in 2030. Over three-quarters of this growth comes from developing countries, which overtake OECD countries as the biggest regional emitter soon after 2010. China, which overtakes the United States as the world's biggest emitter before 2010, accounts for 39% of the global increase between 2004 and 2030. Its emissions more than double between 2004 and 2030, driven by strong economic growth and heavy reliance on coal in power generation and industry. India accounts for 10% of the increase in global emissions.

The sectoral contributors to CO_2 emissions growth are forecast as coal-based power generation (32%), oil use in transport (13%), coal use in non-power sectors (9%), gas-based power generation (8%) and oil used in non-power sectors (7%) in developing countries, followed by oil use in transport (7%) and coal-based power generation (6%) in OECD countries.

These projections concerning energy and environmental trends are not inevitable; there are many policies that if implemented could change them. According to the Alternative Scenario based on enlightened policies, it is possible to substantially alter the course of energy developments in the next half century and to make the energy system more sustainable. To achieve this, countries need to adopt all of the policies related to energy security and energy-related CO_2 emissions that they are currently considering.

These policies include efforts to improve efficiency in energy production and use, increase reliance on non-fossil fuels, and sustain the domestic supply of oil and gas within net energy-importing countries. They would yield substantial savings in energy consumption and reductions in CO_2 emissions. Moreover, these benefits would be achieved at a lower total investment than if such action is postponed. While suppliers' investments decrease, consumers' investments increase but this is more than offset by lifecycle energy cost savings. The cost of fuel saved by consumers is estimated at USD 8.1 trillion, more than offsetting the extra demand-side investments required to generate these savings.

Policies encouraging more efficient production and use of energy could contribute almost 80% of the avoided CO_2 emissions in 2030, with the remainder gained from fuel substitution. More efficient use of fuels, mainly by cars and trucks, accounts for almost 36% of avoided emissions; more efficient use of electricity in a wide range of applications (*e.g.* lighting, air-conditioning, appliances and industrial motors) for 30%; greater efficiency in energy production for 13%; renewables and biofuels for 12%; and nuclear for the remaining 10%.

Another critical policy response is greater investment in energy-related research and development (R&D), in part because new supply-side energy technologies need to be operating on a commercial scale from 2030 or earlier. Scenarios show that it is possible to bring emissions back to current levels by 2050, but this would entail large amounts of extra R&D and widespread deployment of cleaner, more efficient technologies. There is no "silver bullet" technology that alone can attain the emissions target, but more energy efficient production and end-use technologies are indispensable.

Co-ordinating relevant policy fields

Energy contributes to and detracts from sustainable development according to an elaborate interplay of markets, technological development, government policies, social norms and individual behaviour, not just in the energy sector but in many other sectors as well. The relationship between energy and sustainable development is complex, both positive and negative.

On the positive side, it is the services that energy enables, not the energy itself, that most directly advance sustainable development. Better cooking, lighting, space conditioning, transportation, communications, income generating processes and other services are the means by which energy improves human, social, economic and environmental conditions. On the negative side, energy can be produced and deployed in ways that pollute the environment and increase greenhouse gas emissions. The development of various energy sources, including oil, gas and coal, can disrupt ecosystems if not carefully planned.

Energy is vital to providing an array of necessary services, but the nature of its contribution is not fixed. It is possible to alter the end-use devices, methods, infrastructure and behaviour that deliver these services to become more energy efficient or to use alternative types of energy. There are opportunities and barriers to developing and deploying more sustainable energy supplies and end-uses in various sectors, which are influenced by the:

- availability, affordability, security, reliability and safety of energy supplies in the energy system;
- environmental friendliness of energy supplies in the energy system;
- planning, design, construction, operation, financing and pricing of energy-using buildings, industrial processes, transport systems, etc. in end-use sectors;
- social and cultural norms regarding behaviour in end-use sectors;
- access to alternative technologies and energy sources; and
- investment assistance to develop and deploy energy services.

Government policies are key to ensuring that the energy sector advances sustainable development. There are many policy domains – including environment, development, industry, transport, construction, agriculture, investment, science and technology and education as well as energy itself – where policies influence how and how much energy is produced, converted, transported, distributed and used. Ensuring that energy systems develop in a way that best supports and accords with sustainable development requires communication and co-ordination among all relevant policy areas at all levels of government (*i.e.* local, regional, national, international).

Full communication and co-ordination across all policy domains affecting the development and use of energy are still rare, just as they are in many other fields. Addressing energy challenges requires an integrated sustainable development approach based on increased co-ordination among diverse fields and stakeholders. A wide range of government departments and agencies should be involved in the formulation and implementation of energy policies in various sectors.

This can be achieved through the implementation of national sustainable development strategies (NSDS) which were mandated for all countries by *Agenda 21* in 1992. The strategy process offers an opportunity to build on the complementarities of programmes in the economic, environmental and social spheres to improve the long-term effectiveness of complex energy policies. The OECD recommends certain good practices in the overall format and operation of NSDS (**Box 2**). The successful practices pertain to the content (policy dimensions, timeframes, analytical tools), governance and co-ordination aspects (institutions, stakeholders, local links), and management processes (indicators, targets, monitoring) of strategies, which would ensure the energy contributions to sustainable development in the strategy context.

Identifying policy tools and responses

An array of policy tools are needed to ensure that sufficient quantities of energy are delivered to end-users in an affordable, reliable and environmentally friendly manner. Still more policy approaches implemented in conjunction with sectoral policies are needed to advance end-use energy efficiency and CO_2 emissions reductions.

Government-set framework conditions (*e.g.* market rules, pricing mechanisms, taxes, tradable allowances and subsidies), investment and development policies, sectoral policies (*e.g.* agriculture, transport), and technology R&D and deployment priorities have large roles to play in moving all relevant actors (*i.e.* energy supply, end-use energy efficiency, end-use sectors and auxiliary sectors) towards greater sustainability.

Box 2. Good practices in national sustainable development strategies (NSDS)

Successful practices in the national sustainable development strategies of the OECD countries include:

Policy integration – national strategies should give consideration to environmental, economic and social concerns in integrated approaches contained in national plans and reports.

Intergenerational timeframe – national strategies should adopt long-term timeframes which enable inclusion of intergenerational principles and indicators.

Analysis and assessments – integrated assessment tools should be used in national reports to identify the environmental, economic and social costs and benefits of policy and strategy options.

Co-ordination and institutions – a wide range of government departments and agencies should be involved in the formulation and implementation of national strategies, with overall responsibility in the office of the Prime Minister or equivalent.

Local and regional governance – local and regional authorities should be fully involved in the development of national strategies, with certain delivery aspects devolved to sub-national levels.

Stakeholder participation – stakeholders (*e.g.*, business, unions, non-governmental organisations) should participate with government representatives in commissions responsible for developing and implementing national strategies.

Indicators and targets – strategies should be based on structured indicator systems (enumerated in national plans and reports) to assist in monitoring progress and to serve as quantitative targets.

Monitoring and evaluation – independent bodies or processes should be established to act as watchdogs monitoring implementation of national strategies and providing recommendations for their improvement.

Source: *Good Practices in the National Sustainable Development Strategies of OECD Countries* (OECD, 2006).

The synergies and trade-offs across these policies as well as their cost-effectiveness need to be assessed in individual country contexts. However, assessing the sustainability as well as the cost-effectiveness of energy policies and measures does not yet form an integral part of the decision-making process in most countries. Such assessments should lead to the re-evaluation of the current priorities of the policy mix. For example, ensuring cost-effectiveness in addressing greenhouse gas emissions reduction targets is a challenge that all countries face. In many countries, energy efficiency improvements in residential/commercial sectors and the transport sector are lagging behind. And while policies promoting renewable energies are instrumental in energy sustainability, these tend to be costly to develop and implement.

At a minimum, the policy toolbox for promoting energy for sustainable development should include:

1) regulations and standards – agreed government norms for the production and use of energy and protection of the environment;

2) economic instruments – market-based instruments (*e.g.*, taxes, tradeable permits) to internalise externalities and promote the cost-effectiveness of energy and environmental policies and measures;

3) subsidies – phase-out of unproductive and distortive government subsidies (*e.g*. to energy, transport) and provision of transition supports where needed to ease environmental and social costs of change;

4) investment – establishment of undistorted, cost-reflective prices in the energy market and conducive investment conditions to send the right signals to private investors;

5) partnerships and voluntary agreements – joint public/private programmes to develop and deploy sustainable energy approaches with industry;

6) research and development – government R&D and incentives to private R&D to promote innovation on energy for sustainable development;

7) information and communications – campaigns to promote better understanding by the general public of the national and international energy and environment situation and future challenges;

8) assessments and scenarios – sustainability assessments which identify synergies and trade-offs across the economic, environmental and social impacts of energy policy options; and

9) national strategies – good governance approaches based on whole-of-government decision-making, transparency, and understanding of the political economy of promoting change in energy systems.

Widening Energy Access in Developing Countries

Meeting growing energy demand and addressing energy poverty

Energy contributes to a virtuous cycle of human, economic and social improvements that are essential to sustainable development in developing countries (**Figure 2**). Sufficient supplies of clean energy are the basis for raising standards of living, improving the quality and quantity of human capital, enhancing the business and natural environment, and increasing the efficiency of government policies.

However, energy poverty remains a major problem for human health, economic development and environmental sustainability in many parts of the world. Approximately 1.6 billion people – mostly in the rural areas of Sub-Saharan Africa, South and East Asia, and Latin America – lack access to electricity, and 2.5 billion people rely on traditional biomass for cooking and heating. About 1.3 million people – mostly women and children – die prematurely every year because of exposure to indoor air pollution from cooking and heating with traditional, inefficient biomass stoves.

Demand for energy is growing exponentially in developing countries due to rapid population growth (especially in Africa) and rapid economic expansion (especially in China and India). This is projected to lead to a near doubling in primary energy use, much of it unsustainable, by developing countries in the next two decades. As a result of this growth, developing countries will account for 50% of primary energy use and 52% of energy-related CO_2 emissions by the year 2030.

China will experience the greatest increase in energy demand, accounting for 43% of all developing country growth and 30% of total world growth. India, other Asia, the Middle East and Africa will show medium growth in energy consumption. As for energy sources, coal will be the largest growing energy source (mostly in Asia) followed by oil. Gas will continue to be used extensively in the Middle East and Latin America, while the consumption of biomass and waste will increase in Africa.

Huge investments are needed in additional and replacement capacity for producing, converting, transporting and distributing energy in developing countries to meet future needs (**Figure 3**). Most of this investment is needed in the power sector, particularly in China, India and other Asian countries. Other regions need financing also for oil and gas development and use.

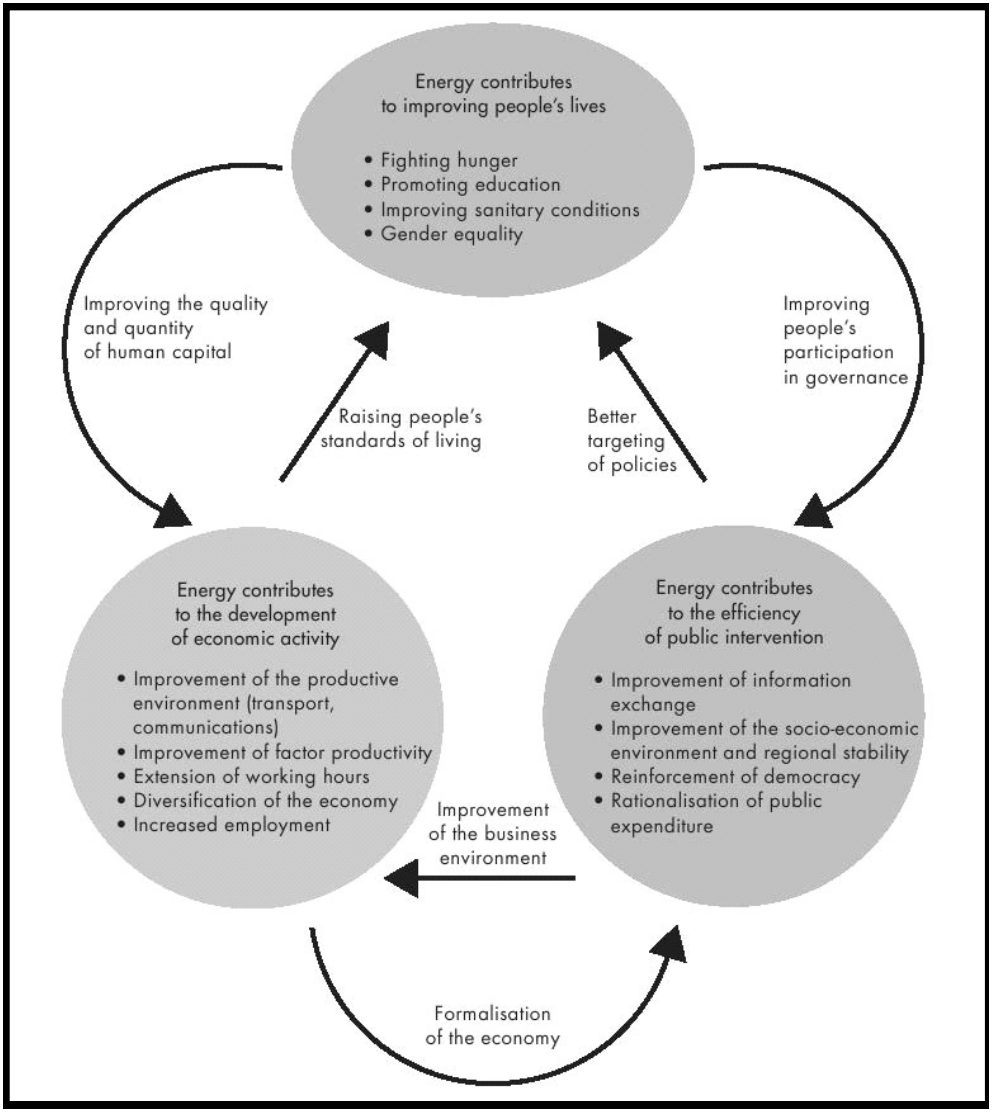
Investment at these high levels represents a dual challenge. Governments have to set policies that attract sufficient private investment and development assistance. Developing country governments, together with investors and donors, need to find more efficient and less expensive ways of delivering energy services so that the financial savings might be invested in other sustainable development needs. They should also ensure sustainable patterns of production and consumption of energy supplies and services.

Increasing access to sustainable energy sources and infrastructure

Lack of access to affordable electricity and heavy reliance on the inefficient and unsustainable use of traditional biomass fuels (*i.e.*, fuelwood, charcoal, agricultural waste and animal dung) are both manifestations and causes of poverty. Electricity and other modern energy sources play a critical role in economic and social development. They alone cannot alleviate poverty – clean water, adequate sanitation, health and education services and communication networks among other things are also needed – but they are indispensable to sustainable development.

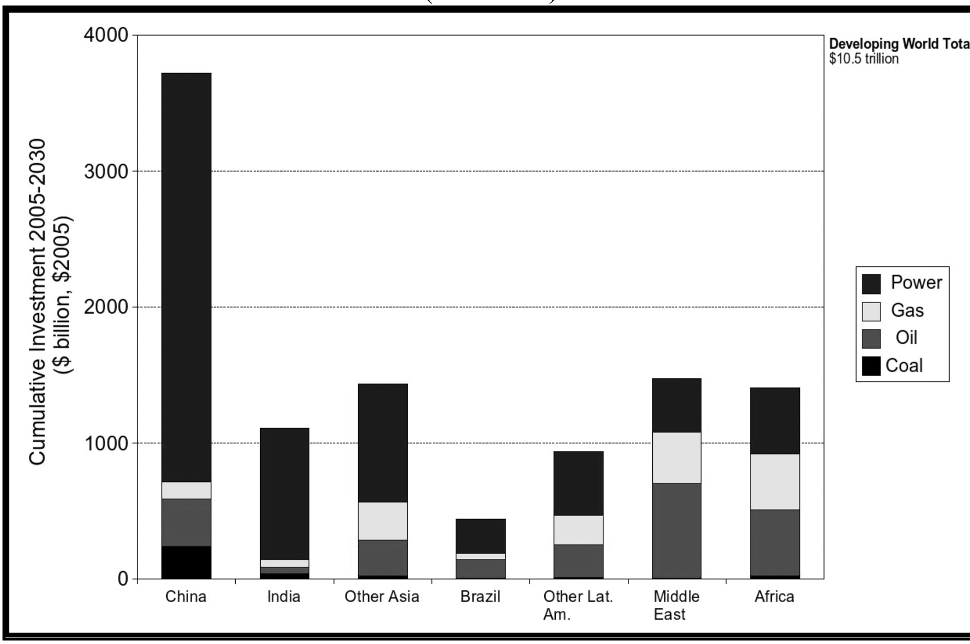
Modern energy services enhance the life of the poor in countless ways. Electric light extends the day, providing extra hours for reading and work. Modern cook-stoves save women and children from daily exposure to noxious cooking fumes. Refrigeration extends food freshness and avoids wastage. Clinics with electricity can sterilise instruments and safely store medicines through refrigeration. Manufacturing and service enterprises with modern energy can be more productive and can extend the quality and range of their products – thereby creating jobs and higher wages.

Figure 2. Links between energy and human, economic and social development



Source: *African Economic Outlook* (OECD/ADB, 2004).

Figure 3. Cumulative investment needed in energy infrastructure by region and fuel (2005-2030)



Note: based on Reference Scenario.

Source: *World Energy Outlook* (IEA, 2006).

In many countries, poverty is prolonged particularly by the unsustainable collection of biomass and its use in traditional, inefficient stoves. This creates indoor smoke pollution leading to serious health damage, such as respiratory diseases, obstetrical problems, blindness and heart disease. It requires large amounts of time for fuel gathering – reducing the time available for other productive activities, such as farming and education. It causes ecological damage (*e.g.* deforestation and soil erosion) and local scarcity of wood in some areas. And it draws agricultural residues and dung away from their use as fertilizer, thus reducing agricultural productivity.

These issues disproportionately affect women, who comprise 70% of all people living in poverty. Women place a high value on improved energy services because they are the primary users of household energy. Women are also most likely to suffer the health effects of energy-inefficient appliances. Their exclusion from the decision-making process in many countries has led to the failure of poverty alleviation programmes.

It is estimated that to achieve the Millennium Development Goals (MDGs), the number of people lacking electricity would need to decrease to below 1 billion and those relying on traditional biomass would need to fall to 1.2 billion by 2015 (**Box 3**). Concerted government action – with support from the industrialised countries – is needed to achieve these targets, together with increased funding from both public and private sources. Policies need to address barriers to access, affordability and supply of electricity and alternative fuels, which are already available at reasonable cost, *e.g.* gas-fired stoves and cylinders. Access to sustainable energy sources should form a central component of broader development strategies.

Box 3. Energy and the Millennium Development Goals (MDGs)

In 2000, the United Nations adopted the *Millennium Declaration* setting out shared targets for dramatically reducing extreme poverty in its many dimensions – income poverty, hunger, disease, exclusion, lack of infrastructure and shelter – while promoting gender equality, education, health, and environmental sustainability, all by 2015. Though access to modern energy services is essential to reducing poverty, no energy targets are specified in the Millennium Declaration. A workshop, sponsored by the UN Millennium Project, held to identify possible energy targets in support of the MDGs, concluded that energy services must be explicitly addressed within the planning for poverty reduction (Goal 1) and for meeting the broader MDGs. The group recommended the following energy targets for 2015:

1) Enable the use of modern fuels for 50% of those who at present use traditional biomass for cooking. In addition, provide support for i) efforts to develop and adopt the use of improved cook stoves, ii) measures to reduce the adverse health impacts from cooking with biomass, and iii) measures to increase sustainable biomass production.

2) Ensure reliable access to electricity to all in urban and peri-urban areas. The longer-term objective of universal access to electricity remains valid, but a more limited target allows MDG planners and national authorities to focus on the concrete investments, delivery systems, and public policies needed.

3) Provide access to modern energy services (in the form of mechanical power and electricity) at the community level for all rural communities

Source: "Energy and the Millennium Development Goals" (Modi *et. al*, 2006).

Including energy issues in national development plans and strategies

Addressing energy challenges successfully cannot be achieved in isolation, but should be an integral part of development planning which links economic, environmental and social concerns. Action plans for development, sustainable development, poverty reduction, achieving the Millennium Development Goals (MDGs), and implementing multilateral environmental agreements (*e.g*., on climate change, biodiversity) have been formulated in most developing countries with the support of multilateral, regional and bilateral development agencies. But these plans remain disjointed and often neglect energy-related issues, which endangers the achievement of their overall objectives.

Energy for sustainable development needs to be more fully integrated into Poverty Reduction Strategies (PRS), plans developed with the World Bank and International Monetary Fund (IMF) to help least-developed countries secure debt remission and low-cost loans. Updated every three years, PRS provide the programmatic basis for co-operation between developing country governments and donors. Similarly, energy issues should be mainstreamed into national sustainable development strategies, which are being formulated in many developing countries with the assistance of the United Nations Environment Program (UNEP), the United Nations Development Program (UNDP), and the UN Division for Sustainable Development (UNDESA/DSD). Regional organisations (*e.g*. the Asian Development Bank, African Development Bank, Inter-American Development Bank) should also put higher priority on sustainable energy development in their assistance programmes.

With regard to bilateral donors, the 2006 OECD Ministerial Meeting between the Environment Policy Committee and the Development Assistance Committee (DAC), which coordinates 90% of official development assistance from bilateral donors, recommended that instruments be developed for better integrating environmental factors into national development plans. To this end, OECD Development and Environment Ministers adopted the *Framework for Common Action around Shared Goals* to improve the coherence of efforts to reduce poverty in developing countries.

The Framework provides support to the implementation of the environmental aspects of the *Paris Declaration on Aid Effectiveness* which envisages a wide range of measures aimed a improving the management and effectiveness of Official Development Assistance (ODA). The Framework emphasises implementation of "good practices" at the interface of environment and development, including integration of environmental considerations in development plans and donor policies and maximising the development-environment potential of international financing instruments.

In this context, energy for sustainable development should be a priority consideration given its central role in poverty alleviation and environmental sustainability. International and regional organisations as well as bilateral donors need to increase the coherency of their development assistance approaches to further sustainable development overall and in regard to energy systems. To this end, proposals have been formulated to promote better coordination among donors for the conception and delivery of development assistance in sustainable development terms (**Box 4**).

Promoting governance and industrial development for energy needs

Advancing development on a sustainable path and securing the investments needed to meet rapidly growing energy demand require active participation by the private sector. Governments must set out attractive frameworks for domestic and foreign investment plus enforceable rules on corporate and business behaviour. The good governance practices which attract business investment are generally the same as those which encourage good environmental and social behaviour on the part of both industry and governments.

Public policies promoting responsible business conduct include providing an enabling environment which clearly defines the respective roles of government and business; promoting dialogue on norms for business conduct; and supporting private initiatives and international co-operation initiatives in support of responsible business conduct. There are a wide range of voluntary codes of conduct for sustainable development developed by international governmental bodies and business associations. These provide guidelines for the ethical behaviour of companies to encourage the incorporation of socio-environmental concerns in their business practices.

Box 4. Proposals for coordinated action on sustainable development

The "sustainable development partners" – including international and regional organisations and bilateral donors – will work together and coordinate activities to:

1. *Policy integration* – promote the development of sustainability strategies at country level as integrating frameworks for achieving economic, social and environmental objectives based on existing tools and frameworks.

2. *Capacity-building* – enhance country capacity to develop and implement sustainability strategies and related good governance practices in accordance with mechanisms of social and economic planning.

3. *Financial planning* – ensure the integration and complementarity of sustainability strategies with national planning and budgeting frameworks, including poverty reduction strategies (PRS).

4. *Environmental awareness* – ensure proper treatment and awareness is given to environmental variables in development plans and co-operation, including natural resources, pollution, energy use and efficiency, responses to multilateral environmental agreements and conventions, etc.

5. *Social awareness* – ensure proper treatment and awareness is given to social variables in development plans and co-operation, including employment, access to education and health care, equity and income distribution, gender, sustainable livelihoods, etc.

6. *Impact assessment* – assist national governments in developing sustainability assessment methodologies to identify synergies and trade-offs across economic, social and environmental dimensions of national policies, plans and strategy options.

7. *Indicators and targets* – make commitments to upgrade national statistical systems and develop indicators to assist in monitoring progress in sustainability strategies and in meeting the Millennium Development Goals.

8. *Transparency and participation* – promote the principles of multistakeholder participation to increase transparency, public participation, consultation and consensus building in implementing sustainability strategies.

9. *Monitoring and evaluation* – engage in joint monitoring and shared learning of country progress in implementing sustainability strategies in accordance with agreed criteria.

10. *Reporting* – streamline national requirements for reporting on national sustainable development strategies, poverty reduction strategies, MDGs, etc.

Source: OECD Horizontal Programme on Sustainable Development.

Among the many business codes of conduct, the OECD *Guidelines for Multinational Enterprises* are the only multilaterally endorsed and comprehensive code that governments are committed to promoting, making them one of the world's foremost corporate responsibility instruments. They aim to help countries and business, labour unions and non-governmental organisations (NGOs) promote sustainable practices by providing a global framework for responsible business conduct. They contain voluntary principles and standards for business in areas including human rights, disclosure of information, anti-corruption, taxation, labour relations, environment, and consumer protection.

At the same time, governments must provide consistent policies and institutions and establish functioning markets to encourage private investment that can support economic growth and sustainable development. In support of this objective, OECD and non-OECD economies have worked together to develop the *Policy Framework for Investment*, which is addressed to governments and complements the OECD *Guidelines for Multinational Enterprises*. The *Policy Framework for Investment* is a tool to help governments create an environment that is attractive to domestic and foreign investors and that enhances the benefits of investment to society. It brings together ten sets of questions covering the main policy domains having a strong impact on the investment environment (**Box 5**). This checklist helps pinpoint areas where governments should redress weaknesses in their policies in order to promote private investment, including for sustainable energy development.

Box 5. The Policy Framework for Investment in brief

Investment policy – Transparency, property protection and non-discrimination are investment policy principles that underpin efforts to create a sound investment environment for all.

Investment promotion and facilitation –- Investment promotion and facilitation measures, including incentives, can be effective instruments to attract investment provided they aim to correct for market failures and are developed in a way that can leverage the strong points of a country's investment environment.

Trade policy – Trade policies can support more and better quality investment by expanding opportunities to reap scale economies and by facilitating integration into global supply chains, boosting productivity and rates of return on investment.

Competition policy – Competition policy favours innovation and contributes to conditions conducive to new investment, especially for small and medium sized enterprises. Sound competition policy also helps to transmit the wider benefits of investment to society.

Tax policy – The level of the tax burden and the design of tax policy, including how it is administered, directly influence business costs and returns on investment. Sound tax policy enables public policy objectives to be achieved while also supporting a favourable investment environment.

Corporate governance – The degree to which corporations observe basic principles of sound corporate governance is a determinant of investment decisions, influencing the confidence of investors, the cost of capital, the overall functioning of financial markets and ultimately the development of more sustainable sources of financing.

Responsible business conduct – Public policies promoting recognised concepts and principles for responsible business conduct, such as those recommended in the OECD Guidelines for Multinational Enterprises, help attract investments and enhance the contribution that investors make to sustainable development.

Human resource development – Policies that develop and maintain a skilled, adaptable and healthy population, and ensure the full and productive deployment of human resources, support a favourable investment environment.

Infrastructure and financial sector development – Sound infrastructure development policies ensure scarce resources are channelled to the most promising projects and address bottlenecks limiting private investment. Effective financial market policies help enterprises and entrepreneurs realise their investment ideas within a stable environment.

Public governance – While there is no single model for good public governance, there are commonly accepted standards of public governance to assist governments in assuming their roles effectively, *e.g.* on regulatory quality and public sector integrity which matter for the investment environment.

Source: *Policy Framework for Investment* (OECD, 2006).

Increasing Energy Research and Development and Dissemination

Identifying priorities for energy research and development

The challenges of long-term energy security and environmental sustainability can only be met through the deployment of efficient and less expensive technologies that are capable of using more plentiful, cleaner and cheaper sources of energy. In addition to the diffusion of current clean energy technologies, better technologies need to be developed and implemented. However, the continuation of current energy research and development (R&D) spending trends is inadequate to deliver the technological advances needed. To promote sustainable energy innovations, research policy and energy policy should be harmonised and coordinated to a far greater degree than is currently the case.

Advances are needed in energy production, conversion, storage and end-use technologies across a broad continuum, spanning from basic science research to technology development to market transformation and diffusion. Given the enormity of the challenge, a great deal of R&D including demonstration is needed. And because markets alone will not provide sufficient incentives for long-term R&D, it falls to governments to also invest in this endeavour.

While overall public budgets for R&D have been generally on the rise in the past decades, public expenditure on energy R&D has remained level since the early 1990s (**Figure 4**). At the same time, private sector expenditures on energy R&D have declined in absolute terms. R&D intensity (measured as a percentage of total turnover) in the energy sector has more than halved from an already low level as opposed to a trend of slightly rising R&D intensity in other sectors.

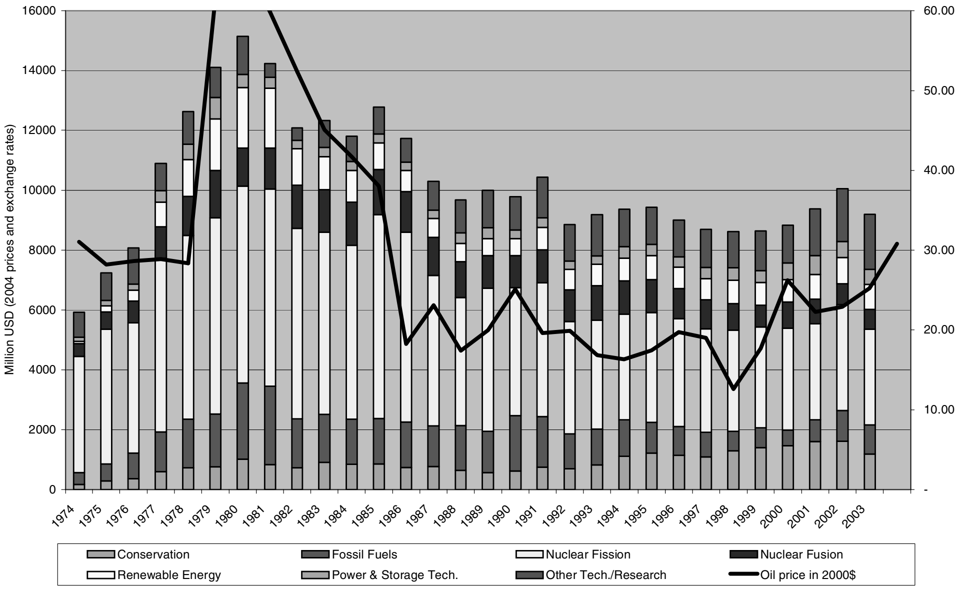
Given limited resources, setting research priorities for sustainable energy technologies must take into account their contributions to reducing greenhouse gas emissions as well as relative incentives for private *vs*. public investments. For example, the declining share of public funding for mature fossil fuel R&D is justified given the maturity of the technology and the strong incentives for the private sector to invest in them. These technologies are often commercially exploitable because they increase efficiency or make extraction and production processes more effective.

Technologies with major R&D needs which can contribute large CO_2 reductions include carbon capture and storage (CCS) for power generation and industrial applications. CCS research is increasing but is still very low. There is a shortage of sizeable R&D projects to advance technological understanding, increase efficiency and drive down costs. To achieve full scale production in a timescale that can significantly influence CO_2 concentrations, at least 10 major power plants fitted with capture technology are needed by 2015. Because the benefits of CCS technology are mainly societal, a larger government role is legitimate; but public investment would need to increase approximately fivefold to reach production targets.

Renewables should be an R&D priority. Given the enormous scale of the resource, research receives only modest funding, although its share has been rising slightly in recent years. The level of solar electric research in particular seems to be relatively modest given its potential, notably in developing countries. R&D investment devoted to more mature renewable technologies – such as geothermal, biomass, wind and hydropower to provide heat, electricity and transport fuels – can also result in cost reductions and efficiency performance improvements as more experience is gained. Their deployment depends partly on the relative pricing of alternative fuels such as oil, coal and gas, but technical advances are possible to improve their competitiveness.

Other useful areas of research include feedstock substitution in industrial processes (*e.g.*, coke in steelmaking; clinker in cement making). Efficient end-use technologies (*e.g.*, in appliances, buildings, transport) would contribute to substantial CO_2 emissions reductions, but their deployment depends less on additional R&D than on CO_2 pricing policies and on regulations, information and other measures to increase public acceptance, financing, information and education, or overcome structural disincentives.

Figure 4. R&D expenditure in IEA countries and oil prices (1974 – 2004)



Source: Background Report of the Round Table on Sustainable Development (OECD, 2006).

Promoting energy technology collaboration

International technology collaboration can help attain sustainable energy advances less expensively, more reliably and for the benefit of a greater number of people. Collaborative efforts help mobilise the necessary investments, support continuity of effort, bring greater exposure to new ideas, and build technical capacity in developing countries. There is a particular need for technology collaboration with rapidly developing countries such as China and India. They present many opportunities for technology development given the quality of research capabilities, high rates of investment, and capacity for technological leap-frogging.

International energy technology collaboration has long been supported by the OECD, International Energy Agency (IEA) and the Nuclear Energy Agency (NEA) through analysis and facilitation of co-operative R&D programmes and projects. In 2004, OECD Science and Technology Ministers issued a *Declaration on International Science and Technology Co-operation for Sustainable Development*, which stresses the need for good research partnership practices to further sustainable growth, including in the energy area. The NEA has pursued roughly 20 international joint research projects, primarily in the areas of nuclear safety and waste management.

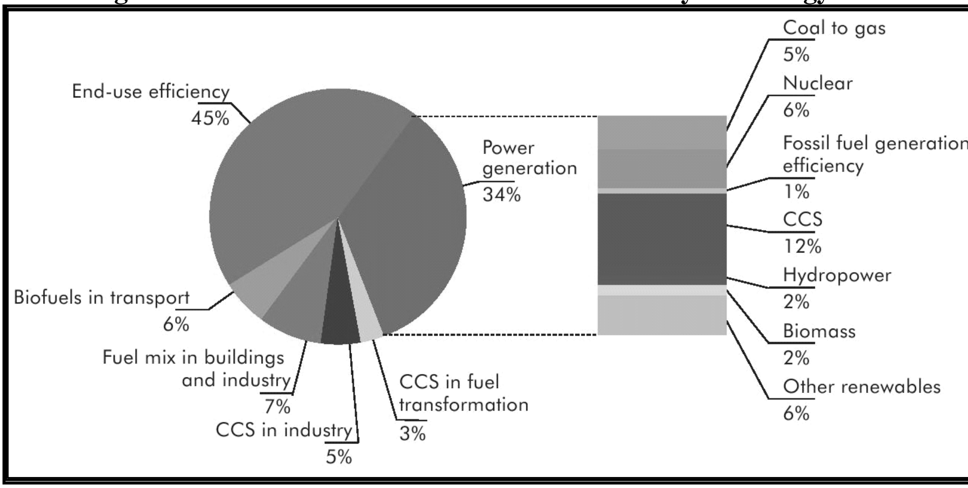
For more than 30 years, the IEA international energy technology collaboration programme has offered a structure for governments to leverage and strengthen their energy research and deployment efforts. This encompasses a collaborative framework – called *Implementing Agreements* – and a system of standard rules and regulations that allow member and non-member governments and other public and private parties to share R&D for particular technologies. Participants in the Implementing Agreements benefit from wider project scale, reduced costs and risks, less duplication of work, accelerated development and deployment, harmonised standards, strengthened national R&D capabilities, information sharing and networking. There are currently 41 Implementing Agreements with several thousand participants from 72 countries, organisations and companies.

In 2006, in response to the G8 Plan of Action, the IEA launched the *Networks of Expertise in Energy Technology* (NEET) initiative during the 14th session of the United Nations Commission on Sustainable Development (UNCSD-14). This initiative is designed to promote the effectiveness and outreach of existing international collaborative efforts on energy technology. Building on the IEA Implementing Agreements, the NEET Initiative links policy-makers, the business community, research and international organisations and other stakeholders in countries that have an increasingly important role in energy supply and consumption.

Developing climate-friendly products and processes

The vast development and deployment of cleaner, more energy efficient technologies will be needed to reduce greenhouse gas emissions. Investment is needed in a broad portfolio of technologies (*e.g.* energy efficiency, carbon capture and storage, renewable energy). In an analysis of technology pathways for reducing CO_2 emissions to current levels by 2050, energy efficiency in end uses was found to be indispensable, accounting for 45% of emissions reductions (**Figure 5**). Other technological contributions could be made by carbon dioxide capture and storage (CCS) in power generation and industry (20%), the use of renewables in power generation (10%), and biofuels in transport (6%).

Figure 5. Potential reductions in CO2 emissions by technology area



Source: *Energy Technology Perspectives* (IEA, 2006).

A variety of barriers discourage the deployment of these climate-friendly approaches. Some have technical problems rendering them unsuitable for the market and in need of further R&D. When a technology is technically proven, demonstration projects are required to show that it works on a commercial scale and under relevant operating conditions. Others face cost barriers in that they are priced higher than incumbent technologies. The costs of less mature technologies can be reduced by R&D and "technology learning". Efficient end-use technologies can face still other barriers in the form of lack of awareness of their benefits relative to costs, lack of market acceptance, and lack of incentives for sustainable consumption by individuals and industry.

Finding carbon-free alternatives in the transport sector is a huge challenge. Ethanol derived from plant material is an attractive fuel with good combustion qualities, but the cost competitiveness of different biofuels depends on available feedstocks and other cost factors such as infrastructure. Today's ethanol production uses predominately starch or sugar crops, limiting the available feedstock, but new technology could enable other biomass feedstocks to be used as well.

For the short and medium term, policies that target fuel efficiency offer the most potential for reducing CO_2 emissions in transport. Higher cost energy sources, including clean energy carriers such as hydrogen and electricity, produced from renewable energy sources, or from fossil fuels with carbon sequestration and storage, will be required if there are to be meaningful cuts in transport sector CO_2 emissions. A switch to hydrogen fuel-cell technologies will require huge infrastructure investments, while major R&D programmes will be needed to bring these technologies to commercial viability.

The transfer and diffusion of clean energy technologies will also require a broad portfolio of policy tools. Technology "push" alone is unlikely to deliver the large long-term emission reductions that are needed. Policies for both technology development and "market pull" are required, including price signals through taxes and economic instruments. International collaboration can pool intellectual resources and investment to enhance clean energy deployment. However, domestic policy frameworks are also important for technology deployment and diffusion. For example, effective technology transfer encompasses more than just equipment hand-over as the protection of intellectual property rights matters for both parties.

Examining the option of nuclear technology

Nuclear energy is a nearly carbon-free technology that has progressed through several generations of development and that can compete favourably with alternatives for base-load electricity generation and enhance the security of energy supply. Periodic surveys give confidence that available natural resources and technology progress will ensure that nuclear fuel requirements will be met in all scenarios of the development of nuclear energy (**Box 6**).

However, three key issues present obstacles to an increased use of nuclear energy: 1) the lack of political stability and regulatory framework stability which increases the business risks of investing in a technology with a capital intensive cost structure; 2) public opposition due to the perceived threats of mainly radioactive waste management and to a lesser extent nuclear accidents; and 3) the possible proliferation of nuclear weapons. Some OECD countries do not consider nuclear energy to be a sustainable energy option.

Regarding waste, among the three categories of radioactive waste – low, intermediate and high – the first two are now dealt with at an industrial level with good safety records. The last one, high-level waste, that concerns only 1% of the volume of radioactive waste but includes 99% of its radioactivity, is the focus of important societal concerns. Experts of NEA countries agree that the safe disposal of such waste in deep geological formations is technically feasible at affordable prices while protecting present and future generations. However, it must be recognised that, except in very few countries, there is very little social consensus to support the implementation of such deep geological repositories. Ethical considerations and differences between actual and perceived risks are at the root of this lack of consensus.

"Generation III" of nuclear energy was developed in the 1990s with a number of advances in safety and economics, including "passive safety" features. Thirteen countries, including those OECD countries with the largest nuclear power sectors recently joined by China and Russia, have joined together to develop "Generation IV" nuclear power plants that offer advantages in the areas of sustainability with a better use of natural resources and less waste production, economics, safety and reliability, and proliferation resistance and physical protection. Assuming current concerns are met, increased use of nuclear power could provide substantial CO_2 emission reductions in a cost-effective manner.

Box 6. Uranium resources, production and demand

The identified amount of conventional uranium resources which can be mined for less than USD 130/kg, just above the current spot price, is about 4.7 million tonnes. Based on the 2004 nuclear electricity generation rate, this amount would be sufficient for 85 years. However, total world uranium resources which could be available at market price are much higher. Based on geological evidence and knowledge of uranium in phosphates, more than 35 million tonnes could be available for exploitation.

At the end of 2004, world uranium production (40 263 tonnes) provided about 60% of world reactor requirements (67 450 tonnes) for the 440 commercial nuclear reactors in operation. The shortfall between production and requirements was made up by secondary sources. These are now in decline, and the shortfall will increasingly need to be made up by primary production.

By 2025, world nuclear energy capacity is expected to grow to between 450 GWe (+22%) and 530 GWe (+44%) from the present generating capacity of about 370 GWe. This will raise annual uranium requirements to between 80 000 tonnes and 100 000 tonnes. The currently identified resources are adequate to meet this expansion.

In the longer term, continuing advances in nuclear technology will allow a substantially better utilisation of uranium resources. Reactor designs are being developed and tested that are capable of extracting more than 30 times the energy from uranium than today's reactors

Source: *Uranium 2005 – Resources, Production and Demand* (NEA/IAEA, 2006).

Promoting Energy Efficiency and Diversity

Increasing energy efficiency in production and use

Improving energy efficiency is the cheapest, fastest and most environmentally friendly way to meet a significant portion of the world's energy needs. Improved energy efficiency reduces the need for investing in energy supply. Many energy efficiency measures are already cost-effective, and they will pay for themselves over their lifetime through reduced energy costs.

Energy efficiency options are generally characterised as having technical and cost barriers that are secondary to other barriers, such as lack of public acceptance, financing, information, education or proper incentives. The exceptions are some industrial options, hybrid vehicles, and certain forms of power generation. But in general, the deployment of energy efficiency options is not delayed due to need for further technical development or cost reductions.

Countries need to pursue energy efficiency policies more diligently in the long-term regardless of the development of fuel prices. In most countries, energy efficiency policy does not receive sufficient emphasis. It tends to receive less attention than renewable energy policy even though they both have similar benefits in terms of energy security and climate change mitigation. At the same time, energy efficiency approaches are often more cost-effective.

There are diverse barriers to greater deployment of energy efficient options. Consumers are often ill-informed and few are concerned with energy efficiency when buying appliances, homes or cars. Business management tends to give energy efficiency a low priority in decision making. There are opportunities for energy efficiency that consumers never see because the manufacturers of refrigerators, televisions or cars do not always take full advantage of the technologies that exist to make their products more energy efficient.

To advance energy efficiency, governments should employ the range of available policy instruments, including regulations and standards, fiscal incentives, public information campaigns, labels, and public-sector leadership in procurement. These can be deployed in a range of sectors:

1) new buildings could be made 70% more efficient than existing buildings through use of insulated windows, modern gas and oil furnaces, and more efficient air conditioners. District heating, heat pumps and solar energy can all save energy. Improved lighting could yield cost-effective savings of 30 to 60%.

2) for households, major improvements have been made in refrigerators, water heaters, washing machines and dishwashers. New technologies such as "smart" metering, micro combined-heat-and-power generation, fuel cells, solar photovoltaic and more efficient lighting can save energy.

3) in industry, energy demand and CO2 emissions can be cut through improved efficiency of motors, pumps, boilers and heating systems; energy recovery in materials-production processes; recycling of used materials; and higher efficiency of materials use. Other approaches are advanced membranes that can replace distillation in some petrochemical processes; "direct casting" in iron and steel; and the use of bio-feedstocks in the petrochemical industry to replace oil and natural gas.

4) in transport, the efficiency of conventional gasoline and diesel vehicles can be improved through turbochargers, fuel injection and advanced electronic methods of engine control; new materials and more compact engines; efficiency gains in vehicle air conditioning; and hybrid vehicles and advanced diesel engines.

Making fossil fuels more climate-friendly

The use of fossil fuels – coal, oil and natural gas– can be made more climate friendly through two primary means: 1) carbon dioxide capture and storage (CCS) at power plants and industrial facilities, and 2) substitution to lower-carbon fuels in power plants and industry.

Carbon capture and storage (CCS) involves capturing the CO_2 generated at power plants and industrial facilities and storing it underground, *e.g.* in depleted oil or gas fields or in underground water layers. These underground reservoirs could allow storage for decades and the captured CO_2 may also be used to enhance the output of oil and gas in the respective fields.

The main capture potential is in the electricity sector, but interesting opportunities exist in synthetic transport fuels processing and industrial sectors, where CCS could reduce CO_2 emissions from coal and natural gas use to near zero. Because, most CO_2 emissions are released from coal-fired power plants, more than half of the potential of CCS is associated with coal-fired processes. Clean coal technologies with CCS offer an important opportunity to constrain emissions and provide lower-cost electricity in rapidly growing economies with large coal reserves, such as China and India.

R&D on CCS needs to be greatly expanded, public awareness and acceptance of storage options should be heightened, and policy incentives including a value for carbon are needed to stimulate the uptake of CCS technologies. Emissions trading systems may offer such incentives, if carbon prices are high enough to make CCS competitive. There is also need for integrated full-scale demonstration plants for CCS technology. Efficient coal combustion technologies such as high-temperature pulverised coal plants and integrated coal-gasification combined-cycle (IGCC) should be used in conjunction with CCS.

For fuel switching, natural gas – the least carbon-intensive fossil fuel – can be used as a substitute for coal and heavy oil products in power production and a variety of industrial processes. In power generation, fuel switching from coal to gas can reduce CO_2 emissions by 50% to 75%. Natural gas combined cycle (NGCC) power plants are more efficient than coal-fired power plants, but the expansion of this technology is limited by uncertainty about future natural gas prices. Fuel costs account for 60% to 85% of total generation costs for NGCCs, much higher than for other power generation technologies. Fuel switching will be limited in the absence of CO_2 policies that place a value on carbon.

In industry, there are opportunities to substitute natural gas for coal in the manufacture of basic materials. For example, gas-based direct reduced iron (DRI) processes can be used in place of coal-based blast furnaces in steel production. In principle, the potential is very high, but so is the cost. The costs of a switch from coal to gas can be low if inexpensive stranded gas (*i.e.* lacking access to markets) can be used. This implies relocation by industry to places where cheap gas resources exist. The main barriers are cost and an increased dependency on natural gas imports.

Expanding the role of renewables

Hydropower, biomass combustion, solar water heating and geothermal technologies are mature and commercially viable in many situations. The principal impediment to the wider commercialisation of other renewable energy technologies (*e.g.*, solar PV, wind, biopower, biofuels, concentrating solar power, ocean energy) is their higher cost compared to conventional technologies and, in the case of wind, wave and solar, their short-term variable character.

To overcome cost barriers, carbon emissions and related externality costs need to be accounted for to raise the price of conventional fossil fuels relative to renewables. In addition, further research is needed on manufacturing and interconnection processes (**Box 7**). In this way, renewable energy technologies could fulfil their large potential contributions to energy security, climate change mitigation and economic development.

Box 7. Policy priorities for renewable energy technologies

1) Connection and integration of variable renewable energy sources into electricity grids.

2) Interconnection safety, codes and standards to help manage the variability of renewable energy sources.

3) Flexible, reliable and low-cost energy storage to help manage the variability of renewable energy sources.

4) Improving the reliability and efficiency of wind turbines, solar PV panels, solar water heaters, ground heat pumps and other emerging technologies.

5) Demonstrating the compatibility and safety of renewable electricity technology.

6) Renewable energy heating and cooling technology deployment.

7) Public acceptability, access to public lands, siting of projects, permitting and royalties, and other socio-economic and environmental concerns, especially for geothermal, wind, hydropower, ocean energy and concentrating solar power.

8) Distributed energy systems as an adjunct or partial replacement of traditional electricity and heating grids.

Source: *Renewable Energy: RD&D Priorities: Insights from IEA Technology Programmes* (IEA, 2006).

Hydropower is already widely deployed and is, in many areas, the cheapest source of power. However, there is considerable potential for expansion, particularly for small hydro plants. Current requirements include continuous improvements in technology, increased public acceptance, and streamlining the project approval process.

The costs of onshore and offshore *wind power* have declined sharply in recent years through mass deployment, the use of larger components, and more sophisticated controls on wind turbines. The best onshore sites are already cost competitive with other power sources, while offshore installations are more costly, especially in deep water. In situations where wind will have a very high share of total generation, it will need to be complemented by sophisticated networks, improved forecasting, back-up systems or storage, to accommodate its variability. Minimising environmental impacts is also important as well as education of the public regarding deployment.

The costs of high-temperature *geothermal resources* for power generation have dropped substantially since the 1970s. Geothermal is a site-specific resource that can only be accessed in certain parts of the world for power generation. Lower-temperature geothermal resources for direct uses like district heating and ground-source heat pumps are more widespread. R&D including for deeper drilling, hot dry rocks, and binary systems can further reduce the costs and increase the scope of geothermal power.

Solar photovoltaic (PV) technology is playing a rapidly growing role in niche applications. Costs have dropped with increased deployment and continuing R&D. Concentrating solar power (CSP) also has promising prospects and several new commercial plants are under construction or planning. However substantial cost reductions are still needed.

The combustion of *biomass* for power generation is a well-proven technology. It is commercially attractive where quality fuel is available and affordable. Co-firing a coal-fired power plant with a small proportion of biomass requires no major plant modifications, can be highly economic and can also contribute to CO_2 emission reductions.

The use of biomass, geothermal and solar thermal systems for *heating and cooling* has considerable potential for increasing the share of renewable energy in many countries. Relatively few policies presently exist to encourage greater deployment but where they do, substantial market growth has occurred.

Liquid *biofuels* currently meet around 1-2% of the global road transport energy demand. Considerable interest has occurred recently in many countries to expand this share and targets and policies have been developed. There is potential for second generation biofuels from ligno-cellulosic feedstocks and trade between north and south. However concerns are growing as to the sustainability of the biomass feedstock resource, and impacts on food, land use and water supplies.

Ocean energy (wave, ocean currents, thermal and saline currents) is approaching the near commercial stage with many devices being tested as prototypes or on a pilot scale. Tidal range technologies have been installed commercially in three locations but no more are planned. Significant R&D investment is necessary to develop this promising renewable energy resource.

Benefiting from Energy-Related Climate Change Policies

Promoting use of economic instruments

Economic or "market-based" instruments can be an effective and economically efficient means of achieving sustainable energy policy goals in many circumstances. These include taxes, emissions trading, subsidy reform, and preferential tariffs.

Economic instruments offer the potential for both static efficiency (reducing costs for pollution abatement) and dynamic efficiency (providing incentives for innovation). They provide increased flexibility for governments and industry through building on the operation of the market and the price system. They can provide government revenue (in particular taxes and charges) that can be used for a variety of purposes.

Environmentally related taxes introduce price signals so that producers and consumers take into account the costs of pollution and resource use associated with their activities. In this way, carbon taxes would internalise the cost of greenhouse gas emissions and raise the price of certain fuels, processes and products. These fiscal incentives would reduce demand for harmful products and increase demand for alternative fuels such as renewables whose prices become more competitive. Environmentally related taxes also increase incentives for the private sector to undertake R&D on sustainable innovations and technologies.

Concern about reducing the competitiveness of energy-intensive sectors is a major obstacle to the full implementation of carbon taxes. Energy intensive industries often receive total or partial exemptions from such taxes even though significant global reductions in carbon emissions could be achieved. In levying carbon taxes, the competitiveness impacts can be reduced by: i) enlarging the group of countries that put similar policies in place, ii) levying border tax adjustments on products from countries having less stringent taxes, or iii) recycling a portion of the tax revenues back to the affected firms. Many countries are now considering such approaches for using carbon taxes to promote more sustainable energy systems.

Emissions allowance trading is the premier instrument for reducing greenhouse gas emissions from energy production and use. This involves applying surplus emissions reductions at certain facilities to meet or redefine emissions reductions at other sources. The emissions trading scheme of the European Union is by far the largest scheme currently in operation, but there are a dozen or so domestic and regional trading programmes in operation or under development. The schemes have different sizes, geographical/sectoral scopes, time-periods, design characteristics, compliance provisions, and rules for "offset" credits. Some are designed to be used for compliance with emission commitments under the Kyoto Protocol, while others are planned or in use in non-Kyoto parties. Some are mandatory; others are voluntary. Some cover direct emission sources only, while others include *e.g.* electricity retailers or users.

The different schemes could be linked into an international trading system in the future. Trading schemes can trigger many of the local actions needed to curb emissions and would be most efficient with widespread (ideally global) coverage. Domestic trading schemes could expand beyond their current coverage of large stationary emissions sources. A global market could incorporate domestic and regional schemes with divergences in design. However, the energy realities of developing countries give most of them little incentive to develop their own broad domestic emissions trading schemes.

Government subsidies can take many forms, including direct grants or payments to consumers or producers; preferential lending; preferential tax credits and exemptions; buyback of production rights; below-cost inputs, infrastructure or services; and special regulations or trade and market rules. Subsidies to energy, as well as to transport, industry and agriculture, distort markets for energy and have largely negative effects on the sustainable use of energy.

Subsidies can be used to lower energy prices, which can raise living standards and increase economic activity, but which can also discourage the adoption of energy efficient devices. Energy subsidies raise the profitability of energy producers, which may encourage or discourage shifts in the fuel mix. Transport subsidies can increase transport activity and favour certain modes of transportation (*e.g.* road vs. rail, or private vs. public), which increase negative environmental impacts. Industrial subsidies may prompt delays to plant restructuring and lead to prolonged inefficiencies in the use of energy.

Energy-related subsidies can have broad impacts on sustainability. They can encourage overuse of fossil fuels and lead to the over-exploitation of resources while contributing to harmful emissions and waste. Socially, these supports can redistribute income from consumers to producers and distort resource allocations across firms and sectors as well as countries. Subsidies may, however, be justified in some cases in order to combat poverty, but should be crafted carefully for these purposes (**Box 8**).

Box 8. Subsidies, energy use and poverty

Subsidies to energy services, as a rule, are ineffective, economically inefficient and contrary to good environmental practice. They may, however, be justified to combat poverty in some cases, but should only be used under specific conditions. They must: be properly targeted and affordable; deliver quantifiable benefits; be easily administered and not cause large economic distortions; be transparent and limited in duration. The way a subsidy is applied is critical to how effective it is and to its cost. Subsidies should normally be restricted to energy services provided through fixed networks -- electricity, natural gas or district heat. Subsidies to freely traded forms of energy, such as oil products, can never be properly limited to poor households. Policies should target the "poor" very precisely so that the mechanism for subsidising a particular fuel does not allow richer households to benefit from the subsidy.

The case for subsidising electrification in poor developing countries is widely accepted in principle, since the developmental benefits are often judged to exceed the long-run costs involved in providing subsidised electricity. Where high up-front connection charges prevent poor people from gaining access to electricity, "lifeline rates" – special low rates for small users – can be a cost-effective way of making services affordable to poor households. Alternatively, governments can finance part of the connection charge or oblige utilities to spread the cost out over time. The challenge is to ensure that electricity subsidies increase access for the poor at the lowest cost, while ensuring that electricity utilities are still able to make money and to continue to invest. That means limiting the size of subsidies and the number of recipients, and compensating the utility for any loss of revenue. This can be done either through higher charges for other customer categories or direct financial transfers from the government budget.

Source: *World Energy Outlook* (IEA, 2004).

A more even playing field at international level in the absence of energy-related subsidies will benefit both OECD and developing countries. The political economy of "how" distortive subsidies might – through co-ordinated and enlightened approaches – be successfully reformed is in need of joint reflection. Only full transparency in subsidy policies and inclusion of stakeholders – including industry and non-governmental organisations (NGOs) – will enable subsidy reform to begin. Whole-of-government decision-making processes are needed to bring together the many relevant agencies at national, regional and local levels. Managing the social effects of subsidy changes – on industries, workers and communities – is key. And in some cases, transitional supports may be needed to get rid of longer-term embedded subsidies, including those to energy, transport and industry.

Tariff reductions for renewable energy and associated technologies would reduce the tax that consumers in some countries pay on these goods. Preferential tariff margins for energy-efficient goods could be part of general trade negotiations. This would benefit those living in rural areas of developing countries where many renewable energy technologies would make a great contribution to energy supply, but are currently too expensive partly due to import taxes. It would help reduce dependence on more polluting and less secure energy sources. To the extent that reducing import tariffs also reduces the costs of grid-connected technologies, these would also become a more affordable option in the portfolio of energy options available to electric utilities. Manufacturers located in OECD and developing countries alike would benefit from increased trade in renewable energy technologies and components.

Furthering climate adaptation efforts

Given current atmospheric concentrations of greenhouse gases and the difficulties in stabilising them in the foreseeable future, a certain amount of climate variability due to global warming appears inevitable. Efforts to adapt to the effects of a changing climate must accelerate – as must mitigation efforts. Adaptation is particularly important in the context of development planning and assistance activities and in domestic policymaking in developing countries.

Early attention to adaptation in all countries can help avoid or reduce potential climate-related impacts on growth and development prospects. It is expected that climate change impacts will affect energy demand patterns, reliability of some energy sources (*e.g.*, hydropower), performance of power plants, and energy infrastructure in general. A range of development activities, including the design of hydropower facilities and energy infrastructure, needs to adapt to the impacts of current and future climate change risks.

Helping vulnerable countries anticipate and adapt to new risks resulting from climate change is key to achieving sustainability. Adaptation to climate change should figure prominently in foreign assistance activities and should be placed into the mainstream of development policies and international aid efforts.

In 2006, OECD Development and Environment Ministers adopted the *Declaration on Integrating Climate Change Adaptation into Development Co-operation* to better integrate climate change adaptation in development planning and assistance, both within their own governments and in activities undertaken with partner countries. In this context, they agreed to:

- promote understanding of climate change and its impacts within their development co-operation agencies and with partners in developing countries;
- identify and use appropriate entry points for integrating adaptation to climate variability and climate change into development co-operation activities;
- assist developing country partners in their efforts to respond to climate variability and climate change;
- improve the relevance and usability of information on the impacts of climate variability and climate change and the costs, distributional and trans-boundary aspects of adaptation activities; and
- encourage regional initiatives that include common actions on impacts and vulnerability assessment and adaptation options.

Early attention to adaptation in all countries can help avoid or reduce potential climate-related impacts on growth and development prospects. Adapting to climate change must be placed into the mainstream of development policies, national strategies and international aid efforts. Helping vulnerable countries anticipate and adapt to new risks resulting from climate change is key to achieving sustainability. A range of development activities, including the design of hydropower facilities and energy infrastructure, needs to adapt to the impacts of current and future climate risks.

Maximising the potential of the Clean Development Mechanism (CDM)

Under the Clean Development Mechanism (CDM), industrialised countries can achieve some portion of their required greenhouse gas commitments under the Kyoto Protocol from “credits” generated through lower-cost emission reductions in projects beyond their own borders. Governments, investors and private companies in industrialised "donor/investor/buyer" countries cam receive credits – in the form of tradable certified emissions reductions (CERs) – for reduction projects they carry out in "host/seller" countries.

Each CDM project must: i) reduce GHG emissions above and beyond "business as usual"; ii) account for GHG emissions that occur outside the project boundary that are attributable to the project; iii) adhere to strict physical boundaries within which GHG emissions will be reduced or sequestered; iv) not involve nuclear technology nor exceed internationally-agreed limits on forestry credits and activities; v) be voluntary and have the host country's approval; vi) meet the sustainable development goals defined by the host country; vii) include the participation of affected communities, groups or individuals; viii) not contribute to environmental decline; ix) not divert official development assistance (ODA); and x) occur in a developing country that is Party to the Kyoto Protocol.

There has been a rapid growth in activity under the CDM, which is currently expected to lead to emission mitigation of more than 1.8 billion tons from over 1 700 individual projects by 2012. However, although there is an enormous potential for renewable energy and energy efficiency projects, much of it remains “un-tapped”, with these project types only accounting for about a fifth of total expected credits from the CDM. There are several reasons for this at the national, international and project level, including limited institutional capacity, difficulties in obtaining sufficient project finance in countries with a high sovereign risk, and the relatively small size of many renewable energy and energy efficiency projects.

The high transaction costs associated with developing and operating CDM projects are another barrier to maximising its potential. The OECD has worked on two proposals to reduce these costs, through economies of scale: 1) the creation of a sectoral crediting mechanism; and 2) the use of CDM programmes and bundles of GHG mitigation actions of multiple project types, in multiple sectors and at multiple sites.

The sectoral crediting mechanism (SCM) would focus on economic sectors, rather than projects, in developing countries. Emissions performance baselines for a specified period would be established for selected sectors (*e.g.* iron and steel, cement) in participating developing countries. These countries would then receive tradable emissions reduction credits, which they could use as they wish – distributing them to individual companies in the sector or selling them for general revenue.

Sectoral crediting mechanisms are a promising means to encourage investment in climate-friendly energy systems. Nevertheless, developing an effective system that is feasible to negotiate and set up presents certain challenges due to wide variations in greenhouse gas intensities among countries and facilities, and the need for technical skills for evaluating, monitoring and verifying sectoral crediting proposals. The demand for credits must be relatively certain to make the effort worthwhile, and the environmental effectiveness of the instrument must be secured.

The second proposal, for CDM programmes and bundles, would allow crediting emissions reductions of multiple project types, in multiple sectors and at multiple sites. There is a large potential for greenhouse gas mitigation in energy and transport that are currently under-represented in the CDM portfolio. However, there is also a large potential for "free riders" if all programmes are eligible. Authoritative definitions of "programmes" and "bundles" and clarification of their differences and overlap are needed, which would allow modification to provisions and clarify CDM projects to avoid double-counting.

Conclusions

Energy is essential for development; energy that is secure, environmentally-friendly, and produced and used efficiently is essential for *sustainable* development. Today's energy system is a cornerstone of modern life. It enables innumerable services capable of improving human, social, economic and environmental conditions in both developed and developing countries.

Yet the current system of energy supply and use is highly unsustainable, and absent major new government policies will become even less so in the foreseeable future. It is insecure and unreliable, because of the heavy dependence on conventional oil, coming from limited reserves concentrated in politically volatile regions, and the inadequate capacity and maintenance of the network infrastructures for delivering gas and electricity. It is environmentally harmful, because of its predominant contribution to anthropogenic global warming, and its heavy contribution to local pollution. It is inaccessible or unaffordable to a large portion of the world's poor. It is frequently used inefficiently and wastefully.

The challenges of ensuring energy for sustainable development are many. Improving the human, economic, social and environmental conditions of the people of today and tomorrow demands much greater levels of energy services – cooking, lighting transport, etc. It also demands that these services be delivered in a manner that is more universally accessible, affordable, reliable, safe and environmentally friendly. This will require fundamental changes in technologies, methods, infrastructure and people's behaviour everywhere. It will also necessitate great ingenuity, investment, work, organisation and leadership.

The change needs to be so profound – in nature and extent – that government, business and social leaders need to use every instrument at their disposable as effectively and efficiently as possible (**Box 9**). They should use markets – with their ubiquitous signals to consumption, investment and behaviour – to deliver much of the change. But they will also need to marshall public R&D, regulations and other instruments when markets do not deliver the necessary change towards sustainable energy.

They will also need to practice good governance in terms of coherence and co-ordination among the many policy domains concerned. Energy development and use should be placed in a sustainable development context to ensure that no dimensions, resources or policy tools are overlooked.

Box 9. Policies to promote energy for sustainable development

1. Regulations and standards to cut air pollution and greenhouse gas emissions from energy and transport sources.

2. Economic instruments (carbon taxes, emissions trading) to internalise environmental costs and promote innovation in the energy sector.

3. Public R&D and incentives to private R&D in priority energy areas (*e.g.*, carbon capture and storage, solar power).

4. Sustainable consumption initiatives to promote use of energy-efficient alternatives in end uses.

5. Reform of energy and transport subsidies to remove market and price distortions in the energy sector.

6. Establishment of favourable business environments and conditions to encourage investment in energy systems and infrastructure.

7. Inclusion of energy as an integral part of development planning and development co-operation.

8. Coordination of energy-related policies in all domains through sustainable development strategies.

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Preface

This brochure is a combined contribution to the 15th session of the United Nations Commission on Sustainable Development (UNCSD-15) from the Organisation for Economic Co-operation and Development (OECD) – including the Development Co-operation Directorate, the Environment Directorate, the Directorate for Financial and Enterprise Affairs, the Directorate for Science, Technology and Industry, and the Round Table on Sustainable Development – together with the International Energy Agency (IEA) and the Nuclear Energy Agency (NEA). It has been produced under the auspices of the OECD Horizontal Programme on Sustainable Development and reviewed by the OECD Annual Meeting of Sustainable Development Experts (AMSDE).

Under the theme of "*Energy for Sustainable Development*", this brochure presents policy findings from OECD, IEA and NEA reports relating to energy, climate change and sustainable development. It focuses on four main topics: i) widening energy access in developing countries, ii) increasing energy research and development and dissemination, iii) promoting energy efficiency and diversity, and iv) benefiting from energy-related climate change policies. The report was prepared with the assistance of John Newman, Energy and Environment Consultant.

This report is published on the responsibility of the Secretary-General of the OECD.

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Introduction: A Broad Look at Energy Issues

Addressing long-term energy security and sustainability challenges

Current demographic, economic, social, and technological trends – if not counterbalanced by strong new government policies – pose major challenges to the long-term sustainability of the global energy system. If governments do not implement policies beyond those already planned between now and 2030, it is projected that:

- energy consumption will increase by over half (53%);
- the energy mix will remain fairly stable and dominated by fossil fuels (80% share);
- energy-related CO2 emissions will increase by over half (55%); and
- large populations of the world's poor will continue to lack access to electricity (about 1.5 billion) and modern cooking and heating services (about 2.5 billion).

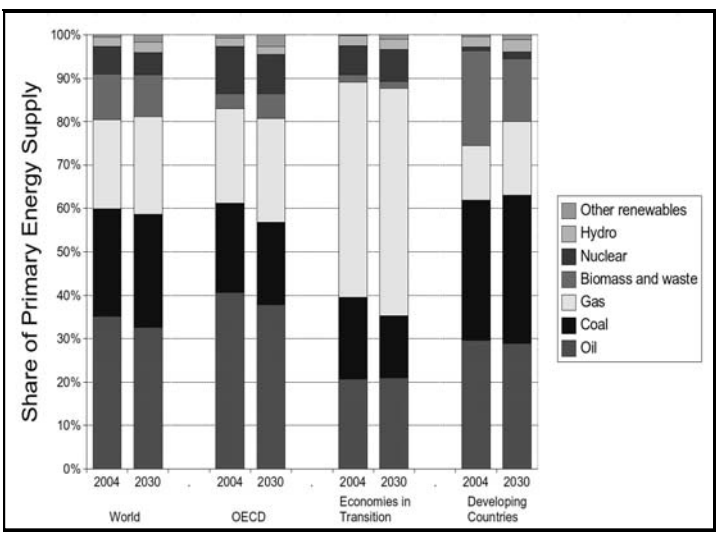
In this scenario, energy consumption increases from 11 200 Mtoe (millions tons of oil equivalent) in 2004 to 17 200 Mtoe in 2030. Over 70% of this growth is expected to come from developing countries, which overtake OECD countries as energy consumers sometime around 2014. Nearly half of the increase in global primary energy use goes to generating electricity and one-fifth of the increase (almost entirely in the form of oil-based fuels) to meeting transport needs.

Growth in energy use and emissions is expected to be particularly marked in some sectors. The sectoral contributors to growth in energy consumption are expected to be power generation (35%), industry (15%), transport (12%) and buildings (6%) in developing countries, followed by power generation (11%) and transport (6%) in OECD countries. Improving efficiency and reducing carbon dioxide (CO_2) emissions should receive early attention in these high growth areas, because these goals are easier and cheaper to attain at the time of new construction than at later retrofit stages.

It is predicted that the global energy mix will remain fairly stable and dominated by fossil fuels to 2030 due to the size and inertia of the energy system and the inability to change it quickly. In this scenario, no fuel's share of the mix changes by more than a few percentage points (**Figure 1**). Fossil fuels remain the largest source of world energy – accounting for about 80% of global demand in 2004 and 81% in 2030. The consumption of each fossil fuel grows at different rates, so their shares of the total shift slightly – oil falls from 35% of the total in 2004 to 33% in 2030; coal rises from 25% to 26%; and gas rises from 21% to 23%. Concerns about continued high consumption of oil and gas raise questions of supply security (**Box 1**).

China and India account for almost four-fifths of the incremental demand for coal. Renewable energy and nuclear power shift to a similarly small degree. Hydropower's share of primary energy use rises slightly. The share of biomass decreases as developing countries switch to modern commercial energy, offsetting the growing use of biomass as feedstock for biofuels production and for power generation. Non-hydro renewables – including wind, solar and geothermal – grow the quickest, but from a small base.

Figure 1. Fuel profile of primary energy use (2004 and 2030)



Note: based on Reference Scenario.

Source: *World Energy Outlook* (IEA, 2006).

Box 1. Energy security and sustainable development

Energy security is a broad concept that focuses on energy availability and pricing. Specifically, it refers to the ability of the energy supply system – suppliers, transporters, distributors and regulatory, financial and R&D institutions – to deliver the amount of competitively-priced energy that customers demand, within accepted standards of reliability, timeliness, quality, safety and environmental impacts, under a wide range of geopolitical, economic, social, technological and weather circumstances.

Traditionally, energy security has been defined in the context of the geopolitical risks to external oil supplies. Today, it is a broader concept, encompassing all energy forms, all the external (foreign) and internal (domestic) links bringing the energy to the final consumer, and all the many ways energy supplies can be disrupted – including equipment malfunctions, system design flaws, operator errors, malicious computer activities, deficient market and regulatory frameworks, corporate financial problems, labour actions, severe weather and natural events, aggressive acts (*e.g.* war, terrorism and sabotage), and geopolitical disruptions.

In practice, the most worrisome disruptions or potential disruptions are those linked to: 1) extreme weather events; 2) mismatched electricity supply and demand; 3) regulatory failures; and 4) concentration of oil and gas resources in certain regions of the world. Insecure energy supplies inhibit development by raising energy costs and imposing expensive (sometimes life threatening) cuts in services when disruptions actually occur.

The energy supply sector can best advance sustainable development by producing and delivering secure and environmentally-friendly sources of energy and by increasing the efficiency of energy use. These overarching qualities are frequently stated in terms of the 3E's – energy security, economic development and environmental protection. The current methods of meeting these criteria involve ensuring fuel diversity, supplier diversity, sound transmission and distribution infrastructure, efficient conversion and delivery technologies, and low- and zero-carbon technologies.

While greenhouse gas (GHG) emissions and the ensuing climate change are not the only environmental problems confronting the energy sector, they are the most universal and most pressing. In the reference scenario, energy-related CO_2 emissions increase from 26.1 Gt CO_2/year in 2004 to 40.4 Gt CO_2/year in 2030. Over three-quarters of this growth comes from developing countries, which overtake OECD countries as the biggest regional emitter soon after 2010. China, which overtakes the United States as the world's biggest emitter before 2010, accounts for 39% of the global increase between 2004 and 2030. Its emissions more than double between 2004 and 2030, driven by strong economic growth and heavy reliance on coal in power generation and industry. India accounts for 10% of the increase in global emissions.

The sectoral contributors to CO_2 emissions growth are forecast as coal-based power generation (32%), oil use in transport (13%), coal use in non-power sectors (9%), gas-based power generation (8%) and oil used in non-power sectors (7%) in developing countries, followed by oil use in transport (7%) and coal-based power generation (6%) in OECD countries.

These projections concerning energy and environmental trends are not inevitable; there are many policies that if implemented could change them. According to the Alternative Scenario based on enlightened policies, it is possible to substantially alter the course of energy developments in the next half century and to make the energy system more sustainable. To achieve this, countries need to adopt all of the policies related to energy security and energy-related CO_2 emissions that they are currently considering.

These policies include efforts to improve efficiency in energy production and use, increase reliance on non-fossil fuels, and sustain the domestic supply of oil and gas within net energy-importing countries. They would yield substantial savings in energy consumption and reductions in CO_2 emissions. Moreover, these benefits would be achieved at a lower total investment than if such action is postponed. While suppliers' investments decrease, consumers' investments increase but this is more than offset by lifecycle energy cost savings. The cost of fuel saved by consumers is estimated at USD 8.1 trillion, more than offsetting the extra demand-side investments required to generate these savings.

Policies encouraging more efficient production and use of energy could contribute almost 80% of the avoided CO_2 emissions in 2030, with the remainder gained from fuel substitution. More efficient use of fuels, mainly by cars and trucks, accounts for almost 36% of avoided emissions; more efficient use of electricity in a wide range of applications (*e.g.* lighting, air-conditioning, appliances and industrial motors) for 30%; greater efficiency in energy production for 13%; renewables and biofuels for 12%; and nuclear for the remaining 10%.

Another critical policy response is greater investment in energy-related research and development (R&D), in part because new supply-side energy technologies need to be operating on a commercial scale from 2030 or earlier. Scenarios show that it is possible to bring emissions back to current levels by 2050, but this would entail large amounts of extra R&D and widespread deployment of cleaner, more efficient technologies. There is no "silver bullet" technology that alone can attain the emissions target, but more energy efficient production and end-use technologies are indispensable.

Co-ordinating relevant policy fields

Energy contributes to and detracts from sustainable development according to an elaborate interplay of markets, technological development, government policies, social norms and individual behaviour, not just in the energy sector but in many other sectors as well. The relationship between energy and sustainable development is complex, both positive and negative.

On the positive side, it is the services that energy enables, not the energy itself, that most directly advance sustainable development. Better cooking, lighting, space conditioning, transportation, communications, income generating processes and other services are the means by which energy improves human, social, economic and environmental conditions. On the negative side, energy can be produced and deployed in ways that pollute the environment and increase greenhouse gas emissions. The development of various energy sources, including oil, gas and coal, can disrupt ecosystems if not carefully planned.

Energy is vital to providing an array of necessary services, but the nature of its contribution is not fixed. It is possible to alter the end-use devices, methods, infrastructure and behaviour that deliver these services to become more energy efficient or to use alternative types of energy. There are opportunities and barriers to developing and deploying more sustainable energy supplies and end-uses in various sectors, which are influenced by the:

- availability, affordability, security, reliability and safety of energy supplies in the energy system;
- environmental friendliness of energy supplies in the energy system;
- planning, design, construction, operation, financing and pricing of energy-using buildings, industrial processes, transport systems, etc. in end-use sectors;
- social and cultural norms regarding behaviour in end-use sectors;
- access to alternative technologies and energy sources; and
- investment assistance to develop and deploy energy services.

Government policies are key to ensuring that the energy sector advances sustainable development. There are many policy domains – including environment, development, industry, transport, construction, agriculture, investment, science and technology and education as well as energy itself – where policies influence how and how much energy is produced, converted, transported, distributed and used. Ensuring that energy systems develop in a way that best supports and accords with sustainable development requires communication and co-ordination among all relevant policy areas at all levels of government (*i.e.* local, regional, national, international).

Full communication and co-ordination across all policy domains affecting the development and use of energy are still rare, just as they are in many other fields. Addressing energy challenges requires an integrated sustainable development approach based on increased co-ordination among diverse fields and stakeholders. A wide range of government departments and agencies should be involved in the formulation and implementation of energy policies in various sectors.

This can be achieved through the implementation of national sustainable development strategies (NSDS) which were mandated for all countries by *Agenda 21* in 1992. The strategy process offers an opportunity to build on the complementarities of programmes in the economic, environmental and social spheres to improve the long-term effectiveness of complex energy policies. The OECD recommends certain good practices in the overall format and operation of NSDS (**Box 2**). The successful practices pertain to the content (policy dimensions, timeframes, analytical tools), governance and co-ordination aspects (institutions, stakeholders, local links), and management processes (indicators, targets, monitoring) of strategies, which would ensure the energy contributions to sustainable development in the strategy context.

Identifying policy tools and responses

An array of policy tools are needed to ensure that sufficient quantities of energy are delivered to end-users in an affordable, reliable and environmentally friendly manner. Still more policy approaches implemented in conjunction with sectoral policies are needed to advance end-use energy efficiency and CO_2 emissions reductions.

Government-set framework conditions (*e.g.* market rules, pricing mechanisms, taxes, tradable allowances and subsidies), investment and development policies, sectoral policies (*e.g.* agriculture, transport), and technology R&D and deployment priorities have large roles to play in moving all relevant actors (*i.e.* energy supply, end-use energy efficiency, end-use sectors and auxiliary sectors) towards greater sustainability.

Box 2. Good practices in national sustainable development strategies (NSDS)

Successful practices in the national sustainable development strategies of the OECD countries include:

Policy integration – national strategies should give consideration to environmental, economic and social concerns in integrated approaches contained in national plans and reports.

Intergenerational timeframe – national strategies should adopt long-term timeframes which enable inclusion of intergenerational principles and indicators.

Analysis and assessments – integrated assessment tools should be used in national reports to identify the environmental, economic and social costs and benefits of policy and strategy options.

Co-ordination and institutions – a wide range of government departments and agencies should be involved in the formulation and implementation of national strategies, with overall responsibility in the office of the Prime Minister or equivalent.

Local and regional governance – local and regional authorities should be fully involved in the development of national strategies, with certain delivery aspects devolved to sub-national levels.

Stakeholder participation – stakeholders (*e.g.*, business, unions, non-governmental organisations) should participate with government representatives in commissions responsible for developing and implementing national strategies.

Indicators and targets – strategies should be based on structured indicator systems (enumerated in national plans and reports) to assist in monitoring progress and to serve as quantitative targets.

Monitoring and evaluation – independent bodies or processes should be established to act as watchdogs monitoring implementation of national strategies and providing recommendations for their improvement.

Source: *Good Practices in the National Sustainable Development Strategies of OECD Countries* (OECD, 2006).

The synergies and trade-offs across these policies as well as their cost-effectiveness need to be assessed in individual country contexts. However, assessing the sustainability as well as the cost-effectiveness of energy policies and measures does not yet form an integral part of the decision-making process in most countries. Such assessments should lead to the re-evaluation of the current priorities of the policy mix. For example, ensuring cost-effectiveness in addressing greenhouse gas emissions reduction targets is a challenge that all countries face. In many countries, energy efficiency improvements in residential/commercial sectors and the transport sector are lagging behind. And while policies promoting renewable energies are instrumental in energy sustainability, these tend to be costly to develop and implement.

At a minimum, the policy toolbox for promoting energy for sustainable development should include:

1) regulations and standards – agreed government norms for the production and use of energy and protection of the environment;
2) economic instruments – market-based instruments (*e.g.*, taxes, tradeable permits) to internalise externalities and promote the cost-effectiveness of energy and environmental policies and measures;
3) subsidies – phase-out of unproductive and distortive government subsidies (*e.g.* to energy, transport) and provision of transition supports where needed to ease environmental and social costs of change;
4) investment – establishment of undistorted, cost-reflective prices in the energy market and conducive investment conditions to send the right signals to private investors;
5) partnerships and voluntary agreements – joint public/private programmes to develop and deploy sustainable energy approaches with industry;
6) research and development – government R&D and incentives to private R&D to promote innovation on energy for sustainable development;
7) information and communications – campaigns to promote better understanding by the general public of the national and international energy and environment situation and future challenges;
8) assessments and scenarios – sustainability assessments which identify synergies and trade-offs across the economic, environmental and social impacts of energy policy options; and
9) national strategies – good governance approaches based on whole-of-government decision-making, transparency, and understanding of the political economy of promoting change in energy systems.

Widening Energy Access in Developing Countries

Meeting growing energy demand and addressing energy poverty

Energy contributes to a virtuous cycle of human, economic and social improvements that are essential to sustainable development in developing countries (**Figure 2**). Sufficient supplies of clean energy are the basis for raising standards of living, improving the quality and quantity of human capital, enhancing the business and natural environment, and increasing the efficiency of government policies.

However, energy poverty remains a major problem for human health, economic development and environmental sustainability in many parts of the world. Approximately 1.6 billion people – mostly in the rural areas of Sub-Saharan Africa, South and East Asia, and Latin America – lack access to electricity, and 2.5 billion people rely on traditional biomass for cooking and heating. About 1.3 million people – mostly women and children – die prematurely every year because of exposure to indoor air pollution from cooking and heating with traditional, inefficient biomass stoves.

Demand for energy is growing exponentially in developing countries due to rapid population growth (especially in Africa) and rapid economic expansion (especially in China and India). This is projected to lead to a near doubling in primary energy use, much of it unsustainable, by developing countries in the next two decades. As a result of this growth, developing countries will account for 50% of primary energy use and 52% of energy-related CO_2 emissions by the year 2030.

China will experience the greatest increase in energy demand, accounting for 43% of all developing country growth and 30% of total world growth. India, other Asia, the Middle East and Africa will show medium growth in energy consumption. As for energy sources, coal will be the largest growing energy source (mostly in Asia) followed by oil. Gas will continue to be used extensively in the Middle East and Latin America, while the consumption of biomass and waste will increase in Africa.

Huge investments are needed in additional and replacement capacity for producing, converting, transporting and distributing energy in developing countries to meet future needs (**Figure 3**). Most of this investment is needed in the power sector, particularly in China, India and other Asian countries. Other regions need financing also for oil and gas development and use.

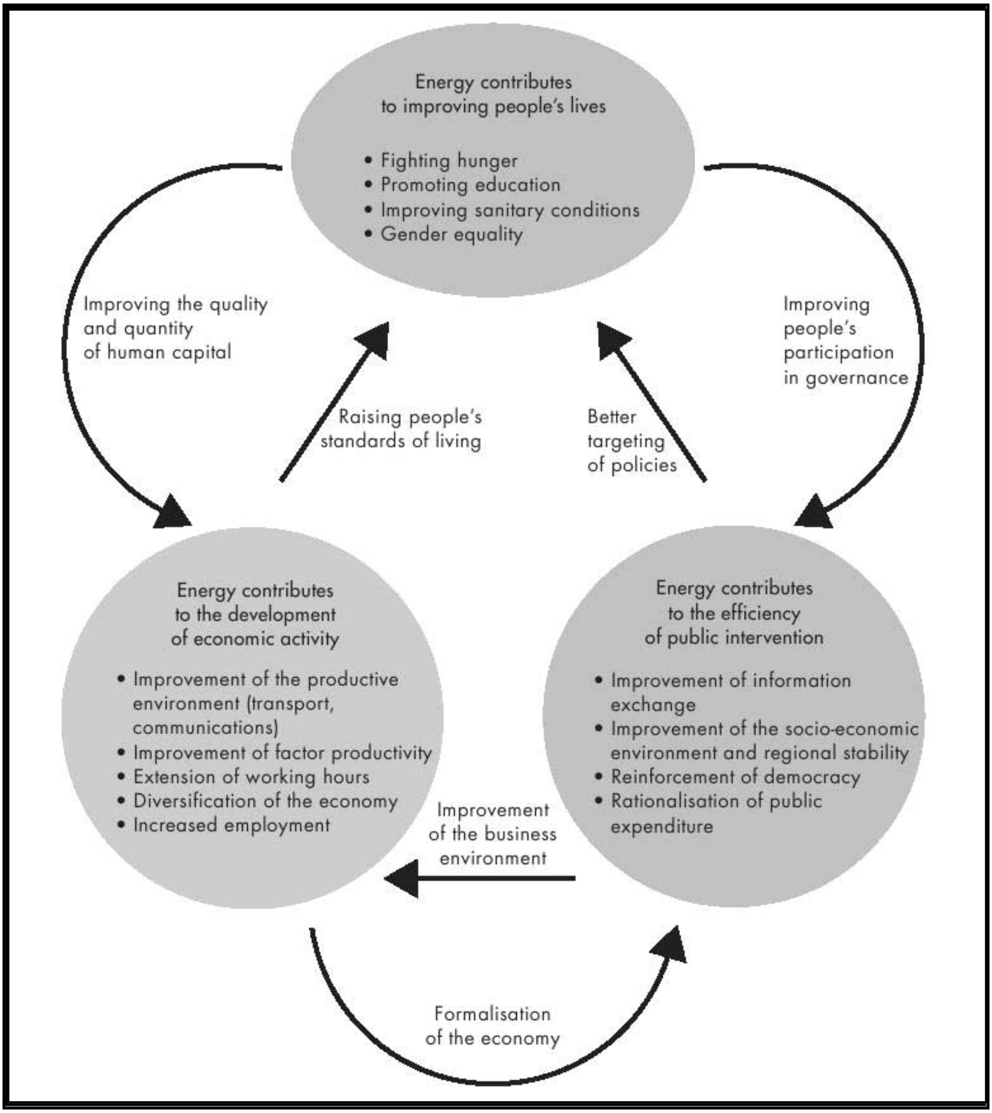
Investment at these high levels represents a dual challenge. Governments have to set policies that attract sufficient private investment and development assistance. Developing country governments, together with investors and donors, need to find more efficient and less expensive ways of delivering energy services so that the financial savings might be invested in other sustainable development needs. They should also ensure sustainable patterns of production and consumption of energy supplies and services.

Increasing access to sustainable energy sources and infrastructure

Lack of access to affordable electricity and heavy reliance on the inefficient and unsustainable use of traditional biomass fuels (*i.e.*, fuelwood, charcoal, agricultural waste and animal dung) are both manifestations and causes of poverty. Electricity and other modern energy sources play a critical role in economic and social development. They alone cannot alleviate poverty – clean water, adequate sanitation, health and education services and communication networks among other things are also needed – but they are indispensable to sustainable development.

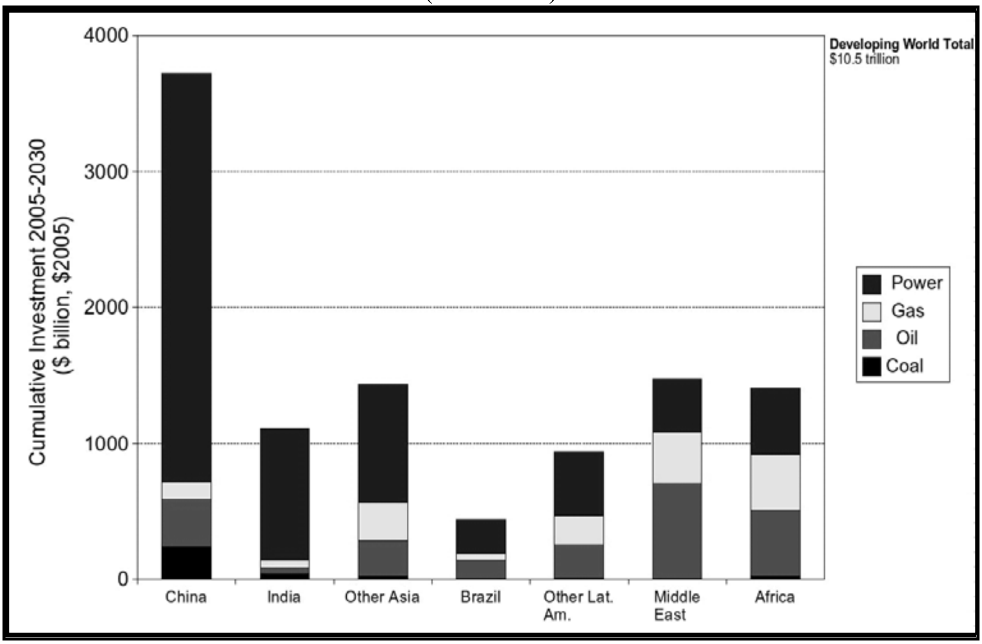
Modern energy services enhance the life of the poor in countless ways. Electric light extends the day, providing extra hours for reading and work. Modern cook-stoves save women and children from daily exposure to noxious cooking fumes. Refrigeration extends food freshness and avoids wastage. Clinics with electricity can sterilise instruments and safely store medicines through refrigeration. Manufacturing and service enterprises with modern energy can be more productive and can extend the quality and range of their products – thereby creating jobs and higher wages.

Figure 2. Links between energy and human, economic and social development



Source: *African Economic Outlook* (OECD/ADB, 2004).

Figure 3. Cumulative investment needed in energy infrastructure by region and fuel (2005-2030)



Note: based on Reference Scenario.

Source: *World Energy Outlook* (IEA, 2006).

In many countries, poverty is prolonged particularly by the unsustainable collection of biomass and its use in traditional, inefficient stoves. This creates indoor smoke pollution leading to serious health damage, such as respiratory diseases, obstetrical problems, blindness and heart disease. It requires large amounts of time for fuel gathering – reducing the time available for other productive activities, such as farming and education. It causes ecological damage (*e.g.* deforestation and soil erosion) and local scarcity of wood in some areas. And it draws agricultural residues and dung away from their use as fertilizer, thus reducing agricultural productivity.

These issues disproportionately affect women, who comprise 70% of all people living in poverty. Women place a high value on improved energy services because they are the primary users of household energy. Women are also most likely to suffer the health effects of energy-inefficient appliances. Their exclusion from the decision-making process in many countries has led to the failure of poverty alleviation programmes.

It is estimated that to achieve the Millennium Development Goals (MDGs), the number of people lacking electricity would need to decrease to below 1 billion and those relying on traditional biomass would need to fall to 1.2 billion by 2015 (**Box 3**). Concerted government action – with support from the industrialised countries – is needed to achieve these targets, together with increased funding from both public and private sources. Policies need to address barriers to access, affordability and supply of electricity and alternative fuels, which are already available at reasonable cost, *e.g.* gas-fired stoves and cylinders. Access to sustainable energy sources should form a central component of broader development strategies.

Box 3. Energy and the Millennium Development Goals (MDGs)

In 2000, the United Nations adopted the *Millennium Declaration* setting out shared targets for dramatically reducing extreme poverty in its many dimensions – income poverty, hunger, disease, exclusion, lack of infrastructure and shelter – while promoting gender equality, education, health, and environmental sustainability, all by 2015. Though access to modern energy services is essential to reducing poverty, no energy targets are specified in the Millennium Declaration. A workshop, sponsored by the UN Millennium Project, held to identify possible energy targets in support of the MDGs, concluded that energy services must be explicitly addressed within the planning for poverty reduction (Goal 1) and for meeting the broader MDGs. The group recommended the following energy targets for 2015:

1) Enable the use of modern fuels for 50% of those who at present use traditional biomass for cooking. In addition, provide support for i) efforts to develop and adopt the use of improved cook stoves, ii) measures to reduce the adverse health impacts from cooking with biomass, and iii) measures to increase sustainable biomass production.

2) Ensure reliable access to electricity to all in urban and peri-urban areas. The longer-term objective of universal access to electricity remains valid, but a more limited target allows MDG planners and national authorities to focus on the concrete investments, delivery systems, and public policies needed.

3) Provide access to modern energy services (in the form of mechanical power and electricity) at the community level for all rural communities

Source: "Energy and the Millennium Development Goals" (Modi *et. al*, 2006).

Including energy issues in national development plans and strategies

Addressing energy challenges successfully cannot be achieved in isolation, but should be an integral part of development planning which links economic, environmental and social concerns. Action plans for development, sustainable development, poverty reduction, achieving the Millennium Development Goals (MDGs), and implementing multilateral environmental agreements (*e.g*., on climate change, biodiversity) have been formulated in most developing countries with the support of multilateral, regional and bilateral development agencies. But these plans remain disjointed and often neglect energy-related issues, which endangers the achievement of their overall objectives.

Energy for sustainable development needs to be more fully integrated into Poverty Reduction Strategies (PRS), plans developed with the World Bank and International Monetary Fund (IMF) to help least-developed countries secure debt remission and low-cost loans. Updated every three years, PRS provide the programmatic basis for co-operation between developing country governments and donors. Similarly, energy issues should be mainstreamed into national sustainable development strategies, which are being formulated in many developing countries with the assistance of the United Nations Environment Program (UNEP), the United Nations Development Program (UNDP), and the UN Division for Sustainable Development (UNDESA/DSD). Regional organisations (*e.g*. the Asian Development Bank, African Development Bank, Inter-American Development Bank) should also put higher priority on sustainable energy development in their assistance programmes.

With regard to bilateral donors, the 2006 OECD Ministerial Meeting between the Environment Policy Committee and the Development Assistance Committee (DAC), which coordinates 90% of official development assistance from bilateral donors, recommended that instruments be developed for better integrating environmental factors into national development plans. To this end, OECD Development and Environment Ministers adopted the *Framework for Common Action around Shared Goals* to improve the coherence of efforts to reduce poverty in developing countries.

The Framework provides support to the implementation of the environmental aspects of the *Paris Declaration on Aid Effectiveness* which envisages a wide range of measures aimed a improving the management and effectiveness of Official Development Assistance (ODA). The Framework emphasises implementation of "good practices" at the interface of environment and development, including integration of environmental considerations in development plans and donor policies and maximising the development-environment potential of international financing instruments.

In this context, energy for sustainable development should be a priority consideration given its central role in poverty alleviation and environmental sustainability. International and regional organisations as well as bilateral donors need to increase the coherency of their development assistance approaches to further sustainable development overall and in regard to energy systems. To this end, proposals have been formulated to promote better coordination among donors for the conception and delivery of development assistance in sustainable development terms (**Box 4**).

Promoting governance and industrial development for energy needs

Advancing development on a sustainable path and securing the investments needed to meet rapidly growing energy demand require active participation by the private sector. Governments must set out attractive frameworks for domestic and foreign investment plus enforceable rules on corporate and business behaviour. The good governance practices which attract business investment are generally the same as those which encourage good environmental and social behaviour on the part of both industry and governments.

Public policies promoting responsible business conduct include providing an enabling environment which clearly defines the respective roles of government and business; promoting dialogue on norms for business conduct; and supporting private initiatives and international co-operation initiatives in support of responsible business conduct. There are a wide range of voluntary codes of conduct for sustainable development developed by international governmental bodies and business associations. These provide guidelines for the ethical behaviour of companies to encourage the incorporation of socio-environmental concerns in their business practices.

Box 4. Proposals for coordinated action on sustainable development

The "sustainable development partners" – including international and regional organisations and bilateral donors – will work together and coordinate activities to:

1. *Policy integration* – promote the development of sustainability strategies at country level as integrating frameworks for achieving economic, social and environmental objectives based on existing tools and frameworks.

2. *Capacity-building* – enhance country capacity to develop and implement sustainability strategies and related good governance practices in accordance with mechanisms of social and economic planning.

3. *Financial planning* – ensure the integration and complementarity of sustainability strategies with national planning and budgeting frameworks, including poverty reduction strategies (PRS).

4. *Environmental awareness* – ensure proper treatment and awareness is given to environmental variables in development plans and co-operation, including natural resources, pollution, energy use and efficiency, responses to multilateral environmental agreements and conventions, etc.

5. *Social awareness* – ensure proper treatment and awareness is given to social variables in development plans and co-operation, including employment, access to education and health care, equity and income distribution, gender, sustainable livelihoods, etc.

6. *Impact assessment* – assist national governments in developing sustainability assessment methodologies to identify synergies and trade-offs across economic, social and environmental dimensions of national policies, plans and strategy options.

7. *Indicators and targets* – make commitments to upgrade national statistical systems and develop indicators to assist in monitoring progress in sustainability strategies and in meeting the Millennium Development Goals.

8. *Transparency and participation* – promote the principles of multistakeholder participation to increase transparency, public participation, consultation and consensus building in implementing sustainability strategies.

9. *Monitoring and evaluation* – engage in joint monitoring and shared learning of country progress in implementing sustainability strategies in accordance with agreed criteria.

10. *Reporting* – streamline national requirements for reporting on national sustainable development strategies, poverty reduction strategies, MDGs, etc.

Source: OECD Horizontal Programme on Sustainable Development.

Among the many business codes of conduct, the OECD *Guidelines for Multinational Enterprises* are the only multilaterally endorsed and comprehensive code that governments are committed to promoting, making them one of the world's foremost corporate responsibility instruments. They aim to help countries and business, labour unions and non-governmental organisations (NGOs) promote sustainable practices by providing a global framework for responsible business conduct. They contain voluntary principles and standards for business in areas including human rights, disclosure of information, anti-corruption, taxation, labour relations, environment, and consumer protection.

At the same time, governments must provide consistent policies and institutions and establish functioning markets to encourage private investment that can support economic growth and sustainable development. In support of this objective, OECD and non-OECD economies have worked together to develop the *Policy Framework for Investment*, which is addressed to governments and complements the OECD *Guidelines for Multinational Enterprises*. The *Policy Framework for Investment* is a tool to help governments create an environment that is attractive to domestic and foreign investors and that enhances the benefits of investment to society. It brings together ten sets of questions covering the main policy domains having a strong impact on the investment environment (**Box 5**). This checklist helps pinpoint areas where governments should redress weaknesses in their policies in order to promote private investment, including for sustainable energy development.

Box 5. The Policy Framework for Investment in brief

Investment policy – Transparency, property protection and non-discrimination are investment policy principles that underpin efforts to create a sound investment environment for all.

Investment promotion and facilitation –- Investment promotion and facilitation measures, including incentives, can be effective instruments to attract investment provided they aim to correct for market failures and are developed in a way that can leverage the strong points of a country's investment environment.

Trade policy – Trade policies can support more and better quality investment by expanding opportunities to reap scale economies and by facilitating integration into global supply chains, boosting productivity and rates of return on investment.

Competition policy – Competition policy favours innovation and contributes to conditions conducive to new investment, especially for small and medium sized enterprises. Sound competition policy also helps to transmit the wider benefits of investment to society.

Tax policy – The level of the tax burden and the design of tax policy, including how it is administered, directly influence business costs and returns on investment. Sound tax policy enables public policy objectives to be achieved while also supporting a favourable investment environment.

Corporate governance – The degree to which corporations observe basic principles of sound corporate governance is a determinant of investment decisions, influencing the confidence of investors, the cost of capital, the overall functioning of financial markets and ultimately the development of more sustainable sources of financing.

Responsible business conduct – Public policies promoting recognised concepts and principles for responsible business conduct, such as those recommended in the OECD Guidelines for Multinational Enterprises, help attract investments and enhance the contribution that investors make to sustainable development.

Human resource development – Policies that develop and maintain a skilled, adaptable and healthy population, and ensure the full and productive deployment of human resources, support a favourable investment environment.

Infrastructure and financial sector development – Sound infrastructure development policies ensure scarce resources are channelled to the most promising projects and address bottlenecks limiting private investment. Effective financial market policies help enterprises and entrepreneurs realise their investment ideas within a stable environment.

Public governance – While there is no single model for good public governance, there are commonly accepted standards of public governance to assist governments in assuming their roles effectively, *e.g.* on regulatory quality and public sector integrity which matter for the investment environment.

Source: *Policy Framework for Investment* (OECD, 2006).

Increasing Energy Research and Development and Dissemination

Identifying priorities for energy research and development

The challenges of long-term energy security and environmental sustainability can only be met through the deployment of efficient and less expensive technologies that are capable of using more plentiful, cleaner and cheaper sources of energy. In addition to the diffusion of current clean energy technologies, better technologies need to be developed and implemented. However, the continuation of current energy research and development (R&D) spending trends is inadequate to deliver the technological advances needed. To promote sustainable energy innovations, research policy and energy policy should be harmonised and coordinated to a far greater degree than is currently the case.

Advances are needed in energy production, conversion, storage and end-use technologies across a broad continuum, spanning from basic science research to technology development to market transformation and diffusion. Given the enormity of the challenge, a great deal of R&D including demonstration is needed. And because markets alone will not provide sufficient incentives for long-term R&D, it falls to governments to also invest in this endeavour.

While overall public budgets for R&D have been generally on the rise in the past decades, public expenditure on energy R&D has remained level since the early 1990s (**Figure 4**). At the same time, private sector expenditures on energy R&D have declined in absolute terms. R&D intensity (measured as a percentage of total turnover) in the energy sector has more than halved from an already low level as opposed to a trend of slightly rising R&D intensity in other sectors.

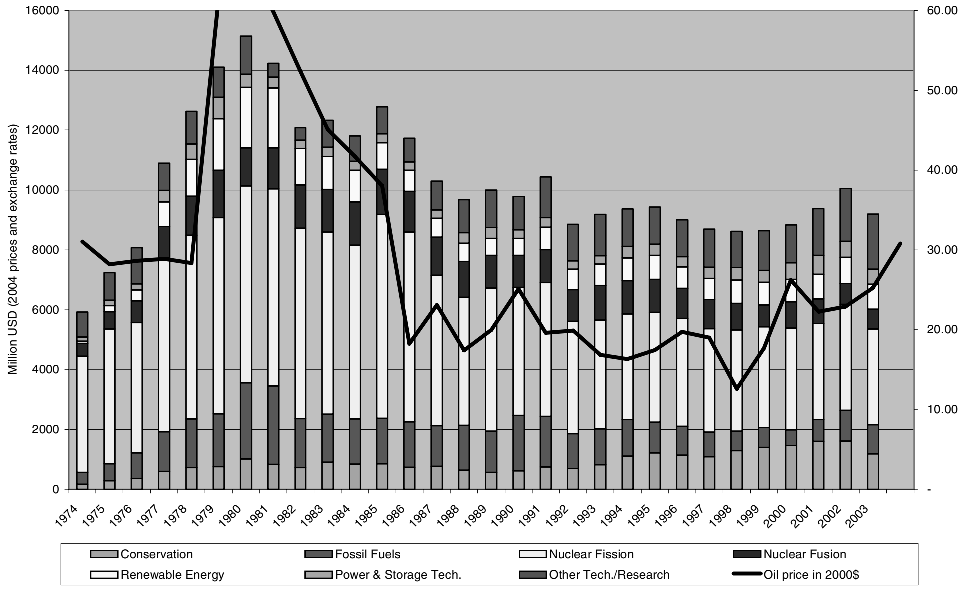
Given limited resources, setting research priorities for sustainable energy technologies must take into account their contributions to reducing greenhouse gas emissions as well as relative incentives for private *vs*. public investments. For example, the declining share of public funding for mature fossil fuel R&D is justified given the maturity of the technology and the strong incentives for the private sector to invest in them. These technologies are often commercially exploitable because they increase efficiency or make extraction and production processes more effective.

Technologies with major R&D needs which can contribute large CO_2 reductions include carbon capture and storage (CCS) for power generation and industrial applications. CCS research is increasing but is still very low. There is a shortage of sizeable R&D projects to advance technological understanding, increase efficiency and drive down costs. To achieve full scale production in a timescale that can significantly influence CO_2 concentrations, at least 10 major power plants fitted with capture technology are needed by 2015. Because the benefits of CCS technology are mainly societal, a larger government role is legitimate; but public investment would need to increase approximately fivefold to reach production targets.

Renewables should be an R&D priority. Given the enormous scale of the resource, research receives only modest funding, although its share has been rising slightly in recent years. The level of solar electric research in particular seems to be relatively modest given its potential, notably in developing countries. R&D investment devoted to more mature renewable technologies – such as geothermal, biomass, wind and hydropower to provide heat, electricity and transport fuels – can also result in cost reductions and efficiency performance improvements as more experience is gained. Their deployment depends partly on the relative pricing of alternative fuels such as oil, coal and gas, but technical advances are possible to improve their competitiveness.

Other useful areas of research include feedstock substitution in industrial processes (*e.g.*, coke in steelmaking; clinker in cement making). Efficient end-use technologies (*e.g.*, in appliances, buildings, transport) would contribute to substantial CO_2 emissions reductions, but their deployment depends less on additional R&D than on CO_2 pricing policies and on regulations, information and other measures to increase public acceptance, financing, information and education, or overcome structural disincentives.

Figure 4. R&D expenditure in IEA countries and oil prices (1974 – 2004)



Source: Background Report of the Round Table on Sustainable Development (OECD, 2006).

Promoting energy technology collaboration

International technology collaboration can help attain sustainable energy advances less expensively, more reliably and for the benefit of a greater number of people. Collaborative efforts help mobilise the necessary investments, support continuity of effort, bring greater exposure to new ideas, and build technical capacity in developing countries. There is a particular need for technology collaboration with rapidly developing countries such as China and India. They present many opportunities for technology development given the quality of research capabilities, high rates of investment, and capacity for technological leap-frogging.

International energy technology collaboration has long been supported by the OECD, International Energy Agency (IEA) and the Nuclear Energy Agency (NEA) through analysis and facilitation of co-operative R&D programmes and projects. In 2004, OECD Science and Technology Ministers issued a *Declaration on International Science and Technology Co-operation for Sustainable Development*, which stresses the need for good research partnership practices to further sustainable growth, including in the energy area. The NEA has pursued roughly 20 international joint research projects, primarily in the areas of nuclear safety and waste management.

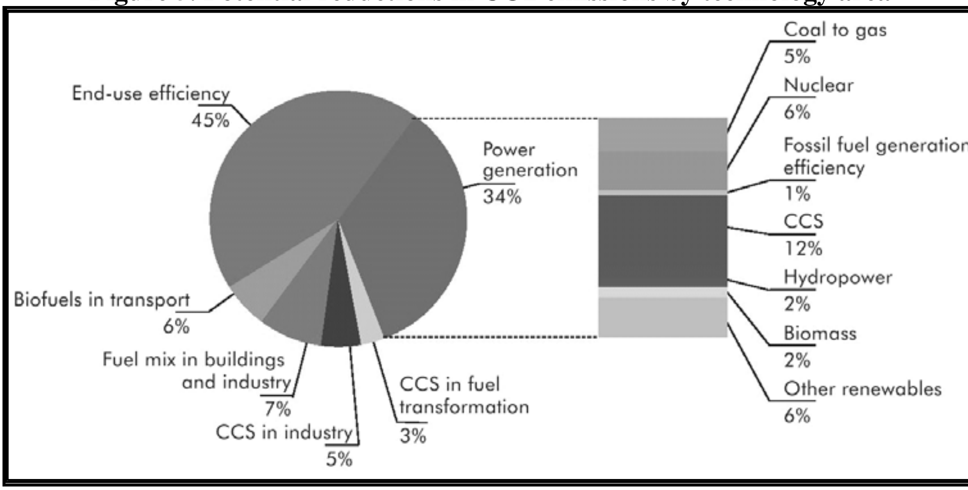
For more than 30 years, the IEA international energy technology collaboration programme has offered a structure for governments to leverage and strengthen their energy research and deployment efforts. This encompasses a collaborative framework – called *Implementing Agreements* – and a system of standard rules and regulations that allow member and non-member governments and other public and private parties to share R&D for particular technologies. Participants in the Implementing Agreements benefit from wider project scale, reduced costs and risks, less duplication of work, accelerated development and deployment, harmonised standards, strengthened national R&D capabilities, information sharing and networking. There are currently 41 Implementing Agreements with several thousand participants from 72 countries, organisations and companies.

In 2006, in response to the G8 Plan of Action, the IEA launched the *Networks of Expertise in Energy Technology* (NEET) initiative during the 14^{th} session of the United Nations Commission on Sustainable Development (UNCSD-14). This initiative is designed to promote the effectiveness and outreach of existing international collaborative efforts on energy technology. Building on the IEA Implementing Agreements, the NEET Initiative links policy-makers, the business community, research and international organisations and other stakeholders in countries that have an increasingly important role in energy supply and consumption.

Developing climate-friendly products and processes

The vast development and deployment of cleaner, more energy efficient technologies will be needed to reduce greenhouse gas emissions. Investment is needed in a broad portfolio of technologies (*e.g.* energy efficiency, carbon capture and storage, renewable energy). In an analysis of technology pathways for reducing CO_2 emissions to current levels by 2050, energy efficiency in end uses was found to be indispensable, accounting for 45% of emissions reductions (**Figure 5**). Other technological contributions could be made by carbon dioxide capture and storage (CCS) in power generation and industry (20%), the use of renewables in power generation (10%), and biofuels in transport (6%).

Figure 5. Potential reductions in CO2 emissions by technology area



Source: *Energy Technology Perspectives* (IEA, 2006).

A variety of barriers discourage the deployment of these climate-friendly approaches. Some have technical problems rendering them unsuitable for the market and in need of further R&D. When a technology is technically proven, demonstration projects are required to show that it works on a commercial scale and under relevant operating conditions. Others face cost barriers in that they are priced higher than incumbent technologies. The costs of less mature technologies can be reduced by R&D and "technology learning". Efficient end-use technologies can face still other barriers in the form of lack of awareness of their benefits relative to costs, lack of market acceptance, and lack of incentives for sustainable consumption by individuals and industry.

Finding carbon-free alternatives in the transport sector is a huge challenge. Ethanol derived from plant material is an attractive fuel with good combustion qualities, but the cost competitiveness of different biofuels depends on available feedstocks and other cost factors such as infrastructure. Today's ethanol production uses predominately starch or sugar crops, limiting the available feedstock, but new technology could enable other biomass feedstocks to be used as well.

For the short and medium term, policies that target fuel efficiency offer the most potential for reducing CO_2 emissions in transport. Higher cost energy sources, including clean energy carriers such as hydrogen and electricity, produced from renewable energy sources, or from fossil fuels with carbon sequestration and storage, will be required if there are to be meaningful cuts in transport sector CO_2 emissions. A switch to hydrogen fuel-cell technologies will require huge infrastructure investments, while major R&D programmes will be needed to bring these technologies to commercial viability.

The transfer and diffusion of clean energy technologies will also require a broad portfolio of policy tools. Technology "push" alone is unlikely to deliver the large long-term emission reductions that are needed. Policies for both technology development and "market pull" are required, including price signals through taxes and economic instruments. International collaboration can pool intellectual resources and investment to enhance clean energy deployment. However, domestic policy frameworks are also important for technology deployment and diffusion. For example, effective technology transfer encompasses more than just equipment hand-over as the protection of intellectual property rights matters for both parties.

Examining the option of nuclear technology

Nuclear energy is a nearly carbon-free technology that has progressed through several generations of development and that can compete favourably with alternatives for base-load electricity generation and enhance the security of energy supply. Periodic surveys give confidence that available natural resources and technology progress will ensure that nuclear fuel requirements will be met in all scenarios of the development of nuclear energy (**Box 6**).

However, three key issues present obstacles to an increased use of nuclear energy: 1) the lack of political stability and regulatory framework stability which increases the business risks of investing in a technology with a capital intensive cost structure; 2) public opposition due to the perceived threats of mainly radioactive waste management and to a lesser extent nuclear accidents; and 3) the possible proliferation of nuclear weapons. Some OECD countries do not consider nuclear energy to be a sustainable energy option.

Regarding waste, among the three categories of radioactive waste – low, intermediate and high – the first two are now dealt with at an industrial level with good safety records. The last one, high-level waste, that concerns only 1% of the volume of radioactive waste but includes 99% of its radioactivity, is the focus of important societal concerns. Experts of NEA countries agree that the safe disposal of such waste in deep geological formations is technically feasible at affordable prices while protecting present and future generations. However, it must be recognised that, except in very few countries, there is very little social consensus to support the implementation of such deep geological repositories. Ethical considerations and differences between actual and perceived risks are at the root of this lack of consensus.

"Generation III" of nuclear energy was developed in the 1990s with a number of advances in safety and economics, including "passive safety" features. Thirteen countries, including those OECD countries with the largest nuclear power sectors recently joined by China and Russia, have joined together to develop "Generation IV" nuclear power plants that offer advantages in the areas of sustainability with a better use of natural resources and less waste production, economics, safety and reliability, and proliferation resistance and physical protection. Assuming current concerns are met, increased use of nuclear power could provide substantial CO_2 emission reductions in a cost-effective manner.

Box 6. Uranium resources, production and demand

The identified amount of conventional uranium resources which can be mined for less than USD 130/kg, just above the current spot price, is about 4.7 million tonnes. Based on the 2004 nuclear electricity generation rate, this amount would be sufficient for 85 years. However, total world uranium resources which could be available at market price are much higher. Based on geological evidence and knowledge of uranium in phosphates, more than 35 million tonnes could be available for exploitation.

At the end of 2004, world uranium production (40 263 tonnes) provided about 60% of world reactor requirements (67 450 tonnes) for the 440 commercial nuclear reactors in operation. The shortfall between production and requirements was made up by secondary sources. These are now in decline, and the shortfall will increasingly need to be made up by primary production.

By 2025, world nuclear energy capacity is expected to grow to between 450 GWe (+22%) and 530 GWe (+44%) from the present generating capacity of about 370 GWe. This will raise annual uranium requirements to between 80 000 tonnes and 100 000 tonnes. The currently identified resources are adequate to meet this expansion.

In the longer term, continuing advances in nuclear technology will allow a substantially better utilisation of uranium resources. Reactor designs are being developed and tested that are capable of extracting more than 30 times the energy from uranium than today's reactors

Source: *Uranium 2005 – Resources, Production and Demand* (NEA/IAEA, 2006).

Promoting Energy Efficiency and Diversity

Increasing energy efficiency in production and use

Improving energy efficiency is the cheapest, fastest and most environmentally friendly way to meet a significant portion of the world's energy needs. Improved energy efficiency reduces the need for investing in energy supply. Many energy efficiency measures are already cost-effective, and they will pay for themselves over their lifetime through reduced energy costs.

Energy efficiency options are generally characterised as having technical and cost barriers that are secondary to other barriers, such as lack of public acceptance, financing, information, education or proper incentives. The exceptions are some industrial options, hybrid vehicles, and certain forms of power generation. But in general, the deployment of energy efficiency options is not delayed due to need for further technical development or cost reductions.

Countries need to pursue energy efficiency policies more diligently in the long-term regardless of the development of fuel prices. In most countries, energy efficiency policy does not receive sufficient emphasis. It tends to receive less attention than renewable energy policy even though they both have similar benefits in terms of energy security and climate change mitigation. At the same time, energy efficiency approaches are often more cost-effective.

There are diverse barriers to greater deployment of energy efficient options. Consumers are often ill-informed and few are concerned with energy efficiency when buying appliances, homes or cars. Business management tends to give energy efficiency a low priority in decision making. There are opportunities for energy efficiency that consumers never see because the manufacturers of refrigerators, televisions or cars do not always take full advantage of the technologies that exist to make their products more energy efficient.

To advance energy efficiency, governments should employ the range of available policy instruments, including regulations and standards, fiscal incentives, public information campaigns, labels, and public-sector leadership in procurement. These can be deployed in a range of sectors:

1) new buildings could be made 70% more efficient than existing buildings through use of insulated windows, modern gas and oil furnaces, and more efficient air conditioners. District heating, heat pumps and solar energy can all save energy. Improved lighting could yield cost-effective savings of 30 to 60%.

2) for households, major improvements have been made in refrigerators, water heaters, washing machines and dishwashers. New technologies such as "smart" metering, micro combined-heat-and-power generation, fuel cells, solar photovoltaic and more efficient lighting can save energy.

3) in industry, energy demand and CO2 emissions can be cut through improved efficiency of motors, pumps, boilers and heating systems; energy recovery in materials-production processes; recycling of used materials; and higher efficiency of materials use. Other approaches are advanced membranes that can replace distillation in some petrochemical processes; "direct casting" in iron and steel; and the use of bio-feedstocks in the petrochemical industry to replace oil and natural gas.

4) in transport, the efficiency of conventional gasoline and diesel vehicles can be improved through turbochargers, fuel injection and advanced electronic methods of engine control; new materials and more compact engines; efficiency gains in vehicle air conditioning; and hybrid vehicles and advanced diesel engines.

Making fossil fuels more climate-friendly

The use of fossil fuels – coal, oil and natural gas– can be made more climate friendly through two primary means: 1) carbon dioxide capture and storage (CCS) at power plants and industrial facilities, and 2) substitution to lower-carbon fuels in power plants and industry.

Carbon capture and storage (CCS) involves capturing the CO_2 generated at power plants and industrial facilities and storing it underground, *e.g.* in depleted oil or gas fields or in underground water layers. These underground reservoirs could allow storage for decades and the captured CO_2 may also be used to enhance the output of oil and gas in the respective fields.

The main capture potential is in the electricity sector, but interesting opportunities exist in synthetic transport fuels processing and industrial sectors, where CCS could reduce CO_2 emissions from coal and natural gas use to near zero. Because, most CO_2 emissions are released from coal-fired power plants, more than half of the potential of CCS is associated with coal-fired processes. Clean coal technologies with CCS offer an important opportunity to constrain emissions and provide lower-cost electricity in rapidly growing economies with large coal reserves, such as China and India.

R&D on CCS needs to be greatly expanded, public awareness and acceptance of storage options should be heightened, and policy incentives including a value for carbon are needed to stimulate the uptake of CCS technologies. Emissions trading systems may offer such incentives, if carbon prices are high enough to make CCS competitive. There is also need for integrated full-scale demonstration plants for CCS technology. Efficient coal combustion technologies such as high-temperature pulverised coal plants and integrated coal-gasification combined-cycle (IGCC) should be used in conjunction with CCS.

For fuel switching, natural gas – the least carbon-intensive fossil fuel – can be used as a substitute for coal and heavy oil products in power production and a variety of industrial processes. In power generation, fuel switching from coal to gas can reduce CO_2 emissions by 50% to 75%. Natural gas combined cycle (NGCC) power plants are more efficient than coal-fired power plants, but the expansion of this technology is limited by uncertainty about future natural gas prices. Fuel costs account for 60% to 85% of total generation costs for NGCCs, much higher than for other power generation technologies. Fuel switching will be limited in the absence of CO_2 policies that place a value on carbon.

In industry, there are opportunities to substitute natural gas for coal in the manufacture of basic materials. For example, gas-based direct reduced iron (DRI) processes can be used in place of coal-based blast furnaces in steel production. In principle, the potential is very high, but so is the cost. The costs of a switch from coal to gas can be low if inexpensive stranded gas (*i.e.* lacking access to markets) can be used. This implies relocation by industry to places where cheap gas resources exist. The main barriers are cost and an increased dependency on natural gas imports.

Expanding the role of renewables

Hydropower, biomass combustion, solar water heating and geothermal technologies are mature and commercially viable in many situations. The principal impediment to the wider commercialisation of other renewable energy technologies (*e.g.*, solar PV, wind, biopower, biofuels, concentrating solar power, ocean energy) is their higher cost compared to conventional technologies and, in the case of wind, wave and solar, their short-term variable character.

To overcome cost barriers, carbon emissions and related externality costs need to be accounted for to raise the price of conventional fossil fuels relative to renewables. In addition, further research is needed on manufacturing and interconnection processes (**Box 7**). In this way, renewable energy technologies could fulfil their large potential contributions to energy security, climate change mitigation and economic development.

Box 7. Policy priorities for renewable energy technologies

1) Connection and integration of variable renewable energy sources into electricity grids.

2) Interconnection safety, codes and standards to help manage the variability of renewable energy sources.

3) Flexible, reliable and low-cost energy storage to help manage the variability of renewable energy sources.

4) Improving the reliability and efficiency of wind turbines, solar PV panels, solar water heaters, ground heat pumps and other emerging technologies.

5) Demonstrating the compatibility and safety of renewable electricity technology.

6) Renewable energy heating and cooling technology deployment.

7) Public acceptability, access to public lands, siting of projects, permitting and royalties, and other socio-economic and environmental concerns, especially for geothermal, wind, hydropower, ocean energy and concentrating solar power.

8) Distributed energy systems as an adjunct or partial replacement of traditional electricity and heating grids.

Source: *Renewable Energy: RD&D Priorities: Insights from IEA Technology Programmes* (IEA, 2006).

Hydropower is already widely deployed and is, in many areas, the cheapest source of power. However, there is considerable potential for expansion, particularly for small hydro plants. Current requirements include continuous improvements in technology, increased public acceptance, and streamlining the project approval process.

The costs of onshore and offshore *wind power* have declined sharply in recent years through mass deployment, the use of larger components, and more sophisticated controls on wind turbines. The best onshore sites are already cost competitive with other power sources, while offshore installations are more costly, especially in deep water. In situations where wind will have a very high share of total generation, it will need to be complemented by sophisticated networks, improved forecasting, back-up systems or storage, to accommodate its variability. Minimising environmental impacts is also important as well as education of the public regarding deployment.

The costs of high-temperature *geothermal resources* for power generation have dropped substantially since the 1970s. Geothermal is a site-specific resource that can only be accessed in certain parts of the world for power generation. Lower-temperature geothermal resources for direct uses like district heating and ground-source heat pumps are more widespread. R&D including for deeper drilling, hot dry rocks, and binary systems can further reduce the costs and increase the scope of geothermal power.

Solar photovoltaic (PV) technology is playing a rapidly growing role in niche applications. Costs have dropped with increased deployment and continuing R&D. Concentrating solar power (CSP) also has promising prospects and several new commercial plants are under construction or planning. However substantial cost reductions are still needed.

The combustion of *biomass* for power generation is a well-proven technology. It is commercially attractive where quality fuel is available and affordable. Co-firing a coal-fired power plant with a small proportion of biomass requires no major plant modifications, can be highly economic and can also contribute to CO_2 emission reductions.

The use of biomass, geothermal and solar thermal systems for *heating and cooling* has considerable potential for increasing the share of renewable energy in many countries. Relatively few policies presently exist to encourage greater deployment but where they do, substantial market growth has occurred.

Liquid *biofuels* currently meet around 1-2% of the global road transport energy demand. Considerable interest has occurred recently in many countries to expand this share and targets and policies have been developed. There is potential for second generation biofuels from ligno-cellulosic feedstocks and trade between north and south. However concerns are growing as to the sustainability of the biomass feedstock resource, and impacts on food, land use and water supplies.

Ocean energy (wave, ocean currents, thermal and saline currents) is approaching the near commercial stage with many devices being tested as prototypes or on a pilot scale. Tidal range technologies have been installed commercially in three locations but no more are planned. Significant R&D investment is necessary to develop this promising renewable energy resource.

Benefiting from Energy-Related Climate Change Policies

Promoting use of economic instruments

Economic or "market-based" instruments can be an effective and economically efficient means of achieving sustainable energy policy goals in many circumstances. These include taxes, emissions trading, subsidy reform, and preferential tariffs.

Economic instruments offer the potential for both static efficiency (reducing costs for pollution abatement) and dynamic efficiency (providing incentives for innovation). They provide increased flexibility for governments and industry through building on the operation of the market and the price system. They can provide government revenue (in particular taxes and charges) that can be used for a variety of purposes.

Environmentally related taxes introduce price signals so that producers and consumers take into account the costs of pollution and resource use associated with their activities. In this way, carbon taxes would internalise the cost of greenhouse gas emissions and raise the price of certain fuels, processes and products. These fiscal incentives would reduce demand for harmful products and increase demand for alternative fuels such as renewables whose prices become more competitive. Environmentally related taxes also increase incentives for the private sector to undertake R&D on sustainable innovations and technologies.

Concern about reducing the competitiveness of energy-intensive sectors is a major obstacle to the full implementation of carbon taxes. Energy intensive industries often receive total or partial exemptions from such taxes even though significant global reductions in carbon emissions could be achieved. In levying carbon taxes, the competitiveness impacts can be reduced by: i) enlarging the group of countries that put similar policies in place, ii) levying border tax adjustments on products from countries having less stringent taxes, or iii) recycling a portion of the tax revenues back to the affected firms. Many countries are now considering such approaches for using carbon taxes to promote more sustainable energy systems.

Emissions allowance trading is the premier instrument for reducing greenhouse gas emissions from energy production and use. This involves applying surplus emissions reductions at certain facilities to meet or redefine emissions reductions at other sources. The emissions trading scheme of the European Union is by far the largest scheme currently in operation, but there are a dozen or so domestic and regional trading programmes in operation or under development. The schemes have different sizes, geographical/sectoral scopes, time-periods, design characteristics, compliance provisions, and rules for "offset" credits. Some are designed to be used for compliance with emission commitments under the Kyoto Protocol, while others are planned or in use in non-Kyoto parties. Some are mandatory; others are voluntary. Some cover direct emission sources only, while others include *e.g.* electricity retailers or users.

The different schemes could be linked into an international trading system in the future. Trading schemes can trigger many of the local actions needed to curb emissions and would be most efficient with widespread (ideally global) coverage. Domestic trading schemes could expand beyond their current coverage of large stationary emissions sources. A global market could incorporate domestic and regional schemes with divergences in design. However, the energy realities of developing countries give most of them little incentive to develop their own broad domestic emissions trading schemes.

Government subsidies can take many forms, including direct grants or payments to consumers or producers; preferential lending; preferential tax credits and exemptions; buyback of production rights; below-cost inputs, infrastructure or services; and special regulations or trade and market rules. Subsidies to energy, as well as to transport, industry and agriculture, distort markets for energy and have largely negative effects on the sustainable use of energy.

Subsidies can be used to lower energy prices, which can raise living standards and increase economic activity, but which can also discourage the adoption of energy efficient devices. Energy subsidies raise the profitability of energy producers, which may encourage or discourage shifts in the fuel mix. Transport subsidies can increase transport activity and favour certain modes of transportation (*e.g.* road vs. rail, or private vs. public), which increase negative environmental impacts. Industrial subsidies may prompt delays to plant restructuring and lead to prolonged inefficiencies in the use of energy.

Energy-related subsidies can have broad impacts on sustainability. They can encourage overuse of fossil fuels and lead to the over-exploitation of resources while contributing to harmful emissions and waste. Socially, these supports can redistribute income from consumers to producers and distort resource allocations across firms and sectors as well as countries. Subsidies may, however, be justified in some cases in order to combat poverty, but should be crafted carefully for these purposes (**Box 8**).

Box 8. Subsidies, energy use and poverty

Subsidies to energy services, as a rule, are ineffective, economically inefficient and contrary to good environmental practice. They may, however, be justified to combat poverty in some cases, but should only be used under specific conditions. They must: be properly targeted and affordable; deliver quantifiable benefits; be easily administered and not cause large economic distortions; be transparent and limited in duration. The way a subsidy is applied is critical to how effective it is and to its cost. Subsidies should normally be restricted to energy services provided through fixed networks -- electricity, natural gas or district heat. Subsidies to freely traded forms of energy, such as oil products, can never be properly limited to poor households. Policies should target the "poor" very precisely so that the mechanism for subsidising a particular fuel does not allow richer households to benefit from the subsidy.

The case for subsidising electrification in poor developing countries is widely accepted in principle, since the developmental benefits are often judged to exceed the long-run costs involved in providing subsidised electricity. Where high up-front connection charges prevent poor people from gaining access to electricity, "lifeline rates" – special low rates for small users – can be a cost-effective way of making services affordable to poor households. Alternatively, governments can finance part of the connection charge or oblige utilities to spread the cost out over time. The challenge is to ensure that electricity subsidies increase access for the poor at the lowest cost, while ensuring that electricity utilities are still able to make money and to continue to invest. That means limiting the size of subsidies and the number of recipients, and compensating the utility for any loss of revenue. This can be done either through higher charges for other customer categories or direct financial transfers from the government budget.

Source: *World Energy Outlook* (IEA, 2004).

A more even playing field at international level in the absence of energy-related subsidies will benefit both OECD and developing countries. The political economy of "how" distortive subsidies might – through co-ordinated and enlightened approaches – be successfully reformed is in need of joint reflection. Only full transparency in subsidy policies and inclusion of stakeholders – including industry and non-governmental organisations (NGOs) – will enable subsidy reform to begin. Whole-of-government decision-making processes are needed to bring together the many relevant agencies at national, regional and local levels. Managing the social effects of subsidy changes – on industries, workers and communities – is key. And in some cases, transitional supports may be needed to get rid of longer-term embedded subsidies, including those to energy, transport and industry.

Tariff reductions for renewable energy and associated technologies would reduce the tax that consumers in some countries pay on these goods. Preferential tariff margins for energy-efficient goods could be part of general trade negotiations. This would benefit those living in rural areas of developing countries where many renewable energy technologies would make a great contribution to energy supply, but are currently too expensive partly due to import taxes. It would help reduce dependence on more polluting and less secure energy sources. To the extent that reducing import tariffs also reduces the costs of grid-connected technologies, these would also become a more affordable option in the portfolio of energy options available to electric utilities. Manufacturers located in OECD and developing countries alike would benefit from increased trade in renewable energy technologies and components.

Furthering climate adaptation efforts

Given current atmospheric concentrations of greenhouse gases and the difficulties in stabilising them in the foreseeable future, a certain amount of climate variability due to global warming appears inevitable. Efforts to adapt to the effects of a changing climate must accelerate – as must mitigation efforts. Adaptation is particularly important in the context of development planning and assistance activities and in domestic policymaking in developing countries.

Early attention to adaptation in all countries can help avoid or reduce potential climate-related impacts on growth and development prospects. It is expected that climate change impacts will affect energy demand patterns, reliability of some energy sources (*e.g.*, hydropower), performance of power plants, and energy infrastructure in general. A range of development activities, including the design of hydropower facilities and energy infrastructure, needs to adapt to the impacts of current and future climate change risks.

Helping vulnerable countries anticipate and adapt to new risks resulting from climate change is key to achieving sustainability. Adaptation to climate change should figure prominently in foreign assistance activities and should be placed into the mainstream of development policies and international aid efforts.

In 2006, OECD Development and Environment Ministers adopted the *Declaration on Integrating Climate Change Adaptation into Development Co-operation* to better integrate climate change adaptation in development planning and assistance, both within their own governments and in activities undertaken with partner countries. In this context, they agreed to:

- promote understanding of climate change and its impacts within their development co-operation agencies and with partners in developing countries;
- identify and use appropriate entry points for integrating adaptation to climate variability and climate change into development co-operation activities;
- assist developing country partners in their efforts to respond to climate variability and climate change;
- improve the relevance and usability of information on the impacts of climate variability and climate change and the costs, distributional and trans-boundary aspects of adaptation activities; and
- encourage regional initiatives that include common actions on impacts and vulnerability assessment and adaptation options.

Early attention to adaptation in all countries can help avoid or reduce potential climate-related impacts on growth and development prospects. Adapting to climate change must be placed into the mainstream of development policies, national strategies and international aid efforts. Helping vulnerable countries anticipate and adapt to new risks resulting from climate change is key to achieving sustainability. A range of development activities, including the design of hydropower facilities and energy infrastructure, needs to adapt to the impacts of current and future climate risks.

Maximising the potential of the Clean Development Mechanism (CDM)

Under the Clean Development Mechanism (CDM), industrialised countries can achieve some portion of their required greenhouse gas commitments under the Kyoto Protocol from “credits” generated through lower-cost emission reductions in projects beyond their own borders. Governments, investors and private companies in industrialised "donor/investor/buyer" countries cam receive credits – in the form of tradable certified emissions reductions (CERs) – for reduction projects they carry out in "host/seller" countries.

Each CDM project must: i) reduce GHG emissions above and beyond "business as usual"; ii) account for GHG emissions that occur outside the project boundary that are attributable to the project; iii) adhere to strict physical boundaries within which GHG emissions will be reduced or sequestered; iv) not involve nuclear technology nor exceed internationally-agreed limits on forestry credits and activities; v) be voluntary and have the host country's approval; vi) meet the sustainable development goals defined by the host country; vii) include the participation of affected communities, groups or individuals; viii) not contribute to environmental decline; ix) not divert official development assistance (ODA); and x) occur in a developing country that is Party to the Kyoto Protocol.

There has been a rapid growth in activity under the CDM, which is currently expected to lead to emission mitigation of more than 1.8 billion tons from over 1 700 individual projects by 2012. However, although there is an enormous potential for renewable energy and energy efficiency projects, much of it remains “un-tapped”, with these project types only accounting for about a fifth of total expected credits from the CDM. There are several reasons for this at the national, international and project level, including limited institutional capacity, difficulties in obtaining sufficient project finance in countries with a high sovereign risk, and the relatively small size of many renewable energy and energy efficiency projects.

The high transaction costs associated with developing and operating CDM projects are another barrier to maximising its potential. The OECD has worked on two proposals to reduce these costs, through economies of scale: 1) the creation of a sectoral crediting mechanism; and 2) the use of CDM programmes and bundles of GHG mitigation actions of multiple project types, in multiple sectors and at multiple sites.

The sectoral crediting mechanism (SCM) would focus on economic sectors, rather than projects, in developing countries. Emissions performance baselines for a specified period would be established for selected sectors (*e.g.* iron and steel, cement) in participating developing countries. These countries would then receive tradable emissions reduction credits, which they could use as they wish – distributing them to individual companies in the sector or selling them for general revenue.

Sectoral crediting mechanisms are a promising means to encourage investment in climate-friendly energy systems. Nevertheless, developing an effective system that is feasible to negotiate and set up presents certain challenges due to wide variations in greenhouse gas intensities among countries and facilities, and the need for technical skills for evaluating, monitoring and verifying sectoral crediting proposals. The demand for credits must be relatively certain to make the effort worthwhile, and the environmental effectiveness of the instrument must be secured.

The second proposal, for CDM programmes and bundles, would allow crediting emissions reductions of multiple project types, in multiple sectors and at multiple sites. There is a large potential for greenhouse gas mitigation in energy and transport that are currently under-represented in the CDM portfolio. However, there is also a large potential for "free riders" if all programmes are eligible. Authoritative definitions of "programmes" and "bundles" and clarification of their differences and overlap are needed, which would allow modification to provisions and clarify CDM projects to avoid double-counting.

Conclusions

Energy is essential for development; energy that is secure, environmentally-friendly, and produced and used efficiently is essential for *sustainable* development. Today's energy system is a cornerstone of modern life. It enables innumerable services capable of improving human, social, economic and environmental conditions in both developed and developing countries.

Yet the current system of energy supply and use is highly unsustainable, and absent major new government policies will become even less so in the foreseeable future. It is insecure and unreliable, because of the heavy dependence on conventional oil, coming from limited reserves concentrated in politically volatile regions, and the inadequate capacity and maintenance of the network infrastructures for delivering gas and electricity. It is environmentally harmful, because of its predominant contribution to anthropogenic global warming, and its heavy contribution to local pollution. It is inaccessible or unaffordable to a large portion of the world's poor. It is frequently used inefficiently and wastefully.

The challenges of ensuring energy for sustainable development are many. Improving the human, economic, social and environmental conditions of the people of today and tomorrow demands much greater levels of energy services – cooking, lighting transport, etc. It also demands that these services be delivered in a manner that is more universally accessible, affordable, reliable, safe and environmentally friendly. This will require fundamental changes in technologies, methods, infrastructure and people's behaviour everywhere. It will also necessitate great ingenuity, investment, work, organisation and leadership.

The change needs to be so profound – in nature and extent – that government, business and social leaders need to use every instrument at their disposable as effectively and efficiently as possible (**Box 9**). They should use markets – with their ubiquitous signals to consumption, investment and behaviour – to deliver much of the change. But they will also need to marshall public R&D, regulations and other instruments when markets do not deliver the necessary change towards sustainable energy.

They will also need to practice good governance in terms of coherence and co-ordination among the many policy domains concerned. Energy development and use should be placed in a sustainable development context to ensure that no dimensions, resources or policy tools are overlooked.

Box 9. Policies to promote energy for sustainable development

1. Regulations and standards to cut air pollution and greenhouse gas emissions from energy and transport sources.

2. Economic instruments (carbon taxes, emissions trading) to internalise environmental costs and promote innovation in the energy sector.

3. Public R&D and incentives to private R&D in priority energy areas (*e.g.*, carbon capture and storage, solar power).

4. Sustainable consumption initiatives to promote use of energy-efficient alternatives in end uses.

5. Reform of energy and transport subsidies to remove market and price distortions in the energy sector.

6. Establishment of favourable business environments and conditions to encourage investment in energy systems and infrastructure.

7. Inclusion of energy as an integral part of development planning and development co-operation.

8. Coordination of energy-related policies in all domains through sustainable development strategies.

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