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Policy issues: Energy and environment

**Background papers for the ministerial-level consultations on energy
and environment for development, chemicals management as well as
tourism and the environment**

Discussion papers presented by the Executive Director

Addendum

Background paper on energy and environment for development

Summary

The present document is a background paper intended to stimulate discussion and highlight issues of concern to Governments to be addressed by ministers and heads of delegation during the ministerial consultations on energy and environment at the ninth special session of the Governing Council/Global Ministerial Environment Forum.

* UNEP/GCSS.IX/1.

Energy and environment for development

I. Executive summary

1. Energy is used each day by every human being on earth in one form or another, and its use lies at the core of modern industrialized society. Global demands for energy are growing rapidly, and although most growth is in developing countries and countries with economies in transition seeking to supply more lighting, cooking, heat, mechanical power, transport, communication and other energy services that drive development, demand for energy is also increasing in the industrialized countries. The use of energy, particularly fossil fuels, places great strains on the environment and has negative impacts on human health. Although technological advances have been remarkable, environmental gains have often been eroded by the increased consumption of energy.

2. Developed countries presently focus on security of supply issues and on reducing the regional and global environmental consequences arising from energy use, in particular climate change. Developing countries and countries with economies in transition are concerned with extending modern energy and transport services to their poorer citizens and solving more immediate human health problems caused by use of inefficient, outdated combustion technologies. The current high price of imported energy, mainly hydrocarbons, is of concern for developed and developing countries, as well as countries with economies in transition, but places a particular strain on poorer countries.

3. The challenge is to bridge these different priorities and bring about a broad consensus for changing the way humans supply and use energy, while at the same time ensuring that enough energy is made available to meet development needs. Because of the large capital investment in the world's energy and transport infrastructure, even with a concerted effort change will come slowly.

4. Climate change is the most pressing environmental problem linked to energy use. Improving energy efficiency offers the greatest short term potential for avoiding carbon dioxide emissions and it is critical to improve existing technological systems both on the demand and supply sides even as global society moves progressively toward their eventual replacement with cleaner and more efficient technologies. Over longer periods, greatly increasing the share of renewal energies in the supply mix and reducing carbon emissions from conventional energy sources are critical. Both require accelerated technology development, supportive policies, improved markets and investment. Much can be done to determine our collective energy future, but good government policies are essential for setting both the direction and the pace of change.¹

II. Introduction

5. Energy is crucial for economic development. Energy is the driver of industrialization and the successive use of different types of energy has in many ways transformed human society over the last 400 years. The increases in prosperity and well-being that economic growth makes possible stimulate demand for energy services such as lighting, heating and cooling, communications and transport, and therefore for energy itself. In many developing countries, this process is only just starting, while in others it remains only wishful thinking.

6. If not managed properly, the use of energy can harm the environment and human health in many ways. The extraction, transportation, processing and use of primary fuels – both fossil and biomass – and the generation and transmission of electricity have detrimental effects at all physical scales. Given the dominance of fossil fuel combustion in today's energy system, many problems manifest themselves through emissions to the atmosphere and different forms of air pollution. At one end of the spectrum, impacts include respiratory diseases in people using dirty cooking fuels in their homes. At larger physical scales, these extend to urban air pollution stemming from transport and industrial activity. At even larger scales, impacts include regional acidification caused by sulphur and nitrogen emissions from fuel combustion or global warming caused by greenhouse gas emissions.

7. Technological advances in energy systems have been nothing short of remarkable, and industrialized countries in particular have been able to reduce or eliminate many of the local and regional impacts of their energy use, particularly over the last 50 years. Climate change, however, remains a major global problem because the solution requires significant changes in the human

¹ A summary of the UNEP Energy Programme as well as a summary of the recent status, major trends and future prospects of renewable energy are provided in document UNEP/GCSS.IX/INF/11.

approach toward energy production and use. Such changes are hard to bring about because of the spatial and temporal distance between the causes of climate change and its consequences.

8. A key challenge for the coming decades is to supply growing numbers of people in developing countries and countries with economies in transition with affordable lighting, cooking, heat, mechanical power, transport and other energy services that they need to improve their lives, and to do so in a manner that is cleaner and more efficient, with fewer impacts on human health and the environment, including climate change.

9. This challenge is reflected in the Plan of Implementation of the World Summit on Sustainable Development, which includes a call to:

- (a) Diversify and increase the global share of renewable energy sources;
- (b) Improve access to environmentally sound energy resources and services through innovative financing mechanisms;
- (c) Remove energy market distortions through actions such as restructuring taxation and phasing out harmful subsidies;
- (d) Improve access to energy markets;
- (e) Accelerate the development and dissemination of energy efficiency and conservation technologies.
- (f) Develop national energy policies and regulatory frameworks that will help create the necessary economic, social and institutional conditions in the energy sector.

10. At the fifty-eighth session of the United Nations General Assembly in 2004 and at the high-level plenary meeting of the sixtieth session in 2005, Governments reaffirmed that the Plan of Implementation provides the intergovernmental framework for energy for sustainable development.

III. Global energy situation

A. Major global concerns

11. The global energy policy scene is to a large extent dominated by three overriding concerns:

(a) Security of energy supply: Oil and gas importers are becoming ever more dependent on these imports. Rising demand for oil in particular heightens concerns over whether additions to reserves are keeping pace with rising production. The recent dramatic increase of oil and gas prices compounds worries about security of supply. Not least, it has caused financial problems in many oil-importing developing countries and countries with economies in transition, where rising bills for imported energy hit the poor in particular.² In terms of security of supply, countries and individual consumers face the same challenge: ensuring continued access to affordable quantities of energy;

(b) Energy for development: In 2002, almost 1.6 billion people in developing countries, representing about one-quarter of the world's population, did not have access to electricity in their homes. An additional 800 million rely on traditional biomass for cooking and heating purposes. It is unlikely that the internationally agreed goals of the United Nations Millennium Declaration for poverty reduction will be achieved unless access to modern forms of energy is dramatically increased in the developing world. Doing so, however, is a large challenge;

(c) Climate change: The energy sector is the main contributor to global greenhouse emissions. In order to meet the aims of the United Nations Framework Convention on Climate Change it is necessary to reduce dramatically the carbon intensity of energy production and use. For countries with obligations under the Kyoto Protocol this process has already been initiated – although at a different pace in different countries. This notwithstanding, even aggressive emission reduction policies do not obviate the need for increased impetus for adaptation measures, mainly through technology support and international cooperation.

² A recent World Bank analysis shows that a sustained \$10 per barrel price increase delivers a shock equivalent to a 1.47 per cent loss of gross domestic product (GDP) for the poorest countries (those with GDP per capita of less than \$300). Even the highest income group (with GDP per capita of over \$9,000) would suffer a 0.44 per cent loss of GDP. Some of the lowest income countries suffer a shock of up to 4 per cent of GDP. If oil prices stay \$20 per barrel higher for any extended period, the effect on GDP would be doubled. Ultimately, higher oil prices compete with national development priorities.

12. The above-mentioned three areas are interlinked and, if dealt with individually, action in one area can have adverse impacts on another. As discussed below, however, it is possible to design policies and programmes with positive impacts in all areas.

B. Future energy development trends

13. These concerns reflect the main findings in the *World Energy Outlook 2004* published by the International Energy Agency (IEA), which estimates that the world's energy needs in 2030 will be almost 60 per cent higher than today and that fossil fuels will still dominate the energy mix.³ Experts foresee a slight decrease in the annual growth rate of energy demand and declining energy intensity, but economic and population growth combined with increased urbanization will result in an estimated growth in demand of around 1.7 per cent each year for the next 25 years, unless major breakthroughs in energy efficiency measures are achieved.

14. In spite of the strong growth in the renewable energy industry over the last decade, almost 85 per cent of the increase in what is termed the "business-as-usual" scenario is expected to be met by increased consumption of fossil fuels. Nuclear energy is projected to decrease its relative share because the planned expansion of nuclear power in some countries will not match the overall increase in global energy demand.

15. These trends depend very much on underlying assumptions about economic growth, global population, the costs of technologies and different primary energy sources, and other similar factors. IEA has therefore also analysed an alternative policy scenario which assumes that countries adopt policies to stimulate both the efficient use of energy and more environmentally-friendly energy production. This scenario is largely based on the full implementation of a set of policies and measures that Governments are currently considering or might reasonably be expected to adopt. The alternative policy scenario does not examine, for example, the consequences of adoption by Governments of more ambitious policies aimed at stabilizing greenhouse gas concentrations in the atmosphere by greatly expanding the role of renewable energy sources or improving energy end use efficiency. Similarly, it does consider the implications of greatly accelerating energy access programmes in developing countries.

16. The interesting finding in the alternative policy scenario is that, with almost the same total investment, it is possible to reduce global energy demand by 10 per cent and anthropogenic greenhouse gas emissions by 16 per cent by 2030, mainly by shifting investments from energy production to energy efficiency technologies, many of them on the demand side.

17. Additional reductions in energy demand and greenhouse gas emissions can be obtained with more ambitious policies. Already in the IEA business-as-usual projection, investments in renewable energy power production will amount to \$1.6 trillion, with even greater investment predicted in the alternative policy scenario.⁴

18. In any event, almost two thirds of the growth in global energy demand in the next 25 years will occur in developing regions, reflecting the rapid economic and population growth in many countries. By 2030, developing countries will account for the major part of the global energy demand, some 48 per cent, compared to 38 per cent in 2002, although their per capita consumption will remain low compared with the average in OECD countries. The percentage of people in developing countries without access to electricity is expected to decrease, but population growth will negate much of the absolute gain so that some 1.4 billion people will still remain without access to electricity in 2030, mainly in South Asia and sub-Saharan Africa. If so, it will be very difficult to meet the goals of the Millennium Declaration in these regions, particularly those related to reducing poverty.

C. Trade and investment

19. The growing demand for energy will require massive investment. Estimates differ, but amounts in the order of \$16 trillion must be invested in the energy sector over the next 30 years to maintain,

³ The *World Energy Outlook* is considered by most energy experts to be one of the most authoritative projections of energy use. Other projections generally concur with IEA estimates.

⁴ IEA envisages the current peak in oil prices to be temporary, and prices over the planning period are assumed to return to \$25–\$30 per barrel. If the current price, exceeding \$60, persists, this will stimulate market interest in efficiency and non-fossil energy supply, and reality could overtake projections in the alternative policy scenario.

replace, and expand infrastructure. Approximately 60 per cent, or \$10 trillion, is required for investments in the electricity sector alone. This is three times the amount invested in the last 30 years and reflects the expected doubling of global electricity demand. The investment pattern would differ somewhat with increased political emphasis on improving end-use energy efficiency, but the capital needs will remain at roughly the same level.

20. Raising the capital will be a significant challenge, particularly in developing countries and countries with economies and transition, where almost half the investment is needed. Investment in these regions is impeded by poorly developed financial markets, products and institutions, as well as high political, credit, currency and economic risks, the lack of local capacity to adapt technology and the lack of infrastructure to deliver services.

21. The IEA assessment indicates that, although availability of fossil fuels will not be a technical constraint in the coming decades, a view that is shared by a number of other projections, the geographical distribution of oil and gas reserves in particular will lead to a marked shift in terms of sources of energy. The Middle East, the Russian Federation and some African countries will become the dominant suppliers of both oil and gas. In the European Union, for example, the percentage of natural gas from imported sources is expected to rise from 50 per cent to more than 80 per cent; the already high oil import ratio will also increase. Other countries, such as the United States of America, will similarly see their imports of oil and gas rise, both in absolute and in percentage terms.

IV. Impacts on human health and the environment

A. Background

22. The production, consumption and use of energy are associated with many different health and environmental impacts. The energy sector is also like other large scale industrial sectors in terms of presenting various workplace safety and accident risks, where fossil resource extraction and processing in particular present some specific hazards.

23. Health and environmental impacts generally encompass air pollution ranging from indoor air pollution to that occurring at the local and regional levels, climate change, ecosystem degradation, water pollution and radiation hazards. An exhaustive list of impacts is much longer and each impact category can be broken down by detailed pollutant components, their pathways to the environment and means of affecting the environment and human health. Analysis of these complex issues is not attempted here, but table 1, which is adapted from the *World Energy Assessment* published in 2000 by the United Nations Development Programme (UNDP), the United Nations Department of Economic and Social Affairs and the World Energy Council, presents an overview of the main types of impacts from the energy sector, their scale compared with the natural baseline and their main causes. Rankings in the so-called human disruption index are not intended to give a picture of the seriousness of the problem, because some of the physical stressors produced by the energy system (known as “insults”) have short lifetimes while others, like many greenhouse gases and radioactive waste, have lifetimes of a century or more. Studies on the various impacts are available in the relevant scientific literature, which describes also the interlinkages between the different impacts and options for addressing them through policies and technological solutions. Some of the major impacts are described in more detail below, together with possible options for addressing them.

Table 1: Environmental insults due to human activities by sector, mid-1990s

Insult	Natural baseline (tons/year)	Human disruption index ^a	Share of human disruption caused by:	
			Commercial energy supply	Traditional energy supply
Lead emissions to atmosphere ^b	12,000	18	41% (fossil fuel burning, including additives)	Negligible
Oil added to oceans	200,000	10	44% (petroleum harvesting, processing, and transport)	Negligible
Cadmium emissions to atmosphere	1,400	5.4	13% (fossil fuel burning)	5% (traditional fuel burning)
Sulphur emissions to atmosphere	31 million (sulphur)	2.7	85% (fossil fuel burning)	0.5% (traditional fuel burning)
Methane flow to atmosphere	160 million	3.75	18% (fossil fuel harvesting and processing)	5% (traditional fuel burning)
Mercury emissions to atmosphere	2,500	1.4	20% (fossil fuel burning)	1% (traditional fuel burning)
Particulate emissions to atmosphere	3,100 million ^c	0.12	35% (fossil fuel burning)	10% (traditional fuel burning)
Non-methane hydrocarbon emissions to atmosphere	1,000 million	0.12	35% (fossil fuel processing and burning)	5% (traditional fuel burning)
Carbon dioxide flows to atmosphere	150 billion (carbon)	0.05 ^d	75% (fossil fuel burning)	3% (net deforestation for fuelwood)

Note: The magnitude of the insult is only one factor determining the size of the actual environmental impact.

^a The human disruption index is the ratio of human-generated flow to the natural (baseline) flow.

^b The automotive portion of human-induced lead emissions in this table is assumed to be 50 per cent of global automotive emissions in the early 1990s.

^c Dry mass.

^d Although seemingly small, because of the long atmospheric lifetime and other characteristics of carbon dioxide, this slight imbalance in natural flows is causing a 0.4 per cent annual increase in the global atmospheric concentration of carbon dioxide.

Source: Adapted from the *World Energy Assessment: Energy and the Challenge of Sustainability*. UNDP, United Nations Department of Economic and Social Affairs and World Energy Council, New York, 2000.

B. Air pollution

24. Combustion of fossil and biomass fuels produces a number of different airborne pollutants that have impacts at different spatial scales. The nature, extent and impact of air pollution depends greatly on factors such as topography, local and regional meteorology, receptor characteristics, the level and rate of industrialization, and overall level of social and economic development. Even with the same pattern of emissions, two areas may experience completely different consequences in terms of air pollution, making it hard to devise generic policy solutions.

25. In industrialized countries, the transport sector is the dominant source of urban air pollution, although various technical improvements and policies have eliminated lead and reduced levels of many of the transport related pollutants other than carbon dioxide. In developing countries and countries with economies in transition, the situation is more mixed; many megacities suffer from a combination of heavy traffic emissions and those arising from industrial and domestic combustion of fossil and biomass fuels. Smaller and less dense urban areas may have fewer transport emissions but more domestic and industrial emissions due to lack of regulation or inability to replace old and inefficient equipment.

26. Technical control strategies are to a large extent available, but their degree of use depends on the ability of Governments to devise and implement policies, their willingness to enforce laws and regulations, adequate funding, and access to technologies. Thus the ability to adopt control strategies is, to a large extent, linked with development progress. Recent success with the introduction of unleaded fuel in the African region, however, is an example where rapid progress has been made despite the limited economic means of many countries.

27. Airborne emissions of pollutants can lead to damage at large distances from the emission source. The average atmospheric residence time of sulphur and nitrogen oxides at European latitudes, for example, is two-three days, during which time they can typically be transported 1,500 to 3,000 kilometres while undergoing chemical reactions that are detrimental from an environmental perspective.

28. Some of the known regional environmental effects of air pollution relate to acidification of soils and water systems caused by deposition of sulphur and nitrogen compounds, eutrophication (the enrichment of water with nutrients like nitrogen) and the formation of damaging tropospheric ozone as a result of sunlight induced atmospheric chemical reactions involving multiple pollutants.

29. Acidification in particular has for some decades been recognized as a problem in Europe and North America, but it has been possible to reduce the problem significantly through regional or national agreements such as the Convention on Long-range Transboundary Air Pollution, which was adopted under the auspices of the United Nations Economic Commission for Europe. With growing energy consumption in developing countries, the danger of acidification problems is increasing, especially in areas with high coal use. For example, some regions of China and India are already facing acid rain problems as severe as those experienced in Europe two decades ago. The issue is of concern in neighbouring countries as well, given its transboundary nature.

30. Technical solutions exist in the form of filters and scrubbers installed at the plant level, but their use requires political determination because the additional costs of installing and operating the equipment must be borne by customers and utilities. Shifts to cleaner fuels are an alternative mitigation option. In both cases, however, there are trade-offs. As filters and scrubbers themselves require considerable energy to operate, their use reduces the overall energy efficiency of power plants, meaning greater emissions of carbon dioxide for a given electrical output. Switching to cleaner natural gas may reduce emissions of sulphur dioxide and consequently lead to an environmental gain, but energy security would be at increased risk if the gas is imported.

C. Climate change

31. Climate change has, over the last decades, evolved into an issue of global concern. Human understanding of the relation between emission levels, concentrations of greenhouse gases in the atmosphere and changes to the global climatic system is improving and there is increasing consensus in both the scientific and political communities that significant reductions in emissions are necessary in order to limit climate changes to manageable levels.

32. The major anthropogenic contribution to emissions of greenhouse gases comes from fossil fuel-based energy related activities, which currently account for over 80 per cent of the total, excluding land use, land use change and forestry. Industrialized countries are responsible for the majority of current and historic emissions, but the rapid growth of energy consumption in countries like China and India has meant that the developing countries are significantly increasing their share.

33. Most scenarios indicate that the emissions reductions required by the Kyoto Protocol to the United Nations Framework Convention on Climate Change are insufficient to forestall rising temperatures and limit climate change. While there is still scientific uncertainty about the speed and magnitude of the envisaged changes, the projected impacts relate to most aspects of human life, including those on water availability, agricultural productivity, biodiversity, human health and infrastructure.

D. Ecosystem health

34. Hydropower developments, and large dams and their resulting reservoirs in particular, can have significant impacts on ecosystems. By blocking a river's flow, dams prevent silt from reaching the downstream basin. By modifying the hydrological regime of a river, dams can alter local climatic conditions and disrupt ecosystems. Habitat fragmentation by large reservoirs is an additional environmental impact of hydropower schemes. From a social point of view, the displacement of people is the main area of concern.

35. As mentioned previously, emissions of sulphur dioxide present in coal, lignite and oil fuels, and nitrogen oxides and their secondary reaction products result in acid deposition that can affect forests, soils and freshwater ecosystems. Acidification causes changes in the chemical composition of the soil, damages vegetation and the built environment and adversely affects terrestrial and aquatic ecosystems. Nitrogen compounds can lead to eutrophication of water bodies by disrupting the nutrient balance of the affected ecosystems.

36. Energy production, consumption and use require the utilization of land resources. The surface mining of coal, refineries and shipping terminals, power plants and transmission lines all occupy land. Hydropower schemes can inundate large areas and their operation can cause erosion along the riverbed both upstream and downstream of the dam site. Similarly, biomass grown for fuel purposes requires large areas of land and, over time, can deplete the soil of nutrients. Renewable energy technologies are not without their own impacts. Often lauded for their distributed nature, wind farms, for example, pose aesthetic concerns and wind turbines that are installed in inappropriate locations have been associated with bird deaths, noise and visual disturbances.

37. Energy production leads to large quantities of hazardous wastes. Again, the nature and significance of the environmental insults varies from technology to technology. Soil at coal-fired power plant sites can become contaminated with various pollutants, in particular heavy metals, and take a long time to return to a natural state after the plant is closed. Similarly, oil spills on land and waste products from oil refining such as wastewater sludge and residues can all easily contaminate land if not treated responsibly. At a different temporal scale, the storage of used nuclear fuel essentially precludes any future use of land in the vicinity of the storage site.

38. Most forms of energy production and transformation also involve the consumption or use of water in some manner, with associated impacts on the resource from which the water is drawn. Fossil fuel thermal and nuclear power plants require large quantities of cooling water to operate, and fish and other aquatic life are often killed when these plants remove water from a lake or river or raise its temperature. Coal mines often require large quantities of water to remove impurities from the coal in coal washing operations; similarly, geothermal plants can require water to extract the energy available in dry rocks. Oil and gas production in offshore environments and the shipment of crude oil and refined products pose the risk of catastrophic spills that affect the marine environment in particular. The water needs of biofuel plantations can be substantial.

E. Human health

39. Globally, it is estimated that around 2.4 billion people rely on biomass for cooking purposes, with most of these living in China, India and sub-Saharan Africa. Some 30–50 million people use simple coal stoves. Given the decentralized and dispersed nature of cooking stoves, there has been relatively little scientific work done to assess their health impacts compared to the impacts of outdoor air pollution in urban environments.

40. Various studies have estimated that indoor air pollution causes up to some 2.5 million premature deaths in women and children under the age of five and accounts for 4–5 per cent of the total global burden of disease. In particular, indoor air pollution is linked to four types of health effects:

- (a) Infectious respiratory diseases such as acute respiratory infections and tuberculosis;
- (b) Chronic respiratory diseases such as chronic bronchitis and lung cancer;
- (c) Adverse pregnancy outcomes, including stillbirths and low birth weight in babies born to women exposed during pregnancy;
- (d) Blindness, asthma and heart disease, of which there is less causal evidence to date.

41. In addressing the problem of indoor air pollution, it is important to understand that this is only one aspect of a much wider set of problems related to household energy use in poor areas of developing countries and countries with economies in transition, and that it is closely related to poverty alleviation and achievement of the goals of the Millennium Declaration. Partial technical solutions to address the problem do exist and many programmes focusing on improving stoves, changing cooking habits and improving ventilation of cooking places have achieved good results. Ultimately, the solution lies in improving access to cleaner and more efficient energy sources, but this can only be achieved as part of general economic development and dedicated poverty eradication programmes, as discussed in the next section.

42. Impacts of local and regional air pollution are to some extent similar to those of indoor air pollution and include different types of respiratory diseases that lead to increased mortality and morbidity. While concentrations of pollutants in outdoor urban environments are generally lower than those associated with indoor air pollution, the exposure time can be much longer if people both live, travel and work in polluted areas.

43. In addition to the impacts on human health described above, energy production, consumption and use releases various toxic chemicals. The combustion of petrol and diesel fuel causes emissions of fine particulates and hydrocarbons, including carcinogenic polycyclic aromatic hydrocarbons (PAH), while the combustion of coal releases arsenic, mercury and other heavy metals which are toxic to humans and animals if inhaled or swallowed. Similarly, burning municipal solid waste to recover energy produces trace amounts of mercury and dioxins.

44. The main human health impacts of nuclear power arise from ionizing radiation. While the disposal of low-level waste and intermediate-level waste may be considered a mature practice, the disposal of high-level waste remains a major source of concern. Long-term deep geological disposal is gaining ground over the earlier focus on reprocessing of spent fuel, although the understanding of geological processes and long-term behaviour of materials needs to be improved for this to become a sound option. Other problems associated with nuclear power include proliferation concerns and the risk of accidents that release radiation.

45. The above causes and results of energy production, consumption and use become intertwined. Humans and ecosystems are often exposed to many pollutants simultaneously and through different pathways. The levels of vulnerability also differ from one individual or ecosystem to another. Thus, real-life exposures are not linear, but rather subject to complex combined and cumulative effects that manifest themselves through multiple environmental pathways, many of which remain poorly understood. This raises the stakes for taking corrective action, not least because improvements in one area can often bring about negative changes in other environmental media. The economic case for intervention, however, is becoming increasingly evident as understanding improves of the links between environmental factors, the burden of disease and the value of ecosystem services.

V. Links between energy and development

A. Background

46. The eight goals of the Millennium Declaration focus on reducing extreme poverty, combating preventable diseases, improving child health and education, arresting environmental degradation and ending discrimination against women. They do not explicitly include energy issues or mention the need for improving access to modern energy. Modern energy is, however, seen as one of the major multipliers of these goals, as few, if any, of them can be achieved without it.

47. At the national level, energy is a crucial input to economic development and is often a prerequisite for industrial growth, transport and communications. At the local and household levels,

energy services provide the basis for cooking, lighting, water pumping, refrigeration, transport and communication.

48. The current situation regarding lack of access to electricity and reliance on biomass resources for cooking and heating needs is shown in table 2. These figures are indicative of the associated energy and development problems only, since access to electricity in itself is not a very useful target unless the associated use of the energy is also documented. Too often, people with access to electricity cannot afford to buy the necessary equipment to use it or the quality of power supply is too poor to provide a reliable alternative to traditional energy sources.

Table 2: Population without access to electricity and relying on biomass for cooking

Country or region	Population without electricity (million)	Population using biomass for cooking (million)	Urban population with electricity (%)	Rural population with electricity (%)
South Asia	814	713	69	33
Sub-Saharan Africa	531	575	52	8
North Africa and Middle East	39	8	99	88
East Asia	216	998	96	83
Latin America	47	96	98	61
Developing countries	1,620	2,390	85	72

Adapted from information provided by the World Bank in 2000 and IEA in 2002.

49. The figures show that, notwithstanding significant progress over the last 25 years – during which time more than 1 billion people in developing countries have gained access to electricity and other modern fuels – the number of people without access is still close to one quarter of the world's population. As noted earlier, current projections do not foresee any major reduction in these numbers over the coming decades unless a dedicated policy push makes it happen. While progress will occur and the number of people with access to modern energy will increase, population growth will erase most of these gains, meaning that it is unlikely the goals of the Millennium Declaration can be met by 2015. IEA analysis shows that, to meet the goals of the Millennium Declaration, an additional 500 million people would need to have access to electricity and up to 700 million would require access to some form of modern cooking and heating fuel, at an overall cost estimated to be around \$200 billion.

50. Poverty reduction strategy papers have been advanced as the national planning framework for defining strategies and priorities for reducing poverty. They are supposed to be country-driven, results-oriented, comprehensive and based on a long-term perspective of poverty reduction. They are increasingly becoming the national frameworks for interaction with development assistance agencies, development banks and other finance institutions, and they are a formal requirement for countries seeking to receive concessional assistance from the World Bank (through the International Development Association) and the International Monetary Fund (through the Poverty Reduction and Growth Facility). Around 70 countries are preparing poverty reduction strategy papers and more than 40 had completed their first papers by mid-2005.

51. In a review by the World Bank, twenty poverty reduction strategy papers prepared by countries in sub-Saharan Africa, South Asia, East Asia, and Latin America were evaluated to identify the treatment of energy access issues and energy linkages with development. The findings of this survey underpin the IEA projections in the sense that energy was given little, if any, attention and, when it was included, the focus tended to be on large infrastructure projects. Energy access issues were generally not addressed and the crucial links between large-scale infrastructure development and access programmes were not mentioned.

52. Energy problems in developing countries and countries with economies in transition are predominantly rural, but this may change in the future. While access to electricity grids will remain a

problem in rural areas due to often remote locations and low density of demand, increased urbanization may indirectly improve the situation in rural areas and create increasing problems in maintaining high urban access rates.

53. There are options for changing this situation and for providing energy for sustainable development. First, a better understanding needs to be established of the links between energy requirements for reaching the goals of the Millennium Declaration, and energy required for industrialization and major infrastructure development. The latter requires large quantities of fuels and electricity, while reaching the goals of the Millennium Declaration in rural and peri-urban areas is more often a matter of providing access to smaller quantities of better forms of energy. The policies and approaches required are quite different, but often confused.

54. National policies and international investment have, in recent decades, tended to focus on large-scale energy systems that support broad economic development. A dominant theme has been that the performance of the energy sector as a whole needs to be improved before it is possible to deal with access and poverty issues, which, for improving rural access in particular, requires significant investments with relatively low returns.

55. From an overall policy perspective, three sets of actions are required at the national level to address the energy requirements for meeting the goals of the Millennium Declaration:

- (a) Improving the efficiency of the energy sector;
- (b) Improving energy access rates in rural areas;
- (c) Improving energy service provision to the poor in peri-urban and urban areas.

Each set of actions is discussed below.

B. Increasing the overall economic performance of the economy, including the efficiency and management of the energy sector

56. Many countries have reformed their power sectors in some form or another to make them more market oriented, cost effective and better managed. While there has been some progress on these general objectives, reform processes have tended to overlook energy access issues. The evidence is that a trickle-down effect does not occur and dedicated action is required to ensure that access issues are addressed.

57. A recent study by the UNEP-facilitated Global Network on Energy for Sustainable Development shows that, with few exceptions, market-oriented reforms have had neutral or adverse impacts on the poor; the study concludes that, if power sector reforms do not have an explicit pro-poor dimension, providing the poor with access to electricity is forgotten. In order to achieve progress on access for the poor, there is a need to protect financing for that purpose, pay attention to the specific sequencing of reforms (preferably provide the poor with access to electricity first, then privatize), and where possible, ensure that the poor are represented in key decision-making bodies.

58. These recommendations are in line with more recent signals from Governments and development finance institutions indicating that reforms and privatization will not in themselves solve problems of energy access, but can be useful when combined with the right selection of policy and financial incentives. Experience with reform efforts has shown that trying to apply a single model to different countries is not successful and that policy tools and technical solutions need to be designed to fit specific national characteristics.

C. Improving access by the rural poor to modern forms of energy, including power

59. Experiences from a number of countries, most prominently China and South Africa, show that programmes to provide electricity in rural areas and broader energy for development programmes can be successful if they are based on a sound national framework. Again, the approach needs to be tailored to the specific country conditions and, for some countries, may require outside financial assistance. In general, options to consider include:

(a) Providing financial resources for rural grid electrification, possibly subsidizing only part of the financial costs and recovering the operating costs to ensure that the system is functional and properly maintained. It is worth noting that, since this is an emerging understanding, subsidy design is an area requiring more experience. Successful examples include performance-based subsidies, where a private sector company is responsible for implementation and the government subsidy on capital cost is tied to services actually delivered to the designated target groups;

(b) Focusing on least-cost options for providing access: For institutional and political reasons, grid extension has, in most countries, been the preferred option for rural electrification, but reform creates opportunities to introduce other options. Decentralized off-grid solutions in remote or sparsely populated areas are, in many cases, much more cost effective than grid extension; these can include combination of photovoltaic systems, liquefied petroleum gas, kerosene or local bio-fuel use. In recent years, several programmes have focused on engaging local entrepreneurs or community organizations in what are broadly known as rural energy service companies. Although some initial grant or loan is most often required to establish such a company, several examples show that it is possible for small businesses to provide good services to paying customers and maintain their financial viability.

60. To make connections affordable to greater numbers of poor people, it is necessary to use innovative ways of providing credit and finance. These can include subsidizing connection fees or working with local finance institutions on targeted loans with pay-back arrangements structured to fit the seasonal cash flow and hence the customers' ability to pay. Some elements of cross-subsidy between high income and low income consumers may also be considered on social equity grounds. In the past few years, several countries have successfully applied simple prepaid meter systems, where consumers simply buy the amount of power they need or can afford, and the provider takes care of the meter costs and maintenance.

61. It is important to bear in mind that many rural households already spend significant amounts of money on energy; in few areas are energy needs fully met by the collection of firewood, and even there the cost is counted in time spent on collecting fuel rather than on productive activities. Many rural households generally buy part of their fuel wood or charcoal in small amounts at very high prices per unit of energy compared with other energy sources. The same is true of candles, batteries and other devices that provide illumination. In fact, in some areas, poor households spend more of their income on energy than well-off families do. It is also important to underline that energy access programmes need to focus on stimulating productive uses in the targeted areas to ensure the necessary income generation. Communal and household uses are important, but will usually not lead to direct economic development.

D. Improving energy service provision to the poor in peri-urban and urban areas

62. The problems experienced in improving energy service provision to the poor in urban areas differ from those experienced in rural settings, in the sense that, although infrastructure investment in extending distribution or other systems is quite modest, it is still difficult to raise that investment. The most effective way to obtain the necessary finance is to give the issue political priority and then find the best tools and approaches to implement cost-efficient programmes.

63. Providing the poor urban consumer with access to electricity creates some of the same problems as providing it to rural households, and the options are generally the same in terms of establishing dedicated finance schemes and involving some form of cross subsidy between wealthy and poorer customers. Improving the financial health of utilities by reducing losses and theft also helps.

64. Expanding use of liquefied petroleum gas for cooking has been possible in a number of countries through targeted programmes, often with an element of subsidy to ensure affordability of the initial equipment. This option is especially attractive where power connections do not have sufficient load to provide for cooking or where overall power production is constrained. Examples from Botswana and Ghana show that liquefied petroleum gas programmes can quickly have significant impact on the use of wood in households and in that way are an attractive option for providing access to clean and affordable modern energy in urban areas. The relevance of liquefied petroleum gas as an option depends

on access to the resource, the cost of establishing distribution networks and the ability to collect revenue from customers so that subsidies are not required for the operational phase. Providing access to biomass gas is becoming increasingly attractive given technological advances in countries such as China and India, where robust, affordable systems are entering the markets. These can supply energy for cooking and, in some cases, electricity generation.

VI. Key policy issues at national and international levels

65. When global energy demand and supply trends are assessed against the three global concerns of improving energy security, combating climate change and expanding access to modern forms of energy in developing countries and countries with economies in transition, it is clear that current policies and regulatory frameworks will not achieve these goals. Governments must stimulate demand for more efficient and cleaner technologies, including technologies that tap renewable sources of energy, improve energy efficiency on the supply and demand sides and make cleaner use of fossil fuels. Correcting policy and market failures is a pre-condition for success.

66. The relative importance of the three energy concerns differs between industrialized and developing countries and those with economies in transition: industrialized countries currently focus on climate change and security of supply as policy priorities, while developing countries are concerned with ensuring an adequate energy supply to meet their development needs. While the driving forces may differ, they are interlinked, both through the global energy and capital markets and politically in the future regimes under the United Nations Framework Convention on Climate Change.

67. The mitigation of climate change basically requires reduction of the emissions of greenhouse gases or alternatively the capture and storage of emissions for a long period. The technical options for reducing emissions from the energy sector can broadly be categorized into:

- (a) Switching to less carbon intensive fuels, for example substituting natural gas for coal;
- (b) Increasing the share of non-fossil energy sources, in particular renewables;
- (c) Improving the conversion efficiency of fossil fuel combustion;
- (d) Improving end-use efficiency in all sectors;
- (e) Promoting conservation and behavioural change to less energy intensive consumption patterns;
- (f) Removing and storing carbon emissions in geological formations or the oceans;
- (g) Promoting better land-use practices and non-carbon dioxide mitigation options.

68. Policy tools play an important role in stimulating technological change and efficiency improvements, and a wide range are already being used in climate mitigation efforts. These include taxes, regulations, voluntary initiatives and the flexible mechanisms introduced as part of the Kyoto Protocol to the United Nations Framework Convention on Climate Change – that is, emissions trading, joint implementation and the Clean Development Mechanism. These market-based mechanisms are intended to reduce the global costs of reducing carbon emissions and thus bring about cost efficiency at the global level.

69. Technology-oriented actions will need to be complemented with efforts to raise awareness and change behaviour regarding energy consumption. These could include programmes to promote environmentally-conscious energy use by individual households, government institutions (through procurement programmes) and businesses – particularly in the construction and building sectors. Companies in the manufacturing sector also have an opportunity to factor energy-efficiency into product design and include it in consumer education programmes.

70. The emerging global carbon market is generally regarded as one of the potentially most important tools for future mitigation efforts and so far the functionality of the market approach has been proven. But the future of this market will depend very directly on political agreements regarding future regimes or commitments after the initial Kyoto Protocol commitment period ends in 2012. Carbon market activities are already heavily influenced by uncertainty about the longer term conditions, which is reflected in the choice of projects and technological solutions having a short payback time.

71. Energy efficiency and conservation measures are able to address all three concerns of supply security, increased access and climate change and would have a significant potential to reduce energy-related carbon dioxide emissions if dedicated policies are put in place and technologies continue

to develop. Likewise, renewable energy technologies – including wind, solar, biomass and geothermal power and hydropower – offer large opportunities to make positive contributions on all three issues. Cleaner fossil technologies and nuclear power will play an important role in the coming decades. How attractive these options are in the longer term depends largely on the extent to which already impressive reductions in cost continue, new technologies come on stream and safety concerns are addressed.

72. Energy use in the transport sector represents a special problem, as it is a major contributor to urban air pollution all over the world. Transportation is becoming one of the major sources of both anthropogenic emissions of greenhouse gases and oil consumption, and exhibits high growth trends in almost all countries. Hydrogen or biofuels may be part of the future solution in this area, and ethanol and biodiesel in particular have promising prospects for making a major impact in the coming decade. The costs and environmental impacts associated with hydrogen production make it a questionable option at present. Costs must be reduced and a means found to produce hydrogen in a manner that reduces the total environmental burden of the hydrogen energy system.

73. Trends in the price of different transport modes show that private motoring and budget air travel have become increasingly inexpensive over the past 25 years, while the reverse is true for public transport, as providers face increasing pressure to cover costs in the face of decreasing government subsidies. In the absence of requirements to internalize its external environmental and social costs, private motoring is likely to continue to grow at the expense of public transport.

74. As a concept, renewable energy covers a number of sources and technologies at different stages of development and maturity, but generally speaking many of the technologies have recently become commercially mature and moved from being a passion for the dedicated few to a big business. In recent years, large global companies have entered the markets for wind, solar and biomass technologies and the finance community is gradually mainstreaming renewable energy into their operations.

75. The Renewable Energy Policy Network for the Twenty-first Century has recently issued a comprehensive global status report on renewable energy developments, which notes that some \$30 billion was invested in renewable energy projects in 2004 and that renewables currently contribute 160 GW of capacity, approximately 4 per cent of the global total power supply. This number does not include large hydropower, which accounts for another 16 per cent of total generation capacity. Most long term projections estimate that renewable energy will play a major role in the global energy supply in the second half of this century, but this process can be accelerated through dedicated policy action by Governments at all levels.

76. UNEP is engaged in a number of activities aimed at accelerating the use of energy efficiency and renewable energy, spanning the areas of policy, finance and capacity-building. The recent increase in oil and gas prices has stimulated concerns about longer-term price levels and security of supply and Government interest in renewable energy has increased significantly, compounded by the fact that this would have a positive effect on local environmental concerns.

77. Cost is, in most instances, the most important barrier, but this is an area where economic policy instruments can quickly make a difference. With the last decades witnessing large scale deregulation and an increased market orientation of the energy sector, the use of economic policy instruments has proven to be effective in stimulating fairly rapid changes. The evolving experiences with carbon finance and emissions trading also show promising results that can provide strong incentives for renewable energy and energy efficiency market development.

78. Because technologies supply the foundation for implementation-oriented policies, concerted efforts are required in the area of research, development and deployment of all promising energy technologies, both to improve the cost efficiency of existing technologies and ensure continued development in new areas like hydrogen and fuel cells. Research, development and deployment efforts must extend to the policy and financial areas as these are equally important and there is, as yet, imperfect understanding of how tools in these areas must also evolve.

79. Experience shows that the policy approaches that have had the most significant and sustained impact on energy for sustainable development in both developed and developing countries and those with economies in transition are all characterized by:

- (a) A combination of different policies, rather than reliance on a single policy;
- (b) Longevity and predictability of policy support;
- (c) Adaptation to and use of markets to deliver efficiency given stated policy goals.

80. In order to address the three concerns of maintaining security of supply, providing energy for development and combating climate change over the coming decades, urgent policy action at the national and international levels is required. The specific policy tools need to be designed to fit specific national and local circumstances. Significant experience exists to guide decisions. Targets and timetables at the global level related either to emissions or technologies can be important instruments to ensure and accelerate national action. But it is not necessary to wait for a global consensus before moving.

VII. Questions for the ministerial consultations

81. Ministers and heads of delegations may wish to focus the discussions around the three themes listed below. Given the breadth of the topic and the different national realities and priorities, the questions under each theme are provided for illustrative purposes only (that is, they are not intended to be exhaustive in their coverage of any of the proposed themes):

- (a) Environmental impacts of energy use:
 - (i) How can energy, environment, and development policy making be integrated more closely, particularly in developing countries and countries with economies in transition? What specific steps can ministers take to ensure that policy planning is not conducted in separate “silos”, as it were?
 - (ii) To what extent can renewable energy sources meet the growing energy needs of developing countries and countries with economies in transition in an environmentally sound manner? Are there specific steps that Governments can take to foster renewable energy uptake, particularly in developing countries and countries with economies in transition?
 - (iii) What precautions are necessary regarding the large-scale development of bioenergy, particularly in view of its possible environmental consequences? What are the trade-offs between bioenergy development and biodiversity, food production, water requirements, and so on? What steps need to be taken to ensure that bioenergy systems contribute positively to meeting energy and environmental needs?
- (b) Energy efficiency and financing cleaner energy systems:
 - (i) What policy changes would allow energy efficiency efforts to expand, including through market mechanism? What steps can Governments take to accelerate efforts that improve energy efficiency in different sectors such as buildings, households, industry, and transport?
 - (ii) How can flows of investment into new energy infrastructure be shifted towards technologies and systems that cause less impact on the environment? Are different approaches needed in developing and developed countries? What good models exist?
 - (iii) How can Official Development Assistance be used more effectively to make advanced technologies available to developing countries and countries with economies in transition?
- (c) Technology advances and cooperation:
 - (i) How can we achieve consensus on the approach to developing hydropower resources in an environmentally and socially acceptable manner, particularly in developing countries and countries with economies in transition?
 - (ii) How can we secure greater public acceptance of renewable energy facilities such as wind farms? What approaches have proved successful and can these be replicated?
 - (iii) What can Governments do to increase the likelihood that clean fossil fuel technologies contribute to a secure energy future? What is the role of

cooperative research, development and deployment programmes in speeding the diffusion of improved fossil fuel technologies?

- (iv) Given technological uncertainties, what steps can Governments take now to prepare for a hydrogen economy or, at a minimum, to preserve options? How can developing countries best prepare for an eventual hydrogen future?
