Nuclear Power in Developing Countries

1. Throughout its 52-year history nuclear power has been mainly used in industrialized countries. Of the world's 441 currently operating nuclear power reactors, 403 (or 91%) are in either OECD countries or countries with economies in transition. In terms of electrical generating capacity, 349 GW(e) out of 368 GW(e), or 95% of nuclear generating capacity is installed in these countries. In terms of new construction, however, the pattern is largely reversed. Sixteen of the 27 new reactors under construction (59%), and 11.1 GW(e) out of 21.8 GW(e) (51%), are in developing countries. The most ambitious plans for nuclear expansion are in China and India. China, with three nuclear power plants (NPPs) under construction at the end of 2005, plans to expand nuclear capacity from 6.6 GW(e) today to 40 GW(e) by 2020. India, with eight NPPs under construction, plans to expand from 3 GW(e) to 29 GW(e) by 2022. Pakistan, with 425 MW(e) and one plant under construction at the end of 2005, plans to add approximately 8 GW(e) by 2030.

2. 2005 was a year of rising expectations for nuclear power in general, partly because of the potential expansion in developing countries due to their continuing need for substantially increased energy supplies, and partly because of concerns about greenhouse gas (GHG) emissions from fossil-fired electricity generation, particularly coal.

3. In March, high-level representatives of 74 governments, including representatives from 31 developing countries, gathered in Paris at a conference organized by the Agency to consider the future role of nuclear power. The vast majority of participants, among them several countries currently without nuclear power programmes, affirmed that nuclear power can make a major contribution to meeting energy needs and sustaining the world's development in the 21st century.

4. This document reviews the prospects and challenges for the expansion of nuclear power in developing countries. Each country is unique, and its national plans and approach reflect the special features of its own situation. At the same time, many countries face similar challenges and can benefit from sharing their assessments and experiences.

A. The Central Motivating Factor – Growing Energy Needs

5. Affordable clean energy services are critical to meeting the economic aspirations of developing countries, advancing sustainable development and meeting the Millennium Development Goals (MDGs). The International Energy Agency (IEA) currently estimates that about 1.6 billion people, mostly in developing countries, do not have access to electricity, and that the number will drop only modestly, to 1.4 billion by 2030. Table 1 shows the current disparity in electricity use per capita for selected countries and regions. Values are generally highest for the Nordic countries, which have abundant hydroelectricity and long cold dark winters; for the small oil-rich countries; and for the geographically big OECD countries (Australia, Canada and USA). The lowest values are for countries in Africa, which had an overall average consumption of 593 kWh/capita in 2003. The African average is only 22% (one fifth) of the world average and 7% (one-fifteenth) of the OECD average.

6. Looking to the future, the Agency's low and high energy projections that were described in Section A.2.1 of the Nuclear Technology Review 2006 project that global energy use will rise,

between 2004 and 2030, by between 47% (low projection) and 100% (high projection). The IEA's latest reference scenario projects a 59% increase between 2002 (the IEA base year) and 2030[1], comparable to the Agency's low projection. The IEA also projects for developing countries as a group (the Agency's projections group countries only geographically) that energy use will grow about twice as fast as the world average, by 106% between 2002 and 2030. For electricity use, projected growth is about twice as fast as for overall energy use, and again the pace in developing countries is twice the world average – 97% growth for global electricity between 2002 and 2030 compared with 209% in developing countries.

Table 1. Per capita electricity use in selected countries and regions, 2003.[2]

	kWh/cap-yr 2003
Ethiopia	33
Nigeria	148
Kenya	158
Ghana	290
Vietnam	503
India	597
Indonesia	526
African average	593
Egypt	1 348
China	1 500
Jordan	1 639
Latin American average	1 911
Thailand	1 922
Turkey	1 996
Mexico	2 113
Islamic Republic of Iran	2 307
Brazil	2 277
Argentina	2 641
World average	2 670
Chile	3 092
Poland	3 704
Hungary	4 056
South Africa	4 997
Russian Federation	6 295
Italy	5 940
United Kingdom	6 731
Saudi Arabia	6 792
Republic of Korea	7 249
Brunei Darussalam	7 975
Austria	8 095
France	8 099
Japan	8 214
OECD average	8 612
Belgium	8 776
Bahrain	10 910
Australia	11 411
United Arab Emirates	12 259
USA	14 040
Kuwait	16 612
Sweden	16 551
Canada	18 425
Iceland	29 412

[1] IEA, *World Energy Outlook, 2004*, International Energy Agency, Paris, 2004.

[2] Source: International Energy Agency, 2003.

7. As a result, by 2030 developing countries are projected to produce, in absolute terms, more electricity than the OECD, even though their per capita electricity use will still lag behind the OECD. Altogether more than 2 400 GW(e) of new or replacement capacity will be needed in the developing countries over that period, representing a cumulative investment of $2.2 trillion.[3] Transmission and distribution add another $3 trillion of investment requirements. But even with these investments, and faster growth in developing countries, the projected gap for 2030 in per capita electricity use is still large: 2 300 kWh/cap in developing countries compared to 10 400 kWh/cap in the industrialized world.

B. Differences Among Countries

8. These broad trends towards increased and more widespread use of electricity in developing countries do not mean that nuclear power is an equally appropriate option for all countries. In general, nuclear power can be more attractive where energy demand is growing rapidly, where alternatives are scarce or expensive, where energy supply security is a priority, where reducing air pollution and GHGs is a priority, where financing can look longer-term, where the domestic legal, regulatory, industrial and research infrastructure is well established, or where high-technology development is a priority.

9. In developing countries, more so than in developed countries, nuclear power has been used by big countries. China and India have by far the biggest nuclear programmes among developing countries, with 15 operating reactors in India and nine in China. Other developing countries with nuclear power programmes include Argentina, Brazil, Mexico, Pakistan and the Republic of South Africa, each with two operating reactors.

10. Limited domestic energy resources were an important factor in the decisions by Argentina, Pakistan and the Republic of Korea to develop nuclear power. While China, India and South Africa had more substantial domestic resources, these were often separated by large distances from energy demand centres, making more attractive the option of nuclear power close to demand centres. Brazil had large hydropower and biomass resources, but many of these were also distant from demand centres, and nuclear power promised both greater supply diversity and desirable nuclear technology spin-offs. Mexico, even though a net energy exporter due to oil, chose to develop nuclear power to diversify its energy supplies in view of low reserve-to-production ratios for its oil and gas resources.[4]

11. In China and India, the sheer size of energy demand, and the speed at which it is growing, mean that essentially all possible energy options must be developed. In both countries, coal-fired electricity generation at the mine mouth is by far the lowest-cost generation option. But as soon as the electricity needs to be transported over long distances, or the coal needs to be transported to a distant power plant, other generating options such as nuclear power become competitive. And again, the pace at which electricity demand is growing strongly supports the rapid expansion of every available option.

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[3] IEA, *World Energy Outlook, 2004*, International Energy Agency, Paris, 2004.

[4] *Comparative assessment of energy options and strategies in Mexico until 2025*, TECDOC-1469, IAEA, 2005.

C. Other Key Factors

C.1. Economics

12. Future decisions on investing in nuclear power in developing countries are likely to turn much more on economics, specifically comparative generating costs, than they did in the past. Existing nuclear power programmes in developing countries have been largely financed by the public sector. The public sector does not require the same rapid return on investments as do private investors in liberalized markets, and it can directly incorporate in its decisions beneficial externalities that are effectively invisible to private investors, such as national energy supply security, the development of an advanced high technology industrial base and environmental protection. In the Republic of Korea, for example, high first-of-a-kind nuclear power costs were accepted as part of a long term national energy strategy that anticipated (and subsequently realized) both eventual cost reductions from 'technology learning' and spin-off economic benefits from developing the country's high technology sector. A recent study estimated these economic spin-off benefits from nuclear power at about 2% of the country's GDP.[5]

13. Nuclear power plant designs generally benefit from economies of scale: as the technology has developed over the years, the designs available on the market and preferred by utilities in industrialized countries have grown larger and larger. The 1 600 MW(e) EPR on which construction started in 2005 in Finland is 32 times the size of the eight, four-decade-old gas cooled reactors retired in the last few years in the UK. The high capital costs and low operating costs of nuclear power plants also make them attractive for baseload power. Thus economic considerations are most favourable for nuclear power in markets that can use large units for continuous baseload generation, and in areas with high demand densities and large electricity grid infrastructures. Large metropolitan areas, or areas with concentrated energy intensive industries are better suited for nuclear power than rural areas with low demand densities or without integrated grids, where off-grid renewables such as biomass, wind, solar or small scale hydropower, if available, may be more appropriate than nuclear power.

14. The comparative economics of nuclear power depend also on the economics of alternatives and thus on the economic prospects of renewables and particularly coal, oil and natural gas, which dominate current and projected electricity generation. The prices of all three have risen substantially in the last few years thus improving nuclear power's competitiveness. Uranium market prices also increased several-fold since 2001, but because uranium constitutes about 5% of nuclear power generating costs, this price increase – unlike those of fossil fuels – has hardly affected electricity costs. The increase in oil prices is of less direct consequence for nuclear power. Oil's share of electricity generation is small and declining. It is somewhat higher in developing countries than for the world as a whole, but still declining, from 12% in 2002 in developing countries to an estimated 5% in 2030 (again using the latest IEA reference scenario). However, power plants fired by natural gas and coal do compete with nuclear power, and rising global demand for gas and coal has pushed up their prices as well. In addition, the prices of gas contracts are often linked to the prices of oil and oil products. The shares of coal in electricity generation are high (38% worldwide and 45% in developing countries) and projected to be relatively stable through 2030. Natural gas, on the other hand, is rising in importance – from 17% in 2002 in developing countries to an estimated 26% in 2030, almost as high as the world average.

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[5] *Study on the Contribution of Nuclear and RI Technology to the National Economy*, Korean Atomic Energy Research Institute, CR-209/2004, 2004.

15. Higher current world market prices for fossil fuels have put nuclear power on the agenda of several developing countries currently without nuclear power and have revived interest in countries with stagnating nuclear power programmes. Current high prices for fossil fuels are also likely to be more permanent than were those of the 1970s because they are driven largely by demand increases. Energy demand growth driven by continuing economic development is expected to persist – hence the pressure on prices is likely to last.

16. High world market prices for fossil fuels have the greatest impact on countries that are highly dependent on energy imports, particularly developing countries with relatively scarce financial resources. A doubling of international prices translates into generation cost increases of about 35-45% for coal-fired electricity and 70-80% for natural gas. In contrast, a doubling of uranium prices (which have also increased recently – see Section A.2.4) increases nuclear generating costs by only 5%.

C.2. Energy Supply Security

17. Because of higher fossil fuel prices and growing energy import dependence, many countries are giving increasing attention to concerns about energy supply security. The IEA reference scenario estimates, for example, that from 2002 to 2030, oil importing developing countries in Asia will reach almost the same (increasing) level of import dependence as the OECD countries, despite starting from a lower level today. Oil-import dependence in the OECD is projected to rise from 63% to 85%; for developing countries in Asia the projected rise is from 43% to 78%. The IEA also emphasizes that the adverse economic impact of higher oil prices is more severe in developing countries, partly because their economies are generally more energy-intensive. "The loss of GDP caused by a $10 oil-price increase would average 0.8% in Asia and 1.6% in very poor highly indebted countries in the year immediately following the price increase. The loss of GDP in the sub-Saharan African countries would be more than 3%."[6] This compares to an estimated GDP loss in the OECD of 'only' 0.4%.

18. Rising fossil fuel and uranium prices not only affect the relative competitiveness of electricity generating options but can also affect supply security. Concerns about energy supply security were important in the nuclear expansion programmes of France and Japan at the time of the 1970s oil shocks, they are one of the arguments advanced in Europe today for expanding nuclear power, and they may prove an important motivation for some countries currently without nuclear power to strongly consider the possibility. Developing countries with sizable domestic fuel resources have recently begun looking at the possibility of introducing nuclear power in the 2015-2020 time frame. These include OPEC members Indonesia and Nigeria. For them the immediate impact of increased oil prices is not the same as that for oil importers, but the logic may lead in the same direction. Nuclear power can be a vehicle to increase export revenues by substituting domestic demand for natural gas (and to a lesser extent oil) with nuclear power. The additional export earnings may well finance the construction of part or all of a country's first nuclear power plants. Also some oil and gas exporters, for example Indonesia, may be interested in nuclear power as a way to reduce currently high rates of oil and gas resource depletion.

19. In sum, the best way to strengthen a country's energy supply security is by increasing the number and resiliency of energy supply options, and for many developing countries, expanding nuclear power would increase the diversity of energy and electricity supplies. Moreover, nuclear power has two features that generally further increase resiliency. The first was noted above: that nuclear electricity generating costs are much less sensitive to changes in fuel prices than are fossil-fired electricity

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[6] IEA, *World Energy Outlook 2004*, OECD International Energy Agency, Paris, 2004.

generating costs. Second, the basic fuel, uranium, is available from diverse producer countries[7], and small volumes are required, making it easier to establish strategic inventories. In practice, the trend over the years has been away from strategic stocks toward supply security based on a diverse well-functioning market for uranium and fuel supply services. But the option of relatively low-cost strategic inventories remains available for countries that find it important.

C.3. Environment

20. Environmental considerations may weigh increasingly in favour of nuclear power. Nuclear power at the point of electricity generation does not produce any emissions that damage local air quality, cause regional acidification or contribute to climate change. There are some emissions associated with plant construction and the nuclear fuel cycle (i.e. mining, enrichment, transportation, etc.). But on a per kWh basis over the lifetime of the plant these are far below emissions from fossil-fired power plants and comparable to those of wind power and biomass conversion.

21. A number of developing countries confront significant urban air pollution and associated public health problems. For them, the most important environmental benefit of nuclear power may be immediate local reduction in particulate and sulphur dioxide pollution if it replaces either old polluting fossil fuelled power plants or direct urban use of coal and other polluting fuels. Nuclear power's very low GHG emissions create less immediate environmental benefits, but they also have been cited by several developing countries as an important advantage of nuclear power. Developing countries face generally higher potential impacts from future climate change than do industrialized countries. They are often more dependent on agriculture, more vulnerable to sea-level rise and severe weather, and less able to afford expensive adaptation. However, under the Kyoto Protocol, developing countries are less able than are industrialized countries to convert nuclear power's very low GHG emissions into a monetary benefit visible to investors. The Protocol's Clean Development Mechanism (CDM), the only one of its three flexibility mechanisms open to developing countries, explicitly excludes nuclear power projects for the first commitment period, 2008-2012. In contrast, emissions trading for Annex I countries (essentially the industrialized countries) does not exclude nuclear power.

D. Prerequisites and Challenges

22. Nuclear power is an advanced technology requiring specific skills and supporting infrastructure, and it involves nuclear material that, if mismanaged, could create risks concerning public health, the environment, illicit trafficking and nuclear weapons proliferation. Nuclear power's first half century has seen the development both of international markets for equipment, fuel and services, and of international agreements designed to protect against risks. A country starting a nuclear power programme can benefit from these markets and the framework of existing agreements in resolving challenges associated with introducing nuclear power, such as establishing the legal basis, assuring a skilled labor force and industrial infrastructure, attracting investments, assuring public safety and building international confidence and support. Specific responses to these challenges in any given country will depend on that country's resources and on its goals for the use of nuclear power, ranging from simply buying electricity from a neighbour with NPPs to multiple nuclear fuel cycle facilities, e.g. fuel fabrication in addition to power generation.

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[7] See Section A.2.4 of the *Nuclear Technology Review 2006*.

D.1. Legislation

23. An initial legal framework relevant to nuclear energy exists in many countries as nearly all countries make use of sealed radioactive sources in industrial or medical applications; 64 countries have experience with research reactors; and most countries are party to one or more international agreements related to peaceful uses of nuclear energy. These include, but are not limited to, the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the Convention on Nuclear Safety, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, the Convention on Physical Protection of Nuclear Material, the Vienna Convention on Civil Liability for Nuclear Damage, the Treaty on the Non-Proliferation of Nuclear Weapons, the Code of Conduct on the Safety of Research Reactors, and the Code of Conduct on the Safety and Security of Radioactive Sources and the Supplementary Guidance on the Import and Export of Radioactive Sources.

24. National legislative requirements are to some extent indicated, e.g. in the above referenced treaties and agreements. However, a country's body of nuclear law, including both its legislative and regulatory components, should include, as described in the IAEA's *Handbook of Nuclear Law*[8], provisions for the regulatory body; for licensing, inspection and enforcement; for radiation protection; for controlling sources of radiation and radioactive material; for the safety of nuclear facilities; for emergency preparedness and response; for the transport of radioactive material; for managing radioactive waste and spent fuel; for nuclear liability and coverage; for relevant safeguards provisions and export and import controls; and for physical protection of nuclear material and facilities. It should be emphasized that each State must develop its own legislative framework based on its own situation, including its constitutional and legal framework, cultural traditions, scientific, technical and industrial capacities, and financial and human resources. Legal texts developed by other States can provide useful references as to how others have resolved issues of legislative drafting. The core approach is that the regulatory body should be independent from agencies that promote nuclear activities, and the prime responsibility for the safety of any facility rests with the operating organization[9]. The national legal environment, in terms of laws governing contracts, ownership, liability, taxes, financial transactions, and government regulation, can create advantages for effective operation of international networks and markets of nuclear equipment, fuel and services, as well as attract investment capital.

D.2. Technical and Managerial Capability

25. Other important factors are the technical and managerial capabilities of a country's workforce, institutions and industry with respect to nuclear technologies. For example, the more experience a country has in handling and regulating nuclear materials through experience with research reactors and with medical and industrial radioactive sources, the better position it is in to introduce nuclear power. Nonetheless, a nuclear power programme would require a significant expansion in the demands on the workforce, on relevant institutions and on supporting industry.

26. While no country can adopt nuclear power without an appropriate level of technical capability, it is not necessary that a country have all the skills to operate and manage all activities of a nuclear power plant when it decides to start its first nuclear power project. Although it is essential to make appropriate provisions for the human resources that will be required during design selection, bid

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[8] *Handbook of Nuclear Law*, International Atomic Energy Agency, 2003.

[9] *The Safety of Nuclear Installations*, Safety Series No. 110, IAEA, July 1993.

evaluation, licensing, construction, commissioning and operation, it may be that many of the necessary skills can be obtained from the nuclear plant supplier, at least in the first few years. At the very least, however, a country must possess sufficient knowledge to ensure safe, reliable operation and competence in regulation, operation and management of all nuclear activities. Well established organizational and management programmes are essential for developing and building up capabilities for the safe and reliable operation of nuclear power plants.

D.3. Financing

27. A principal challenge for many countries is financing. Nuclear power is a capital intensive technology with reported overnight capital costs for the designs available today ranging between about $1 500 and $2 200 per kW(e), depending on technology, unit size and location. The nuclear industry is working to reduce these costs to $1 200 to $1 500 per kW(e) over the next decade through standardization, series construction, harmonization of national safety requirements, innovation and technology learning. Still even if these cost reductions could be accomplished by 2015, a 600-1 000 MW(e) nuclear power plant would have investment costs of $720 million to $1.5 billion. For comparison, natural gas combined cycle (NGCC) power plants in a similar capacity range would cost about $350-800 million. Moreover, NGCC plants are available in smaller units than nuclear power. Thus the investment requirement for a complete NGCC project could be as small as $60 million for a 100 MW(e) unit.

28. Capital in developing countries is often scarce, and energy projects must compete for capital with other national investment needs including health care, education, transportation and industrial development. Government budgets as well as the resources of state-owned utilities are often inadequate even for small investment projects. In addition, all investments carry risks, and risks spread among several smaller projects (say ten $100 million projects) can be more attractive to investors than the risk of a single large billion dollar investment. For nuclear power, risks include cost overruns and delays during construction, unsatisfactory technical operating performance, low subsequent demand for the product (electricity) in the market place, low product prices due to low-cost competition, and unexpected changes in regulations and relevant government policies.

29. One approach to lowering the investment requirement for nuclear power is the development of commercial reactor designs that are smaller than those currently offered on the market. These are discussed briefly in the section on technology below. Smaller reactors would reduce the required initial investment and lower associated infrastructure costs; in countries with small electricity grids they would also be matched to the grid.

30. For effective investment in a nuclear power project, electricity tariffs must be high enough to cover full generating costs. Other important features are market transparency and a ‘level playing field’ with respect to alternative sources of electricity.

31. In many cases, governments attach high priority to providing affordable electricity based on their socio-political priorities. Government guaranteed long term feed-in tariffs could alleviate investor concerns about short term returns on their investments. In this case, several commercial concepts could be applied. The strategy of build-own-operate provides external financing and relieves the host country of investment risks while creating less pressure to develop the necessary local skilled labour force and infrastructure. Build-own-operate-transfer is similar, but includes the eventual transfer of the plant to the local utility or authority, including all assets and liabilities. Additional variations on these themes include the leasing of a plant or fuel.

32. In the case where a country or utility has accumulated sufficient equity or can offer sufficient collateral (e.g. based on revenues from oil and gas exports), the country can reduce its exposure to the

up-front risks of cost overruns and construction delays by arranging turnkey contracts with vendors, in which all risks are borne by the vendor until the plant is completed and connected to the grid.

33. Should fuel leasing or spent fuel take-back agreements become broadly available, these would effectively outsource spent fuel management and possibly reduce eventual waste disposal requirements and strengthen non-proliferation assurances. Although such arrangements have received increased attention recently, and although they are not unprecedented, their practical application today remains limited.

34. Additional ways to reduce costs include requiring a sizable localization factor, i.e., contributions to plant construction based on local industries and labour. These may reduce capital costs due to lower costs for labour and some material in developing countries and can reduce foreign exchange requirements. Regional or multi-country sponsorship of a nuclear project can reduce the costs and risks borne by any one country. Regional integration would have the additional advantage cited above – the creation of a larger grid allowing countries with small national grids to still take advantage of the economies of scale represented by the large units currently offered by vendors.

D.4. Technology

35. In addition to the institutional innovations discussed above, technological innovation together with persistent evolutionary improvement in current technologies, also serve to reduce the threshold that must be overcome to begin a nuclear power programme.

36. Many developing countries have existing electricity grids that are either small, unreliable, or both. This creates problems for the introduction of nuclear power. The nuclear power plant designs currently available and on the market and proven through operational experience are generally large and operate most cost-effectively as baseload plants. There are basically three approaches to the problem: increased grid reliability, bigger grids and smaller nuclear power plants. Increased grid reliability is especially important if a country wishes to introduce nuclear power. The second approach, increasing the grid size, can take the form of direct expansion of the grid, which can be expensive or impractical, or of integrating with another grid, particularly through interconnections with the electrical grids of neighbouring countries. In well integrated regions the total grid can be many times the size of a national system, providing a more secure power supply and fewer interruptions to the demand load.

37. Concerning the third approach, there are many designs for small and medium sized reactors (SMRs), some of which are likely to become available commercially within the next ten years, that could be more readily incorporated in a small grid. SMRs do not benefit from economies of scale, but lend themselves to a number of alternative approaches to reducing unit costs: system simplification, component modularisation, factory fabrication and direct site installation, the possibility of staggered construction of multiple modules, and standardization and construction in series.

38. In 2005 the Korean Atomic Energy Research Institute (KAERI) applied for a construction permit for a $1/5^{th}$ scale, 65 MW(th) prototype of a system-integrated modular advanced reactor (SMART), which ‘cogenerates’ electricity while desalinating seawater. In the Russian Federation, a barge-mounted floating 300 MW(th) KLT-40S cogeneration plant is completed and licensed for construction to begin in Severodvinsk in 2007. The 165 MW(e) pebble bed modular reactor (PBMR), developed in South Africa, is planned for demonstration at full size by 2012.

39. A number of the SMR designs being developed are in the category of ‘reactors without on-site refueling’. These are defined as reactors designed for infrequent replacement (every five to 25 years) of well-contained fuel cassettes in a manner that impedes clandestine diversion of nuclear fuel

material. The category includes factory fabricated and fuelled reactors, and the general expectation is that the supplier country would retain all back-end responsibilities for spent fuel and waste. The potential benefits include possibly lower construction costs in a dedicated facility in the supplier country; lower investment costs and risks for the purchaser, especially if the reactor is leased rather than bought; reduced obligations for spent fuel and waste management; and possibly a higher level of non-proliferation assurances to the international community.

E. International Possibilities to Facilitate the Introduction of Nuclear Power in Interested Countries

40. The nuclear reactor and fuel cycle industry today functions well and provides both choice and resiliency to its customers. However, there are several non-market disincentives, or barriers, facing countries contemplating either starting nuclear power programmes or expanding currently small programmes. These are summarized below, along with suggestions for how they might be reduced.

41. With current heightened concerns about proliferation and security, the risk of a political interruption in fuel cycle services is a disincentive for a country considering nuclear power. The December 2004 report of the UN Secretary-General's High Level Panel on Threats, Challenges and Change, the February 2005 report of the IAEA Director General's Expert Group on Multilateral Approaches to the Nuclear Fuel Cycle, and the UN Secretary-General's March 2005 report, *In larger freedom: towards development, security and human rights for all*, recommend exploring possible arrangements for assured supplies of nuclear material needed to fuel power reactors. Current discussions of assurances focus on enrichment because of its immediate proliferation risk, although some proposals to strengthen non-proliferation suggest multinational approaches to other parts of the nuclear fuel cycle as well.

42. New entrants into nuclear power also face two back-end challenges that the original nuclear power pioneers did not. First, there is a greater expectation that before introducing nuclear power a country will establish its waste solution more definitively than in the past. Second, national laws in many States prohibit the export and import of high-level waste, and precedents for the permanent export of spent fuel or high level waste are very limited. A national disposal site for a small nuclear programme could be prohibitively expensive. Implementation of cost-effective multilateral disposal options could allow more countries to benefit from nuclear power.

43. As has been noted several times, new nuclear power plants are expensive to build but inexpensive to operate, and this front-loaded cost structure is amplified for a country starting a nuclear programme. It must establish a legal structure, a regulatory structure, a spent fuel and waste management plan and otherwise build up the necessary infrastructure. To the extent any of these start-up costs could be reduced through new international arrangements, the benefits of nuclear power would become more accessible to aspiring countries. Such arrangements, implemented through the IAEA or other institutions, could provide assistance with planning, contracting, financing, training, outsourcing and public information as well as with the fuel cycle issues already discussed.