Maintaining and increasing the overall assets available to future generations.

# Nuclear Power and Sustainable Development

A central goal of sustainable development is to maintain or increase the overall assets (natural, man-made and human or social assets) available to future generations, while minimizing consumption of finite resources and not exceeding the carrying capacities of ecosystems. The development of nuclear power broadens the natural resource base usable for energy production, increases human and man-made capital, and, when safely handled, has little impact on ecosystems.

Today, nuclear power is mostly utilized in industrialized countries that have the necessary technological, institutional and financial resources. Many of the industrialized countries that are able and willing to use nuclear power are also large energy consumers. For them, it is particularly appropriate to apply their high-technology assets to put uranium resources to productive use, thereby conserving finite resources for other countries and for future generations. Their development of nuclear power assures that future generations, including those in currently developing countries, will find the nuclear option also open to them.

Energy is essential for sustainable development. With continuing population and economic growth, and increasing needs in the developing world, substantially greater energy demand is a given, even taking into account continuing and accelerated energy efficiency and intensity improvements.

Electricity demand will grow even faster, based on long term trends in final energy use away from solid and liquid fuels. Electricity is simply cleaner, more flexible and more convenient for consumers. In many applications — information technologies for example — it is essential.

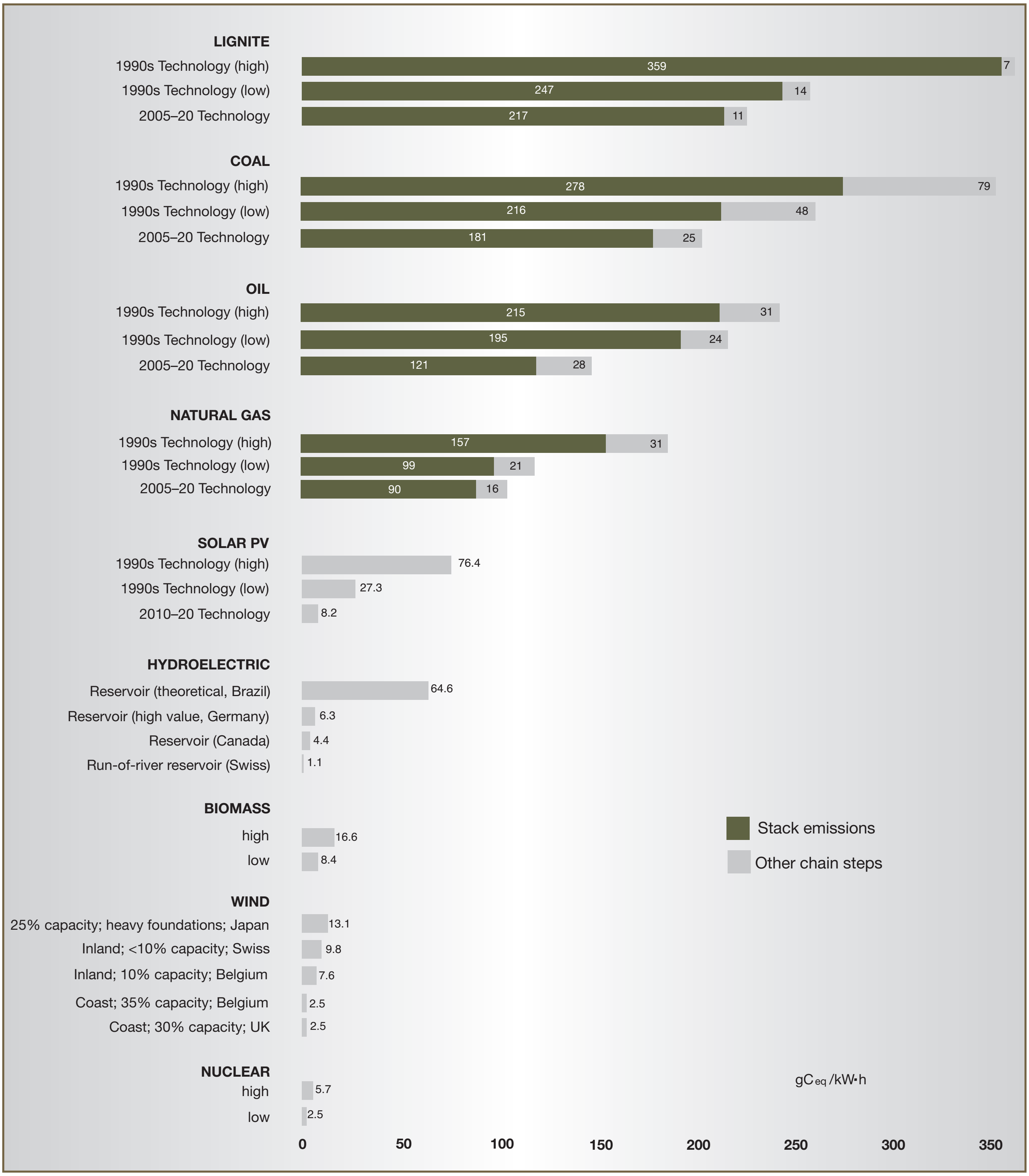
Nuclear power currently generates 16% of the world's electricity. It produces virtually no sulfur dioxide, particulates, nitrogen oxides, volatile organic compounds (VOCs) or greenhouse gases (GHGs). The complete nuclear power chain, from resource extraction to waste disposal including reactor and facility construction, emits only 2–6 grams of carbon equivalent per kilowatt-hour ($gC_{eq}$/kW·h). This is about the same as wind and solar power including construction and component manufacturing. All three are two orders of magnitude below coal, oil, and natural gas (100–360 $gC_{eq}$/kW·h).

Globally, nuclear power currently avoids approximately 600 million tonnes of carbon (MtC) emissions annually, about the same as hydropower. The 600 MtC avoided by nuclear power equals 8% of current global GHG emissions. In the OECD countries, nuclear power has for 35 years accounted for most of the reduction in the carbon intensity per unit of delivered energy.

Existing operating nuclear power plants (NPPs) for which initial capital investments are largely depreciated are also often the most cost-effective way to reduce carbon emissions from electricity generation. In fact in the United States in 2000, NPPs were the most cost-effective way to generate electricity, irrespective of avoided carbon emissions. In other countries the advantages of existing nuclear generating stations are also increasingly recognized. Interest has grown in extending NPP operating life-times and actual licensed life-time extensions of up to 60 years are already a reality.

New NPPs have been more expensive to construct than fossil alternatives, particularly gas-fired plants. Where coal is available nearby or necessary natural gas infrastructures exist, new coal- or gas-fired power plants have generally lower electricity generating costs than new NPPs. In liberalized energy markets that emphasize short pay-back periods, the high capital costs of NPPs and long pay-back periods are an important disadvantage relative to fossil-fueled — particularly gas-fired — power plants. However, recent increases in gas prices have narrowed the margin for natural gas.

If gas prices continue to rise, the advantage of low and stable nuclear fuels costs will make NPPs increasingly




*The range of total greenhouse gas emissions from electricity production chains (Source: Spadaro, Joseph V., Lucille Langlois, and Bruce Hamilton, 2000: "Assessing the Difference: Greenhouse Gas Emissions of Electricity Generating Chains", IAEA Bulletin, Vol. 42, No. 2, Vienna, Austria).*

competitive. And, irrespective of fossil fuel price expectations, new NPPs continue to be built and planned in a number of countries that have limited fossil fuel resources (such as Japan, the Republic of Korea and several Eastern European countries); that require long-distance fuel transportation (e.g., India and China); that give high priority to energy supply diversity and security, to technology development, and to emission reductions (e.g., Finland); or that wish to export particularly natural gas resources for cash (e.g., Russia).

For the future, technological progress can be expected to reduce NPP costs along with the costs of renewables and advanced fossil fuel technologies as each competes with the other. The best way to assure cost-effective electricity production is to continue to liberalize electricity and energy markets. Well-designed market liberalization promotes cost reductions and allows different markets to be served by the most appropriate technologies — more solar and wind power where it is sunny and windy, and more large centralized generation where energy densities are high, as in cities and mega-cities.

Fair markets are also the best way to assure cost effective GHG reductions. The sooner a clear, predictable, unbiased market for GHG reductions is established (without prejudice for or against nuclear power, or any other alternative), the greater the incentives for near term cost-effective investments in GHG reductions.

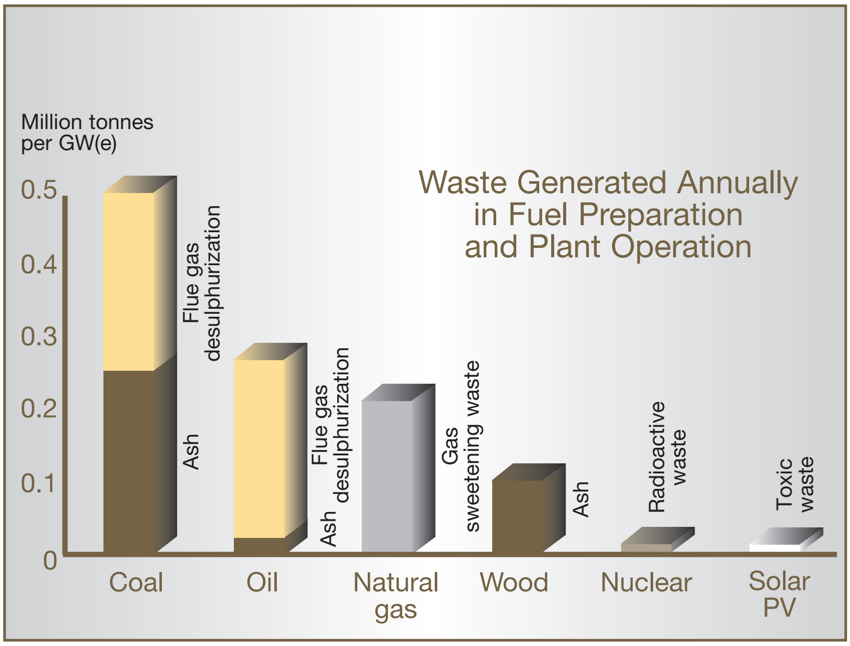
Sustainable development will require steady progress toward internalizing all environmental and life-cycle costs associated with energy production and use. Nuclear power today has already internalized costs to a greater extent than alternative technologies. Current nuclear electricity costs in most countries incorporate all safety costs throughout the fuel chain, the costs of eventual NPP decommissioning and the costs of waste management including disposal of low, intermediate, and high level waste.

Waste minimization is a central tenet of sustainable development. Unlike the solid and toxic waste produced by other fuel chains, the solid waste produced by NPPs is small in volume, well confined and highly monitored.

Final repositories for low level radioactive waste from NPPs, medical, research, and other applications have been licensed and are already in operation in many countries. High level waste is more controversial. Although the scientific and technical communities generally agree that high level wastes can be disposed of safely in stable geologic formations now, there is also time to work out broadly acceptable solutions assuring full public participation. Spent fuel from NPPs has been safely stored for decades at reactors and interim storage sites. With some moderate modifications, these can provide needed storage for many years if necessary, allowing time to thoroughly work out publicly accepted long term solutions.

The process of siting a high level waste disposal facility is most advanced in Finland, Sweden and the United States. In Finland, the Government has approved, and the Parliament has ratified, a decision “in principle” for a final repository for spent fuel in a cavern near the nuclear power plants at Olkiluoto. Separate construction and operating licenses, issued by the Government, will be required. Construction would start in 2011 and operation about ten years later. In Sweden, two of six original candidate communities have been selected for, and have agreed to, detailed geological investigations. These should run for five or six years. The Swedish nuclear fuel and waste management company, SKB, hopes to make a final site proposal by about 2007. In the United States, the Waste Isolation Pilot Plant began receiving military transuranic waste for permanent disposal in 1999. For waste from NPPs, the US Department of Energy determined in May 2001 that the proposed Yucca Mountain disposal site meets new radiation standards set by the Environmental Protection Agency. In February 2002, the White House approved proceeding with Yucca Mountain. In May and July, the two houses of Congress voted their concurrence.

On balance, the safety record of nuclear power is second to none, and the philosophy is one of continual improvement. Substantial technical and institutional improvements in response to the industry’s two major accidents, Three Mile Island in 1979 and Chernobyl in 1986, have been thoroughly diffused throughout the industry. The broad acceptability of current reactor safety levels is attested to by the approval that they have received in practice — in the US about 100 NPPs have been providing approximately 20% of the electricity supply since the 1980s; in Western Europe about 150 NPPs provide approximately 30% of the electricity; in France 59 NPPs provide 77% of the electricity.




Effective safeguards against nuclear weapons proliferation and terrorism are required as long as nuclear technologies generate, or can be used to generate, weapons-grade fissile material irrespective of whether the material is used for NPPs, medical, agricultural or other peaceful applications. The Treaty on the Non-Proliferation of Nuclear Weapons (NPT), extended indefinitely in 1995, is at the center of the international non-proliferation regime. Other components of the regime are the Convention on the Physical Protection of Nuclear Material and nuclear-weapon-free zones in different parts of the world. Growing adherence to Additional Protocols, which build on the NPT and other safeguards agreements, further strengthens the regime. Such agreements are critical whatever the future of civilian nuclear power, and efforts to strengthen them will advance the cause of non-proliferation much more than restrictions on nuclear power.

Improvements in operational practices, engineering support, strategic management, fuel supply, and spent fuel disposition — motivated in part by increasingly liberalized electricity markets — have reduced costs, improved safety and led to steady increases in NPP availability factors. The cumulative impact has been substantial — since 1990 availability factors have increased by an amount equivalent to building 33 GW(e) of new capacity, i.e., 33 new NPPs of 1000 MW(e) each.

Evolutionary performance improvements will continue in NPPs and the nuclear fuel cycle, as they do for all technologies. But for the longer term expansion of nuclear power's contribution to meeting growing global energy needs, it will be important to develop distinctive new innovative NPP and fuel cycle designs characterized by significantly improved economics, better resource utilization, minimization of radioactive waste, furtherance of non-proliferation objectives (i.e., ensuring that nuclear materials cannot easily be diverted for non-peaceful objectives) and enhancement of safety through technological processes and engineered barriers. To speed innovation, the International Atomic Energy Agency (IAEA) has established a new International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). INPRO complements and extends other national and international initiatives on new innovative designs to advance economic competitiveness, safety, waste management, and proliferation resistance.

Currently nuclear power is most suitable for electricity production, as are hydro, wind, and solar power. However, technological progress is likely to make possible the eventual cost-effective production of chemical fuels, including hydrogen, from all these sources. They could thus help meet transportation energy needs now largely met by oil. Nuclear power plants, whose comparative advantage is base-load electricity production around the clock, would be well suited to producing, while the cities sleep, the hydrogen transport fuel to keep them moving the next day.

Finally, nuclear power might also be extensively used in the future for seawater desalination, thereby helping to address another pressing challenge of sustainable development — the provision of plentiful, safe, and secure supplies of clean fresh water for a growing global population.

The choice of technologies to advance sustainable development in any given country is a sovereign choice, and each country will need a mix of technologies suited to its situation and needs. Given the advantages of nuclear power in contributing to sustainable development objectives, it should be an important part of the mix in many countries. The essence of the Brundtland Report's definition of sustainable development is the importance of expanding possibilities and keeping options open — not foreclosing them for future generations. In line with the Agenda 21 principle of differentiated responsibilities among countries, those countries who are able and willing have a particularly important role to play in keeping the nuclear option open, broadening the resource base, reducing harmful emissions, expanding electricity supplies, and increasing the world's technological and human capital.

More information is available on the Agency's WorldAtom website:
*http://www.iaea.org/worldatom/Programmes/Energy/pess/pessindex.shtml*

For additional information contact:

Mr. Alan McDonald
Planning and Economic Studies Section
Department of Nuclear Energy
International Atomic Energy Agency
Wagramer Strasse 5, P.O. Box 100
A-1400 Vienna, Austria
Tel: +43-1-2600-22650
Fax:+43-1-2600-29598
E-mail: A.McDonald@iaea.org

International Atomic Energy Agency Information Series
Division of Public Information
02-01574 / FS Series 3/01/E/Rev.1