Nuclear Energy: Safe, Clean, and Affordable

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In these days of climate change and energy crisis, it's too bad that the word "Nuclear" has a connotation that brings back memories about the nuclear disaster of Chernobyl and the near miss of Three Mile Island. People are rightfully scared of potential accidents and the proliferation of nuclear weapons even though it has been proven that those accidents were the result of mismanagement. Over the last few decades nuclear plants have proven to be reliable and have in general a superb safety record. It is critical to note that nuclear plants have the capability to generate an incredible amount of clean and non-polluting energy which could be instrumental in mitigating the current global crisis of carbon dioxide (CO_2) emissions drastically, if not entirely. Perhaps the question should be asked: Is nuclear power worth a serious look?

The international community for nuclear energy is well aware of the atrocious affects of nuclear accidents and it has invested unprecedented efforts on preventive and safety measures to make sure that nuclear plants around the world are safe and reliable. As part of its regular programme of work but also its 21 international joint projects, the Nuclear Energy Agency (NEA) which is a part of the Organization for Economic Cooperation and Development (OECD) continually strives to help ensure that nuclear energy remains safe, clean and affordable. Its work as Technical Secretariat of the Multinational Design Evaluation Programme (MDEP) and the Generation IV International Forum (GIF) also contributes to this goal. Under the MDEP, nuclear regulators are aiming to enhance safety worldwide through increased co-operation, aiming in particular at improving the efficiency and the effectiveness of the design review process and at achieving greater convergence of regulatory practices. The GIF is looking to develop Generation IV reactors with improved sustainability, economics, safety and reliability, proliferation resistance and physical protection.

It is a most common and accepted practice that most countries with operating nuclear plants have active programmes to develop disposal facilities for high-level nuclear waste. It was reported that these programmes have made significant technical progress in the past 20 years in identifying suitable sites and procedures for safely isolating radioactive waste from the environment. There is a wide agreement among scientists that geological isolation is the best method to dispose of high-level and long-lived wastes. Most governments have adopted this approach.

As a result of all these international efforts, things are starting to look better for the nuclear industry from a safety point of view. The NEA projects that nuclear energy capacity is set to increase by as little as 55% and as much as 375% between now and the middle of the century. To achieve this increase, a growing number of reactors will need to be built from now until 2030, followed by an average of 23 to 54 1000 MWe reactors

per year (low and high scenarios) between 2030 and 2050. It was stated that these construction rates are fully compatible with the historical building experience of the 1970s and 1980s.

According to a report, as of July 2008, there were more than 430 operating nuclear plants in 31 different countries around the world and together they provided about 15 percent of the world's electricity in 2007. Some of these countries depend more on nuclear power than others. For instance, in France 77 percent of the country's electricity comes from nuclear power; Lithuania comes in second, with an impressive 65 percent; and in the United States, 104 nuclear power plants supply 20 percent of the electricity overall, with some states benefiting more than others. The irony of course is that no nuclear plants have been built in the US in decades.

It was reported by the Nuclear Energy Institute, that the power produced by the world's nuclear plants would normally produce 2 billon metric tons of CO_2 per year if they depended on fossil fuels. In fact, a properly functioning nuclear power plant actually releases fewer radioactivities into the atmosphere than a coal-fired power plant. By not depending on fossil fuels, the cost of nuclear power also isn't affected by fluctuations in oil and gas prices.

Tom Terbush of the Electric Power Research Institute stated that a typical nuclear generating unit can produce enough power for nearly a million homes.

Here is an indication of current global interest in nuclear energy:

- The Indian Prime Minister's recent visit (November 25, 2009) to Washington was to tie up the details of the highly important and quintessentially symbolic bi-national nuclear cooperation agreement. Accordingly, India is planning to build an additional seven nuclear power plants by 2020 and access to American nuclear technology is key to India's plans. India, is reported to be concerned about the mushrooming demand for electricity,and in addition to building the current reactors, it has a further 23 nuclear plants on the drawing boards to add to its existing 17 plants, according to industry group the World Nuclear Association;
- At the same time, the central government in China is backing ambitious growth in their nuclear plans and has 20 nuclear plants under construction. They will have built another 32 new plants by 2020, and the long range plan is to have 300 more nuclear plants by 2050; and
- As far as France is concerned, they are planning to meet their total electricity needs with nuclear power in the next few years and this is going to help them with a daunting target of slashing its carbon dioxide emissions by 75 percent by the year 2050.

According to a report published by OECD, with a growing number of countries planning to build new nuclear reactors, under the MDEP, national regulatory authorities are aiming at increasing the protection of the public and the environment. In particular, through this enhanced co-operation, regulators will improve the efficiency and effectiveness of the design review process and will increase convergence of regulatory practices.

The nuclear regulators of ten countries, including Canada, China, Finland, France, Japan, Korea, Russia, South Africa, the United Kingdom and the United States, are participating in the MDEP. The NEA is the Technical Secretariat for the programme. The International Atomic Energy Agency (IAEA) also takes part in MDEP activities.

The main use of nuclear energy is to generate electricity and indeed the demand for electricity is growing palpably. According to the OECD World Outlook 2008:

- From 1980 to 2006 total world primary energy demand grew by 62%, and to 2030 it is projected to grow at a slightly lesser rate (45%, average 1.6% per year, from 491 EJ to 712 EJ). Electricity growth is even stronger, and is projected to almost double from 2006 to 2030 (growing at average 2.6% per year from 18,921 TWh to 33,265 TWh). Increased demand is most dramatic in developing countries. Currently some two billion people in the world have no access to electricity, and it is a high global priority to address this lack;
- With the United Nations predicting world population growth from 6.5 billion in 2006 to 8.2 billion by 2030, demand for energy must increase substantially over that period. Both population growth and increasing standards of living for many people in developing countries will cause strong growth in energy demand, expected to be 1.6% per year, or 45% from 2006 to 2030; and
- The 2006 edition of this report demonstrates that nuclear power could make a major contribution to reducing dependence on imported gas and curbing CO2 emissions in a cost-effective way, since its

uranium fuel is abundant. However governments must play a stronger role in facilitating private investment, especially in liberalized electricity markets where the trade-off between security and low price has been a disincentive to investment in new plant and grid infrastructure. The 2008 IEA report said that investment of US$ 26 trillion is required by 2030 under the reference scenario, and $6.5 trillion more under an alternative low-carbon energy scenario. Under this, nuclear capacity increases 85% to 680 GWe and energy demand reduces by some 10% and CO2 emissions reduce by 27% compared with 2006. Of the $26 trillion amount, $13.6 trillion is for electricity: about half for generation and the rest for transmission and distribution.

It was also reported that apart from nuclear being virtually carbon-free, it points out that energy security is enhanced due to nuclear fuel's high energy density, which means that transport is less vulnerable and storage of large reserves is easy.

The main resource for generating nuclear energy is uranium, a material for which there is little other use.

Here are the characteristics of uranium according to World Nuclear Association:

- Uranium is a very heavy metal which can be used as anabundant source of concentrated energy;
- It occurs in most rocks in concentrations of 2 to 4 parts per million and is as common in the Earth's crust as tin, tungsten and molybdenum. It occurs in seawater, and can be recovered from the oceans;
- It was discovered in 1789 by Martin Klaproth, a German chemist, in the mineral called pitchblende. It was named after the planet Uranus, which had been discovered eight years earlier;
- Uranium was apparently formed in supernovae about 6.6 billion years ago. While it is not common in the solar system, today its slow radioactive decay provides the main source of heat inside the Earth, causing convection and continental drift;
- The high densit**y** of uranium means that it also finds uses in the keels of yachts and as counterweights for aircraft control surfaces, as well as for radiation shielding; and
- Its melting point is 1132°C. The chemical symbol for uranium is U.

Like other elements, uranium occurs in several slightly differing forms known as 'isotopes'. These isotopes differ from each other in the number of particles (neutrons) in the nucleus. Natural uranium as found in the Earth's crust is a mixture largely of two isotopes: uranium-238 (U-238), accounting for 99.3% and uranium-235 (U-235) about 0.7%.

There is enough uranium known to exist to fuel the world's fleet of nuclear reactors at current consumption rates for at least a century, according to the latest edition of the world reference on uranium published recently.

Based on official information gathered from 40 countries, Uranium 2007 - Resources, Production, and Demand, provides a comprehensive review of world uranium supply and demand as of 1st January 2007. Here are some highlights:

- The uranium market has demonstrated recent strength, with major new investments and expenditures for exploration increasing more than 254% over the two-year period from 2004-2006. Over $774 million was spent globally on exploration in 2006. While global production dipped by 6% from 2005-2006, significant production increases were noted in Kazakhstan and the US;
- The demand picture is increasingly complex, with significant nuclear power builds underway in China, India, Korea, Japan and the Russian Federation, and phase-out programmes underway in several European countries. Yet the report notes that new builds along with plant life extensions should increase global installed nuclear capacity in the coming decades, thereby increasing demand for uranium. Projections for 2030 indicate a range of expected growth in demand from a low estimate of 38% to a high case of roughly 80%; and
- In contrast to some other energy resources such as oil, the geographical distribution of uranium resources remain quite varied. Currently uranium is mined in 20 countries, with Iran being the latest entrant. Canada and Australia currently account for 44% of global uranium production, and other top uranium producers are Kazakhstan (13%), Niger (9%), Russian Federation (8%), Namibia (8%), Uzbekistan (6%), and the United States (5%).

The bottomline is that in spite of investing billions of dollars on the development and promotion of renewable technologies for years, it is utterly disappointing that only 2 percent of world's total electricity is met with

renewables whereas nuclear energy is meeting 15 percent of the total electricity needs in the world. It is abundantly clear from various reports that the global population is growing at an alarming rate which will continue to generate a massive demand for electricity and the combination of efficiency, conservation, and renewables may not be enough to meet the future electricity demand with clean energy. Maybe the obvious and sane option that is available for the world is to further capitalize on the enormous potential of nuclear energy in order to bridge the global gap between the supply and demand of clean energy. Incidentally, this will require people around the world to overcome the conscious or unconscious fear associated with the safety of nuclear plants and invest munificently into nuclear energy as governments alone may not be able to keep up with the investment opportunities for this industry.

The good news is that clean energy will not only help protect the environment and improve the quality of human lives but it will also help create new jobs for a sustainable global economy.

This is the first introductory article of a series of articles that Dr. Ali will be writing as a result of his research on the subject of nuclear energy.