Keynote Address

SUSTAINABLE DEVELOPMENT AND NUCLEAR TECHNOLOGY

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The development in the world today is closely linked to development of new technologies and their maturation as industry. The industrial revolution, from the seventeenth to the nineteenth century, gave birth to the steam engine, textiles, printing press, etc. Countries that underwent this industrial revolution became developed, as machines took over some of the work from man; while countries that did not undergo industrialization remained underdeveloped and agrarian. This Industrial revolution had no direct linkage with science. However, the new technologies of the twentieth century were knowledge-based. Examples of these are: Nuclear technology, Space technology, Biotechnology, Information technology etc. Moreover, development in each new technology benefits other contemporary technologies; in fact, they reinforce one another. Furthermore, new technologies help generate knowledge, which further breeds newer technologies, thus leading to an explosive growth, both in science and in technology. Thus, there is a synergy in knowledge and technology. As no knowledge can be acquired as a black box, therefore new technologies also cannot be acquired as black boxes. For adoption and absorption of technology, a certain indigenous capacity is needed in the form of appropriate human development and S&T infrastructure. Each modern technology has an impact on all sectors of development, such as agriculture, human health, water resources, energy, etc.

For countries of the South, the problems of development extend far beyond the issues of economic strategy alone. Market forces that promote particular science and technology in the developed country do not exist in poor countries. There is a dearth of science and technology that is crucial to addressing the critical problems of countries of the South; science and technology in the South is generally both too little and too weak. Furthermore, there is an absence of informed and sound decision-making.

Some fundamental changes in outlook are needed, both in areas of science and in economic planning, for ensuring sustained development. Development requires the national economic plans to be intertwined with corresponding science and technology plans. The laboratory scientist, as well as technologist, has to learn business management, while the economist has to be aware of realistic potential of various new S&T applications. Scientists and technologists have to reach out to build partnerships with entrepreneurs in the private sector. World-wide strategic planning, by integration of the real human needs with the applications of science and technology, has to be undertaken to map a path across the fast-changing global scenario.

The concept of sustainable development has been elaborated in the Brundtland Commission report (1987). This report defines sustainable development as “the development that meets the needs of the present, without compromising the ability for the future generation to meet their own needs”. The major elements of development are food-security, sufficient availability of clean water, proper health-care, clean air and reliable energy-supply at affordable price, while ensuring the graded shift from agrarian to industrial economic strategies.

Nuclear Technology has the ability to contribute in a significant manner to all issues of development – indeed as a sustainable development. Let us now see in detail how nuclear technology can contribute to the sustainable development. Nuclear technology may be broadly divided into nuclear power applications and nuclear non-power applications. We will first take up the non-power applications. These applications are mainly in the fields of food and agriculture, medicine and health, water resources and industry, all of which are essential components of sustainable development.

NON-POWER APPLICATIONS

Agriculture and Food Security

Radiation-induced mutations produce better crops, which give high yields, are early maturing, have

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improved resistance to drought, salinity and/or to disease and insect-attack. There are now over one thousand, radiation-induced mutated crops in use, around the world and more are constantly being added. Nuclear Insect Sterilisation Technique (SIT) has been used extensively in Africa to eradicate the Testse flies; in the Mediterranean region, the Mediterranean fruit flies have also been eradicated through this technique, thus not only saving money but also protecting humans from the harmful effects of pesticides.

Radiation is being used in China and several other countries to preserve food, by eliminating bacteria and pathogens that can cause disease and even death. This technique has good potential, as it also protects users and the environment from the harmful effects of chemicals that are presently being used in fumigation of food. As Ozone depleting fumigation chemicals are banned, this irradiation technology has the potential to become increasingly indispensable for trans-boundary trade in agricultural products, as countries adhere to standards of food hygiene.

For sustainable agriculture, it is important to get the maximum benefit from agricultural inputs, such as fertiliser and water. Here, again, nuclear techniques are finding increased use in determining water and fertiliser-uptake, thus optimising their use. These techniques are also being used for mapping of micro-nutrients in the soil.

As far as Pakistan is concerned, agriculture is the mainstay of the country. Nuclear techniques are supplementing the efforts of the conventional agricultural research, e.g. nuclear techniques used in mutation-breeding have resulted in producing improved varieties of cotton, wheat, chickpeas, mungbeans and rice.

Salinity is a major problem in the canal-irrigated areas of Pakistan. Here, Isotope hydrology, in conjunction with biotechnology, can provide economic utilisation of saline soils. Pakistan Atomic Energy Commission's highly successful programme of reclaiming saline soil has received the support of the International Atomic Energy Agency (IAEA). An inter-regional IAEA model-project has initiated joint efforts with seven other countries, namely Morocco, Tunisia, Egypt, Syria, Iraq, Iran and Myanmar, for reclamation and utilisation of water-logged and saline wasteland.

Human Health and Medicine

Caring for human health is an essential component of sustainable development. Nuclear techniques are finding increased use in diagnoses and treatment of diseases. Nuclear medicine techniques are indeed powerful diagnostic techniques. Over ninety percent of all the produced radioisotopes are used in the area of health. Isotopes are also being used in nutrimental studies to track the intake of vitamins and other nutrients. Production of Radio-pharmaceuticals is increasing throughout the world, to meet an increasing demand. Radiotherapy is now an established technique for treatment of cancer. Its use will increase, as cases of cancer are increasing rapidly in the developing world. Another important use of nuclear technology is in sterilisation of medical products. A gamma-irradiation facility for sterilization of medical products, called Pakistan Radiation Services (PARAS), is currently running as a profitable commercial enterprise.

Water Resources

There is an increasing awareness in the world that fresh water is a precious and limited resource. All over the world, and in Pakistan, groundwater aquifers are shrinking due to over-exploitation, or are being lost due to degradation of water-quality from pollution caused by human activity. World-wide, the demand for water is increasing due to increase in population and higher standards of living. Global warming will put additional and increasing demands on water-requirements. Sustainable management of freshwater resources requires appropriate technologies. Isotope techniques, based on stable and radioactive isotopes, as well as radioactive tracers, offer effective tools for assessment and development of water-resources.

Isotope Hydrology is now being utilised in several areas, such as exploration and assessment of ground-water resources, especially in arid areas, surface and ground-water pollution, modelling of dynamic-

processes affecting the movement of ground-water, surface-water, and precipitation, origin of salinity and impact on ground-water and assessment of geothermal resources, to name a few. One success story of isotope-hydrology is the study of Arsenic contamination of groundwater in Bangladesh. The problem of water-continuation by naturally occurring Arsenic confronted the government, and Isotope-hydrology was the only tool which could identify the source of water in different aquifers and thus identify safe aquifers. Sediment and seepage-tracing, through isotope techniques, is being used to study dam-stability and calculations of its life.

Global warming is now an established phenomenon. Investigation of atmospheric processes at micro and macro-scales is required to accurately predict future world-temperature and weather. Isotope techniques are now being used in investigation of precipitation and atmospheric processes; they are also being used in Paleoclimatic studies.

Industry

Non-destructive Testing (NDT) is an integral part of quality-control and quality-assurance requirement in a modern industrial plant. Nuclear NDT services are being used in a number of industries, including oil-refineries, fertiliser and other chemical plants, hydroelectric as well as thermal power-plants. Nuclear analytical techniques are used in laboratories for quality-assurance. Radiotracers and Nucleonic Control Systems are also finding use in industry.

NUCLEAR POWER GENERATION

Nuclear power-plants are operating in 30 countries around the globe. Sixteen percent of the world's electricity is now being generated through nuclear reactors. There are 438 operating nuclear plants running, safely in the world. The Key-factors for sustainability of any power option are sustainable supply of fuel, compatibility with environment and long-term economic viability. The long-term availability of different fuels is listed below:

Table - 1: The Long-Term Availability of Different Fuels

Uranium (once through)	150 years
Oil	40 years
Gas	60 years
Coal	200 years
Breeder Reaction	1000 years
Thorium Cycle	Several thousand years

It is obvious that, barring coal, no other fuel has any long-term sustainable supply opportunity. In comparing the pollutionability, we note that Coal is the most polluting, followed by oil, and gas, the nuclear cycle being the least polluting, as shown in the Table below:

Table - 2: GHG Emissions from Electricity-Production Chains (GCeq /kWh)

Nuclear	2.5-5.7
Wind Power	2.5-13.1
Large Hydro	4-6
Solar PV	27-76
Natural Gas	120-188
Oil	219-246
Coal	264-357

Long-term economic viability requires long plant-life and high plant-factor. The life of nuclear plants is being extended all over the world, especially in the USA, where there is a program to double the life of the plants. Plants-factors of up to 90 % are being achieved in Finland. Economic viability also requires security of supply; this is also in favour of the nuclear option.

Some negative aspects have been cited by the opponents of nuclear power; these are:

- Radiation effect;
- Safety and severe accident aspects;
- Nuclear-waste management and storage; and
- Proliferation.

We now discuss these, one by one:

Radiation is a fact of everyday life. On the average, natural radon gas accounts for 49% of radiation-exposure to humans, 40% exposure is due to cosmic radiation; only 11% is human-induced, almost entirely due to medical exposure. Serious environmental consequence of Chernobyl accidents compared to Three Mile Island (TMI) shows the importance of containment. Now, all new power-plants have measures for containment, even the Chernobyl type. There is also a large accumulated operational experience of over 9,000 reactor-years of operation, with remarkable lack of problems. No other large-scale technology, used world-wide, has a comparable safety record.

As far as nuclear waste is concerned, the quantities in question are remarkably small, relative to other industries. Small quantities permit containment strategies. If no reprocessing of spent fuel is done, the fuel can easily be kept in dry storage. If reprocessing is required, there are a number of technologies available; such as verification, cementation, etc. These are available in individual countries. Eventually, waste will be stored in deep underground storage-facilities, to prevent the radiation from affecting humans and entering the food-chain. As far as nuclear proliferation is concerned, nuclear power-plants are not essential for proliferation of nuclear weapons: the five original nuclear weapon states first developed nuclear weapons and then built nuclear power plants:

To summarise, world population is likely to keep growing for several decades yet, so the energy-demands will increase even faster. Renewable energy resources cannot provide most of these demands. Security of energy supplies is essential for sustainability. On all these counts, nuclear power has an edge over other power options. The future of nuclear power will, of course, depend on a number of factors, such as safety-record and public perception and awareness.

CONCLUSIONS

I wish to return to climate changes. The developed and the developing world have various divides, such as income divide, science divide and digital divide. There also is a climate divide. Poor countries, in general, constitute the tropical and arid impoverished regions of the world, while the rich countries are in the temperate region.

The anthropogenic climate-change, which is underway, is likely to impact far more heavily on the already poor world, than on the rich world. It is, therefore, of paramount importance for us to keep a close watch on the Global climate-change and gear ourselves to meet the new challenges.

Speaking of globalisation, it is becoming more and more apparent that the poor countries will remain in a disadvantageous position if globalisation remains restricted to trade. Globalisation should also provide equal opportunities by way of access to knowledge and skills. What is needed is a universal political will around the globe, to address the prevailing asymmetries and to promote knowledge-sharing as well as a sense of responsibility to use science and technology for peace and development.

Finally, the South will have to work together closely for sustainable development and alleviation of poverty, as the countries in the North will remain reluctant to address the real needs of the poor. In the light of this, initiatives such as the one taken by COMSATS deserve full support from all quarters.