

# ENVIRONMENTAL CHALLENGES AND OPPORTUNITIES FOR THE DEVELOPING COUNTRIES

## ABSTRACT

*Environmental degradation and issues of climate change have attracted world's attention during the past several decades. Both rich and poor nations are prone to the adverse socio-economic consequences of environmental deterioration and Global Warming. But the poor and developing countries suffer much more than the developed ones. Due to economic compulsions and technological constraints, a large number of developing countries is unable to take firm policy-decisions for quick actions to address the climate and environment-related problems. Most of the challenges in this regard are specific to the developing countries. This article identifies some of these challenges, which pertain to conceptual uncertainties, energy scarcities, disappointment with the multilateral initiatives, weak international cooperation and lack of global direction for the future action. However, some opportunities have also been envisaged despite these challenges. As a major opportunity, the case of nuclear power has been highlighted, which has the potential to address the climate-related problems with appreciable advantage over other carbon emitting energy sources. The role of renewable energy technologies in mitigating carbon dioxide emissions is also important, although these technologies still require further technical advancement and commercial acceptability.*

*International mechanisms to manage nuclear power on global level have good prospects in the future. Policy perceptions for a consensual, legally binding and sustainable post Kyoto Protocol agreement have also been treated with reference to the requirements of the developing countries. The conclusions re-emphasize the need of collective global action against the climate change, on urgent basis, and more proactivity on the part of developing countries to draw benefits from the post-Copenhagen negotiations. Developed countries need to enhance cooperation with the developing countries in capacity-building through transfer of technology and financial assistance.*

## 1. INTRODUCTION

During the past several decades, two main issues of socio-economic importance have attracted extensive international attention. These are sustainable development and the environmental degradation. The emergence of both these issues at the world scene was primarily due to the social, economic, political and

security imperatives, which had surged, partly as a consequence of the two world wars and rapid decolonialization. Both the issues are deeply interconnected and universal in nature. They cannot be addressed separately or by compartmentalized policy approaches, as was perceived in the early years of the debate. Environment constitutes an essential component of any policy or strategy dealing with sustainable socio-economic development.

A lot has been said and written about the environment and its relationship with the well-being of human society. Mankind is well-aware of the fact that an unhealthy environment is a major obstacle to achieving social and economic progress, happiness and peace in the world. It is also sadly acknowledged that Earth's environment, as a whole, is being degraded at an alarming rate without much convincing prospects of its early addressal or retrieval. The world is mainly engaged in endless rhetoric rather than decisive actions to mitigate the widespread devastation of the planet that may occur due to the casual attitude of its inhabitants.

Among so many negative consequences of the continued environmental deterioration the most harmful for the entire planet is thought to be the climate-change, which is attributable to Global Warming. Scientists have shown that Earth's atmosphere and oceans are becoming increasingly warm due to increased concentrations of emitted carbon dioxide, methane, oxides of nitrogen and chlorofluorocarbons, commonly known as greenhouse gases (GHGs). These GHGs are thrown into the atmosphere as a result of human activity, like burning of fossil fuels, certain agricultural practices and widespread use of cryogenic appliances.

Awareness campaigns all over the world have made Global Warming and climate-change very commonly used terms. People believe that most of the natural calamities and erratic weather patterns are due to climate change, pollution and other adverse effects of the environmental degradation. This is indeed a positive development as far as general awareness is concerned, as both rich and poor countries are becoming increasingly conscious of the negative influence of the climate change on their lives. They are more motivated to act and to contribute to the remedial schemes prescribed by the governments, NGOs and other concerned stake-holders.

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## 2. THREATS AND PROMISES

The harmful effects of climate change affect every one on this planet, but the people of poor and developing countries bear the brunt. The rich nations, using their abundant intellectual, economic, political and technical resources, can deal with climate related problems much more efficiently and easily than the resource-starved poor nations. The irony is that the rich nations have been, and still are, the biggest contributors towards world's pollution and carbon dioxide emissions, but they demand sacrifices from the poor and developing countries to mitigate the effects of Global Warming. However, due to global nature of climate change, both rich and the developing countries are now equally obliged to listen to each other for sharing the climatic burden. In this context, the time has come when Nature itself will force both the developed and the developing countries to come to the negotiating table and agree on sensible decisions that are necessary for future course of action.

However, the developing countries must realize that they will suffer much more than the developed countries due to the adverse consequences of unabated climate change, if they do not re-align their national policies with the forthcoming opportunities of international cooperation aimed at ameliorating the global climate. With this cooperation, many existing challenges for the developing countries may very likely change into opportunities, providing them benefits, such as access to higher scientific and technical knowledge, better industrial capacities, transfer of sophisticated technologies, stronger commercial interactions, chances of more patents, enhancement in communication capacity, better vocational training facilities, all leading to stronger economies and higher standards of living. The most profitable occasion to create such an international cooperation will be the post Copenhagen negotiations, leading to the extension of Kyoto Protocol which is to expire in 2012.

## 3. PRESENT POSITION OF THE DEVELOPING COUNTRIES

The developing countries are aware that the adverse effects of climate-change and unchecked environmental pollution may continue to play a negative role in their socio-economic development, unless appropriate remedial measures are taken as early as possible. They are also aware that climate change will require review of their relevant policies and strategies. They are equally cognizant of the fact that

rich and poor countries have to fight the battle against the climate-change collectively over a long period of time, which will require massive financial assistance and transfer of technology from the advanced nations. The costs of fighting the climate-change for the developing countries are very high. A serious and prolonged effort by these countries will not be possible from their own inadequate resources. They may agree to take some small steps under international pressure, but such attempts may soon become unsustainable. The existing atmosphere of uncertainty in the availability of timely international cooperation to effectively undertake necessary corrective measures for tackling the problems of climate-change may retard the pace of decision making in the developing countries.

## 4. SOME PERTINENT CHALLENGES

Given the aforesaid background, a large number of developing countries are facing some pertinent challenges in the fight against atrocities of climate-change. These may be briefly described as follows:

### 4.1 Conceptual Challenges

These challenges are linked with doubts about the reality of the climate-change itself, credibility of the supporting scientific evidence, authenticity of the climate policies, and the unresolved confusion on adopting either sustainable or conventional socio-economic patterns of development. These conceptual challenges force the poor and developing countries to raise two questions. First, should they really invest in the climate-change and, second, should they adopt the environment-sensitive sustainable socio-economic development plans, given the fact that they are living under severe economic stresses and uncertainties.

It seems appropriate to further elaborate the aforementioned conceptual challenges for clarity and better understanding.

**4.1.1 The Contrary Views on Climate Change:** A short critical review (Sacchetti, 2008) has forwarded arguments against the commonly held view that the atmosphere is alarmingly getting warmer and that whatever Global Warming is taking place is actually not the Anthropogenic Global Warming (AGW), i.e., warming caused by human activity. It says:

- The Earth is not significantly hot. "The average global temperature has not increased during the

years since 1998, despite an increase in atmospheric carbon dioxide of 15 ppm (4%) over the same period”.

- Historical precedence shows that the past highs and lows in Earth’s temperatures have occurred without industrial human activities. Why cannot the present climate trends also reflect a similar natural trend? This thinking is backed by a Harvard-Smithsonian study of 2003. In this study, some 200 climate studies were examined and the conclusion was that the 20<sup>th</sup> century was neither the warmest century, nor the century with the most extreme weather of the past 1000 years.
- There is one common ground among all sides of the Global Warming debate, that Earth’s climate has always seen changes. Through examination of historical accounts and scientific evidence, it is clear that Earth’s climate has never stayed constant. The argument goes further saying that for small changes in climate with tenths of a degree, there is no need for an external cause and that Earth is never exactly in equilibrium.
- Some scientists correlate Earth’s warming with radiation influx from the Sun. Solar radiation fluctuations over a period of time have the ability to create some effect on Earth’s climate. In addition to the Sun’s variable activity, radiations from the depths of the space also enter Earths’ atmosphere and create electrically charged ions, which spur cloud formation. It is argued that these cosmic particles from far reaches of space may play a role in climate-change. A corollary to this hypothesis would be that a hyperactive Sun may divert the interstellar radiation, diminishing the cloud formation, which could in turn spur Global Warming.
- There are some other hypotheses about Global Warming which involve factors like ocean trends, water vapours, celestial phenomena, etc. Some skeptics refer to uncertainties associated with the computer models, which can cause doubts about the real authenticity of findings and predictions on Global Warming.

**4.1.2 Doubtful Scientific Claims:** Intergovernmental Panel on Climate Change (IPCC) has been a long time international authority to conduct scientific research and to give advice on climate-related policies. In its 4<sup>th</sup> Assessment Report, the IPCC has given a statement that the Himalayan glaciers could completely

disappear by 2035. This claim has been strongly contested by scientific community on climate-change and other concerned quarters (Nature, 2010, and Hulme, M., 2010). However, now IPCC has admitted that in drafting the relevant paragraph, clear and well-established evidences were not applied properly. Nevertheless, IPCC stood by the conclusion about glacier-loss in this century in major mountain ranges, including the Himalayas. This kind of scientific reporting can create doubts in the minds of policy-makers about the authenticity of scientific findings on which they have to base their national-level decisions - in this case involving a particular view on climate-change. A conceptual challenge of this nature can create a far reaching effect on the readiness of a developing country to move forward and make investment of its meager financial resources.

**4.1.3 Policy Dilemmas:** Another conceptual challenge facing many poor and developing countries is linked to the unsettled debate on the choice of sustainable socio-economic development over the conventional development. The sustainable development demands additional efforts for ensuring an equally prosperous future for the coming generations as that of the present generation. This also involves sacrifices by the present generation to spare enough economic resources for the use of the future ones. As environment constitutes one of the essential components of sustainable socio-economic development, special but tough economic arrangements have to be made so that the coming generations inherit a unadulterated environment from the previous generations.

The poor and developing countries are usually unable to meet the requirements of sustainable socio-economic development easily, as they are more concerned with addressing the immediate needs of their people. Two articles on the contentious debate on sustainable development and uncertainty of its conclusions with particular reference to the developing countries may provide further elaboration of this issue (Hasibullah, 2006 and 2007). However, in the context of development itself, a new approach is emerging, which emphasizes the preference of equity and social justice over the concept of excessive economic growth. This approach is gaining consensus (Khan, A. 2010). The full-fledged emergence of this approach may also present a new challenge for the developing countries to devise right policies to tackle climate-change in conjunction with economic development. Such policy-difficulties can be appreciated when one considers, for example, the inferences of two studies

## Environmental Challenges and Opportunities for the Developing Countries

published recently. The first study (Jones and Olken, 2010) says that in poor countries, a 1 degree Celsius rise in a climate related temperature in a given year reduces its economic growth by about 1.1 percentage points and its exports can drop by 5.7%. The second study, on the other hand, finds that “the poor want biomass, not biodiversity” (Lewis and Antony, 2010). These two climate-related yet oppositely oriented ground-realities represent typical policy dilemmas faced by several poor and developing countries.

### 4.2 Energy Challenges

Energy is the lifeline of all mankind. Socio-economic development of all nations, rich or poor, depends upon energy supply and security. Fossil-fuel is the main source of energy around the globe. Combustion of fossil-fuel produces carbon dioxide, which is considered to be the major cause of Global Warming and consequent multifarious environmental problems. People in rich countries use about 25 times more energy than those in the developing countries. Consequently, they pollute Earth’s atmosphere with carbon dioxide and other GHGs in overwhelmingly higher proportions than do the developing nations. However, the negative socio-economic impacts due to climate-change, caused primarily by the rich societies, are much more devastating for the poor countries than the developed countries. The world’s consumption of energy produced by fossil-fuels, more by the industrially advanced societies than the others, will expectedly grow continuously. However, the industrially advanced countries are expecting that the developing countries will drastically reduce their GHG emissions.

Unfortunately, the alternative energy sources, like hydro, solar and wind, etc., that do not pollute atmosphere significantly are neither enough to meet

the present and the near-future energy demands of the world, nor will they be economically attractive to the general public, at large. Replacement of technology, based on fossil-fuel with clean-energy technology will involve huge investments and a long time. Consequently, the developing countries may have to live with climate-change and other environmental problems for many decades to come. This view is supported by the figures given in the Table-1 that offers a glimpse of the trends of world energy scenario till 2030 (Estimated Figures) in relation to population increase (slight decrease expected during 30s) and carbon dioxide emissions. This table shows approximately 51% increase in the world carbon dioxide emissions in 20 years’ time if the current policies and practices continue. It is not clear how developing countries will be able to adjust themselves, in terms of climate-change threats and their economic progress.

The following points, given in the World Bank’s Report, “Johannesburg and Beyond: An Agenda for Action”, need consideration in the context of economic growth and related environmental risks:

- In order to meet MDG of halving, by 2015, approximately 29% of world’s population living on less than one US dollar a day, the low-income countries will have to grow at per capita rate of 3.6%.
- In 2050, around 65% of people will be living in urban areas, if the present trend continues.
- At current rate of biodiversity-loss, the world in 2050 will be much less biodiverse and huge funding would be required to preserve biodiversity.

**Table - 1: World Energy Scenario upto 2030**

Year	2010	2020	2030
Population (Million)	6855	7558	8164
Final Energy Consumption *(Mtoe)	8682	10425	12132
Electricity Generation (TWh)	19339	26122	34716
Percentage of Renewables in Gross Inland Consumption	11	9	8
Electricity Consumption per capita (KWh)	2.4	3.0	3.7
Carbon Dioxide Emissions (MT of CO <sub>2</sub> )	29376	36738	44498

\* Mtoe: Mega tonnes of oil equivalent

Source: World Energy Technology and Climate Policy Outlook 2030 (EU Publication)

- At estimated growth rate in per capita GDP of 2% in rich countries and 3.3% in low-income countries, the world income will rise to over 80 trillion US dollars by 2030, as 65% of the countries would be in high-income category. By 2050, world's income will be around 140 trillion, with 40% low and middle income countries. This growth-pattern would pose risks to the natural environment and these risks are greater in the developing countries. It is also envisaged that by 2050 another 150 million megawatts of electricity capacity would be required, which will most likely entail an environmental threat within the current technological paradigm.

Another pertinent study (UN-WEC, 1995) on "Global Energy Scenarios to 2050 and Beyond" by World Energy Council takes into account the long-term issues of environment and climate-change. This report in collaboration with the International Institute of Applied System Analysis (IIASA) gives a coverage of scenarios upto 2050 and also upto 2100. However, on account of more reliability of short-term scenarios, it is appropriate to refer to those which terminate by 2050. Table-2 gives a comprehensive picture of 2050 scenario comprising population growth and the energy scenarios along with other related information.

The figures appearing in Table-2 are only estimates based on "middle-of-the-line" assumptions and are independent of those given by another source in Table-1. Growth in population will result in growth in demand and consumption of energy, which will be much higher in the developing countries than the developed ones as seen in Table-2. The carbon dioxide emitting energy-sources, i.e., coal, oil and gas, will outweigh the renewable energy sources (64% vs. 22%) thus resulting in colossal addition of 10 giga tons of carbon in the atmosphere by 2050. This is why there is an immediate need of increasing the share of nuclear energy in the overall mix of global energy demand. Nuclear energy is well-developed and has much more potential of coming on the grid on global level, than the renewables which are still waiting to be developed for sustainable commercial utilization. There is another reason for the nuclear energy to quickly come to the world energy scenario. This is a fact that the economies of developing countries, particularly in Asia, are growing rapidly and there is no alternative to using fossil-fuel as a major mix for the total energy requirement. Increased economic activity will lead to more GHG emissions and subsequent climate-change. Emissions are expected to grow by a factor of 4 in China and India by 2030 (Amann and Wagner, 2008-2009). This will have a huge impact on

**Table - 2: 2050 Scenarios (Estimates based on moderate assumptions)**

World Population (2050)	10 Billion
World Economic Growth (1990-2050)	2.2% p.a.
<b>Primary Energy Demand (2050)</b>	20 (Gtoe)
<b>Primary Energy Mix (2050)</b>	<b>Share</b>
• Coal	21%
• Oil	20%
• Gas	23%
• Nuclear	14%
• Renewable	22%
<b>Energy Consumption Increases (1990-2050)</b>	<b>Estimates (in 60 years)</b>
• OECD Countries	33%
• Economies in Transition	41%
• Developing Countries	281%
• Global	118%
Carbon Emissions (2050)	10 (Gtc)
Environmental Taxes	Nil

Gtoe: Giga tons ( $10^9$ ) of oil equivalent

Gtc: Giga tons of carbon

**Source:** World Energy Council Report: Global Energy Scenarios to 2050 and Beyond

## Environmental Challenges and Opportunities for the Developing Countries

environment and climate-change and will thus remain a huge challenge for the developing countries for a long time to come.

### 4.3 Challenges Arising from Multilateral Initiatives

Environmental degradation and climate-change are global issues and therefore an integrated cooperation between the advanced and developing nations is essential for their satisfactory addressal. Two major initiatives, in this connection, have been taken by the world community. The first is the poverty alleviation initiative, called the Millennium Declaration and the second is popularly known as the Kyoto Protocol. The former prescribes 8 goals to eradicate poverty, hunger, disease, illiteracy, etc., from the developing world. Environmental sustainability is one of its important goals. Targets and relevant assessment of each goal are given annually. The overall final review is expected in 2015. The developing countries had attached great hopes to this initiative ten years ago when it was launched but so far the results have not been upto their expectations (United Nations, 2009). Regarding the goal on environment, the targets states, "Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources". The assessment given in the above referred report states, "A continued rise in greenhouse gas emissions is another reminder of the urgency of climate-change problem". This grim warning arises due to the reported figures of carbon dioxide emissions which show increases between 1990 (base year) to 2006 in both the developing and developed world. The problem with the MDGs initiative is that most of the responsibility of achieving the prescribed targets is left to the governments. This is not a realistic approach for the developing countries. The international cooperative mechanisms for the implementation of the MDG policies and strategies are vague and weak. Lack of commitment on the part of developed countries to provide funding and technical assistance are considered to be the major cause of disappointment. Developing countries may not be able to meet the environmental targets of the MDGs by the deadline of 2015. Addressal of environmental issues by the developing countries alone under the existing circumstances will remain a big challenge for several decades to come.

The second international initiative related specifically to climate-change - the Kyoto Protocol - may have even more disappointments for the developing countries. This overambitious, highly committed Protocol, consisting of 28 Articles, was born in Kyoto-

Japan in 1992 under the UN Framework Convention on Climate Change and was aimed at stabilizing and reducing the global carbon dioxide emission to a reasonable limit with closer international cooperation. Funding and technical assistance was to be provided by the industrially advanced nations to the developing countries to enhance their capacities to confront the climate related problems. The developed nations were required to assume greater role to reduce the adverse effects of climate change as they had been bigger contributors of carbon dioxide emissions for the past two centuries. However, the developed countries did not show enough willingness to take solid political, social and technical measures, mainly due to the fear of economic problems. These measures were necessary to make the Protocol a success. This response from the developed countries was the main reason for the slow progress of the Protocol. It took 5 years for the Protocols' development and another 10 years to ratify it. Even other countries, which are parties to the Protocol, have not done enough to achieve the desired results.

Several international meetings have since been held in order to find a common agreement on the size of cuts on carbon dioxide emissions, responsibilities of developed and developing member countries, funding mechanisms and nature of technology-transfer. In order to find a legally binding successor of Kyoto Protocol, which is ending in 2012, the world leaders met in Copenhagen (Denmark) in December 2009. Against all hopes, this well-attended conference could not reach a clear agreement on the nature of the intended legal instruments. It is said that the failure was mainly due to sharp disagreements among the developing countries on various elements of the text. However, a deal was struck among some major players and it was hurriedly announced to the other participants, causing a great deal of resentment and frustration among them.

The only positive aspects of the conference were that a commitment to limit Global Warming to 2 degree Celsius (without setting global emission targets for 2020 or 2050) was made and the developed countries pledged US\$ 30 billion for the developing countries for the period 2010-2012, as well as long-term financing of a further US\$ 100 billion a year by 2020 to be mobilized from a variety of sources (IISD, 2009). These pledges have not materialized so far, to the disappointment of the developing countries (AFP, 2010). Meanwhile, the International Institute for Environment and Development has mentioned several hurdles in delivering these finances (IIED,

2010), which could jeopardise the outcome of the conference. The main hurdle, quoted by this policy analysis, would be the unpredictability of the time when these funds will be made available to the developing countries. With the expectation that a large number of developing countries would be in favour of an international, legally binding and consensus agreement which could provide them a good opportunity to play their due role in the international efforts to combat the climate-change, it would be unfortunate if the attitude of the advanced countries as shown in the Copenhagen Conference prevails in the future negotiations on climate issues. Denial of equal participation of the developing countries in policy and decision-making processes would presumably pose another crucial challenge for the developing countries.

#### 4.4 Role of the United Nations Organization

The United Nations Organization (UNO) can play an important role in creating an international consensus to meet various challenges that have been lingering on for a long time concerning the climate-change. As a matter of fact it was the United Nations under whose patronage the international negotiations on climate-change started in 1991 (UN Framework Convention on Climate Change) and have continued with the involvement of the world community, scientific fora, and NGOs, etc. It was also the UN General Assembly which in 2000 adopted the Millennium Development Goals that are intrinsically related to environment and its links to the world's socio-economic development. The UN has held major conferences on environment in 1972, 1992 and 2002. Moreover, the UN has hosted all negotiating processes on global climate affairs, such as ozone depletion, air pollution, biodiversity, desertification, drought and regulation of toxic chemicals. Therefore, it is logical that the UN may continue to help the international climate negotiations, especially those now due after the Copenhagen Summit Conference held in December 2009. The UN can use its diplomatic expertise to push the climate-negotiations to a successful conclusion, to the satisfaction of all the concerned parties.

It is widely believed that the UN would be the most logical and productive forum for strengthening international cooperation for the transfer of technology and provision of funding to implement the agreed decisions linked with all environmental and climate-change affairs. However, the present procedures of the UN are considered to be time-consuming. For the climate-change issues, the UN may consider reforming the relevant procedures, so as to accelerate

decision-making in its various departments. The Kyoto Protocol is going to end in 2012 and there is still a lot to be done by the international community to prepare itself for an agreeable, viable and productive post-Kyoto Agreement that would be legally binding for all its signatories. There would be need of a dedicated organizational entity within the UN system that could permanently manage the climate-change affairs and other environmental issues, which come under the UN purview.

Again there will be specific collaborative issues with respect to the developing countries when the UN moves forward on climate-policies and strategies. For example, the replacement of current technology being used in the developing countries with new environment-friendly technologies will be one of the major challenges. This will require close understanding and spirit of cooperation among the industrially advanced and economically poor countries. The UN will need special mechanisms to create a sustainable collaborative relationship between the rich and the poor countries in order to achieve the climate-change targets. In this context, the industrially advanced nations will have to show strong commitments towards collaboration, allowing the developing countries to have access to the knowledge, technology and expertise available to them. The UN will also play its due role in ensuring the flow of timely and certain financial assistance from the advanced countries to the developing ones. Only two years are left before the world community decides on a viable successor to the Kyoto Protocol. The UN has to take a leadership role to make that happen. The developing and developed countries are still optimistic about the continuing efforts of the UN to save them from the threats of Global Warming and the environmental degradation.

#### 4.5 Opportunities within the Challenges

The world's energy demands will continue to increase in the future, due to economic growth and rapid population expansion. Carbon dioxide emissions from burning the fossil-fuel, under business as usual scenario, will also increase and will further aggravate the climate conditions. It is very likely that a point of "no return" may come well within this century. Supplementing the future energy demands with non-carbon dioxide emitting sources thus becomes inevitable.

Unfortunately, the alternate clean energy sources are not yet available in sufficiently enough quantities to

## Environmental Challenges and Opportunities for the Developing Countries

fulfill the needs of the world. Only hydro and nuclear electricity generating possibilities are there to partly meet the needs of industry, transport, construction, district-heating, etc. The hydro-potential in most of the developing countries is almost saturated due mainly to severe water shortages, which are attributed significantly to climate-change. Solar, wind, geothermal energy as well as energy from oceanic waves have not become economically viable so far. The only practical option left is the nuclear electricity.

*Nuclear Energy:* The world has a long and satisfactory working experience with nuclear power plants; the misconceptions about safety and waste-management are largely sorted out by now. The initial costs of nuclear power plants are still higher than those of the conventional power plants but the cost of production of electricity is quite economical. It is anticipated that considerable cost reductions in nuclear power plants will take place when more plants are ordered on global scale. Due to world's energy-security concerns, arising out of fossil-fuel price-hike, oil spills, green-energy movements and political policies, the overall public opinion is gradually reverting back to the nuclear energy as an option to meet energy needs. According to the International Atomic Energy Agency (IAEA) publication (IAEA Document, 2009), there were 438 nuclear power plants worldwide at the end of 2008 with generating capacity of 371562 MW (e). At the same time there were 44 new reactors under construction with a capacity of around 40000 MW (e). The share of nuclear power in global electricity generation was 14%. Total operating experience through 2008 was about 13475 years. Europe's four industrially advanced countries are now using nuclear electricity upto 50% of the total energy mix, viz. Belgium 54%, France 76%, Lithuania 73% and Slovakia 56%.

The revival of nuclear power in the world can be weighted from the following facts reported in the above-mentioned IAEA report:

- Construction work on 10 new nuclear power reactors had started in 2008.
- Many countries are raising their targets for the share of nuclear power in meeting their energy needs in the near future. These include India, China and the Russian Federation.
- The UK, according to a White Paper published in January 2008, has stressed that it was in the public interest for nuclear energy to continue to

form part of the UK's low carbon energy mix, in order to help meet targets of reduction in carbondioxide emissions and to ensure the security of energy supplies.

- Italy, Romania, Bulgaria, Finland, Switzerland and Slovakia are taking necessary measures to restart or expand their nuclear power programmes.
- In Canada, licenses have been issued to build new reactors or to extend the operation of their already existing nuclear power plants.
- In the USA, ten power uprates have been approved, totaling 2178 MW(th). Three license renewals totaling 51 by 2008 have been made. Applications for 26 new nuclear power plants have been launched.
- World interest in starting new nuclear power programmes has been high. IAEA has been requested by 55 Member States to assist them to introduce nuclear power in their energy mixes.
- The number of approved IAEA technical cooperation projects on analyzing energy-options increased from 29 to 41 for the project-cycle in 2009. The number of projects on uranium exploration and mining increased from 4 to 9, and the number of projects on introducing nuclear power increased from 13 to 44. Ten IAEA expert-missions to help Member States to introduce nuclear power were conducted during 2007 and 2008 in Belarus, Egypt, Jordan, Nigeria, Philippines, Sudan and Thailand.

In addition to the above-mentioned revival activities for the use of nuclear power in a wide global geographical range, two significant developments have taken place in the oil-rich Middle East. Saudi Arabia and the Gulf Cooperation Council have shown interest in nuclear power, for which they have already taken initial steps (Swahel 2006 and 2010). According to this report by Science and Development Network, Saudi Arabia is planning to create a city for nuclear and renewable energy to meet Saudi Arabia's growing energy needs and reduce its dependence on fossil-fuels. Also the six-member Gulf Cooperation Council has agreed to develop nuclear energy technology jointly for peaceful purposes. It may be significant to reckon that members of the Gulf Cooperation Council received three IAEA's advisory missions on nuclear power development during the period 2007 and 2008.



The interest of the above oil-rich nations in nuclear power shows two trends. First, the long-term dependence on oil cannot be ensured and the second that the Middle Eastern region is increasingly becoming sensitive to climate-change. This major policy-shift in the oil-producing and exporting countries of the Middle East is a positive sign for the future of Earth's climate.

The worlds' confidence in utilizing nuclear power as an answer to the future clean energy demands is also evident from the projected growth figures published by the IAEA (Nuclear Technology Review, 2009). IAEA has revised both the low and high projections upwards. In the updated low projections, global nuclear power capacity reaches 473 GW(e) in 2030 compared to a capacity of 372 GW(e) at the end of 2008. In the updated high projection, it reaches 748 GW(e). Three other world energy agencies, i.e., the OECD's International Energy Agency, OECD's Nuclear Energy Agency and US Energy Information Administration have also revised their future nuclear electricity projections for 2030 and 2050 showing significant increases in the installed capacity (ibid). Table-3 shows percentage increases (high and low) of world's projected nuclear capacities in 2030 by four international agencies in comparison with IAEA's figures of 2009. The increase in the trend is obvious. The lower values are generally consistent at around 45% increase. Leaving aside the higher values, the lower values show significant increase in the next 20 years.

The 2009 Review also quotes International Energy Agency's two climate policy scenarios. The "550 policy scenario", which corresponds to long-term stabilization of the atmospheric greenhouse gas concentration at 550 parts per million of carbon

dioxide, equates to an increase in global temperature of approximately 3°C. The second scenario, "450 policy scenario" equates to a rise of around 2°C. In the 550 policy scenario, installed nuclear capacity in 2030 is 533 GW(e); in the 450 policy scenario it is 680 GW(e). This shows that lower global temperatures can be achieved with higher share of nuclear power in the overall energy mix.

It appears that nuclear power will be the only practicable clean energy source for future replacement of fossil and other carbon dioxide emitting fuels on a bigger scale. Other clean sources like hydro, solar, wind, etc., may also serve as valuable sources for the future energy mix but on a much smaller scale. As and when the world community decides in line with this premise, an excellent opportunity will be available for the developing countries to participate in the efforts of the technically advanced countries in the future development and expansion of nuclear power on a commercial scale. The nuclear power technologies can develop much more quickly as there already exists sufficient knowledge, industrial infrastructure, management and marketing experience in the world. Funding mechanism's can be evolved on global level to facilitate nuclear power's commercialization and deployment under international policy frameworks.

*Renewable Energy Technologies:* Notwithstanding the high potential of the nuclear energy to provide assured and clean source of power in the coming decades, the importance of renewable energy technologies cannot be ignored. Generally speaking, this category of energy sources includes solar energy, wind power, hydropower, biomass, biofuel and geothermal energy. Out of these, biomass and biofuel, which are gaining increasing attention these days, are

**Table - 3: Comparison of Nuclear Energy Projections (% age Increase in Low and High Values for 2030 as Compared to IAEA's values of 2009)**

Name of the Agency	Low	High
IAEA	46	131
EIA	46	50
IEA	42	112
WNA	-23	131

IAEA: International Atomic Energy Agency  
 EIA: Energy Information Administration (USA)  
 IEA: International Energy Agency (OECD)  
 WNA: World Nuclear Association

**Source:** IAEA Nuclear Technology Review 2009

## Environmental Challenges and Opportunities for the Developing Countries

carbon-emitting and, hence, cannot be considered as clean sources of energy. The remaining sources are clean but limited in their commercial use. Nonetheless, around 18% of global energy-consumption has been reported to have come from renewables in 2006 (Wikipedia, 15th July 2010). Table- 4, derived from the same source, illustrates the increase from 2004 to 2008 in some mainstream renewables.

If the commercial interest continues globally on renewables, it is likely that cost reductions and easy operability of the appliances would help the public acceptability of the renewable energy sources. However, the general trends in commercial breakthroughs during the last two decades have been somewhat erratic. The commercial R&D on the renewables showed ups and downs with the fluctuating prices of oil. Shortfalls in research-funds due to recent international economic crisis have also impeded the progress of commercial development and marketing. Table-2 shows share of renewables as 22% of the total primary energy mix in 2050 whereas nuclear energy has been kept at the same level (14%) as present. This does not seem to be a likely scenario as the assumptions on which the estimates of nuclear energy in Table-2 were made in 1995 have considerably changed after 2000 because the use of nuclear energy is being revitalized on large scale due to changed governmental policies of the industrialized world. Renewable energy technologies, due to their limited scope in industrial and public consumption, will largely remain as compensatory technologies in the overall global energy production sources for some time.

### 4.6 Policy Perspectives

Environment and climate concerns are changing the world's thinking on the relationship between the developed and the developing countries for shaping a healthy, prosperous and peaceful future. Climate-change sees no borders. The atmosphere and environment is common for both rich and the poor countries. All nations of the world will have to make concerted efforts to face the challenges of climate-change and environmental degradation. The climate-change can become a binding force among the rich and poor nations to adopt common policies and strategies and fight a united battle against all the odds. Climate-change has a strong potential to create a spirit of wider international cooperation and networking.

Presently, the international community does not seem to be reacting seriously to the fast deteriorating condition of the environment. Both the developed and the developing countries have to take decisions for action, without further delays. Developing countries will have to overcome decision-making challenges, with the encouragement, cooperation and help of the developed countries. Green house gases are being released into the atmosphere continuously and in constantly increasing quantities but enough is not being done to address this activity. Nevertheless, some concerned sections of the society have been giving due consideration to the policies and strategies that can bring a change. A selected compilation of such policy-considerations, made partly from the IAEA Bulletin of March 2008, is given below:

- To confront climate-change, there should be no distinction between the developed and the

**Table - 4: Renewable Energy Technologies Increases (2004-2008)**

Renewable Energy Source	Increase
Solar photovoltaic capacity	6 fold to 16 gigawatts
Wind Power capacity	25% to 121 gigawatts
Solar heating capacity	2 fold to 145 gigawatts
Biodiesel Production	6 fold to 12 billion liters per year
Ethanol production	2 fold to 67 billion liters per year
<b>Total power capacity from new renewables</b>	<b>75% to 280 gigawatts</b>

developing countries.

- An appropriate post-Kyoto agreement, under the aegis of the UN is required soon. This should offer an opportunity and due flexibility to the countries to implement GHGs emission-reduction strategies that are in harmony with their national circumstances. This international agreement should also include consensus on four pathways for addressing mitigation (activities to halt or to reduce the rate of climate-change), adaptation (to change life-style to lower the shocks of climate-change), technology hurdles and financial constraints. As far as mitigation and adaptation initiatives are concerned, it will be useful if a mix of policies for both these initiatives is evolved.
- There should be an agreement on global targets to start with. For example, all countries should commit to collectively reduce global emissions by at least 50% by the year 2050. Different developing countries may agree to reduce their energy intensity targets appropriately and in line with their responsibilities and capacities.
- It may be recognized that all emission sources and sinks are relevant to climate-change solutions and should be included in the proposed agreement.
- Harmonized universal carbon-taxation system could reduce emissions and generate financial resources that could be used for developing clean energy sources.
- Placing a price on carbon may be considered for ensuring dissemination of right technologies on right scale. Additionally, there would be a need of a policy mix that relates to regulations in buildings, construction design and resource allocation for public transport options.
- The poor societies in developing countries do not possess enough capabilities for adaptation. Strong mitigating measures are needed to minimize the cost of adaptation, without which adaptation may be impossible in some countries.
- Adaptation should be a part of poverty-reduction strategies. Special funds need to be allocated for adaptation plans in the developing countries.
- A climate fund would be needed to address the risks of climate-change. For developing countries this fund should be at least US \$ 50 billion per year

in order to undertake activities supporting a comprehensive climate-change agreement, which should be free from administrative or technical hurdles.

- It is essential to build trust between the rich and poor countries at all levels of development and create an equitable basis and new modalities for genuine international cooperation to tackle the intertwined challenges of energy and climate-change.
- Reduction of global GHG emissions by 50% at acceptable costs by clean technologies requires a technological revolution similar to that in the space and telecommunication sectors. But it is essential that appropriate clean energy technologies are made available, as widely as possible, to the developing countries. It is also important that as much research as possible should be carried out exclusively in the developing countries. Without technology transfer and provision of adequate funding, the gigantic task of reducing GHG emissions cannot be accomplished.
- Nuclear power would play a pivotal role for providing an assured and clean energy supply in the future energy-scenarios linked with reducing GHG emissions. A global mechanism under IAEA supervision, needs to be developed that could look after all the matters connected with nuclear-power production, distribution, finances, safeguards, regulation, safety and security, waste disposal and decommissioning of facilities. IAEA's proposal on multinational management of nuclear fuel-cycle (Rauf and Vovchok, 2008) may be revamped to facilitate adequate increase in the world nuclear electricity generation, as an integrated support mechanism for meeting the challenge of climate-change and environmental degradation. Maximum number of clean energy starved countries of the world need to include nuclear power in their national development policies, alongwith renewable clean energy technologies as an appropriate energy mix.

## 5. CONCLUSIONS

- Continued deterioration of Earth's environment and unchecked greenhouse gas emissions into the atmosphere will present more serious socio-economic challenges to the poor and developing countries than to the developed nations.

## Environmental Challenges and Opportunities for the Developing Countries

- The negative impacts of unabated environmental deterioration on the rich and industrialized nations would be due to two factors. First, the universal disasters will increase and affect their economies. Second, the flow of economic resources from the poor and developing countries to the rich nations will be constrained due to their increased vulnerability towards the climate-change.
- Environmental threats and challenges are universal. Both developed and developing countries will have to assume equal and collective responsibilities to address the threats and challenges, in this regard. The world may not succeed in halting or reducing the devastating effects of climate-change and environmental degradation, unless there is firm commitment on part of the developed and developing countries for a sustainable cooperation over a long period of time. Capacity building in the developing countries to a sufficiently high level is necessary, with the help of the developed countries.
- Nuclear power generation on global level will have to be increased sufficiently in order to provide the world with a clean and assured energy source on the industrial scale. The scope of developing other clean-energy sources like hydro, solar, wind, is quite limited for the time being. These sources can however, serve as a supplement to the nuclear energy, if developed to an acceptable level.
- Politicizing the environmental and climate-change issues, while deciding a universal regime that may serve as a successor to Kyoto Protocol, will not be in the interest of the international community. Plain objectives to confront climate-related issues with international scientific, technical and financial cooperation, would be a hallmark of a realistic international agreement. Lessons learnt from the Copenhagen Conference in December 2009 can serve as guidelines for future climate negotiations.
- The world does not have long to prepare itself to launch a well-planned, integrated, strategized and determined campaign to combat the climate-change and environmental deterioration. Many years may be needed to stabilize the greenhouse gas emissions, check deforestation and stop chemical pollution of land, air and oceans. By that time, Earth's environment may well reach a point of no return. This cautionary scenario demands more alertness from the developing countries.

Early preparedness for the future challenges and opportunities, at national and global levels, would serve their socio-economic interests, as well as of the future generations.

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