Global Climate Change and Sustainable Energy Development: Focus on Emerging Issues and Strategies for the Asia-Pacific Region

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ABSTRACT

Global warming and greenhouse effects are a direct consequence of climate change, triggered mainly by emissions of greenhouse gases (GHGs). Various national and international agencies are actively involved through carefully drawn program initiatives to progressively reduce GHG emissions. Clean development mechanisms (CDMs), emissions trading, and the emerging carbon market, aiming at carbon neutrality in phases, are among some of the major initiatives at both national and regional levels that are seemingly gaining momentum in an effort to comply with Kyoto Protocol commitments over time. International Financial Institutions (IFCCCs), e.g., The World Bank, ADB, etc. have played a pivotal role in proactively helping to reduce emissions at the sector, project, national, and regional levels. National and international policy support towards sustainable energy development in a mission mode is suggested in this article as a pragmatic approach to bringing a reversal of climate change processes (while ensuring energy security and health/environmental safety) through progressive reduction of emissions. The emerging issues and corresponding strategic policies related to the larger question of energy security in the wake of global climate change for the Asia-Pacific region in particular are presented. A sustainable energy development approach and initiatives are discussed at some length in the article.

The accumulated knowledge on the science of global climate change, visible evidences, and advances in research findings on the adverse impacts of these changes (on ecology, human and animal life,

energy, and the economy) necessitate proper review and documentation of these events. Such documentation will serve as a guide for our future options, alternative strategies, and long-term policies that must evolve to address the declining trend of climate quality to save the planet from further devastation in the future. A global review of the scientific literature on the subject, with careful scrutiny and analysis, also calls for a deeper awareness, appreciation, and understanding of the interrelationship between reversing the processes of climate change and simultaneously building the concept of a new paradigm of sustainable energy development. This article seeks to harmonize these two apparently conflicting approaches.

The article, among other things, seeks to cover wide-ranging arenas and emerging interconnected issues, such as the scientific reasons for global climate change, the magnitude of change, the impact of change, emissions trading, and CDM initiatives (to achieve carbon neutrality, energy security, etc.) that may lead to evolving the concept of sustainable energy development in a systemic gestalt. The article also addresses illustrative policy and program measures to abate and mitigate climate change by reduction of greenhouse gas emimssions, proactive roles of international funding and cooperation among agencies to supplement regional and domestic efforts, and exploration of the implicit and coherent nexus between climate and energy security. It explores the specific nature of emerging problems that get in the way of abating climate change and seeks to find a solution through integrated and holistic approaches to the extent feasible with global initiatives and maximum inter-regional cooperation.

GLOBAL WARMING & CLIMATE CHANGE

The terms *global warming* and *climate change* are often used conterminously, but the two phenomena are different. *Global warming* is the rise in global temperatures due to an increase of heat-trapping carbon emissions in the atmosphere. *Climate change,* on the other hand, is a more general term that refers to changes in many climatic factors (such as temperature and precipitation) around the world (Jordan, 2006). These changes are happening at different rates and in different ways. The world mostly agrees that something needs to be done about global warming and climate change. The first stumbling block, however, has

been trying to get an agreement on a unanimous framework. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was created by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) to assess scientific knowledge on global warming. The IPCC concluded in 1990 that there was broad international consensus on climate change being human-induced. That report led the way to an international convention for climate change, namely the United Nations Framework Convention on Climate Change (UNFCCC), signed by over 150 countries at the Rio Earth Summit in 1992 (http://www.globalissues.org/issue/178/climate-change-and-global-warming).

The IPCC reported on the phenomena for the first time in 1990. IPCC, among other things, stated that greenhouse gas (GHF) concentrations in the global atmosphere were rising as a result of human GHG emissions, principally from fossil-fuel burning. This is clearly a global problem, with yet another dimension. While the global dependency on fossil energy for economic growth remains nearly 100% at this time, the IPCC noted that cuts in GHG emissions on the order of 60-80% were required immediately if rising atmospheric GHG concentrations were to be stabilized just at the present raised values (IPCC, 2001).

There is another even more difficult dimension to this global problem. The IPCC also noted that stabilization of atmospheric GHG concentrations at any value was contingent on cuts of this magnitude in some give time frame. Scientists have found that the four most important variable greenhouse gases whose atmospheric concentrations can be influenced by human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs). Historically, CO_2 has been the most important, but the other atmospheric trace gases are also radioactively active in that they can affect Earth's heat budget and thereby contribute to greenhouse warming of the lower atmosphere. The Kyoto Protocol on climate change also regulates three other trace gases, namely hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur-hexafluoride (SF6), whose limited concentrations in the atmosphere are anticipated to grow over the long term (GCEP-http://www.gcrio.org/gwcc/index.htm).

Greenhouse Effect

Atmospheric scientists first used the term greenhouse effect in the early 1800s. At that time it was used to describe the naturally

occurring functions of trace gases in the atmosphere and did not have any negative connotations. It was not until the mid-1950s that the term greenhouse effect was coupled with concern over climate change. The greenhouse effect is the process in which the emission of infrared radiation by the atmosphere warms a planet's surface (http://en.wikipedia.org/wiki/Greenhouse_effect). The world's carbon dioxide emissions are expected to increase by 1.9 percent annually between 2001 and 2025. Much of the increase in these emissions is expected to occur in the developing world, where emerging economies, such as China and India, fuel economic development with fossil energy. Developing countries' emissions are expected to grow (above the world average) at 2.7 percent annually between 2001 and 2025 and to surpass emissions of industrialized countries near 2018 (http://www.ucar.edu/learn/1_3_1.htm).

Global Climate & Energy Project at Stanford

The Global Climate and Energy Project (GCEP) at Stanford University seeks new solutions to one of the grand challenges of this century: supplying energy to meet the changing needs of a growing world population in a way that protects the environment. GCEP's mission is to conduct fundamental research on technologies that will permit the development of global energy systems with significantly lower greenhouse gas emissions. *In 1904, Jane Stanford defined the challenge for this young university: "Let us not be afraid to outgrow old thoughts and ways, and dare to think on new lines." The Global Climate and Energy Project takes up Jane Stanford's challenge to posterity, embracing the innovative spirit*—John Hennessey, President, Stanford University (http://gcep.stanford.edu/pdfs/gcep_brochure.pdf)

Convincing evidence that Earth's climate is undergoing significant—and in some cases alarming—changes has accumulated rapidly in recent years, especially during the past three decades. Increasing atmospheric concentrations of greenhouse gases (mainly carbon dioxide but also methane, nitrous oxide, CFCs, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons) are implicated inextricably in the global warming trends. Since 1751, over 270 billion tons of carbon have been released to the atmosphere from the consumption of fossil fuels and cement production. Globally, liquid and solid fuels accounted for 77.5 percent of the emissions from fossil-fuel burning in 1997. Combustion of gas fuels (e.g., natural gas) accounted for 18.3 percent (1211

million metric tons of carbon) of the total emissions from fossil fuels in 1997 and reflects a gradually increasing global utilization of natural gas. Emissions from cement production rose to 206 million metric tons of carbon, a twenty-fold increase since the 1920s. Emissions from gas flaring for 1997 were estimated to be 66 million metric tons of carbon, well below the levels of the 1970s. Collectively, emissions from cement production and gas flaring contributed less than 5 percent to the total emissions for 1997 (Victor and Cullenward,2007).

Reflection on Climate Change Phenomena by International Scientific Communities

In 2001, no fewer than sixteen major academies of science from throughout the world issued a statement which reads, in part, as follows (Dale Allen Pfeiffer, 2004):

> *The work of the Intergovernmental Panel on Climate Change (IPCC) represents the consensus of the international scientific community on climate change science. We recognize IPCC as the world's most reliable source of information on climate change and its causes, and we endorse its method of achieving this consensus. Despite increasing consensus on the science underpinning predictions of global climate change, doubts have been expressed recently about the need to mitigate the risks posed by global climate change. We do not consider such doubts justified.*
>
> *…we support the IPCC's conclusion that it is at least 90% certain that temperatures will continue to rise, with average global surface temperature projected to increase by between 1.4 and 5.8°C above 1990 levels by 2100. It is now evident that human activities are already contributing adversely to global climate change. Business as usual is no longer a viable option. … We urge everyone—individuals, businesses and governments—to take prompt action to reduce emissions of greenhouse gases. The balance of the scientific evidence demands effective steps now to avert damaging changes to the earth's climate.*

Impact of Climate Change

The various recommendations emanating from this summit, among other things, led the way and laid the foundation for evolving the concept of sustainable development (http://www.uea.ac.uk/env/cserge/pub/wp/pa/pa_1998_02.htm). The major impacts of global climate change are manifested in:

- gradual rise in global surface temperature (i.e. global warming)
- melting of icebergs and concomitant rise in sea levels
- continuous buildup of greenhouse gases leading to the green-house effect
- depletion of ozone concentration/layers
- catastrophic natural disasters and calamities (e.g. hurricanes, typhoons, earthquakes, landslides, tsunamis)
- loss of vegetation, animals, biodiversities, marine flora and fauna (Crowley, 2000)

The widespread retreat of glaciers and icecaps in the 21st century will also lead to higher land surface temperatures and increasing water stress (Church et al., 2001). By 2025, as much as two-thirds of the world population, much of it in the developing world, may be subjected to moderate to high water stress. Estimates of the effects of climate change on crop yields are predominantly negative for the tropics, even when adaptation and the direct effects of CO_2 on plant processes are taken into consideration. Ecological productivity and biodiversity will be altered by climate change and sea-level rise, with an increased risk of extinction for some vulnerable species. In the final analysis, scientists will continue to study the critical and important issues of the effects of adverse air quality and climate change on crop production, as well as the larger question of global food security (Folland & Karl, 2001).

Addressing global climate change is a paramount challenge of the 21st Century. Since the beginning of the industrial revolution, atmospheric concentrations of CO_2, the main heat-trapping GHG, have risen 35 percent. This increase is primarily from the burning of fossil fuels and from deforestation. If current trends in GHG emissions growth are not altered, global temperatures are expected to rise between 1.4 and 5.8° C (2.5 to 10.4° F) by 2100, according to the IPCC. Such temperature changes are likely to have detrimental impacts on agricultural production, water supply, forests, and overall human development. The World Bank has identified critical linkages between climate impacts and poverty reduction, pointing out that if atmospheric CO_2 concentrations were to double from pre-industrial levels, "developing countries would suffer economic costs of 5-9 percent of GDP, several times higher than industrialized countries, and the poor in the bank's borrowing countries would be at the greatest disadvantage (IPCC, 2001)." Industrialized countries

are largely responsible for the build-up of GHGs in the atmosphere thus far, and they must bear the brunt of the mitigation effort. But developing countries can play an important role in reducing emissions growth within the context of their continued economic development. Nearly 80 percent of the world's population lives in developing countries, which already account for over 40 percent of current world emissions; given present trends, this share will rise to 56 percent by 2025 (Shah, 2008).

Mitigation Measures

Mitigation measures to reduce greenhouse gas emissions have a certain cost. However, they also provide an economic benefit by reducing the impacts of climate change and the costs associated with them. In addition, they can bring economic benefits by reducing local air pollution and energy resource depletion. If the benefits of avoided climate change are taken into account and a "carbon price" is established for each unit of greenhouse gas emissions, this could create incentives for producers and consumers to significantly invest in products, technologies, and processes that emit less greenhouse gas. The resulting mitigation potential is substantial and could offset the projected growth of global emissions over the coming decades, or even reduce emissions below current levels (Garg *et al,* 2003). Mitigation measures could contribute to stabilizing the concentration of greenhouse gases in the atmosphere by 2100 or later. To achieve low stabilization levels, stringent mitigation efforts are needed in the coming decades. This could reduce global GDP by up to a few percent. Changes in lifestyle and behavior that favor resource conservation can contribute to climate change mitigation. Mitigation measures can also have other benefits for society, such as health cost savings resulting from reduced air pollution. However, mitigation in one or a group of countries could lead to higher emissions elsewhere or to effects on the global economy. The mitigation potential for different sectors is a function of carbon price (Chandler *et al,* 2002).

No one sector or technology can address the entire mitigation challenge. All sectors, including buildings, industry, energy production agriculture, transport, forestry, and waste management could contribute to overall mitigation efforts through, for instance, greater energy efficiency. Many technologies and processes that emit less greenhouse gas are already commercially available or will be in the coming decades. In order to stabilize the concentration of greenhouse gases in the atmo-

sphere, emissions would have to stop increasing and then decline. The lower the stabilization level aimed for, the more quickly this decline would need to occur. Worldwide investment in mitigation technologies, as well as research into new energy sources, will be necessary to achieve stabilization. Delaying emission-reduction measures limits opportunities to achieve low stabilization levels and increases the risk of severe climate change impacts (Nair *et al*, 2003).

Policy Support as Incentive to Mitigation Action

A wide variety of policy tools can be applied by governments to create incentives for mitigation action, such as regulation, taxation, tradable permit schemes, subsidies, and voluntary agreements. Past experience shows that there are advantages and drawbacks for any given policy instrument. For instance, while regulations and standards can provide some certainty about emission levels, they may not encourage innovations and more advanced technologies. Taxes and charges, on the other hand, can provide incentives but cannot guarantee a particular level of emissions. It is important to consider the environmental impacts of policies and instruments, their cost effectiveness, and their institutional feasibility, as well as how costs and benefits are distributed.

Although the impact of the Kyoto protocol's first commitment period (2008-2012) on global carbon emissions is expected to be limited, it has allowed the establishment of a global response to the climate problem, as well as the creation of an international carbon market and other mechanisms that may provide the foundation for future mitigation efforts. Switching to more sustainable development paths can make a major contribution to climate change mitigation. Policies that contribute to both climate change mitigation and sustainable development include those related to energy efficiency, renewable energies, and conservation of natural habitats. In general, sustainable development can increase the capacity for adaptation and mitigation and reduce vulnerability to the impacts of climate change.

Mitigation measures that aim to reduce greenhouse gas emissions can help avoid, reduce, or delay many impacts of climate change. Policy instruments could create incentives for producers and consumers to significantly invest in products, technologies, and processes that emit less greenhouse gas. Without new mitigation policies, global greenhouse gas emissions will continue to grow over the coming decades and beyond.

Rapid world-wide investments and deployment of mitigation technologies, as well as research into new energy sources, will be necessary to achieve a stabilization of the concentration of greenhouse gases in the atmosphere.

Human Development Report: Link between Climate Change & Human Development

The *2007 Human Development Report (HDR-2007)* explores the links between climate change and human development. These links raise important questions about social justice, cross-generational equity, and human security. These questions have generated wide-ranging policy dialogues about social discounting, pricing carbon, and distributing obligations for decarburizing global economic growth. Equally pressing, but less widely considered, is the challenge to empower vulnerable communities to adapt to climate change. For a large section of humanity, damaging climate change is either a current reality of an imminent threat. One of the aims of HDR-2007 is to explore ways in which climate change will interact with wider factors to increase vulnerability; hold back poverty reduction; widen inequalities based on region, income, and gender; and aggravate ecological pressures. The underlying problems to be addressed are well known. If trends in greenhouse gas emissions are not fundamentally altered, global temperatures will rise by between 1.4 and 5.8°C by 2100. Averting the dangerous climate change scenario will require national and international action to prevent CO_2 emissions exceeding 450 ppmv. Because of the long-range time horizon for reducing carbon stocks, this implies a dramatic shift in energy policy. Driven by a combination of economic and population growth, global energy demand is projected to increase by just over one half between now and 2030.

INTER-COUNTRY COOPERATION

Inter-country cooperation can play an important role in addressing issues related to energy supply and demand and the efficient distribution of energy resources through, among others, connectivity and trade. While improving energy security is primarily a domestic issue, trans-boundary energy cooperation could play an important complementary role. Currently, most governments are individually seeking

and taking measures to ensure a steady supply of energy resources to sustain their economic growth. In the era of globalization, a collective cooperation framework could supplement national efforts and bring mutual benefits. A cooperation framework could include a coordinated planning and development approach for trade and exchange, which could lead to the integration of energy infrastructure aimed at facilitating the supply of energy to final consumption destinations beyond national boundaries. It is heartening to note that platforms for cooperation have already been initiated in some sub regions, including Southeast Asia, Northeast Asia, South Asia and West and Central Asia. The least developed and landlocked developing countries in these sub regions stand to benefit through active engagement in their respective regions. Moreover, another initiative for broad trans-Asian energy cooperation that the UN's Economic and Social Commission, for Asia and the Pacific (ESCAP) has been pursuing, following the 62nd session of the Commission, could also benefit the least developed and landlocked developing countries through synergies and linkages among various sub-regions (http://intranet.unescap.org/cmg/2006/CMG3-II/English/CMG3-II_6E.pdf).

Kyoto Protocol

The *Kyoto Protocol to the United Nations Framework Convention on Climate Change* is an amendment to the international treaty on climate change, assigning mandatory emission limitations for the reduction of greenhouse gas emissions to the signatory nations. The Kyoto Protocol is an agreement made under the UNFCCC. Countries that ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain or increase emissions of these gases. The Kyoto Protocol now covers more than 160 countries globally and over 55% of global greenhouse gas (GHG) emissions (http://unfccc.int/resource/docs/convkp/kpeng.pdf).

Emissions trading, the market-based instrument used for environmental protection, has been adopted as one of the primary tools for international cooperation to reduce the green house gas emissions under Kyoto Protocol. However, emissions trading is not altogether new—tradable rights for pollution control was proposed in 1968—and trading programs have been implemented to reduce emissions of oxides of sulphur and nitrogen, carbon-dioxide, and other pollutants.

Since carbon credits are tradable instruments with a transparent price, financial investors have started buying them for pure trading purposes, mostly through the derivative/paper market. This market is expected to grow substantially, with banks, brokers, funds, arbitrageurs, and private traders eventually participating. Kyoto protocol enables a group of several Annex-I countries to join together to create a so-called bubble, a cluster of countries that is given an overall emissions cap and is treated as a single entity for compliance purposes. The EU elected to be treated as such a group and created the EU Emissions Trading Scheme (ETS) as a market-within-a-market entity (http://en.wikipedia.org/wiki/European_Union_Emission_Trading_Scheme).

The Kyoto Protocol introduced the following three flexibility mechanisms to supplement the domestic activities of the developed (Annex I) countries. The flexibility mechanisms are:

- Clean Development Mechanism (CDM)
- Joint Implementation (JI)
- International Carbon Trading (ICT)

Of these three, only the CDM is applicable between developed and developing countries that have ratified the protocol. The certified emission reductions (CERs) that result from CDM project activities have considerable economic use to both the host (developing) and investor (developed) countries. During the last few years the mechanisms have aroused worldwide interest in carbon investment and the carbon market, which is growing as companies and governments have started purchasing emissions credits through voluntary trading schemes, carbon investment funds, and government procurement tenders.

One of the serious limitations in implementing the Kyoto Protocol under the UNFCCC is obviously its limited participation in real emissions reductions. The 17 year-old Annex I/non-Annex I dichotomy is outdated, but the current climate-addressing structure doesn't easily allow for changes. One cannot imagine a successor agreement to Kyoto for the second commitment period (beyond 2012) that replicates the central feature of Kyoto—namely that only Annex I countries (and not even all of them) have an obligation to reduce their net emissions. If there is to be any successor agreement to Kyoto, that has to change.

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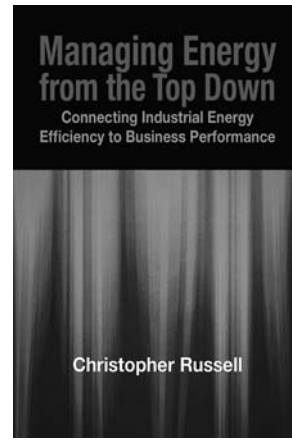

Christopher Russell

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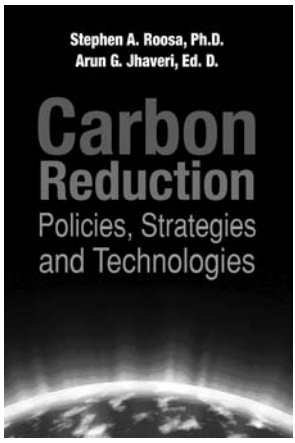

Stephen A. Roosa, Ph.D. and Arun G. Jhaveri, Ed.D.

In this time of increasingly pressing concern about global climate change and its potentially irreversible and detrimental impacts on the world's population, it is considered urgent to find effective means for significantly reducing local, regional, national and international greenhouse gas emissions in homes, businesses, industries and communities around the planet. This book, first of all, describes in clear, concise and understandable terms the nature and scope of the climate change problem. The authors then combine their considerable expertise to offer specific guidelines for defining and applying the most effective carbon reduction policies, strategies and technologies. Finally, they propose a well-defined blue-print or road map for an action plan for use by practicing engineers, scientists, technicians, managers, and decision-makers, which can be implemented to help control and abate the alarming increases in carbon dioxide and other greenhouse gas emissions.

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Clean Development Mechanism

The clean development mechanism (CDM) is one of the innovative features of the Kyoto Protocol. It encourages investments in projects that provide sustainable development in developing countries, while at the same time limiting GHG emissions. The CDM was introduced in Article 12 of the Kyoto Protocol. Under this mechanism, legal entities in developed countries can invest in projects in developing countries that reduce GHG emissions. Once certified, these emission reductions can be used to meet the commitments made by the developed countries under the protocol. Although there are no immediate targets for the developing countries, it can be seen as an additional source of foreign direct investment into national emission reduction/mitigation projects, which would contribute to sustainable development and a decrease in worldwide GHG emission levels (http://en.wikipedia.org/wiki/Clean_Development_Mechanism).

Signals of climate change are already visible around the world. Some of the projected impacts that can adversely affect lives, economies, and ecosystems are its impacts on the Asian monsoon (the main source of fresh water), agriculture, and other life-saving systems such as rivers, etc. Climate change will cause an increase in vector-borne diseases, extreme weather events (and their frequency), loss of life and property in unprecedented proportions, etc. The Kyoto Protocol is an important step towards stabilization of the concentration of GHGs in the atmosphere to prevent dangerous anthropogenic interference with the Earth's climate system.

A transaction in certified emission reductions (CERs) trading, an important instrument of CDM projects, involves the buying of GHG emissions credits by entities (companies, governments, etc.) from companies or governments involved in projects related to CER, mostly in developing countries (http://www.cogeneration.net/certified_emission_reduction.htm). The idea is to make developed countries pay for their wild ways with emissions while at the same time rewarding countries with good behavior in this regard. For example, if a company in India can prove it has prevented emission of x-tons of carbon, it can sell an associated amount of points or carbon credits to a company, in say the US, which has been emitting carbon. This allows industries in developed countries to offset their emissions of carbon dioxide by investing in reforestation and clean energy projects, such as large-scale tree plantations, in developing countries as a lucrative alternative to

reducing emissions. Planting 100,000 hectares of new forest can remove 1mn ton of carbon per year from the atmosphere (http://en.wikipedia.org/wiki/Certified_Emission_Reduction).

Global Energy Markets & Interrelated Issues

Energy markets are currently going through a period of tremendous change. The deregulation of the electricity market is in full swing. The market price mechanism has replaced the old system of fixed rates. The new free electricity market is marked by sharply fluctuating prices that may lead to unexpected and unfavorable price risks. The gas market is about to undergo the same deregulation process. The more traditional oil markets are volatile too, as has been witnessed over past years. Besides economic fluctuations in the market, both political and seasonal influences are playing a major role in the price movements of energy markets. While oil is essential to fuel economic growth, its supply is volatile, being subject to short-term interruptions as well as longer-term lapses in the rate of supply development. Sustaining modest economic growth worldwide for the next several decades will require massive new international investments in oil and gas. The world energy markets are inherently global, and no single country can exempt itself from the interdependencies of that market. Geographical differences in the location of supply and demand will continue to expand trade. Differences in resource ownership and access to capital and technology will require increasing cooperation between IOCs and NOCs. The consuming and producing countries share a mutual interest in this expansion and in avoiding volatility. In fact, these interdependencies generate a web of mutual interests between producers and consumers that can provide a basis for reducing the security problem. While there is no certainty that cooperation in expanding supplies over the next several decades will succeed, there is certainty that the cost of failing to do so will be enormous.

THE ENERGY SECURITY ISSUE AND THE LARGER QUESTION OF FUTURE SUSTAINABILITY

The 1970s oil shocks confronted the developing countries with a new set of energy security issues. Few of the oil-importing countries

had the necessary foreign exchange reserves to absorb price increases. Concerns about macroeconomic management and fiscal balance—national affordability—rose to the fore. Energy security was enhanced through reliance (sometimes an over-reliance) on domestic resources, bilateral energy trading relationships with reliable nearby partners, and access to regional markets. However, vulnerability to significant price fluctuations remains a major energy security concern for both oil- and gas-exporting countries and net importers of energy products and services.

A second energy security preoccupation in developing countries is the ability to adapt and apply imported energy technologies to local needs and manage them successfully. In the perception of many developing countries, failure to adapt and manage implies a continuing dependence on foreign technical know-how, a dependence that is usually interpreted as insecurity. Over time, the lack of open, transparent markets and good governance also contributes to the degradation and dysfunction of complex energy technologies. Failure to adapt technologies to local conditions also implies that energy service priorities will be determined on the basis of an exogenous energy technology that cannot meet the affordability and priority social needs of emerging market economies, especially in rural areas.

A third energy security issue is that developing countries have good reason to harbor concerns about the vulnerability of their energy infrastructure to disruption by natural or man-made events. The recent extensive losses of the electric transmission and distribution facilities of Orissa (by cyclone) and Gujarat (by earthquake) in India stand as powerful testimony; floods can be equally damaging, and droughts threaten the viability of hydroelectric facilities. In addition, power stations, refineries, pipelines, and transmission lines are early targets in cases of domestic insurrection, civil war, and international conflict.

Finally, in developing countries that export hydrocarbon, the misuse and inequitable distribution of the rents from energy trade can itself be a driver of discontent, domestic instability, and violence, which are all threats to domestic energy markets, private investment flows, and infrastructure. Squandering valuable resource revenues may also result in disinvestment in the very energy production facilities that brought financial riches, ultimately threatening the pace and sustainability of domestic energy resource development.

Integrated Energy Policy for Energy Security: A Case for India

India faces formidable challenges in meeting its energy needs and providing adequate energy of desired quality in various forms in a sustainable manner and at competitive prices. India needs to sustain an 8-10 percent economic growth rate over the next 25 years in order to eradicate poverty and meet its human development goals. To deliver a sustained growth rate of 8% through 2031-32 and to meet the lifeline energy needs of all citizens, India needs, at the very least, to increase its primary energy supply by 3 to 4 times and its electricity generation capacity/supply by 5 to 6 times that of 2003-04 levels. With 2003-04 as the base, India's commercial energy supply would need to grow from 5.2% to 6.1% per annum, while its total primary energy supply would need to grow at 4.3% to 5.1% annually. By 2031-32, power generation capacity must increase to nearly 800,000 MW from the current capacity of around 160,000 MW, inclusive of all captive plants. Similarly, requirement of coal, the dominant fuel in India's energy mix, will need to expand to over 2 billion tons/annum based on the domestic quality of coal. Meeting the energy challenge is of fundamental importance to India's economic growth imperatives and efforts to raise its level of human development. The broad vision behind the energy policy is to reliably meet the demand for energy services of all sectors at competitive prices. Further, lifeline energy needs of all households must be met, even if that entails directed subsidies to vulnerable households. The demand must be met through safe, clean, and convenient forms of energy at the least cost in a technically efficient, economically viable, and environmentally sustainable manner. Considering the shocks and disruptions that can be reasonably expected, an assured supply of such energy and technologies at all times is essential to providing energy security for all. Meeting this vision requires that India pursue all available fuel options and forms of energy—both conventional and non-conventional.

In addition, India must seek to expand its energy resource base and seek new and emerging energy sources. Finally, and most importantly, India must pursue technologies that maximize energy efficiency, demand-side management, and conservation. Coal shall remain India's most important energy source until 2031-32 and possibly beyond. Thus, India must seek clean coal combustion technologies and, given the growing demand for coal, also pursue new coal extraction technologies such as in-situ gasification to tap its vast coal reserves, which are dif-

ficult to extract economically using conventional technologies. The best approach is directed to realizing a cost effective energy system. For this, the following are needed (Planning Commission, 2006):

(i) Competitive energy markets, wherever possible. (However, competition alone has been shown to have its limitations in a number of areas of the energy sector, and independent regulation becomes even more critical in such instances.)
(ii) Pricing and resource allocations that are determined by market forces under an effective and credible regulatory oversight
(iii) Transparent and targeted subsidies
(iv) Improved efficiencies across the energy chain
(v) Policies that reflect externalities of energy consumption
(vi) Policies that rely on incentives/disincentives to regulate market and consumer behavior
(vii) Policies that can be implemented
(viii) Management reforms that create accountability and incentives for efficiency

Key and high priority recommendations of the Integrated Energy Policy are summarized below:

Ensuring Adequate Supply of Coal with Consistent Quality

Coal accounts for over 50% of India's commercial energy consumption, and about 78% of domestic coal production is dedicated to power generation. This dominance of coal in India's energy mix is not likely to change until 2031-32. Keeping in view the competitiveness of coal-based power generation through imported coal at coastal areas, power projects at coastal locations are to be encouraged.

Ensuring Availability of Gas for Power Generation

There is a total generation capacity of 12,604 MW based on gas and liquid fuels. The bulk of it is base-loaded under combined cycle operation. However, gas supplies have been restricted and overall utilization remains at only 54.5%. While requiring that no new gas capacity be built without firm and bankable gas supply agreements, effort should be made to allocate available domestic gas supplies to the fertilizer,

petrochemicals, transport, and power sectors at prices that are regulated to yield a fair return to domestic gas producers. Such a practice should be enforced until a better demand-supply balance emerges and domestic gas production achieves some of the potential that is often cited. A more competitive market can then function.

Power Sector Reforms

These must focus on controlling the aggregate technical and commercial losses of the state transmission and distribution utilities. This is essential to creating a financially robust power sector in each state. Only financially healthy state power distribution utilities can provide the needed comfort with payment security to attract private investment in the power sector at internationally competitive tariffs.

Recommendations include:

- Establish control of huge technical and commercial losses in distribution.
- The liberal captive and group captive regime foreseen under the Electricity Act, 2003 must be realized on the ground.
- To achieve these objectives, it is essential to separate the cost of the pure wires business (carriage) from the energy business (content) in both transmission and distribution at different voltages.
- The open access provisions of the Electricity Act, 2003 should be implemented.
- A robust and efficient interstate and intrastate transmission system, with adequate surplus capacity and the capability of transferring power from surplus regions to deficit regions, is a must for ensuring optimal operation of the system.
- Rehabilitation of existing thermal stations, which could raise capacity at the least cost in the short-run.

Reduction in Cost of Power

In terms of purchasing power parity, power tariffs in India for industry, commerce, and large households are among the highest in the world. It is important to reduce the cost of power to both increase the competitiveness of the Indian economy and promote consumer welfare.

The government policy should ensure that generation and transmission projects be competitively built on the basis of tariff-based bid-

ding. Public sector undertakings should also be encouraged to participate in such bids, even though the tariff policy allows them a five-year window wherein projects undertaken by the public sector need not be bid competitively. Regulators should set multi-year tariffs and differentiate them by time of day.

Market-based instruments should be developed which effectively extend the tenure of debt available to power projects to, perhaps, 20 years. This will reduce the capacity charge in the earlier years and spread it more evenly over the life of the project.

Unit sizes should be standardized and global tenders invited for a number of units to get substantial bulk discount. Distribution should be bid out on the basis of a distribution margin, or paid for by a regulated distribution charge determined on a cost plus basis including a profit mark-up similar to that paid for generation as suggested above.

Rationalization of Fuel Prices

Relative prices play a most important role in the choice of technology, fuel, and energy form. They are thus the most vital aspect of an integrated energy policy that promotes efficient fuel choices and facilitates appropriate substitution.

Energy Efficiency and Demand-side Management

Lowering the energy intensity of GDP growth through higher energy efficiency is important for meeting energy demand and security needs. The energy intensity of India's growth has been falling and is about half of what it used to be in the early 70s. Currently, we consume 0.16 kg of oil equivalent (kgoe) per dollar of GDP expressed in purchasing power parity terms. India's energy intensity is lower than the 0.23 kgoe of China, the 0.22 kgoe of the US, and a World average of 0.21 kgoe. India's energy intensity is even marginally lower than that of Germany and OECD, at 0.17 kgoe. However, Denmark at 0.13 kgoe, UK at 0.14 kgoe, and both Brazil and Japan at 0.15 kgoe are ahead of India. These figures and many sector studies confirm that there is room to improve and that energy intensity can be brought down significantly in India with current commercially available technologies.

Emissions Trading

Emissions trading is an administrative approach used to control pollution by providing economic incentives for achieving reductions

in the emissions of pollutants (http://en.wikipedia.org/wiki/Emissions_trading#cite_note-0). It is sometimes called *cap and trade*. In voluntary carbon markets, activities that reduce GHGs produce verified emission reductions (VERs) that can be sold to companies or individuals wishing to voluntarily reduce their carbon footprints. GHG emission reduction projects developed under the Kyoto Protocol's clean development mechanism (CDM) have been highly successful in reducing emissions and generating certified emission reductions (CERs), which are then purchased by governments and organizations in Europe and Japan to help meet their emission reduction targets (Bohm,2000). Although voluntary reductions are similar to regulated credits, they are different in some important ways. Several voluntary markets are in development around the world. However, there is no single regulating body currently enforcing quality standards in relation to the development and trading of VERs. For this reason it is important to partner with a company like Eco Securities, which has extensive experience developing high quality emission reduction projects that deliver real and measurable emission reductions. Although there are varying estimates of the potential for CDM projects in India, it is roughly estimated to be in the range of about 300 million tons of CO_2 equivalent, including 90 million tons from renewable energy sources alone. The various end-use segments represented in CDM projects are (1) power; (2) industrial sector energy efficiency, including small-scale industries; (3) industrial cogeneration; (4) transport; (5) renewable energy; (6) agriculture and livestock; (7) municipal solid waste; and (8) land use, land-use change, and forestry (http://www.kyomecha.org/pdf/TERI_Report_0729.pdf).

India's Ministry of Environment and Forests (MoEF) is the modal ministry for all matters related to climate change, both national and international, including the UNFCCC, the Kyoto Protocol, and CDM activities and processes in India. The government has constituted its designated national authority, the national CDM authority, and has established other enabling conditions to provide incentives for CDM project developers and investors to implement activities in India. This enabling environment at the center facilitates project activities and works toward removing any hurdles and barriers to CDM project development. The government takes on such tasks for project developers and investors on request. It has already approved a number of CDM capacity-building initiatives in India by countries like Japan (IGES), Germany (GTZ), etc. (http://www.

kyomecha.org/pdf/TERI_Report_0729.pdf).

Renewable energy technologies (RETs), despite their techno-economic potential, have found meager deployment due to a myriad of barriers. Recent developments in global climate change negotiations, which culminated in the Kyoto Protocol, are likely to remove some of the crucial barriers to RETs that permitted fossil fuels to externalize the environmental costs. India has gained valuable experience in promoting RETs by using different approaches and has achieved a few successes, notably biogas and wind energy. However, a synthesis of this experience shows that a number of barriers still remain to be overcome if RETs are to become commercially viable alternatives. Attempts to introduce renewable energy technologies (RETs) were undertaken in most developing countries after the energy crisis of 1973. Most of these attempts were later abandoned because of a variety of reasons, e.g. the crash of oil prices in 1986, teething problems inevitably encountered in developing new technologies, lack of trained manpower, lack of coordination among various agencies involved (government agencies, R&D institutions, entrepreneurs, and users), lack of consistent government policies, etc. The mid-1990s appear to have been a much better time to promote RETs because of the realization of gross environmental problems associated with the use of fossil fuels and the possibility of joint implementation of renewable energy projects in the near future. (http://144.16.65.194/hpg/envis/enedoc104.html).

India is one of the success stories of the CDM, with 32.83% of all registered CDM project activities and 14.7% of CERs from registered projects (source: UNFCCC). India's dependence on fossil fuels creates high carbon intensity, providing industry with an excellent opportunity to generate large volumes of carbon credits from energy efficiency and clean energy projects (http://www.greenpowerconferences.com/carbonmarkets/carbonmarkets_india_2008.html?gclid=CLuyzoLwzZUCFQOqbwodClTOig).

Augmenting of Indigenous Resources for Increased Energy Security

India's energy resources can be augmented by exploration to find more coal, oil, and gas, or by recovering a higher percentage of in-place reserves. Developing the thorium cycle for nuclear power and exploiting non-conventional energy, especially solar power, offer possibilities for India's energy independence beyond 2050 as outlined below.

- Covering all coal-bearing areas with comprehensive regional, detailed drilling could make a significant difference to the estimated life of India's coal reserves.

- India's extractable coal resources could be augmented through in-situ coal gasification that makes use of those coal deposits which are at greater depth and cannot be extracted economically by conventional methods.

- Extracting coal bed methane before and during mining could augment the country's energy resources.

- Enhanced oil recovery and incremental oil recovery technologies could improve the proportion of in-place reserves that could be economically recovered from abandoned/depleted fields.

- Isolated deposits of all hydrocarbons, including coal, may be tapped economically through sub leases to the private sector.

Using Energy Abroad

In case India can access cheap natural gas overseas under long-term (25-30 years) arrangements, it should consider setting up captive fertilizer and/or gas liquefaction facilities in such countries. This would essentially augment energy availability for India.

Role of Nuclear and Hydro Power

There will be full realization of the hydro potential of the country by 2032. India has a potential of 150,000 MW capacity. The exploitation has been only to the extent of about 20%. Nuclear energy theoretically offers India the most potent means to long-term energy security. India has to succeed in realizing a three-stage development process and thereby tap its vast thorium resources to become truly energy independent beyond 2050. Continuing support to the three-stage development of India's nuclear potential is essential.

Role of Renewables

From a longer-term perspective, and keeping in mind the need to maximally develop domestic supply options as well as the need to diversify energy sources, renewables remain important to India's energy

sector. It would not be out of place to mention that solar power could be an important player in India's attaining energy independence in the long run. With a concerted push and a 40-fold increase in the contribution to primary energy, renewable may account for only 5 to 6% of India's energy mix by 2031-32. While this figure appears small, the distributed nature of renewables can provide many socioeconomic benefits.

Ensuring Energy Security

India's energy security, at its broadest level, is primarily about ensuring the continuous availability of commercial energy at competitive prices to support its economic growth and meet the lifeline energy needs of its households with safe, clean, and convenient forms of energy, even if that entails directed subsidies. Reducing energy requirements and increasing efficiency are two very important measures for increasing energy security. However, it is also necessary to recognize that India's growing dependence on energy imports exposes its energy needs to external price shocks. Hence, domestic energy resources must be expanded. For India, it is not a question of choosing among alternative domestic energy resources but exploiting all available domestic energy resources to the maximum as long as they are competitive.

Ensuring energy security requires dealing with various risks. The threat to energy security arises not just from supply risks and the uncertainty of availability of imported energy, but also from possible disruptions or shortfalls in domestic production. Supply risks from domestic sources, such as from a strike in CIL or the railways, also need to be addressed. Even with no disruption of supply, there can be the market risk of a sudden increase in energy price. Even when the country has adequate energy resources, technical failures may disrupt the energy supply to some people. Generators could fail, transmission lines may trip, or oil pipelines may spring a leak. One needs to provide security against such technical risks. Risks can be reduced by lowering energy requirements through increasing efficiency in production and use, substituting domestic fuels for imported fuels, diversifying fuel and supply choices (gas, ethanol, orimulsion tar sands, etc.), and expanding the domestic energy resource base. Risks can also be dealt with by increasing the ability to withstand supply shocks through creation of strategic reserves, the ability to import energy and face market risk by building hard currency reserves, and providing redundancy to address technical risks.

Boosting Energy-related R&D

Demonstrations of new technologies, their economic assessment, and further R&D to make the new technology acceptable and attractive to customers are recommended before commercialization and diffusion.

Energy Sector: Need for Good Governance

With a population of around 1.1 billion, India is the world's second most populous country and ranks fifth in the world in terms of primary energy consumption, accounting for about 3.5 percent of the world's commercial energy demand. With a GDP growth rate of around 8% during the tenth 5-year plan of the government (2002-2007), India is currently one of the fastest growing economies of the world. The future levels and patterns of energy use in India, therefore, have important implications, both at the national level in terms of the environmental impact of energy use and issues of access and equity, and at the global level in terms of the geopolitics of energy supply and GHG emissions related to the combustion of fossil fuels.

Beginning in February 2005, Chatham House, London and the Centre for Energy, Petroleum, and Mineral Law Policy (CEPMLP) at Dundee University facilitated a dialogue between participants from government; national and international oil companies; and NGOs and financial institutions from 23 developing and developed oil- and gas-producing countries. The conclusions of this dialogue have been supplemented with in-house research on international governance practices. The main conclusions of the project to March 2007, and 40 general governance benchmarks for the petroleum sector, are set out in *Good Governance of the National Petroleum Sector: The Chatham House Document*. This report sets out the analysis and discussions on which these conclusions are based, and it provides examples from country case studies, as well as checklists and guidance for the petroleum sector policy/strategy maker. It is a living text for good governance debate around the world, and it will be revised to reflect future discussions and comments from petroleum sector stakeholders. Participants in the project were clear that, though principles might be universal, practice depends on the national context and the state of development of the sector. The report envisages promoting a greater awareness of the rich breadth of experience upon which producing countries can draw, and it provides a starting point for making practical improvements to governance systems.

Corporate Governance vs. Sustainability Risks of the Oil & Gas Sector

The integrated oil and gas sector is faced with a distinct set of sustainability risks and opportunities, mainly focused on environmental, social, and emerging market issues connected to: access to new reserves, the increasing demand for clean energy, regulatory (carbon) constraints associated with climate change, product development and renewables, environmental management and safety, attracting employees in a climate of labor shortages, product safety and development, health and safety, stakeholder relations, and local community interactions. Environmental issues are quantitative, qualitative, and diverse in assessment, with eco-efficiency practices, environmental management systems, accounting and reporting methods, environmental opportunities, and risk, among other areas, incorporated into an investor's analysis.

With proper governance mechanisms in place, integrated oil and gas companies are better placed to implement an effective sustainability strategy. Advantages associated with a good sustainability strategy and strong performance include greater operational efficiency, reduced risk of accidents, an improved public image that can result in increased market share, greater ease in meeting tightening regulatory requirements, and, in some cases, improved access to project finance, particularly for emerging market operations. One of the key factors that must be looked into for realistic assessment of sustainability, especially for a long-term project in the oil and gas sector (or for that matter, in the energy sector) is senior management's/board of director's commitment to sustainability. Companies that have not developed effective governance mechanisms remain open to a variety of risks, including negative media campaigns, problems recruiting talented people, fines, and project delays. Further, sustainability issues tend to crop up quickly and unexpectedly; inadequate governance implies that companies will be unable to respond effectively, thus magnifying these risks (http://www.csrwire.com/pdf/OilAndGas2006Exceprt.pdf).

Environmental and Social Challenges in Oil Sector Management

Traditionally, environmental and social issues have been largely negotiated bilaterally between the national government and oil companies. Now, many new stakeholders can affect outcomes with respect to business operations in the oil sector, including: (i) local communities and civic organizations; (ii) media and advocacy groups (domestic and international); (iii) local development NGOs; (iv) donor agencies; (v)

national and local businesses; and (vi) regional and local government. The roles, functions, and responsibilities of government agencies and oil companies change, depending upon where an oil project is in its life-cycle. Corporate social responsibility (CSR) is no longer just corporate philanthropy in the oil and gas sector. Companies now see a strong business case for CSR, with expected ROI, and not just a business expense or charity. Good CSR practices encourage the following cardinal principles: (i) long-term perspective; (ii) collaboration among multiple parties or stakeholders, leading to public-private partnerships and local "ownership"; (iii) transparency and accountability; (iv) monitoring and evaluation of programs; (v) third-party auditing; (vi) treating communities as active decision-makers; and (vii) changing the relationship regarding CSR between oil companies and governments.

The following can be suggested as a broad strategic framework for integrating governance, social, and CSR issues of the oil and gas sector:

- Approach environmental and social issues with close collaboration between government and oil companies.
- Emphasize a long-term perspective for relationship-building, mutual trust, and confidence.
- Articulate major social and environmental objectives.
- Encourage openness and transparency with multiple stakeholders.
- Utilize "expectation management" to lower unrealistic demands on government to use oil revenues effectively.
- Address environmental and social aspects of the oil sector early in the negotiations and planning phase—not later during full development and production.
- Employ tough negotiations upfront to achieve a "level playing field" that delineates clearly defined roles and responsibilities.
- Enact laws and policies, but place equal emphasis on creating the institutional capacity for oversight and compliance.
- Apply a holistic perspective in addressing environmental and social issues.

Strategic Oil & Gas Reserve Policy for Energy Security in the Asia-Pacific Region

The Asia-Pacific region has emerged as a dominant hub of globalization, driven by a high level of economic and industrial development. One predominant interest of the countries in the region is to ensure an uninterrupted flow of energy to fuel their growing economies, as well

as unhindered access to sources of raw materials and markets for their products. China, India, Japan, ASEAN, and South Korea have based their economic and industrial expansion on an incessant consumption of energy. Any interruption of energy supplies would adversely impact the economic growth of the region, particularly that of China and India, who have set for themselves targets to maintain an economic growth rate hovering around 10% in the coming years.

There are several causes for disruptions of energy supplies. At one end of the spectrum, disruptions could emerge from wars and competition, and there could also be unforeseen contingencies of a violent regime change in supplier countries, which would likely employ energy denial measures such as brinkmanship strategies to pursue their respective regime's agendas. There is also the threat of terrorists seizing sources of supply. At the other end of the spectrum, the fear of concerted attacks by other non-state actors, such as pirates, could disrupt the sea-based energy supply chain. Notwithstanding the prospects of newer and attractive sources of energy, Asia-Pacific reliance on distant oil sources like the Persian Gulf will continue for the foreseeable future. Given these vulnerabilities and sources of disruption, the emergent future of the oil-dependent Asia-Pacific economies needs to contend with several uncertainties, requiring the seeking of robust energy security measures. These contingencies should also prompt insulating measures that would render these economies immune to disruption, with a view of ensuring stability of the energy supply.

The primary aim of these countries is to avoid the pitfalls of shortage and disruption while employing alternative strategies to restore access to existing or newer sources of supply. The necessity to address the vulnerabilities and shocks in disruption of energy supplies has prompted Asia-Pacific countries to employ political, diplomatic, economic, and security measures to maintain an uninterrupted energy supply chain. Specifically, regional countries are also in the process of building strategic oil reserve stockpiles to enhance their immunity to energy supply disruption. Strategic oil reserves rely on the buffer stock of oil, thereby insulating growing economies and industries from the shocks of supply disruptions and sudden price rises. These reserves are also crucial in case a state is engaged in war, sudden financial crisis, or even natural disasters like Hurricane Katrina, which resulted in colossal damage to offshore oil platforms that lead to a major disruption in the production and refining capacity of the US.

Several Asia-Pacific countries have begun to develop their strategic oil reserves. China plans to have an 800 million barrel strategic reserve, to be stored at four facilities fully operational in 2008. Reports suggest that China completed filling a 16-tank storage facility at Zhenhai in October 2006. Japan has a total of 171 days of consumption reserve. Unlike China, which specifies the quantity of reserves (i.e. millions of barrels), Japan does not report the actual number of its reserves. It is believed that at current consumption rates, 171 days of oil for Japan would correspond to nearly 980 million barrels. India is a newcomer in the community of strategic oil reserve holders. It has begun the development of a strategic crude oil reserve expected to be 40 million barrels. South Korea has a reported reserve of 43 million barrels, Taiwan 13 million barrels, and Australia some 90 days of reserves in addition to over 200 days held in private reserves. Among the ASEAN countries, Thailand recently increased the size of its strategic reserve from 60 days to 70 days of consumption. Singapore has an estimated storage capacity of 31.8 million barrels of crude oil and 64.5 million barrels of oil products.

In these circumstances, especially for the less developed countries, a regional approach to building strategic oil reserves should be moot, to serve in times of an unforeseen crisis. Such a facility can also be considered a stabilizing instrument for growth in Asia, as it would offset sudden price hikes in the world market and effect a proportionate increase of supply within an economic region, to withstand either nature-induced or human-induced disruptions. The development of a strategic oil reserve will also serve as an instrument of staying power in the transition to diversify sources of supply and develop new access to proximate sources of energy. Finally, the idea of a regional approach to building strategic oil reserves would also act as a confidence-building measure, enhancing intra-regional energy security and stability. The estimated strategic oil and gas reserves of the major countries in the Asia-Pacific Region are given below in a representative manner.

China

In 2007 China announced an expansion of its crude reserves into a two-part system. Chinese reserves would consist of a government-controlled strategic reserve, complemented by mandated commercial reserves. This new joint government/enterprise strategic reserve plan is the follow-up to a March 2007 announcement on the construction

of a second strategic reserve with an additional 209.44 million barrels. China's reserve structure is:

- Government Reserves: 101.9 million barrel strategic reserve.
  - — Central government, National Development and Reform Commission (NDRC):
    - Dalian, Liaoning Province: approximate planned capacity 19 million barrels (3,000,000 m^3); planned completion 2008.
    - Qingdao, Shandong Province: approximate planned capacity 19 million barrels (3,000,000 m^3); planned completion 2008.
    - Zhenhai, Zhejiang Province: 52 storage tanks with a capacity of 33 million barrels (5,200,000 m^3); filled as of December 2007.
    - Zhoushan, Zhejiang Province: approximate planned capacity 33 million barrels (5,200,000 m^3); 7.6 million barrels (1,210,000 m^3) filled as of June 2007.
  - — Oil reserve base controlled by local governments:
  - Guangdong Province has begun plans for a reserve.
  - Hainan Province has begun plans for a reserve.

- Enterprise Reserves: 209.44 million barrel strategic reserve.
  - — Commercial oil reserves by major Chinese oil companies, PetroChina, Sinopec, and CNOOC:
    - PetroChina facility, Shanshan County, Xinjiang Uygur Autonomous Region: planned capacity of 50.9 million barrels (8,090,000 m^3).
    - PetroChina facility, Tieling, Liaoning Province: 8 storage tanks with a capacity of 5.03 million barrels (800,000 m^3); completion October 2008.
    - Sinopec facility, Shanghai: under construction.
    - Sinopec facility, Ningbo: under construction.
    - Sinopec facility, Zhanjiang; under construction.
    - Sinopec facility, Caofeidian: under construction.
    - Sinochem facility: under construction.
    - Unknown company, Heilongjiang Province.
    - Unknown company, Gansu Province.
  - — Oil storage reserves by medium and small Chinese oil companies.

India

India has begun the development of a strategic crude oil reserve sized at 37.4 million barrels, enough for two weeks of consumption. Petroleum

stocks have been transferred from the Indian Oil Corporation (Indian Oil) to the Oil Industry Development Board (OIDB). The OIDB then created the Indian Strategic Petroleum Reserves Ltd (ISPRL) to serve as the controlling government agency for the strategic reserve. The current facilities, among others, include:

- Mangalore, State of Karnataka: capacity of 11.22 million barrels (1,784,000 m^3).
- Padur village, Udipi in the state of Karnataka: capacity of 18.7 million barrels (2,970,000 m^3).
- Visakhapatnam, State of Andhra Pradesh: capacity of 7.48 million barrels (1,189,000 m^3).

Japan

As of 2003, Japan has an SPR composed of the following three types of stockpiles:

- — State controlled reserves of petroleum at ten different locations, totaling 320 million barrels.
- — Tomakomai Eastern Oil Reserve Storage Base: 55 storage tanks, total capacity 34 million barrels (5,400,000 m^3).
- — Mutsu-Ogawara Storage Base: 53 storage tanks, total capacity 31 million barrels (4,900,000 m^3).
- — Kuji Storage Base: 3 storage tanks, total capacity 10.5 million barrels (1,670,000 m^3).
- — Akita Storage Base: 15 storage tanks, total capacity 23.4 million barrels (3,720,000 m^3).
- — Fukui Storage Base: 27 storage tanks, total capacity 17.9 million barrels (2,850,000 m^3).
- — Kikuma Underground Petroleum Storage Facility: 8 storage tanks, total capacity 8.9 million barrels (1,410,000 m^3).
- — Shirashima Storage Facility: 8 tankers (4.4 million barrels each), total capacity 35.2 million barrels (5,600,000 m^3).
- — Kamigotou Storage Base: 7 storage tanks, total capacity 21.45 million barrels (3,410,000 m^3).
- — Kushikino Storage Base: 3 storage tanks, total capacity 10.5 million barrels (1,670,000 m^3).
- — Shibushi Storage Base: 40 storage tanks, total capacity 27.6 million barrels (4,390,000 m^3).
- Privately held reserves of petroleum held "in accordance with the Petroleum Stockpiling Law" of 129 million barrels.

- Privately held reserves of petroleum products for another 130 million barrels.

The state stockpile equals about 92 days of consumption, and the privately held stockpiles equal another 77 days of consumption, for a total of 169 days or 579 million barrels. The Japanese SPR is run by the Japan Oil, Gas, and Metals National Corporation.

Singapore

Singapore has an SPR composed of 31.8 million barrels (5,060,000 m^3) of crude oil, with an additional 64.5 million barrels (10,250,000 m^3) of oil products, for a total of 96.3 million barrels.

South Korea

South Korea has an SPR composed of 76 million barrels, equal to about 57 days of consumption. It recently announced plans to increase its SPR to around 141 million barrels by 2010.

Taiwan

According to January 1, 2005 estimates by the *Oil and Gas Journal*, Taiwan's proven oil reserves are approximately 4 million barrels. Total oil production for 2005 is expected to be on the order of 8,404 bbl/d, of which 800 bbl/d is in the form of crude. Oil consumption for 2005 is estimated at the rate of 1,045,000 bbl/d. The majority of the oil is consumed by the industrial sector. Most of Taiwan's crude oil imports come from the Persian Gulf, though West African countries are also important suppliers. To prevent supply disruptions, Taiwan's refiners are under a regulatory requirement to maintain stocks of no less than 30 days of consumption. Refiner-held strategic petroleum stocks are the norm in Asia, and Taiwan's policy is similar to those of Japan and South Korea (http://www.eia.doe.gov/emeu/cabs/taiwan.html). Taiwan has an SPR with a 1999 reported size of 13 million barrels.

Thailand

Thailand has recently increased the size of its SPR from 60 days to 70 days of consumption. Coastal Energy Company (Coastal Energy), formerly PetroWorld Corp., is an independent energy company. The company is principally engaged in onshore and offshore oil and gas acquisition, exploration, development, and production activities. Its

operations are predominantly concentrated in the Gulf of Thailand. The company has 100% working interests in two offshore blocks, G5/43 and G5/50, in Thailand. The company also holds interests in onshore Thailand and has production from the Phu Horm gas field. Geographically, the company operates in the Cayman Islands, Thailand, the UK, and the US. The company is headquartered in Texas, of the US. Its report is an essential source for key operational data, analysis, and strategic insight into the company. The report provides the latest annual and quarterly overview of valuation, share price performance, production, reserves, reserve changes, capital expenditures, acreage, performance metrics, and results of oil and gas operations (http://www.marketresearch.com/product/display.asp?productid=2478894&g=1).

Indonesia

One project that holds tremendous promise for Indonesia's future in worldwide LNG markets is BP's Tangguh project in Papua province (also known as Irian Jaya). Tangguh contains over 14 Tcf of natural gas reserves found onshore and offshore the Wiriagar and Berau blocks. The project will involve two trains, with a combined capacity of 340 billion cubic feet per year (Bcf/y), expandable to 680 Bcf/y. BP's current plans call for the project to be completed by 2008. Initial planning was stalled when BP lost the bids to supply Guandong Province and Taiwan in early 2003. However, in late 2003 and early 2004, BP secured supply agreements with Fujian, China for 127 Bcf/y, with leading Korean steel producer POSCO for 75 Bcf/y, and with Sempra Energy for 180 Bcf/y over 15 years to begin in 2008. These supply agreements made possible the $2.2 billion investment to develop the fields. Under new oil and natural gas legislation enacted earlier in 2005, the Indonesian government in March 2005 extended BP's contracts to 35 years for three natural gas production blocks associated with Tangguh (http://www.oilgasarticles.com/articles/434/1/Natural-Gas-Reserves-in-Indonesia/Page1.html).

Myanmar

Official statistics reveal that foreign investment in Myanmar's oil and gas sector had reached 3.398 billion U.S. dollars in 89 projects as of the end of May 2009, standing second in the country's foreign investment after electric power. According to the Central Statistical Organization, in the fiscal year 2008-09, Myanmar produced 6.89 million

barrels of crude oil and 11.381 billion cubic-meters (BCM) of gas. More statistics showed that during the year, Myanmar gained $2.384 billion from exporting 10.674 BCM of natural gas. Following the exploration and development of two huge offshore gas fields of Yadana and Yetagun, the Thai PTTEP has been engaged in five more offshore blocks (M-7, M-9, M-3, M-4 and M-11) as the sole operator in the Mottama offshore area since 2003. Seven test wells have been found with large and commercial gas deposits since 2005, which are Zawtika-1, Gawthaka-1, Karkonna-1, Zawtika-2, Zawtika-3, Zawtika-4, and Zawtika-5. In June 2008, the PTTEP and PTT Public Co Ltd. jointly signed a deal with Myanmar on the sale of natural gas produced from the M-9 block in Myanmar's Mottama offshore area. With a total estimated gas reserve of more than 8 trillion cubic feet (TCF), or 226.5 billion cubic meters (BCM), and a production rate of about 300 million cubic feet (MCF), or 8.49 million cubic meters (MCM) per day, the M-9 field is expected to be able to produce and export gas to Thailand by late 2012 (http://news.xinhuanet.com/english/2009-07/28/content_11785540.htm).

In the summer of 2009, Myanmar signed a memorandum of understanding with PetroChina to supply large volumes of natural gas from reserves of the Shwe gas field in the Bay of Bengal. The contract runs for 30 years. What the Myanmar-China pipelines will allow is routing of oil and gas from Africa (The Sudan, among other sources) and the Middle East (Iran, Saudi Arabia) without depending on the vulnerable chokepoint of the Malacca Strait. Myanmar becomes China's "bridge" linking Bangladesh and countries westward to the China mainland, independent of any possible future moves by Washington to control the strait (http://www.atimes.com/atimes/Southeast_Asia/IJ17Ae02.html).

Bangladesh

Some media reports quoting *Petrobangla's* submission to a parliamentary standing committee have indicated that that the proven gas reserve may run out as early as 2011, and if actions can be taken to convert probable reserve to proven reserve, this may last until 2015. The following figures appeared in media reports (http://www.energybangla.com/index.php?mod=article&cat=SomethingtoSay&article=1839):

- Recoverable reserve of 23 discovered Gas Fields: 15.41 Tcf.
- Gas already used throughπ December 2008: 8.05 Tcf.
- Remaining recoverable reserve: 7.36 Tcf.

- 79 wells of 17 producing fields producing: 1870-1900MMCFD.
- 6 gas fields operated by 4 IOCs producing: 970 MMCFD.
- 11 gas fields of 3 PB companies producing: 930 MMCFD.
- Gas consumption pattern; power (grid): 700-730MMCFD.

CHALLENGE OF THE 21ST CENTURY—EMERGENCE OF CARBON NEUTRALITY & A CARBON-LITERATE SOCIETY

The challenge of the 21st century will be for society to regain a healthy relationship with our "living" earth. The signs are clear that right now we are failing in that task. Unless we change our ways, it is likely that comfortable civilization as we know it will disappear. Climate change is not just an environmental problem—it is a societal problem. The simple truth is that humanity is changing the atmosphere; every day we add around 70 million tons of invisible carbon dioxide, the very gas that we know controls the temperature of the planet.

Carbon neutrality is a simple concept, but the details are complex. The concept of carbon neutrality is fairly straightforward in theory, but in practice the details are complex and in some quarters even controversial. Going "carbon neutral" means that all the carbon climate change impact has been calculated and accounted for, reducing the carbon footprint has been investigated, and carbon credits have been purchased to offset unavoidable greenhouse gas emissions. Carbon neutrality offers individuals, businesses, and other institutions the opportunity to take personal responsibility for the global warming implications of their lifestyle. In response to a rapid increase in public awareness about global warming in the last 12 months, many corporations are focusing on how they can manage their carbon impacts. A carbon neutral company is one where net CO_2 equivalent emissions from its activities are zero. In principle, a product or service can also be made carbon neutral (carbon neutral: http://www.noco2.com.au/).

World civilization is dependent on fossil fuels and is starting to recognize the consequences. However, we are still predominantly carbon- illiterate. Carbon dioxide, the primary greenhouse gas caused by burning fossil fuels, is invisible to all and unknown to many, and there are few economic penalties for its release. The key question is how to break this vicious circle and create action. Consumers are becoming more aware, but it is unrealistic to expect major change until carbon is properly priced in the economy, which requires government action.

Lead energy/power-generating companies have the ability to break the cycle by helping raise consumer awareness, challenging government, and looking for business opportunities in a carbon-constrained world. There is clearly a need for more research to be done on understanding what exactly encourages people to reduce their emissions, as well as the extent to which the practice of offsetting has an effect on such behavior and how much it can play a role in educating people about climate change (http://www.carbonsense.com/documents/DevelopingCarbon-Literacy.pdf).

The biggest-spending consumers in the voluntary offset market are businesses. As with individuals, the motivation for offsetting varies. Some companies argue that they recognize the threat of climate change and try to act responsibly, but some of the motivations for offsetting will be strategic—they might be to meet corporate social responsibility (CSR) obligations, generate goodwill, or attract the growing number of customers attracted by environmental action. Future efforts should be directed to bridge the gap between a carbon-literate and a carbon-illiterate society. Sustained efforts will also be required to address concerns on developing sustainable energy portfolios in context with environmental management and climatic changes, while at the same time meeting the growing needs of society for enhancing developmental matrices and improving human developmental indices (http://www.carbonsense.com/documents/CarbonSense_whatwouldagenuinelycneutralBTlook-like.pdf).

International Cooperation & Major Global Initiatives for Energy Security & Sustainable Development

The Organization for Economic Cooperation and Development (OECD)/International Energy Agency (IEA) and recent reports on the World Energy Outlook 2004 (IEA, 2004) project that over the next 30 years global primary energy demand will grow by 1.7% per annum from 9.20 billion tons to 15.30 billion tons of oil equivalent, and that this demand will be met primarily by conventional fossil energy such as oil, natural gas, and coal in the near term. Energy from renewable resources is also expected to grow in the mid-century term but will remain a small percentage of the total energy mix in the near term. Based on a number of statistics, it is also projected that many communities across the globe living at or below the poverty line (1.40 billion people according to IEA) will remain without access to modern energy systems such as electric-

ity, which is an essential requirement for social and economic development. The overall value of the global carbon market was estimated at over $10 billion in 2005. In the first quarter of 2006 alone, the value of carbon market transactions reached $7.5 billion. This growth is driven by high prices in the EU ETS market for allowances. EUAs worth $8.2 billion were traded in 2005. This corresponded to 322 million tCO_2e and represented almost a 40-fold increase over the previous years' volumes. The following is the text of a declaration at the 2007 EU-U.S. summit on energy security, efficiency and climate change:

Ensuring secure, affordable supplies of energy and tackling climate change are central, interlinked global challenges facing the international community. Addressing these issues requires urgent, sustained global action and an integrated policy approach, using a wide range of regionally, nationally or internationally defined policy tools and measures. We are determined to ensure access to affordable, clean, and secure sources of energy to underpin sustainable global economic growth and to protect our environment. Tackling the challenge of energy security will also require unprecedented international cooperation in several areas, including increasing energy efficiency, market transparency, diversifying energy supplies—including the share of renewable energies—and protecting and maintaining the world's energy supply system…. We reaffirm our commitment to international cooperation on global observation and will continue to exercise leadership in the development of the Global Earth Observation System of Systems (GEOSS), including working to strengthen weather observing, climate and air quality monitoring, and forecasting for human health, global disaster preparedness and monitoring, and drought monitoring and forecasting. We encourage participation in the November 30, 2007 Fourth Earth Observation Ministerial in Capetown, South Africa (http://www.eurunion.org/partner/summit/Summit20070430/EnergSecur&ClimChnge.pdf)

The World Bank has been a pioneer in the carbon market, mainly through the establishment of carbon procurement funds to secure carbon credits on behalf of investors (Feinstein, 2002). These funds typically enter into pay-on-delivery contracts and contribute to the positive cash flow of projects after the start of operations and the delivery of emission reductions. Recently, some funds have secured limited insurance against non-delivery of CERs and are able to offer partial upfront payments. The funds in the World Bank portfolio were not solely intended to procure carbon credits but also to help create demand and spur the global carbon market (World Bank, 2007).

The *G-8 Gleneagles Plan of Action* on climate change, clean energy,

and sustainable development specifically flagged "tradable certificates and trading of credits" and "project-based and voluntary offset mechanisms" as elements of a carbon market that need further policy development. The World Economic Forum Roundtable, in a statement released just prior to the G-8 Summit, urged governments to "establish a long term, market-based policy framework extending out to 2030… and define greenhouse gas emissions rights through a cap and trade system or other market-based mechanisms…"

Market-based mechanisms, and emissions trading in particular, have been singled out by political and business leaders because they have the potential to significantly reduce costs and increase the feasibility of achieving the deep long-term reductions required to address the risks of climate change. These approaches can also mobilize investment in low-carbon energy technologies and promote technology transfer to less developed countries (http://www.earthobservations.org/docs/resolutions/G-8%20Plan%20of%20Action%20Cites%20GEOSS.pdf)

The Emerging International Carbon Market

The carbon markets are a prominent part of the response to climate change and have an opportunity to demonstrate that they can be a credible and central tool for future climate mitigation. The carbon market grew in value to an estimated US$30 billion in 2006 (€23 billion), three times greater than the previous year. The market was dominated by the sale and resale of European Union Allowances (EUAs) at a value of nearly $25 billion under the EU ETS (€19 billion). Project-based activities, primarily through the clean development mechanism (CDM) and joint implementation (JI), grew sharply to a value of about US$5 billion (€3.8 billion) in 2006. The voluntary market for reductions by corporations and individuals also grew strongly to an estimated US$100 million (€80 million) in 2006. Both, the Chicago Climate Exchange (CCX) and the New South Wales Market (NSW) saw record volumes and values traded in 2006 (World Bank, 2007).

The carbon market is to play a significant role in helping achieve the deep GHG emission reductions required over the next 20 years; decision-makers will need to consider how best to broaden and deepen the reach of that market. The broader the reach of the carbon market—through greater participation of countries and/or coverage of key sources and sectors and/or companies—the more efficient and effective it will be in minimizing costs and mobilizing investment. Broad cov-

erage can also address concerns about leakage of emissions-intensive economic activity between countries, as well as competitiveness more generally. Broadening and deepening the market will likely require a more flexible range of options to meet widely differing national circumstances and needs.

The criteria for the years after 2012 will include how to broaden participation in the carbon market in developing countries in a way that minimizes cost uncertainties and promotes economic growth and investments in low-carbon technology. In particular, the engagement of less advanced developing countries in the carbon market needs to be supported. The CDM will likely continue to play an important role and may expand its scope to address policy-based crediting and a broader range of projects. Efforts are underway to strengthen and streamline the CDM. A strengthened CDM can help build practical experience and confidence with market-based approaches across the developing world and position the CDM to contribute beyond 2012. Its ability to achieve this, however, is limited by uncertainty over the value of CDM credits beyond the 2012 timeframe. Without a clear signal from policymakers, the flow of investments through the CDM is likely to diminish significantly over the next couple of years.

The worldwide carbon market developed as a response to the threat of climate change caused by the excessive emission of greenhouse gases, in particular carbon. Today, 182 countries are working to limit carbon emissions, although the biggest polluter, the USA, has yet to ratify the accord (Warren Bell & Drexhage, 2005). The carbon market approach is that of a cap and trade system. The government or body running the carbon market will set an annual cap on the amount of emissions that participants such as industry and governmental bodies can cause. The World Carbon market, starting from essentially nothing, has become a major business.

Carbon trading has raised $14 billion in renewable energy investment in developing countries between 2002 and 2006. The global carbon trading market was worth an estimated $30 billion in 2006, a 200 percent increase from 2005. The European Union is currently responsible for over 80 percent of the global market. As of mid 2007, it has driven approximately $13 billion in investments in 60 carbon funds, up from around $5 billion invested in 40 carbon funds by May 2006.

The pointarbon.com "Carbon 2008" estimated that the world carbon market was worth $60 billion and would grow a further 50 to 80

percent in 2008. Traded carbon credits have grown 64 percent from 1.6 gigatons to 2.7 gt. Consensus forecasts are for carbon prices to reach $37 per ton by 2010 and $54 by 2020, with optimism that this will lead to a reduction in EU emissions during that period.

The EU carbon market, the European Union Emissions Trading Scheme (EU ETS), is expected to witness carbon credit shortages by 2010, and this will lead to improvements in efficiency and increased usage of renewable energy sources. Indeed, carbon prices will be a key to the success of the EU ETS and of similar markets elsewhere in the world, i.e. a global carbon market. Europeans are increasingly expecting a global market to be formally created after the Kyoto Protocol lapses in 2012. They believe that the early signs of success are there and that the knowledge gained so far is applicable on a worldwide scale (http://www.economywatch.com/carbon_market/).

Emissions Trading Modalities: Cap & Trade System

As mentioned earlier, emissions trading is an administrative approach used to control environmental pollution by providing economic incentives for achieving reductions in the emissions of pollutants. Kyoto is a cap and trade system that imposes national caps on the emissions of Annex I countries. On average, this cap requires countries to reduce their emissions 5.2% below their 1990 baseline over the 2008 to 2012 period. The first step in setting up a cap and trade program is deciding which greenhouse gases and emissions sources are covered and who is responsible for holding allowances. Some sectors that might be included under the cap are electric power, manufacturing, transportation, and fossil fuel use. Emissions trading strategy should utilize financial market best practices and spread market exposure over the year for trading a net-long or net-short position. This exposes the firm to an average price traded value over the year and not a single off price. The larger the short or long exposure, the closer the position should be actively managed by financially experienced personnel. Options of floating price forwards and swaps can also be used to ensure a beneficial average annual price exposure and minimize transaction costs. An effective and active trading strategy will help ensure that market trends are tracked and that market timing of transactions are effective. There are few barriers to cap and trade emissions trading, so long as markets evolve, especially across Europe. Liquidity has improved, and one common market across Europe has evolved for emissions that is more akin to financial markets like

foreign exchange than to flow-based commodity markets where there are still massive barriers to the creation of an effective pan European traded market.

Compliance and Enforcement

Multiple commitment periods offer significant opportunities for enforcing compliance. The principal tools for enforcing compliance include declaring non-compliant parties ineligible for trading and reducing assigned amounts in subsequent commitment periods. Currently, the protocol establishes that there will be negotiations to fix assigned amounts in subsequent commitment periods, but it has perhaps not been generally recognized how important that task is in promoting compliance within the first commitment period. Transparency is another tool for ensuring compliance, since much of domestic law presumes that enforcement will be based upon public opinion and normative pressures to comply. Transparency is an important complement to enforcement because it makes violations apparent, and the fear of detection promotes compliance. Transparency systems require the disclosure of basic information regarding obligations, actual emissions, and trading activity in order to allow judgments about compliance status. To date, transparency systems have relied heavily on self-reported data and have worked best when data have been made available to the public. Such data need to be collected and verified at the international level, which will require the use of international public databases of self-reported and verified information, under the responsibility of an authorized body. Numerous issues concerning carbon trading regimes have yet to be worked out, but they could significantly affect the various parties involved in trading. These issues include:

- Whether countries' controlling regimes will be compatible with trading
- The effect of restrictions on permit availability or demand
- Impacts of international transfer payments
- Measurement and reporting of emissions, sinks, and costs
- Accountability and enforceability

Carbon Market: The Regulatory Instruments

The emerging global carbon market is growing exponentially as states and countries around the world use the power of the market to control greenhouse gas emissions. In the US, a voluntary market has sprung up to help provide a method to track these emission reductions

for concerned individuals and businesses. Carbon offset and renewable energy credits typically represent investments in alternative energy enterprises, energy efficiency technology development, and forestry- or agriculturally-related (carbon sequestration) projects. International and federal legislation has been enacted to deal with GCC issues. The Montreal Protocol was originally signed in 1987 and substantially amended in 1990 and 1992; it governs compounds that deplete ozone in the stratosphere—chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform.

The Voluntary Carbon Markets

The voluntary carbon market (VCM) has developed independently of government targets and policies and is a place where anybody, from businesses to NGOs to individuals, can participate in the business of offsetting. Carbon credits are also created in the voluntary market, but unlike the compliance market where credits are tradable under the Kyoto flexible mechanisms, credits in the voluntary market are generally non-fungible (i.e., they are not tradable between schemes). There is a legally-binding voluntary market where parties can set self-imposed, legally binding greenhouse gas emissions reductions targets; an example of this is the Chicago Climate Exchange. In voluntary carbon markets, activities that reduce GHGs produce verified emission reductions (VERs) which can be sold to companies or individuals wishing to voluntarily reduce their carbon footprints. GHG emission reduction projects developed under the Kyoto Protocol's clean development mechanism (CDM) have been highly successful in reducing emissions and generating certified emission reductions (CERs), which are then purchased by governments and organizations in Europe and Japan to help meet their emission reduction targets. The current voluntary offset market is seen as potentially undercutting the compliance market with cheaper offsets that are not clearly additional and sending the wrong price signals. Since the public and the media often do not distinguish between compliance and voluntary markets, there is also a risk of damaging the reputation of compliance markets. To secure quality and transparency in the voluntary market, it is argued that voluntary offset standards should closely follow CDM procedures and apply them to VERs (e.g., the CDM approach to additions, the documentation of reductions, and the monitoring and verification processes). Standards that share this viewpoint include VER+ and the voluntary offset standard (VOS).

Voluntary Carbon Standards

The voluntary carbon standard has been developed by The Climate Group and the International Emissions Trading Association (IETA). The voluntary carbon standard aims to ensure that all voluntary emission reduction projects that want to trade in VCUs are independently verified to meet specific criteria and that these will represent "real, quantifiable, additional, and permanent project-based emission reductions." The VCS will provide protocols and criteria to certification entities and project developers on specifications for creating, verifying, and registering VCUs. The VCS has created a registry managed by the Bank of New York that is used to register, transfer, and retire VCUs from the market. There are two elements to standardized offset crediting: (1) streamlining the estimation of project baselines by using standard assumptions and emission factors; and (2) deciding the "additionality" of projects using standard eligibility criteria. The basic requirements for developing standardized baselines have been well-documented. Standardized approaches work best when projects and their baseline alternatives are fairly homogeneous, when similar technologies and practices are in use across wide geographic areas, and when performance data on those technologies and practices are readily available. Even when certain types of projects are highly suited to standardized methods, most carbon offset programs have relied on at least some project-specific data in order to accurately estimate baseline emissions. Because standardization involves balancing policy objectives related to cost, equity, and environmental integrity, institutional processes should be transparent and accountable. Efforts should focus on project categories with high suitability for standardization and the greatest potential contribution to sustainable development, such as renewable energy, industrial energy efficiency and process emissions, and efficient vehicles.

Carbon Credit Offsetting and its Standardization

A carbon credit becomes a carbon offset when the value of the credit is invested in projects that reduce emissions. Tradable GHG reductions are often purchased to offset or "neutralize" a company's carbon dioxide emissions and are therefore commonly referred to as "carbon offsets." Carbon offsets are a unique commodity. In essence, they are a claim or property right to a specific, verified reduction in GHG emissions. Carbon offsets originate from projects or activities (i.e.,

"offset projects") explicitly designed to reduce GHG emissions. In purchasing and retiring an offset, a company in effect makes the claim that it has foregone reducing its own emissions but is instead paying someone else to achieve the same net result. Carbon offsets are intangible, so their integrity depends on assurances about how well they meet certain defining criteria. Offsetting is a way for individuals and companies to compensate for their own greenhouse gas emissions by investing in projects that remove carbon from the atmosphere or reduce or eliminate GHG emissions compared to conventional methods. The idea is that by offsetting the emissions level for an activity (e.g., a flight), the activity becomes "carbon neutral." Carbon offsets are generated by renewable energy, efficiency projects, and other projects that avoid the release of CO_2 or other greenhouse gasses. This rise of offsets has been accompanied by greater "carbon literacy" among companies and consumers, with hard questions being asked, not just of the offset providers, but also of the relevance of offsets in the wider carbon emissions solution/climate change challenge.

Achieving Carbon Neutrality

Carbon neutral, or carbon neutrality, is a term used to describe the actions of organizations, businesses, and individuals taking measures to remove as much carbon dioxide from the atmosphere as each put into it. Being carbon neutral, or having a net zero-carbon footprint, refers to achieving net-zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount sequestered or offset. The carbon neutral concept may be extended to include other greenhouse gases (GHG) measured in terms of their carbon dioxide equivalence—the impact a GHG has on the atmosphere expressed in the equivalent amount of CO_2. The term climate neutral is used to reflect the fact that it is not just carbon dioxide (CO_2) that is driving climate change (even if it is the most abundant) but also other greenhouse gases regulated by the Kyoto Protocol, namely: methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulphur hexafluoride (SF6). The overall goal of carbon neutrality is to achieve a zero-carbon footprint. Being carbon neutral involves calculating your total climate-damaging carbon emissions, reducing them where possible, and then balancing your remaining emissions, often by purchasing a carbon offset such as paying to plant new trees or investing in green technologies like solar and wind power.

ADDRESSING CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT ISSUES

Sustainable development has become part of all climate change policy discussions at the global level, particularly due to adoption of Agenda 21 and the various conventions resulting from UNCED-1992 (http://www.un.org/geninfo/bp/enviro.html). The generally accepted and used definition as given by the Brundtland Commission is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (http://simple.wikipedia.org/wiki/Brundtland_Commission#cite_note-0)

Climate change and other sustainable development policies are often but not always synergistic. There is growing evidence, for example, that decisions about macroeconomic policy, agricultural policy, multilateral development bank lending, insurance practices, electricity market reform, energy security, and forest conservation, which are often treated as being apart from climate policy, can significantly reduce emissions. On the other hand, some decisions—for example those about improving rural access to modern energy sources—may not have much influence on global GHG emissions. Climate change policies related to energy efficiency and renewable energy are often economically beneficial, improve energy security, and reduce local pollutant emissions. Other energy supply mitigation options can be designed to also achieve sustainable development benefits, such as avoided displacement of local populations, job creation, and health benefits.

Sustainable development has become an integrating concept embracing economic, social, and environmental issues (L´el´e, 2001). Sustainable development does not preclude the use of exhaustible natural resources, but it requires that any use be appropriately offset. This concept is not acceptable to many developing countries, since it seems to disregard their aspirations for growth and development. Further, sustainable development cannot be achieved without significant economic growth in the developing countries. Three critical components in promoting sustainable development are economic growth, social equity, and environmental sustainability. Switching to more sustainable development paths can make a major contribution to climate change mitigation, but implementation may require overcoming multiple barriers. Climate change and other sustainable development policies often benefit each other, though not always. There is a growing understanding of the pos-

sibilities for choosing and implementing mitigation options in several sectors to create synergies and avoid conflicts with other aspects of sustainable development (http://www.global-greenhouse-warming.com/sustainable-development-policies.html).

Climate Change and Global Poverty Alleviation:

As the IPCC recently concluded, climate change is already creating devastating impacts for the world's poorest and most vulnerable people, especially those in developing countries, even though they are the least responsible for causing it. Those impacts will become all the more severe in the coming decades and will sometimes even reverse the development process as a whole. Climate change is already a major driver of impoverishment and conflict around the world, but that fact has not yet been given the urgent attention it demands. Over the past century, the United States and other wealthy countries have been and continue to be responsible for a disproportionate amount of the greenhouse gas emissions that cause global warming. With only five percent of the world's population, the United States emits about 25 percent of greenhouse gases generated by human activity (IPCC-http://www.foe.org/pdf/climatedevelopment-principlels121007.dpf).

Energy for Sustainable Development

Energy is a critical instrument for socioeconomic and sustainable development (Suarez, 1995). Energy is both an engine of development and a source of many problems the world faces today. Some 2.4 billion people in developing countries lack modern fuels for cooking and heating, and approximately 1.6 billion people do not have access to electricity. Yet human activities, primarily the combustion of fossil fuels, have caused the Earth to warm and its climate to change on both global and regional scales since the pre-industrial era, with most of the warming occurring during the last 50 years. The current energy infrastructure is unsustainable, vulnerable to natural disasters, and woefully insufficient in many developing countries. Energy wastage during the course of production and transmission is a serious problem. Perhaps half of the forecasted growth in global greenhouse gas emissions could be avoided by greater energy efficiency alone. Energy poverty is a barrier to sustainable development for many poorer rural communities in all regions of the world. Although the millennium development goals (MDGs) lack explicit targets related to the provision of energy to the poor, access to

affordable energy is imperative for poverty alleviation and sustainable human development.

Governments should provide incentives, within legal and policy frameworks, for public, private, and community-level action towards greater fuel efficiency and the use of appropriate technologies. Countries with such incentive systems can serve as examples of utility-based incentives for renewable energy technologies (RETs); tax incentives; fuel displacement levies and feed-in laws; extension of loans to renewable energy promoters and consumers shifting to RETs; market mechanisms; and pricing policies such as net metering facilities and tax-exemption on public bus purchases. Such incentives have the potential of encouraging private sector players to promote the use of renewable energy, including wind, solar, and hydropower. Developed countries should further international cooperation to transfer renewable energy technologies and capacity-building to developing countries. However, efforts by developed nations to provide energy from waste incineration must be opposed, as incineration emits large amounts of toxins and other substances harmful to the environment in general and to human beings in particular.

Governments should implement existing commitments with relevance to energy for sustainable development, including those made in Agenda 21, the WSSD, and the Johannesburg Plan of Implementation (WSSD, 2002). Additionally, we call upon governments to specify and agree on measures to address climate change in the energy sector at CSD-14. It is critical for countries to implement fully and expeditiously the UN Framework Convention on Climate Change, its Kyoto Protocol, and related climate change agreements, policies, and partnerships. All stakeholders working within the intergovernmental system should explore decreasing and offsetting carbon emissions from civil aviation related to their work.

Due to the vulnerability of the energy sector to corruption during the privatization process, governments and development partners should ensure that appropriate mechanisms are put in place to ensure transparency and good governance as a prerequisite to privatization. Governments should also strengthen their regulatory role with regard to the energy sector so as to protect the public from exploitation by private sector players, especially multinational corporations. Governments should involve civil society in multi-stakeholder participatory processes during the design, implementation, and monitoring

of energy programs (http://www.unep.org/civil_society/GCSF/contributions/statement_to_GC9.pdf). Energy is central to sustainable development and poverty reduction efforts. It affects all aspects of development—social, economic, and environmental—including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues. None of the millennium development goals (MDGs) can be met without major improvement in the quality and quantity of energy services in developing countries. UNDP's efforts in energy for sustainable development support the achievement of the MDGs, especially MDG 1, reducing by half the proportion of people living in poverty by 2015. Through an integrated development approach, UNDP-sponsored international initiatives/programs proactively help create enabling policy frameworks, develop local capacity, and provide knowledge-based advisory services for expanding access to energy services for the poor (http://www.undp.org/energy/).

Sustainable Energy Development for the Asia-Pacific Region

The Asia-Pacific region, among the world's most populous and diverse, includes many of the world's communities that are most at risk from catastrophic events brought about by climate change and other fossil-fuel consumption-related impacts. The region needs a coherent and effective framework for sustainable development—which inevitably has to mandate the rapid deployment of renewable energy and energy efficiency policies and practices. When we look at Asia, what we see clearly is a remarkable success story of rapid economic growth and poverty reduction. In less than a generation, the Asian people have transformed their economies, many of which are now among the most vibrant and dynamic economies in the world. Along with growth, Asia's energy consumption has been rising steadily, and the need to reduce poverty and meet the millennium development goals means that it will continue to rise. With most of its energy coming from fossil fuels, a primary source of greenhouse gas emissions, Asia now accounts for nearly one-quarter of the world's GHG emissions. The International Energy Agency (IEA, 2004) has estimated that the region will require between $4 trillion and $5 trillion from now to 2030 for new energy infrastructure. Most of the investment will be directed toward electricity, primarily coal-fired power plants. On this basis, it is reported that global energy-related carbon dioxide emissions

will surpass 40 billion tons in 2030, with Asia contributing about 40% of total emissions.

The World Summit on Sustainable Development (WSSD, 2002) took place from 26 August-4 September 2002, in Johannesburg, South Africa. The goal of WSSD was to hold a 10-year review of the 1992 United Nations Conference on Environment and Development (UNCED) to re-invigorate a global commitment to sustainable development. The WSSD brought together more than 20,000 formally registered participants from 191 governments, 118 United Nations agencies and international organizations, and numerous non-governmental organizations, as well as representatives from the private sector, civil society, academe, and the scientific community. The WSSD negotiated and adopted two main substantive outputs: A WSSD Plan of Implementation and the Johannesburg Declaration on Sustainable Development. In addition, a large number of partnerships were launched to help implement the commitments made at WSSD. In the context of sustainable development in the Asia and Pacific region, the chapter on regional initiatives calls for action in the following areas: capacity building for sustainable development; poverty reduction; cleaner production and sustainable energy; land management and biodiversity conservation; protection and management of and access to freshwater resources; oceans, coastal, and marine resources and sustainable development of small island developing states; and atmosphere and climate change (http://www.adb.org/Documents/Conference/WSSD/WSSD.pdf).

The World Council for Renewable Energy (WCRE-World Bank, 2004) called for the urgent development and enactment of such a framework. It is ready to assist governments and inter-governmental organizations in the energy policy formulation process as well as in the adoption of specific sustainable energy strategies (http://www.gdrc.org/uem/energy/renewable-energy-agenda-2004.html). Such strategies are to reinforce existing sustainable development efforts that are pursued in the region by national, provincial, and municipal governments; a number of aid and lending institutions; and a large number of non-governmental organizations. Most current development programs are still far too reliant on fossil-fuel or nuclear-based projects. Furthermore, regional development policy signals set by many leading countries are frequently colored by short-term resource extraction and trade objectives with too little regard for local and global sustainability. The local viability of the poorest nations and indigenous communities remains severely under-recognized.

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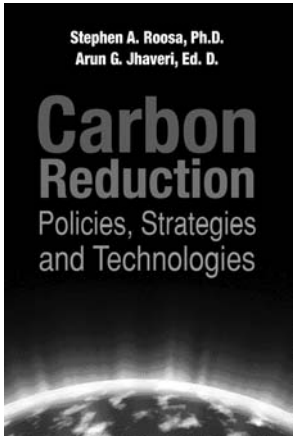

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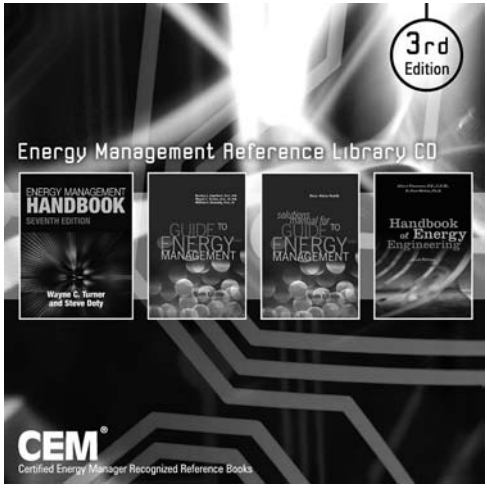

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Renewable energy applications in the Asia-Pacific region—when delivered as sustainable solutions that respond to local environments and communities—are essential to deliver genuine results on millennium development goals and all five development imperatives of the World Summit on Sustainable Development 2002 (WSSD, 2002) development (http://www.gdrc.org/uem/energy/renewable-energy-agenda-2004.html). These imperatives are:

- Water: sustaining communities and industry without waste or pollution
- Energy: generated from clean, renewable sources
- Health: ensuring clean water, air, and sanitation
- Agriculture: renewable base with sustainable forms of irrigation
- Biodiversity: elimination of habitat destruction (such as energy poverty-induced deforestation practices, or water depletion and contamination in fossil and nuclear power generation)

Policy Initiatives for the Developing Countries in the Asia-Pacific Region

The WCRE Asia Pacific (World Bank, 2004), urges the implementation of the recommendations of the World Bank Extractive Industries Review final report, "Striking a Better Balance," as they relate to renewable energy, specifically the following (http://www.gdrc.org/uem/energy/renewable-energy-agenda-2004.html):

- Assist governments in adopting sustainable energy strategies that address the energy needs of the poor and minimize externalities such as climate change.
- Internalize the cost of greenhouse gas emissions into all World Bank Group (WBG) economic decision-making.
- Increase investments in sustainable energy resource development. This includes setting targets for increasing the proportion of investment in renewable energy within the energy portfolio, increasing annually at 20 percent (up from 6 percent of investment) to achieve a better balance with support for other projects.
- Phase out lending in fossil-fuel projects over time.

- Implement initiatives for technology transfer related to climate change and further research into appropriate technology.

In addition, the WCRE urges regional governments to:

- Build local renewable industry capacity and capability so as to deliver the social and economic benefits that renewable energy can provide.
- Support tariff-free renewable energy trade and technology transfer.
- Offer loans for renewable energy technology dissemination programs through private entrepreneurship; these will not only create decentralized electricity companies in non-electrified areas but also produce income-generation opportunities.
- Enforce a strict split between aid program fund sources and providers such as executing agencies and consultants. Specific solutions must be offered competitively, not be technology pre-determined, and meet stated sustainability aims on a locally appropriate basis. Appropriate renewable energy, industry sustainability protocols are needed to achieve this.

Global Trend in Sustainable Energy Development

Investment in sustainable energy is rapidly increasing, as evidenced by $70.9 billion of new investment in 2006, which was 43% more than in 2005, and a similar continued growth trajectory in 2007. This is in response to a number of global challenges and concerns, including climate change, increasing energy demand, and energy security. The investment community recognizes the importance of the sector and the opportunities for value creation it presents. Consumers and companies are supporting the roll out of a new energy infrastructure and a change in individual and corporate behavior. Most importantly, governments and policy makers are introducing legislation and support mechanisms to accelerate the development of the sector. The Report on Global Trend in Sustainable Energy Investment (http://www.un-ngls.org/site/article.php3?id_article=299) presents the dollar view of the current status of sustainable energy development, including both the renewable energy (RE) and energy efficiency (EE) sectors. The analysis is based on the different types of capital flows and their movement over time, combined with regional and sector trends. The implications for all stakeholders of this rapidly-evolving capital build-up

are examined. The information is intended to provide financiers, policy makers, and drivers with an overview of the status of sustainable energy market development to help them weigh their commitments to the sector (http://www.leonardo-energy.org/drupal/node/2180).

Global Roundtable on Climate Change

Recent scientific and technological advances provide the world with increasingly visible and troubling evidence that human activity is having a dangerous impact on the Earth's climate system. Consequently, there is an urgent need to better understand the threats posed by human-induced climate change and to build a consensus on proactive initiatives that can help society mitigate and adapt to its impacts. The Global Roundtable on Climate Change assists this effort by bringing together officials and leading experts from business, civil society, international organizations, and research institutions for five years of meetings and related activities. The Roundtable has five overarching objectives (http://www.earth.columbia.edu/grocc/grocc4_statement.html):

- To assist development of a global consensus on core scientific, technological, economic, and policy issues related to climate change—one that simultaneously considers the need to mitigate the very significant risks posed by anthropogenic climate change and the need for economic growth and human development around the world.

- To identify technological and policy options for mitigating climate change while meeting global energy needs.

- To champion demonstration projects that test and scale sustainable energy technologies, and other activities and policies that address climate change.

- To provide a unique forum for discussion, analysis, and exchange of ideas among businesses, international institutions, non-governmental organizations, policy makers, and leading academic experts from across economic sectors and all parts of the world.

- To catalyze new initiatives and interactions among Roundtable participants to address climate change.

Convened by The Earth Institute at Columbia University, the Roundtable is made possible by a generous grant from the Lenfest Foundation, which is dedicated to supporting programs primarily in the areas of education, the arts, and the environment. Detailed information on the Roundtable can be found at http://www.earthinstitute.columbia.edu/grocc/. The Roundtable meetings, as well as important intersession activities, have included discussions of the current scientific understanding of climate change, technological and policy options for mitigating climate change while meeting global energy needs, potential areas for demonstration projects, possible roles for the business community in discussing and addressing the climate issue, and potential principles that the Roundtable might agree upon as important for the development of more effective global action. These activities have provided the basis for the document, "The Path to Climate Sustainability: A Joint Statement by the Global Roundtable on Climate Change."

The Joint Statement has received endorsements from key economic stakeholders and independent experts: leading corporations from all economic sectors, with varied interests and operations in all regions of the world; smaller firms with very different perspectives and concerns; a diverse array of civil, religious, environmental, research, and educational institutions; and a distinguished list of some of the world's leading experts in the fields of climate science, engineering, economics, and policy studies. The ability of so many key stakeholders with such diverse views to agree upon the Joint Statement demonstrates the possibility of fostering a global consensus on a positive, proactive approach to meeting the challenge of global climate change. (www.earth.columbia.edu/grocc).

The Earth Institute at Columbia University is the world's leading academic center for the integrated study of Earth, its environment and society. The Earth Institute builds upon excellence in the core disciplines—earth sciences, biological sciences, engineering sciences, social sciences, and health sciences—and stresses cross-disciplinary approaches to complex problems. Through research, training, and global partnerships, The Earth Institute mobilizes science and technology to advance sustainable development while placing special emphasis on the needs of the world's poor. (www.earth.columbia.edu).

SUMMARY

The article has, among other things, highlighted the specific nature of various emerging problems that hinder abating climate change, with a view to suggest probable solutions through integrated and holistic approaches of emissions reduction to attain carbon neutrality and sustainable energy development via carefully designed local and global initiatives and inter-governmental cooperation. The article has also attempted to clearly analyze to what extent the various approaches and strategies suggested can be implemented, with appropriate institutional arrangement and governing principles. The various limitations—especially in respect to global norms for emissions reduction commitments for compliance of the Kyoto Protocols and accounting standards for emissions trading of carbon credits—have been briefly touched upon, with desired lines of actions.

Given the backdrop of accumulated knowledge on the scientific reasons for global climate change and research findings on the various adverse impacts (on ecology, human and animal life, etc.), proper documentation and analysis of these events is necessary to guide future options, strategies, and long-term policies leading to the abatement and stabilization of the declining climate change trend. This must be achieved in order to save the planet from further ecological devastation. A global review of the scientific literature on the subject, with careful scrutiny and analysis, should stimulate society at large to have a deeper appreciation and understanding of the necessity that reversing the processes of climate change and promoting the concept of sustainable energy development (through action–oriented programs) must be interrelated. This is especially true at a time when concerns about global warming and its greenhouse effects are sharing the world stage with concerns about global energy and economic crises.

Emissions reduction through country, regional, and global models (based on the flexible, clean development mechanism and initiated and developed by the concerted efforts of various international organizations and financial institutions) can go a long way to progressively reduce emissions of greenhouse gases, making the planet a safer place in which to live. Sustainable energy development can serve as a catalyst to this value chain. Notable examples of such global initiatives with the prospect of developing into inter-country and inter-regional programs for replication and adaptation include: (i) European Union Emission

Trading Scheme (EU ETS), (ii) UK Emissions Trading Scheme (UK-ETS), (iii) Indo-German Energy Program (IGEN), (iv) Clean Air Canada, (v) Japan's Voluntary Emissions Trading Scheme (JVETS), (vi) International Greenhouse Partnerships (IGP) Program, (vii) UNIDO Knowledge Network for Industrial Technology Transfer, (viii) U.S.-Japan Agreement on Cooperation in Environmental Protection, (1975), (ix) Unived Nations Economic Commission for Europe—Long Range Trans-boundary Air Pollution (LRTAP), (x) South Asian Regional Initiatives (SARI), (xi) Global Environment Facility (GEF), (xii) World Bank Pilot Program for Climate Resilience (PPCR), (xii) Mexican Multilateral Climate Change Fund (MCCF), (xii) Bi- and Multilateral Carbon Auction Levy Funding under IPREA, (xiv) Germany's BMU Funded International Climate Initiative (ICI), (xv) UNEP's Carbon Neutral Network, and (xvi) Society of Building Science Educators (SBSE).

The role of an exchange is to facilitate emissions trading but also to guarantee each trade. In order to trade carbon credits on an exchange like the New York Mercantile Exchange (NYMEX), Paris Bourse, the International Petroleum Exchange, or the Sydney Futures Exchange, one must go through a member of the exchange. Currently, there are at least six exchanges trading in carbon allowances: the Chicago Climate Exchange; European Climate Exchange; Nord Pool; Power Next; Multi Commodity Exchange; and National Commodity and Derivatives Exchange. Recently, Nord Pool listed a contract to trade offsets generated by CDM carbon projects called certified emission reductions (CERs). Many companies are now engaged in emissions abatement, offsetting, and sequestration programs to generate credits that can be sold on one of the exchanges. The emergence of the opportunity for revenue generation by taking up structured CDM projects has given a new dimension to the accounting and taxation of transacted carbon credits through exchanges/derivative markets. For instance, India's carbon credit trading is expected to reach $100 billion by 2010. In 2007, a total of 160 new projects were registered with UNFCCC. However, such transactions through exchanges should be subject to maintaining global accounting standards, with regulatory and legal safeguards for accountability, transparency, and compliance with stipulated disclosure norms. For a proper understanding on the modalities of emission trading, a good understanding of carbon-economics encompassing a number of the elements of business accounting and finance are required. These include the economic modeling

of demand and supply of carbon credits and allowances, forward and spot pricing, risk management business value, capital allocation, and possibly the International Financial Reporting Standards (IFRS) directives for accounting for carbon and related transactions. In addition, taxation issues of direct carbon taxes, value-added taxes (VAT), and goods and services taxes (GST), as well as transfer pricing implications of carbon trading also need to be considered.

Harmonizing emerging global markets and energy security on the one hand and continuing with comprehensive strategies of sustainable development (without slowing down the global economy with lesser dependence on conventional sources of energy) on the other hand will indeed be a gigantic task. This is especially so, given the extensive use of fossil-fuels as a major feedstock in sustaining the present pace of industrial growth and given future energy demands, particularly those placed by the G-8 nations and/or BRIC (Brazil, Russia, India and China) nations. Sustainable development has become part of all climate change policy discussions at the global level, particularly due to adoption of Agenda 21 and the various conventions resulting from the UNCED-1992. The generally accepted and used definition of sustainable development, as given by the Brundtland Commission, is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Approaches to ensuring energy supply security in the 21st century should therefore differ from past approaches that concentrated on conventional energy (predominantly fossil-fuels) substitution.

Besides sustainable growth challenges, new approaches will need to tackle the new energy security issues raised by market liberalization. The enhanced role of markets is tied closely to the process of globalization. Globalization, which is still gaining momentum, has encouraged competition and strengthened markets and regional and international trade, particularly for crude oil and oil products, natural gas, and energy services. Globalization is bringing new opportunities for energy security, such as better access to markets and services and the transfer of technologies that are helping to reduce the cost of energy exploration and expand proven reserves. International trade involving energy resources (including emissions trading) and services therefore becomes vital for energy security.

The idea of sustainable development is gaining acceptance and momentum on the official level as well as among the public. Sus-

tainable development demands environmental preservation. Energy production and utilization, particularly in the case of fossil fuels, can be major sources of environmental degradation. These detrimental environmental impacts have a direct bearing on the future of energy—in terms of fuels and the extent of their use—and on energy security. The United Nations Framework Convention on Climate Change, adopted at the Rio Earth Summit in 1992 (Johnson, 1993), and the Kyoto Protocol, signed by more than 160 countries in 1997 (UNFCC, 1997), call for major reductions of greenhouse gas emissions (which are primarily caused by energy use).

In the G-8 Meeting of the Major Economic Forum (MEF) held on 9 July, 2009 in L'Aquila, Italy, the leaders of the largest economies agreed to a goal of achieving at least a 50% reduction in global greenhouse gas emissions by 2050. As global emissions have risen by around a fifth since 1990, a later baseline would represent a higher final emissions goal. It was recognized that an 80% emissions reduction goal would require robust mid-term reductions, although no intermediate targets were set (http://www.world-nuclear-news.org/EE-G8_endorses_emissions_cuts_and_nuclear-0907096.html).

Equally important will be taking a holistic review of the basis and criteria being used in the cap and trade mechanism of emissions trading. A rational and balanced approach for emissions reduction commitments by a nation should ideally be converting the use of quantum of emissions generated in absolute terms (i.e. primary criteria) over to computing on per capita (i.e. secondary criteria) basis.

Secondly, the voluntary carbon market should be equally Kyoto Protocol compliant by bringing in a more stringent regulatory regime to fix accountability in terms of both domestic and international tax and tariff control mechanisms. But progress does not necessarily proceed without implicit, inherent, and practical challenges. Emissions from the developing countries are on the whole lower than those of the developed economy, and they will need to continue to rise in the short-term as economic growth is maintained and poverty is addressed. However, developing countries will also need to be significantly slowing and peaking emissions reduction growth in the coming decade.

To substantiate this point, attention may be drawn to a new report from the "Breaking the Climate Deadlock" project involving a strategic partnership between "A" country and the Climate Group, showing how major reductions, even by 2020, are achievable if we fo-

cus actions on certain key technologies (viz. eco-technologies involving mainly renewables), deploy policies that have been proven to work (viz. appropriate technologies), and invest now in developing those future technologies (viz. carbon capture storage, coal-bed methane, geothermal, ocean hydrates, etc.) that will take time to mature to operational status.

The year 2009 was a crucial year for climate change. At a pivotal UN conference in Copenhagen at the end of 2009, governments of the world met to seek agreement on the continuation of the global climate treaty in an effort to build on and strengthen the Kyoto Protocol. The G8 leaders meeting in Italy the previous July availed the opportunity to set a course for success. In doing this they realized the triple advantage of action against climate change (http://us-cdn.creamermedia.co.za/assets/articles/attachments/22098_wwfbinaryitem12911.pdf)

- Action now will start to clean up our climate act, keeping the option open for the planet to avoid catastrophic climate change.

- Action now will set the world on a sustainable energy path, which in the short run can help stabilize the economy and, in a few decades, can provide ample energy for the whole planet.

- Action now can help develop a low-carbon economy that helps avoid millions of climate refugees and massive cost for later adaptation to climate impacts.

According to the 2004-UNFCCC Global Convention, developed countries must periodically negotiate with global partners on mitigation commitments to avoid what is termed "dangerous anthropogenic interference" with its climate systems. Fulfilling the commitments, as agreed and at the schedules approved, would greatly affect the use of energy resources and could compromise global economic progress. This is so because there is seemingly a large hiatus between the commitments and the means for implementation. For example, targets agreed upon by negotiators were not necessarily implemented by legislators or other policymakers in the past decade. Implementation of such targets is hindered not only by cost but also by the need (or domestic economic compulsions) to maintain both energy security and the projected pace of growth over a planned period of time.

CONCLUSIONS

To sum-up the impressions drawn from these experiences, all indications are that conventional fossil fuels will continue to dominate the global energy scene for at least the first couple of decades in the 21st century, despite the dwindling *global strategic reserve* position. Moreover, the demand for energy services will also continue to increase concomitantly. Most of the growth (broadly measured by GDP) will likely to be in the developing countries, particularly from BRIC nations (including China and India from the Asia-Pacific Region) that can ill afford the high cost of containment and stabilization measures (viz. mitigation, adaptation etc.). It is therefore essential to find ways and viable means to contain energy-related emissions without necessarily compromising energy security in a cost-effective, participatory, sustainable, and eco-friendly manner, using, among other things, an optimal level of energy-mix that largely and progressively replaces conventional fossil fuels by alternative renewables. While doing so, as an environmental safeguard, growing importance will also have to be given to efficient carbon management, with adaptability amply demonstrated through some of the nationwide program initiatives involving carbon neutrality, carbon foot-printing/offsetting, and carbon literacy that have been pioneered in a mission-mode manner by some of the developed economies of the world, namely the USA, UK, Canada, Germany, Japan, and Australia. These advances and experiences should be harmonized, adapted, and rationally shared by the developing economies of the world—especially those representing the Asia-Pacific region (a mammoth population)—in the sprit of building synergy, equality, and a unified carbon-neutral global society in the available *carbon space* of the planet.

References

Dr. Sarkar's references will be published in Volume 30, No. 2.

ABOUT THE AUTHOR

Dr. A.N. Sarkar obtained his doctorate in biochemistry from the University of Wales (1977) and has worked over three decades in areas such as petrochemicals, R&D, the environment, central ministries, external donor agencies, and academics. He has served as a chair professor

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