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Energy Security Insights

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Energy Collaborations to further energy security

In the global energy field, there are just two main collaborative agreements stretching across a number of countries that have stood the test of time and have established their usefulness. The first is the emergency oil stock holding by the 26 members of the IEA (International Energy Agency), mainly comprising countries on both sides of the Atlantic, but also Japan and Korea. Established in 1974, the member countries agreed to maintain emergency oil stocks equivalent to at least 90 days of net oil imports, to participate in oil allocation if supplies were severely disrupted, and to have a programme to restrict demand to 7%–10% of national oil consumption. The last time this scheme was activated was when Hurricane Katrina hit the Gulf coast of the US in 2005, severely disrupting oil production, imports, and refinery operations.

The second is the Energy Charter Treaty, which was started as a regional effort by European countries in the 1990s. Apart from facilitating investments and trade in energy between countries and addressing transit issues, it provides for a dispute settlement mechanism between parties to the treaties and between investors and host governments. There are over 50 signatories to the treaty. In the context of the Iran–Pakistan–India gas pipeline, Iran and Pakistan have observer status but India, so far, has not applied.

When Shri Mani Shankar Aiyar was India's petroleum minister, he had initiated a dialogue between the main oil producers in OPEC (Organization of Petroleum Exporting Countries) and consuming countries in Asia.
But there has been no follow-up since. Efforts are underway to create an East Asian community for regional cooperation between China, Japan, and South Korea. However, regional cooperation between the ASEAN (Association of South East Asian Nations) countries including other regional countries such as India and Australia has not made much headway. Although, there is scope for considerable hydropower trade between Bhutan, Nepal, India, Bangladesh, and Myanmar, it is only in the case of Bhutan and India that this has been successful, though the quantities are small. There is now a Maoist-led government in Nepal and its approach to economic cooperation with India is awaited. In this issue of *Energy Security Insights* some of the above topics have been addressed, which express guarded optimism for the future. Also included are articles on energy collaboration on nuclear fusion, India–US renewable energy collaboration, and a concept paper on joint strategic oil stocks in Asia on the lines of the IEA.

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Energy security through regional collaboration: the case of North East Asia

Brigid Gavin and Sangsoo Lee*

Today's energy challenge is global in nature and transcends the capacity of nation-states to act alone. Global energy demand is projected to rise by more than half over the next 25 years while the conditions of global energy supply become increasingly uncertain. The international price of oil closed at $142 a barrel on 27 June 2008. Prices have almost doubled in the past year, partly on concern that world oil production will fail to keep pace with surging demand in countries such as China and India. Oil will remain the most heavily traded fossil fuel but trade in natural gas is expected to grow faster. The largest share of world oil supply comes from West Asia, which is one of the most politically unstable regions of the world. The big increases in natural gas will come from Russia, West Asia, and North Africa, all of which are regions of risk. The current climate of soaring oil prices and hardening global competition for energy resources poses major questions for global energy security—how to increase production and also get the oil and gas safely over long distances from producing to consuming countries. Massive investment will be needed to ensure exploration and development, transport, and distribution, all of which requires collaboration between producing, consuming, and transit countries.

But no global framework for governing trade and investment in energy exists today and the global multilateral process has stalled in other areas, notably in the WTO (World Trade Organization). By contrast, regional organizations have made more progress in matters of general economic interest, which includes regional energy cooperation. The EU (European Union) was built on energy collaboration with the creation of the ECSC (European Coal and Steel Community) in the 1950s as a means of overcoming national rivalries that were rooted in 'resource nationalism'. The ECT (Energy Charter Treaty) was created in Europe in the 1990s as a means of overcoming historical antagonisms that had divided the East and West by emphasizing shared values and interests. That vision is more valid today than ever before. It is this vision that has an important role to play in building a solid multilateral framework for energy security.

NEA (North East Asia) is the most dynamic economic region in the world today but it also has serious tensions over access to energy resources, especially between China and Japan. On the other hand, NEA is currently engaged in a process of regional integration and cooperation that aims to create an EAC (East Asian Community) that looks to Europe as both inspiration and model (Gavin and Lee 2007). Within this process of emerging regionalism in East Asia, what is the role of energy cooperation? How is energy security understood in a collaborative way? What are the mechanisms available for such collaboration? Those are the issues to be addressed in this paper but first a brief review of projected energy demand for the NEA region is given.

Projected energy demand in NEA

NEA includes three of the world's major energy importers – China, Japan, and South Korea – as high economic growth has led to a rapid increase in energy demand. According to the IEA (International Energy Agency), the energy consumption of NEA will continue to display rapid growth and will exceed that of North

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America by the 2020s (Kensuke 2005). China's oil consumption exceeded that of Japan in 2003 and will overtake the US to become the world's largest energy consumer soon after 2010 if it can afford to continue its present consumption pattern (IEA 2007). China's primary energy demand is projected to more than double from 2005 to 2030—an average annual growth rate of 3.2%. While China's coal is available in great amounts, it cannot be used for modern forms of transportation and is also harmful for the environment.

Japan is the fourth-largest oil consumer in the world behind the US, the EU, and China, the second-largest net importer of oil and gas and is almost completely dependent on imports. However, in the long-term, future energy demand in Japan will moderately level off, because its economy has reached a matured stage as its energy technology has improved and as its population starts to decrease in the next few years. Similarly, South Korea's energy needs such as oil and natural gas are almost completely dependent on imports from overseas. It now ranks among the major oil importers in the world and 70% of its imported oil comes from West Asia (IEA 2006). Meanwhile, South Korea's total primary energy demand is predicted to rise by 37% between 2006 and 2020, equivalent to an average annual rate of 2.3% if oil is available in sufficient amounts and at an affordable price.

In sum, growing energy import dependence is a source of increasing insecurity and poses a serious risk of disruption to the region's economies. Moreover, if the current upward trend of oil prices continues, the present tendency towards a recession in NEA could become much deeper than many predict today.

Considering energy security in a collaborative way

Energy security in NEA is understood today as the provision of reliable supplies of energy that are available at a reasonable cost and in a sustainable manner. Thus, the three pillars of energy security are security of supply, economic efficiency, and environmental protection. Following the first oil shocks of the 1970s, NEA governments treated energy security as a key part of national security, keeping it firmly in the domain of national sovereignty.

The two traditional mechanisms used by the NEA governments to achieve energy security fall into two categories: political and economic. The political approach puts primary emphasis on maintaining the flow of energy supplies by enhancing strategic links with energy-producing countries, promoting foreign investment of domestic companies in those countries, and increasing control over supplies though state-owned companies. The protection of safe passage of oil supplies via oil tankers to the importing countries was backed by military power. China has been the major exponent of this strategic approach.

The economic approach aims to achieve energy security by improving the efficiency of energy markets. The goal is to reduce dependence on imports by improving the efficiency of energy use. This requires de-regulation of domestic energy markets and the promotion of investment in new technologies that will reduce or replace fossil fuels. Information technology can also contribute to the development of new and renewable energies. In the long term, the market approach aims to achieve a better balance between demand and supply. Since the 1970s, Japan has become the most energy-efficient country in the world.

The boundary between those two approaches is not always clear-cut, given the fact that both approaches are needed to achieve a satisfactory level of energy security. Market measures and the private sector can contribute significantly to greater energy efficiency but government actions are needed, for example, to ensure strategic stockpiling of oil reserves.

Emerging processes of regional collaboration in NEA

Traditional national mechanisms are giving way to increasing regional cooperation and integration in East Asia today, albeit very slowly. Notwithstanding obvious obstacles to future regional integration, such as the diversity in levels of economic development, levels of affluence, size of population, and different political systems, East Asia is undeniably moving towards a more collaborative stance across a wide policy spectrum, including energy and environment. It was the Asian Financial Crisis of 1997 that provided the catalytic shock that triggered this new process. Recognition of the absence of any regional mechanisms to deal with the crisis led to the creation of the ASEAN (Association of South East Asian Nations)+3 framework for cooperation that covers some 20 policy areas today.[1] Since its establishment in 1998, ASEAN+3 Summit meetings occur on an annual basis, and it is now recognized as the main vehicle to achieve the goal of an EAC based on deepening integration between all countries of the region. Regional collaboration has been further extended in the ASEAN+6 framework, which includes India as well as Australia and New Zealand.

Regional collaboration for economic efficiency

Energy collaboration in East Asia will build upon the successful process of market-led regional integration that has taken place over the past 20 years. Led by Japanese multinational companies, this bottom-up process of transfer of capital and technology to the less-developed economies of the region has created a sophisticated system of regional production networks based on vertical specialization of industry in an increasing number of manufacturing sectors. This broad basis provides the platform for launching extensive energy collaboration, which will be once again led by Japan, given the fact that it is the most energy-efficient country in the region.

Indeed, this process has already been initiated at the highest political level. When Fukuda Yasuo, the Prime Minister of Japan visited China in December 2007, both leaders agreed on the promotion of cooperation in the field of environment and energy, which will disseminate Japanese technology on a business basis, as well as provide training for 10 000 people in Japan for three years. The most promising technologies include CCT (clean coal technology), gas co-generation, operation of nuclear plants, and high-voltage transmission. Also, they reached an agreement about how to deal with the difficult issue of the long-standing dispute over territorial boundaries and resources of gas and oil in the East China Sea.

Regional collaboration for environmental protection

The consequences of climate change could pose serious challenges for the national and regional security of East Asia in the near future. NEA is the biggest SO_2 (sulphur dioxide) emitter in the world. The CO_2 emission (carbon-equivalent) is projected to increase from 1400 MT (million tonnes) in 2000 to 1880 MT in 2010 and 2540 MT in 2020, causing massive transnational problems of acid rain. China is now the world's largest CO_2 emitter. Despite the progress achieved during the past few decades, pollution, especially from the use of coal, remains a serious threat to the environment, and emission levels will have negative long-term effects. It is predicted that China will be responsible for 37% of global emissions by 2030. Although reliance on coal is much less when compared to China, it has nonetheless caused South Korea to be a major producer of CO_2 emissions. South Korea's emissions have been forecasted to treble between 2000 and 2030.

However, regional collaboration on climate change, energy, and environment is now taking place within the framework of ASEAN+3 in a manner that may overcome the bitter North–South divide that has permeated global discussions on this topic. The East Asian Summit of 2007 emphasized that developed countries should continue to play a leading role, but the 'principle of common but differentiated responsibilities' must also be accepted. By implication, developing countries in East Asia should accept appropriate responsibilities in proportion to their level of economic development. Furthermore, their active participation in the process of developing an effective, comprehensive, and equitable post-Kyoto international climate change arrangement under the UNFCCC (United Nations Framework Convention on Climate Change) was called for.

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[1] ASEAN (Association of South East Asian Nations) includes 10 countries of South East Asia. However, the process is driven by the three economically powerful countries of NEA (North East Asia).

Regional collaboration for security of supply

Measures to ensure the security of supply are more closely linked with national security, and therefore, slower progress on regional collaboration will take place due to the historical legacy of mistrust between countries of the region. Nevertheless, the establishment of the state-led ASEAN+3 institutional framework may be expected to provide momentum over the medium to longer term. One key area of importance here would be joint stockpiling of reserves into a regional pool to enhance regional energy security. The current situation in which Japan and South Korea hold oil reserves for a 90-day period while China only has reserves for a 30-day period may require the provision of technical assistance to China in order to achieve greater convergence. Another issue of strategic importance is the safe transportation of oil tankers to the Far East and especially through the Malaccan Strait, a region prone to piracy and possibly terrorism. However, this touches on sensitive military issues that will require more effort towards regional collaboration.

A common regional position towards energy-producing countries

East Asia's lack of a common regional position vis-à-vis energy-producing countries reduces its bargaining power in the multilateral context. The ECT (Energy Charter Treaty) is the most important multilateral framework for promoting long-term energy cooperation by fostering economic and political cooperation between countries. The ECT started as a regional effort in Europe in the 1990s, but it now includes some NEA countries—Japan and Mongolia are signatories while China and South Korea have observer status. Full adherence on the part of NEA countries could give new political momentum to the ECT to play its role in full and, in particular, help to establish a new equilibrium between the oil-importing countries in Europe and North Asia vis-à-vis one of the most important suppliers, namely Russia.

Russia holds the world's largest natural gas reserves, the second-largest coal reserves, and the eighth-largest oil reserves (EIA 2007). Russia is also the world's largest exporter of natural gas, and the second-largest oil exporter. It should be stressed, however, that those are official Russian figures and must be considered with caution. Much of the resources in Russia, especially natural gas, are located in East Siberia and the Far East and could serve as supply for China and the two Koreas, as well as Japan in the future. Indeed, given Russian Far East's relative close proximity to NEA, its energy resources present an opportunity for the NEA countries to diversify energy supplies as well as decrease reliance on West Asia. However, competition from Europe is hard regarding Siberian gas resources. There is opposition in the Duma against selling to Asia. The first step in preparing for the large-scale utilization of East Siberian oil fields has been to build a pipeline back to Russia to safeguard the supplies for already existing contracts with European and Russian consumers. Russia provides about 25% of total EU energy needs and 30% in the case of Germany.

Although Russia has signed the ECT, its repeated refusal to ratify the treaty has created increasing political tensions with Europe and will also be problematic for East Asia in the future. The most important provisions of the ECT concern the protection of foreign investment by oil companies in producing countries, the free movement of energy products across borders, the facilitation of energy transit via cross-border pipelines, and the settlement of disputes through internationally recognized means of legal arbitration. It is based on the principles of openness, transparency, and non-discrimination in energy markets. While Russia reportedly fears that the ECT would open up Russian oil and gas fields to foreign competition, the Russian state-owned gas monopoly has been accorded free entry into European markets. Calls for reciprocity are now becoming louder in this context. Furthermore, Russia seeks the support of the EU for its accession to the WTO, which governs global trade on multilateral principles similar to those of the ECT.

The ECT could play an important role in promoting regional energy collaboration in NEA. It could provide a platform for discussions between energy consumers and producers on the most politically sensitive issues such as the construction of pipelines, the transit of oil across borders, and the resolution of disputes over investment though internationally accepted legal mechanisms. It could also facilitate more cross-border trade and technology collaboration leading to more open and competitive markets and contribute to improving energy efficiency and sustainable development. But equally, if not more important, it could enhance its bargaining power by facilitating inter-regional collaboration with Europe within the multilateral framework of the ECT.

Conclusion

The energy demands of NEA countries will continue to increase in line with their high economic growth. It will become more and more difficult to satisfy that demand at an affordable cost. At the same time, China, Japan, and South Korea will grow more dependent on oil from West Asia, but will continue to seek to diversify supply, especially through Russia's Far East.

Against this background, we observe emerging regional energy cooperation under the framework of ASEAN+3. True to East Asian tradition, this cooperation is most advanced in the economic field. China, with vast energy resources and a cheap labour force, is rapidly becoming one of the world's largest energy markets. Japan has a competitive advantage with its cutting-edge technology on energy efficiency, renewable energy, and capital holdings. South Korea has risen to the global stage with its vitality, dynamic human resources, and technological capabilities. The above constitutes great potential for energy cooperation and growth in the region and it has already started though transfer of technology for energy efficiency and renewable energy technologies.

Environment, long the ugly duckling of East Asian economic development, has not yet turned into the legendary beautiful white swan. But environment is moving up the regional agenda and a common regional position for the post-Kyoto arrangement, currently under negotiation, could contribute to a major breakthrough at the global level.

Russia's abundant supply of energy resources, which could provide an invaluable asset for the region, now requires full adherence of all NEA countries to the ECT. As the most appropriate multilateral framework governing the crucial areas of international trade and investment in energy, it is crucially important to incorporate Russia—a goal that could best be achieved by inter-regional collaboration between NEA and Europe.

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Cross-border power trading in South Asia: emerging new paradigms

Mahendra K Lama*

In South Asia, access to electricity is at a nascent stage. This is because countries in South Asia are predominantly dependent on external sources for their energy supplies. Supply and price risks could lead to socio-economic instability and economic hardships by increasing economic vulnerabilities. South Asian countries are steadily moving into this vortex of insecurity, given the fact that they have largely remained energy importers and increasingly face a serious energy shortfall. Energy is a crucial factor in the economic, foreign, and security policy of these countries. Yet, there is very little interconnection among these issues in the political discourse in the region. Except in the case of Bhutan, foreign policies of the South Asian countries within the region never tend to get integrated with energy issues.

In South Asia, the very nature and direction of the sources of energy supplies, demand, consumption, and distribution, and the related geopolitics call for a regional approach to energy security. No individual nation in South Asia can ensure it alone. Therefore, from the sustainable development perspective as well as the security-militaristic aspect, the rational management of natural resources in South Asia is important for optimizing socio-economic benefits and minimizing security-militaristic instabilities. This directly implies that choice is singularly limited to cooperation and integration both because of the very structures of the market and the distributions of factors of production as well as natural resources in the region. The cost of non-cooperation translates into political instability, primarily triggered by an uneven development process across the countries in South Asia, and fast-growing aspirations of the masses.

New paradigm of energy security

The South Asian region needs a new paradigm of energy cooperation—one that is based on exclusive commercial harnessing of natural resources. The instrument chosen here is 'cross-border power trading', which has been a major success in many other regional groupings including in Europe (UTCE [Union for the Coordination of Transmission of Electricity] and Nord Pool) and Africa (SAPP [Southern African Power Pool] created in 1995). This instrument is now being operationalized in the ASEAN (Association of South East Asian Nations) region as well. Therefore, economic gains based on regional cooperation in the energy sector have become a firmly established practice across several regional groupings. Many developing countries, because of their low income and resultant small market size, are unable to independently capture the inherent economies of scale in major infrastructural projects. Cross-border exchanges and power trading will foreground energy cooperation in South Asia.

This new energy security paradigm aims at depoliticizing the harnessing of energy-related natural resources. It takes advantage of the positive aspects of the geopolitics in the region. It not only promotes effective utilization of natural resources but also consolidates market integration processes. It increases the threshold of energy security through reliability of power supply and large-scale transformation in the sectors contributing to economic growth. It demonstrates how durable infrastructures and diverse stakeholders created by such arrangements help in building confidence and

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strengthening the geopolitical dynamics at the regional level. It tries to drive and direct the entire discourse onto a much wider, sustainable, and beneficial system of exchange (mainly of electricity) on the basis of rational–commercial principles.

A number of organizations in the region and outside have been consistently working towards fostering cooperation in South Asia's energy sector. SAARC has set up an Energy Centre at Islamabad and BIMSTEC (The Bay of Bengal Initiative for MultiSectoral Technical and Economic Cooperation) has now decided to establish a BIMSTEC Centre for Energy for facilitating energy studies and exchange of expertise. Cross-border power trade on a bilateral basis already takes place widely between India and Bhutan, and to a certain extent between India and Nepal.

Power trading potential in South Asia

There are revealing variations in the installed capacities of power utilities in South Asia. These variations reflect the potentialities based on the natural endowments of the countries in the region. Hydropower has been the most vital source of total installed capacity in Bhutan (100%), Nepal (90%), and Sri Lanka (65%), whereas, thermal power dominates in Bangladesh (95% is gas based), India (72 are mainly steam based), and Pakistan (71%). In some countries of South Asia, the composition of installed capacity has been changing. Share of hydro sources has gone down very steadily in India and Pakistan.

South Asian countries are largely energy importers. Most of these countries have increasingly faced a serious power shortfall because of the excess of industrial and residential demand. For the South Asian region as a whole, it is estimated that on an average the demand for power has increased at an annual rate of 9%—doubling its magnitude every eight years, whereas, the supply side has recorded both a smaller as well as an erratic growth pattern. This has increasingly led to power cuts and rationing. A major chunk of the energy demand could come from the rural areas, as the predominantly rural population in the region is gradually demanding more and more power.

The seasonality factor in both power generation and demand is evident in South Asia. This has therefore generated a lot of interest in cross-border power trading. Two distinct trends are discernible as far as pattern in power demand is concerned in Bangladesh. First, demand goes down during December–February, while from March to May, load shedding becomes a common feature. Even the day peak of the system cannot be maintained in this season. As a result, industrial, commercial, and agricultural activities suffer. Second, the demand for electricity increases sharply in the evening mainly because of an evening shopping culture. This is a critical problem in the power system operation. A sizeable generation capacity to the tune of at least 1200 MW (megawatt) remains unutilized during off-peak hours and in effect remains shut. If possible, this available capacity can be a ready source for regional cooperation for the import–export of electricity from neighbouring countries. In India, there exists clear seasonality in power generation, particularly in hydel power generation. The peak months for hydropower generation are August–September, while the lean months are from January to June. In Nepal, the peak demand of the integrated power system is usually during December–January. This is the period when generation from the hydro power plants is low. Although, February to April is the driest period, the demand in these months is relatively lower. Since it is an integrated single system, the region-wise seasonality characteristic loses its identity, as the interconnections transfer power from the surplus region to the deficit region.

In SAARC, the hope and conviction lies in the fact that member countries have mentioned cross-border power trading in the context of the operationalization of reforms in the power sector. This is backed by the reality that this region offers a rich potential in harnessing regional hydel power generation out of which only a very small proportion has been exploited (hardly 10%–15%) so far.

Interconnection between power systems of contiguously located countries and their coordinated operation provides immense technical and economic benefits. This is feasible in the South Asian region given the fact that already a sizeable network of interconnections exists among the South Asian countries. The India–Bhutan power exchange, widely regarded as a major success story, is a case in point. The increasing possibility of accessing the Chinese, Myanmarese, and Afghan markets makes power trading more attractive and robust.

The West Seti Project of Nepal is another type of bilateral power exchange that can even be extended to Bangladesh. The re-opening of the Nathu la trade route offers great potential for exporting power to South West China. Pakistan's informal offer to India in 1998 for selling surplus power matched the demand in the northern and the western regions of India. Pakistan's transmission system, from Jomshoro in the south to Tarbela and Peshawar in the north, runs close to the adjoining borders of India. This may not require complex transmission extensions to the Indian borders. A Joint Study Group of Indian and Sri Lankan government (2003) strongly proposed a regional power pool between the two countries. Afghanistan is already laying a transmission line to Pakistan and Uzbekistan.

Bilateral power trading: existing arrangements

As options for power trading in the broader ambit of regional cooperation in South Asia, the following three mechanisms can be cited: bilateral power trade, pool-based approach, and wheeling facilities.

Bilateral power trading

India–Nepal Power Exchange

The systematic power exchange between India and Nepal has been underway since the last three decades. An agreement between the Government of Nepal and India exists for exchanging power up to 50 MW as and when required by the border towns. The power exchange at present is on a goodwill basis and up to 60 MW of power is imported by Nepal in its time of need. This exchange quantum has recently been increased to 150 MW. There is another 132-kV (kilovoltage) interconnection in the Far Western Region, which proposes to import power from India by Nepal under the Mahakali Treaty.

Though there are a number of potential projects that could be developed as export-oriented projects, in Nepal there is increasing scepticism about the relative tariff as compared to Indian projects. However, a World Bank study shows that even with the 'notoriously unavailable' cost of Indian projects, the cost of Nepalese projects is likely to be competitive (World Bank 1999). Peak shortage in the Indian power system is another major problem that would make the import of power from Nepal rather attractive.

Nepal and India signed an Electric Power Trade Agreement in 1997. This allows any party in Nepal or India to enter into an agreement for power trade between the two countries, irrespective of them being government, semi-government, or private enterprises. The parties can themselves determine the terms and conditions of such an agreement, including the quantum of supply and its price. The parties will be afforded all the assistance and granted all the incentives and concessions for both generation and transmission of power in accordance with the relevant laws of the respective countries.

India–Bhutan Power Exchange

In case of the 336-MW Chukha project on Wanchu river, Bhutan earned as much as BTN 2367 million ($52 million) in 2002/03 mainly from its power export to India (1472 GWh [gigawatt-hour]). This constituted almost 45% of Bhutan's exports to India and 11% of Bhutan's GDP (Royal Monetary Authority of Bhutan 2000). This project was constructed with Indian assistance of Rs 2.45 billion with a 60% grant and 40% loan. The sale of surplus power to highly power-deficit areas of West Bengal, Orissa, and the North East has been the hallmark of this project. The transmission link has also been a great success and is likely to be upgraded to help in the evacuation of 4500 MW from three large potential power projects, which are being built in Bhutan.

Any power-trading arrangement in the region should take note of this success story, which is based on the following principles: strong institutional arrangements and linkages, and clear-cut provisions for delivery point, wheeling charges and transmission losses, system monitoring, control, metering, accounting of energy, outage and maintenance, schedule, and billing and payment. Joint action of the PTC (Power Trading

Corporation of India) and CHPC (Chukha Hydro Power Corporation) in the full utilization of the generating capacity and in transmission; and strong provision of re-import of energy by Bhutan's Department of Power and PTC makes the payment to CHPC within 45 days of the receipt of the bills.

However, Bhutan is keen to diversify its power market given the fact that India is the only buyer. Also, a number of hydel plants are under construction in India's north-east region, which may to a large extent lead to a diminution in the demand for Bhutanese power.

West Seti Project of Nepal

Another revealing example is that of West Seti power project in Western Nepal. This is a third type of power exchange, which is likely to take place in the region. A unique feature of this arrangement is the involvement of a private agency for the first time as a power-generating unit primarily for exports to India. This indicates a changing paradigm of power exchange—a direct outcome of a new hydropower development policy that has opened power development to private producers. The West Seti Power project (750 MW) is being built by SMEC (Snowy Mountain Engineering Company) and the power purchaser is likely to be PTC. Point of delivery will be the India–Nepal border. The quantity of electricity to be supplied by SMEC to PTC will be approximately 3000 GWh per annum. The annual distribution of supplied energy will be approximately 500 GWh per quarter (January–March, April—June, and October–December) except for the wet season (July–September) when the energy supply will be approximately 1500 GWh. Types of energy will be primarily peak energy in dry seasons and base energy in the wet season.

This will be the first dedicated export project with the added advantage that it will not require grid synchronization. The transmission would be directly to the Indian grid without connection to the NEA (Nepal Electricity Authority) system. The West Seti Power Project will feed only the Indian system and will work as an integral part of the Indian system. India is negotiating with the Nepalese government to purchase power from this project. The deal will be negotiated for 25 years for which the levelized tariff is computed at $0.07. A number of crucial assumptions have been made. The annual saleable energy starting from 2007 to 2031 is going to be maintained at 3000 million units. Rupee exchange rate is going to be devalued at 6% per annum. That is, the tariff per unit will increase by about 6.75% per annum. 'When the project begins production, it would give revenue of $60 million per annum to the Nepal government' (The Hindu 2008).

Pool-based approach

The pool-based approach, also known as agent-based integrated simulation, can also provide support to develop competitive long-run market equilibrium in regional power trade. This approach involves the working together of several agents such as a set of manufacturers, a monitoring, advisory, and channelizing regional body. These agents develop their own strategies to explore and exploit capacity and other constraints in the market. They also evolve their own market clearing as well as settlement mechanisms. Each of the agents represents one of the generating firms. A key feature of this model is that it uses a micro-level, bottom-up representation of the market, with each generating firm (public and private) represented at the level of its individual plants.

Establishing an RPTC (Regional Power Trading Corporation) could be a highly beneficial market mechanism for the SAARC region. This could be called 'SAARC-RPTC', which could provide market feedback to individual power producers (agents) as well as the power consumers. The SAARC-RPTC could maintain and disseminate information on plant structures, avoidable cost of production, plant sales prices, sales volume, rate of utilization, profits generated, target utilization and market conditions, consumer behaviour, and ongoing plant building and future investment in the sector.

This in essence would involve the pooling of surplus power generated by individual plants in the participating countries and transporting into deficit ones by a coordinated exchange mechanism depending on demand and consumer categories (estimated consumer surplus). However, information asymmetry in this type of a model can create market havoc and hence, serious aberrations. Therefore, a major task of the SAARC-RPTC would be to gather and analyse information on generation, demand, transmission, and payment modes well in advance and arrange for the smooth operation of the market. The idea would be to evolve an effective bidding system for individual plant generators depending on the plant capacity and fuel use, and so on across the entire spectrum of its activities.

Wheeling facility

The physical boundaries in South Asia are such that it is only India that shares common borders with almost all its neighbouring countries. However, there are very distinct advantages for countries like Bangladesh, Pakistan, and Sri Lanka to import power from Bhutan and Nepal because of the lower tariff and supply reliability. At the same time, power-generating countries would also like to diversify their markets. For instance, Bhutan is keen to expand the market for its power exports. At present, India is the only buyer for its power.

Interestingly, the changing dimensions of power trading match the existing infrastructure in the form of expansive transmission lines in all the bordering states of India, including the North East, Tamil Nadu, Jammu and Kashmir, Punjab, and Gujarat. Therefore, India as a transit corridor for power transfer could give a major boost to both the power-trading activities and the process of regional cooperation and integration. India could also ensure full use of its transmission lines and generate substantial revenue in the form of wheeling charges (Lama 2004).

Challenges in South Asia

Energy security in South Asia has seriously remained entangled in the geopolitics of the region. India's centrality in South Asia is a result of both its size as well as its exclusive geographical location. Seventeen provincial states of India (out of 28) have international land borders. These borders highlight the opportunities that South Asia can harness collectively. However, it also shows how various cooperation/integration ventures including various energy-related ideas, projects, and linkages could be hindered by narrow politico-strategic interpretations of these borders.

A Tripartite Ministerial Meeting between India–Myanmar–Bangladesh held in Yangon on 13 January 2005 agreed to import natural gas through pipeline from Myanmar via Bangladesh. It mentioned that the 'Government of Myanmar agrees to export natural gas to India by pipeline through the territory of Bangladesh and India to be operated by an international consortium… The route of the pipeline may be determined by mutual agreement of the three governments with a view to ensuring adequate access, maximum security and optimal economic utilization'. It was considered to be a major policy shift in India's approach to issues of cooperation in the neighbouring region on two grounds. First, it was a clear shift from a traditional bilateral approach to a new tripartite one. Second, this was a deal negotiated and managed by the Ministry of Petroleum and not the Ministry of External Affairs.

The deal, however, could not be implemented purportedly because India did not agree to the following demands from Bangladesh.

- Transmission of hydro-electricity from Nepal and Bhutan to Bangladesh through the Indian territory
- Corridor for the supply of commodities between Nepal and Bhutan and Bangladesh through Indian territory
- Taking necessary measures to reduce trade imbalances between the two countries (Joint Press Statement 2005).

Though this was discussed on the sidelines of the tripartite deal and even a formal-joint bilateral press statement was issued by the Indian and Bangladeshi ministers with some very positive views on these demands by the former, the entire deal collapsed. It is now essentially a deal between India and Myanmar. Bangladesh's demands looked very reasonable particularly in the context of the conspicuous trend of steady liberalization and economic integration the region has recorded in the last decade or so. India has to now bear a very heavy cost of diverting this gas pipeline through its own territory in Assam. It has also forgone a good opportunity to make substantive geo-strategic and socio-economic gains in the long run. The goodwill amongst diverse stakeholders that such a project would have generated would have proven beneficial for India in resolving its longstanding demands vis-à-vis Bangladesh. This includes getting better access to energy projects in Bangladesh and transit facilities to reach the states in the North East. It could have triggered a number of projects in Bangladesh with a large-scale development impact. This could have in turn hindered the cross-border movement of people in search of better livelihood.

Conclusion

Regional energy security can be ensured largely through the process of interdependence and measures of sustained cross-border exchanges. However, issues such as the exhaustive draining of natural resources like coal, natural gas, and oil reserves, as well as the low level of political confidence in sharing hydro resources have presented serious reservations on enhancing the level of energy security in South Asia. Cooperation always implies that certain resources, geographical locations, and even physical and social infrastructures are shared as is national control over these resources. On the contrary, the loss of control over resources by nation-states in turn could also imply a loss of national sovereignty. This is true for countries like Bangladesh (gas) and Nepal (hydel resources). This brings an element of reluctance and a withdrawal syndrome sets in from the regional cooperation process. This has been amply reflected in an array of negotiations on gas with Bangladesh (Lama, Sainju, and Ahmad 2005) and hydel power projects like Karnali, Pancheswar, and Rapti in Nepal (Lama 1985; Lama and Bahadur 1995). Therefore, tackling this perception of national sovereignty over resources itself is a major hurdle. It demands extending a new form of cooperation that not only builds confidence among these countries to cooperate but also addresses their concerns comprehensively.

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US–India renewable energy collaboration: the road ahead

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Introduction

Today, both the US and India are facing mammoth energy and environmental security challenges as perhaps never before in history. Ever-increasing reliance on imported oil, rising global energy prices, continuing dominance of fossil fuels in the energy mix, and the urgency of addressing climate change all call for concerted action. The US continues to be the largest energy consumer in the world, accounting for close to 22% of world primary energy consumption (BP 2008). Driven by rapid economic growth and huge development needs of its billion-plus population, India's appetite for energy is also rising rapidly. India is the fifth-largest energy consumer in the world. High oil prices and traditionally high dependence on foreign oil, which stands at about 70% in case of US and over 75% in case of India, makes the case for substitution strong.

Financial repercussions on oil-based economies through impact on the fiscal health as well as the massive oil subsidies being doled out are but one part of this picture. Geopolitics of oil is linked with vital national security concerns, which neither of the two nations can ignore as long as they continue to be heavily dependent on foreign oil. Then there is the debate over peak oil itself. There are also huge concerns – both domestic and global – about how the US and India will address the problem of increasing GHG (greenhouse gas) emissions. According to the UN Human Development Report of 2007, the US is the largest GHG emitter in the world contributing to 20.9% of global CO_2 emissions in 2004. These rapidly converging strategic energy, environment, and national security concerns for two of the largest democracies of the world bring us to a case, now stronger than ever, for increased cooperation for stimulating rapid advances in RE (renewable energy) research, development, and deployment. This is already happening to some extent. With this backdrop, this article looks at the ongoing RE collaboration between the US and India and then lays down a roadmap for strengthening this relationship in the future.

Ongoing collaborations

Government: bilateral and multilateral efforts

The US–India Energy Dialogue launched on 31 May 2005 reflected a transformed strategic relationship between the US and India—a relationship that was called for by the US President George W Bush and the Indian Prime Minister Dr Manmohan Singh. One of the five Working Groups under the dialogue—the New Technology and Renewable Energy Working Group—seeks to 'promote the development and deployment of clean, new, and RE technologies leading to enhanced energy security and stable energy markets that will support desired levels of economic growth with appropriate concern for the environment'. The mandate of this Working Group includes creating public–private sector partnerships, as well as the promotion of investment, trade, and technology cooperation in the development of renewable resources. In 2005, Indo-US Science and Technology cooperation agreement was signed in Washington. On 24 June 2006, the US–India Energy Security Cooperation Act of 2006 was passed unanimously by the US Senate. In February 2008, talks for a bilateral investment treaty to help spur business in both directions were started.

The APP (Asia–Pacific Partnership) on Clean Development and Climate is another effort to accelerate the development and deployment of clean energy technologies. The partnership was announced in July 2005 at the 38th ASEAN Ministerial in Vientiane, Laos. APP is a partnership among seven major Asia–Pacific countries – Australia, Canada, China, India, Japan, Korea, and the US – that have come together voluntarily to advance clean development and climate objectives, recognizing that development and poverty eradication are urgent and overriding goals at the international level. The partnership builds on the foundation of existing bilateral and multilateral initiatives. APP has a task force on 'Renewable Energy and Distributed Generation' that aims to facilitate demonstration and deployment of RE technologies in partner countries, matching country development needs with deployment of RE technologies, systems, and practices; enumerating financial and engineering benefits of RE systems. In 2007, as part of the partnership, the US announced grants for 23 clean technology projects for India. These projects range from setting up RE business hubs with support from USAID (United States Agency for International Development) and GE (General Electric) to identifying barriers impeding investment in hydropower in collaboration with the US Hydropower Council, the US Department of Commerce, and the US Department of Energy to the USEA (US Energy Association) working with experienced US regulatory commissions, electric utilities, RE/distributed generation companies as well as Indian utilities to help them deploy RE and DG (distributed generation) technologies more efficiently (APP 2008). In addition to these programmes, the USAID South Asia Regional Initiative for Energy (SARI/Energy) has been engaged in promoting RE initiatives in India in partnership with a number of US organizations. These include National Renewable Energy Laboratory, US Department of Energy, US Department of State, Federal Energy Regulatory Commission, as well as several other private and governmental entities. USAID also worked with the CII (Confederation of Indian Industry) and Government of Andhra Pradesh on the Green Building Centre in Hyderabad, which has since spurred an active green building movement throughout India. REEEP (Renewable Energy and Energy Efficiency Partnership) is yet another platform through which US is helping in building renewable energy market in India.

Private sector

Opportunity for US companies

US–India private sector collaboration in the field of RE has seen a significant growth in the last few years. India's significant economic growth and RE market potential continues to foster this dynamic relationship in many ways. India is the fourth-largest wind energy producer in the world, after Germany, Spain, and the US. The REN 21 Renewable Global Status Report 2007 ranks India third in terms of wind power added and fourth in terms of solar hot water added (REN21 2007). The Indian RE industry offers a lucrative business opportunity to US companies. According to the US Department of Commerce, the RE market in India is estimated at $500 million and is growing at an annual rate of 15%. According to the Eleventh New and Renewable Energy Five-year Plan proposed by the GoI (Government of India), from 2008 to 2012, the RE market in India will reach an estimated $19 billion. In the Indian RE sector, foreign investors can enter into a joint venture with an Indian partner for financial and/or technical collaboration and also for setting up RE-based power generation projects.

Ernst and Young's 'Renewable Energy Country Attractiveness Indices' for quarter four of 2007 placed India third while the US as number one in the world (E&Y 2007). Data from UNEP's (United Nations Environment Programme) report *Global Trends in Sustainable Energy Investment 2008* shows that venture capital and private equity RE investment in India reached $265 million in 2007 compared to $45 million in 2004—an almost six-fold increase! The report also says that Indian companies largely looked to foreign markets for new capital, raising $1.4 billion overseas in 2007 (UNEP 2008). Merrill Lynch made its first private equity investment in India's renewables sector in October 2007, with a $55-million investment in the wind turbine manufacturer Vestas RRB India. Earlier in 2008, New York-based emissions commodity asset management company, Green Ventures International, launched a $300-million India Carbon Fund. The first-of-its-kind in India, the fund will buy CERs (certified emission reductions) or carbon credits from companies operating under CDM (Clean Development Mechanism), and then sell them to buyers in Europe. US-based Kleiner Perkins Caufield and Byers, the VC (venture capital) that funded Amazon.com and Google too, has shown its interest to actively invest in clean-technology companies in India.

California-based PV (photovoltaic) modules maker Signet Solar has announced that its Indian operations, expected to start production by the end of 2009, will be the company's largest global facility. The Indian operations with manufacturing facilities in different locations are expected to produce 300-MW of panels in five years at an investment of Rs 2000 crore (approximately $466 million). The first phase of this project will have a capacity of 60 MW (MNRE 2008). US-based Astonfield Renewable Resources, a subsidiary of Astonfield Management, is planning to set up a nationwide RE project of 500 MW. The company will take up these greenfield projects over the next 5 to 7 years (Das 2008). As noted in the previous section, several other US private sector companies are also engaged in India through the Asia–Pacific Partnership. In another interesting partnership, the Multi Commodity Exchange of India – India's largest commodities exchange, which has a strategic alliance with the Chicago Climate Exchange – launched futures trading in carbon credits in January 2008 (The Economic Times 2008).

Opportunity for Indian companies

It is interesting to note that this flourishing relationship in the private sector is not unidirectional. An increasing number of Indian companies are also tapping the US RE market. According to REN21 Renewables 2007 Global Status, with an investment of $10 billion, the US was one of the world leaders in creating new renewable capacity in 2006. The report ranks US number one in terms of wind power added as well as ethanol production, second in bio-diesel production, and third in grid-tied solar PV. India has been exporting components and turbines for many years. Suzlon Energy has grown beyond the domestic market to emerge as the world's fifth-largest wind turbine supplier with over 10.5% of global market share (Kabtta and Kant 2008). Suzlon Wind Energy Corporation focuses on the North American market and is a step-down subsidiary of Suzlon Energy Ltd, India. Since it began its push into the US in 2005, Suzlon has secured an 8% share of the US wind market (Johnson 2008). Another company to watch for is Moser Baer, India's largest and the world's second-largest optical storage media manufacturer. Moser Baer aims to distinguish itself as a significant player in the global PV market by leveraging its high-volume manufacturing expertise and planned investments of nearly $3.2 billion in research, development, and manufacturing of products dedicated to generating solar power. It has a multi-million dollar investment in a US-based company, Solfocus, the developer of the high-CPV (concentrator photovoltaic) technology in partnership with world-renowned PARC (Palo Alto Research Center) in California. The company also has a significant equity stake in Solaria, a US-based technology company that has developed a unique form of low-concentration solar PV technology. It is capable of producing power equivalent to two to three times the power produced by conventional PV modules using the same amount of silicon material. Besides, it has a minority stake in Stion Corporation, a nanostructures development company based in the Silicon Valley in California, for producing extremely low-cost solar power generating surfaces (Moser Baer 2008). Reliance Petroleum, a subsidiary in which US major Chevron Corp. has a 5% stake, has also announced plans to seek opportunities in RE. Indian IT companies are also venturing into green-energy-related solutions, which could have a significant demand in the US as more and more RE policies are adopted and demand for related software goes up.

Academic, research, and NGO collaborations

In addition to the governmental and private sector partnerships, a number of innovative partnerships with universities, research institutions, and NGOs are steering the US–India RE partnership. With support for NREL (National Renewable Energy Laboratory), USA, TERI (North America) has developed an enterprising project for training 'Women as solar power entrepreneurs' in the Sundarbans. The women are engaged in a variety of businesses including charging and renting solar lanterns on a daily basis, designing and assembling small electronic items as well as repairing solar home systems. Apart from the financial independence, a sense of pride arising from the newly acquired skill and confidence is the biggest contribution of the project. In 2007, Applied Materials, a global nanotechnology major headquartered in Santa Clara, California, donated a state-of-the-art nano-manufacturing lab costing over $7.5 million to IIT Mumbai. The nano manufacturing lab will serve as a centre of excellence to promote and catalyse research activity contributing to the creation of an ecosystem to nurture and promote the nano manufacturing industry in India. According to Mike Splinter, CEO of AMAT, this made IIT Mumbai the first institute globally to handle an eight-inch silicon wafer used in making chips (The Economic Times 2007). In 2008, a conference supported by the Indo-US Science and Technology Forum will focus on 'Scalable Nanomaterials for Enhanced Energy Transport, Conversion, and Efficiency'. In partnership with its US partners, TERI North America is actively working for the 'Lighting a Billion Lives' campaign, which aims to take solar devices to one billion people around the world.

The road ahead

The above discussion has highlighted some of the government, private, academic, and NGO partnerships that are acting as a catalyst for the US–India RE collaboration. While these efforts are promising, there is a long road ahead in order to fully meet the RE potential in both the US and India. The case for RE collaboration between two of the largest democracies in the world is strong on multiple fronts—be it the risk and increasing costs of rising oil imports, GHG emissions associated with a high fossil fuel usage, or the energy security objectives set forth by both nations. Meeting the respective national RE potential and targets calls for a conducive policy regime in combination with funding mechanisms, investment structures, as well as cutting edge innovation in research, development, and deployment of RE-related technologies to increase their efficiencies and bring down costs. There is a need to develop better renewable resource assessment tools to facilitate better planning, implementation, and monitoring of RE projects. At the same time, a comprehensive review of the IPRs (intellectual property rights) regime for such technologies is required. The new US administration will have a key role in strengthening the US–India RE collaboration in future. All efforts should be made to build on synergies of present programmes and promote knowledge sharing that can help both nations to learn from the success as well as failures of each other. Some suggestions in this regard include the following.

US–India Renewable Energy Fund

The US and Indian government should formalize a bilateral Renewable Energy Fund, the primary mission of which would be to make investments in RE technology companies. The fund would also facilitate partnerships between the US and Indian clean energy firms. In his State of the Union Address in 2008, President Bush committed to providing $2 billion to create a new international clean energy technology fund to help confront climate change worldwide. At the G8 meeting in Japan in July 2008, Indian Prime Minister Manmohan Singh also called for a Global Clean Energy Fund. Given India's critical role as one of the most rapidly growing energy markets in the world, it becomes critical that significant funds are dedicated for promoting RE investments in the country. A dedicated Renewable Energy Fund should be considered to ensure concerted efforts on the RE business including energy storage as well as companies providing products and services, such as software that specially caters to the RE sector.

US–India Renewable Energy Incubator Programme

The role of such an incubator would be to nurture the US–India RE startup companies and stimulate green jobs. REIP (Renewable Energy Incubator Programme) would utilize expertise and resources from both the US and India to help startup RE companies to develop their products to cater to the needs of the US and Indian markets, attract funding from sources in both countries, build strong RE management teams, as well as accelerate the time taken by nascent technologies to get to the market. The programme would build on partnership between the US and Indian governments, private sector, NGOs, as well as engineering and business programmes of various leading universities.

A number of clean energy business incubators exist in the US that can offer useful lessons for institutional, funding, and operational aspects of REIP. For example, the CEI (Clean Energy

Incubator), launched in August 2001, is a joint effort between the ATI (Austin Technology Incubator) and the NREL promoting the development of viable businesses focusing on clean energy. The ATI is a key programme of the IC² Institute at the University of Texas at Austin, a unique non-traditional centre for research and educational excellence engaged in a quest for constructive forms of capitalism that will allow communities and nations to grow and prosper. IC² combines technology, entrepreneurship, and education to improve the world by creating wealth and sharing prosperity. Since 2002, CEI has served 18 companies within the renewable and energy efficiency sectors. More specifically, these companies range from geothermal power and biofuels, to wind energy and water conservation. With CEI's assistance, companies fill in knowledge gaps and build stronger business propositions, helping to increase their chance for success.

Linking development assistance and renewable energy

There is a need to establish stronger linkages between development assistance and RE. This can work in a number of ways. First, the quantum of US funds dedicated to RE projects in India should be increased. Clean energy and water is one of USAID's focus areas in India. As discussed earlier, USAID South Asia Regional Initiative for Energy (SARI/Energy) has been engaged in promoting RE initiatives in India in partnership with a number of US organizations. Increased development assistance for micro financing of RE projects could also play a key role in meeting India's electrification targets. A study by USAID's Microenterprise Development Office brings out two potential structures for micro-finance umbrella programmes: (a) broader umbrella programmes with a micro-finance component, and (b) micro-finance: only umbrellas which work towards development of the micro-finance sector (USAID 2006). A portfolio of projects for such umbrella programmes should be specially developed for RE-related projects in India and would also offer many benefits for promoting overall socio-economic development in the country. Second, there is a strong case for strategic integration of RE into other development projects linked to health, education, and poverty alleviation. Finally, for giving a push to research, development, and deployment of RE technologies as well as for designing and scaling solutions for the bottom of the pyramid clean energy markets, models from other development project areas should be studied in detail.

Sister solar cities

The 'Solar America Cities' and Indian Solar Cities programmes should work with each other to build an innovative partnership to build sister solar cities in both countries. Such a programme could be based on unique cross-country public–private–people partnership model, which brings together policy-makers, private sector, as well as civil society from both the nations closer to work towards the common goal of building solar cities. Under the Solar America Cities programme, the US Department of Energy is already working with its national laboratories, 25 cities across the US, and a variety of municipal, county, and state agencies, universities, solar companies, utilities, developers, and non-profit organizations. The city solar partnerships are committed to developing a sustainable solar infrastructure that removes barriers and encourages the adoption of solar energy by their residents and businesses, and increases the number of solar installations within the municipalities. These cities are taking a comprehensive, city-wide approach that lays the foundation for a viable solar market and provides a model for other cities to follow. In addition to funding, DoE provides hands-on assistance from technical experts to help Solar America Cities integrate solar technologies into city facilities and energy planning. Experts are available to assist Solar America Cities in streamlining local regulations and practices (for example, zoning and building codes) that affect the adoption of solar technologies by residents and businesses. They can also help the cities develop solar financing options and incentivize programmes as well as promote solar technology among residents and local businesses through outreach and curriculum development. As India moves ahead with its own Solar Cities programme, which is still in an early phase of its learning curve, it can gain important lessons from the US Solar Cities programme. A unique programme like the Solar Sister Cities can not only help replicate best practices for solar cities of the future but also build stronger ties between the civil societies of the US and India.

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Joint strategic oil stocks in Asia: an analysis

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IEA's strategic petroleum reserve: a coordinated mechanism

Disruptions in oil supplies, such as the one in 1973, are inextricably linked to price spikes and economic recession. Such shocks pose serious implications for energy security largely due to their impact on economic prices and costs. It was in order to combat the threat of sudden oil disruptions in the future that the IEA (International Energy Agency) launched an emergency response mechanism in 1974.

Under the IEP (International Energy Programme) agreement, IEA member countries (generally developed OECD [Organization for Economic

[1] The author thanks Anandajit Goswami, TERI, for his valuable comments.

Cooperation and Development] nations) are required to maintain oil reserves equivalent to at least 90 days of net oil imports, and 'in the event of a major oil supply disruption—to release stocks, restrain demand, switch to other fuels, increase domestic production, or share available oil, if necessary' (OECD/IEA 2007). Under the IEA programme, every member country must have an effective plan to use their SPR (strategic petroleum reserve) through IEA-coordinated action. The stock obligations of member countries are monitored on the basis of monthly oil data and quarterly stockholding reports submitted by member countries themselves.

Literature from the IEA mentions how stock-draw has remained one of the most effective short-run emergency response measures against oil shocks. Decisions regarding stock holding and release of oil are reached through a cooperative mechanism. Although the IEA's mandate has gradually broadened to incorporate energy security, environmental protection, and economic development, initially IEA's main role was to coordinate measures in times of oil supply disruptions. IEA's joint strategic oil stock therefore represents a successful example of energy collaboration over time.[2] There have been instances of several supply shocks, for example, the Gulf War of 1991, Venezuelan strike in 2002/03, and the Iraq war in 2003, when release from the IEA's SPR proved to be welfare enhancing.

The IEA's emergency response mechanism to deal with sudden supply shocks was formed mainly as a response to the oil crisis of 1973. The crisis compelled all member countries to cooperate, and their sustained coordinated action over the years emerged as a pillar of success for the IEA. For Asian countries on the other hand, the necessity to maintain joint oil stockpiles will become self-evident only when a supply shock of a magnitude similar to the 1973 oil crisis takes place. Since the import dependence of the Asian countries on West Asia is a relatively recent phenomenon, the Asian economies are still not fully cognizant of the possibility of disruptions in oil supply. However, the current and projected trends of import dependencies in Asia indicate that countries in Asia are motivated enough to initiate joint stockpiling efforts as a precautionary measure.

In this paper, the economic nature of joint stockpiling and the importance of coordinated action, particularly in the context of the Asian economies, are analysed.[3] Some efforts made in this direction by Asian countries are mentioned below. Joint oil stockpiling is seen as an international public good. Hence, the paper also identifies mechanisms that can combat the free-rider problem inherent in the provision of international public goods. The literature on public goods helps identify key mechanisms that Asian countries could potentially adopt to make energy collaborations, such as joint oil stockpiles, a feasible and mutually beneficial investment for member countries.

Crude oil supply shock: Asian economies on edge?

Cooperation in maintaining strategic oil stocks has been a successful example of energy collaboration for IEA member countries. Asian countries have not taken any such coordinated action to address sudden oil supply shocks. However, in the last decade, the fastest rate of increase in demand (about 52%) for oil has occurred in the Asia–Pacific region that includes countries such as India

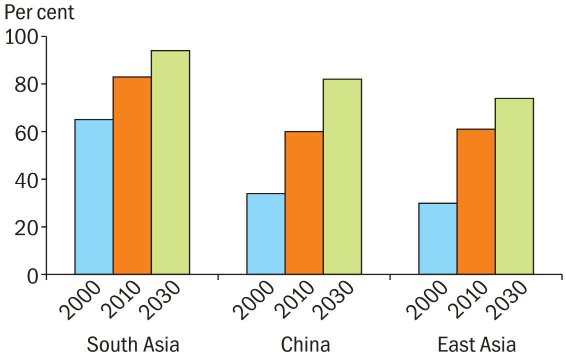

Figure 1 Net imports as per cent of oil supply
Source IEA (2001)

[2] The mechanism includes coordinating stock holding of all member countries, periodic monitoring of the same, and suggesting other demand restraining measures.

[3] The political feasibility of such cooperation is not under the purview of the discussion here.

and Pakistan. Figure 1 from IEA depicts the oil supply scenario of major Asian economies.

Asian economies have also increasingly become dependent on crude oil imports from West Asia. Asia accounted for about 64.5% of total oil export from West Asia in 2004 (Calder 2004). This figure was 53% in 1990 (IEA 2000). Thus, the inter-regional alliance between the rest of Asia and West Asia appears to be mutual. Asian countries like Japan, China, and India are also investing in oil and gas fields in countries such as Iran and Qatar. However, West Asian countries have always been geopolitically unstable. Also, any accident or disruption in the Strait of Hormuz or the Strait of Malacca (for China and Japan specifically) would certainly affect oil supply to Asian countries. Therefore, it has always been in the interest of the Asian countries to hedge against such future uncertainties regarding oil supply.

Apart from diversifying source of oil import, and investing in overseas oil and gas fields, countries such as Japan and Korea have already started maintaining strategic oil stocks to hedge against sudden oil disruptions. China and India have also recently followed suit. As per the ASEAN (Association of South East Asian Nations) Petroleum Security Agreement of 1986, the issue of joint stockpiling was discussed under the CERM (Common Energy Response Measures). However, this has not been pursued in a coordinated manner. Recently, the CERM has again come into sharp focus in the discussions amongst Asian economies. For instance, at the Beijing Asian Energy Workshop in 2004, the possibility of joint stockpiling was discussed. A significant development in this regard took place in June 2008 when energy officials from India, China, the US, Japan, and South Korea met in Japan to discuss energy-related issues such as countermeasures against rocketing crude oil prices (Xinhua 2008). At the meeting, China and India agreed to take part in keeping oil stockpiles for dealing with oil price turbulence in the future. The countries together also emphasized the significance of strategic oil stocks and discussed possible cooperation and coordination amongst the Asian countries.

Strategic oil stocks: an international public good

The benefits of the rational use of strategic oil stocks, such as a joint oil stockpile, are well known. Oil is released from the stock when there is a supply disruption for a short duration, for example when war spreads or when there are any accidents in shipping routes, and so on.[4] The oil stock is replenished when the situation returns to normal and price of fuel stabilizes. In a dynamic framework, a strategic oil reserve helps contend with short-term supply shocks. However, when oil stocks are held and used by several countries in common under a coordinated action plan, there is greater benefit to all the countries. There are two reasons for this.

First, given the fact that oil is an essential resource for regular economic activities, spare production capacity, fuel switching, demand restraints, and alternative technology development are common measures to mitigate the adverse effects of possible oil supply interruptions. Maintaining SPRs are also a similarly beneficial investment. All these measures are public goods. That is, the benefits that accrue from pursuing these measures are enjoyed by all national economies, even though the measures are taken by a few countries. This is due to the non-excludability property of the benefits obtained from reduced economic losses. Oil supply disruptions anywhere in the world affect oil markets of all the economies, particularly oil-importing countries. Therefore, actions taken by any country to mitigate the impact of sudden oil supply disruptions would affect global oil markets in a positive way as well. Thus, the transnational nature of the benefits ensuing from joint SPR makes it an international public good. As a result, the benefit from rational usage of strategic stocks of oil also permeates to all economies irrespective of the extent of the individual involvement in the strategic stock holding. Therefore, the social benefits are greater than those perceived by the investing country.

Second, SPR investments as international public goods pose an inadvertent problem—that of free riding. The countries which do not invest

[4] A recent example is the disruption in USA's oil supply caused by Hurricane Katrina in 2005.

in the SPR enjoy the benefits from SPR investments made by other countries. This is a typical free-riding problem. This ultimately leads to inefficient market allocations. This is because the countries that invest in SPR enjoy benefit from insurance against short-run supply shocks. But investing in SPR causes a positive externality to other economies that do not actually invest in the joint oil stockpile. Thus, market return to the investing countries is less than the social benefits. This causes market failure and an under investment in SPR.[5]

Efficient provision through transnational cooperation

Public economics literature provides detailed analysis of the problem of free riding and suggests several solutions such as government provisions and dominant assurance contracts. However, in the case of SPR, negotiations take place at the international level where the players are different countries. Thus, contract mechanisms are not likely to work. A joint liability mechanism that requires all member countries to participate through a coordinated action plan is more appropriate in this case. Since the effect of oil supply disruptions or strategic oil release has a greater impact on countries within a geographical zone, the joint mechanism must involve countries that are in the same band in terms of geopolitical characteristics. This ensures participation from all member economies so that all positive externalities are internalized and efficiency is attained.[6]

Economic theory has explained market failure and under-provision of public goods in the context of non-cooperative game theory (Bergstrome, Blume, and Varian. 1986; Cornes and Sandler 1984). Contributions to public goods can be seen as strategies of the players concerned. However, a large number of articles with experimental evidence suggest that subjects are sometimes cooperative (Dawes and Thaler 1988). There are also several sophisticated mechanisms for the implementation of an efficient allocation of public goods (Clarke 1971; Groves 1973; Laffont 1979). However, these mechanisms may be complicated in transnational issues like SPR investments. Many arguments have been put forward regarding such international public goods—ranging from doing nothing to forming global governance bodies (Barrett 1994; Helm 1991; Zacher and Sutton 1996).[7]

There is also a lot of literature that discusses the implementation of joint or collective mechanisms with respect to the provision of transnational public goods. Barett (1994), for example, discusses structures of such mechanisms that make incentives for cooperation compatible between the players involved.[8] In the context of the Asian economies, the feasibility of a joint stockpiling mechanism would depend mainly on the extent of cooperation amongst member countries. Sandler (1998) identifies factors that promote collective action at the transnational level. For instance, a key factor identified is the mixture between nation-specific and transnational public benefits. This implies that as the proportion of a country-specific benefit relative to the global benefit increases, the likelihood of that country becoming active in the alliance also rises proportionately. Another factor is the presence of a nation that can take the lead in coordinating action. However, the necessity of a lead nation, at least in the context of Asian joint oil stockpiling seems weak—no country can be

[5] The inefficiency following free-rider problem is well documented in the literature dealing with provision of public goods. Market allocation provides a level of public good where benefit gained from additional investment (marginal benefit) equals required cost to be incurred for doing the same (marginal cost). But market posits a benefit function that is undervalued. This is simply because it takes into account only the benefits accrued to the investor. Thus, positive externality enjoyed by other agents is not captured in the benefit function. Since the marginal benefit function is downward sloping and marginal cost function is upward sloping (based on some standard assumptions), an under-valued marginal benefit function implies less investment than the optimal one. Thus, market fails to bring efficiency in the transaction of public goods.

[6] Positive externality is the benefit that all the countries enjoy from the usage of the strategic petroleum reserves by some specific countries.

[7] This paper does not take any extremist position; in this sense it is akin to Sandler's position (1998).

[8] Sandler (1998) also considered a strategic n-player framework to enforce cooperation as a dominant strategy. However, this discussion is not exactly under the purview of this article.

singled out to take such a position among Asian oil-importing giants. Sandler also talks about removal of uncertainty. The benefit from such coordinated action with respect to the public good (in case of strategic oil stock it is insurance against supply shocks) must be vivid in all member economies' perception. Montreal Protocol got a big push after the link between CFCs (chlorofluorocarbons) and stratospheric ozone destruction became known. Collective action followed rapidly after this information was available.

Conclusion

This paper mainly emphasizes the importance of strategic oil stocks for Asian countries, its public good characteristics, and its implementation through a joint stockpiling mechanism. Critics might look at it as a mere imitation of developed countries' activities, that is, IEA. However, the necessity of such a measure seems inevitable for ensuring energy security in the Asian region given the current geopolitical situation regarding world oil trade.

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Energy collaborations in nuclear fusion

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Introduction

In absolute terms, the world's energy needs will grow much more rapidly during this century than at any time before. A large fraction of the world's population that uses little energy today will use more tomorrow as has been the case with China and India. Currently, about 4.5 billion people use less than the world's average, and of this, 1.6 billion do not have access to electricity. If they all catch up with the present average, the future average use of energy will rise by about 60%. Further, if the world's population increases by approximately 50% by 2050, energy consumption will also double (Mank and Burkart 2006). The doubling of world energy in large measure will be a consequence of the sharp increase in economic growth, particularly in countries such as China and India, where energy use per capita is currently very low by Western standards (Smith 2004). Nearly 80% of the primary energy supply in the world is derived from burning fossil fuels (oil, coal, and natural gas), which has serious implications for climate change. However, addressing energy security concerns and mitigating GHG (greenhouse gas) emissions simultaneously is not easy. Even if we were in a position to find ways to capture and store CO_2 (carbon dioxide) at a reasonable cost, so as to make it possible to continue burning fossil fuels, they would eventually run out. Today, an important alternative technology that will be able to satisfy a substantial part of our global energy needs is nuclear fission. However, nuclear energy does not power cars and industrial furnaces, although cars and furnaces will eventually be powered by electricity or hydrogen generated (indirectly) by nuclear fission, or fusion.

There is therefore great impetus for global action and collaboration in the energy sector given the fact that there are costs and constraints attached to addressing the spiralling demand for energy as well as mitigating climate change. The shortfall in supply is a threat that faces all countries in common. It is for this reason that energy collaborations play an important role in bringing together like-minded parties. The increasing worldwide energy demand asks for new solutions and changes in the energy policies of countries, pushing science to new frontiers. This article highlights one such collaborative venture—that of international scientific collaboration in the area of nuclear fusion energy. The article also emphasizes the important role that nuclear fusion power may play in the future energy mix of the world.

Need for fusion energy

Energy conservation and using renewable energy sources, although vital, will not be sufficient to meet the growing world energy requirements. Nuclear energy using fission is an important part of the worldwide energy mix and has great potential for becoming part of a sustainable energy security programme. However, there are concerns in many countries regarding this method of power generation—concerns that have not yet been effectively addressed. A future possibility is the nuclear reaction of fusion, the source of solar (and other stellar) energy.[1] Though many scientific and technical issues are still to be resolved in fusion, controlled fusion is becoming more and more realistic.[2]

The potential for nuclear fusion power, therefore, cannot be ignored. The basic substances needed for the fusion process, namely, deuterium and lithium, are available

[1] Two kinds of nuclear reactions can be used to produce energy: fission, that is, gaining energy through the break-up of heavy elements like uranium; and fusion, that is, gaining energy by merging light elements such as deuterium and tritium.

[2] The progress made by researchers the world-over in bringing the nuclear fusion reactor closer to commercialization is well acknowledged.

throughout the world in almost inexhaustible quantities.[3] A cubic metre of seawater contains 34 grams of deuterium, the energy equivalent of 300 000 litres of oil. When nuclear fusion becomes commercially feasible, the oceans, seas, and lakes could supply enough deuterium for roughly 1000 reactors over a million years (Stankovij 2006). However, it would not be realistic and ecologically sound to plan our energy roadmap at the cost of depleting our water resources. Nevertheless, even if we use 1% of these waters, we could still power a thousand fusion reactors for about 10 000 years. The sheer duration that this quantity of fuel can sustain with high reliability in supply will play a major role in making the fusion power plant commercially viable. Also, if one wishes to use nuclear fusion as an interim source of energy, until such time when better sources of energy are discovered or developed, nuclear fusion would give us sufficient time to come up with better alternatives to electricity generation and efficient plans for resource utilization.

The words of IAEA (International Atomic Energy Agency) Director General, Dr El Baradei during the 49th Session of the IAEA General Conference held in 2005, best summarizes the worldwide drive for energy collaborations in fusion energy.

> *While some of us may be sceptics when it comes to any science that takes such a long time to develop, there is no denying that nuclear fusion promises some welcome characteristics: an inexhaustible source of energy in light nucleus atoms; the inherent safety of a nuclear reaction that cannot be sustained in a non-controlled reaction; and few negative environmental implications. With the construction of the ITER, the international scientific community can begin devoting serious attention to this long-term objective.*

Nuclear fusion collaboration

Joint European Torus

Many energy planners have recognized the great potential in nuclear fusion, and nations have vied for first position in taking a lead role in fusion research. However, largely due to costs of research, countries have come together to share facilities, human resources, and funds, so as to jointly take forward the work in nuclear fusion. One such example is the JET (Joint European Torus). The UKAEA (United Kingdom Atomic Energy Authority) research facility at Culham in Oxfordshire is host to the JET experiment and also to three other experimental *tokamaks*, that is, nuclear fusion devices that work on the principle of magnetic confinement.

JET was established from June 1978 to 1999 to construct and operate the JET machine. Since the beginning of 2000, the JET experimental programme has been managed under the EFDA (European Fusion Development Agreement). The EFDA was created to provide a framework for national fusion research parties to participate in collective activities such as JET. The EFDA runs for a fixed term of years, and can be extended. The goal of EFDA is to develop the necessary scientific and technical basis in European research and

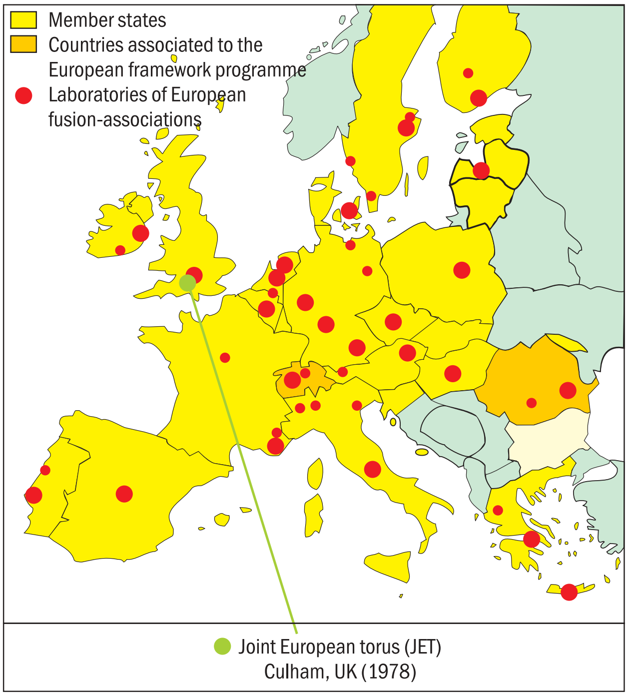

Figure 1 Countries that are part of the JET collaboration
Source Green (2006)

[3] Tritium is also required initially and is subsequently bred in the lithium blanket of the reactor, as part of the fusion process, for future reactions.

industry for the construction of ITER (International Thermonuclear Experimental Reactor) and a prototype fusion power plant, and to strengthen European capabilities. EFDA coordinates the technological work carried out by European fusion labs and industry, and coordinates European contributions to international collaborations such as ITER. The UKAEA has been contracted to maintain and operate the facility, while experimental work is carried out by visiting teams of scientists from all the associated EURATOM laboratories working on the fusion programme.

The JET facility is collectively used by EURATOM associations from more than 20 European countries. The JET device is currently the world's largest operational *tokamak*. The JET facilities include plasma-heating systems capable of delivering up to 30-MW (megawatt) of power, an Active Gas Handling System, and a Beryllium Handling Facility, providing JET with a unique tritium and beryllium capability, respectively. Over the next few years, JET's technical capabilities will be significantly enhanced in order to optimally support the ITER's final detail design and in preparation for exploiting its enhanced features.

International Thermonuclear Experimental Reactor

If JET was at the continental level, ITER goes beyond by operating internationally. ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power. The partners in the project are the EU (European Union) (represented by EURATOM), Japan, China, India, South Korea, the Russian Federation, and the US. ITER is seen as the international way towards the peaceful use of controlled nuclear fusion energy. It combines two major elements in the development of fusion as a source of energy: (1) the exploitation of the established potential of the *tokamak* configuration to reach reactor conditions, and (2) the use of international collaboration to share the burden of costs and to accelerate progress by pooling resources and expertise. With ITER, fusion reactor conditions shall be achieved with temperatures as high as several hundred million kelvin and extremely high densities (about 1020/ m^3) to ignite the plasma and sustain the reaction.

IAEA has been an integral part of ITER since its inception, and its activities on controlled nuclear fusion research have been advised by an expert body —the IFRC (International Fusion Research Council). At the November 1985 Geneva Superpower Summit, Premier Gorbachev, on the advice of academician Evgenij Velhikov and others, and after talking the matter over with President Mitterand of France, took the initiative to propose the development of an international project. The project was to comprise Europe, Japan, the US, and the USSR in order to develop fusion energy for peaceful purposes through the joint construction of the device. In 1988, the IAEA ITER office started to support the CDA (conceptual design activities) for this device. With the signing of the ITER EDA (Engineering and Design Activities) Agreement and Protocol 1 in July 1992, the ITER EDA led to a first comprehensive design and final report.[4]

After 2002, negotiations to pick a site for the installation of the device began and this attracted growing interest, especially after President Bush announced on 30 January 2003 that the USA would join ITER again.[5] India joined the ITER in December 2005, reflecting the increasing worldwide interest in developing nuclear fusion energy. The EU and France will contribute half of

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[4] Soon after the ceremony to celebrate the achievements of the ITER activities, on 14 December 1998 at the ITER San Diego Joint Work Site, the US withdrew from further participation. However, within the ITPA (International Tokamak Physics Activities), initiated by the IEA (International Energy Agency) and IAEA (International Atomic energy Agency), a redesign of ITER was possible leading to a new and smaller design. The total R&D resources committed in nine years by the parties amounted to about 660 kIUA (1 kIUA = $1 million in 1989).

[5] Even though America did exit the ITER at one point, it simultaneously built an enviable network of nuclear fusion laboratories across the country with collaborating universities and state institutes. The Republic of Korea and the People's Republic of China joined ITER in January 2003. Canada withdrew from ITER on 23 December 2003.

the total cost (Euro12.8 billion), while the other partners—Japan, China, South Korea, the US, and Russia—will contribute 10% each. Japan will provide the high-tech components, host a Euro 1 billion materials testing facility and will have the right to host a subsequent demonstration fusion reactor (called DEMO). Finally, at a Ministerial Meeting in May 2006 in Brussels, an agreement was signed by the ministers representing more than half of the world population to build the world's biggest fusion experiment in Cadarache, France.

Exchanges between JET and ITER

The UK will play a leading role in ITER by contributing expertise acquired as a result of hosting the JET. JET has a sizeable team of scientists, engineers, and technicians with considerable experience in fusion energy. Today, most work at JET is done to complement the work at ITER. Most of the scientific objectives of JET have been realigned to take into account the concerns of ITER. Technological developments and targets have been planned in coordination with aiding ultimate ITER objectives. For example, development of ITER-like wall materials, heating schemes, reactor diagnostics, and plasma scenarios in the JET programme have been planned and are carried out with the goal of serving as inputs to ITER work.[6] Installation of major components is expected to start by end of 2008.

JET represents the EU's efforts in fusion science. Several member states of the EU have contributed to the establishment and maintenance of JET financially and by providing human resources. The ITER represents an international level of interactions taking place between regional collaborations like the JET, and other member countries like Japan, Russia, and India, and these in turn contribute to the worldwide effort in ITER.

ITER: the future potential

The ITER parties represent about half of the world's population. That alone is an enormous achievement, both politically and technically. For the other half of the world, it represents a major hope for future energy supplies. A reasonable goal for future supply is a mix of fossil fuels, renewable energy, and nuclear fission, roughly in equal proportions, with other energy sources as minor partners. By about 2050, we will know considerably more about the economic feasibility of nuclear fusion, hydrogen, and certain renewable energies, and we will have to re-adapt ourselves to a new energy mix. By 2050 therefore, these energy options must be ready and mature enough to take on the role of major energy-producing technologies in the power sector. Hence, research and development currently being carried out in emerging technologies, like nuclear fusion, is required and justified as part of the larger work towards a secure energy future for the world. This opportunity has spurred many countries to invest in fusion research. The US alone, which had exited ITER earlier, has allocated nearly $493 million for fusion in the financial year starting 2009 (US DoE 2008). This represents a 170% increase from the current financial year's funding allocation. The ITER is a good international platform for fusion research to be carried out by nations that may not have the ability to commit large sums to a domestic programme similar to the scale of the ITER.

Even if the huge potential for increasing energy efficiency is tapped, additional energy needs are likely to come up, for example, to meet future needs of mankind for fresh water via desalination of sea water. As for nuclear fusion, a commercial power plant is several decades away. Fusion may play no role in the provision of energy in the next three to four decades, although it may play an important one thereafter. Despite this and the high

[6] The JET programme in support of ITER was launched to provide answers to urgent ITER-related questions such as tritium retention, metallic plasma-facing components under ITER-relevant power loads in between and during transients and disruptions, compatibility of metal-dominated wall with ITER plasma scenarios, and qualification of many diagnostics to ITER needs. Activities currently are underway to fully replace the first wall material with beryllium in the main chamber and tungsten in the diverter, to upgrade the overall heating power up to approximately 45 MW, to install a High-Frequency Pellet injector (end 2007), to upgrade the plasma control system, to progress technology R&D in support of ITER.

initial investment costs required, fusion research is supported worldwide because of its great long-term potential and its ability to replace fossil fuel plants by meeting base loads.

A strategy to improve expertise and participation of emerging economies and developing countries is needed, in view of the energy demand in China and India. The evolution of power technology, including a new generation of fission reactors (Generation-IV reactors) and fusion reactors, will have to be based on close international collaboration. The IAEA has the mandate to assist this development to accelerate and enlarge the contribution of atomic energy towards peace, health, and prosperity through the facilitation of the ITER process and the encouragement of scientific and technical collaboration among its member states.

Conclusion

What we have in the JET and ITER are examples of energy collaborations working across political boundaries to achieve a common goal through the exchange of information and support by way of monetary, technological, and human resources. Such energy collaborations work towards global and regional goals of energy security and help in giving the region a balanced growth by uniformly distributing the responsibilities and the beneficial outcome of such ventures. As a 'fusion of national interests' and improvement in foreign relations take place, the working relationship established between ITER and JET member countries can help in aiding closer cooperation between countries in other areas like poverty eradication, the fight against terrorism, and disaster management. These energy collaborations thus help in contributing to the larger fabric of world peace and security.

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Centre for Research on Energy Security

CeRES (Centre for Research on Energy Security) was set up on 31 May 2005. The objective of the Centre is to conduct research and provide analysis, information, and direction on issues related to energy security in India. It aims to track global energy demands, supply, prices, and technological research/breakthroughs – both in the present and for the future – and analyse their implications for global as well as India's energy security, and in relation to the energy needs of the poor. Its mission is also to engage in international, regional, and national dialogues on energy security issues, form strategic partnerships with various countries, and take initiatives that would be in India's and the region's long-term energy interest. *Energy Security Insights* is a quarterly bulletin of CeRES that seeks to establish a multistakeholder dialogue on these issues.

Previous issues of this newsletter are available at <http://www.teriin.org/div_inside.php?id=41&m=3>.

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