Asian Energy Institute

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Contents

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The AEI (Asian Energy Institute) is a network of 17 energy institutes from Asian countries. These include Bangladesh, China, India, Indonesia, Iran, Japan, Jordan, Korea, Kuwait, Malaysia, the Philippines, Pakistan, Sri Lanka, and Thailand. Besides, there are 14 associate members, both within and outside Asia. The AEI was formally established in August 1989. Its aims and objectives are to promote greater information exchange; facilitate sharing and dissemination of knowledge; undertake research and training activities that are of common interest to its members; and analyse global energy developments and their implications. TERI hosts the secretariat of the AEI at present. The secretariat publishes a biannual newsletter that informs the readers about the diverse research activities undertaken by the member institutes. Currently, the AEI is hosting the regional secretariat for REEEP (Renewable Energy and Energy Efficiency Partnership) in South Asia.

Editorial

*R K Pachauri**

Recent global developments have had a major impact on the economies of several countries of the world. These are likely to stimulate a detailed discussion in the coming months, which may have a major bearing on how growth and development were to take place in the future. If one goes back to the beginning of industrialization, it becomes apparent that the world progressed in producing more and more goods and services largely because of greater use of fossil fuels, which began with consumption of coal, essentially in the steam engine during the middle of the nineteenth century, and expanded to the use of oil and natural gas for a range of industrial and other applications. Global oil prices, which had touched $147 per barrel some months ago, have now declined to below $50 per barrel. The fluctuations in prices that have taken place recently are likely to lead to a major impact on the thinking of strategic planners and decision makers. There is a growing and widespread realization that the world's energy future would have to be very different from what we had become accustomed to in the past.

One major area of focus is likely to be efforts to promote higher levels of efficiency in the entire energy cycle. Of course, this would not only involve improvements in efficiency in the supply of energy, but also major changes on the demand side, which would actually lead to a transformation of several activities. Two sectors set to become examples of major transformation are transport and housing. In the transport sector, there would be a movement towards more efficient vehicles which would essentially be brought about through improved design of engines and transmission systems, but also as a result of new materials being used for the design of vehicles. Additionally, a serious effort will be made to produce biofuels in a manner that does not necessarily conflict with production of food. In this respect, current efforts to convert corn into ethanol or palm oil production for use as biofuels are likely to be seen as aberrations that clearly will not last very long and are certainly not likely to be expanded to a large scale. On the other hand, there is a strong possibility of much greater efforts to produce second generation biofuels, which would aim to convert cellulosic material into liquid fuels as well as the plantation of non-edible oil crops (particularly those that grow under soil and water conditions different from those required for foodgrain production). The world will also have to move towards greater use of public transport, which would require proactive policies, with local governments investing in public transport projects in towns and cities and national governments promoting inter-city travel through railways and waterways.

In the housing sector, a major change is likely to come about through sensitive designs that use solar passive techniques, better utilization of daylight, and involve the use of building materials that are low in energy intensity. Insulation technologies and materials will be used on a much larger scale, and the use of active solar for applications like water heating and generation of electricity will also find much greater application.

Given the fact that economic growth in the Asian region is likely to outstrip growth in other parts of the world, this continent has to take a lead in bringing about a global transition in energy use. For this purpose, a debate has been on with several authorities suggesting that the equivalent of the International Energy Agency should be established through the development of an Asian Energy Agency. Such an entity would necessarily require the support and involvement of governments in the region, but it would have to be constituted in such a way that it relies on high level expertise and knowledge to command respect not only in the region, but also globally.

The AEI (Asian Energy Institute) has been in existence for almost 20 years now, and I wonder if the time has come for it to assume an active role in trying to move towards the establishment of an Asian Energy Agency. In keeping with the signs of the time, such an agency need not be a purely government-dominated organization but should ideally be a combination of all stakeholders including government, business, civil society, and research and academia. As we enter the twentieth year of existence of the AEI, perhaps we should raise our vision and efforts to bring into existence an agency of the type that resembles, but is not necessarily a reflection of, the International Energy Agency, functioning within an Asian context.

The proposal for an Asian Energy Agency to cover Asia is not a case of keeping up with the Joneses but one that would clearly be of benefit to the Asian region, given that this continent houses the majority of the human race and, therefore, has a major stake in the energy future of the world and, certainly, of this continent. The Asian Energy Agency could be a useful forum to develop coordinated energy policies for Asia, ensure freer trade in energy technologies, and possibly even undertake joint R&D activities by which new technologies could be developed for the benefit of all the countries in the region. Asia is now also a major consumer of LNG (liquefied natural gas), and banding of the major consuming countries together would perhaps help in securing better and more stable prices for LNG imports. In essence, just as the International Energy Agency has evolved from a club of major oil consuming countries in the developed world, the Asian Energy Agency would also evolve with a personality entirely its own. It would be useful for the AEI to initiate a dialogue in this direction.

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The fuel versus food dilemma and India's biofuel policy

*B Bhattacharya**

Introduction

The world's fascination with biofuels is largely attributed to the twin problems of climate change and the perceived finiteness of crude oil supplies. The increasingly scarce proven reserves of crude and consequential escalation in prices, besides the strategic threat perception arising out of the skewed physical distribution of oil reserves, mandate a re-assessment of alternative sources of energy including biofuels. There is an additional benefit if these alternative sources of energy are also conducive to managing climate change.

On initial assumptions, biofuels scored on both counts—in providing an alternative to oil, and in addressing climate concerns. However, at that stage, the possible impact of the rise in biofuel production (on a scale which can reduce the volume of crude used) on the acreage distribution of cultivable land, commodity prices, and inflationary pressures in general, was not factored in. The drive towards biofuels initially came at a time when commodity prices had stagnated for long. Developments during the last year, however, have raised concerns regarding the desirability of the government-mandated use of biofuels, as well as its efficacy and long-term sustainability. High commodity prices, especially food prices, which are mostly independent of biofuel policy interventions, have compounded the problem.

The enormous rise in crude oil prices, which was caused partly by supply side considerations but also purely speculative activities, resulted in a sharp rise in input costs for agricultural commodities. The FAO (Food and Agriculture Organization) has estimated the output and input price changes for select products (Table 1). The rise in input costs was far higher than the output prices. Since the input costs are mostly for oil and fertilizer, there is little chance of reduction in the short term (OECD–FAO 2008).

The FAO's food price index increased by 12% between 2005 and 2006, 27% during 2007, and 52% during January–April 2008. Rising food prices tend to affect poorer countries relatively more, as expenditures on food account for a higher share of the household budgets in these countries. FAO has estimated food price inflation and its impact on the CPI (consumer price index) (Table 2). It is observed that amongst the countries surveyed, the expenditure share of food varied from a low of 9.8% (in the US) to a high of 64.5% (in Bangladesh). Similarly, the contribution of food prices to variation in CPI stood between 0.2% (in Switzerland) and 15.9% (in Sri Lanka).

Table 1 FAO estimated output and input price changes for select products

Period (January–April)	*Meat*	*Dairy*	*Cereals*	*Oils*	*Sugar*	*Food price index*[a]
2007/08	9	49	80	94	23	52
2006/07	5	35	32	29	–39	12

Period (January–April)	*Ammonia*	*Urea*	*CAN*	*NPK*	*DAP*	*IRAC crude oil*[b]	*Input price index*
2007/08	82	31	85	213	163	70	99
2006/07	4	29	15	41	33	–3	19

IRAC – imported refiner acquisition cost, [a] Butter, cocoa, beans, corn, cottonseed oil, hogs, lard, steers, sugar, and wheat. Input price index: ammonia, urea, CAN, NPK, DAP, and IRAC crude oil, [b] IRAC of crude oil in the US.

Source FAO (2008)

Rising food prices: assessing the impact of biofuels production

Commodity prices have been on the rise during the last two years, and several explanations have been offered, especially for food products. Some of these explanations are enumerated below.

- Growing demand for food in the large, emerging economies, particularly China and India, due to their economic prosperity.
- Heavy speculation in the futures market.
- Export restrictions imposed by several food-exporting countries, leading to panic buying in the global market.
- Increased demand for select agricultural products used as feedstock for biofuels' production.

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Table 2 Food price contribution to consumer price inflation (select countries)

Country	Total CPI change[a](%)	*Food price inflation*[a]	*Expenditure share of food*	*Food contribution to total change in CPI*[b]
Developing				
Guatemala	8.04	11.6	38.9	4.5
Sri Lanka[c]	19.37	25.6	62	15.9
Botswana	7.7	18.3	21.8	4.0
India[c]	4.6	5.8	33.4	1.9
Indonesia	6.8	11.4	26.7	3.0
Pakistan[c]	10.6	18.2	41.5	7.6
South Africa	8.6	13.6	21	2.9
Jordan	5.4	9.1	39.7	3.6
Peru	4	6.4	29.6	1.9
Senegal	5.8	10.9	40.3	4.4
Egypt	9.5	13.5	41.5	5.6
Haiti	9.9	11.8	50.3	5.9
Kenya	15.4	24.6	50.5	12.4
Bangladesh	10.3	14.2	64.5	9.2
China	8.7	23.3	27.8	6.5
Developed				
USA	4.0	5.1	9.8	0.5
France	2.8	5.0	16.3	0.8
Germany	2.8	7.4	10.4	0.8
UK	2.5	5.6	11.8	0.7
Japan	1.0	1.4	19.0	0.3
Greece	4.4	6.6	17.8	1.2
Spain	4.4	7.1	21.9	1.6
Switzerland	2.4	2.2	11.0	0.2
Poland	4.3	7.1	30.4	2.2
Sweden	3.1	5.9	13.4	0.8

CPI – consumer price index, [a] – percentage change from February 2007 to February 2008, [b] – includes beverages and tobacco, [c] – contribution is column 2 × 3/100.

Source OECD–FAO (2008)

There is no unanimity of opinion as to the relative impact of these forces; and it seems that the cumulative impact of these forces may have contributed to the current price spiral. The evidence emerging from empirical data is mixed—net import-export ratios of food products in China and India do not reveal any large-scale deterioration, which should have been observed if the increased demand for food in these countries was the principal factor behind the price rise. Further, commodity price rise was also observed in the case of items not affected by the biofuels phenomenon. This holds true for rice, which does not compete with maize and soyabean production for cultivable land as these are not substitutable. The water requirements of rice and soya/maize vary considerably. One hypothesis that can explain a generalized rise in commodity prices is that finance capital may have shifted from paper assets (currencies and securities) to real assets (commodities). According to Kielkopf, 'If the cause of commodity price inflation is a monetary phenomenon, …market speculation in commodities is an instrument through which monetary expansion and inflation occur as banks finance margin calls through lower interest rates, allowing spectators to bid prices ever higher' (Kielkopf 2008).

A biofuels initiative of UNCTAD (United Nations Conference on Trade and Development), which began in 2005, has conducted an appraisal of the possible impact of biofuels related demand on select agricultural product prices in the last year (UNCTAD 2008).

- Wheat prices rose by 126% during January–April 2008, as compared to the same period in 2007. But since only 1.4% of wheat is used for biofuel production in the EU (European Union) and a marginal 0.6% globally, rise in prices cannot be attributed to this factor.
- The rise in maize prices is more modest, even though its use as fuel feedstock is substantial, especially in the US. Maize prices rose by 23% during July 2007–March 2008. In the US, the use of maize for ethanol production is estimated to have doubled between 2005/06 and 2007/08. It has been forecasted that in 2009, almost 38% of total maize use in the US, estimated at 100 million tonnes, will be for biofuels production. Therefore, there may well be a link between maize utilization for ethanol production and maize prices.
- Sugar, a significant biofuel feedstock, has seen high volatility in prices during 2007 and 2008 (first trimester). It is felt that sugar production currently exceeds consumption and increasing demand for sugar for ethanol production has not changed this situation.
- The rise in prices of vegetable oils has been very high—94% in 2008 and 140% in 2007. Biofuels are becoming a significant driver in the oilseeds market, both directly through the use of vegetable oils for bio-diesel production, and indirectly through increased cereal demand for ethanol production, which affects the relative prices of oilseeds and thereby the competition for arable land between these crops.

UNCTAD's review concludes that: '…increased biofuels production has been, for certain crops and certain countries, a driver of food price inflation, but not the dominant one' (UNCTAD 2008). The biofuels market functions in most countries on the basis of mandated amounts or voluntary blending targets; the law requires or recommends a certain percent of biofuels to be mixed with fossil fuels. If the required percentage goes beyond the production capacity of the agricultural sector, and if there is a preference for specific feedstocks, the functioning of the markets gets influenced. The resulting pressures could exacerbate the market price reaction and contribute to generating expectations of even higher prices in the futures market.

The US has laid down ambitious targets for biofuels usage under the Energy Independence and Security Act of 2007. The total amount of biofuels to be added to gasoline is required to increase to 36 billion gallons by 2022 from 4.7 billion gallons in 2007. The Act further specifies that 21 billion gallons of the 36 billion gallons must come from non-corn starch products, such as sugar and cellulose. The EU has passed a directive to reduce greenhouse gas emissions and the EU's dependence on external fuel sources. This directive requires member states to set indicative targets for increasing the use of biofuels so that these account for 5.75% of the EU transport fuels by 2010. In March 2007, after four years of having used biofuels, the EU set a still more ambitious target of sourcing 10% of transport fuels from renewable sources by 2020.

Economic analysis of the price effect

The trade-offs between biofuels related demand and rise in prices is complex to model. There are, however, several studies that have made attempts in this direction. A recent study by IFPRI (International Food Policy Research Institute) has projected prices of two kinds of agricultural feedstock, maize and oilseeds, for two alternate scenarios up to 2020. Scenario One is based on current biofuel investment plans. Under this scenario, prices of maize and oilseeds are estimated to go up by 26% and 18%, respectively. Scenario Two envisages double the biofuels expansion. The estimated price rise then goes up to 72% for corn and 44% for oilseeds (IFPRI, cited in Renewable Fuels Agency 2008).

The IFPRI study is based on a partial equilibrium analysis, which does not take into account long-term inter-sectoral adjustments. Another study analyses the same relationship in a general equilibrium framework (Overseas Development Institute 2008). The results still show a fairly substantial price rise for principal agricultural feedstock, though at a somewhat lower level.

India's biofuels policy

The main features of the country's National Biofuels Policy are as follows.

- An indicative target of 20% by 2017 for the blending of biofuels, bio-ethanol and bio-diesel, has been proposed.
- Bio-diesel production will be from non-edible oilseeds grown on waste/degraded/marginal lands.
- The focus would be on indigenous production of bio-diesel feedstock.
- Bio-diesel plantations on community/government/forest wastelands would be encouraged while plantation on infertile irrigated lands would not be encouraged.
- The MSP (minimum support price) with the provision of periodic revision for bio-diesel from oilseeds would be announced to provide fair price to growers.
- The MPP (minimum purchase price) for the purchase of bio-ethanol by OMCs (oil marketing companies) would be based on the actual cost of production and import price of bio-ethanol. In case of bio-diesel, the MPP would be linked to the prevailing retail diesel price.
- The National Biofuels Policy envisages that biofuels may be brought under the ambit of 'declared goods' by the government to ensure unrestricted movement of biofuels within and outside states. It is also stated in the Policy that no taxes and duties should be levied on bio-diesel.

An appraisal

It is evident that the formulators of India's Biofuels Policy have exercised caution, thus avoiding falling into the food versus fuel trap. It, therefore, explicitly recognizes that biofuels are to be based 'solely on non-food stocks to be raised on degraded lands or wastelands that are not suited to agriculture.' To make this effective at a sufficiently large scale, it is imperative to have a comprehensive national atlas of such lands to find out what scale of production is theoretically feasible. The suggested long-term prospects of Jatropha as basic feedstock also call for re-examination, keeping in view its gestation period and sustainability of supply of seeds which are reportedly in short supply.

However, still more significant is the issue of availability of land. It has been observed that India currently consumes 45 MT (million tonnes) of diesel. Even a 5% blend will require 2.25 MT of bio-diesel, which will need 2.2 mha (million hectares) of land. If the country is to go up to the targeted figure of 20% blend, the land requirement will rise to an astronomical figure of 8.8 mha. It is the availability of land that ultimately puts a ceiling on bio-diesel production.

Future prospects

No economic policy is sustainable in the long run if its legitimacy stems only from administrative fiats. The current use of biofuels, as well as the usage in the near term, is based on government mandates. The policy will be effectively sustained if, and only if, the economic costs of biofuels are brought to a level where manufacturers will continue to comply, even if the mandate is withdrawn. One of the major determinants of whether this can happen in the future is the price of crude, a commodity, the price behaviour of which is least predictable. Leaving this aside as an exogenous variable, policies relating to biofuels need to focus on two major areas.

- Identification of non-food sources
- Next generation technology

These two are not necessarily exclusive, and some firms are engaged in both areas. In India, Tata Chemicals is working on technology to produce bio-ethanol from sweet sorghum. Some researchers have identified this as the ideal bio-ethanol crop for India. It has comparative advantages in terms of sustainability, processing, and superior by-products such as bagasse. It can be used in its entirety for ethanol production, and is also cost-competitive. To produce 1000 litres of ethanol, the feed stock cost is $82 for sweet sorghum, $89 for corn, and $112 for sugar cane (Singh 2008). Second generation technology, which utilizes biomass, can also provide freedom from the food versus fuel dilemma.

References

FAO (Food and Agriculture Organization). 2008
Soaring food prices crisis: high prices and incentives
Details available at <http://www.fao.org/fileadmin/user_upload/ISFP/Incentives.pdf>, last accessed on 27 September 2008

Kielkopf J. 2008
Gut check: what explains the rice price, then?
Details available at <www.voxeu.org/index.php?q=node/1437>, last accessed 27 September 2008

OECD–FAO (Organization for Economic Co-operation and Development–Food and Agriculture Organization). 2008
Agricultural outlook 2008–2017
Details available at <http://www.fao.org/es/ESC/common/ecg/550/en/AgOut2017E.pdf>, last accessed on 28 September 2008

Overseas Development Institute. 2008
Review of the indirect effects of biofuels, economic effects and food insecurity: a report to the Renewable Fuels Agency
Details available at <www.renewablefuelsagency.org>

Renewable Fuels Agency. 2008
The gallagher review of the indirect effects of biofuels production
Details available at <http://www.dft.gov.uk/rfa/_db/_documents/Report_of_the_Gallagher_review.pdf>

Singh S. 2008
'Tata Chemicals' ethanol plant validates claims on sorghum
Details available at <http://www.livemint.com/2008/09/24220413/Tata-Chemicals8217-ethanol.html>, last accessed on 28 September 2008

UNCTAD. 2008
UNCTAD's position on biofuels policies and the global food crisis
Details available at <http://www.unctad.org/Templates/Page.asp?intItemID=4526&lang=1>, last accessed on 28 September 2008

US–India renewable energy policies: a comparative assessment*

Neha Misra#

Introduction

Globally, the RE (renewable energy) sector has gained renewed momentum in the last decade. This resurgence has come about, in large part, due to an influx of domestic, regional, and international concerns regarding the pervasive impact of traditionally high fossil fuel dependence on the level of greenhouse gas emissions. Energy, environment, and national security concerns have set the stage for a paradigm shift in the way RE is perceived by policy-makers, businesses as well as citizenry around the world. Both in the US and India, several efforts are underway to stimulate the domestic RE markets, while also increasing the countries' share of the growing RE pie internationally. This article looks at the present status of RE in both countries and its estimated potential. It then explores the common ground and variations between some of the existing federal and state level RE policies. Finally, it makes a case for strengthening the US–India partnership for developing the RE market, both domestically and internationally, by sharing best practices in some key areas.

Renewable energy scenario: how green is the valley?

Present status

According to the *Renewables 2007 global status report*, the US ranks third in the world in terms of existing renewable power capacity, closely followed by India, which ranks fifth. In terms of new capacity additions, the US is *numero uno* in terms of wind power added as well as ethanol production, second in bio-diesel production, and third in grid-tied solar PV (photovoltaic). India, in turn, stands globally third in terms of wind power added and fourth in terms of solar hot water added (REN21 2008). Though these shining global rankings are good news for the RE sector in the US and India, RE still forms a very small portion of the energy mix in both the countries. In 2007, RE (including hydropower) formed a mere 7% and 6.8% of the energy mix of the US and India respectively (EIA 2008, BP Statistics 2008). The US net summer electricity generation capacity in 2007 stood at 999 GW (gigawatts), of which 11% (that is, 107 GW) came from renewables (EIA 2008). This was dominated by conventional hydroelectric power (73%), followed by biomass (10%), wind (15%), geothermal (2%), and solar/PV (0.5%). As on 31 March 2007, the total installed capacity of the utilities in India was 132.32 GW, of which 32% (that is, 42.4 GW) came from renewables. This was again dominated by conventional hydroelectric (81%), while wind and other renewables formed the rest (TERI 2007).

Estimated potential

If one were to look at the status of the RE sector in US and India through the lens of estimated potential of existing technologies, the present report card leaves much to ask for. A US DOE (Department of Energy) study shows that it is realistically possible for wind energy to contribute up to 20% of US electricity generation by 2030, which is way more than the present share of 1.5%. The Natural Resources Defence Council estimates that the US could produce about 7500 MW of power from roughly 39 million tonnes of crop residue that presently goes unused each year (NRDC 2008). According to the Solar Energy Industries Association, US, the identified potential of concentrating solar power production in South West US alone is approximately 200 GW, which could produce about 473 000 GWh per year. India too has substantial latent RE potential—be it wind energy with an installed capacity of 8757.40 MW, out of a potential of 45 000 MW (19%); small hydro (up to 25 MW) capacity of 2180.84 MW, against an existing potential of 15 000 MW (14.5%); or biomass power/cogeneration with an existing installed capacity at 1406.63 MW, against a potential of 21 000 MW (6.7%) (MNRE 2008). For solar PV power, the level of exploitation in India is dismally low at 30 MW, against a potential of 50 000 MW (20 MW/km^2) (0.0006%) (Deccan Herald 2008)

Thus, while there are patches of green in both the US and Indian energy mix, it remains to be seen how green the valley will ultimately get, and equally important, is the sense of urgency with which this is done in order to address climate change. In utilizing its vast RE potential, India faces the challenge of

* The figures in the article assume an exchange rate of $1 = Rs 44

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scaling up not only grid-connected RE solutions, but also distributed applications to leapfrog 78 million households presently without any access to electricity whatsoever, to a certain minimum, affordable, and reliable electricity supply. Addressing energy poverty is also critical in order to meet India's Millennium Development Goals and RE can play a key role here. In turn, the US, as the largest energy consumer and GHG emitter in the world, faces growing domestic and international pressure to step up its push for clean renewable sources of energy. To get an insight into how these nations are addressing energy and climate challenges through RE, we now look at existing policy framework and goals therein.

Renewable Energy Policy Framework

In recent times, an increasing number of policies in the US and India have recognized RE as a critical element of the strategy to enhance energy security while also dealing with climate change. Table 1 gives a snapshot of some of the key policies in this regard.

Federal policies

National energy legislation and supporting policies

Both the US and India have assigned importance to RE through nationally adopted policies. Table 2 shows five key US legislations enacted in the last five years with significant implications for the development of the RE sector. Of these, the Energy Policy Act of 2005 was the first major energy law enacted in the US in a decade (since the Energy Policy Act of 1992). In addition to the enacted policies shown in Table 2, on 26 June 2008, a new bill called 'The Renewable Energy Jobs and Security Act' was introduced in the US Congress in an effort to create the federal FIT (feed-in tariff) legislation. If passed, the bill would create a federal FIT system of payments for small- to mid-sized RE suppliers (sites of up to 20 MW in size). This is similar to the FIT policies in Germany, Spain, France, and other European countries in respect of (1) guaranteed interconnection through uniform minimum standards to be implemented by the FERC (Federal Energy Regulatory Commission) and the states; (2) a mandatory purchase requirement through fixed-rate 20-year contracts (the FERC would set minimum national REP [renewable energy payment] rates at levels designed to provide for full cost recovery, plus a 10% internal rate of return on investment, for commercialized technologies under good resource conditions); and (3) rate recovery

Table 1 Renewable energy promotion policies in the US and India

Policy instrument	*US*	*India*
Feed-in tariff	*	*
Renewable portfolio standard	*	*
Capital subsidies, grants or rebates	✓	✓
Investment or other tax credits	✓	✓
Sales tax, energy tax, excise tax or VAT reduction	*	✓
Tradable renewable energy certificates	*	–
Energy production payments or tax credits	✓	✓
Net metering	*	–
Public investment, loans or financing	*	✓
Public competitive bidding	*	✓

US – United States
* implies that some regions within the two countries have state/province-level policies but there is no national-level policy. Only enacted policies are included.

Source REN 21 (2008)

Table 2 Five key US federal laws impacting RE in the last five years

Year	*Policy*	*Implication on renewable energy development*
2005	The Energy Policy Act	Emphasizes the role of RE in ensuring US energy security. RE Tax credits, Federal Purchase Requirement, Renewable Fuel Requirements.
2007	The New Direction for Energy Independence, National Security, and Consumer Protection Act	Requires electricity suppliers in the US to produce 15% of their electricity using RE resources by 2020.
2007	The America Creating Opportunities To Meaningfully Promote Excellence In Technology, Education, and Science Act (America COMPETES Act)	Establishes the ARPA-E (Advanced Research Projects Agency-Energy) within the Department of Energy to support transformational energy technology research projects with the goal of enhancing the nation's economic and energy security.
2007	The Energy Independence and Security Act	Aims to help reduce US dependence on oil by expanding production of renewable fuels in the country. The federal government has also set a goal for biofuels to make up to 30% of the gasoline supply by 2030, and for 20% of power to be generated by wind.
2008	The Emergency Economic Stabilization Act	Extension of Renewable Energy Tax Credits, provisions for Clean RE Bonds

RE – renewable energy, US – United States
Source Author's compilation

through a regionally partitioned national system benefits charge (Rickerson, Bennhold, and Bradbury 2008)

On 18 September 2008, in the midst of the Wall Street financial turmoil, the US Select Committee on Energy Independence and Global Warming emphasized that extending the RE tax credits in the country alone would save 116 000 American jobs and $19 billion in investment. When the Emergency Economic Stabilization Act of 2008 was passed by President Bush to bailout the US financial system from the prevailing crisis, incentives for RE were included in the package. The Act contains incentives for RE in the form of provisions for extension of credit for wind facilities, solar energy, fuel cells, micro turbines, and geothermal heat pump systems; expansion of biomass facilities; production credits for electricity produced from marine renewables (waves, tides, currents in ocean, estuaries, and tidal areas); and new renewable energy bonds. These measures in the Act came as a big relief to the US RE industry, which was anxious about its future in the wake of uncertainty regarding the fate of federal RE tax credits, which were originally expiring by the end of 2008.

In case of India, a significant regulatory impact on RE was made by the Electricity Act, 2003 (EA 2003), which provides for the determination of quotas or RPO (Renewable Purchase Obligations) by SERCs (State Electricity Regulatory Commissions). This has been followed by a number of other policies (Table 3). India's Science and Technology Policy, 2003, seeks to ensure energy security on a sustainable basis (DST 2008). However, it is interesting to note that the entire text of the policy document makes only a single reference to RE.

In 2006, an expert committee submitted its report on India's IEP (Integrated Energy Policy). The IEP suggests that capital subsidies, which only encourage investment without considering ensuing outcomes, should be phased out. In such cases, power regulators in India must seek alternative incentives to encourage utilities to integrate RE into their systems. Wherever appropriate, the policy recommends that regulators should mandate feed-in laws for RE as provided under the EA 2003. While the policy makes these and a number of other useful recommendations, a key difference when compared to the US policy, is the simple fact that the US energy policy is mandated by law. While such a national energy law remains awaited in India, some other initiatives have been announced for RE. For example, in March 2007, the GoI (Government of India) launched a special incentive package to encourage investments for setting up semiconductor fabrication and other micro-technology and nanotechnology manufacturing industries, aimed at attracting global investments. Subsequently, on 29 January 2008, the MNRE (Ministry of New and Renewable Energy) announced a generation-based incentive for grid-interactive generation of solar power from megawatt-size solar power plants. While these policies are giving much needed support to India's RE industry, it should be noted that according to India's Eleventh Five-year Plan (2007–12), based on present technology, even with a concerted push and a 40-fold increase in their contribution to primary energy, modern renewables (excluding hydroelectricity) may account for only 5%–6% of India's energy mix by 2031/32. By 2012, the GoI intends to achieve 10% of the installed power generation capacity from RE.

In June 2008, the GoI released the NAPCC (National Action Plan on Climate Change) with important provisions related to the development of RE as part of India's strategy to meet its development needs while also yielding co-benefits for addressing climate change. The NAPCC is India's first countrywide framework to address climate change with the approval and support of the GoI. It proposes a solar mission to significantly increase the share of

Table 3 Five key Indian policies impacting RE in the last five years

Year	*Policy*	*Implication on renewable energy development*
2003	Electricity Act, 2003	Directs states to specify a percentage of energy to be procured from RE sources, and the Government of India to prepare a national policy, permitting stand-alone systems (including those based on renewable sources of energy) for rural areas.
2005	National Electricity Policy	Stipulates measures for progressively increasing the share of electricity from non-conventional sources .
2006	National Tariff Policy	Mandates states to specify Renewable Purchase Obligation by distribution licensees in a time-bound manner; provides guidelines for purchase of renewable power.
	National Rural Electrification Policy	Sets forth the goal to provide 'power to all' by 2012; promotes off-grid solutions based on stand-alone systems for improving electricity access.
2008	National Action Plan on Climate Change	Proposes a National Solar Mission while also recognizing the need to expand the scope of other renewables and non-fossil options such as nuclear energy, wind energy, and biomass.

Source Author's compilation

solar energy in India's energy mix, while recognizing the need to expand the scope of other renewable and non-fossil options such as nuclear energy, wind power, and biomass energy.

Institutional arrangements

A key difference in the management of RE programmes under the US and Indian governments lies in the absence of a single nodal agency dealing with the entire basket of renewable sources (including conventional hydroelectric), R&D efforts, and connectivity issues in case of India. America's RE portfolio is managed by the DOE, which was created in 1977 with the passing of the DOE Organization Act. The Act brought together, for the first time, not only most of the US government's energy programmes, but also S&T (science and technology) programmes, and defence responsibilities. The DOE's office of EERE (Energy Efficiency and Renewable Energy) is the key agency engaged in development of RE in the country. It manages the entire basket of RE technologies, including conventional hydroelectric. Also under the DOE are (1) Office of Electricity Delivery and Energy Reliability, which works on the supply side to build a modern and robust grid to ensure delivery of RE sources, and on the demand side to develop new smart grids and plug-in hybrid vehicles; (2) Office of Science, which supports fundamental research programmes in basic energy sciences (the thematic areas of the office, which could have significant implications for advancement of RE, include programmes on nano-scale sciences for new materials, and processes and transformational science of biofuel breakthroughs); (3) National laboratories and technology centres dedicated to research on clean energy; and (4) Energy Information Administration, which is the statistical agency of the DOE, providing policy-independent data, forecasts, and analyses, to promote sound policy-making, efficient markets, and public understanding regarding energy, and its interaction with the economy and environment. In addition to these offices, the America COMPETES Act, 2007, (Table 2) purports establishment of the ARPA-E (Advanced Research Projects Agency-Energy) within the DOE, which is to be modelled after the Defence Advanced Research Projects Agency of the Department of Defence.

In contrast to the presence of the DOE as a nodal agency in charge of various aspects of America's RE portfolio (and energy at large), India has multiple agencies dealing with RE development in the country. In the wake of the challenges posed by the oil shock of 1970s, the Indian government showed vision in promoting RE with the establishment of the Department of Non-Conventional Energy Sources in 1982. This was upgraded to the status of a dedicated ministry in 1992, which was renamed the Ministry of New and Renewable Energy in 2006 (MNRE 2008). The MNRE is the nodal agency for India's RE portfolio minus conventional hydropower, which is managed by the MoP (Ministry of Power). Any generating company tending to set up a hydro-generating station requires the concurrence of the Central Electricity Authority, which advices the MoP on all technical and techno-economic matters. (TERI 2007). The bio-diesel purchase policy as well as the ethanol-blending programme is administered by the Ministry of Petroleum and Natural Gas.

Under the MNRE is the IREDA (Indian Renewable Energy Development Agency) which is responsible for promoting, developing, and extending financial assistance for RE and energy efficiency/conservation projects. The MNRE supports a few specialized centres for solar, wind, and small hydro energy though not as many in number or as widely spread across the country as in the case of the US. India also does not have a specialized statistical analysis and modelling agency in the energy sector on lines of the EIA (Energy Information Administration).

The Planning Commission is responsible for formulating plans for effective and balanced utilization of resources and determining priorities across various sectors. The energy policy is guided by the Power and Energy, Energy Policy and Rural Energy Division of the Planning Commission, in consultation with central ministries and state governments, through Five-year Plans and annual plans. To enable better coordination amongst various energy-related ministries and departments, the Prime Minister constituted an energy coordination committee in 2005, which is yet to have a substantial impact vis-à-vis the very reason of its genesis. The DST (Department of Science and Technology) is responsible for promoting S&T in India, though it does not have a programme focused exclusively on RE development. Nevertheless, one of the DST programmes, which could benefit the RE sector directly or indirectly, includes a mission on nano S&T which aims to foster, promote, and develop all aspects of nano science and nanotechnology that have the potential to benefit the country. Besides these efforts, the Indian government is looking at the creation of a 'National Solar Mission', on the lines of the Atomic Commission (Live Mint 2008).

Federal renewable energy funding

Over the 30-year period from the DOE's inception at the beginning of FY (fiscal year) 1978 to FY 2007, the US federal spending for RE R&D amounted to about

16% of the energy R&D in total, compared with 15% for energy efficiency, 25% for fossil, and 41% for nuclear (CRS 2008). In FY 2007, the DOE's spending plan included $1.5 billion for the Office of EERE. This represented 6.4% of the total DOE budget for 2007, which stood at $23.5 billion (the DOE budget represents about 0.8% of the US federal budget while the EERE budget amounts to 0.0005%).[1] Federal funding of more than $574 million was awarded to businesses, industries, universities, and others EERE financial assistance programmes. In the case of India, the MNRE's total budget for 2007/08 is Rs 1061.31 crores ($230 million). This reflects approximately 0.5% of the Indian government's planned expenditure in the Union Budget 2007/08. The MNRE demand for grants includes allocation for R&D activities spread across various sub-programmes of the ministry, including Rs 8 crores ($2 million) for an upcoming National Institute of Renewable Energy, which is still under construction. In the absence of a nodal agency responsible for the energy sector in India, historical data tracking energy R&D is also not easily available and a comprehensive R&D vision is lacking. In absolute terms, while one can empathize with India's lower RE budget due to its developing country status, much larger funds will be required to fully tap the country's RE potential. As private sector investment is growing, there is also a need to step up government funds for RE. This is an area where the US can help India secure more funds through bilateral and multilateral arrangements.

State policies

Renewable portfolio standards

Currently, 26 US states (out of 50) plus the District of Columbia, have RPS (renewable portfolio standards) policies in place as a matter of state law. These states account for more than half of the electricity sales in the US. Four other states – Illinois, Missouri, Virginia, and Vermont – have non-binding goals for the adoption of RE instead of an RPS. The targets range from 4% for Massachusetts by 2009 to 25% by 2025 for Illinois and Oregon. Texas has put its target at 5880 MW by 2015 (DOE–EERE 2008a). According to a recent study by the Lawrence Berkeley National Laboratory, assuming that full compliance is achieved, the current mandatory state RPS policies will require an addition of about 60 GW of new renewables capacity by 2025, equivalent to 4.7% of projected 2025 electricity generation in the US, and 15% of projected electricity demand growth (Wiser and Barbose 2008).

In India, pursuant to the mandate set by the EA 2003, more than a dozen SERCs have also set state-level quotas and purchase obligations that promote RE. These include Andhra Pradesh, Gujarat, Himachal Pradesh, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal. The quotas range from 0.5% of total energy consumption (including third party sales) for the period 2004–07 for Madhya Pradesh to 10% for the period 2006–09 for Tamil Nadu (TERI 2007). The enforcement of RPS on various state utilities has met with some difficulties with respect to arriving at a realistic resource assessment, as well as determining the approach state electricity regulators should follow to fix RPS. It has also been suggested to move from the cost-plus approach of tariff determination used by most states, to more effective approaches like benchmarking and avoided cost, where more accurate and economically efficient tariff estimates can be made (Gaba and Gupta 2008).

Capital subsidies, loans, rebates, and tax credits

To stimulate the local RE industry, a number of states in both the US and India have come up with a basket of financial incentives in the form of capital subsidies, loans, rebate programmes, and tax incentives. California's SMUD (Sacramento Municipal Utility District) has taken a unique approach to providing its customers with solar power by paying enXco Inc. to install a 1-MW (megawatt) solar power system. The SMUD's customers can sign up to buy a share of this system. The programme provides an alternative to owning a solar system where customers need to pay a large upfront cost or pay a few hundred dollars a month on a loan payment until the system is paid off. The monthly amount of SolarShares power generated by the customer's system shows as a credit on the bill and offsets the amount that the customer pays for electricity produced through other methods (SMUD 2008). Michigan's Next Energy programme provides certified RE businesses an incentive to claim credit for their qualified payroll amount. Hawaii has passed a bill that will provide loans of up to $1.5 million and up to 85% of the cost of RE projects at farms and aquaculture facilities (DSIRE 2008).

Likewise, a number of state financial incentives are available in India. For example, biomass power

[1] DOE (Department of Energy). 2006. US Department of Energy, FY 2007 Congressional Budget Request

generation is eligible for a 10-year tax holiday, 100% depreciation in the first year for select power generation equipment, concession or full exemption of excise duty on RE devices as well as exemption of general state tax in a number of states. The Gujarat Energy Development Agency subsidizes water-pumping windmills to the extent of 60%. Solar street lights, decentralized power generation through biomass as well as revival of large size biomass plants are eligible for up to 90% of subsidy, while rural electrification through solar PV is eligible for up to 100% subsidy support.

Feed-in tariffs

While the federal FIT bill awaits legislation, a number of US states already have FIT policies in place. It is noteworthy that the US was the first country to enact a national feed-in law in the form of the PURPA (Public Utilities Regulatory Act) in 1978. Passed in response to the unstable energy climate of the 1970s, PURPA required utilities to buy power produced by qualifying facilities (usually cogeneration or RE) through long-term contracts based on the avoided cost of conventional fuels (REN21 2008).[2] Today, a number of US states are in the process of formulating feed-in-policies designed for the emerging electricity markets. California has the most diverse mix of RE amongst the US states, and the most renewable electricity (excluding hydropower) (DOE-EERE 2008b). On 14 February 2008, the California Public Utilities Commission announced the availability of new tariffs to support the development of up to 480 MW of renewable generation capacity from small facilities throughout California. These FITs present a simple mechanism for small renewable generators to sell power to a utility at predefined terms and conditions, without contract negotiations. This includes a 10-, 15-, or 20-year non-negotiable contract to participating small renewable generators, sized up to 1.5 MW at time-differentiated market-based prices (DSIRE 2008). Michigan is another state to introduce FIT legislation, based on Germany's model to increase RE use.

India, in turn, is credited to be the first developing country to establish FITs (REN21 2008). Driven by the EA 2003, several states in India have introduced FIT policies. After the GoI announced FIT up to a maximum of Rs 15/kwh (34 cents/KWh) in the case of grid-connected systems in March 2008, West Bengal declared a solar FIT at Rs 11/kwh (25 cents/kWh) with other states set to follow (Financial Express 2008). Punjab has an FIT of Rs 7/kWh (16 cents/kWh) for solar PV and Rs 5/kWh (11 cents/kWh) for solar thermal, for ten years. Rajasthan has a solar energy tariff as high as Rs 15.78/kwh (36 cents/kWh) for solar PV plants and Rs 13.78/kwh (31 cents/kWh) for concentrated solar power plants. A critique of the Indian FIT policies pertains to the cost-plus approach under a rate of return framework, which lacks incentive for cost minimization, and does not encourage optimal utilization of RE resources in the country (Singh 2007).

Lessons

Both the US and India are emerging global leaders in the field of RE. This growth has been possible due to the confluence of a number of national- and state-level policies. While most government projections continue to recognize the dominance of fossil fuels in the energy mix in the foreseeable future, a sound policy regime that promotes investment and cutting-edge breakthroughs in technology could push the frontiers of the RE industry way beyond the present level. India, being a developing country, faces the challenge of addressing climate change while also bringing masses out of the vicious circle of energy poverty. As Indian policy-makers try to reconcile these objectives, they will not only need sound domestic policies but also an international regime that recognizes and addresses these challenges effectively. It will also be critical that these policies be substantiated with commitment of significant funds. The US, in turn, needs to promote an even stronger RE industry, not only domestically but also help countries like India leapfrog to a cleaner development path by rapid advances in RE. In his new book *Hot, Flat and Crowded*, acclaimed New York Times columnist and Pulitzer Prize winning author, Thomas L Friedman, makes a case for a green revolution and discusses how it can renew America. Such a green revolution is not a zero-sum game. By sharing opportunities and best practices for RE development, the US and India can help each other while advancing the cause of clean energy globally. Similarities in the federal-state structures of both countries would render possible an even greater degree of applicability of lessons from best practices. While some of this is already happening through bilateral agencies like USAID (United States Agency for International Development), multilateral efforts like the Asia Pacific Partnership on Clean Development and Climate as well as the private sector, there is a need to scale up these efforts. To this effect, it is suggested that a

[2] Several states actively implemented PURPA (Public Utilities Regulatory Act) but most implementation was discontinued in the 1990s.

dedicated umbrella – for example, the US–India RE Fund – with meaningful commitment of resources, be established with the mission to help India leapfrog to a cleaner development path (Misra 2008). This fund should be used for an in-depth assessment of best practices to deal with:

- *Institutional issues* While the MNRE has played a vital role in fostering RE development in India, which deserves to be acknowledged, the country has a long way to go to meet its RE potential. One area which needs attention relates to coordination between various governmental departments and ministries dealing with RE. Useful lessons can be drawn from the evolution of the US RE sector, where the DOE serves as the executive agency to deal with the country's entire energy portfolio and related policies. To strengthen the Indian RE sector's modelling and data analysis capacity, an agency on the lines of the EIA should be set up. The Fund should also be used to set up a US–India RE incubator programme with time-bound and result-driven targets for expanding RE markets.
- *Legal issues* While the EA 2003 and related policies gave a significant push to the RE sector in India, the country is yet to align its RE policy under a federal law. In this regard, India can learn vital lessons from the US experience, where RE policies are backed by wide-ranging (and timely) legislations. While the report for the IEP in India was prepared in 2006, in the absence of supporting legislation, it will lack teeth. The coalition government driven politico-economic landscape of India, and the pressures of a competitive global RE industry call for certainty in the policy structure to be backed by law.
- *Regulatory issues* RPS and FITs, tools for the promotion of RE, are being adopted by more and more states in both the US and India. As adoption of these measures is increasing, so is the need to learn from the varied experiences across both countries for ensuring optimal design, implementation, monitoring, and harmonization of such instruments in the future. The RE pricing methodologies should be efficient and should provide a degree of certainty to investors and financing institutions. At the same time, pricing reforms pertaining to non-renewable sources of energy, which can alter the relative economics of RE, should be implemented.
- *Financial issues* Financial incentives to RE in the form of capital subsidies, low interest loans, rebates, and tax credits, are vital for making RE more competitive with fossil fuels, which presently do not internalize the cost of carbon. As we have seen, both the US and India have a wide range of such incentives available at the federal and state levels. There is a need to share best practices for designing 'new' incentives, while also learning from the ones already in practice. A comprehensive catalogue of these incentives should be prepared, and their performance and impact on investment must be reviewed.
- *Technology issues* Tapping the existing potential of RE would require significant advances across a wide portfolio of technologies. The suggested US–India RE Fund should have dedicated funds for R&D across different new and renewable technologies. As we have seen, the US has already enacted a law to set up an agency to support transformational energy technology research projects, on the lines of the Defence Advanced Research Projects Agency. India, too, is considering a National Solar Mission on the lines of the Atomic Energy Commission. To spur the next green revolution, lessons should be drawn from the success of past programmes (such as the Apollo space programme and the Manhattan Project), which provided breakthroughs in disruptive technologies.

References

BP (British Petroleum) Statistics. 2008
BP Statistical Review of World Energy 2008
London: BP Statistical Review of World Energy
Details available at <http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/downloads/pdf/statistical_review_of_world_energy_full_review_2008.pdf>

CRS (Congressional Research Service). 2008
Congressional Research Service, renewable energy R&D funding history: a comparison with funding for nuclear energy, fossil energy, and energy efficiency R&D
[Congressional Research Service Reports and Issue Briefs]

Deccan Herald. 2008
Explore renewable sources to fight energy crisis
Details available at <www.deccanherald.com/CONTENT/Aug112008/eb2008081083849.asp>, last accessed on 11 October 2008

DOE–EERE (Department of Energy–Energy Efficiency and Renewable Energy). 2008a
States with Renewable Portfolio Standards
Details available at <apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm>, last accessed on 12 October 2008

DOE–EERE (Department of Energy–Energy Efficiency and Renewable Energy). 2008b
Office of Energy Efficiency and Renewable Energy Databook 2008

DSIRE (Database of State Incentives for Renewables and Efficiency). 2008
Database of State Incentives for Renewables and Efficiency 2008
Details available at <http://www.dsireusa.org/>

DST (Department of Science and Technology). 2008
Science and Technology Policy 2003
New Delhi: DST
Details available at <http://dst.gov.in/stsysindia/stp2003.htm>, last accessed on 12 October 2008

EIA (Energy Information Administration). 2008
Renewable Energy Consumption and Electricity Preliminary 2007 Statistics
Washington, DC: EIA

Financial Express. 2008
Feed in tariff and solar energy
Details available at <http://www.financialexpress.com/news/Feedintariff-and-solar-energy/317634>, last accessed on 11 October 2008

Gaba V and Gupta S. 2008
Electricity tariffs for energy secure India
Energy Security Insights April 2008

TERI (The Energy and Resources Institute). 2007
TEDDY (TERI Energy Data Directory and Yearbook) 2007
New Delhi: TERI

Live Mint. 2008
Government urged to energize solar power industry
Details available at <http://www.livemint.com/2008/09/29224315/Govt-urged-to-energize-solar-p.html?h=B>, last accessed on 11 October 2008

Misra N. 2008
US–India renewable energy collaboration: the road ahead
Energy Security Insights July 2008

MNRE (Ministry of New and Renewable Energy). 2008
Ministry of New and Renewable Energy Annual Report 2007/08
New Delhi: MNRE

NRDC (Natural Resources Defence Council). 2008
Natural Resources Defence Council
Details available at <http://www.nrdc.org/air/energy/renewables/biomass.asp>, last accessed on 11 October 2008

REN 21. 2008
Renewables 2007 global status report
Washington, DC: REN21 Secretariat and Worldwatch Institute

Rickerson W, Bennhold F, and Bradbury J. 2008
Feed-in tariffs and renewable energy in the USA – a policy update

SMUD (Sacramento Municipal Utility District). 2008
Sacramento Municipal Utility District (SMUD)
Details available at <http://www.smud.org/community-environment/solar/solarshares.html>, last accessed on 11 October 2008

Singh A. 2007
A market for renewable energy credits in the Indian power sector
[Renewable and Sustainable Energy Reviews (2007)]

Wiser R and Barbose G.2008
Renewable Energy Portfolio Standards in the United States: a status report with data through 2007
Lawrence Berkeley National Laboratory

Bibliography

SEIA. 2007
US Solar Energy Industries Association (SEIA): a year in review 2007
[US Solar Industry]

Nuclear fusion power in Asia: an energy option of the future

*William A Gracias**

Introduction

The world demand for primary energy is expected to reach 159 MTOE (million tonnes of oil equivalent) by 2030 (IEEJ 2006), of which one half will be as a result of growth in Asia. Concomitantly, as more and more processes/products are electrified, the demand for electricity will increase drastically. Asia's installed power generation capacity stood at about 1090 GW in 2005 (EIA 2005). With an average growth rate of about 6.5% per annum in installed capacity in the last 26 years, the total installed capacity in Asia is set to touch about 5302 GW by 2030, with China and India being major players. Despite large installed capacity, Asia is facing a shortage of electricity. India alone has faced an average power deficit of 9.9%, with a peak of 16.6% in 2007/08 (CEA 2008). To contain power crises, nations have looked at various strategies, from securing external energy supplies to developing new resources for power generation. In this regard, nuclear fusion energy presents a potential area for countries to invest in for developing the power sector.

Since the commercial feasibility of this futuristic option has not yet been demonstrated, countries are reluctant to consider nuclear fusion as a significant option in defining energy strategies for the future. This paper delves into the current state of research and development in nuclear fusion in Asia, and the possibilities it holds for meeting energy demands in the future, particularly in energy-deficient India and China. It argues that in addressing long-term energy security concerns, nuclear fusion provides an alternative.

Nuclear fusion as an energy option

Exploration of new energy options and strategies to enhance conventional supply is of immense relevance to Asia, home to two of the biggest energy consumers, China and India. With high economic growth rates, these energy-deficient nations are continually seeking to reduce their heavy reliance on fossil fuel imports. Currently, coal and petroleum dominate the energy mix of India (about 60%) and China (about 80%), with nearly 20% of capacity comprising of hydro resources for China (Huang and Zheng [in press]) and 26% for India.[1] Given the decreasing fossil fuel reserves, and the rising concern for global climate, an energy mix dominated by fossil fuels is neither sustainable nor economically sound. High fossil fuel prices will increasingly influence policies and consumption patterns, while affecting economic and human development indices.

Among the available energy options today – fossil fuels, nuclear energy (fission), and renewable energy sources – none can alone take on base loads while at the same time effectively address the concerns of pollution and public safety. Nuclear fission power does hold a good chance of being an effective replacement to coal-based plants. But with the development of nuclear fission power, concerns regarding safety of nuclear reactors will have to be appropriately addressed. Further, the concern over nuclear energy programmes being used to support alleged nuclear weapons programmes in some countries has fuelled international debate over the development of nuclear fission technology. Among renewable energy sources, only large hydro plants can provide considerable power capacity, but their social and environmental impacts continue to draw immense criticism.

In this context, nuclear fusion energy opens up new opportunities. Some countries have joined hands to develop a common experimental fusion reactor (Figure 1) at Cadarache, France, to demonstrate that exploitation of fusion power is possible and viable.[2] Interestingly, four of the seven collaborating countries belong to Asia—Japan, Korea, China, and India. These Asian nations have also embarked on their own independent research programmes to develop nuclear fusion energy plants. The reason why countries across the world are supporting this international research effort is the immense potential of fusion power to address the challenge of meeting increasing energy demand: a single gram of fusion fuel (mostly deuterium and tritium in equal proportions) can produce 90 000 kWh of electrical

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[1] Ministry of Power and Ministry of New and Renewable Energy, Government of India
Details available at <http://mnes.nic.in> and <http://powermin.nic.in>

[2] The facility at Cadarache is being built by the ITER (International Thermonuclear Experimental Reactor), which also means 'the way' in Latin). The ITER is a consortium of seven nations—France, Italy, India, the US, Japan, the UK, and China. The reactor is expected to be ready for operation by 2018. Each of the consortium members is part of the developmental team and is committing a share of funding, technology, and man-power towards this project.

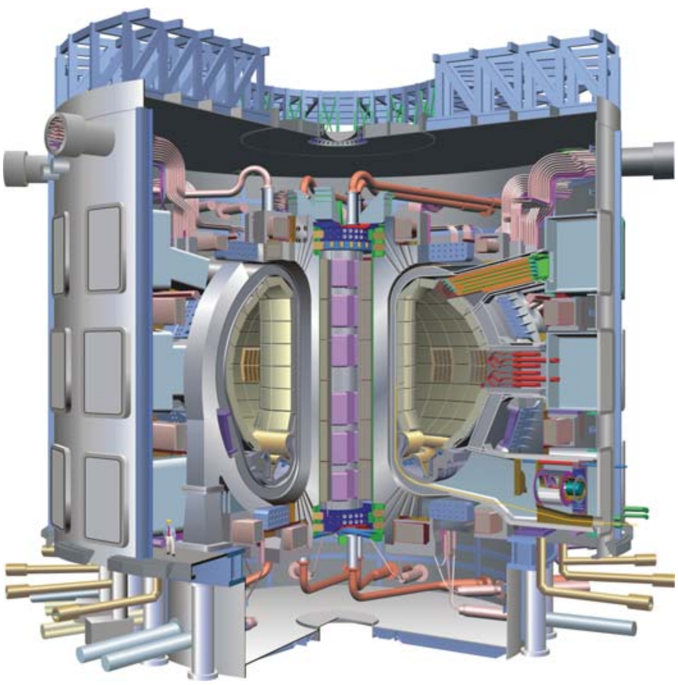

Figure 1 Cut-away section of the ITER (International Thermonuclear Experimental Reactor)
Source ITER organization <www.iter.org>

energy, which is equivalent to 90 000 kgs of Indian coal, which in turn produces 131 tonnes of CO_2[3] alone (apart from other green house gas emissions). Also, compared to nuclear fission, fusion power is safer and produces very little radioactive waste with significantly shorter half-lives, and thus considerably shorter disposal periods.[4] With radioactive waste management and disposal being a major impediment in the promotion of nuclear fission, fusion power could serve as a better alternative in the foreseeable future.

Research and development in Asia

Fusion energy – the energy produced in the sun and in other stars – is the energy produced when two light nuclei collide to form a heavy nucleus. The most common fuels for the production of this form of energy are hydrogen isotopes— deuterium and tritium. The potential of these resources is so vast that even if one-tenth of the ocean's waters were to be used to extract deuterium[5], it would last for more than a thousand years. Another material required for a fusion plant is lithium, which is found in plenty in rocks.

Currently, two main methods to achieve fusion conditions are being researched—MCF (magnetic confinement fusion) and ICF (inertial confinement fusion). In MCF, fusion plasmas are created by heating hydrogen gas ions using neutral particle beams and electric current or radio-frequency waves. The plasma of ionized gas is then confined in the reactor vessel by powerful magnetic field lines where fusion of reacting fuel particles occurs. In inertial confinement, however, the heating is carried out by a powerful and expensive laser system, and the plasma is confined by mass inertia of imploded fuel. Of the two methods, MCF has received more international attention, particularly for power generation.

In the last three to four decades, groups of researchers across the world, including Asia, have been making commendable efforts in the area of fusion energy research. Beginning with the Russian experimental machine called the 'Tokamak' (fusion reactors working on the principle of magnetic confinement) way back in the 1960s, research into nuclear fusion energy has gone a long way nearing fusion triple product[6] conditions (Figure 2). Initial attempts were focused on proving that

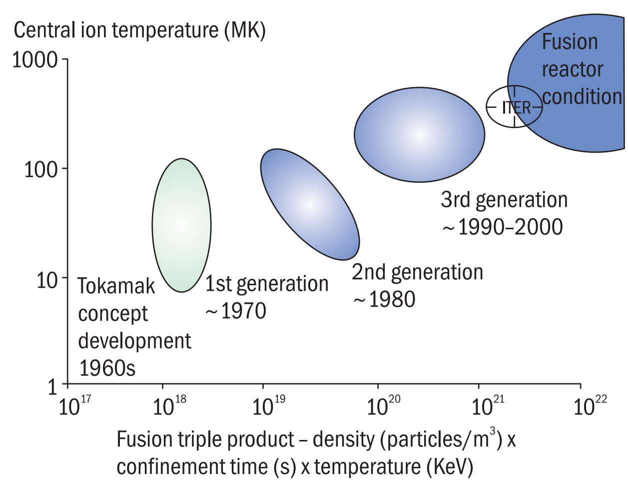

Figure 2 Progress in controlled magnetic fusion with fusion reactor conditions being touched by the new International Thermonuclear Experimental Reactor device.
Source Mank and Burkart (2006)

[3] Bureau of Energy Efficiency's training site. Details available at <http://www.energymanagertraining.com/kaupp/Article17.pdf>

[4] Most high-level radioactive wastes from fission power plants require interim storage for many decades before they can be safely disposed, owing to their high radioactivity. In fusion power plants, the level of radioactivity in wastes is lower requiring shorter storage periods.

[5] Tritium is produced inside the fusion reactor itself, as it is not freely available in nature.

[6] Triple product is a product of density, temperature and confinement time of the fusion ions in a particular fusion confinement scheme (inertial, mirror, and magnetic/torroidal). This product is a good measure of the efficiency of the confinement scheme.

it was feasible to affect a controlled fusion reaction on earth. Once that was established, further research went into how to sustain it for long periods (more than a few seconds). Currently, research is on to allow fusion reactions to sustain themselves (by a process called ignition) in the reactor for at least 300 seconds[7] and thereby generate more power from fusion than is consumed by the reactor in reaching fusion conditions (nearly five times or more). This is called gain factor, or breakeven. Once this has been achieved, commercialization of nuclear fusion technology will be easier.

Further, existing technologies easily serve to fulfil the engineering needs of nuclear fusion power plants, thus reducing the overall cost of the nuclear fusion path by not necessitating additional research into many new supporting technologies. The planned fusion power plants shall use energy conversion methods and technologies, which are quite similar to the existing set-up in conventional power plants used to produce steam.[8] Many equipment manufacturers and a gamut of ancillary industries can, therefore, cater to the fusion power sector without many drastic design changes in their products and processes (and with lesser cost). Clearly, the initial investment in a nuclear fusion reactor is very high. But over long periods of operation and due to the large quantum of power that can be generated, this method of power generation can become economical.

In Asia, countries that have dedicated research programmes for fusion power development are Japan, South Korea, China, and India. Japan's research initiatives are the oldest among Asian nations and the world. Since the initiation of fusion research at the JAEA (Japan Atomic Energy Agency) in 1961, the scale of the Japanese reactors has progressively increased from JFT-2, JFT-2a, and JFT-2M to JT-60, incorporating the latest achievements in experiments and discoveries in theory. In 1998, the JT-60 device achieved the world's highest energy gain factor of 1.25. More recently, the JAEA reported that plasma with high confinement and high pressure, also required for the ITER device, was successfully sustained for 28 seconds (a world record), with an improvement in the magnetic field structure using ferritic steel.[9] Japan has also successfully demonstrated remote operation of the fusion device through enhanced security networks, a key concept required for the ITER operation.

In Korea, the National Fusion Research Institute has developed the world's second superconducting Tokamak under the KSTAR (Korea Superconducting Tokamak Advanced Research) project. This is the only such reactor in the world after China's EAST (Experimental Advanced Superconducting Tokamak) reactor. KSTAR is mainly interested in advanced scenarios: planned as a medium-sized device of the Tokamak type, KSTAR will contribute new modes of operation, thus paving the way for a Tokamak with continuous operation. The Korean device is equipped with superconducting niobium-tin magnet coils, which are the same as that planned for the ITER device.[10] Hence, like the Japanese programme, the Korean programme will also be able to give critical inputs to the ITER partnership.

China too has been actively engaged in nuclear fusion R&D. In 1995, the IoP (Institute of Plasma), CAS (Chinese Academy of Sciences), successfully developed China's first superconductivity Tokamak device, which made China the fourth country in the world capable of producing such a device. A series of major scientific experiments were carried out on this device. In 1998, a major breakthrough was achieved by realizing a 5.7-second long pulse discharging.[11] More recently, a research centre has been officially launched to study magnetic confinement of plasma and related theories, on the 'Science Island', one of China's key thermonuclear fusion research and experiment bases. Based on the world's first superconducting Tokamak, EAST, which was successfully developed in 2006 by the CAS IoP, the newly-established centre aims at promoting research and development in nuclear fusion science and technology, improving the advanced steady-state operation mode of the Tokamak, upgrading experimental facilities in this regard, and starting a physical and engineering build-up for the eventual development of a commercialized nuclear fusion reactor.[12] Besides these developments, a

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7 ITER (International Thermonuclear Experimental Reactor). Details available at <http://www.iter.org/a/index_nav_1.htm>

8 The fusion reactor will effectively only replace the furnace of, say, a coal power plant in a thermal power generation set-up. The boiler and turbine system will be the same in a nuclear fusion power plant, except with some modifications and capital expenditure in providing radiation shielding to the working fluid (usually steam) in the heat exchanger.

9 Japan Atomic Energy Agency. Details available at <http://www.jaea.go.jp/english>

10 National Fusion Research Institute, Korea. Details available at <http://www.nfrc.re.kr/english/research/kstar.html>

11 Ministry of Science and Technology, People's Republic of China. Details available at <http://www.most.cn/eng/programmes1/index.htm>

12 Chinese Academy of Sciences. Details available at <http://english.cas.cn/eng2003/news/detailnewsb.asp?infono=27363>

training centre for nuclear fusion research has been established at the Zhejiang University in Hangzhou, the capital city of East China's Zhejiang Province, to boost development of expertise in the nuclear fusion field. The University's State Fusion Theory and Simulation Centre will be China's first research institute specializing in nuclear fusion training.

In India, fusion research is primarily carried out by the IPR (Institute for Plasma Research), an aided institute of the Department of Atomic Energy, Government of India. Besides this, the Saha Institute for Nuclear Physics (also an aided institute) carries out fundamental research related to nuclear fusion science. The Indian programme is focused on developing indigenous capability in fusion science. The facilities are equipped with fully operational Tokamaks that are used to carry out experiments. India is currently constructing a SST (steady-state[13] Tokamak) at the IPR, which will be one-of-its-kind in the world, with a wide range of diagnostic equipment and heat supply modes. Apart from its indigenous programme objectives, most work being carried out is focused on supplementing ITER activities. The IPR plans to start work on the second stage device (SST 2) by 2015–20 in order to focus on ITER-like experiments. The IPR also runs a FCIPT (Facilitation Centre for Industrial Plasma Technologies) at Gandhinagar, which helps in sharing technologies with industries, from its current work in plasma. The FCIPT links industry with the IPR knowledge base in plasma sciences and associated technologies. This is exploited to generate advanced and non-conventional plasma-based technologies for material processing and environmental remediation.

Among the superconducting devices existing or under construction in Asia, EAST (China) shares with SST (India) and KSTAR (South Korea) the divertor configuration, the superconducting polloidal and torroidal field coil systems. In contrast to KSTAR, EAST places, from the beginning, emphasis on steady state operation with actively cooled plasma-facing components. Compared with SST, with which it shares the operation objective, EAST is larger and also has a fully superconducting central solenoid. In the long run, all three devices will be able to make valuable contributions to steady state advanced Tokamak operation, like those typically planned for the ITER operation.

Work on the world's first commercial fusion power plant is expected to start by 2030. This would depend on the success of the preceding stages of the fusion power development programme (that is, the ITER device), followed by the DEMO[14] device (Figure 3) by around 2040. Hence, commercial fusion power can be expected in the next four to five decades. Current research efforts need to continue without slack in order to keep to the projected timeline. The only way to expedite development is to have more countries join in the international effort and devote more resources towards nuclear fusion research. With Asian countries making good progress in fusion research with ITER-like devices, which can serve as test beds for alternative scenarios to be tried on the ITER device, the success of ITER is likely to have a significant Asian contribution.

Conclusion

As Asian nations compete for common energy resources and technologies, these nations are continuously changing the contours of their energy portfolios. For example, if the recently signed Indo–US nuclear deal had not received the mandatory clearance from the NSG (Nuclear Suppliers Group), it would have significantly constrained the growth of nuclear energy's share in India's energy mix. Thus, in altering the boundaries of their energy realms, countries also lend new dimensions to inter-state relations. The development of a 'neutral'[15] energy resource is quintessential to security and energy sufficiency. A neutral resource, like deuterium for nuclear fusion, because of its wide availability and low cost, minimizes competition for resources among nations.

Nuclear power generation is expected to expand rapidly in Asia. Of the 114 GW increase in installed capacity for nuclear power generation expected across the world up to 2030, 110 GW of capacity will be added by nuclear plants in Asia alone. The growth will be highest in China and India, with projections of nearly 50 GW and 32 GW of installed capacity respectively, by 2030. With the coming of age of nuclear fusion energy, the energy mixes of large Asian countries, such as China and India, could be substantially altered.

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[13] Steady state is a mode of operation of the Tokamak, wherein the external current supplied to the plasma is done in a continuous fashion rather than in pulses, as in the pulsed mode. This helps in better performance of the machine.

[14] DEMO: demonstrative fusion power plant, a commercial plant that has been conceived to be much bigger than ITER (International Thermonuclear Experimental Reactor).

[15] Neutral resource, for the purposes of this paper, refers to a source that every country has ready access to.

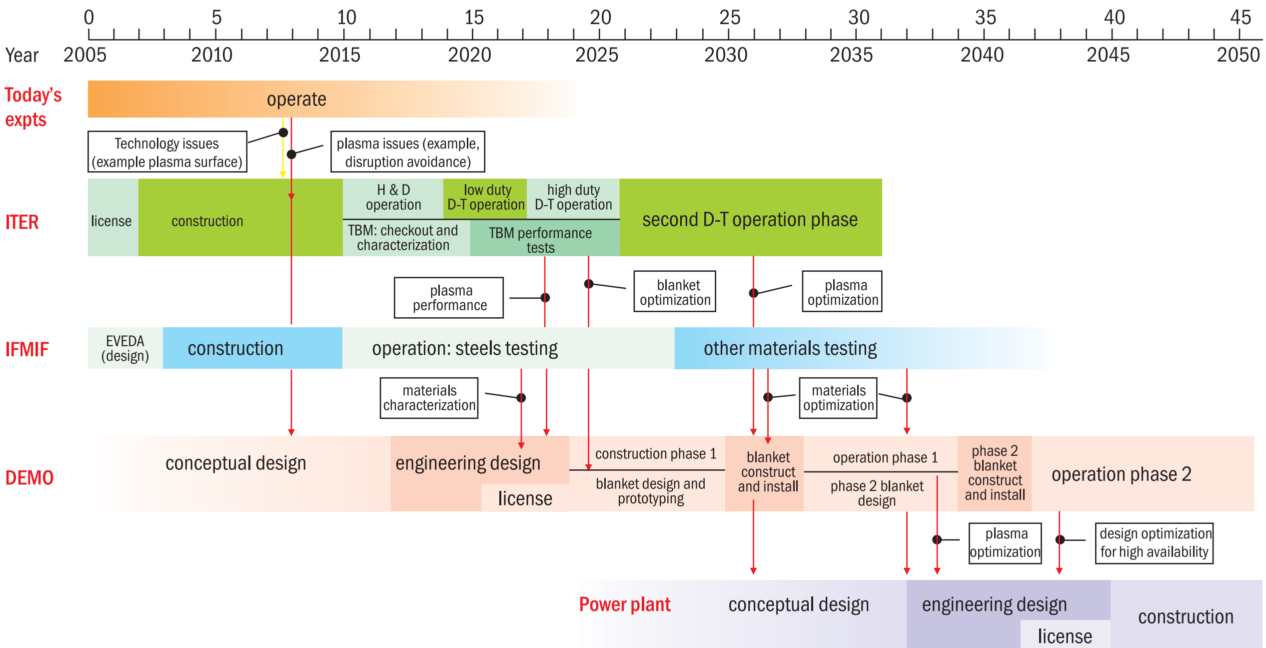

Figure 3 Fusion power development timeline
Source ITER <www.iter.org>

Countries like the US, the UK, and Japan have a large network of laboratories and institutes that are engaged in nuclear fusion research. What is needed is more secured funding towards R&D for new ancillary technologies related to fusion energy research, like diagnostics and high performance materials. More nations should join the ITER consortium and pledge funds for fusion research.

With initial successes in fusion and the encouraging results from various experiments the world over, one can be assured of sizeable benefits from nuclear fusion energy in the second half of this century. The success of ITER is bound to have significant impact on the treatment of fusion science and R&D in energy planning and formulation.

References

CEA (Central Electricity Authority). 2008
Power Scenario at a Glance
New Delhi: CEA, Ministry of Power, Government of India
Details available at <http://www.cea.nic.in/planning/POWER%20SCENARIO%20AT%20A%20GLANCE/PSG%20OCT08.pdf>, last accessed on 20 October 2008

EIA (Energy Information Administration). 2005
International Energy Annual 2005
Washington, DC: EIA
Details available at <http://www.eia.doe.gov/pub/international/iealf/table64.xls>

Mank G and Burkart W. 2006
Controlled nuclear fusion: ITER, the first step towards a new energy source
In *Nuclear Energy 2006* Touch Briefings June 2006
Details available at <www.touchbriefings.com/pdf/2178/Mank.pdf>, last accessed on 18 October 2008

Huang H and Zheng Y. (in press)
Present situation and future prospect of hydropower in China
Renewable and Sustainable Energy Reviews

IEEJ (The Institute of Energy Economics, Japan). 2006
Asia/World Energy Outlook 2006
Details available at <http://eneken.ieej.or.jp/en/data/pdf/362.pdf>, last accessed on 16 October 2008

Time for global action on climate change: will India lead the way?

*Shreekant Gupta**

Growing scientific consensus on the clear and present danger of global warming is matched by the stasis that continues to grip global collective action on the most serious environmental challenge facing humanity. While the devastation wrought by the recent cyclone in Myanmar and the earthquake in China may or may not be connected to climate change (popularly known as global warming), it drives home the fact that no country is safe from nature's wrath (recall hurricane Katrina). Such tragedies are a grim and continuing reminder of its destructive potential. Mounting scientific evidence from studies, led by the Nobel prize-winning IPCC (Intergovernmental Panel on Climate Change) clearly points to a warming world with frequent extreme weather events (droughts, floods, and cyclones), rising sea levels, retreating glaciers, and more variable monsoon. At the same time, there is gridlock on climate change negotiations, with the North and South locked into intractable positions and mutual finger-pointing. An emerging power, such as India, can ignore this impasse only at its own peril. Millions in India and in neighbouring countries are at risk from climate-induced impacts. To mention just one example, 46% of the population of Bangladesh lives within 10 metres of the average sea level. A 1.5 metre rise in sea level would displace 34 million people in that country. Even a fraction of these people seeking safe haven as 'environmental refugees' would burden India far more than the political refugees did in 1971.

There is potential reward in decisive action by India. Taking the lead in breaking the global gridlock on collective action on climate change would demonstrate the country's ability to lead the community of nations. It would also offer a win-win opportunity for the Indian economy. But in order to do so, there is an urgent need to move beyond parroting the 'economic-development-cannot-be-sacrificed-to-solve-a-problem-created-by-the-rich-North' mantra. That mantra granted, what does one do next? At this question, India's political and industrial elites, and the environmental *chatterati*, lapse into delightfully vague proposals ranging from 'changing-the-way-we-live' to making the shift to a new world of technological silver bullets, such as a hydrogen-powered future. We have been there before and heard it all at countless international fora, to which our elites jet tirelessly toting up their own carbon footprint. Do we then wait for the biggest polluter of all, the US, to have a change of heart?

The time is ripe for India to seize the initiative and put some hard-headed yet sensible and practical suggestions on the table.

First, some numbers: the concentration of CO_2 (carbon dioxide) and other gases such as methane, which cause global warming and are collectively known as GHGs (greenhouse gases), can go up to at most 550 PPM (parts per million) for climate change to be manageable (the so-called stabilization target). One way to visualize this is to think of the concentration of GHGs in the atmosphere as a gigantic drum full of water. The water pouring into this drum is what the world spews into the atmosphere as the water level rises to the danger mark. While we cannot do anything about what is already in the drum we can collectively slow down the flow into the drum. This is a modest step for the sake of Mother Nature and for our own survival, but a massive step for the world as a whole. Further, this slowing of the flow cannot be sudden since the world economy has its own momentum.

In effect, we need to reduce GHGs emitted per person by more than half from today's level. Thus, 9 billion people alive on the planet in 2050 should on average emit about 3 tonnes of CO_2 per person as compared to about 7 tonnes per person that is emitted by 6 billion people today. Of course, this average is unevenly distributed with a typical US citizen emitting 20 tonnes of CO_2, a European 10 tonnes, a Chinese 3.5 tonnes and an Indian a mere 1 tonne per year. Here lies the win-win opportunity of a global cap-and-trade trading system of GHGs, whereby each person on the planet would have a quota/entitlement to emit GHGs that could be bought and sold. Such a system has worked remarkably well for SO_2 (sulphur dioxide) within the US and GHGs within the European Union. With a per capita allocation of about 3 tonnes of CO_2 per person, India (unlike China whose emissions already exceed this level) would be a seller in the GHG market and industrialized countries of the North would be buyers. Under this arrangement, India could increase its GHG emissions to accommodate economic growth and yet have spare 'hot air' to sell (and more, if it undertook GHG reduction activities).

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Given that countries such as the US are at very high per capita levels of CO_2 at present, they would not be able to simply 'buy their way out' of meeting their obligations. But GHG reductions would be distributed more evenly and at lower cost to the world as a whole, and would also yield income transfers to sellers.

If safeguards were built into a system of global GHG trading to prevent prices from shooting too high or falling too low, interests of buyers and sellers would be protected (think of this as price stabilization akin to foodgrain markets). An aggressive promotion of this price-stabilized GHG-trading scheme by India would address the US concerns that GHG abatement would hurt the US economy and that countries such as India and China should also commit to binding GHG emission targets. The US now has a new president who is committed to acting on climate change, most likely through a cap-and-trade scheme. What better than for India to set the agenda through pre-emptive action?

Energy efficiency and renewable energy uptake: creating networks and partnerships

*Sonya Fernandes**

Energy information is dynamic, and no single organization can fill the gaps in the picture without partnering and/or networking with like-minded bodies. Partnerships are important as they connect multiple actors—businesses, governments, international institutions, and NGOs (non-governmental organizations). They catalyse exchange of ideas, avoiding wasteful duplication of unsuccessful projects in efficient energy utilization and use of renewable sources, while facilitating knowledge sharing and dissemination of success stories.

For South Asian initiatives, engaging with organizations in Europe is extremely important as most of Europe has set high targets for renewable energy uptake and is looking to invest in the Asian market to get CDM (Clean Development Mechanism) benefits. Launched in October 2003, REEEP (Renewable Energy and Energy Efficiency Partnership) came into existence as a response to this need. It is a global partnership for accelerating and expanding the market for renewable energy and energy efficiency technologies.

REEEP has eight regional secretariats, and its partners include governments, businesses, NGOs, financiers, and representatives of civil society. In the five years since its inception, the organization has successfully created networks and partnerships to bridge the existing information gaps on renewable energy and energy efficiency. Though REEEP partners are diverse and multi-functional, their profile is in line with REEEP's key objective of influencing policy and regulation. REEEP partners also work towards the creation of innovative finance mechanisms to make small-sized renewable energy and energy efficiency projects bankable and economically attractive.

REEEP has formed strong networks and sub-networks, and has about 260 partners representing 40 governments, businesses, and NGOs. REIL (Renewable Energy and International Law) has been set up in association with the Yale Centre for Environmental Law and Policy, the Centre for Business and the Environment at Yale, the Yale Project on Climate Change, Baker and McKenzie's Global Clean Energy and Climate Change Practice, and Climate Change Capital. It is an international policy and law network, which brings together business and finance communities, policy-makers, scholars, lawyers, and science and technology experts, to create enabling legislative and policy frameworks for clean energy on the international, national, and sub-national levels.

SERN (Sustainable Energy Regulation Network), established in 2004, is a REEEP core-funded sub-network, led by the Centre for Management under Regulation, University of Warwick, UK. The core function of SERN is to assemble information on regulatory initiatives in various regions to integrate renewable energy and energy efficiency into energy systems. It focuses on the transfer of good practices. SERN transfers research outcomes on regulation from

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the academic world to regulators and works with regulators' associations in Africa, the Caribbean, East European countries, and India (with TERI [The Energy and Resources Institute]). It is also now starting work with South-East Asian countries. SERN has 350 individual members drawn from every continent, and acts – at the request of governments – as advisor to integrate renewables and energy efficiency in energy policies and regulatory frameworks.

Through another of its sub-network, EEC (Energy Efficiency Coalition), REEEP reaches out to policy-makers on adopting efficient technologies to cut energy use and emissions. Bringing together government, civil society, and business voices, it aims to bridge the gap between political will and action on the ground. Since the energy efficiency market is fragmented to some extent, the scope of the coalition will be expanded step-by-step to cover various sectors, including the following.

- Energy efficiency in buildings
- Industrial energy efficiency
- All energy efficiency sectors, including generation and transportation

The existing information gap on renewable energy and energy efficiency led REN21 (Renewable Energy Policy Network for the 21st Century) and REEEP to join hands and work together towards the establishment of a user-friendly and comprehensive information portal on clean energy policy, regulation, and financing. The REN21 is a global policy network where ideas are shared and action is encouraged to advance renewable energy. It provides a forum for leadership and exchange in international policy processes, and promotes appropriate policies that increase the use of renewable energy in developing and industrialized economies. Open to a wide variety of dedicated stakeholders, it connects governments, international institutions, NGOs, industry associations, and other partnerships, initiatives, and individuals. The REEEP and the REN21 have also created an information gateway at <www.reegle.info>. Reegle is designed to be both a repository of quality information, and an entry point to relevant data sources and key providers of information. Reegle's content is derived from data and information in existing databases, covering the following dimensions with regard to renewable energy and energy efficiency.

- Jurisdiction and laws
- Policies and measures
- Finance and investment
- Reports and analyses
- Latest news
- Stakeholders

Through networks and partnerships, much of REEEP's efforts are being successfully amplified globally, making possible its overarching goal of rapid renewable energy and energy efficiency uptake.

REEEP announces

Call for proposals

For EUR 4.3 million in grant funding

The REEEP (Renewable Energy and Energy Efficiency Partnership) announces a call for project proposals that support the development of markets for renewable energy and energy efficiency. The REEEP call is an open tender seeking projects from priority countries—Brazil, China, India and South Africa, and from across the developing world.

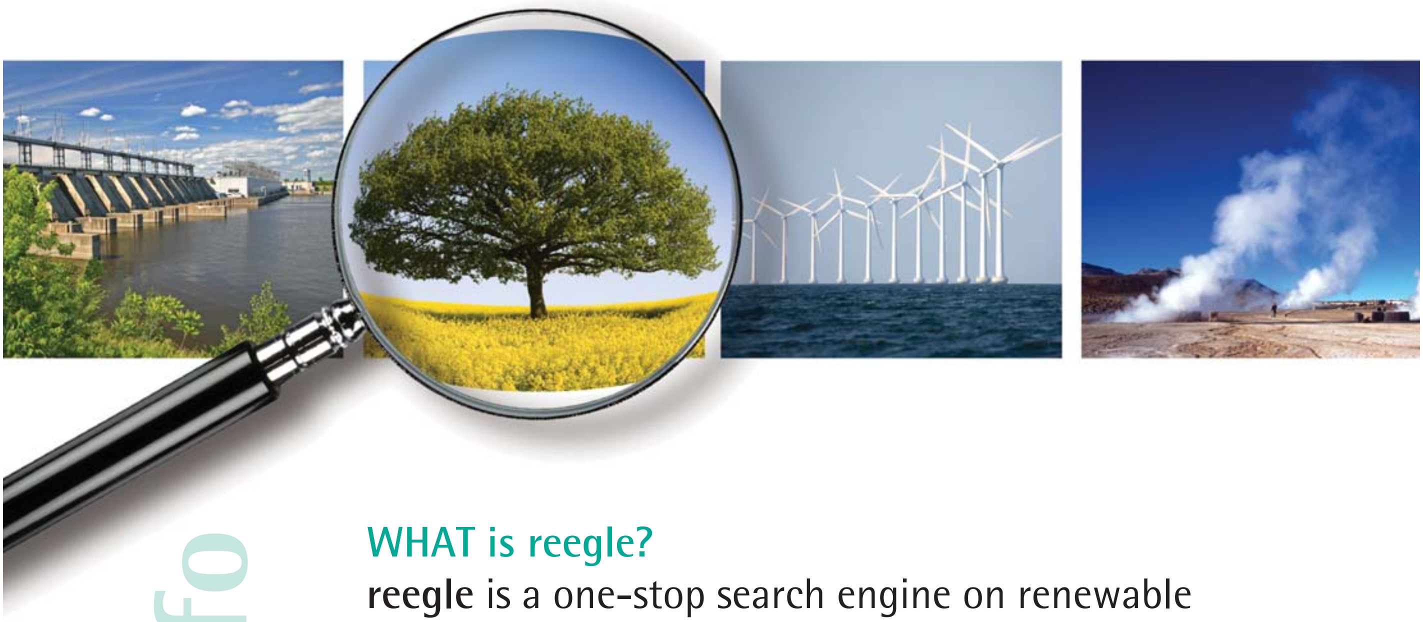
The project call is REEEP's largest in its five-year history with more than EUR 4.3 million available for projects in least-developed countries and emerging market economies. The programme cycle has received funding from a consortium comprising Australia, Ireland, Italy, Norway, and the UK. REEEP is now intensifying its efforts to directly engage governments and financial institutions in its programme. It invites countries with specific policy, legislative or regulatory needs, or development finance institutions with the need for financing structures and business models, to develop projects directly with REEEP.

Full proposals for replication and scale-up of successful past projects, and projects from governments and development financial institutions should be submitted by 20 February 2009. For more information on how to apply, please visit <http://www.reeep.org/7th-programme-call>. To increase operational efficiency, transparency, and openness, all proposals will be submitted for evaluation via the REEEP's new online PMIS (Programme Management Information System).

reeep renewable energy & energy efficiency partnership

reegle

information gateway for renewable energy and energy efficiency



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