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NEW RENEWABLE ENERGY IN INDIA: HARNESSING THE POTENTIAL

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INTRODUCTION

As the world undertakes its path towards development, growth and employment generation, it becomes imperative to appreciate the looming ramifications of environmental degradation and ecological imbalances – best reflected in carbon emissions – caused by climate change. Growth in emission has been directly linked to overall economic growth and this linkage is unlikely to be broken in the years to come. At the same time, it is increasingly being realized that climate change is unequivocal and therefore an international collective action is critical in driving an effective, efficient and equitable response to this challenge.

For a large country like India, with its over one billion population and rapid economic growth rate, no single energy resource or technology can act as a panacea to address all issues related to availability of fuel supplies, environmental impact, particularly, climate change, and health externalities. Therefore, it is necessary that all non-carbon emitting resources become an integral part of an energy mix, as diversified as possible to ensure energy security to a country like India.

Given India's vibrant entrepreneurial culture, history of technology innovation and the vast domestic market, the country is ideally positioned to capitalize on the advantages that renewable energy has to offer. Although renewable energy technologies currently represent a fraction of the energy market in India, they have tremendous potential to undergo rapid growth and provide alternative solution to fossil fuels. With varied agro climatic zones providing sufficient raw sources like sunlight, wind, flowing water and flora, India offers ample opportunities to shift to large scale use of new renewable energy sources.

The increase in production of renewable energy, inter alia, entails an active involvement of business and financial institutions backed by adequate support and an enabling policy environment from the Government. Given the strong support provided by the Government, India has the potential to position itself as a world leader in the drive to leverage the expertise and resources of businesses and private investors. With such strong support from the Government, backed by concrete measures, renewable energy is likely to become the cornerstone of energy sector, with focus on clean energy, which would have enormous potential. Firms that manage climate-change risks and tap such new and emerging opportunities are likely to gain competitive advantage in the days to come.

Given this background, this study seeks to highlight the potential of renewable energy in India by analyzing the relatively newer sources of such energy, viz. solar (photovoltaic), wind and biomass.

RENEWABLE ENERGY: A STRATEGIC IMPERATIVE

The world today fulfils its energy requirements from a wide array of energy sources. However, fossil fuels (viz. oil, coal and natural gas) account for around four-fifths of total energy use, a share that has largely remained unchanged for over a decade. These fossil fuels continue to remain dominant sources of energy, primarily because they are relatively inexpensive and currently abundant, are energy rich, and the global infrastructure today is well positioned to produce, deliver and use them. Nonetheless, given the emerging scenario, it is of utmost importance to explore and understand the various other viable alternatives to conventional energy. This is all the more critical in light of the evolving energy transitions, which are creating shifts in energy demand faster than ever expected, and as a result, challenging the existing infrastructure and suppliers, and causing energy price volatility. This is further exacerbated by concerns over the possible longer-term supply constraints to conventional oil and gas and coal supplies, apart from the geographical distribution of these resources. Looming over everything is the increased urgency attached to assuage the major driver of climate change – the greenhouse gas (GHG) emissions. Energy-related GHG emissions account for about 70% of total emissions and are projected to increase by about 50% by 2030, unless supportive and effective policy measures are introduced. Energy related carbon dioxide alone accounts for 61% – 65% of global greenhouse gas emissions.

Key Drivers of Renewable Energy in India

There has been an increasing realisation on enhancing the use of renewable energy as a primary instrument for achieving the twin objectives of energy sufficiency and climate change mitigation. In a country like India, increasing investment in the deployment of clean technologies would not only help in reducing carbon footprints but also help in the provision of much needed energy and promote economic development. If commitments made by the key stakeholders to overcome policy, technical and financial barriers are accelerated, India could become a potential world leader in the development of renewable energy technologies, thereby playing a decisive role in combating climate change. With India becoming globally more responsible in its endeavour towards sustainable development, the possibility of renewable energy becoming a cornerstone for meeting the country's future energy requirements are significantly high. The key drivers that are likely to further India's cause to promote renewable energy in the country are Energy Security, Climate Change, and Opportunities in the Carbon Market.

Energy Security

Energy is the engine for growth and its access is of strategic importance to every country. Energy multiplies human labour and increases productivity in agriculture, industry and services. Thus, easier, cost-effective and sustainable access to energy in the developing world holds the key to bridging the widening inequality prevalent in such economies. While the conventional sources of energy (oil, coal and natural gas) are currently easier in terms of access, primarily due to associated infrastructure designed for their conversion to usable forms, the same cannot be said of either their sustainability over medium and long-term or their cost-effectiveness. Countries without their own fossil fuel supplies have begun to evince increasing interest in renewable energy sources, not only because of the price stability they bring, but also because they are indigenous and locally produced. Thus, the adoption and promotion of renewable energy technology becomes critical for ensuring energy security. This is buttressed by the fact that the economics of renewables are expected to improve further as they develop technically, and as their saving of greenhouse gas emissions are assigned a monetary value.

From India's point of view, energy security today has become a matter of prime concern, especially in light of the fact that the country imports more than three-fourths of its crude oil requirements. Given that renewable energy options are cost-effective compared to traditional measures in the longer term and on a lifecycle cost basis, coupled with their proven sustainability over longer periods, the adoption of renewable sources of energy is bound to shoot up if India is to ensure its energy security. Energy security, in turn, is a function of three primary factors – demographic trends, economic growth, and volatile fossil fuel prices. Going forward, trends in all these three factors further necessitate the increased deployment of renewable sources.

Climate Change

The move towards the adoption of renewable energy is strengthened by the wide scale proliferation of global warming leading to climate change. The threat of climate change emanates from the accumulation of greenhouse gases at an unprecedented rate in the atmosphere. Emissions of GHGs cumulate in the atmosphere because the rate at which they diffuse in the atmosphere exceeds the rate at which they decay naturally. Increasing emissions of GHGs from human activities have led to a marked increase in global temperature. Although global warming today has become a major concern for the world community at large and countries across the globe are trying to find a cohesive solution for its mitigation, international consensus on long term stabilization targets of GHGs are yet to be agreed upon. Most discussions focus on stabilization levels between 450 parts per million (ppm) and 550 ppm of carbon dioxide equivalent (CO_2e). Without Government initiatives on energy or climate change, global temperatures could rise by as much as 6^0C by the end of 21^{st} century.

As far as India is concerned, the total CO_2 emissions are about 4% of total global CO_2 emissions. India's per capita emissions, even with 8% to 9% GDP growth every year for the next decade or two, are likely to be well below developed country averages. Its energy intensity of production has been falling with improvements in energy efficiency, autonomous technological changes and economical use of energy. Various climate modelling studies indicate that India's per capita emissions will be around 2 tonnes to 2.5 tonnes of CO_2e by 2020 and around 3 tonnes to 3.5 tonnes of CO_2e by 2030, as compared to around 1 tonne to 1.2 tonnes of CO_2e, presently.

Carbon Market Opportunities

While investment in renewable energy infrastructure is of paramount importance given the current scenario, the opportunity evolving as a result of this investment in the carbon market also remains promising and can act as an impetus to the utilisation of clean and renewable technologies. Carbon credit markets came into existence because of the increasing concerns for environment across the world. Credits can be exchanged between organizations at a price, and are bought and sold in international markets at the current market price.

Many industrialised governments that have ratified the Kyoto Protocol have already begun implementing domestic policies and regulations that will require emitters to reduce greenhouse gas emissions, according to the established targets. So far, experience has shown that the cost of reducing one ton of CO_2 can range from US$ 15 up to US$ 100 in industrialized countries. By contrast, there are many opportunities to reduce greenhouse gases in developing countries at a cost of US$ 1 to US$ 4 per ton of CO_2. Hence, an emission reduction that can be achieved at a lower cost has value to a public or private entity in an industrialised country that is required by regulation to reduce its emissions.

Governments play a crucial role in setting regulatory standards and in supporting a low-carbon research, development and deployment. Flexible mechanisms that have emerged from the Kyoto Protocol have created the path for developing countries to participate in carbon markets. This has opened up newer opportunities for developing countries like India. These opportunities are best reflected in the size of the carbon market. Even as global GDP declined in 2009, the carbon market demonstrated exceptional resilience – the total value of the market grew 6% to US$ 144 billion by end-2009, with 8.7 billion tons of CO_2e traded. However, 2010 could witness the first year of negative growth for the carbon market with Bloomberg New Energy Finance projecting US$ 121 bn by end 2010, roughly a 5% decline from 2009. In the longer-term, however, and assuming passage of cap and trade legislation in the US, projections indicate that the global carbon market could turn over up to US$1 trillion per year by 2020.

As far as India is concerned, it accounted for 23.5% of all registered CDM projects as of March 2010 (480 out of 2090 projects) and ranked second after China. Globally, China dominates the CDM market with close to 36% of volumes transacted, followed by India, which generated around 40 million carbon credits, with another 140 million being in the pipeline. According to the Prime Minister's Economic Advisory Council, about 850 green projects with a huge investment of US$ 14.45 billion are in pipeline, with revenues from 200 projects expected to earn around US$ 2.16 billion until 2012. About 225 Indian projects in the fields of biomass, cogeneration, hydropower, and wind power with a potential of 225 million CERs have been registered.

The increasing opportunities emerging in the carbon market for India is bound to provide a strong impetus to the development of clean and renewable energy sector. The majority of projects that have sold carbon credits so far have included renewable energy projects. India, with a large portion of the population in rural areas, that have limited access to electricity, creates a big opportunity for the deployment of clean energy projects, through solar, wind and biomass sources. In terms of rural development and usage of renewable energy, there is an abundance of opportunities for the Indian developers, especially when the counterparts of developed countries are ready to provide capital for development. This would help institutions in these countries achieve their reduction targets.

RENEWABLE ENERGY: A GLOBAL PERSPECTIVE

An analysis of the demand for the new renewable energy technologies, viz., solar photovoltaic, wind and biomass indicates a clear shift in global preference towards these technologies as sources of energy, especially in generation of electric power. Renewable technologies are likely to dominate global power plant construction in the decade from 2010 to 2020, exceeding the total for coal, oil, natural gas, and nuclear power combined. The continued rapid growth, primarily of renewable energy technology, despite the financial crisis and economic downturn, is a testament to the inherent attractiveness of the technology. Renewable energy continues to grow primarily due to national energy policy in the key markets. Many Governments have realized the strategic long-term importance of renewable power generation and have placed it at the core of their economic growth plans.

The primary source for global renewable energy has been traditional biomass, whose share in global energy consumption in 2008 stood at 13.1%, followed by hydro power at 3.2%. New renewables (wind, solar, biomass, geothermal) accounted for 2.7% share, marginally higher than 2.4% contributed in 2006. The electricity sector is expected to be the pioneer of renewable energy utilisation. Many renewable electricity technologies have been experiencing steady growth over the past two decades, of up to 35% annually, and going forward, are expected to consolidate at a high level. The anticipated growth of electricity use in transport would further promote the effective use of renewable power generation technologies.

In terms of power generation, renewable energy accounted for around 18% of global electricity production in 2009, although its share in power generation capacity at 1230 GW (7% growth over 2008) was a shade above 25% of the global capacity estimated at 4800 GW in 2009. The increasing significance of renewables in power generation can be assessed from the fact that renewable capacity accounted for 47% (140 GW) of all types of new generating capacity added to the world's grids (about 300 GW), cumulatively during 2008 and 2009. The renewable power capacity excluding large scale hydropower aggregated 305 GW in 2009, an impressive growth of 22% over the previous year. Within this, wind, solar (photovoltaic-grid) and biomass together accounted for 76.7% of global renewable power capacity (excluding large hydro-power).

While recent trends in growth of renewable energy capacities might appear impressive, the potential that these sectors have as sources of energy is immense and yet to be fully tapped. This can be understood in better perspective, if seen in the context of the maximum energy realisable from such sources, in the absence of any technological or economic restrictions. Thus, for instance, the energy in sunlight, on an average, is about one kilowatt per square metre worldwide. In one day, sunlight which reaches the earth produces 2850 times the current annual energy requirement of the world, i.e. enough energy to satisfy the world's current power requirements for almost eight years. Even though only a percentage of that potential is technically accessible, this is still enough to provide nearly six times more power than what the world currently needs. On the whole, it is estimated that the major sources of renewable energy could potentially provide more than 3000 times the current global energy requirements.

Perhaps, as a reflection of measures to tap the aforesaid potential, investments in renewable energy capacities have been witnessing an upward trend, and was approximately US$ 150 bn in 2009, as compared to US$ 130 bn in 2008. Of this, about US$ 100 bn was invested in new utility-scale renewable energy development (including biofuels refineries but excluding large hydro) and about US$ 50 bn in small-scale projects such as rooftop solar photovoltaic and solar hot water. In terms of components, there were significant investments in 2009 in plants and equipments to manufacture solar modules, wind turbines, and other generating devices. Global exports of products which were related to (albeit only to a relatively small extent) renewable energy supply amounted to US$ 284.8 bn, exhibiting an average annual growth of 20.8% during the 5-year period 2004 to 2008. Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes (HS 854140) was the single largest item exported, amounting to US$ 43.2 bn in 2008 and also recorded an impressive average annual growth of 35.7% during 2004 to 2008. Germany was the largest exporter of renewable energy supply related products with exports in 2008 aggregating US$ 40.3 bn followed by China (US$ 37.4 bn), USA (US$ 26.9 bn), Japan (US$ 24.6 bn), France (US$ 11.6 bn) and Italy (US$ 11.5 bn). In terms of imports, USA was the largest importer in 2008 with imports amounting to US$ 35.2 bn followed by Germany (US$ 27.1 bn), China (US$ 25.8 bn), Spain (US$ 14.4 bn) and South Korea (US$ 9.8 bn).

Global Photovoltaic Industry

The solar PV industry can be broadly categorised into three separate value chains – upstream, manufacturing, and downstream. The most important part of the upstream segment is the production of the main raw material – polysilicon. The manufacturing segment involves various stages comprising wafer and cell manufacturing, module production and manufacturing of balance of system components. The downstream stage largely involves the PV system integration and varies greatly between the different applications. Given that the countries across the globe have a differing set of incentives for various PV applications, the downstream segment is rather heterogeneous across countries worldwide. In terms of market dynamics, the PV market has been growing at over 40% per annum with global PV installations in 2009 being almost six times the 2004 level. Thin film's share of the global market increased from 14% in 2008 to 19% in 2009 for PV cells, and from 16% to 22% for PV modules. The global cumulative PV capacity (grid-connected and off-grid installation) reached 25 GW in 2009. The addition in grid-tied PV capacity in 2009 alone is estimated to be 7 GW, with off-grid accounting for 3 GW to 4 GW.

More than half of the new installations in 2009 (grid connected) were in Germany, which continued to be the country with the largest PV electricity capacity amounting to 9.8 GW in 2009 (47% share), followed by Spain (with 3.4 GW capacity), Japan (2.6 GW) and USA (1.2 GW). Even in terms of new installations, Germany led the way with an addition of 3.8 GW of solar PV capacity in 2009, followed by Italy (0.7 GW), Japan (0.5 GW) and USA (0.4 GW). Other major markets included the Czech Republic, which witnessed a nine-fold increase in total capacity to 411 MW compared to 2008, primarily due to generous feed-in tariff structure for solar PV, followed by Belgium (292 MW), France (185 MW, with another 100 MW off-grid by end

2009), and China (160 MW). The trend towards large-scale (greater than 200 KW) PV plants continued around the globe, with the number of such plants exceeding 3,200 in 2009, up from 2,450 during the previous year. The majority of these plants are operating in Spain, Germany, and the United States, although an increasing number are being installed in Asia.The top 15 PV cell manufacturers produced 65% of the 10.7 GW of cells manufactured in 2009, with firms in China and Taiwan together producing nearly half (49%) of the global total, followed by Europe (18%), Japan (14%), and USA (6%). Favourable policy frameworks are expected to further accelerate PV deployment in these countries.

In terms of international trade in PV panels/modules (HS 844140), global exports aggregated US$ 43.2 bn in 2008, recording an average annual increase of 35.7% during the 2004-2008 period. PV panels/modules represented a share of 37.2% in global exports of US$ 116 bn of solar energy related goods and components. Germany and China were the two main players in both export and import of PV panels/modules, accounting for 15% and 27%, respectively in exports and 20% and 11%, respectively in global imports of PV panels/ modules in 2008. Other major exporters of PV panels/ modules were Japan (14%), Taiwan (10%) and USA (6%), while major importers included Spain (20%), USA (7%), Korea and Hong Kong (5% each). India's exports of PV panels increased from US$ 85 mn in 2004 to US$ 529 mn in 2008 (1.2% share in global exports), making it the 15th largest exporter. In terms of import, India was ranked 20th with total imports amounting to US$ 420 mn in 2008 as against US$ 45 mn recorded in 2004.

Global Wind Energy

Wind as a source of energy has been gaining increasing significance, more so during recent years, not only as a renewable and environmental friendly source, but also as a cost effective one. The global wind resource is huge, capable of generating more electricity than the world's total power demand, and is geographically well distributed across the globe. The global cumulative installed capacity of power generated from wind energy increased from around 40 GW at the end of 2003 to over 158 GW at the end of 2009, with the annual installed capacity increasing from 8.2 GW in 2004 to 38.3 GW in 2009, thereby recording a CAGR of 36%. The additional capacity of 38.3 GW for wind power in 2009 was the highest among all the renewable technologies, an indication of the sector's potential. USA maintained its position as the largest market in wind power globally with a cumulative installed capacity of 35.1 GW in 2009, while China, with a total capacity of 25.8 GW, edged past Germany (marginally less than 25.8 GW) to become the second largest market. Spain was the fourth largest market with a cumulative installed capacity of 19.2 GW, followed by India at 10.9 GW of installed wind power capacity in 2009.

If the year 2009 is analysed in isolation, China emerges as the single largest player in terms of capacity addition to wind power – its addition to installed capacity aggregated 13.8 GW, representing more than one-third of the global addition of 38 GW to installed capacities in 2009. The speed of addition to wind power capacity in China has been tremendous wherein it has doubled existing capacities for the fifth consecutive year. USA, with a capacity addition of little over 10 GW, was the second largest contributor to global wind power capacity additions in 2009, followed by Spain (2.5 GW), Germany (1.9 GW) and India (1.3 GW). The market in 2009 also witnessed a stabilisation of wind turbine prices.

In terms of distribution, the offshore wind sector has been gradually inching up, driven primarily by a continuous decline in good onshore sites. This segment of the wind industry added 641 MW of capacity in 2009, representing an increase of 72% over 2008, bringing the total offshore wind energy capacity to a little over 2 GW. Most of the offshore wind capacity is located in Europe, with United Kingdom (883 MW in 2009) and Denmark (639 MW) being the main players.

On the supply side, the most significant development in 2009 was the emergence of Chinese wind turbine manufacturers, which resulted in the market shares of other major companies declining considerably. Three out of the top ten manufacturers were from China (Sinovel, Goldwind and Dongfang), with a combined market share of 22.9% in 2009. Overall, Vestas of Denmark continued to be the leader with a 12.5% market share (notably lower than 17.8% share in 2008) followed closely by GE (12.4%), Sinovel (9.2%) and Enercon (8.5%). Suzlon of India dropped to eighth position, with a decrease in market share to 6.4% in 2009, from 8.1% in 2008. Another discernible trend that has emerged in the wind power sector is the growing market for small scale wind systems – both off-grid and grid-tied – which are generally considered to include turbines that produce enough power for a single home, farm, or small business.

The growth in capacity of wind energy installations in the world shows that there is a growing global demand for wind power. Several countries now meet a significant share of their electricity demand from wind power, including Denmark (20%), Spain (14.3% and where wind overtook coal for the first time in 2009); Portugal (11.4% in 2008), Ireland (9.3% in 2008), and Germany (6.5% in 2009). What is also significant is the fact that in both Europe and USA, wind power accounted for 39% of all new electric generating capacity in 2009 – more than any other generating technology for the second year running.

In terms of international trade, world exports of wind turbines (HS 850231) has grown at a rapid pace – nearly quintupling from US$ 1.1 bn in 2004 to US$ 5.3 bn in 2008. Germany overtook Denmark as the largest exporter of wind turbines in 2008 with exports aggregating US$ 2004 mn compared to Denmark's exports of US$ 1250 mn. India, which had negligible exports of wind turbines in 2004 (~US$ 1 mn) increased its exports phenomenally to US$ 651 mn to emerge as the third largest exporter in 2008 (compared to its 12th rank in 2004). In terms of imports, USA was by far the largest market with imports of wind turbines shooting up from mere US$ 64 mn in 2004 (5.6% share) to US$ 2679 (39.7% share) mn in 2008.

Global Biomass Energy

The use of biomass as a source of energy for both power generation and heating as also for transportation has been increasing across the globe. Today, biomass power plants exist in more than 50 countries around the world and supply a growing share of electricity. Overall, the biomass power capacity (excluding electricity generated from municipal solid waste or industrial waste) amounted to 54 GW by the end of 2009. The European Union remained the top region with electricity capacity from biomass aggregating 16.0 GW in 2009. Within EU, the main countries included Germany with biomass power capacity of 4 GW, and Spain with 0.4 GW in 2009. In fact, several European countries expanded their total share of power from biomass, including Austria (7%), Finland (20%), and Germany (5%). Wood and wood waste account for the vast majority (more than three-fourth) of biomass power production in Europe, followed by black liquor, and other plant and animal wastes. The use of wood pellets – manufactured from wood waste, short-rotation wood, and other sources – for electricity generation (and heat) is also increasing rapidly in Europe. Although the European market is the most developed in terms of power generation from biomass, by late 2009, USA took the lead in power capacities with about 80 operating biomass projects in its 20 states providing approximately 8.5 GW of power capacity.

Power generated from biomass has also increased significantly in many developing countries. China's capacity increased by 14% in 2009 to 3.2 GW and the country plans to install up to 30 GW by 2020. India, which generated 1.9 TWh of electricity with solid biomass in 2008, had a biomass power capacity of 1.5 GW in 2009. By the end of 2009, India had installed 835 MW of solid biomass capacity fuelled by agricultural residues (increase of about 130 MW in 2009) and more than 1.5 GW of bagasse cogeneration plants (up by nearly 300 MW in 2009, including off-grid and distributed systems). The country is well on its way of achieving the targeted 1.7 GW of biomass power capacity by 2012. Brazil has also shown an increase in biomass usage for energy generation with over 4.8 GW of biomass cogeneration plants at sugar mills, which generated more than 14 TWh of electricity in 2009.

THE NEW RENEWABLE ENERGY SECTOR: REFLECTIONS FROM THE INDIAN MARKET

India is the fifth largest primary energy consumer and the fourth largest petroleum consumer globally. Rapidly growing economic and social development coupled with increasing population has spurred increased energy consumption across all the major sectors of the economy. This is reflected in the country's growing demand for fuel and power. While India's petroleum consumption has gone up from 100 million metric tons in 2001-02 to more than 138 million metric tons in 2009-10, the installed power generation capacity has increased from 107 GW to 164 GW during the same period. The current power generation mix (as at end July 2010) in India is dominated by coal with a share of 53.2% (87.1 GW), followed by large hydropower (22.6% share; 37.0 GW) and gas (10.6%; 17.3 GW). Renewable energy sources rank fourth with an installed capacity of around 16.4 GW. It is projected that by 2020, India would need 327 GW of power generation capacity to fulfill its projected demand, which would imply an addition of nearly 15 GW per year. The encouraging aspect of the growth in India's installed electricity capacity, especially during recent times, has been the increasing application of renewables as energy sources. Although the country continues to rely on coal as the primary energy source, its share in installed capacity has declined from 59.3% in end March 2003 to 53.2% in end July 2010. As opposed to this, the share of renewable energy sources has shot up from a mere 1.5% to 10.0% during the same period. The importance accorded by the Government to renewable energy can be assessed from the fact that India remains the only country in the world having a Ministry exclusively dedicated to renewable energy, viz. Ministry of New and Renewable Energy (MNRE).

According MNRE, cumulative capacity of about 17,173.9 MW grid-interactive power generations from various renewable energy sources had been installed up to 30.6.2010. These include: Wind Power – 12009.48 MW, Small Hydro Power – 2767.05 MW, Biomass power – 910.10 MW, Bagasse Cogeneration – 1411.53 MW, Solar power - 12.28 MW and Urban and Industrial waste-to-energy – 72.46 MW.

As far as trends in financial investments in the renewable sector in India are concerned, they have more or less mirrored those for the world as a whole. Thus, following the global contraction in financial investments in 2009 – from US$ 130 bn in 2008 to US$ 119 bn in 2009 – investments in the renewable energy sector in India also witnessed a decline of 21% – from US$ 3.4 bn in 2008 to US$ 2.7 bn in 2009. Notwithstanding the decline, which was largely a fallout of the cautious approach of bank financing in the wake of global economic meltdown, India was ranked eighth in the world based on financial investments in the new renewable energy sector in 2009. Investments in renewable technologies in India have maintained a general upward trend since 2004, save for the last two years, which can be considered an aberration since these were an outcome of the global economic crisis. Overall, during the period between 2004 and 2009, financial sector investments in renewable energy sector in India registered an average annual growth of 33.1%, increasing from US$ 1.1 bn to US$ 2.7 bn. This growth, though impressive in itself, pales out when compared to global financial investments in this sector which increased by an average annual rate of 53.9% and that too from a much higher base – from US$ 18 bn to US$ 119 bn during the same period.

Renewable energy investment in India in 2009 was dominated by asset-based finance, with US$ 1.9 bn (73%) coming in this form, as against US$ 3.1 bn in 2008. Public market activity in India accounted for a large proportion of the remainder with US$ 0.7 bn (25%). Private equity and venture capital activity in India constituted a rather small proportion of all investment, at just 4% of the total, or US$ 0.1 bn, as compared to US$ 0.4 bn in 2008.

Based on the products identified as being related to renewable goods, India had a trade deficit to the tune of US$ 810 mn out of a total trade figure of US$ 7.6 bn in 2008. While India's exports of renewable goods aggregated US$ 3.4 bn, India's imports of the same amounted to US$ 4.2 bn in 2008. An interesting point to note is that though there is a deficit, exports of renewable goods, on an average, have increased at a faster pace than imports during the period 2004 to 2008. Germany was India's largest trading partner for the identified renewable goods and equipments in 2008 with two-way trade amounting to US$ 1219 mn. Germany was followed by China, whose trade with India aggregated US$ 1059 mn, almost wholly a result of strong imports by India. USA, Spain, Japan, Italy and Brazil were India's other major trading partners for renewable goods in 2008. From an export perspective, USA was India's largest export destination with exports totaling US$ 597 mn in 2008 (17.6% share) – an appreciable average annual growth of 84.3% during the 2004-2008 period. As far as imports are concerned, China emerged as the most important source for India's renewables with imports from the country amounting to US$ 1016 mn in 2008, up significantly from US$ 132 mn in 2004.

In terms of the product basket, the most actively traded renewable energy goods by India in 2008 was photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes (HS 854140) with amount traded being US$ 949 mn in 2008, more than six fold increase over the 2004 level of US$ 158 mn. However, if only exports are considered, then wind-powered electric generating sets were the single largest item with exports in 2008 aggregating US$ 651 mn followed by PV panels/ modules (HS 854140) with exports worth US$ 529 mn recorded in 2008.

This ranking is all the more encouraging from the renewable goods perspective, given that wind powered generating sets and PV panels/modules are the items identified as being key 'single use' products exclusively used for renewable technologies (with the former being used exclusively for generation of power from wind, and the later for generation of power from sunlight), unlike other identified products, which are for multiple use, i.e. only a small portion of these products, if at all, might be related to the deployment of renewable energy technologies and products.

Photovoltaic Industry in India

The use of photovoltaics in energy generation in India has been increasing steadily, although the potential of leveraging the energy embedded in sunlight is yet to be tapped to the desired level. This is indeed ironical considering that India is a tropical country endowed naturally with almost 300 days of sunlight in a year. Nonetheless, during recent times, apart from various Government entities, several private firms and corporates have begun evincing interest in energy generation from PV cells.

With a large proportion of power generated from photovoltaics being off-grid, and given the large number of small solar systems involved, the total installed PV capacity in India can at best only be an estimation, and not an absolutely accurate figure. An estimated 30 MW of new PV capacity was installed in India in 2009 taking the total cumulative PV capacity to 120 MW. This is significantly higher than the cumulative installed PV capacity of 31 MW in 2006, indicating a near four-fold increase in the intervening years between 2006 and 2009. In terms of the value chain, the total solar cell manufacturing capacity in India is estimated to have touched 175 MW, while the total PV module manufacturing capacity was estimated to have reached 240 MW in 2008-09. Both these segments of the PV industry in India have grown significantly, especially during the recent past. PV cell capacity has more than quintupled from a mere 32 MW in 2004-05 to 175 MW in 2008-09, and manufacturing capacity of PV modules has surged from 45 MW to 240 MW during the same period.

On an average, globally, annual installed PV capacity expressed as a percentage of total module production has ranged between 80% and 90%. However, in case of India, this ratio has averaged 15% during the 2005-06 to 2008-09 period. A plausible reason for this could be that the domestic market in India for PV installation is almost entirely off-grid and involves a large number of small solar applications, resulting in a limited demand for PV cells and modules within the domestic shores.

The value chain of PV industry in India comprises four major segments, viz. silicon and thin film manufacturers; solar appliance manufacturers; Engineering, Procurement and Construction players; and Project Developers. Currently, there are about 15 entities engaged in the production of PV cells in India, some 20 companies are present in the PV modules space and nearly

50 companies are engaged in the assembly and supply of PV Systems (PV cell and PV modules). More and more firms are setting up, or expanding manufacturing units and developing forward linkages to develop solar power plants in India, although the market is still dominated by joint ventures and technical collaboration with foreign firms that specialise in PV products. The solar PV technology in India is dominated by crystalline silicone with 90% of PV modules manufactured in the country using this technology, while only 10% of PV modules are manufactured using Thin Film or amorphous silicon technology. Other emerging technologies are either not yet being commercially utilized, or are still at the research and development stage.

In India, PV installations almost entirely comprise off-grid and small capacity applications. Out of the total installed PV generation capacity estimated at 120 MW, almost 97% is in the form of off-grid applications, most visible in lighting applications in cities and towns, and in small electrification systems and solar lanterns in rural areas. The non-Government market for small, off-grid PV installations are served by both major Indian PV system manufacturers and several smaller system integrators. PV has also begun to be deployed, albeit to a small degree, in powering water pump sets running surface/submersible pumps on farms, and in small industrial units. The railways, telecom and other government departments and agencies (including the defence and space research organizations) remain the largest consumers of PV in India. The PV industry in India is poised to grow significantly in the foreseeable future, given India's locational advantage, favourable PV industry dynamics, vibrant export and carbon credit markets, and conducive Government's policy initiatives.

The key single use exclusive item being traded under photovoltaic is photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels (PV panels/modules). This was the largest product exported by India in 2008 under the PV and related goods category. Even more encouraging has been the growth in its exports – from just US$ 85 mn in 2004 to as much as US$ 529 mn in 2008 – more than six-fold increase in just a matter of 4 years. Germany and Spain are the two countries which figure among India's major export destinations as well as import sources of PV panels/modules. While Spain was the largest export destination contributing 40%, Germany was the biggest source of imports accounting for 38% of India's total imports of PV panels/modules in 2008. The other major export markets were Germany (37%), France, South Korea (3% each), Italy and USA (2% each). In terms of import, Taiwan was one of the key sources accounting for 32% of India's total imports of PV panels/modules in 2008.

Overview of Wind Energy Segment in India

India, with a large peninsula belt, and two-season monsoon, has significant potential in generating wind energy. Apart from onshore generation, India also has potential for tapping offshore belts for wind energy. Although offshore generation of power is an expensive proposition under present technologies, with the required capital averaging between US$ 2 million and US$ 3 million per MW, offshore wind farms enjoy much higher plant load factors. Also, as demand increases and technology improves, cost is expected to come down.

Power generated from wind energy has witnessed a steady increase in the Indian market. Total installed wind power capacity reached 11.75 GW as at end March 2010, up from 1.63 GW in 2001-02, thereby registering a healthy average annual growth of 28.6%. The country added 1564.7 MW to the installed capacity in 2009-10 as against 1484.0 MW in 2008-09. Although high in itself, this is only a small percentage of the estimated potential – the onshore gross potential that can be harnessed from wind energy in India is estimated at about 48.5 GW with Karnataka, Gujarat and Andhra Pradesh offering the maximum potential. However, in terms of actual installed capacities, wind power is concentrated mainly in the southern state of Tamil Nadu, with an installed capacity of 4875.9 MW (as at end March 2010), representing 41.5% of India's total installed wind energy capacity.

India has a wind electric generator of diverse unit sizes, ranging from 225 KW to 1.65 MW. These installations have cumulatively fed over 54 billion units of electricity to the state electricity grids; of which, the installations in Tamil Nadu alone have contributed over 32 billion units of electricity. Notwithstanding this, the geographic dispersion of wind farms in India has been gradually witnessing a shift. With increasing interests in renewables, the dominance of Tamil Nadu has been gradually declining as other states, including Maharashtra (2071.6 MW), Gujarat (1864.6 MW), Karnataka (1506.9 MW) and Rajasthan (1091.7 MW) have started to catch up. Specific policies have been introduced by the state Governments (through the State Electricity Regulatory Commissions) to encourage setting up of wind power projects. The policies cover regulations pertaining to types of investments, as also the buy-back of power at a contracted rate.

India also manufactures wind electric generators through (a) joint ventures or under licensed production; (b) subsidiaries of foreign companies under licensed production; (c) Indian firms with indigenous technology. An indigenization level of 50% to 80% has been achieved in machines. A few manufacturers have started manufacturing wind electric generators without any foreign collaboration. The annual production capacity of domestic wind turbine was about 3000 MW in 2009-10. The trend in recent installations indicates a shift towards better aerodynamic design, use of lighter and larger blades, higher towers, direct drive, and variable speed gearless operation using advanced power electronics typically to suit moderate wind regime and weak local grid network. The manufacturing of wind turbines with latest technology like permanent magnet generator has also started in the country. The wind energy industry has taken up indigenised production of blades, gearboxes, yaw components and controllers etc.

Analysis of India's trade reveals that wind turbines – the key single use item identified as being used exclusively for the production of wind energy – was the single largest product traded by India in the wind energy sector in 2008 with total trade aggregating US$ 653 mn, with almost the entire amount (US$ 651 mn) being for the purpose of exports. Exports of wind turbines have grown at a phenomenal pace – from a mere US$ 1 mn in 2004 to as much as US$ 651 mn in 2008 – a stupendous average annual growth of 885.1%. This growth has been fuelled primarily by India's robust exports to USA which shot up from US$ 22 mn in 2005 to US$ 203 mn in 2008, placing it as the largest export destination for wind turbines from India (a share of 31%). The other major export destinations for wind turbines in 2008 included Brazil (US$ 145 mn; 22% share), Australia (US$ 109 mn; 17%), Portugal (US$ 81 mn; 13%), Spain (US$ 63 mn; 10%) and Turkey (US$ 35 mn; 5%).

Wind energy industry in India has been and is likely to continue to be on an upward strategic move. With the fundamental drivers (such as growing energy demand, relatively low generation cost, Government initiatives, technology and the ever expanding carbon market) for Indian wind energy sector remaining strong, India would be in a position to capitalize on the opportunity, not only in promoting wind energy for the cause of mitigating climate change, but also to use this window of opportunity to meet the ever growing domestic power demand faced by the country. It is expected that a minimum of 2,200 MW of new wind power capacity will be installed in India in the financial year 2010-2011. Thus, the outlook for the wind energy sector in India is likely to remain fairly bright.

Biomass Energy in India

Biomass is an important energy source for power generation especially in developing countries like India. For the last 15 years, biomass power has become an industry attracting annual investment of over ₹ 1000 cr, generating more than 9 GW of electricity per year and creating employment opportunities in rural areas. Biomass in India basically includes solid biomass (organic, non-fossil material of biological origins), biogas (principally methane and CO_2 produced by anaerobic digestion of biomass and combusted to produce heat and/or power), liquid biofuels (bio-based liquid fuel from biomass transformation, mainly used in transportation applications), and municipal waste (wastes produced by the residential, commercial and public services sectors and incinerated in specific installations to produce heat and/or power). The cost of biomass fuel is considerably lesser than other sources. While the cost of power from a diesel generator could be upwards of ₹ 12 per unit, the cost of biomass power could typically be around a third of that amount. At the same time, the approximate capital cost of biomass energy is about ₹ 4 cr per MW. The cost of setting up a coal-based power plant, on the other hand, is between ₹ 5 cr and ₹ 6 cr per MW.

Blessed with ample sunshine and rains, India offers an ideal environment for biomass production. A target for addition of 1,700 MW capacity, comprising 500 MW of biomass power projects and 1,200 MW of bagasse cogeneration projects has been proposed during the 11th Plan period. In addition, 400 MWe energy power from industrial and municipal waste and 100 MWe of distributed renewable generation for power and heat has been proposed which include biomass resources. By June 2010, the cumulative biomass power/ bagasse cogeneration based power capacity had reached 2312.6 MW, which comprised 901.1 MW of biomass power projects and 1411.5 MW of bagasse cogeneration projects. The year 2009-10 witnessed a significant increase in biomass power / bagasse cogeneration capacity addition of 384 MW (125 MW biomass projects and 259 MW bagasse cogeneration projects). A cumulative biomass power potential of about 18,000 MWe from the surplus agro residues have been estimated in India. With the present utilization pattern of crop residues, the amount of surplus biomass materials is about 150 million tonnes, which could potentially generate about 18,000 MWe of power.

The States of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal have potential for setting up biomass based power projects of 100 MW or above. The biomass power potential in the identified districts of the above States ranges from 10 MW to 100 MW. Sugar mills having crushing capacity of 2500 tonnes of cane crushed per day, in the states of Maharashtra, Uttar Pradesh, Tamil Nadu, Karnataka, Andhra Pradesh, Bihar, Gujarat, Punjab and Haryana, have an estimated potential of about 5000 MW surplus power generation through optimum bagasse based cogeneration. With the setting up of new sugar mills and the modernization of existing ones, the potential of bagasse cogeneration is estimated at 5,000 MW.

RENEWABLE ENERGY : A FUNDING PERSPECTIVE

One of the major constraints inhibiting the realization of the potential of renewable energy is availability of capital. Inability of firms in obtaining finance for renewable energy projects has often been seen as a strong deterrent to investments in many countries around the world, including India. The main hurdle in investment in renewable energy remains the high up-front costs, particularly for installing equipments. To some degree, strengthening capacity building, promoting enabling environment, developing suitable policy frameworks, and improving demands for renewable energy technologies (RET) can help in mitigating the steep transaction costs and create markets. Such capacity building initiatives are a prerequisite to stimulate investments in the renewable energy sector.

In the context of India, a well constructed policy support mechanism by the Governments, both at the centre and at the state levels, including fiscal incentives, is crucial for the success of renewable energy programs. Such mechanisms are required to help support shifting the investment paradigm of energy sector away from the typically undervalued investment costs of fossil fuels. Given the barriers, innovative financing mechanisms could lead the way to increase the demand for investments in RET, and generate a sustainable market for the deployment of RET. The success of the usage and the proliferation of RET would only be possible through a two pronged strategic approach (a) sound financial support mechanism; and (b) constructive policy initiatives enabling enhanced investment in the sector.

The methods of financing RET sector have mostly been conventional debt and equity products. However, of late, financing mechanism of renewable energy has become a mainstream activity with various innovative financing modes having been introduced at different stages of the evolution of the RET - from concept to its commercial use.

The development and commercial viability of RET is an expensive affair since significant costs are incurred at both the stages. Equipment manufacturers, construction contractors, integrators/assemblers (those who bundle technologies together into an integrated package) and service providers are all critical players in the RET sector. Their innovations, expertise and performance are critical in making RET a commercially viable technology. The risks associated with financing development of such technologies are high, especially given that the sector is largely at its nascent stage and the commercial utilization of technologies is still to pick up. In spite of these deterrents, given the opportunities this industry offers for sustainable growth, the players in this sector have been successful in devising means and mechanisms to finance its growth, at the various stages of the technology and project development cycle of this industry.

The various investor groups which have been proactive in undertaking possible interventions at various stages of technology development and the project development cycles of the renewable energy sector are – the innovator entrepreneurs, developers, angel investors, venture capital, private equity firms, and infrastructure funds apart from the capital market.

Policy Initiatives

Policy initiatives remain the backbone to the success of RET. As the sector requires huge amount of capital, a conducive policy oriented ambience is expected to encourage greater investments into the sector. In a country like India, which is a highly value-conscious mass market, public is unlikely to pay substantial premiums for goods/services tagged “clean” for quite some time to come. In such a scenario, clean energy projects may not be sustainable without Government support, primarily in the form of capital infusion. This can be done in a number of ways, from sanctioning grants (reduces initial investments costs), introducing tax credits (to reduce capital or operating costs), including low interest loans and grants (lowers capital recovery requirements), to introducing green purchasing targets (which may help to create a market-pull by committing to buy green power for their operations) in the country, apart from bringing in renewable portfolio standards and feed-in-tariff.

Multilateral Financing Mechanisms

Many multilateral financial institutions across the globe have taken steps to facilitate investments and promote renewable energy by providing special credit lines and funds. There are several multilateral programmes of cooperation that aim at increasing the utilization of renewable sources of energy in the context of climate change mitigation. Today, all major multilateral agencies are incorporating environmental consideration in their programmes. Although the share of financial assistance from these institutions is not as big as bilateral aid or private sector investment, they can still play a pivotal role in promoting international cooperation in the new emerging mechanism. Demand is increasing for multilateral financing because these institutions offer loans for a longer period (Islamic Development Bank offers loans with maturities of up to 15 years), unlike typical commercial banks who would offer a loan with a maturity of no more than 5-7 years.

SUM UP

The electricity generated from renewable energy sources accounted for 25% of global power capacity, and 18% of global power production in 2009. During the same year, renewable energy sources accounted for 60% of newly installed power capacity in Europe, and more than 50% in the USA. The sustainable energy investment in 2009, including generation from renewable sources and energy efficiency projects, indicates the determination of countries across continents, including developing countries, to transform the financial and economic crisis into an opportunity for green investment.

It is estimated that the newly installed capacity from renewable sources in the world as a whole could increase by over 50% in a couple of years. This could be achieved through innovative financing and incentive mechanisms. Favourable policies are already in place in more than 100 countries; however, to maintain the upward trend in renewable energy growth, policy efforts need to be taken up to a higher level in these countries, and need to be introduced in the remaining countries, thereby encouraging massive scale up of renewable technologies.

India has been at the forefront of renewable energy technology with the country being amongst the first in the world to have a full fledged Ministry catering to this niche sector. However, the success level is relatively low as compared to China, who has moved ahead within a short span of time. India, unlike many countries in Europe, has a distinct advantage in generating energy from all the three emerging renewable energy technology fields – photovoltaic, wind, and biomass – and therefore, it is imperative for the policy makers to facilitate harnessing of this huge potential, by supporting this industry. Suitable mechanisms could be created to overcome the barriers at the early stage of project development, while simultaneously creating enhanced deal flow for later stage entry by private and foreign institutional investors.

1: INTRODUCTION

"We do not inherit the Earth from our ancestors; we borrow it from our children"

- Anonymous

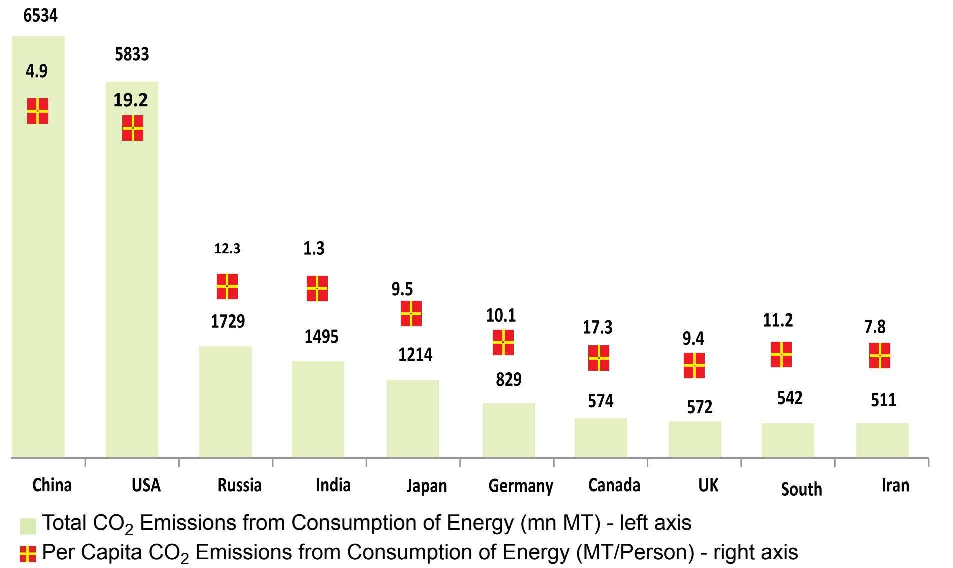
Human-induced climate change – i.e. a change in the statistical properties of the climate system, when considered over periods of decades or longer – has today become a global phenomenon, not just confined to any particular country or region in its causes or consequences. Issues such as rising sea levels, drought, and managing greenhouse gas (GHG) emissions have forced nations across the world to take proactive measures at mitigating causes of climate change. Coupled with these issues is the rising concern on energy prices and the fast depleting fossil fuel resources across the world.

As the world undertakes its path towards development, growth and employment generation to ameliorate the lives of millions of people, it becomes imperative to appreciate the looming ramifications of environmental degradation and ecological imbalances – best reflected in carbon emissions caused by climate change. Of late, growth in emission has been directly linked to overall economic growth and this linkage is unlikely to be broken in the years to come. At the same time, it is increasingly being realized that climate change is unequivocal and therefore an international collective action is critical in driving an effective, efficient and equitable response to this challenge.

Energy and climate are inextricably linked with any change in energy sector activity seemingly affecting the latter. The irony is that the energy so used is neither adequate to satiate the demands of the global populace nor is it helping the planet to remain healthy and inhabitable for future generations. Although, there is no single remedy to this issue, a series of measures could be undertaken by various stakeholders in addressing challenges arising out of climate change and thereby help in sustainable development[1]. One of the most critical measures of climate change mitigation is enhancing the usage of clean and renewable sources for meeting the ever increasing global energy demand. This is evident from the amount of carbon dioxide emissions which remains the key reason for climate change. The situation gains even more significance when considering the exponential growth in current and future demand for energy emanating from

[1]Sustainable Development basically implies meeting the needs of the present without compromising the ability of future generations to meet their own needs

Exhibit 1: Top 10 CO_2 Emitters from Energy Consumption in the World in 2008



Source: US Energy Information Administration, Exim Bank Analysis

emerging countries to fuel their rapidly growing economies.

As can be seen from Exhibit 1, China was the largest emitter of carbon dioxide (CO_2) from the consumption of energy in the world in 2008, primarily due to its dynamic economic growth. With 6534 million metric tons (MT) of total CO_2 emission in 2008, China overtook USA whose CO_2 emission actually declined from 6003 mn MT in 2007 to 5833 mn MT in 2008. Other major CO_2 emitting countries were Russia, India, Japan and Germany. However, in terms of per capita emissions, USA led all the major countries with CO_2 emissions of 19.2 MT/person followed by Canada (17.3 MT/person), Russia (12.3 MT/person), South Korea (11.2 MT/person) and Germany (10.1 MT/person). India, with a per capita CO_2 emission of 1.3 MT/person was ranked the lowest among the top 10 CO_2 emitters from energy consumption in 2008.

Set against this backdrop, the progressive substitution of fossil fuels as primary sources of energy becomes a critical component of any noteworthy measure aimed at climate change mitigation. This is especially relevant for a country like India whose energy need is increasing rapidly in line with its strong economic growth. However, this renders the country being embroiled in the twin objectives of sustaining its economic growth (which can only be fuelled with increasing energy consumption) while simultaneously maintaining a low carbon emission environment. According to the International Energy Outlook 2010, primary energy consumption in India is projected to increase by over 1.5 times by 2030, from 20.3 Quadrillion Btu in 2007 to 34.1 Quadrillion Btu in 2030, thereby growing at an average of 2.6% per year. Given this level of increase, it is important for India to reduce its dependence on CO_2 emitting sources (primarily fossil fuels – oil, coal and natural gas) and enhance its production of alternative sources of energy, which promote a greener economy. The only way to do so is to promote production and use of renewable sources of energy such as hydro, wind, solar and biomass. This would not just reduce India's carbon footprints but would also have an added benefit of improving the country's trade deficit, as nearly three-fourth of India's oil demand is met through imports.

The increase in production of renewable energy, inter alia, entails an active involvement of business and financial institutions backed by adequate support and an enabling policy environment from the Government. It is only by harnessing private sector capital and unleashing the power of the markets to boost investment in green technology and pollution-reducing projects that the challenges of climate change can be met. India today has the potential to position itself as a world leader in this drive to leverage the expertise and resources of businesses and private investors. It is already the third largest market in low-carbon and 'green' goods and the sector is expanding rapidly.

For a large country like India, with its over one billion population and rapid economic growth rate, no single energy resource or technology constitutes a panacea to address all issues related to availability of fuel supplies, environmental impact, particularly, climate change, and health externalities. Therefore, it is necessary that all non-carbon emitting resources become an integral part of an energy mix, as diversified as possible to ensure energy security to a country like India.

Given India's vibrant entrepreneurial culture, history of technology innovation and the vast domestic market, the country is ideally positioned to capitalize on the advantages that renewable energy has to offer. Although renewable energy technologies currently represent a fraction of the energy market in India, they have a tremendous potential to undergo rapid growth and provide an alternative solution to fossil fuels. With varied agro climatic zones providing sufficient raw sources like sunlight, wind, flowing water and flora, India offers ample opportunities to shift to large scale use of new renewable energy sources.

With clean technology becoming an investment category in its own right, public financial institutions and banks, private equity and venture capital funds are emerging as significant investors in the Indian clean technology companies in the country. The industry has already seen significant deal flow and attractive market opportunities have fuelled investment interest and accelerated market penetration of renewable energy. According to

Exhibit 2 : Benefits of Renewable Energy Technology

Renewable energy improves supply security:

- Renewable energy sources are inexhaustible and their natural availability is much higher than current global annual energy consumption.
- The current technical potential for renewable use is six times higher.
- Renewable energy sources are available in most regions of the world, not just in specific geographical areas as is the case with fossil and nuclear resources.
- This leads to less import dependency, more stable energy prices, stronger market competitiveness and improved long-term prospects.

Renewable energy provides greater flexibility:

- Offers a broad portfolio of applications, sources and technology solutions for different climate and societal conditions.
- Meets the need for small and large-scale energy services in urban and rural regions.
- Offers technologies not only for power generation, but for heat generation, cooling and fuels for transportation.

Renewable energy addresses environmental concerns by:

- Reducing the environmental damage resulting from fossil fuel use, thereby cutting the associated external costs.
- Reducing the unsustainable use of firewood and thus deforestation, a major concern in many developing countries.
- Reducing the unforeseeable environmental and proliferation risks of cost-intensive nuclear energy generation with its unresolved problems of nuclear waste disposal.

Source: Exim Bank Analysis

Venture Intelligence, the first three months of 2010 has already witnessed five private equity deals in clean technology sector aggregating US$ 150 mn. The renewable energy sector has also booked two venture capital deals aggregating US$ 11 million during the same period. Apart from this the Ernst & Young Renewable Energy Country Attractiveness Indices (November 2010), ranks India as the third most attractive country worldwide in terms of all renewables sources of energy (Table 1).

The Government has also been playing the role of facilitator in encouraging the production and use of energy generated

Table - 1 : Ernst & Young Renewable Energy Country Attractiveness Indices

Country	All Renewables	Onshore Wind	Offshore Wind	Solar PV	Solar CSP	Biomass
China	71	79	69	67	40	58
USA	66	70	56	70	75	61
Germany	63	63	73	65	22	63
India	63	71	42	68	63	58
Italy	61	65	53	67	59	56

Source: E&Y, November 2010

from renewable sources. The Ministry of New and Renewable Energy (MNRE), Government of India has set a target of 10,000 MW of energy production from renewable sources during the 11th Five Year Plan period (i.e. 2007 to 2012). The Government has also announced a slew of measures in the Union Budget 2010-11, including:

- ❖ An increase in plan outlay for the MNRE by 61% from Rs. 620 crore in 2009-10 to Rs.1,000 crore in 2010-11;
- ❖ Clean energy cess on coal produced in India/imported at a Rs.50 per tonne to be levied for creation of National Clean Energy Fund;
- ❖ Concessional customs duty of 5% to machinery, instruments, equipment and appliances etc. required for the initial setting up of photovoltaic and solar thermal power generating units;
- ❖ Exemption from Central Excise duty for the manufacture of rotor blades for wind energy generators, among others.

Going forward, such proactive measures are not only likely to be maintained but also strengthened. With strong support from the Government, backed by concrete measures, renewable energy is likely to become the cornerstone of an emerging industry based on clean energy, and one which would have enormous potential. Firms that manage climate-change risks and exploit these new emerging opportunities are likely to gain competitive advantage in the days to come.

Given this background, this study seeks to highlight the potential of renewable energy in India by analyzing the relatively newer sources of such energy, viz. solar (photovoltaic), wind and biomass. Chapter - 2 outlines the imperatives and the impinging needs of using new renewable energy under the evolving macroeconomic scenario of the country. Chapters - 3 and 4 examine the overall scenario of select renewable energy technologies, viz. solar (photovoltaic), wind energy and biomass energy, both globally and in India. These chapters also make an attempt to assess the market conditions and world trade in products relevant for the renewable energy sector (both single and multiple uses) and the potential that India offers in the deployment of these new renewable energy technologies. Chapter - 5 seeks to analyse the various modes of financing renewable energy at different levels of commercial production, apart from examining the various policy initiatives taken in major countries across the globe to promote the use of renewable energy industry. The concluding chapter endeavours to draw out a set of options for policymakers to promote production and use of renewable energy in India, both by improving general conditions and by creating a proactive market for renewable energy technologies in the country.

2: RENEWABLE ENERGY: A STRATEGIC IMPERATIVE

The world today fulfils its energy requirements from a wide array of energy sources. However, fossil fuels (viz. oil, coal and natural gas) account for around four-fifths of total energy use, a share that has largely remained unchanged for over a decade. These fossil fuels continue to remain dominant sources of energy primarily because they are relatively cheap and currently abundant, are energy rich, and the global infrastructure today is well positioned to produce, deliver and use them. Nonetheless, given the emerging scenario, it is of utmost importance to explore and understand the various other viable alternatives to conventional energy. This is all the more critical in light of the evolving energy transitions which are creating shifts in energy demand faster than ever expected, and as a result challenging the existing infrastructure and suppliers, and causing energy price volatility. This is further exacerbated by concerns over the possible longer-term supply constraints to conventional oil, gas and coal supplies, apart from the geographical distribution of these resources. Looming over everything is the increased urgency attached to the major driver of climate change – greenhouse gas (GHG) emissions. Energy-related GHG emissions account for about 70% of total emissions and are projected to increase by about 50% by 2030, unless supportive and effective policy measures are introduced[2]. Energy related carbon dioxide alone accounts for 61% - 65% of global greenhouse gas emissions[3].

The source of energy and its production is expected to have a profound effect on global development in the 21st century. Global warming is likely to have pernicious effects particularly for developing economies, with their high exposure and low adaptive capacity to climate change. Concerted efforts and putting together conducive policies to fulfil the twin objectives of energy sufficiency and climate change mitigation, through the promotion of renewable energy is highly desirable under such circumstances. As studies by the International Energy Agency (IEA), United Nations Inter-Governmental Panel Committee on Climate Change (IPCC), and other sources have indicated, in order to limit GHG emissions to 450 parts per million (ppm) by 2030, renewable energy measures will have to contribute 23% of potential GHG reductions.

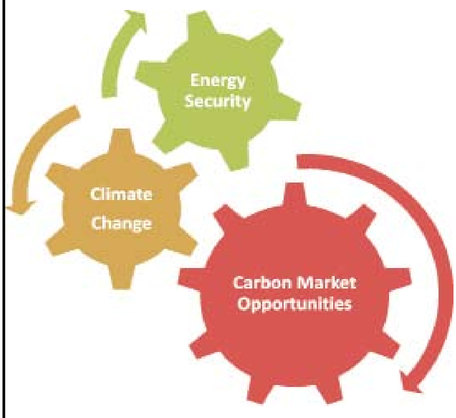
[2] Beyond Bonn: World Bank Group Progress on Renewable Energy and Energy Efficiency in Fiscal 2005 –2009

[3] International Energy Agency 2008, IPCC 2007

KEY DRIVERS OF RENEWABLE ENERGY IN INDIA

Given the twin objectives, there has been an increasing realisation on enhancing the use of renewable energy as a primary instrument for climate change mitigation. In a country like India, increasing investment in the deployment of clean technologies would not only help in reducing carbon footprints but also help in the provision of much needed energy and promote economic development. If commitments made by the key stakeholders to overcome policy, technical and financial barriers are accelerated, India could become a potential world leader in the development of renewable energy technologies, thereby playing a decisive role in combating climate change. With India becoming globally more responsible in its endeavour towards sustainable development, the possibility of renewable energy becoming a cornerstone for the country's future energy requirements are significantly high. The key drivers that are likely to further India's cause to promote renewable energy in the country are Energy Security, Climate Change, and Opportunities in the Carbon Market.

Exhibit 3: Key Drivers of Renewable Energy in India



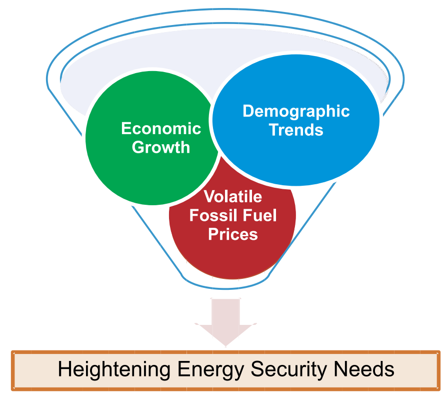
Source : Exim Bank Analysis

ENERGY SECURITY

Energy is the engine for growth and its access is of strategic importance to every country. Energy multiplies human labour and increases productivity in agriculture, industry and services. Thus, easier, cost-effective and sustainable access to energy in the developing world holds the key to bridging the widening inequality prevalent in such economies. While conventional sources of energy (oil, coal and natural gas) are currently easier in terms of access, primarily due to associated infrastructure designed for their conversion to usable forms, the same cannot be said of either their sustainability over medium and long-term or their cost-effectiveness. Over the past few years, oil prices have fluctuated sharply, jumping to a record high in July 2008 of US$ 147 per barrel and then falling back sharply to US$ 34 per barrel in December 2008. For the whole of 2009, the average oil price was still high – between US$ 60 and US$ 80 per barrel. With gas prices rising in line with the price of oil, the impact has been exasperated, accelerating the necessity for ensuring secure sources of energy.

The IEA defines energy security as "the uninterrupted physical availability at a price which is affordable, while

Exhibit 4: Factors Leading to Energy Insecurity



Source : Exim Bank Analysis

respecting environment concerns". However, security of energy supply is not only influenced by the cost of fuels but also by their long term physical availability. Countries without their own fossil fuel supplies have begun to evince increasing interest in renewable energy sources, not only because of the price stability they bring, but also because they are indigenous and locally produced. Thus, the adoption and promotion of renewable energy technology becomes critical for ensuring energy security. This is buttressed by the fact that the economics of renewables are expected to improve further as they develop technically, and as their saving of greenhouse gas emissions are assigned a monetary value. As far as India is concerned, energy security today has become a matter of prime concern, especially in light of the fact that the country imports more than three-fourths of its crude oil requirements. Given that renewable energy options are cost-effective compared to traditional measures in the longer term and on a lifecycle cost basis, coupled with their proven sustainability over longer periods, the adoption of renewable sources of energy is bound to shoot up if India is to ensure its energy security. Energy security, by itself, is a function of three primary factors – demographic trends, economic growth, and volatile fossil fuel prices.

Demographic Trends

The United Nations has predicted that the world population would increase from 6.5 billion in 2006 to 8.5 billion by 2030, an average rate of increase of a little more than 1% per year. This is bound to affect the size and composition of energy demand, a trend which would be further fuelled by increasing standards of living for many people especially in emerging countries like China and India, and by the increasing rate of urbanisation in these economies. In fact, as per the United Nation statistics, the share of world population living in cities crossed 50% in 2008 – growing by nearly 1.6 times more than rural population since 1950. It is projected that between 2010 and 2050, the global urban population would increase by 2.8 billion[4] - nearly 45% of the current world population. Of this, 58% would be accounted for by Asia, with China and India alone

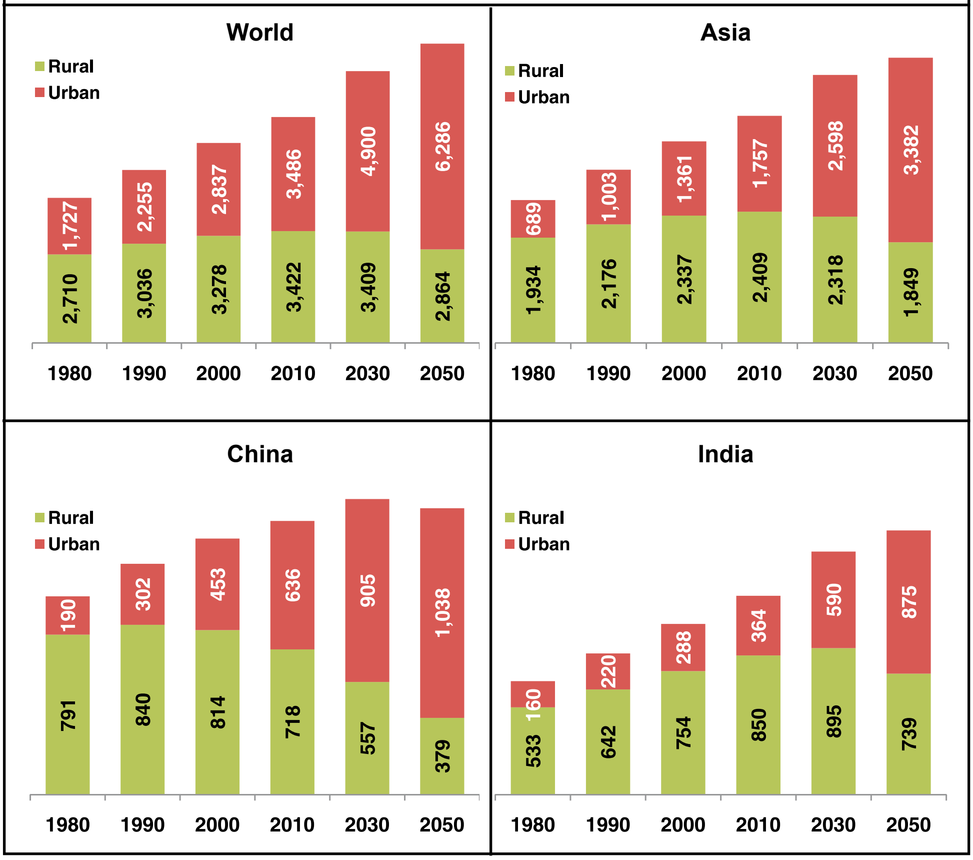
[4]UN's World Urbanization Prospects: The 2009 Revision Population Database (online accessed on July 26, 2010)

contributing 33% to the increase in global urban population between 2010 and 2050.

This scale of urbanisation would put tremendous pressure on existing energy resources – cities account for roughly 75% of global energy consumption and 80% of greenhouse gas emissions[5].

According to IEA's World Energy Outlook 2009, world primary energy demand is expected to increase by 1.5% per annum between 2007 and 2030, from a shade above 12,000 million tonnes of oil equivalent (MTOE) to 16800 MTOE – an overall increase of 40% during this period. In line with the urbanisation process, it will be the

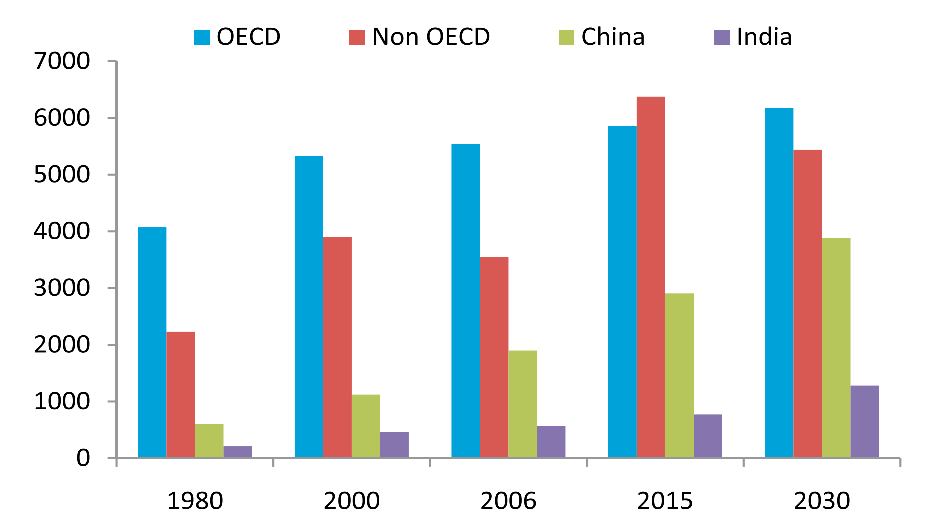
Exhibit - 5 : Rural and Urban Population Projections : World, Asia, China and India, (mn)



Source: UN's 2009 Revision Population Online Database accessed on 26.06.2010, Exim Bank Analysis

[5]United Nations as cited in "India's Urban Awakening", McKinsey Global Institute

Exhibit - 6 : World Primary Energy Demand Projections (MTOE)



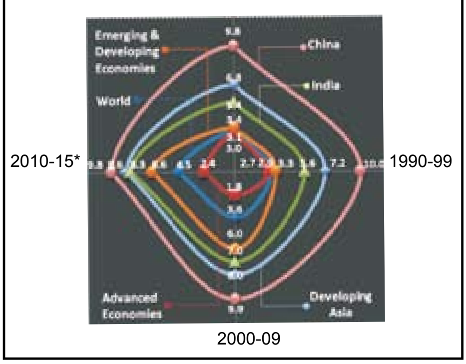
Source : World Energy Outlook, IEA, Exim Bank Analysis

emerging Asian economies that would be the main drivers of this demand, followed by the Middle East. The IEA predicts that by 2050, almost 70% of the energy needs will be originating from the developing countries, where growth will be propelled by a burgeoning population having large unmet energy demands and lower levels of energy efficiency. With urban Indian population predicted to swell by more than half a billion by 2050, India's task is cut out – the country is likely to face formidable challenges in meeting its energy needs and in providing adequate energy of desired quality in various forms in a sustainable manner and at competitive prices.

Economic Growth

Coupled with the increase in population and its rapid urbanisation, strong economic growth, especially in the emerging economies, has brought to fore the significance of energy security – both in terms of access to supplies and financial stability – for most emerging countries. The growth in energy use in

Exhibit - 7 : Real GDP Growth (Annual Average Percentage Change)



Note: Calculated from IMF Projections

Source : Derived from IMF Data Mapper online database accessed on July 27, 2010, Exim Bank Analysis these emerging economies is closely related to the growth in the modern sectors such as industry, motorized transport and formation of more urban centric lifestyles. This has been proven by various studies, most recently on the acceleration in energy demand arising out of stupendous growth in many of the East Asian economies.

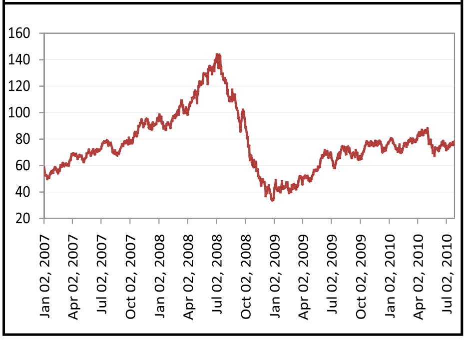
The IMF has projected that the world economy will grow at an annual average rate of 4.5% during the next 5 years (2010-15) – significantly higher than the average rates of growth recorded in the earlier three decades (1980-2009). This growth will be driven largely by developing Asia – China and India in particular. As against the projected growth of 2.4% for advanced economies during 2010-15, developing Asia is projected to grow by 8.6%, with China predicted to grow by 9.8% and India by 8.3%. Considering that energy is a fundamental component of economic progress, the dynamic growth in emerging economies of Asia would inevitably put an enormous pressure on energy resources as these economies would need significant energy to fuel their expansion.

Although India has remained an energy deficit economy, the supply has grown at a fair pace but not enough to fulfil the demand arising as a result of its strong economic performance. Energy deficit levels in India have remained consistently high with demand outstripping supply by 8% - 10% in recent times. Though, the number of households with access to electricity has risen over past decades, the access is still far from universal with availability of modern cooking fuels and technologies being still limited, especially in rural areas. According to WEO 2008, there are still more than 400 million people without access to electricity in India.

Volatile Fossil Fuel Prices

Over the past few years, oil prices have moved up and down in a very unpredictable manner, reaching a record high of US$ 147 per barrel in July 2008 and then falling back precipitously to US$ 34 per barrel in December 2008. Overall, average oil prices increased strongly from 2003 to mid-July 2008, after which prices collapsed as a result of concerns about the deepening recession. In 2009, oil prices trended upward throughout the year, from about US$ 42 per barrel in January to US$ 74 per barrel in December. Such highly volatile price fluctuations create uncertainty for the global economy. When firms and

Exhibit - 8 : Daily Crude Oil Prices - US$/barrel (Europe Brent Spot)



Source : US Energy Information Administration, Exim Bank Analysis investors are uncertain about future oil prices, they find it desirable to postpone investment decisions. As uncertainty about future oil prices increases, the value of postponing investment decisions increases in tandem. Further, uncertainty about how firms might fare in an environment of higher energy prices is likely to reduce investor confidence and increase the interest rates that firms would have to pay for capital. Together, these two effects tend to reduce investment spending, thereby destabilising overall economic activity. One of the primary reasons for the widely fluctuating fuel prices is the fact that supplies of all proven resources of fossil fuels – oil, coal and natural gas – are increasingly becoming scarce and more expensive to produce, thereby necessitating the need for ensuring secure and stable sources of energy supplies.

The recent global financial crisis, economic downturn, and significant fluctuations in energy prices, particularly crude oil, have made future price projections uncertain. The dramatic fluctuations in oil prices have resulted in higher forward price projections for fossil fuels. According to the US Energy Information Administration (EIA), Annual Energy Outlook, 2009, the Reference Scenario[6] predicts heightened concerns about oil prices. It is anticipated that given the GDP growth rates, non-OECD countries, especially India and China, will be amongst the largest consumers of oil, thereby leading to rise in imports and an economic burden. Under the Reference Scenario, oil prices are assumed to fall from the 2008 level of US$ 99.7 per barrel to US$ 61.3 per barrel in 2009, but then again rebound to touch at US$ 115.4 per barrel by 2020, and US$ 130 per barrel by 2030 (2008 dollar rate). The Outlook further predicts India's spending on oil and gas to surpass that of Japan's by 2020 to become the world's third largest importer, which again showcases India's rising propensity for oil in the years to come.

Exhibit - 9: World Oil Prices in Three Price Cases 1980-2030 (US$/Barrel)

Source : US Energy Information Administration, Exim Bank Analysis

[6]Reference Scenario are baselines against which a change in greenhouse gas emissions and removals is measured. These scenarios can be established on the basis of projections of the carbon stock changes that would have occuried from "business as usual" activities or from continuation of pre-1990 activities.

Despite seemingly large reserves of fossil fuels, like oil, in the world, it may become increasingly difficult to cater to future energy demand. Rising prices for these fuels would increase the cost-competitiveness of other sources of energy such as renewables, which could lead to more technical innovations in alternate sources of energy and incentivise their development, especially when fossil fuels become difficult and expensive to extract.

CLIMATE CHANGE

The move towards the adoption of renewable and clean energy technology is further strengthened by the wide scale proliferation of global warming leading to climate change. The threat of climate change emanates from the accumulation of greenhouse gases at an unprecedented rate in the atmosphere. Greenhouse gases make up only about 1% of the atmosphere, but they act like a blanket around the earth as they trap the heat and keep the planet warmer than it would otherwise be. A rise in temperature is accompanied by changes in climate such as cloud cover, precipitation, wind patterns, and the duration of seasons. Human activities are responsible for making the blanket thicker as the natural levels of these gases are being supplemented by emissions of CO_2 from the burning of coal, oil, and natural gas; through additional methane and nitrous oxide produced by farming activities and changes in land use; and by several long-lived industrial gases that do not occur naturally.

Climate change today is an inevitable consequence because of the past and current emissions. The climate does not respond immediately to external changes and GHGs will continue to affect the earth's natural systems for years, even if they are reduced and their atmospheric levels stop rising. Emissions of GHGs cumulate in the atmosphere because the rate at which they diffuse in the atmosphere exceeds

Box 1 : Peak Oil Theory

The research into the future of oil in energy mix often discusses the concept of "peak oil". This idea refers to the point at which half of the world's accessible reserves have been extracted. At that point, according to peak oil theory, oil production will start to drop and demand will outstrip supply.There have been many predictions about when the world will reach peak oil. M King Hubbert, the man who devised the theory and illustrated it in a bell shaped curve, estimated global oil production to peak in 1995. The International Energy Agency has estimated oil production to peak at some time between 2013 and 2037, whereas oil companies tend to argue that as technology continues to improve and make previously uneconomic deposits profitable to exploit, there will be ample supplies even after that.

the rate at which they decay naturally. Since pre-industrial times, increasing emissions of GHGs from human activities have led to a marked increase in atmospheric GHG concentrations. The United Nations Inter-Governmental Panel Committee on Climate Change (IPCC) has assessed that the global average net effect of human activities since 1750 has been one of warming. A temperature increase of 0.74°C occurred during the last century and for the next two decades, a warming of about 0.2°C per decade is projected as GHG emissions continue to rise at their current pace and double from their pre-industrial level. Even the 'best case' computer climate models[7] estimate the average global temperature to rise by 1.8°C to 4.0°C by the year 2100. An analysis by IEA (2008) projects annual GHGs to grow from 44 giga tonne (GT) CO_2 - equivalent (CO_2- eq.) in 2005 to 60 GT CO_2- equivalent in 2030, an increase of 35%. The share of energy related CO_2 emissions in total emissions is forecast to increase from 61% in 2005 to 68% in 2030.

The Copenhagen Accord, agreed at the climate change summit in December 2009, has the stated aim of keeping the increase in global temperatures to below 2°C, and then considering a 1.5°C limit by 2015. However, the national emissions reduction pledges submitted by various countries to the United Nations coordinating body, the UN Framework Convention on Climate Change (UNFCCC), in the first half of 2010 are likely to lead to a world with global emissions of between 48 GT of CO_2 equivalent and 54 GT of CO_2 equivalent per year by 2020, which is about 10%-20% higher than today's levels[8]. Further, it is to be noted that

Table 2: Impact of Policy Scenarios:
CO_2 concentration, Temperature increase, Emissions and Energy demand

CO_2 concentration (ppm)	Temperature Increase	Global emissions by 2030(GT)		Global Energy Demand (MTOE)		Expenditure on energy Efficiency & Power Plants (US$ trn)
		Energy Related CO_2	Total GHG	2020	2030	2010-2030
550	3^{0}C	33	48	14360	15480	4.1
450	2^{0}C	26*	36	14280	14360	9.3

* Emissions peak in 2020 at 32.5 GT and then declines to 25.7GT in 2030

Source: IPCC 2007, IEA 2008

[7]Large and complex mathematical computer programmes used to simulate global climate, models are based on mathematical equations that seek to represent the physical processes that govern the earth-atmosphere system.

[8]Energy Revolution Report 2010, Greenpeace

international consensus on long term stabilization targets are yet to be agreed upon. Most discussions focus on stabilization levels between 450 parts per million (ppm) and 550 ppm[9] of carbon dioxide equivalent[10]. Without government initiatives on energy or climate change, global temperatures may rise as much as 6°C by the end of 21st century. This outcome of the IPCC trend scenario can be compared with a 3°C rise under policy scenario[11] in which greenhouse gases are stabilized at 550 ppm of CO_2 eq. and a 2°C rise under a policy scenario (where policy agents like Governments of various countries make a concerted effort to mitigate rise in temperature) in which concentrations are stabilized at 450 ppm.

As far as India is concerned, total CO_2 emissions are about 4% of total global CO_2 emissions. India's per capita emissions, even with 8% to 9% GDP growth every year for the next decade or two, are likely to be well below developed country averages. Its energy intensity of production has been falling with improvements in energy efficiency, autonomous technological changes and economical use of energy. Various climate modelling studies indicate that India's per capita emissions will be around 2 tonnes to 2.5 tonnes of carbon dioxide equivalent by 2020 and around 3 tonnes to 3.5 tonnes of carbon dioxide equivalent by 2030, as compared to around 1 tonne to 1.2 tonnes presently. Though India has conveyed that its per capita emission levels will never exceed the average levels of developed countries, the Government needs to accelerate its clean energy framework by implementing suitable renewable energy policies at a faster pace.

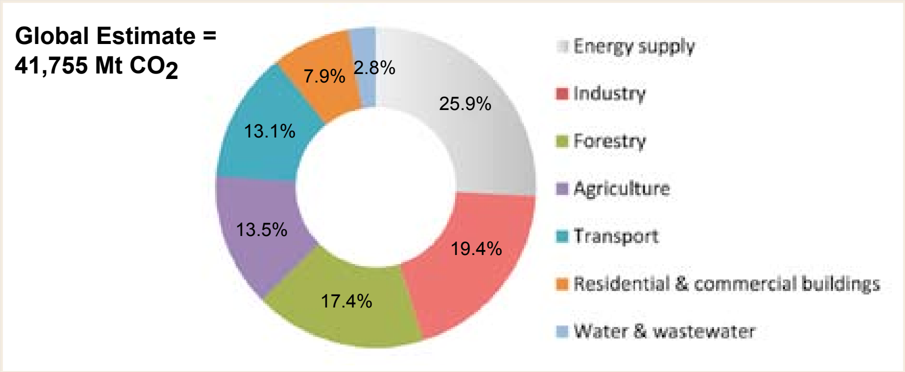
The preceding paragraphs clearly indicate that climate change today has become a major concern for the global community at large and countries across the globe are trying to find a cohesive solution for its mitigation. According to a recent research, global average surface and lower-troposphere temperatures during the last three decades have been progressively warmer than all earlier decades, and the 2000s (2000-09) was the warmest decade in the instrumental record. Further, atmospheric greenhouse gas concentrations continued to rise, with CO_2 increasing at a rate above the 1978 to 2008 average. The study drew on 11 different indicators of climate, and found that each one pointed to a world that was warming owing to the influence of greenhouse gases, a result of human activities. The need for mitigating climate change can

[9] A ratio-based measure of the concentration of greenhouse gases in the atmosphere. CO_2 is usually measured in parts per million; in 2007 the atmospheric concentration of CO_2 had passed 384 ppm - an increase of more than 100 ppm since 1750

[10] A unit of measurement used to compare the climate effects of all greenhouse gases to each other. CO_2 eq is calculated by multiplying the quantity of a greenhouse gas by its global warming potential. The term comes from the fact that CO_2 is the most common greenhouse gas and other gases are measured in units called "CO_2 equivalents".

[11] Policy scenario is one in which there is an intervention to mitigate climate change / rise in temperature

Box 2: Global Greenhouse Gas Emissions by Sector



Electricity generation is the single largest source of anthropogenic CO_2 emissions (greenhouse gas emissions resulting from human activities which include burning of fossil fuels for energy, deforestation, land-use changes and emissions of other GHGs) from large point sources and is forecast to be the fastest-growing source by 2050. This is largely because 41% of the world's energy production is coal-fired; and the global abundance and relatively cheap nature of coal ensures this trend is set to continue, with China and India rapidly building new coal-fired power stations. Although projections vary, global power generation capacity is forecast to approximately double to 33,000 terawatt-hours (tWh) by 2030, with fossil fuels, particularly coal, being the major fuel type.

The energy sector remains the largest contributor to climate change and is responsible for the largest growth in global GHG emissions. The weight of the energy sector in terms of its emissions means that there is no adequate restraint to climate change without solutions from the energy sector. Any significant reduction in carbon emissions will require a fundamental shift in the way power is produced. The 2008 International Energy Agency World Energy Outlook's most ambitious energy decarbonisation policy scenario foresees dramatic change in the power sector - with renewable technology playing a crucial role in the days ahead.

Source: IPCC, Fourth Assessment Report: Climate Change 2007 hardly be overstressed, especially for developing countries who are the most vulnerable. It is estimated that these countries would bear 75%-80% of the costs of damages caused by the changing climate. Even 2°C warming above preindustrial temperatures– the minimum the world is likely to experience – could result in permanent reductions in GDP of 4%-5% for Africa and South Asia[12]. If rising temperatures are to be kept within acceptable limits then there is a need to significantly reduce greenhouse gas emissions. Thus, the climate change imperative would call for enhanced usage of sources of energy which are carbon neutral – mainly the renewable sources. With a global consensus emerging on the importance of climate change mitigation, the usage of renewable sources is likely to be given a major thrust. According to IEA, the share of renewables in global primary energy demand excluding traditional biomass is projected to climb from 7% in 2006 to 10% by 2030. This has been assumed under the condition that renewable technologies are going to mature and that higher fossil fuel prices make renewables more competitive under a strong policy support regime. This rise in demand is projected to be met by the associated increase in supplies from renewable energy sources. According to WEO 2009, the use of non-hydro modern renewable technologies would witness the fastest pace of growth with most of the increase being in the power generation sector. The share of non-hydro renewables in total power output is projected to increase from 2.7% in 2007 to 8.6% in 2030, with wind power expected to witness the largest increase in absolute terms.

CARBON MARKET OPPORTUNITIES

While investment in renewable energy infrastructure is of paramount importance given the current scenario, the opportunity evolving as a result of this investment in the carbon market also remains promising and can act as an impetus to using clean and renewable technology. Carbon credits markets came into existence because of the increasing concerns for environment across the world. Credits can be exchanged between organizations at a price and are bought and sold in international markets at the current market price. This mechanism was actually finalized in the Kyoto Protocol[13] and the market mechanics thereafter were established through Marrakesh Accord. The Kyoto Protocol allocates caps or quotas on the maximum amount of CO_2 emission for developed (Annex-1 countries)[14] and developing countries. These are then converted

[12]State of the Climate in 2009, July 2010, US National Oceanic and Atmospheric Administration

[13]An international agreement that sets binding targets for the reduction of human-caused GHG emissions by 37 industrialized countries. It requires an emission reduction of 5% collectively from 1990 levels in the period 2008-12. Adopted in 1997 under the UNFCCC, and entered into force on 16th February 2005, it has been signed by over 180 countries.

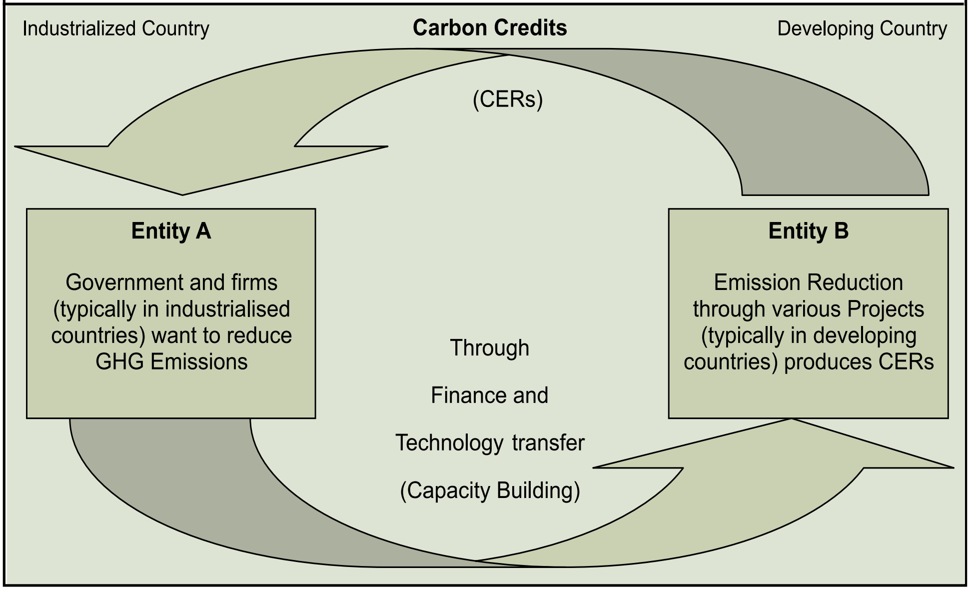
[14]Groups of countries with different obligations under international climate agreements: - Annex 1 countries include industrialized countries and economies in transition, which were committed to return their greenhouse-gas emissions to 1990 levels collectively.

into credits and businesses in a country, that have not used up their quotas and can then trade that unused quota with businesses that are about to exceed their quota as credits. For example, if an environmentalist group plants enough trees to reduce emissions by one ton, the group will be awarded a credit. If a steel producer has an emissions quota of 10 tons, but is expecting to produce 11 tons, it could purchase this carbon credit from the environmental group.

Meeting the Kyoto targets would entail public and private investments. Many industrialised governments that have ratified the Protocol have already begun implementing domestic policies and regulations that will require emitters to reduce greenhouse gas emissions, according to the established targets. So far, experience has shown that the cost of reducing one ton of CO_2 can range from US$ 15 up to US$ 100 in industrialized countries. By contrast, there are many opportunities to reduce greenhouse gases in developing countries at a cost of US$ 1 to US$ 4 per ton of CO_2. Hence, an emission reduction that was achieved at a lower range has value to a public or private entity in an industrialised country that is required by regulation to reduce its emissions.

It must be understood that carbon markets is not a sufficient condition, but it is an innovative mechanism for the transition to a low-carbon economy.

Exhibit - 10 : Concept of Carbon Credits

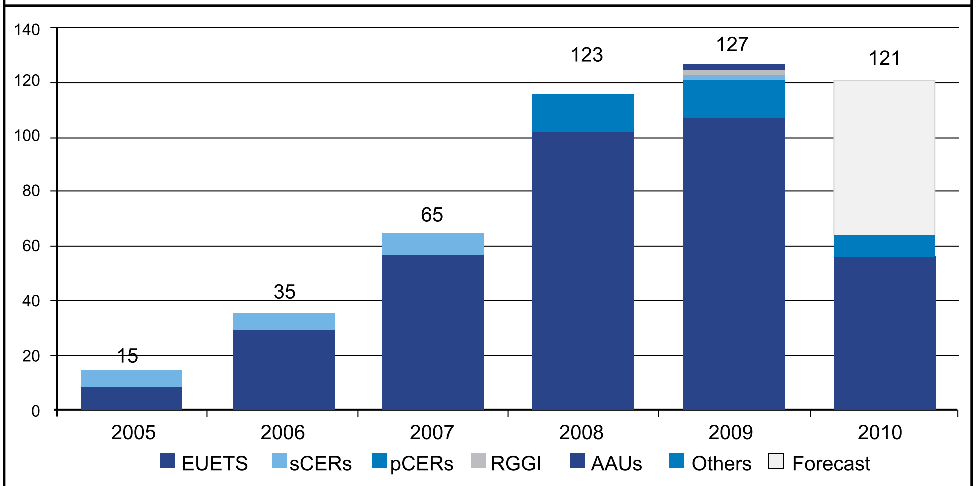


Source: Exim Bank Analysis

Governments play a crucial role in setting regulatory standards and in supporting low-carbon research, development and deployment. Flexible mechanisms that have emerged from the Kyoto Protocol have created the path for developing countries to participate in carbon markets. This has opened up newer opportunities for developing countries like India. These opportunities are best reflected in the size of the carbon market. Even as global GDP declined in 2009, the carbon market demonstrated exceptional resilience – the total value of the market grew 6% to US$ 144 billion by year's end with 8.7 billion tons of carbon dioxide equivalent (CO_2e) traded[15]. However, 2010 could witness the first year of negative growth for the carbon market with Bloomberg New Energy Finance projecting US$ 121 bn by end 2010, roughly a 5% decline from 2009. In the longer-term, however, and assuming passage of cap and trade legislation in the US, projections indicate that the global carbon market could turn over up to US$1 trillion per year by 2020.

The European Union Emissions Trading Scheme (EU ETS) remained the main driver of the global carbon market with a total of US$ 119 billion worth of allowances and derivatives trade in 2009. In terms of the three mechanisms of the Kyoto Protocol that enable emissions trading, viz. emissions trading, Clean Development Mechanism (CDM) and Joint Implementation, the CDM segment was the largest in 2009 at US$ 2.7 bn. China was the largest seller of Certified Emission Reduction (CER), although Africa and Central Asia, historically overlooked regions,

Exhibit- 11: Value of Global Carbon Markets (US$ bn)



Note: This data is marginally different from World Bank data quoted earlier

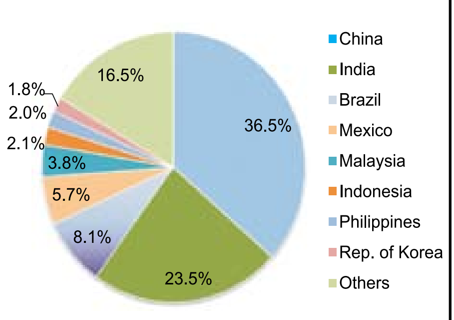
Source: Bloomberg New Energy Finance, Exim Bank Analysis

[15] State and Trends of the Carbon Market 2010, World Bank

increased their share as buyers sought diversification. Overall, Asia remains the leading supplier of CERs in the global carbon market, holding approximately 77% of the share. More than 3,714 projects are being developed under the CDM all over Asia across various sectors. Most of these are future installed power projects, which have a capacity of around 58 GW in hydro, wind, biomass, geothermal, biogas, landfill gas, solar, tidal, and energy efficiency-based own generation.

As far as India is concerned, it accounted for 23.5% of all registered CDM projects as of March 2010 (480 out of 2090 projects) and ranks second after China. Globally, China dominates the CDM market with close to 36% of volumes transacted with India being second even in terms of carbon credit transacted volumes in the world. The country has generated around 40 million carbon credits, and approximately 140 million are in pipeline. According to the Prime Minister's Economic Advisory Council, about 850 green projects with

Exhibit - 12: Registered Project Activities by Host Countries Total = 2090 (as on 12.03.2010)



Source : UNFCC, Exim Bank Analysis

a huge investment of US$ 14.45 billion are in pipeline, with revenues from 200 projects expected to earn around US$ 2.16 billion until 2012. Energy-efficiency projects from industries contribute to a major portion of the registered green projects. About 225 Indian projects in the fields of biomass, cogeneration, hydropower, and wind power with a potential of 225 million CERs have been registered.

Ever since it was established in 2001, the carbon market has captured the imagination of Indian entrepreneurs. The increasing opportunities emerging in the carbon market for India is bound to provide a strong impetus to the development of clean and renewable energy sector. The majority of projects that have sold carbon credits so far include renewable energy such as wind power, biomass cogeneration and hydropower. India, with a large portion of the population in rural areas, that have limited access to electricity, creates a big opportunity for the deployment of clean energy through solar, wind, or biomass. In terms of rural development and usage of renewable energy, there is an abundance of opportunities for the Indian developers, especially when the counterparts of the Annex-1 countries are ready to provide capital for development. This would help institutions in these countries achieve their reduction targets.

SUM UP

Given the current and the anticipated energy scenario, renewable energy technology is inevitably going to play a pivotal role in securing a sustainable global energy system in a country like India, with large disparity in energy dissemination. Though, renewable energy technology has relatively high installation costs, operating costs remains low. In many countries, some renewable energy technologies are already competitive compared to conventional energy sources, as for instance, biomass or biogas applications in Thailand. With a proactive policy of the Government of India, most renewable technology costs are expected to fall significantly below those of conventional energy sources within the next couple of decades. Monetising carbon emissions would further incentivise the application of renewable sources. Increased use of renewables is also an insurance against rising import prices of fossil fuels. One of the profound features of renewable energy technology is the essential longevity of renewable supply which is perhaps infinite in contrast to conventional energy sources. Introduction and deployment of renewable energy technology on a large scale will certainly help India to be self reliant to sustain the growth momentum in the years to come and mitigate issues like spike in fuel prices, energy scarcity, and above all, cater to the larger objective of climate change mitigation and sustainable development.

3. RENEWABLE ENERGY: A GLOBAL PERSPECTIVE

INTRODUCTION

In addressing the challenge of mitigating climate change, the source of primary energy is of fundamental importance. Most forms of economic activity rely on some type of primary energy. Since the dawn of the industrial revolution, reliance on fossil-fuels has been one of the main reasons for climate change. The preceding chapter illustrated the pressing needs to embrace renewable energy, both in India and across the world, and highlighted that breaking the direct link between energy use and greenhouse gas emissions through a switch to renewable forms of energy will not only be a pivotal step in addressing the problem of global warming but also serve to put economic growth on a low-carbon trajectory and in a more sustainable manner.

The application of energy derived from renewable sources has been expanding rapidly across the globe over the last few years, a consequence of consistent increase in investments in this sector. The main new renewable energy technologies along with their applications have been highlighted in Table - 3.

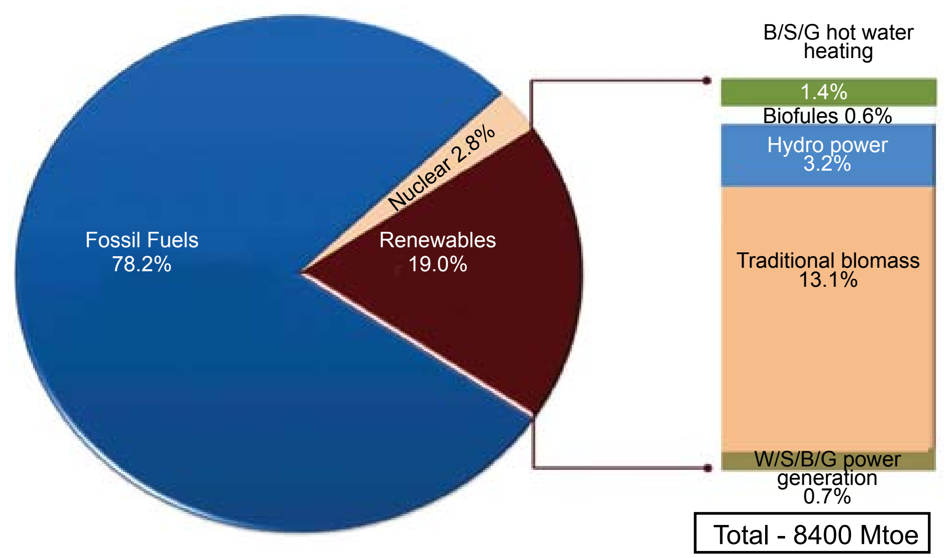
Renewable energy still accounts for a small share of the global energy mix. In 2008 (the latest period for which data is available), the share of renewable energy in world final energy consumption was 19%, a percentage point higher than that prevailed in 2006. However, one of the primary binding constraints that have prevented a wider usage and application of renewables as sources of energy has been their cost competitiveness vis-à-vis conventional sources of energy. The

Table 3 – Renewable Energy Sources and Technologies: Main Applications

Source	Electricity	Heating and Cooling	Transport
Wind	Onshore Offshore		
Solar	Photovoltaics Concentrated Solar Power	Solar Thermal	
Bioenergy	Biomass Biogas	Biogas Bioethanol	Biomass Biodiesel Biogas

Source: Exim Bank Analysis

Exhibit 13 : Renewable Energy Share in Global Final Energy Consumption (2008)



Note : W-Wind; B-Biomass; S-Solar; G-Geothermal
Source : Renewables 2010 Global Status Report REN21, Exim Bank Analysis

Table 4: Renewable Technologies – Typical Characteristics and Costs

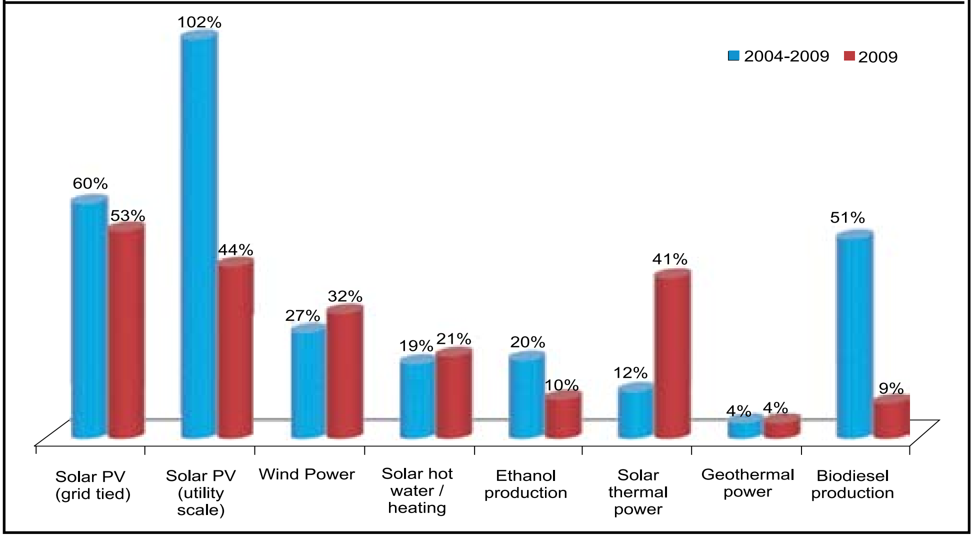
Technology	Typical Characteristics	Typical Energy Costs (U.S.cents/kilowatt-hour)
Power Generation		
On-shore wind	Turbine size: 1.5 MW–3.5 MW Blade diameter: 60 meters–100 meters	5–9
Off shore wind	Turbine size: 1.5 MW–5 MW Blade diameter: 70 meters–125 meters	10–14
Biomass power	Plant size: 1 MW–20 MW	5–12
Rooftop solar PV	Peak capacity: 2 kilowatts–5 kilowatts-peak	20–50
Utility-scale solar PV	Peak capacity: 200 kW to 100 MW	15–30
Rural Energy		
Biomass gasifier	Size: 20 kW–5,000 kW	8 –12
Small wind turbine	Turbine size: 3 kW–100 kW	15–25
Household wind turbine	Turbine size: 0.1 kW–3 kW	15–35
Solar home system	System size: 20 watts–100 watts	40–60

Note: Costs are indicative economic costs, exclusive of subsidies or policy incentives. Typical energy costs are under best conditions, including system design, and resource availability. Optimal conditions can yield lower costs, and less favourable conditions can yield substantially higher costs.
Source: REN 21

cost of renewable electricity generation has generally remained higher than those of existing coal or gas-fired power stations. The typical characteristics and costs of new renewable technologies have been presented in Table 4. Though currently high, it is important to note that existing infrastructure for power generation has been geared towards conventional energy sources. This is further exasperated by the fact that conventional energy sources receive an estimated US$ 250 billion to US$ 300 billion[16] in subsidies per year worldwide, resulting in heavily distorted markets which artificially reduce the price of power and keep renewable energy out of the market place. Add to this is the fact that the markets do not internalize the cost of carbon emissions from fossil fuels – if markets factored in the cost of climate damage from greenhouse gas pollution, the need for renewable energy support would dramatically reduce. Notwithstanding these factors, the economic viability of renewables are expected to improve as they develop technically, as related infrastructure is put in place, as the price of fossil fuels continues to rise and as their saving of CO_2 emissions are given a monetary value.

The primary source for global renewable energy has been traditional biomass, whose share in global energy consumption in 2008 stood at 13.1%, followed by hydro power at 3.2%. New renewables (wind, solar, biomass, geothermal) accounted for 2.7% share, marginally higher than 2.4% contributed in 2006 (Exhibit 13). The electricity sector is expected to be the pioneer of renewable energy utilisation. Many renewable electricity technologies have been experiencing steady growth

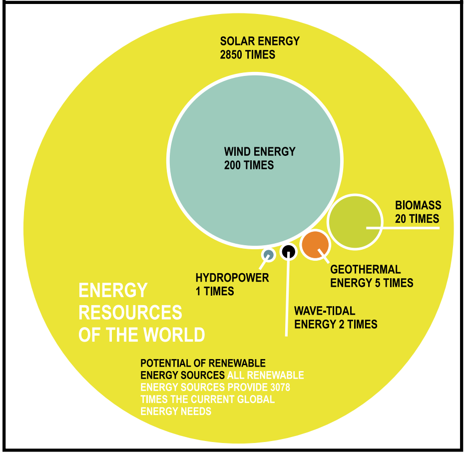
Exhibit- 14: Average Annual Growth Rates of Renewables Energy Capacity (end 2004-2009)



Source : Renewables 2010, Global Status Report, REN21, Exim Bank Analysis

[16]World Energy Assessment: Energy and the Challenge of Sustainability', United Nations Development Programme

Exhibit - 15: Renewable Energy Resources of the World



Source : German Advisory Council on Global Change

over the past two decades of up to 35% annually and, going forward, are expected to consolidate at a high level. In fact, it is projected that in the next couple of decades, the majority of electricity will be produced from renewable energy sources. The anticipated growth of electricity use in transport would further promote the effective use of renewable power generation technologies. Given this and the fact that majority of the application of energy generated from renewable sources is currently geared towards power generation – a trend that is likely to continue even in the foreseeable future – the analysis of renewables in this study has been based upon power generation as being the primary end-use of the energy so generated as opposed to energy utilised for transportation or for cooling and heating purposes.

In terms of power generation, renewable energy accounted for around 18% of global electricity production in 2009, although its share in power generation capacity at 1230 GW (7% growth over 2008) was a shade above 25% of the global capacity estimated at 4800 GW in 2009. The increasing significance of renewables in power generation can be assessed from the fact that renewable capacity accounted for 47% (140 GW) of all types of new generating capacity added to the world's grids (about 300 GW) cumulatively during 2008 and 2009. The cumulative renewable power capacity excluding large scale hydropower aggregated 305 GW in 2009, an impressive growth of 22% over the previous year. Within this, wind, solar (photovoltaic-grid) and biomass together accounted for 76.7% of global renewable power capacity. The average annual growth in energy capacities of various sources of renewable energy over the period 2004-2009 is depicted in Exhibit 14. As is evident, solar related sources have been the ones which have recorded the most appreciable growth rates.

While recent trends in growth of renewable energy capacities might appear impressive, the potential that these sources have as sources of energy is immense. This can be understood in better perspective if seen in the context of the maximum energy realisable from such sources in the absence of any technological or economic restrictions. Thus for instance, the energy in sunlight, on an average, is about one kilowatt per square metre worldwide[17]. According to the Research Association for Solar Power, in one day, sunlight which reaches the earth produces

[17] Energy Revolution Report 3rd edition 2010, Greenpeace and European Renewable Energy Council

2850 times the current annual energy requirement of the world, i.e. enough energy to satisfy the world's current power requirements for almost eight years. Even though only a percentage of that potential is technically accessible, this is still enough to provide nearly six times more power than the world currently requires. As per the Energy Revolution Report 2010, *"the total technical potential of renewable energy sources at the upper limit would exceed demand (of 503 Exajoules per annum in 2007) by a factor of 32. However, barriers to the growth of renewable energy technologies may come from economical, political and infrastructural constraints. That is why the technical potential will never be realised in total".* On the whole, it is estimated that the major sources of renewable energy could potentially provide more than 3000 times the current global energy requirements (Exhibit 15).

TRENDS IN INVESTMENTS IN RENEWABLE ENERGY SECTOR

Perhaps, as a reflection of measures to tap the aforesaid potential, investments in renewable energy capacities have been witnessing an upward trend. According to REN 21, total investment in renewable energy capacity (excluding large hydro) was about US$ 150 bn in 2009, as compared to US$ 130 bn in 2008. Of this, about US$ 100 bn was invested in new utility-scale renewable energy development (including biofuels refineries but excluding large hydro) and about US$ 50 bn in small-scale projects such as rooftop solar photovoltaic and solar hot water. In terms of components, there were significant investments in 2009 in plants and equipments to manufacture solar modules, wind turbines, and other generating devices. The importance accorded to renewables among international business can be gauged by the fact that the total investment of US$ 150 bn in renewable energy capacity represented nearly 40% of annual investment in the upstream oil and gas industry, which was a little over US$ 380 bn. Global venture capital and private equity investment in clean energy companies aggregated US$ 4.5 bn in 2009, while public markets investment in quoted clean energy firms reached US$ 12.8 bn. Government and corporate research, development, and deployment spending on clean energy technology in 2009 was estimated at US$ 24.6 bn, although a major proportion of which (68%) went to energy efficiency technologies. Germany and China were the investment leaders in 2009, each spending roughly US$ 25 bn to US$ 30 bn on new renewables capacity, followed by USA (with about US$ 15 bn in investment), Italy and Spain (about US$ 4 bn to US $ 5 bn each). The trend of strong investments in clean energy assets continued in 2010 with investments amounting to US$ 29.5 bn in the first quarter (Q1) of the year, an increase of about 63% over the corresponding period of 2009 and about 13.5% higher than the fourth quarter of 2009. Q1 of 2010 also witnessed a continuation of the recovery in venture capital and private equity investment in clean energy, which touched US$ 2.9 bn – a year-on-year increase of 93.3% and a quarter-on-quarter increase of 70.5%.

Table 5: Top 20 Investors of Greenfield Investments in Environmental Technologies Manufacturing, 2003–2009

Name of Company	World	Developed economies	Developing economies	South-East Europe & CIS
Vestas Wind Systems (Denmark)	21	13	8	
Siemens (Germany)	13	7	5	1
General Electric (United States)	13	3	10	
Abengoa (Spain)	12	10	2	
BP (United Kingdom)	12	10	2	
LM GlasFiber (Denmark)	11	7	4	
Areva Group (France)	10	6	4	
SW Umwelttechnik Stoiser & Wolschner (Austria)	10	10		
Sanyo Electric (Japan)	9	6	3	
Alstom (France)	8		8	
Kyocera (Japan)	8	2	6	
BioDiesel International (BDI) (Austria)	7	7		
Hyflux (Singapore)	7		7	
Bronzeoak (United Kingdom)	6		6	
Archer Daniels Midland (United States)	5	1	4	
First Solar (United States)	5	2	3	
D1 Oils (United Kingdom)	5		5	
EVN (Austria)	5	1	1	3
Owens Corning (United States)	5		5	
Carl-Zeiss-Stiftung (Germany)	5	5		

Source: UNCTAD, based on data from the Financial Times, the FDI Intelligence database

The increasing trend is also visible in cross border investments in low-carbon foreign direct investment (FDI) activities, primarily in renewables and environmental technology manufacturing. Greenfield investments in renewable power generation have generally been on the rise since 2003, except for a recent dip in developed and transition economies due to the financial and economic crisis. According to UNCTAD's World Investment Report 2010, there were 728 greenfield investments in renewable power generation and 806 in manufacturing of environmental-technology products (such as wind turbines, solar panels and biodiesel plants, as well as associated parts) during the period 2003-2009. The majority of investments in renewable power generation were in developed economies, mainly by established power utilities, with about 25% investments being in developing economies. Within the latter, cross-border mergers and acquisition operations were concentrated primarily in Brazil, China, India and Turkey. In the case of environmental-technology products, developing economies are becoming increasingly popular investment destinations, attracting more projects than developed economies over the past two years. Nearly half of the 806 reported investments during 2003-2009 were in developing countries, more than 85% of which involved developed country multinational companies (Table 5).

WORLD TRADE IN NEW RENEWABLES – AN ASSESSMENT

Set against this backdrop, this chapter would also seek to explore the global market and the potential thereof of three major sources of renewable energy (i.e. new renewables), namely, solar energy (photovoltaic), wind energy, and energy from biomass, which together account for more than three-fourth of global renewable power capacity. The chapter also makes an attempt to analyse the global trade of goods that could be considered relevant to the renewable energy sector using United Nations Commodity Trade Statistics Database (Comtrade). The analysis has been undertaken under the Harmonised System (HS) customs codes at the 6-digit level – the most disaggregated level of internationally traded products for which cross country comparison is possible. In the absence or rather paucity of products (under HS 6-digit level) that can be classified as being exclusively serving the renewable energy sector (i.e. single use exclusive items), the identification of goods and components used in renewable energy supply has been based on a study by the International Centre for Trade and Sustainable Development (ICTSD) entitled “Trade Flows, Barriers and Market Drivers in Renewable Energy Supply Goods”. There are 53 such products identified at HS 6-digit level, details of which are mentioned in Annexure 1. To the extent that most of the identified products are ‘multiple-use’ (i.e. only a small portion of these products might be related to the deployment of renewable energy technologies and products), the trade figures are likely to be exaggerated and have to be interpreted accordingly. Nevertheless, there are a couple of products that are predominantly single-use items and are directly linked to the new renewable energy markets. These products are photosensitive semiconductor devices (HS Code – 854140) and wind turbines (HS Code – 850231) and analysis of these two items would be undertaken in a greater detail in this chapter. The examination of multiple use products would serve to provide an indication of the trade potential for renewable energy goods and components, and even if a small percent of the total trade in these products is assumed to be directly related to the deployment of renewable energy, the amount would still be significant. As the ICTSD study notes *“The trade figures are much larger than actual trade in renewable energy supply* *products and components. First, most 6-digit HS codes that cover "single-use" products include unrelated products. Second, in the case of components, total trade under the provisions of a particular 6-digit HS code is included, although only a small part, if any, may be related to the deployment of renewable energy technologies and products. For instance, ball bearings are included because they are used in the production of wind turbines, but the data will include total trade in ball bearings used for any purpose… thus trade figures should not be read as 'trade in renewable energy supply products' but rather as trade in components that may, at least in part, be exposed to developments in the renewable energy sector"*[18].

Based on the methodology as outlined above, global exports of products which were related to (albeit only to a relatively small extent) renewable energy supply amounted to US$ 284.8 bn, exhibiting an average annual growth of 20.8% during the 5-year period 2004-2008 (refer Annexure 1 for details). Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes (HS 854140) was the single largest item exported amounting to US$ 43.2 bn in 2008 and also recorded an impressive average annual growth of 35.7% during 2004-2008. Other major export items included other chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products), not elsewhere specified or included: other detail (HS 382490 – US$ 39.0 bn), static converters (HS 850440 – US$ 37.4 bn), parts of electric motors, generators, generating sets and rotary converters (HS 850300 – US$ 20.1 bn) and gears and gearing, other than toothed wheels, chain sprockets and other transmission elements presented separately; ball or roller screws; gear boxes and other speed changers, including torque converters (HS 848340 – US$ 16.7 bn). Germany was the largest exporter of renewable energy supply related products with exports in 2008 aggregating US$ 40.3 bn followed by China (exports of US$ 37.4 bn), USA (US$ 26.9 bn), Japan (US$ 24.6 bn), France (US$ 11.6 bn) and Italy (US$ 11.5 bn). In terms of imports, USA was the largest importer in 2008 with imports amounting to US$ 35.2 bn followed by Germany (US$ 27.1 bn), China (US$ 25.8 bn), Spain (US$ 14.4 bn) and South Korea (US$ 9.8 bn). The remainder of this chapter would individually explore the market, trade and potential thereof and future outlook of the three new renewable sources of energy, viz. photovoltaic, wind and biomass.

PHOTOVOLTAIC INDUSTRY

The photovoltaic (PV) technology across the globe is rapidly progressing and is increasingly being considered as an innovative source of renewable energy. With concerns over the rising cost of conventional energy, and environmental

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[18]Trade Flows, Barriers and Market Drivers in Renewable Energy Supply Goods, ICTSD Issue Paper No. 10

implications, robust capital investments are being made in new and renewable energy sources, enabling technological breakthroughs in many streams. The PV technology is one of the most promising ways to generate electricity from sunlight in a decentralized manner, especially in un-electrified households and at unmanned locations. Solar PV technology enables direct conversion of sunlight into electricity. PV cells, commonly known as solar cells, are used to convert light (photon) into electricity. The essence of this process is the use of a semiconductor material which can be adapted to release electrons (the negatively charged particles that form the basis of electricity). The most common semiconductor material used in photovoltaic cells is silicon[19], an element most commonly found in sand. All PV cells have at least two layers of such semiconductors, one positively charged and the other negat ively charged. When light shines on the semiconductor, the electric field across the junction between these two layers causes electricity to flow. Greater is the intensity of the light, the greater will be the flow of electricity. A photovoltaic system does not therefore need bright sunlight in order to operate, and can generate electricity even on cloudy days.

The global solar PV technology is broadly classified into three categories, viz., first generation (silicon) technology; second generation (thin film) and third generation (concentrated PV) technologies. The first generation technology has significant capacity built up in countries like Germany, Japan and China. However, shortage of raw silicon restricts the global capacity under this technology, which has also restricted the production and increased per unit cost of production. The second-generation technology has been slowly coming into commercial scale with large number of firms, especially in Europe and North America, building up manufacturing capacities. The third generation technology has been developed to overcome the shortcomings of both first and second generation technology,

[19]Wafer based crystalline silicon (c-Si), amorphous silicon (a-Si), Copper-Indium-Gallium-Selenide (CIGS), Cadmium Telluride (CdTe) are known technologies for PV that are presently in production. Among these, c-Si is dominant PV technology and captures over 90% of the PV market.

Note: Average power output of a PV system is called ‘watt peak’ – as in kWp / MWp / GWp. To ease the reading, this paper voluntarily omits the “p” symbol for “peak”; thus, W, kW, MW or GW would stand for Wp, kWp, MWp or GWp.

Watts peak is a convenient measure because the output of typical devices varies widely with levels of sunshine and other conditions. Mean output will typically be much lower than peak output; however if a system has been installed in an appropriate situation, peak output should be achieved under good conditions (e.g. the afternoon of a sunny summer’s day). Even under these conditions, however, not all the peak output will be delivered to the users, since (at least in typical household situations) some power will be lost in the conversion of the DC current produced by the photovoltaic cells into the AC required for household use.

and aims to provide higher efficiency at lower manufacturing cost. Some of the PV categories under this technology include: dye-sensitised solar cells, quantum dots, nano-antennae, nano-modified materials and organic cells. The innovations in the third generation technologies have been primarily occurring in the North America region. In India, the third generation technology could be a success, as it can be cost effective and has the potential to match grid parity in the years to come. This technology can simultaneously resolve the critical challenges of energy, economy, and environment. Power generation using this technology can also bring electricity into rural areas that do not have sufficient power network. It is not only zero-emission technology but also supports local job and wealth creation, thus fuelling local demand. This inherent scalability allows for applications to be placed directly at the point of need, be it a 50 kW rooftop installation for an office, or a 50 MW single-axis tracker installation for a utility substation. Decentralized solar power could minimize the massive complications that come with conventional centralized energy.

The Global Photovoltaic Industry Structure

The solar PV industry can be broadly categorised into three separate value chains – upstream, manufacturing, and downstream – as illustrated in Table 6. The most important part of the upstream segment is the production of the main raw material – polysilicon. The refinement and production of silicon is very capital and energy intensive and requires high-tech equipment. Historically, the silicon industry was dominated by a handful of firms from Germany, the United States, and Japan that supplied the global semiconductor industry with high-purity silicon. However, several new entrants, mostly from Asia, are now reshaping the industry, competing largely at the lower end of the market with lower grade silicon that can only be used for solar cells.

The manufacturing segment involves various stages with the first stage comprising wafer manufacturing wherein the process involves casting silicon in big furnaces and slicing them into wafers. Wafers are primarily produced through the multi-crystalline process because of its cost advantage and higher throughput levels. Wafers are then turned into solar cells through a five-step process: etching and polishing, cleaning, diffusion, antireflective coating, and screen printing. After the individual cells have been created, they are soldered together in series and encapsulated in multiple layers of glass and plastic to form a solar module. While wafer and cell production are relatively sophisticated and capital intensive (globally, only about 50 firms are active in wafer manufacture and around 100 firms in cell manufacturing business), module manufacturing has low entry barriers given its reliance on labour and relatively low capital requirements. Thus, this segment has witnessed many new entrants in recent years, particularly from China and other emerging markets. In 2009, around 500 firms were competing globally for market share. The balance

Table 6: The Global Photovoltaic Industry Value Chain

VALUE CHAIN	STAGE	TYPICAL CHARACTERISTICS
UPSTREAM	Research & Development	Mostly in-house at integrated solar firms and component suppliers.
	Polysilicon production	Global supply dominated by 8 OECD firms but many new entrants; most producers focus on silicon production but some also produce wafers and some integrated solar firms have expanded to silicon production; high entry barriers.
	Other materials	Materials other than silicon such as glass, aluminium, etc. for panels or other components.
MANU-FACTURING	Wafer manufacturing	Around 50 companies globally: integrated solar firms, silicon suppliers, and wafer-module manufacturers; relatively high entry barriers.
	Cell manufacturing	More than 100 companies globally: Cell manufacturers only; wafer-module manufacturers and integrated solar firms; relatively low entry barriers.
	Module manufacturing	More than 400 companies globally: integrated solar firms, wafer-module manufacturers and cell-system manufacturers; very low entry barriers.
	BOS components manufacturing	Production of inverters, mounting structure, batteries and other electronic equipment.
DOWNSTREAM	System design	Design of rooftop and field installations: integrated solar firms, system integrators and external service firms.
	System integration	Final manufacturing of BOS components: integrated solar firms and system integrators
	Project development	Development of larger-scale projects: integrated solar firms, system integrators, external service firms.
	Financing	Integrated solar firms and project developers with banks and other financial services providers.
	System installation & construction work	Local providers of construction and installation services
	Operation and maintenance	Integrated solar firms, system integrators, external service firms.

Source: World Resources Institute

Box 3 : Photovoltaic Basics

Simply put, photovoltaic is the creation of electricity from a light source – here sunlight. A large area diode made of semi conducting materials, upon radiation of sunlight produces electricity. Semi conducting materials have electrical conductivity intermediate to conductors and insulators.

A basic photo voltaic cell is also known as a solar cell and is made up of materials like silicon, commonly used in the microelectronics industry. Simply put, it is a large area diode or a positive-negative junction. A thin semiconductor wafer is specially treated for it to be able to create an electrical field - positive on the one side and negative on the other. When light energy strikes the wafer or solar cell, it generates two types of charge carriers termed as electron (negative polarity) and hole (positive polarity). The electric field present in the material helps separate carriers of opposite polarity resulting in a voltage. If an electrical load, for example a bulb is attached to the positive and negative sides of the cell, it results in electric current.

When a large number of solar cells are connected together electrically and mounted on a frame or platform, it is known as a solar photovoltaic module. Photovoltaic modules can be used to generate and supply electricity at certain voltages - a 12-volt system being the most common.

An array is an interconnection of large number of modules to meet the higher wattage requirement of load. The larger the area of the modules and arrays, the higher the amount of electricity produced. Photovoltaic modules and arrays produce Direct-Current (DC) electricity. They can be connected in both series (for higher voltage) and parallel (for higher current) electrical arrangements to produce any required voltage and current.

Solar Photovoltaic modules generate power when exposed to sunlight. This power can be harnessed in several ways - depending on how the electricity has to be used. Typically there can be 2 types of systems: Grid Tied Systems[20] and Off Grid[21] (Standalone) Systems. Depending on the requirement, the modules are typically connected to a battery via a charge controller - that regulates the amount of charge on the battery and prevents discharging. The power now obtained from the charged battery is in the form of Direct Current (mostly used in Standalone Systems) which can be converted to Alternating Current (mostly used in Grid Tied Systems) by an inverter.

[20]Grid-connected PV power installed refers to the total PV power installed, which is connected to the grid and registered by the energy regulator at the end of the year.

[21]Off-grid PV power installed refers to the total PV power installed, which is not connected to the grid. Typical off-grid applications are repeater stations for mobile phones, electrification for remote areas or rural electrification in developing countries.

Box 4 : Applications of Solar PV Systems

Solar PV systems find applications in diverse areas such as households, agriculture, telecommunications, defence, and in manufacturing sector for generation of power. A few applications in both domestic and industrial sector have been covered below: -

Solar PV for Outdoor Lighting

Solar street lighting systems basically consist of a PV panel, inverter and storage battery connected to a light source. It can replace conventional outdoor lighting system and operate for more than 8 hours a day. These systems have been installed in many industrial complexes. The cost of solar streetlight would vary from ₹ 18,000 to ₹ 21,000 per system. These systems can be fitted with automatic sensors, which would switch on/switch off the solar street lighting depending on the light intensity.

Solar Water Pumping Systems

Solar power is used for pumping water to agricultural and industrial use. These systems consist of solar panels, DC – AC converter in case of AC motors, flow optimizer and a submersible pump. These systems can be installed in open wells and bore wells to the depth varying from 30 feet to 80 feet. Depending on the depth and solar radiation, water output would vary.

Solar Photovoltaic Power Plant

A typical solar power plant consists of solar array, charge controller and inverter and AC distribution system. Though the initial investment for solar PV power plants is high, it is economically viable if the life cycle cost approach and environmental benefits are considered.

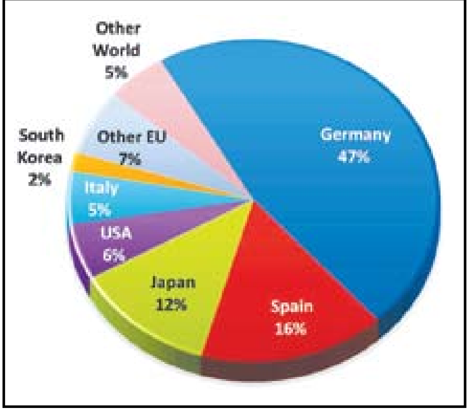
Building Integrated Photovoltaic (BIPV) module

Photovoltaic power systems integrated with building design allow the possibilities of combining energy production with other functions of the building envelope, including structural support, weatherproofing, shading etc. Cost savings through these combined functions can be substantial. Building Integrated Photovoltaic modules allow the architect to create environmentally benign and energy efficient buildings without sacrificing comfort, aesthetics or economy. Cost of BIPV systems is site and location specific and would be higher than the normal solar PV system of same capacity. However, since BIPV systems are installed either on roof or sidewalls of a building, the structural cost would be substantially reduced.

of system (BOS) components includes a wide range of goods such as solar panel mounting equipment, PV charge controllers, PV current monitoring devices, inverters, cables and wiring, connectors, etc. System integrators do not produce these components themselves but overwhelmingly source them from external suppliers.

The downstream stage largely involves the PV system integration and varies greatly between different applications. While some vertically integrated firms are active in the full range of downstream activities, from system integration to installation and maintenance, other firms in the market are active as big developers, smaller independent firms, or utilities that have large enough installations to run their own development operations. Given that the countries across the globe have a differing set of incentives for various PV applications, the downstream segment is rather heterogeneous across countries worldwide.

Exhibit - 16 : Solar PV: Existing Capacities in Top 6 countries (2009)

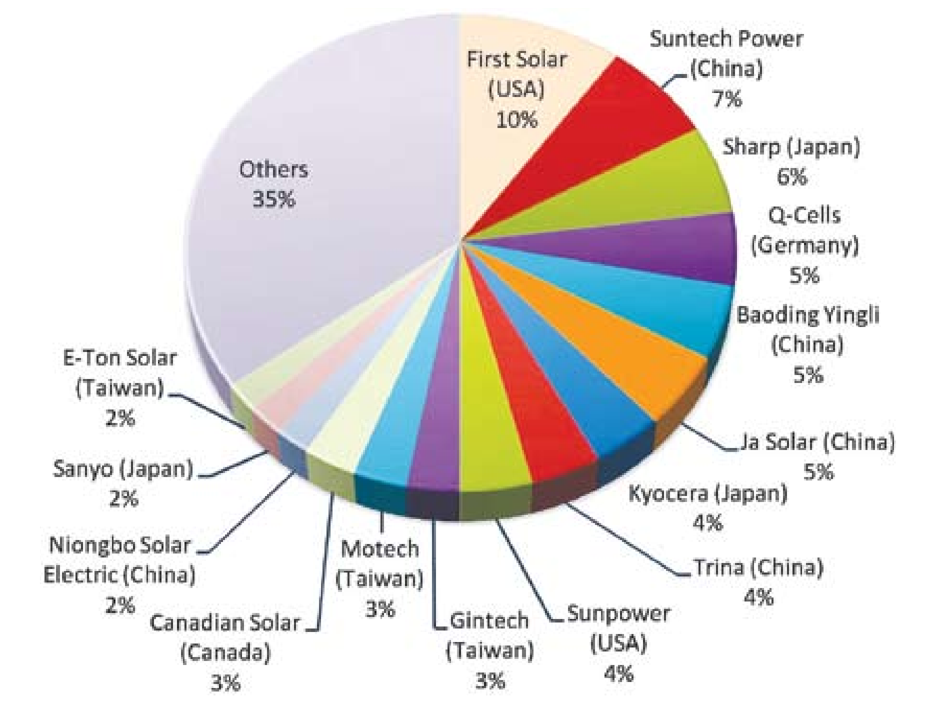


Source : Renewables 2010 Global Status Report, REN21, Exim Bank Analysis

The PV Industry – A Global Overview

The global photovoltaic (PV) market has been growing at over 40% per annum in recent years and the contribution it can make to electricity generation is increasingly gaining significance. The importance of PV stems from its decentralised/centralised character, its flexibility for use in an urban environment and huge potential for cost reduction. The current research and development in the PV industry is focused on improving existing modules and system components by increasing their energy efficiency and reducing raw material usage. While technologies like PV thin film or dye sensitive solar cells are developing rapidly, the mature technology, viz. crystalline silicon, is consistently increasing efficiency while simultaneously reducing cell thickness (from 230 to 180 microns over the last five years). Consequently, electricity capacities using PV panels have been moving northward, with global PV installations in 2009 being almost six times the 2004 level. Thin film's share of the global market increased from 14% in 2008 to 19% in 2009 for PV cells and from 16% to 22% for PV modules. The global cumulative PV capacity (grid-connected and off-grid installation) reached 25 GW in 2009. The addition in grid-tied PV capacity alone is estimated to be 7 GW in 2009 with off-grid accounting for 3 GW to 4 GW. More than half of the new installations in 2009 (grid connected) were in Germany, which continued to

Exhibit - 17 : Shares of Top 15 Solar PV Manufacturers in 2009



Source : Renewables 2010 Global Status Report REN21, Exim Bank Analysis

be the country with the largest solar PV electricity capacity amounting to 9.8 GW in 2009 (47% share), followed by Spain (with 3.4 GW capacity), Japan (2.6 GW) and USA (1.2 GW). Even in terms of new installations, Germany led the way with an addition of 3.8 GW of solar PV capacity in 2009 followed by Italy (0.7 GW), Japan (0.5 GW) and USA (0.4 GW). Other major markets included the Czech Republic, which witnessed a nine-fold increase in total capacity to 411 MW compared to the level prevailed in 2008, primarily due to generous feed-in tariff structure for solar PV, followed by Belgium (292 MW), France (185 MW, with another 100 MW off-grid by end 2009), and China (160 MW) (Exhibit 16). In fact, the Czech Republic installed more new solar PV per capita than any other country except Germany. The trend towards large-scale (greater than 200 KW) PV plants continued around the globe, with the number of such plants exceeding 3,200 in 2009, up from 2,450 during the previous year. The majority of these plants are operating in Spain, Germany, and the United States, although an increasing number are being installed in Asia.

The solar PV industry witnessed a decline in PV module prices in 2009,

Box 5 : Feed-in Tariff (FiT)

A Feed-in Tariff (also called Feed-in Law, Solar Premium, Renewable Tariff or Renewable Energy Payments) is a premium rate paid for electricity generated from renewable sources, fed into the distribution grid, through Government schemes / legislation. By early 2010, at least 50 countries around the world had adopted FiT regulations supporting generation of renewable energy. Germany is considered to have introduced one of the most successful FiT laws in the world. This is being measured in the growth of renewable energy fed into the distribution grid, and the increase in investments in installed PV capacity.

FiT is being introduced in a number of countries, as the entry costs of renewable energy are higher. The pricing mechanism in the market fails to recognize the hidden advantages of renewable energy, such as environmental and social benefits. FiT redresses such systemic market failures and encourages the usage of renewable energy, through a financial incentive package. Feed-in tariffs are seen as the best way forward, especially in developing countries. By 2009, this system had incentivised 75% of PV capacity worldwide and 45% of wind capacity. Based on experience, feed-in tariffs are the most effective mechanism to create a stable framework to build a domestic market for renewables. They have the lowest investment risk, highest technology diversity, lowest windfall profits for mature technologies and attract a broad spectrum of investors.

from an average of US$ 3.5 per watt in early 2008 to about US$ 2.0 per watt in December 2009. This price decline resulted in a purchasing lag as many buyers, expecting further price declines, waited until late in the year to place orders. Many firms were stuck with high-priced contracts for material supplies, and found it difficult to reduce costs. To retain competitiveness, firms focused on increasing efficiency, reducing operating costs, and increasing capacity utilization at factories. Low-cost, high-quality manufacturing and the ability to respond to rapidly changing market conditions became the hallmark of resilient and profitable players. At the firm level, the major companies engaged in the global photovoltaic sector are presented in Exhibit 17. As is evident, these are primarily firms based increasingly in Asia, especially Japan, China and Taiwan – perhaps an indication of their local deployment in future and also of the importance accorded by the respective governments to clean technology. The top 15 PV cell manufacturers produced 65% of the 10.7 GW of cells manufactured in 2009 with firms in China and Taiwan together producing nearly half (49%) of the global total, followed by Europe (18%), Japan

Table 7: Global Exports of Photovoltaic and Related Goods (US$ mn)

S. No.	HS Code	2004	2005	2006	2007	2008	Avg. Annual Growth (%)
1	854140	12980	15692	20359	27427	43189	35.7
2	850440	19887	21892	26678	32981	37398	17.2
3	841989	4780	5122	5785	6624	7939	13.6
4	841990	3443	4161	4759	6619	7026	20.1
5	900190	4733	5324	5873	6340	6394	7.9
6	850239	1688	1570	2112	2766	3630	22.4
7	711590	1206	1414	2079	2527	2872	24.9
8	841919	935	1093	1372	1668	2287	25.3
9	900290	1510	1560	1629	1652	1606	1.6
10	732290	845	947	1050	1153	1191	9.0
11	700991	571	603	674	780	888	11.7
12	700992	500	584	632	775	796	12.6
13	830630	412	405	439	471	411	0.3
14	900580	305	314	341	344	376	5.4
	Total	53795	60681	73782	92127	116003	21.3

Note: Product descriptions corresponding to respective HS codes are given in Annexure 1.

Source: UN COMTRADE Database, Exim Bank Analysis

(14%), and USA (6%). Favourable policy frameworks are expected to further accelerate PV deployment in these countries. The annual global PV capacities could increase exponentially, if appropriate policies including Feed-in Tariffs (FiT) are implemented on a wider scale.

International Trade in Photovoltaic

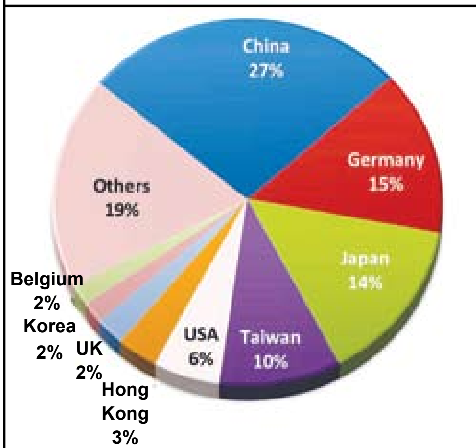
As outlined earlier, the products considered to be related to PV trade are primarily multiple use items with the exception of photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels and light-emitting diodes (HS 854140). If all such multiple use products are included, then global exports amounted to US$ 116 bn in 2008, an average annual growth of 21.3% during the period 2004-2008 with increase in 2008 alone being 25.9% (Table 7). The major exporters included China (US$ 25.8 bn), Germany (US$ 15.5 bn), Japan (US$ 11.8 bn), USA (US$ 9.9 bn) and Taiwan (US$ 6.2 bn). China and Germany are countries with the most vigorous growth rates in exports of PV related products recording an average annual increase of 43.2% and 29.7%, respectively during the 2004-2008 period. China, USA and Germany figured among the top five countries even in terms of imports in 2008 with China recording imports of US$ 14.8 bn, followed by USA at US$ 13.9 bn and Germany at US$ 13.0 bn. Other major importing countries were Spain (US$ 9.6 bn) and Hong Kong (US$ 6.4 bn). Among the major markets, Spain exhibited the maximum dynamism with an exceptional average annual growth rate of 97.7% during 2004-2008.

As far as India is concerned, it was ranked the 20th largest country in 2008, both in terms of exports as well as imports of photovoltaic and related goods. While India's exports amounted to US$ 1.3 bn, the country's imports of PV goods were marginally higher, aggregating US$ 1.4 bn. However, the encouraging point to note is that exports of PV and related goods from India have been far more robust, having recorded an average annual increase of 55.8% during the 5-year period between 2004 and 2008 as against that of 45.7% (still high) registered for imports during the same period.

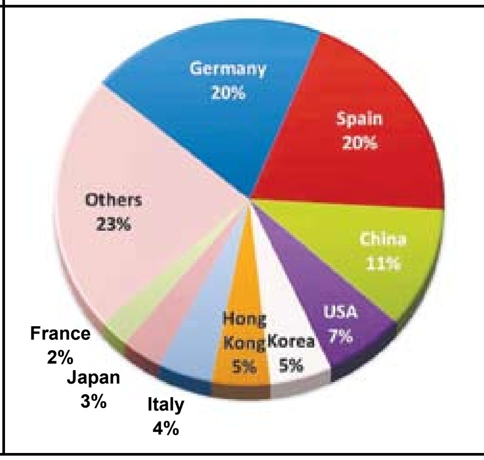
The key single-use item identified for solar energy is photovoltaic cells whether or not assembled in modules or made up into panels and light-emitting diodes (PV panels/ modules HS-854140). Global exports of this product amounted to US$ 43.2 bn in 2008, recording an average annual increase of 35.7% during the period 2004-2008. PV panels/modules represented a share of 37.2% in global exports of US$ 116 bn of solar energy related goods and components. Germany and China were the two main players in both export and import of PV panels/ modules in 2008, accounting for 15% and 27%, respectively, in exports and 20% and 11%, respectively, in global

Exhibit - 18: International Trade in PV Panels – Major Players (2008)

Major Exporters of PV Panels (2008)
Total US$ 43.2 BN



Major Importers of PV Panels (2008)
Total US$ 43.2 BN



Source: Derived from UN COMTRADE Database, Exim Bank Analysis imports of PV panels/ modules. Other major exporters of PV panels/modules were Japan (14%), Taiwan (10%) and USA (6%), while major importers included Spain (20%), USA (7%), Korea and Hong Kong (5% each) (Exhibit 18). In addition to being the single largest exporter of PV panels in 2008, China also registered the best performance after Czech Republic, recording an average annual growth rate of 107% during 2004-2008, increasing its exports from US$ 0.6 bn in 2004 to US$ 11.7 bn in 2008.

Czech Republic merits a special mention here considering that it managed to increase its exports of PV panels by over 100 times – from a near negligible figure of US$ 8 mn in 2004 to as much as US$ 862.5 mn in 2008 which resulted in its share in global exports increasing from a mere 0.1% to 1.7% during the 2004-2008 period. Analysing the reasons for the success of Czech Republic would provide key lessons for India – a topic which has been touched upon separately in this study. India has also fared rather well in terms of exports of PV panel, which, though not as spectacular as the Czech Republic, increased by more than six-fold from US$ 85 mn in 2004 to US$ 529 mn in 2008 (1.2% share in global exports), making it the 15th largest exporter of PV panels/ modules in the world in 2008. In terms of import, India was ranked 20th in 2008, with total imports of PV panels/ modules amounting to US$ 420 mn, as against US$ 45 mn recorded in 2004.

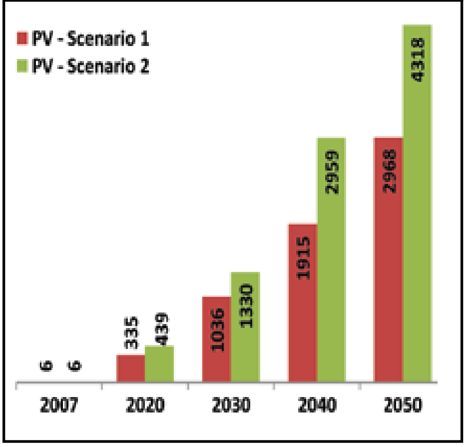
Germany, Spain and China together accounted for more than half (51%) of the world imports of PV panels/modules in 2008. In the case of Germany, imports of PV panels/ modules have recorded an average annual growth of 47.2%, increasing from US$ 1.88 bn in 2004 to US$ 8.35 bn in 2008. China has emerged as the largest supplier of PV panels/modules to Germany, increasing its share from 9.6% in 2004 to 38.5% in 2008, mainly at the cost of Japan, the second largest supplier whose share slipped from 38.2% to 10.7% during this period. Another notable exporter to the German PV market was the Czech Republic, whose exports to Germany aggregated US$ 720 mn in 2008, an exponential average annual increase of 318.2% during 2004-2008, resulting in an increase in its share from just 0.3% to 7.7% during this period. India was ranked the ninth largest supplier of PV panels to Germany with its exports totalling US$ 207 mn in 2008, an average annual growth of 30.4% during 2004-2008.

The second largest import market for PV panels/modules was Spain, marginally less than Germany with imports amounting to US$ 8.27 bn in 2008, an average annual growth of 204.8% during 2004-2008. The remarkable feature of Spain has been its stupendous increase in imports of PV panels/modules, which has catapulted the country from being the 19th largest importer in 2004 (when its imports were just US$ 103 mn) to the second largest importer in 2008. The main country to gain from this spurt in Spanish demand has been China which increased its export of PV panels to Spain from a mere US$ 7 mn in 2004 (6.4% share) to as much as

US$ 4391 mn in 2008 (53.1% share), making it by far, the largest supplier of PV panels/modules to Spain. Other countries which leveraged on Spain's increasing appetite for PV panels/ modules were Germany and Taiwan, with exports of the former increasing from US$ 28 mn to US$ 1694 mn while exports of latter increased from US$ 4 mn to US$ 564 mn during the 2004-2008 period. India also fared well in the Spanish PV market, increasing its exports from just US$ 3 mn in 2004 to US$ 231 mn in 2008 (an average annual growth of 231.3%), thereby positioning the country as the fifth largest source of PV imports for Spain in 2008.

The third largest market of PV panels was China with imports aggregating US$ 4422 mn in 2008 as against US$ 2064 mn in 2004. China sourced its demand for PV panels/ modules predominantly from Asia with Japan, Taiwan, South Korea and Malaysia being the top four suppliers, together catering to 71.0% of the country's imports of PV panels/ modules in 2008. The only non-Asian suppliers among the top 10 importing sources for China in 2008 were Germany (US$ 116 mn) and USA (US$ 85 mn). It is indeed a matter of further analysis that China's neighbouring country India, with exports of US$ 1 mn in 2008 to China, was ranked way down at 26th position. It is even more surprising that India's exports of PV panels to China have in fact declined consistently from US$ 5 mn in 2006 to US$ 2 mn in 2007 and further to US$ 1 mn in 2008 while the same figures for India's global exports of PV panels show a clear upward trend with exports of US$ 131 mn in 2006, US$ 207 mn in 2007 and US$ 523 mn in 2008.

Exhibit - 19 : Projected Electricity Generation Capacity from Photovoltaic Under Two Scenarios (in GW)



Source : Energy Revolution Report 2010, Greenpeace, Exim Bank Analysis

PV Market – Outlook

The global photovoltaic market has been growing at a rapid pace, a trend which is likely to continue or even bettered in the foreseeable future. Consequently, it is going to play a significant role in the global energy mix, especially in terms of contribution to electricity generation. The importance of PV stems from its decentralised/ centralised character, its flexibility for use in an urban environment and huge potential for cost reduction that it offers. Added to this is the fact that the source of PV energy is virtually unlimited - there is enough solar radiation available globally to provide 2850 times as much energy as is currently in use worldwide. On a global average, each square metre of land is exposed to enough sunlight to produce 1,700 kWh of power every year. With improvements in existing

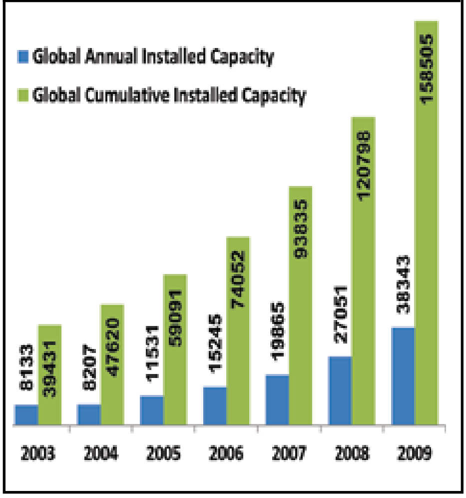
PV modules and system components and the resultant increase in their energy efficiency, the contribution of PV to global energy demand is only going to head north. Technologies like PV thin film or dye sensitive solar cells are developing quickly and present a huge potential for cost reduction. The mature crystalline silicon technology has been consistently increasing its cell and module efficiency while the cell thickness is rapidly decreasing, ensuring portability and ease of installation. The progress ratio[22] for PV modules during the last 30 years has also been comparatively high at 0.8 indicating a cost reduction of 20% each time the installed capacity doubles.

According to the European Renewable Energy Council and Greenpeace, global electricity generation capacity from photovoltaics is projected to increase from 6 GW in 2007 to 2968 GW in Scenario 1 (which, inter alia assumes reduction in CO_2 emissions to 10 giga tonnes in order to keep the increase in global temperature under +2°C by year 2050) and 4318 GW in Scenario 2 (which envisages a more amenable environment for renewables such as faster implementation of smart grids and expanding super grids, and incorporates a stronger effort to develop better technologies to achieve CO_2 reduction). Scenario 2 also assumes much shorter technical lifetimes for coal-fired power plants – 20 years instead of 40 years, faster annual growth rates of renewable energy sources, especially solar photovoltaics, wind and concentrating solar power plants. Based on this, it is projected that PV capacity would touch 1000 GW by 2025. With this kind of projected growth, the share of PV in electricity generation capacity from renewable energy would increase from 0.6% in 2007 to 21.1% (21.3% in Scenario 2) by 2030, and further to 31.0% (32.6% in Scenario 2) by 2050.

WIND ENERGY INDUSTRY

Wind as a source of energy has been gaining increasing significance, more so during recent years, not only as a renewable and environmental friendly source, but also as a cost effective one. The global wind resource is huge, capable of generating more electricity

Exhibit - 20 : Global Wind Power Capacity (MW)



Source : GWEC, Exim Bank Analysis

[22]Progress ratio or learning factor reflects the correlation between cumulative production volumes of a particular technology and a reduction in its costs. Thus for instance, a learning factor of 0.8 means that costs are expected to reduce by 20% every time the cumulative output from the technology doubles.

than the world's total power demand, and is geographically well distributed across the globe. Wind turbines can be operated not just in the windiest coastal areas but also in landlocked countries. Currently, wind turbines are produced by a relatively mature mass production industry employing a technology that is efficient, cost effective and quick to install. One large wind turbine can produce enough electricity for about 5,000 households.

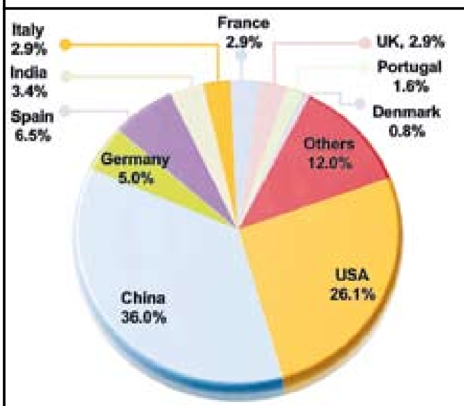
Wind energy projects can be set up in a short span of time, although they have a low-load factor. With a good transmission system, wind energy can be balanced by hydropower and can contribute to meeting peak demands. The advantage of using wind energy compared with other sources of power is that it creates no waste, uses no water and unlike solar PV panels, does not need much room. The increasing popularity of wind energy can be gauged by its rapid geographic dispersion – while in 1990s, wind power existed only in a few countries, today, the use of wind energy for power generation has expanded to more than 80 countries worldwide. Generation and use of wind energy is also gaining significance as the first commitment period under the Kyoto Protocol, whose objective is curbing carbon emissions and combating climate change, comes to an end in 2012.

Wind Energy – Global Scenario

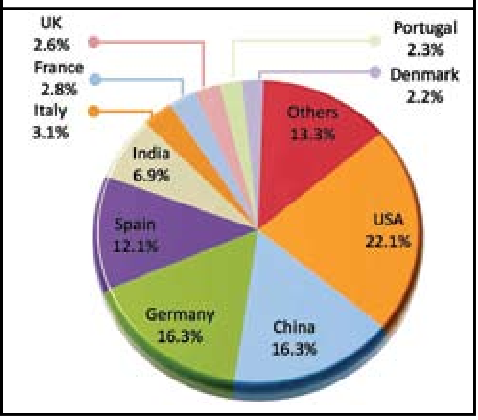
The global cumulative installed capacity of power generated from wind energy increased from around 40 GW at the end of 2003 to over 158 GW at the end of 2009, thereby recording a compounded annual growth rate (CAGR) of more than 25%. According to the Global Wind Energy Council (GWEC), a global forum for the wind energy sector, the annual installed capacity also grew by a CAGR of over 36% during the period 2004-2009 from 8.2 GW of annual installed

Exhibit - 21 : Global Wind Power Capacity by Countries

Wind Power Capacity Added in 2009 (Total : 38.3 GW)



Wind Power Cumulative Capacity in 2009 (Total 158.5 GW)



Source : GWEC, REN21, Exim Bank Analysis

Box 6 : Wind Energy - Some Technical Insights

Most commercial wind turbines today operate on a horizontal axis with three evenly spaced blades. These are attached to a rotor from which power is transferred through a gearbox to a generator. The gearbox and generator are contained within a housing called a nacelle. The electricity output is then channelled down the tower to a transformer and eventually into the local grid network. Wind turbines can operate from a wind speed of 3 metres to 4 metres per second (mps) up to about 25 mps. Limiting their power at high wind speeds is achieved either by 'stall' regulation – reducing the power output – or 'pitch' control – changing the angle of the blades so that they no longer offer any resistance to the wind. Pitch control has become the most common method.

Wind Turbine Components

Blades: Most wind turbines have three blades which are generally 30 metres to 50 meters long, with the most common sizes around 40 meters. Longer blades are being designed and tested. Blade weights vary, depending on the design and materials.

Controller: There is a controller in the nacelle and one at the base of the turbine. The controller monitors the condition of the turbine and controls the turbine movement.

Gearbox: A gearbox increases the rotational speed of the shaft. A low-speed shaft feeds into the gearbox and a high-speed shaft feeds from the gearbox into the generator. Some turbines use direct drive generators that are capable of producing electricity at a lower rotational speed. These turbines do not require a gearbox.

Generators: Wind turbines typically have a single AC generator that converts the mechanical energy from the wind turbine's rotation into electrical energy.

Nacelles: The nacelle houses the main components of the wind turbine, such as the controller, gearbox, generator, and shafts.

Rotor: The rotor includes both the blades and the hub (the component to which the blades are attached).

Towers: Towers are usually tubular steel towers 60 metres to 80 meters high that consist of three sections of varying heights.

Production Methods : Steel is the primary material used in wind turbines, but there is also significant use of adhesives, aluminium, blade core materials, concrete, copper, and fibreglass. Wind project developers contract with OEMs for the delivery of the entire turbine, which includes the nacelle, blades, and tower. OEMs are companies that design wind turbines and sell the turbines under their name. OEMs usually produce the nacelle in-house, while blades and towers are produced either by the OEM or to the OEM's specifications by a supplier. The leading global OEMs manufacture nacelles in-house. Nacelles, blades, and towers are shipped from the plant directly to the construction site, where they are installed by the project developer.

Source: Wind Turbines – Industry & Trade Summary; US International Trade Commission

Box 7 : Offshore and Onshore Wind Energy – A Comparison

Compared to onshore, offshore wind energy has greater potential but marine conditions pose great challenges to project delivery – weather, wind and waves are the dominating factors. All things considered, offshore wind energy requires a whole new approach to wind power in terms of wind turbine technology and scale, foundation types, logistics for installation and maintenance as well as port infrastructure.

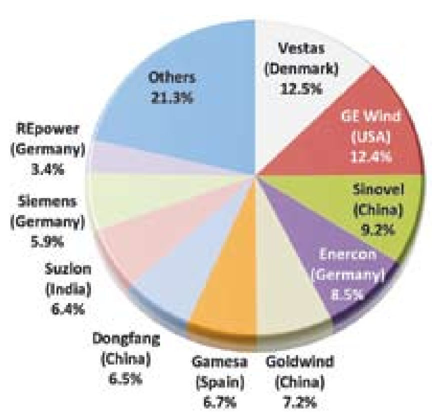
	Onshore	Offshore
Resources	* 2000 full load hours * Limited sites available * At full load, one wind turbine produces a household 's annual consumption* in 200 minutes	* 4000 full load hours * Large sites available * At full load, one wind turbine produces a household's annual consumption* in 40 minutes
Dimensions	* 1 MW-3 MW wind turbines * Wind farms of 20 MW-50 MW * Investment of € 30 million to € 70 million per wind farm	* 3-5 MW wind turbines * Wind farms of 100 MW -1000 MW * Investment of € 1 billion to € 2 billion per wind farm
Environment	* Smooth conditions * Unrestricted access (24 hours / 7 days a week)	* Rough marine conditions * Distance to shore 1-70 km * Access limited by high waves and storms
Foundations	* Built on solid ground * Standard concrete piles and foundations cast on site	* Differing soil conditions (soil, clay, rock) and erosion * Foundation type depends on water depth and soil capacity

* based on average annual consumption of 3500 KWh
Source: Vestas

capacity in 2004 to 38.3 GW of annual installed capacity in the year 2009. In fact, the additional capacity of 38.3 GW for wind power in 2009 – equivalent to nearly a quarter of the global cumulative installed capacity – was the highest among all the renewable technologies, an indication of the sector's potential. USA maintained its position as the largest market in wind power globally with a cumulative installed capacity of 35.1 GW in 2009, while China, with a total capacity of 25.8 GW, edged past Germany (marginally less than 25.8 GW) to become second largest market. Spain was the fourth largest market with a cumulative installed capacity of 19.2 GW followed by India at 10.9 GW of installed wind power capacity in 2009 (Exhibit 21). If the year 2009 is analysed in isolation, China emerges as the single largest player in terms of capacity addition to wind power – its addition to installed capacity aggregated 13.8 GW, representing more than one-third of the global addition of 38 GW to installed capacities in 2009. The speed of addition to wind power capacity in China has been tremendous wherein it has doubled existing capacities for the fifth consecutive year. USA, with a capacity addition of little over 10 GW, was the second largest contributor to global wind power capacity additions in 2009 followed by Spain (2.5 GW), Germany (1.9 GW) and India (1.3 GW). The market in 2009 also witnessed a stabilisation of wind turbine prices. The value of the 2009 market in terms of turnkey cost/turnover reached around € 51 bn (approx. US$ 73 bn based on end-December exchange rate).

In terms of distribution, the offshore wind sector has been gradually inching up, driven primarily by a continuous decline in good onshore sites. This segment of the wind industry added 641 MW of capacity in 2009 representing an increase of 72% over 2008, bringing the total offshore wind energy capacity to a little over 2 GW. Most of the offshore wind capacity is located in Europe, with United Kingdom (883 MW and Denmark (639 MW) being the main players in 2009. China was the first country in Asia (apart from Japan) to install a major offshore wind project in 2009, adding 63 MW by year-end (for a project that touched 102 MW upon completion in early 2010).

Exhibit - 22 : Top 10 Global Wind Turbine Supplier (2009) - Total 38.3 GW



Source : BTM Consult Apts, March 2010

On the supply side, the most significant development in 2009 was the emergence of Chinese wind turbine manufacturers, which resulted in the market shares of other major companies declining considerably. Three out of the top ten manufacturers were from China (Sinovel, Goldwind and Dongfang), with a combined market share of 22.9% in 2009. The growth of these three companies was primarily based almost entirely on the sales to the domestic Chinese markets. Overall, Vestas of Denmark continued to be the leader with a 12.5% market share (notably lower than 17.8% share in 2008) followed closely by GE (12.4%), Sinovel (9.2%) and Enercon (8.5%). Suzlon of India dropped to eighth position, with a decrease in market share to 6.4% in 2009 from 8.1% in 2008. But the company also acquired the majority of REpower's shareholding in 2009, adding a market share of 3.4%. The Suzlon Group as a whole therefore accounted for 9.8% of the world market in 2009 (enough to catapult it to third position in the Top 10 if it were treated as one company).

As against the 2009 market, the earlier years were dominated by European companies, largely due to the traditionally large size of the European market resulting in strong position of Europe-based original equipment manufacturers (OEMs) in the wind turbine manufacturing industry. Even in 2009, at least two Europe-based OEMs were among the top three suppliers of wind turbines in eight of the ten largest markets. Vestas (based in Denmark) and Enercon (Germany) supplied wind turbines to the largest number of markets. US-based General Electric Co. (GE) was the world's second largest supplier in 2009, primarily due to its strong presence in the U.S. market (an estimated 84% of turbines supplied by GE were to the US market). As regards Chinese OEMs, their steep increase in market share was almost exclusively the result of the growth in the domestic market (an estimated 99.8% of turbines supplied by the five largest Chinese OEMs was to China). This could change in the next few years as many Chinese OEMs actively seek to enter foreign markets.

Another discernible trend that has emerged in the wind power sector is the growing market for small scale wind systems – both off grid and grid tied – which are generally considered to include turbines that produce enough power for a single home, farm, or small business[23]. Although still at a nascent stage in terms of actual power generating capacity, small, grid-connected turbines are increasingly getting popular, especially in Europe and USA, although, in terms of sheer numbers, China remained the largest market for small wind turbines, reportedly adding about 50,000 in 2009 for a total of around 400,000, installed by the end of 2009.

The growth in capacity of wind energy installations in the world shows that there is a growing global demand for wind power, which is emissions-free and can be installed quickly, to produce renewable energy. Several countries now meet a significant share of their electricity demand from wind power, including Denmark (20%), Spain (14.3% and where wind overtook coal for the first time in 2009); Portugal (11.4% in 2008), Ireland (9.3% in 2008), and Germany (6.5% in 2009). What is also significant is the fact that in both Europe and USA, wind power accounted for 39% of all new electric generating capacity in 2009 – more than any other generating technology for the second year running. Thus, wind energy market is increasingly playing an important role in terms of meeting energy requirements, especially those related to electricity generation. This trend is only going to strengthen further as concern for climate change mitigation and clean energy increases among the global populace in general and emerging markets of China and India in particular.

Global Trade in Wind Energy Components

This section attempts to assess the trends in international trade of products and components that could be considered to be related to the generation of energy from wind, following the methodology outlined in the first section of this chapter

[23]The American Wind Energy Association defines "small-scale" as less than 100 kW, but size can vary according to needs and/or laws of a country

(27 such items have been identified). As is evident from Table 8, world exports of wind energy products and components amounted to US$ 107.1 bn in 2008, registering an average annual growth of 20.8% during the period 2004-2008. What is significant is the fact that the annual growth in exports of wind energy products has been increasing progressively during this period – 16.1%, 17.3%, 23.8% and 25.7% p.a. respectively, during 2004-2008. The major wind energy related product that was exported was parts of electric motors, generators, generating sets and rotary converters (HS 850300), with world exports in 2008 amounting to US$ 20.1 bn, almost double of what they were in 2004. Other major products related to wind energy that were exported included gears and gearing, ball screws, gear boxes, speed changers/ torque converters (HS 848340), ball bearings (HS 848210), liquid dielectric transformers, having a power handling capacity exceeding

Table 8: Global Exports of Wind Energy Related Goods (US$ mn)

S. No.	HS Code	2004	2005	2006	2007	2008	Avg. Annual Growth (%)
1	850300	10158	12220	14093	17170	20060	18.6
2	848340	7950	9346	10531	13167	16734	20.6
3	848210	8127	8905	9572	10895	12277	10.9
4	850423	1640	2077	2623	3983	6339	41.0
5	850431	3875	3752	4329	5281	5567	9.9
6	850231	1097	1914	3191	3909	5341	50.1
7	850164	1158	1394	1924	2758	4806	44.0
8	841290	1652	2234	2703	3134	4657	30.2
9	848220	2363	2717	3074	3662	4648	18.5
10	730820	728	1101	1276	1946	3700	52.4
11	848230	1386	1576	1827	2315	2833	19.7
12	848250	1193	1377	1577	2029	2692	22.8
13	850434	581	688	1048	1592	2138	39.2
14	902830	1034	1065	1062	1448	1721	14.5
15	850421	726	832	1151	1613	1706	24.7
16	848280	928	960	1184	1495	1650	15.9
17	850422	469	517	843	1273	1632	38.1
18	903039	1739	1911	2021	1448	1573	-1.0
19	850433	465	534	674	901	1116	24.6
20	890790	399	506	649	1036	1104	30.3
21	848240	709	737	825	929	1087	11.4
22	850161	505	570	685	848	946	17.1
23	850432	343	389	467	584	648	17.4
24	850162	386	384	488	580	621	13.1
25	903020	203	213	221	375	563	32.1
26	903031	467	518	520	532	505	2.1
27	850163	206	203	249	298	436	21.8
	Total	**50487**	**58640**	**68807**	**85201**	**107100**	20.8

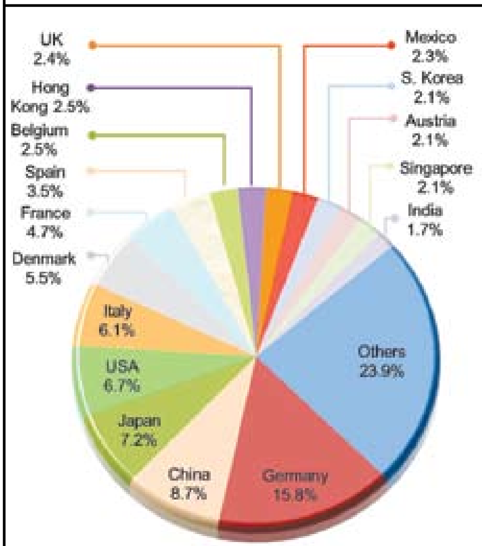
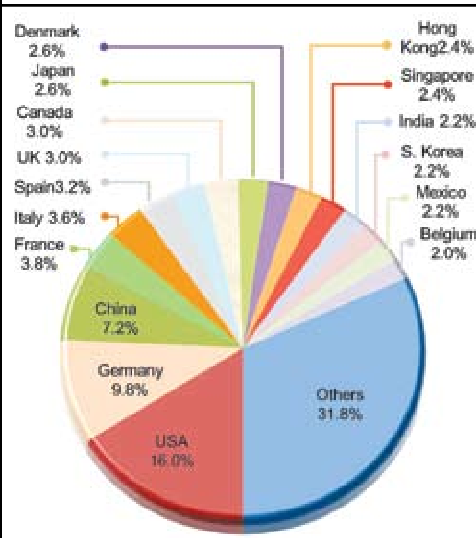
Note: Product descriptions corresponding to respective HS codes are given in Annexure 1.

Source: UN COMTRADE Database, Exim Bank Analysis

10,000 kVA (HS 850423) and electric transformers, having a power handling capacity less than 1 kVA (HS 850431).

In terms of major players, Germany again predominated with exports in 2008 aggregating US$ 17.0 bn, more than double of what they were in 2004. China, with exports of US$ 9.3 bn was the second largest exporter of wind energy components followed by Japan (US$ 7.7 bn), USA (US$ 7.1 bn) and Italy (US$ 6.6 bn) (Exhibit 23). If a comparison is made between the major exporters of wind energy components and major producers of wind energy, there are divergences – thus for instance although India's share in world wind power capacity is 6.9%, the country is not among the major exporters of wind energy components, commanding a share of only 1.7% in 2008. This is because there is a difference in the manufacture of wind energy components and the actual establishment of wind farms. While wind energy components are traded, wind farms are established in places where there is adequate government support and incentives and favourable consumer demand. Thus, traders of components of wind technology and their assembly may actually differ. For example, suppliers of components may not be the same as the firms which assemble these components. If this were true, then the major producers of wind energy would also figure as importers of these components. In fact, this is true for a majority of countries

Exhibit - 23: International Trade in Wind Energy Related Goods - Major Players (2008)

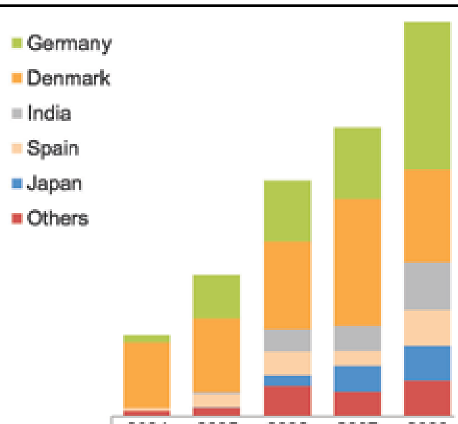
Major Exporters of Wind Energy Goods (2008) - Total US$ 107.1 bn	Major Importers of Wind Energy Goods (2008) - Total US$ 107.1 bn
	

Source : Derived from UN Comtrade database, among the top importers of wind energy components. The importing countries are primarily those in Europe, USA and Japan, where wind energy is a relatively mature industry. The only country outside these regions that was among the top 10 importers was China, with imports of wind energy components aggregating US$ 7.3 bn in 2008 (7.2% share).

The main single use item that could be considered as being used exclusively for the generation of power from wind is wind turbines (HS 850231 – wind-powered electric generating sets). As is evident from Exhibit 24, world exports of wind turbines has grown at a rapid pace – nearly quintupling from US$ 1.1 bn in 2004 to US$ 5.3 bn in 2008, thereby registering an impressive average annual growth of 50.1% during the period. This was driven largely by exponential growth in most of the top exporters save for Denmark, largely because of the base effect – the country was by far the largest exporter of wind turbines in 2004 with a share of over 80% in global exports – and perhaps also a reflection of its own domestic demand – among the top 20 countries with the greatest cumulative installed wind power capacity, Denmark has the highest levels of wind energy penetration in their electricity grids, estimated at roughly 20% of the

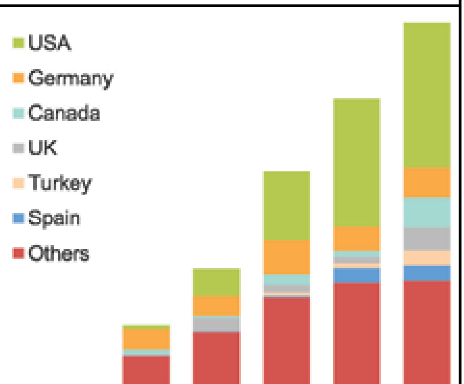
Exhibit - 24 : Trends in International Trade of Wind Turbines (HS 850231) by Major Players

Trends in World Exports of Wind Turbines (US$ mn)



	2004	2005	2006	2007	2008
Germany	97	590	832	969	2004
Denmark	888	998	1182	1719	1250
India	1	24	296	336	651
Spain	37	182	327	198	479
Japan	0	8	143	354	469
Others	74	112	411	333	488

Trends in World Imports of Wind Turbines (US$ mn)



	2004	2005	2006	2007	2008
USA	64	504	1280	2365	2679
Germany	376	366	638	453	563
Canada	94	41	175	109	545
UK	10	248	160	121	421
Turkey	6	0	54	92	285
Spain	9	9	27	265	274
Others	586	1024	1664	1936	1974

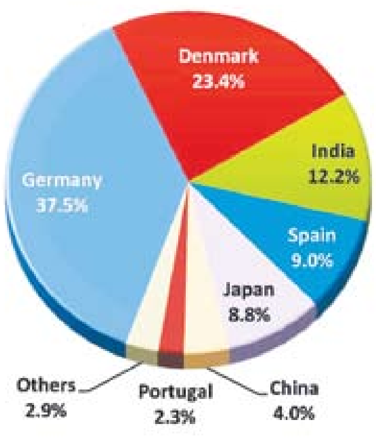
Source : Derived from UN Comtrade Database country's electricity demand as at end 2009 compared to the global average of 1.8% Germany overtook Denmark as the largest exporter of wind turbines in 2008 with exports aggregating US$ 2004 mn compared to Denmark's exports of US$ 1250 mn. India, which had negligible exports of wind turbines in 2004 (~US$ 1 mn) increased its exports phenomenally to US$ 651 mn to emerge as the third largest exporter in 2008 (compared to its 12th rank in 2004).

In terms of imports, USA was by far the largest market with imports of wind turbines shooting up from mere US$ 64 mn in 2004 to US$ 2679 mn in 2008 – a stupendous average annual growth of 234.9%. As a result, the share of USA in global imports of wind turbines increased from 5.6% in 2004 to 39.7% in 2008. This outcome is not surprising considering that USA has maintained its lead position as the largest market in wind power with a cumulative installed capacity of 35.1 GW in 2009. Other major import markets in 2008 were Germany (8.4% share), Canada (8.1%), UK (6.2%), Turkey (4.2%) and Spain (4.1%) (Exhibit 25).

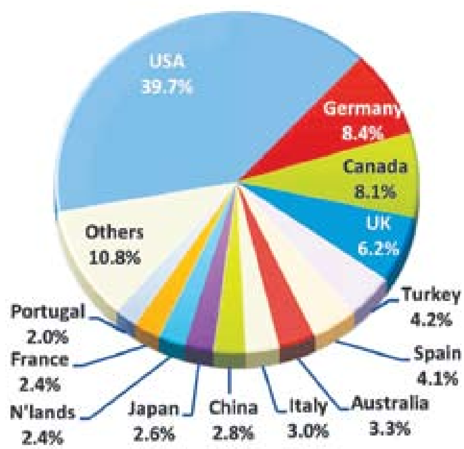
Another discernible observation that can be made from the analysis of global trade in wind turbines is the fact that while exporting countries are relatively handful, countries importing wind turbines are fairly spread out geographically. This bodes particularly well for a country like India which had a 12.2% share in world exports of wind turbines in 2008. In fact, the top 5 exporting countries contributed over 90% share in world exports of wind turbines in 2008. As against this, the top 5 importing markets accounted for

Exhibit - 25: Major Exporters and Importers of Wind Turines (HS 850231) in 2008

Major Exporters of Wind Turbines (2008) - Total US$ 5.3 bn



Major Importers of Wind Turbines (2008) - Total US$ 6.7 bn

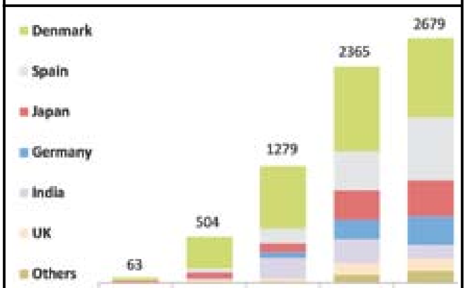


Source : Derived from UN comtrade Database

Note: export and import figures are different because imports are calculated on c.i.f. basis while exports are on f.o.b. basis only 67% of imports of wind turbines in the same year.

Considering that USA, the major import market for wind turbines with a share of almost 40% in 2008, has the largest cumulative wind power installed capacity in the world, and the fact that wind power contributed 39% of all new US electric generating capacity in 2009, the market merits a deeper analysis. According to the US Department of Energy, additions to wind power capacity in 2009 shattered old records with roughly 10 GW of new capacity added and about US$ 21 bn invested in the US market. The main market drivers for the persistent growth in wind energy installations in 2009 included carryover of projects initially planned for completion in 2008; elements of the American Recovery and Reinvestment Act of 2009 (Recovery Act), including the Section 1603 Treasury Grant Program; the expiration of bonus depreciation rules at the end of 2009; and state renewables portfolio standards.

Exhibit - 26 : Major Suppliers of Wind Turbines to USA - Recent Trends (US$ mn)



	2004	2005	2006	2007	2008
Denmark	34	342	684	928	868
Spain	1	48	160	428	690
Japan	25	63	98	315	395
Germany	0	0	57	212	310
India	0	14	230	262	148
UK	3	25	40	131	138
Others	0	12	10	89	130

Source : Derived from UN Comtrade Database, Exim Bank Analysis

General Electric remained the top turbine manufacturer in the United States market with a share of 40% (by capacity) in 2009, followed by Vestas (15%), Siemens (12%), Mitsubishi (8%), Suzlon (7%), Clipper and Gamesa (6% each), REpower (3%), Acciona (2%), and Nordex (1%). Thus, manufacturers with modern wind turbines installed in the United States now hail not just from the developed countries like United States, Europe, and Japan, but also from countries like India and, for the first time in 2009, China. Seven of the ten wind turbine manufacturers with the largest share of the U.S. market in 2009 now have one or more manufacturing facilities operating in the United States, and two of the remaining three have announced specific plans to open facilities in the future. These figures compare to just one utility-scale wind turbine manufacturer (GE) assembling nacelles in the United States in 2004 – a clear indicator of the potential for wind power manufacturers in the US market, both currently and in the near future. The manufacturers are localizing production in the United States in order to take advantage of the growing market, reduce transportation costs, minimize the risks associated with currency fluctuations, ease logistical challenges associated with exporting large nacelles and components, and avoid import duties.

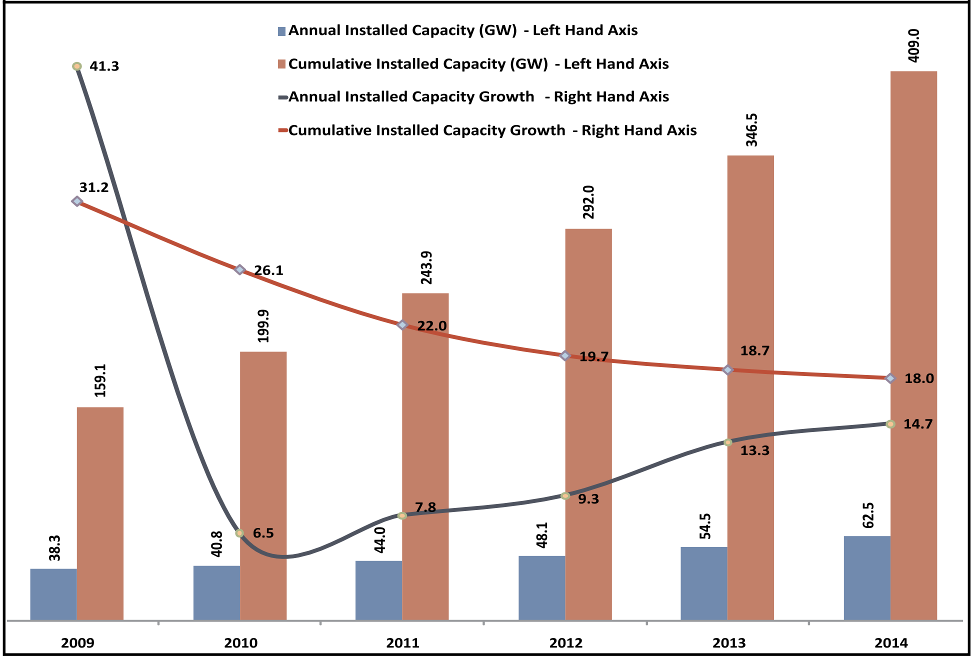
In terms of imports, USA has remained the largest importer of wind turbines during the last five years with its imports increasing by an annual average of 238.0% during the period 2004-2008 – from a mere US$ 63 mn to US$ 2679 mn. Denmark has traditionally been the largest supplier of wind turbines to the US market and remained so even in 2008, catering to 32.4% of the country's imports of wind turbines – far lower than 54.0% that supplied in 2004. Spain has emerged as the fastest growing supplier of wind turbines to the US, increasing its share from 1.6% in 2004 to 25.8% in 2008. Other major suppliers of wind turbines to the US market in 2008 included Japan (14.7%), Germany (11.6%), India (5.5%) and UK (5.2%) (Exhibit 26). In terms of specific components of wind power, notable trends in US imports include an increase in imports of blades and other components ("parts of other engines and motors" and "parts of generators") from Mexico and India in 2009, and a sizable shift of tower and lattice mast imports away from Europe and Canada and towards Asia. Similarly, from 2006-2009, an increasing share of generator imports have come from Asia, whereas European imports have declined.

Wind Energy Outlook

Wind energy is gradually emerging as an important source in the world's energy markets. Although future projections of global wind capacities vary according to various agencies, all of them project a healthy pace of increase. Thus, according to GWEC, wind capacity is projected to touch 409 GW by 2014, up from 158 GW at the end of 2009, while the Danish consultancy, BTM Consult projects a slightly higher figure of 447 GW, almost three times its present level. Within ten years (i.e. by 2019), wind power capacity is projected to reach nearly 1,000 GW and meet 8.4% of the world's electricity demand. GWEC projects that 62.5 GW of new capacity would be added to the global total in 2014 compared to 38.3 GW added in 2009. The global average annual growth rates based on the projection would thus be 20.9% in terms of total installed capacity, and 10.3% for annual additions to installed wind capacities. Though high in themselves, these rates remain modest compared to past developments (of last ten years), when the average increase was over 28% for both total and annual capacity additions. The market drivers for the projected growth are likely to be the existing end-user countries of Europe, North America and especially Asia, each of which had installed more than 10 GW of new capacity in 2009. In Asia (India and China), the market drivers would be strong economic growth and the resulting higher energy demand; in Europe the driver is likely to be the determined political action to combat global warning; and in North America, it would be a mix of global warming and energy security. It is also projected that the global market for wind turbines would touch US$ 124 bn in 2014 as against US$ 75 bn in 2010 and US$ 63 bn in 2009.

Power generation costs are projected to come down further with the average size

Exhibit - 27 : Wind Energy Forecast 2010 - 14



Source : GWEC, Exim Bank Analysis

of wind turbines projected to increase, thereby bringing down costs per kWh of electricity generated. Conventional onshore wind is likely to witness new improved technologies which focus on greater load factors through improved design (and reliability) rather than just increasing the swept area of the blade. There could also be a renewed market for sub 2.5 MW, possibly sub 1.5 MW, community sponsored wind turbines. As far as offshore wind is concerned, it still has many challenges but is now building significant momentum in the UK and Germany in particular, with 5 MW to 10 MW turbines likely to become the norm. According to the European Wind Energy Association (EWEA), in 2009, 582 MW of offshore wind were installed in the EU, up 56% over the previous year. Cumulative capacity increased to 2,063 MW. For 2010, it is expected that a further 1,000 MW of offshore wind will be installed in Europe. This would represent around 10% of the 2010 market. By 2020, EWEA projects between 40 GW and 55 GW of offshore wind farms to be feeding electricity to the grid in the EU, producing between 145 and 198 TWh of electricity.

BIOMASS ENERGY

Biomass is a broad term used to describe materials of recent biological origin such as wood, crops, algae and other plants as well as agricultural and forest residues that can be used as a source of energy. Biomass is the only renewable energy source that can potentially replace fossil fuels in all energy segments, viz., heating, electricity generation or as fuel for transportation. The term ‘bio energy’ is used for biomass energy systems that produce heat and/or electricity and 'bio fuels' for liquid fuels used in transport. Although, traditionally, biomass has been used primarily for cooking and heating, there is significant potential to expand biomass use provided it becomes increasingly competitive vis-à-vis other energy sources. Energy generated from biomass is renewable, easily stored, and, if sustainably harvested, CO_2 neutral. This is because the gas emitted during their transfer into useful energy is balanced by the CO_2 absorbed when they were growing plants. Electricity generating biomass power plants work just like natural gas or coal power stations, except that the fuel must be processed before it can be burnt. These power plants are generally not as large as coal power stations because their fuel supply needs to grow as near as possible to the plant. Heat generation from biomass power plants can result either from utilising a Combined Heat and Power (CHP) system, piping the heat to nearby homes or industry, or through dedicated heating systems.

Biomass has been making substantial contribution in meeting global energy demand. This contribution can be further expanded significantly in the future, which could help in mitigating greenhouse gas emissions, contributing to energy security, providing opportunities for social and economic development in rural communities, and improving the management of resources and wastes. Wood is the largest biomass energy resource used today but biomass sources also include crops and forestry, agricultural, and urban wastes. These wastes (industrial as well as municipal) can also be transformed into biogas through a biomethanation[24] process. The biogas can be upgraded[25] and used to generate power or process heat on a commercial basis. In recent years, biomass-derived energy has been receiving increasing attention as one of the prospective solutions for ensuring energy security for developing countries, especially India, which continue to rely on imported oil, thereby exposing the country to critical disruptions in fuel supply. Unlike the other renewable energy sectors, thrust on biomass energy did not result from concerns over shortage of other energy sources, but from environmental preoccupations (elimination of pollution, treatment of waste, control of greenhouse gas emissions).

However, expansion of energy derived out of biomass poses some challenges. The potential competition for land and for raw material with other biomass uses needs to be carefully managed. While the productivity of food and biomass feedstock could be increased by improved agricultural practices, the use of conventional crops for energy use can be expanded with careful consideration of land availability and food demand. In the medium term, lignocellulosic crops[26] (both herbaceous and woody) could be produced on marginal, degraded and

[24]Production of methane gas by the biological breakdown of organic matter in the absence of oxygen

[25]Gaseous biofuels or biogas can be upgraded to Substitute Natural Gas (SNG) and "blended" with natural gas in any mixture or be processed into "green" Compressed Natural Gas (CNG) thus becoming directly available as a powerful and very clean-burning liquid fuel to be used in gas-engine vehicle

[26]Lignocellulosic biomass refers to plant biomass that is composed of cellulose, hemicellulose, and lignin.

Box 8 : Biomass Technology

A number of processes can be used to convert biomass into usable energy forms. These can be classified into thermal systems, which involve direct combustion of solids, liquids or a gas via pyrolysis or gasification, and biological systems, which involve decomposition of solid biomass to liquid or gaseous fuels by processes such as anaerobic digestion and fermentation.

Thermal Systems:

Direct combustion is the most common way of converting biomass into energy, for heat as well as electricity. Worldwide it accounts for over 90% of biomass generation.

Gasification is a thermo-chemical process in which biomass is heated with little or no oxygen present to produce a low energy gas, which can then be used to fuel a gas turbine or combustion engine to generate electricity. Gasification offers superior efficiencies compared to conventional power generation.

Pyrolysis is a process whereby biomass is exposed to high temperatures in the absence of air, causing the biomass to decompose. The products of pyrolysis always include gas ('biogas'), liquid ('bio-oil') and solid ('char'), with the relative proportions of each depending on the fuel characteristics, the method of pyrolysis and the reaction parameters, such as temperature and pressure. Lower temperatures produce more solid and liquid products and higher temperatures more biogas.

Biological Systems:

These processes are suitable for very wet biomass materials such as food or agricultural wastes, including farm animal slurry.

Anaerobic digestion means the breakdown of organic waste by bacteria in an oxygen-free environment. This produces a biogas typically made up of 65% methane and 35% CO_2. Purified biogas can then be used both for heating and electricity generation.

Fermentation is the process by which growing plants with a high sugar and starch content are broken down with the help of micro-organisms to produce ethanol and methanol. The end product is a combustible fuel that can be used in vehicles.

Biofuels:

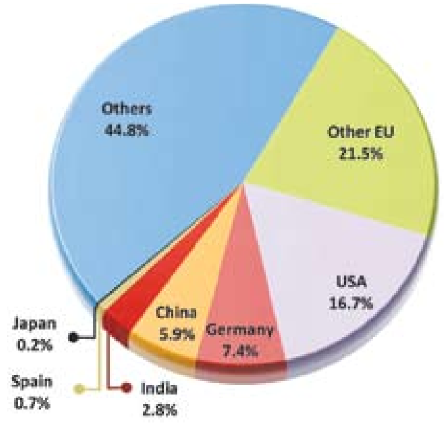
Biomass can be converted directly into liquid fuels called biofuels for application in the transportation sector.

Bioethanol is a fuel manufactured through the fermentation of sugars, done by accessing sugars directly (sugar cane or beet) or by breaking down starch in grains such as wheat, rye, barley or maize. In the European Union, bio ethanol is mainly produced from grains, with wheat as the dominant feedstock. In Brazil, the preferred feedstock is sugar cane, whereas in the USA it is corn (maize). Bio ethanol can either be blended into gasoline (petrol) directly or be used in the form of Ethyl Tertiary Butyl Ether (ETBE).

Biodiesel is a fuel produced from vegetable oil sourced from rapeseed, sunflower seeds or soybeans as well as used cooking oils or animal fats. If used vegetable oils are recycled as feedstock for bio diesel production this can reduce pollution from discarded oil and provides a new way of transforming a waste product into transport energy. Blends of bio diesel and conventional hydrocarbon-based diesel are the most common products distributed in the retail transport fuel market.

Source: European Renewable Energy Council and Greenpeace

Exhibit - 28 : Renewable Electric Power Capacity from Biomass (2009)
Total : 54 GW



Source : Renewables 2010, Global Status Report, Exim Bank Analysis.

surplus agricultural lands in order to provide the bulk of biomass resource. In the longer term, aquatic biomass (algae) could also be significantly tapped as a source of sustainable biomass.

Biomass: A Global Scenario

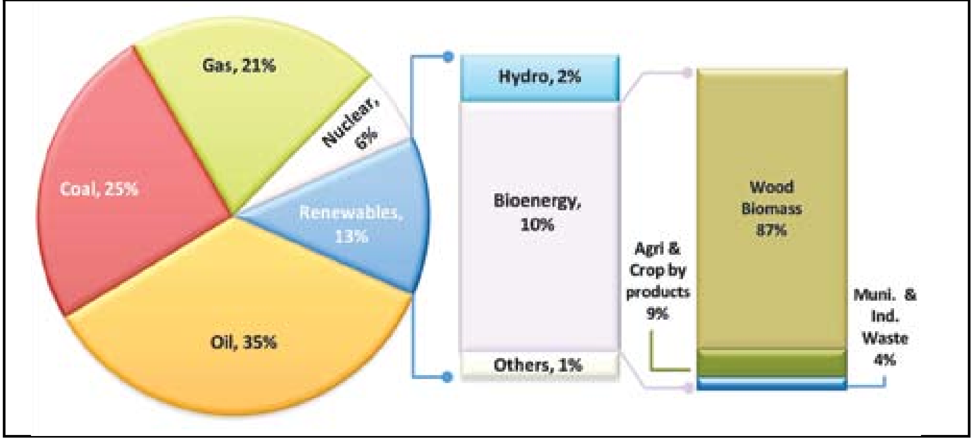
The use of biomass as a source of energy for both power generation and heating as also for transportation has been increasing across the globe. Today, biomass power plants exist in more than 50 countries around the world and supply a growing share of electricity. Overall, the biomass power capacity (excluding electricity generated from municipal solid waste or industrial waste) amounted to 54 GW by the end of 2009[27]. The European Union remained the largest region in terms of biomass power capacity with electricity capacity from biomass aggregating 16.0 GW in 2009. Within EU, the main countries included Germany with biomass power capacity of 4 GW and Spain with 0.4 GW in 2009 (Exhibit 28). In fact, several European countries expanded their total share of power from biomass, including Austria (7%), Finland (20%), and Germany (5%). Wood and wood waste account for the vast majority (more than three-fourth) of biomass power production in Europe, followed by black liquor[28] and other plant and animal wastes. The use of wood pellets – manufactured from wood waste, short-rotation wood, and other sources – for electricity generation (and heat) is also increasing rapidly in Europe. Although the European market is the most developed in terms of power generation from biomass, by late 2009, USA took the lead in power capacities with about 80 operating biomass projects in its 20 states providing approximately 8.5 GW of power capacity.

Power generated from biomass has also increased significantly in many developing countries. China's capacity increased 14% in 2009 to 3.2 GW and the country plans to install up to 30 GW by 2020. India, which generated 1.9 TWh of electricity with solid biomass in 2008, had a biomass power capacity of 1.5 GW in 2009. By the end of 2009, India had installed 835 MW of solid biomass capacity fuelled by agricultural residues (increase of about 130 MW in 2009) and more than 1.5 GW of bagasse

[27]If municipal solid waste were included, the global biomass power generation figure might increase by at least 12 GW. However, statistics on trends in biomass power usage is difficult to track globally on an annual basis.

[28]Black liquor is a liquid waste by product of the paper pulping industry

Exhibit - 29 : Share of Biomass in Total Primary Energy Supply



Source : IEA, 2006; IPCC, 2007, Exim Bank Analysis

cogeneration plants (up nearly 300 MW in 2009, including off-grid and distributed systems). The country is well on its way of achieving the targeted 1.7 GW of biomass power capacity by 2012. Brazil has also shown an increase in biomass usage for energy generation with over 4.8 GW of biomass cogeneration plants at sugar mills, which generated more than 14 TWh of electricity in 2009.

The critical factor for the commercial viability of biomass utilisation is the cost of the feedstock, which ranges from the relatively economical waste wood and residual materials to the more expensive energy crops. The resulting spectrum of energy generation costs is correspondingly broad. One of the most economical options is the use of waste wood in steam turbine combined heat and power (CHP – also known in USA as cogeneration) plants. Gasification of solid biomass, on the other hand, which opens up a wide range of applications, is still relatively expensive. In the long term favourable electricity production costs is likely to be achieved by using wood gas both in CHP units (engines an d fuel cells) and in gas-and-steam power plants. Great potential for the utilisation of solid biomass also exists for heat generation in both small and large heating centres linked to local heating networks.

According to the International Energy Agency (IEA), under the Reference Scenario[29], biomass contributed approximately 50 EJ[30] of energy globally in 2006, thereby representing 10% of global annual primary energy consumption (Exhibit 29). As per the diverse range of feedstock, the technical potential[31] for biomass is projected to be possibly as high as 1500 EJ/yr

[29]Reference Scenario provides a baseline picture of how global energy markets would evolve if the governments make no changes to their existing policies and measures.

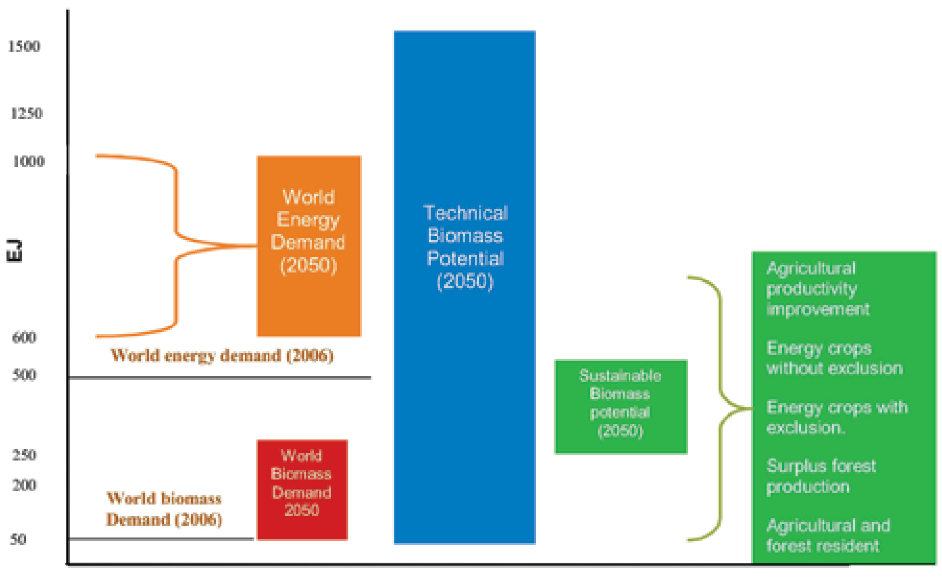
[30]1 EJ = 1018 Joules (J) = 1015 kilojoules (kJ) = 24 million tonnes of oil equivalent (Mtoe); EJ=Exa Joule

[31]Technical potential is the potential that is limited by the technology used and the natural circumstances.

(Exhibit 30) by 2050, although most biomass supply scenarios that take into account sustainability constraints indicate an annual potential of between 200 EJ/yr and 500 EJ/yr (excluding aquatic biomass). Forestry and agricultural residues and other organic wastes (including municipal solid waste) would provide between 50 and 150 EJ/year, while the remainder would come from energy crops, surplus forest growth, and increased agricultural productivity. Projected world primary energy demand

Exhibit - 30 : Projected Biomass Demand in the World

- Total world primary energy demand in 2050 in World Energy Assessment (600 – 1000 EJ/year)
- Modelled biomass demand in 2050 as found in literature studies (50 – 250 EJ/year)
- Technical potential for biomass production in 2050 as found in literature studies (50 -1500 EJ/year)
- Sustainable biomass potential in 2050 (200-500 EJ/yr) ; Sustainable biomass potentials consist of: (i) residues from agriculture and forestry (~ 100 EJ); (ii) surplus forest production - net annual increment minus current harvest (~ 80 EJ); (iii) energy crops, excluding areas with moderately degraded soils and/or moderate water scarcity (~ 110 EJ); (iv) additional energy crops grown in areas with moderately degraded soils and/or moderate water scarcity (~ 70 EJ) and (v) additional potential when agricultural productivity increases faster than historic trends thereby producing more food from the same land area (~ 140 EJ).



* Technical and sustainable biomass supply potentials and expected demand for biomass (primary energy) based on global energy models and expected total world primary energy demand in 2050. Current world biomass use and primary energy demand are shown for comparative purposes.

Source: Adapted from Domburg (2008), Exim Bank Analysis

Table 9: Global Exports of Biomass Related Goods (US$ mn)

S. No.	HS Code	2004	2005	2006	2007	2008	Avg. Annual Growth (%)
1	382490	20253	21782	24854	29237	39042	18.2
2	841182	4897	5530	5670	6773	7933	13.0
3	220710	1336	2022	3422	3269	5489	46.0
4	841940	515	747	753	1058	1913	41.8
5	841280	342	452	521	566	1182	41.2
6	220720	276	395	661	962	1090	42.3
7	841620	587	648	794	923	1061	16.0
8	380210	491	572	678	845	1037	20.6
9	840682	382	434	641	820	890	24.4
10	847920	374	426	445	617	782	20.9
11	840681	479	520	484	509	760	14.0
12	841931	182	202	277	333	498	29.5
	Total	**30114**	**33730**	**39200**	**45912**	**61677**	**19.9**

Note: Product descriptions corresponding to respective HS codes are given in Annexure 1.

Source: UN COMTRADE Database (PC-TAS), Exim Bank Analysis

by 2050 is expected to be in the range of 600 to 1000 EJ (compared to about 500 EJ in 2006). Scenarios looking at the penetration of different low carbon energy sources indicate that future demand for energy from biomass could be up to 250 EJ/yr (Exhibit 30). This projected demand falls well within the sustainable supply potential estimate, so it may be reasonable to assume that biomass could sustainably contribute between a quarter and a third of the future global energy mix. However, whatever is actually realized will depend on the cost competitiveness of energy from biomass and on future policy frameworks, such as greenhouse gas emission reduction targets and the associated agreement on global climate change mitigation framework.

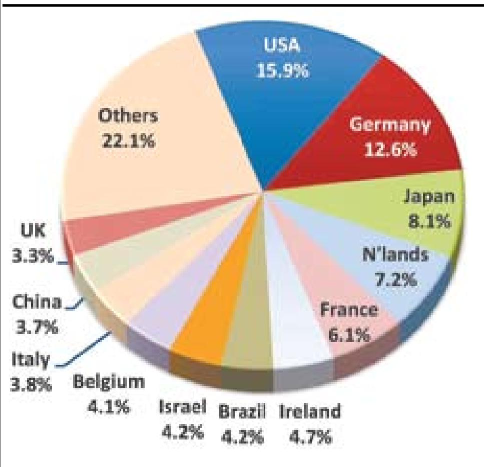
International Trade in Biomass – Some Reflections

Following the methodology outlined in the beginning of this chapter, an effort has been made in this section to arrive at an indicative trade figure for biomass and related components which can be assumed to be influenced at least to a certain extent by the demand from the biomass energy industry. Thus, based on this, the associated equipment and components would include, for example, boilers, steam turbines, gas turbines, generators and equipment for gas cleaning and for filtering. In addition, the key item is biofuels which also acts as the demand driver for equipment used in the process of fermentation, distillation and purification. Thus, based on this, the category of biomass and related components would include 12 items at the HS-6 digit level as outlined in Table 9.

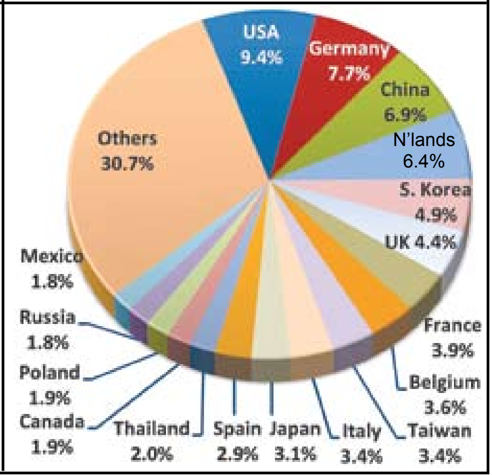
As is evident, world exports of biomass products and related equipment and components amounted to US$ 61.7 bn in 2008, registering an average annual growth of 19.9% during the 2004-2008 period. World exports of

Exhibit - 31: International Trade in Biomass Related Goods - Major Players (2008)

Major Exporters of Biomass Related Goods (2008) - Total US$ 61.7 bn



Major Importers of Biomass Related Goods (2008) - Total US$ 61.7 bn



Source : Derived from UN Comtrade Database

biomass products has been dominated by HS 382490, i.e. other chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products), not elsewhere specified or included: other. This category includes biodiesel and accounted for 63.3% share of world exports in biomass and related components as identified above. However, given the large weight of HS 382490, which not only includes biodiesel but also many chemical preparations that are not based on biomass, this figure should be interpreted with due care and allowance needs to be made for the overestimation embedded in the data at the HS 6 digit level. Undenatured ethyl alcohol or bioethanol (HS 220710) contributed 8.9% and was ranked the third most important item traded in this category. Thus, together, these two alone (i.e. biofuels) accounted for nearly three fourth of global exports of the identified items. Consequently, the weightage of biomass component and equipment was relatively low, with the main category being other gas turbines of a power exceeding 5,000 kW (HS 841182) with exports in 2008 aggregating US$ 7.9 bn (12.9% share).

In terms of major exporters of biomass products, and related components and equipment, USA topped the list with exports in 2008 amounting to US$ 9.8 bn (15.9% share), registering an average annual growth of 25.6% during the period between 2004 and 2008. USA was followed by Germany with exports aggregating US$ 7.8 bn in 2008 (12.6% share), Japan (US$ 5.0 bn exports; 8.1% share), the Netherlands (US$ 4.5 bn; 7.2%) and France (US$ 3.7 bn; 6.1%). USA and Germany were also

Table 10: Exports and Imports of Ethyl Alcohol (Bioethanol) – HS 220710 (US$ mn)

Country	2004	2005	2006	2007	2008
Brazil	461	743	1437	1439	2366
Netherlands	53	96	138	58	639
France	156	167	193	347	561
El Salvador	10	28	157	142	195
Sweden	5	24	33	28	158
World	1336	2022	3422	3269	5489

Country	2004	2005	2006	2007	2008
USA	257	346	1582	961	1283
Netherlands	48	99	164	450	650
Germany	90	143	204	285	597
Sweden	22	58	94	170	269
Japan	156	213	261	263	253
World	1336	2022	3422	3269	5489

Source: UN Comtrade Database, Exim Bank Analysis

the largest importers with imports of the former aggregating US$ 5.1 bn (9.4% share) while that of the latter amounting to US$ 4.1 bn (7.7% share) in 2008. Other major importers included China (US$ 3.7 bn imports; 6.9% share), the Netherlands (US$ 3.5 bn; 6.4%), South Korea (US$ 2.6 bn; 4.9%) and UK (US$ 2.4 bn; 4.4%) (Exhibit 31).

As mentioned earlier (Exhibit 31), biomass energy is predominantly traded in the form of biofuels (either as bioethanol or biodiesel). The largest producer of bioethanol, viz. Brazil, also figures as the largest exporter with exports aggregating US$ 2366 mn in 2008, up from a mere US$ 461 mn in 2004. Other major exporters of bioethanol were the Netherlands (US$ 639 mn), France (US$ 561 mn), El Salvador (US$ 195 mn) and Sweden (US$ 158 mn). In terms of imports, USA was by far the largest importer of ethyl alcohol with imports amounting to US$ 1283 mn in 2008, a sharp increase from US$ 257 mn recorded in 2004. The Netherlands and Sweden also figured among the top five import market with imports in 2008 totalling US$ 650 mn and US$ 269 mn, respectively (Table 10). However, it needs to be emphasised that at the 6-digit HS level, it is not possible to know how much of the internationally traded ethyl alcohol is used for fuel.

In the case of USA, fuel ethanol consumption has grown significantly during the past few years, and going forward, this trend is likely to continue and even strengthened especially in light of the establishment of a renewable fuel standard (RFS) which requires US transportation fuels to contain a minimum amount of renewable fuel, including ethanol. Although a large portion of the US market is supplied by domestic refiners producing ethanol from American corn, imports have begun to play an increasing role, reflected in the spurt in the country's import demand during recent years.

The other major item being traded among the products identified under the biomass energy is other chemical products which includes biodiesel (HS 382490). Again, it needs to be noted that at the 6-digit HS level, biodiesel is included in HS code 382490, which also includes a large range of unrelated chemical products and preparations. Table 11 show the top five exporters and

Table 11: Exports and Imports of Chemical Products (incl. Biodiesel) – HS 382490 (US$ mn)

Country	2004	2005	2006	2007	2008
Germany	3550	3994	4572	5356	6228
USA	1670	2009	2270	2973	5201
Japan	2204	2593	2938	3126	3483
Netherlands	1794	1993	2263	2603	3441
Ireland	2159	2221	2306	2558	2918
World	20253	21782	24854	29237	39042

Country	2004	2005	2006	2007	2008
China	1748	2530	2958	3031	3271
Germany	1802	2085	2324	2496	3155
USA	899	995	1202	1577	2936
Netherlands	882	1068	997	1452	2518
South Korea	1117	1328	1571	1880	2221
World	20253	21782	24854	29237	39042

Source: UN Comtrade Database, Exim Bank Analysis

importers of products classified under this code. For many of these countries, biodiesel represents only a small part of trade, which makes it difficult to analyze the ranking of countries shown. Given this limitation, the analysis can at best be indicative. Thus, for HS 382490, which includes biodiesel, the main exporters in 2008 included Germany (US$ 6.2 bn), USA (US$ 5.2 bn), Japan (US$ 3.5 bn), the Netherlands (US$ 3.4 bn) and Ireland (US$ 2.9 bn). Exports of countries like Japan and Ireland are unlikely to represent biodiesel, given their relatively limited land resources. As regards imports, the major market in 2008 was China with imports amounting to US$ 3.3 bn followed by Germany (US$ 3.2 bn), USA (US$ 2.9 bn), the Netherlands (US$ 2.5 bn) and South Korea (US$ 2.2 bn).

SUM UP

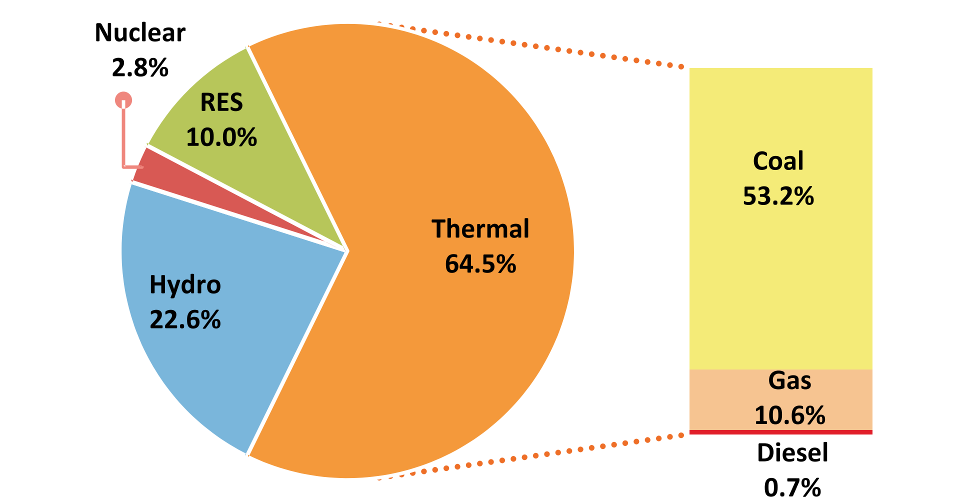
This chapter made an attempt to provide a global perspective on the new renewable technologies, viz. solar photovoltaic, wind and biomass. The analysis undertaken indicates a clear shift in global preference towards these technologies as source of energy, especially in generation of electric power. Renewable technologies are likely to dominate global power plant construction in the decade from 2010 to 2020, exceeding the totals for coal, oil, natural gas, and nuclear power combined. The continued rapid growth of renewable energy technology, despite the financial crisis and economic downturn, is a testament to the inherent attractiveness of the technology. Renewable energy continues to grow due to national energy policy in the key markets. Many governments have realized the strategic long-term importance of renewable power generation and have placed it at the core of their economic growth plans. An attempt was made to assess the international trade in renewables, which corroborated the rapid pace of deployment of renewable energy at the global level. With climate change mitigation gaining an ever increasing significance, the thrust on renewables is only going to increase further. With expected improvements in technology coupled with the volatile movements in the price of fossil fuel and their continuous depletion, the prospects of renewables remain bright, a factor which India needs to leverage upon. The following chapter would discuss new renewable technologies in the Indian context.

4. THE NEW RENEWABLE ENERGY SECTOR: REFLECTIONS FROM THE INDIAN MARKET

BACKGROUND

This chapter would seek to analyse the status of the new renewable energy sector in India including the country's international commercial engagements in wind, solar PV and biomass industry and the outlook for these sectors. India is the fifth largest primary energy consumer and the fourth largest petroleum consumer globally. Rapidly growing economic and social development coupled with increasing population has spurred increased energy consumption across all the major sectors of the economy. This is reflected in the country's growing demand for fuel and power. While India's petroleum consumption has gone up from 100 million metric tons in 2001-02 to more than 138 million metric tons in 2009-10, the installed power generation capacity has increased from 107 GW to 164 GW during the same period. The current power generation mix (as at end July 2010) in India is dominated by coal with a share of 53.2% (87.1 GW) followed by large hydropower (22.6% share; 37.0 GW) and gas (10.6%; 17.3 GW). Renewable energy sources[32]

Exhibit 32: Installed Power Generation Capacity in India by Source (Total as on July 31, 2010 - 163.7 GW)

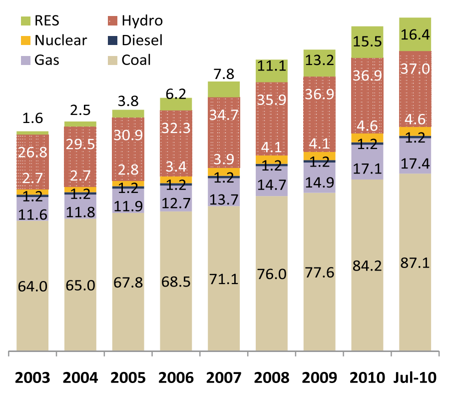


Source: Petroleum Planning and Analysis Cell, Central Electricity Authority, Exim Bank Analysis

[32]Renewable Energy Sources (RES) include small hydro project, biomass gas & power, industrial waste, and wind energy

rank fourth with an installed capacity of around 16.4 GW (Exhibit 32). The IEA predicts that by 2020, India would need 327 GW of power generation capacity to fulfil its projected demand, which would imply an addition of nearly 15 GW per year. The encouraging aspect of the growth in India's installed electricity capacity, especially during recent times, has been the increasing application of renewables as energy sources. Although the country continues to rely on coal as the primary energy source, its share in installed capacity has declined from 59.3% in end March 2003 to 53.2% in end July 2010. As opposed to this, the share of renewable energy sources has shot up from a mere 1.5% to 10.0% during the same period (Exhibit 33). The importance accorded by the Government to renewable energy can be assessed from the fact that India remains the only country in the world having a Ministry exclusively dedicated to renewable energy, viz.

Exhibit 33: Growth in Installed Electricity Capacity (GW)



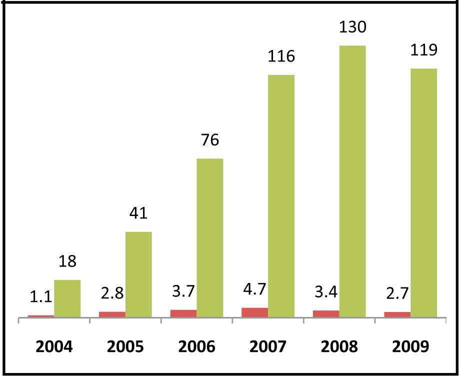
Source: Central Electricity Authority, Exim Bank Analysis

Ministry of New and Renewable Energy (MNRE).

According MNRE, cumulative capacity of about 17,173.9 MW grid-interactive power generations from various renewable energy sources had been installed up to 30.6.2010. These include: Wind Power - 12,009.48 MW Small Hydro Power - 2767.05 MW Biomass power - 910.10 MW Bagasse Cogeneration - 1411.53 MW Solar power - 12.28 MW and Urban and Industrial waste-to-energy - 72.46 MW.

As far as trends in financial investments in the renewable sector in India are concerned, they have more or less mirrored those for the world as a whole. Thus, following the global contraction in financial investments in 2009 – from US $ 130 bn in 2008 to US$ 119 bn in 2009 - investments in the renewable energy sector in India also witnessed a decline of 21% – from US$ 3.4 bn in 2008 to US$ 2.7 bn in 2009. Notwithstanding the decline, which was largely fallout of the cautious approach of bank financing in the wake of global economic meltdown, India was ranked eighth in the world based on financial investments in the new renewable energy sector in 2009. Investments in renewable/technologies in India have maintained a general upward trend since 2004, save for the last two years, which can be considered an aberration since these were an outcome of the global economic crisis. Overall, during the period between 2004 and 2009, financial sector investments in renewable energy sector in India registered an average annual growth of

Exhibit 34: Trends in Financial Sector Investment in Renewable Energy: India & World (US$ bn)



Source: Bloomberg New Energy Finance & UNEP

33.1%, increasing from US$ 1.1 bn to US$ 2.7 bn (Exhibit 34). This growth, though impressive in itself, pales out when compared to global financial investments in this sector which increased by an average annual rate of 53.9% and that too from a much higher base – from US$ 18 bn to US$ 119 bn during the same period. Renewable energy investment in India in 2009 was dominated by asset-based finance, with US$ 1.9 bn (73%) coming in this form, as against US$ 3.1 bn in 2008. Public market activity in India accounted for a large proportion of the remainder with US$ 0.7 bn (25%). Private equity and venture capital activity in India constituted a rather small proportion of all investment, at just 4% of the total, or US$ 0.1 bn, as compared to US$ 0.4 bn in 2008.

INDIA'S INTERNATIONAL TRADE IN RENEWABLE GOODS

Based on the products identified as being related to renewable goods (on the premise outlined in the previous chapter), India had a trade deficit to the tune of US$ 810 mn out of a total trade figure of US$ 7.6 bn in 2008[33]. While India's exports of renewable goods aggregated US$ 3.4 bn, India's imports amounted to US$ 4.2 bn in 2008. An interesting point to note is that though in deficit, exports of renewable goods, on an average, have increased at a faster pace than imports during the 2004-2008 period – as against an average annual growth in imports of 33.2%, exports registered an average annual increase of 51.9%. Thus, while imports were more than double of exports in 2004, they were only about a quarter more than exports in 2008 (Exhibit 35).

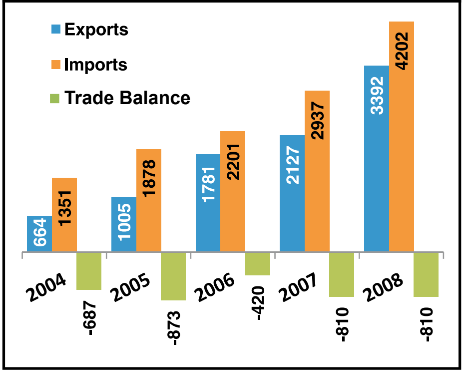
Germany was India's largest trading partner for the identified renewable goods and equipments in 2008 with two-way trade amounting to US$ 1219 mn. Germany was followed by China, whose trade with India aggregated US$ 1059 mn, almost wholly a result of strong imports by India. USA, Spain, Japan, Italy and Brazil were India's other major trading partners for renewable goods in 2008. From an export perspective, USA was India's largest export destination with exports totalling US$ 597 mn in 2008 (17.6% share) – an appreciable average annual growth of 84.3% during

[33]Although the data for 2009 for India is available from DGCIS, the same has not been taken in the analysis so as to maintain consistency and comparability with the global data.

the 2004-2008 period. Spain was the second largest export destination, and exhibited an even better performance with export shooting up from just US$ 3 mn in 2004 to as high as US$ 323 mn in 2008 – a phenomenal average annual increase of 270.5% (albeit from a low base). Germany (US$ 266 mn), Brazil (US$ 183 mn), Australia (US$ 152 mn), the Netherlands (US$ 151 mn), and UAE (US$ 134 mn) were the other major export markets for India's renewables in 2008. As far as imports are concerned, China emerged as the most important source for India's renewables with imports from the country amounting to US$ 1016 mn in 2008, up significantly from US$ 132 mn in 2004. Germany (US$ 953 mn), USA (US$ 300 mn), Japan (US$ 250 mn), Italy (US$ 200 mn) and Taiwan (US$ 169 mn) were the other major sources of imports for renewables in 2008 (Exhibit 36).

In terms of the product basket, the most actively traded renewable energy goods by India in 2008 was photosensitive semiconductor devices,

Exhibit 35: India's Trade in Renewables (US$ mn)



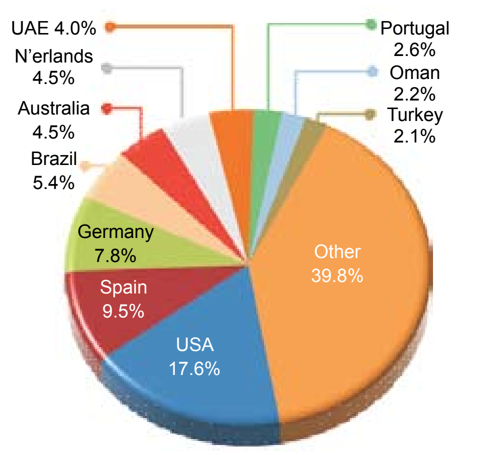
Source: Derived from UN Comtrade Database

including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes (HS 854140) with amount traded being US$ 949 mn in 2008, more than six fold increase over the 2004 level of US$ 158 mn. Other major renewable energy related goods and equipments that were traded by India in 2008 included static converters (HS 850440; US$ 939 mn of total trade), wind-powered electric generating sets (HS 850231; US$ 653 mn), parts of electric motors, generators, generating sets and rotary converters (HS 850300; US$ 641 mn), towers and lattice masts (HS 730820; US$ 552 mn) and gears and gearing, other than toothed wheels, chain sprockets and other transmission elements presented separately; ball or roller screws; gear boxes and other speed changers, including torque converters (HS 848340;US$ 483 mn).

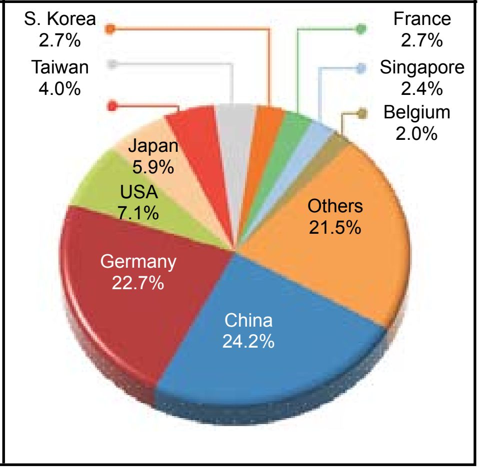
However, if only exports are considered, then wind-powered electric generating sets (HS 850231) were the single largest item with exports in 2008 aggregating US$ 651 mn (an exponential increase from just US$ 1 mn recorded in 2004) followed by PV panels/modules (HS 854140) with exports worth US$ 529 mn recorded in 2008 (up from US $ 85 mn in 2008) (Exhibit 37). This ranking is all the more encouraging from the renewable goods perspective, given that wind powered generating sets and PV panels/modules are the items identified (as was highlighted in the previous chapter) as being key 'single use' products exclusively used for renewable technologies (with the former being used exclusively for generation

Exhibit 36 : India's Trade in Renewable - Major Partners

India's Exports of Renewable Goods : Major Destinations (Total : US $ 3.4 bn in 2008)



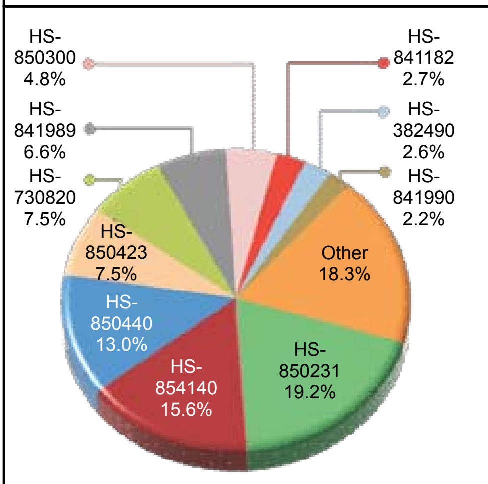
India's Imports of Renewable Goods: Major Sources (Total : US $ 4.2 bn in 2008)



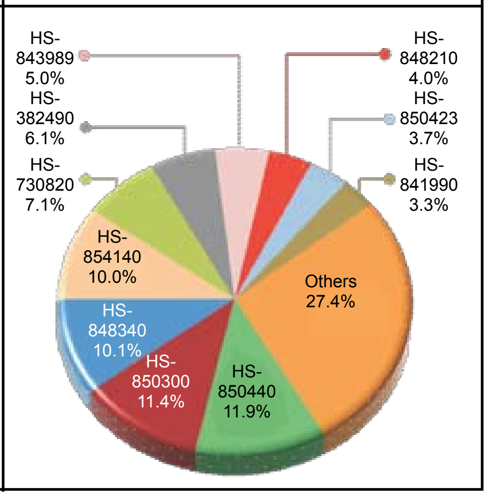
Source : Derived from UN Contrade Database

Exhibit 37 : India's Trade in Renewables - Composition

India's Exports of Renewable Goods : Major Products (Total : US $ 3.4 bn in 2008)



India's Imports of Renewable Goods: Major Products (Total : US $ 4.2 bn in 2008)



Source : Derived from UN Comtrade Database of power from wind, and the later for generation of power from sunlight), unlike other identified products, which are for multiple use, i.e. only a small portion of these products, if at all, might be related to the deployment of renewable energy technologies and products.

The other major new renewable energy related exports in 2008 included static converters (HS 850440; US$ 440 mn), liquid dielectric transformers having a power handling capacity exceeding 10,000 kVA (HS 850423; US$ 255 mn) and towers and lattice masts (HS 730820; US$ 253 mn). The top five exported items together accounted for nearly two-third of the total exports of renewable energy goods and equipments in 2008, up significantly from a little more than one-third share that they contributed in 2004. This was primarily due to a rapid increase in the two key ‘single use’ items, used exclusively for the renewable energy sector, viz. wind-powered electric generating sets and PV panels/ modules.

In terms of imports, static converters (HS 850440; US$ 499 mn), parts of electric motors, generators, generating sets and rotary converters (HS 850300; US$ 477 mn), gears and gearing, other than toothed wheels, chain sprockets and other transmission elements presented separately; ball or roller screws; gear boxes and other speed changers, including torque converters (HS 848340; US$ 424 mn), PV panels/ modules (HS 854140; US$ 420 mn) and towers and lattice masts (HS 730820; US$ 299 mn) were the top five products that were imported by India, together accounting for a shade above 50% of the total imports of renewable energy related goods and equipments in 2008.

The following sections seek to individually examine the status of photovoltaic, wind and biomass energy sectors in India, the products and equipment of respective renewable technologies being traded by the country, the prospects and outlook of these sectors and the various initiatives taken, both at the industry and especially at the Government level, for enhancing the application of new renewable technologies in generation of sustainable energy.

PHOTOVOLTAIC

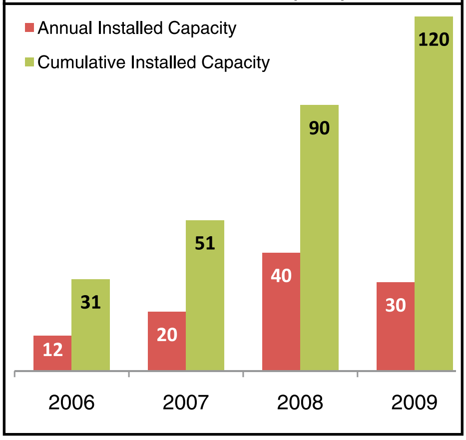
The use of photovoltaics in energy generation in India has been increasing steadily, although the potential of leveraging the energy embedded in sunlight is yet to be tapped to the desired level. This is indeed ironical considering that India is a tropical country endowed naturally with almost 300 days of sunlight in a year. The binding constraint that has thus far hindered the realisation of PV potential appears to be the high capital expenditure incurred initially for solar PV installations. Nonetheless, during recent times, apart from various Government entities, several private firms and corporates have begun evincing interest in energy generation from PV cells.

The Domestic PV Market

With a large proportion of power generated from photovoltaics being off-grid, and given the large number of small solar systems involved, the total installed PV capacity in India can at best only be an estimation, and not an absolutely accurate figure. Estimates by the European PV Industry Association[34] suggest that around 30 MW of new PV capacity was installed in India in 2009 taking the total cumulative PV capacity to 120 MW (Exhibit 38). This is significantly higher than the cumulative installed PV capacity of 31 MW in 2006, indicating a near four-fold increase (average annual growth of 58.1%) in the intervening years between 2006 and 2009. In terms of the value chain, the total solar cell manufacturing capacity in India is estimated to have touched 175 MW, while the total PV module manufacturing capacity was estimated to have reached 240 MW in 2008-09. Both these segments of the PV industry in India have grown significantly, especially during the recent past. While PV cell capacity has more than quintupled from a mere 32 MW in 2004-05 to 175 MW in 2008-09, manufacturing capacity of PV modules have performed even better increasing from 45 MW to 240 MW during the same period (Exhibit 38(b)).

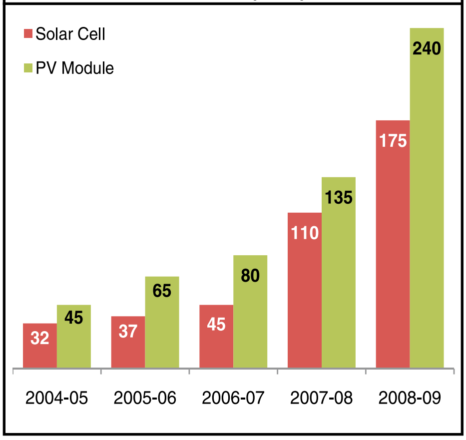
On an average, globally, annual installed PV capacity expressed as a percentage of total module production has ranged between 80% and 90%. However, as is evident, in case of India, this ratio (which is only an approximate, since installed PV capacity is indicated for calendar years, while those for PV cells and modules are provided for financial years) has averaged 15% during the 2005-06 and 2008-09 period. A plausible reason for this could

Exhibit 38 (a): Installed PV Capacity (Annual and Cumulative) in India - Recent Trends (MW)



Source: EPIA

Exhibit 38 (b): PV Cells and Modules - Trends in Manufacturing Capacity in India (MW)



Source: MNRE Presentaion at Solar Conclave 2010

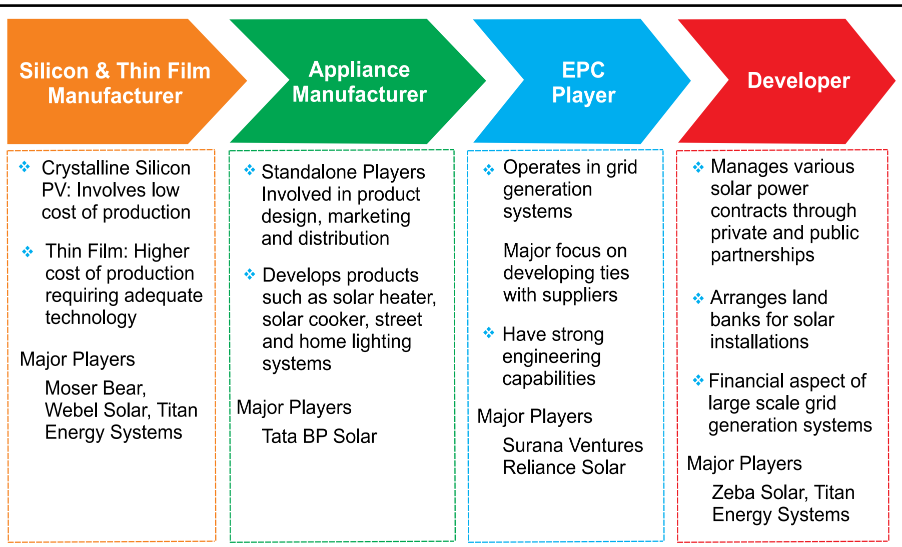
[34]Global Market Outlook for Photovoltaics Until 2014, May 2010 Update, EPIA

be that the domestic market in India for PV installation is almost entirely off-grid and involves a large number of small solar applications, resulting in a limited demand for PV cells and modules within the domestic shores. In fact, a large share of PV cells and modules averaging almost two-third of domestic production is being exported annually from India.

The PV cell manufacturing in India started with the involvement of public sector agencies (like Bharat Heavy Electricals Ltd., Central Electronics Ltd., Bharat Electronics Ltd., and Rajasthan Electronics & Instruments Ltd.), and Government owned research organizations, with private sector players entering the fray rather late. Currently, there are about 15 entities engaged in the production of PV cells in India, some 20 companies present in the PV modules space and nearly 50 companies are engaged in the assembly and supply of PV Systems (PV cell and PV modules). More and more firms are setting up, or expanding manufacturing units and developing forward linkages to develop solar power plants in India, although the market is still dominated by joint ventures and technical collaboration with foreign firms that specialise in PV products. The value chain of PV industry in India comprises four major segments, viz. silicon and thin film manufacturers, solar appliance manufacturers, Engineering, Procurement and Construction (EPC) players and Project Developers. A schematic presentation of the value chain and its key characteristics are presented in Exhibit 39.

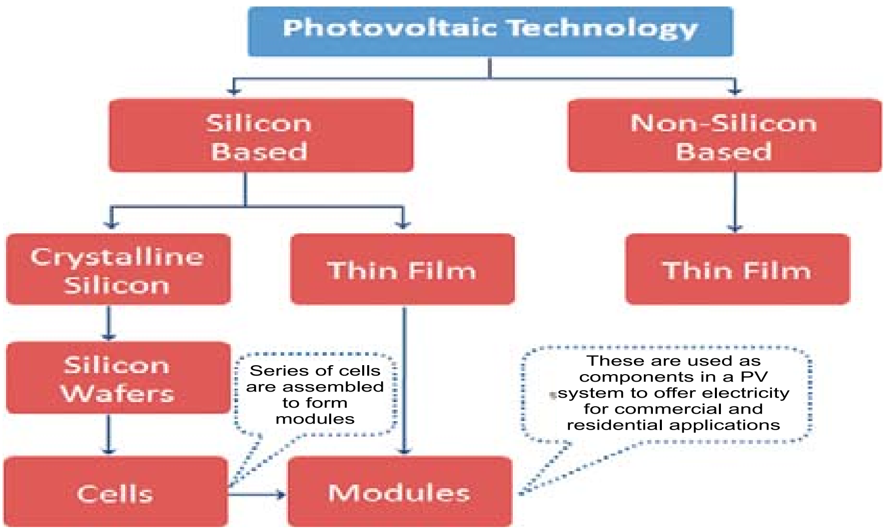
The solar PV technology in India is dominated by crystalline silicone with 90% of PV modules manufactured in the country using this technology, while only 10% of PV modules are manufactured using Thin Film or

Exhibit 39: Value Chain in the Indian Photovoltaics Market



Sources : Adapted from IVG Global Partners

Exhibit - 40 : Schematic Presentation of PV Technology



amorphous silicon technology. Other emerging technologies are either not yet being commercially utilised or are still at the research and development stage. While a schematic presentation of PV technology is presented in Exhibit 40, a comparison of the main technologies in use in the PV industry is given in Table 12.

PV Applications in India

The applications for photovoltaics in India, at present, are very different from the global mix of solar applications, where grid connectivity accounts for about three-fourth of installed capacity and off-grid lighting and consumer applications account for the balance.

Table 12: Characteristics of PV Technologies in Use in India

Technologies	Extent of commercialisation	Market share	Stabilised efficiency	Raw material requirement	Long term stability (modules warranty)	Remarks
Crystalline Silicon (mono & poly)	Fully commercialised	Approx. 90% for the last few years	13-18% at commerci al scale	10-12 gm silicon per Watt for thickness of 250 microns	20-25 years	Better power/ unit area
Thin Film	Relatively less commercialised	Approx. 10% for the last few years	6-9%	0.7-0.9 gm silicon per Watt	20-25 years	Relatively less power / unit area
New Emerging (Organic)	At R&D or pilot study stage		4-6%	Regular commercial production not yet stabilised	Yet to be established	Uses relatively cost effective material

Source: India Semiconductor Association

In contrast, in India, PV installations almost entirely comprise off-grid and small capacity applications. They are most visibly seen in lighting applications (street lighting, traffic signalling, domestic power back-up) in cities and towns, and in small electrification systems and solar lanterns in rural areas. PV has also begun to be deployed, albeit to a small degree, in powering water pump sets running surface/submersible pumps on farms, and in small industrial units. The railways, telecom and other government departments and agencies (including the defence and space research organizations) remain the largest consumers of PV in India (Table 13).

Table 13: Installations of PV Based Systems in India

PV Based Systems	Total No. of Installations
Solar Street Lightning Systems	88297
Home Lighting Systems	584461
Solar Lanterns	792285
Solar PV pumps	7334
Grid interactive renewable power from Solar	9.13 MW

Source: MNRE, Annual Report, 2009-10

Estimates of installed PV systems, published by the MNRE indicate the kind of applications that are typically deployed across the country today. PV industry sources estimate that total installed PV generation capacity is in the region of 120 MW, almost 97% of which is in the form of off-grid applications. The non-government market for small, off-grid PV installations are served by both major Indian PV system manufacturers and several smaller system integrators. High capital costs, lack of consumer awareness on the economics of PV, land acquisition problems, lack of common industry standard and financing constraints have been the main bottlenecks inhibiting the growth for non-government PV market in India.

India's Foreign Trade in PV

India's total trade in PV and related components has been increasing significantly – from US$ 539 mn in 2004 to US$ 2680 mn in 2008, recording an impressive average annual growth of 49.9%. The country's main trading partners for PV in 2008 included Germany (total trade of US$ 491 mn), China (US$ 317 mn), USA (US$ 309 mn), Spain (US$ 236 mn) and Taiwan (US$ 161 mn). Together, these five countries accounted for 57.5% of India's total trade in PV and related goods in 2008. In terms of products, HS 854140 (photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes), with total trade of US$ 949 mn in 2008, was India's largest traded PV product followed by HS 850440 (static converters) at US$ 939 mn, HS 841989 (other machines and mechanical appliances for the treatment of materials by a process involving a change of temperature: other) at US$ 434 mn and HS 841990 (other machines and

Table 14: India's Export and Import of PV and Related Products (US$ mn)

HS Code	EXPORTS					IMPORTS				
	2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
854140	85	99	135	213	529	45	59	125	169	420
850440	68	170	352	338	440	142	222	296	437	499
841989	40	92	103	148	223	49	73	83	118	211
841990	24	46	69	87	73	37	72	78	138	137
Others	14	16	18	24	33	35	62	89	95	115
Total	**231**	**423**	**677**	**810**	**1298**	**308**	**488**	**671**	**957**	**1382**

Note: Product descriptions corresponding to respective HS codes are given in Annexure 1.

Source: Derived from UN Comtrade Database

mechanical appliances for the treatment of materials by a process involving a change of temperature: parts) at US$ 210 mn. These four products contributed 94.5% to all PV and related goods traded by India in 2008.

Trade in PV and related components from India is seemingly evenly distributed in terms of exports and imports with the former aggregating US$ 1298 mn, and the latter totalling US$ 1382 mn in 2008. While the ranking of top PV and related products being exported remain the same as those for total trade, in terms of imports, HS 850440 was the largest item being imported by India in 2008 followed by HS 854140 (Table 14).

USA, Spain, Germany and the Netherlands were the main export markets for India's PV and related products in 2008, together accounting for 59.4% of the country's total exports in 2008. While exports to USA has witnessed consistent increase during the 2004-2008 period, exports to Spain and Germany have seen a sudden

Table 15: India's Major Export Markets of PV and Related Products (US$ mn)

Country	2004	2005	2006	207	2008	Avg. Annual Growth (%)
USA	43	119	196	198	214	62.6
Spain	2	4	29	43	213	292.2
Germany	59	68	60	84	206	47.2
Netherlands	10	25	100	100	138	122.0
Singapore	4	12	21	44	49	99.0
Saudi Arabia	7	3	11	13	47	122.3
Qatar	1	2	2	4	38	262.5
UAE	4	16	30	41	36	103.0
France	2	3	9	26	29	112.6
China	25	53	61	21	26	67.9
Others	74	118	158	236	302	45.6
World Total	**231**	**423**	**677**	**810**	**1298**	**55.8**

Source: Derived from UN Comtrade Database

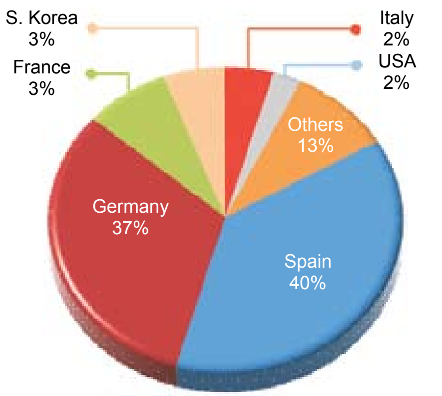
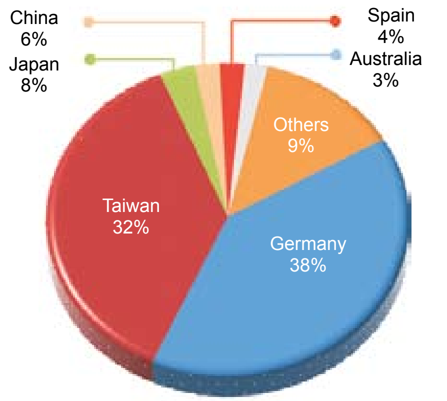
spurt in 2008, with exports to the former quintupling over the 2007 level of US$ 43 mn (Table 15).

The key single use exclusive item being traded under photovoltaic is HS 854140 (photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes). What is significant is to note that this was indeed the largest product exported by India in 2008 under the PV and related goods category. Even more encouraging is the growth in its exports – from just US$ 85 mn in 2004 to as much as US$ 529 mn in 2008 – more than six-fold increase in just a matter of 4 years. However, it may be noted that the HS category at 6-digit level also includes light emitting diodes (LED) in addition to PV modules and panels and if the amount traded in LED is significant, then the above data could lead to misleading analysis. Hence, to overcome this limitation, the data at HS 8-digit level provided by Directorate General of Commercial Intelligence and Statistics (DGCIS) for India's foreign trade, specifically of LED (HS 85414020), have also been examined. It was found that both exports and imports of LED by India was rather insignificant – while India's total exports of LED amounted to US$ 1 mn in 2007, and US$ 1.4 mn in 2008, India's imports were US$ 16.6 mn, and US$ 19.0 mn, during the same period. This works out to a negligible share (less than 0.1%) in the total exports, and only 9.8% and 4.5% for total imports, under HS 854140 (6-digit level) during 2007 and 2008. Given this, for the purpose of analysing trade patterns, HS 854140 could be safely assumed to be a single use item exclusively used for the photovoltaic industry.

Keeping this in perspective, India's main trading partners of PV panels/modules are presented in (Exhibit 41). As is evident, Germany and Spain are the two countries which figure among India's major export destinations as well as import sources of PV panels/modules. While Spain was the largest export destination contributing 40%, Germany was the biggest source of imports accounting for 38% of the India's total imports of PV panels/modules in 2008. The other major export markets were Germany (37%), France, South Korea (3% each), Italy and USA (2% each). In terms of import, Taiwan was one of the key sources accounting for 32% of India's total imports of PV panels/modules in 2008. Japan (8%), China (6%), Spain (4%) and Australia (3%) were the other important import sources.

Looking over a larger timeframe, the analysis of trends in India's international trade of PV panels/modules reveals that the emergence of Spain as the largest export destination is a recent phenomenon, primarily a result of a more than five-fold increase in exports to the country in 2008 (Table 16). This sudden spurt could seemingly be an aberration corroborated by the development in the Spanish PV market. According to International Energy Agency Photovoltaic Power

Exhibit 41: PV Panels/Modules (HS 854140) – India's Major Trading Partners in 2008

India's Exports of PV Panels : Major Markets (Total: US$ 529 mn)	India's Imports of PV Panels: Major Sources (Total: US$ 418 mn)
	

Source: Derived from UN Comtrade Database, Exim Bank Analysis

Table 16: Trend in India's Export and Import of PV Panels/Modules (US$ mn)

Country	INDIA'S EXPORTS					Country	INDIA'S IMPORTS				
	2004	2005	2006	2007	2008		2004	2005	2006	2007	2008
Spain	2	4	28	42	212	Germany	8	13	21	31	158
Germany	57	63	55	74	196	Taiwan	1	1	24	38	133
France	2	1	6	17	17	Japan	1	1	6	10	33
S. Korea	1	0	0	0	12	China	2	5	8	12	24
Italy	1	3	2	10	12	Spain	7	1	0	11	19
USA	7	9	18	18	11	Australia	18	21	34	25	11
Others	15	19	26	52	69	Others	6	15	32	40	40
Total	85	99	135	213	529	Total	43	57	125	167	418

Source: Derived from UN Comtrade Database

Systems Programme (IEA-PVPS), the annual installed PV power in Spain reached 2.6 GW in 2008 – almost five times the size of the market in 2007 – largely an outcome of the feed-in tariff scheme. However, in 2009, the Spanish annual market almost totally collapsed to around 2% of the 2008 market size. This followed mounting concern about the growth rates experienced in the Spanish PV market in 2007 and 2008, the speculative nature of some investments and the relative lack of PV installations in the residential sector. The development in the Spanish PV market holds clear lessons for India – the need for export diversification of PV panels/modules beyond Spain and Germany. As is evident from Table 17, these two markets, on an average, have accounted for two-thirds of India's exports of PV panels/modules during the 2004-2008 period, rendering India's export vulnerable to developments in their domestic markets.

In terms of importing PV panels/ modules, there has been a discernible shift in favour of sourcing from Asian countries, specifically Taiwan, Japan and China, although Germany continues to be the biggest supplier of PV panels/modules to India. Another significant trend that can be observed is the decline in importance of Australia as a source of imports – the country's share in India's imports have undergone a consistent declines – from a high of 41.9% in 2004 to 27.2% in 2006 and further to 2.6% in 2008. In fact, till 2006, Australia was India's largest source of imports of PV panels/modules. Thus, the above analysis brings out one clear trend – while India's source for imports of PV panels/modules have diversified significantly during 2004-2008, India's export markets continue to be very narrow, restricted largely to Spain and Germany, thereby calling for a need to diversify.

PV Industry in India – The Key Enablers

The PV industry in India is poised to grow significantly in the foreseeable future on account of five broad set of features that place it at an advantageous position, viz. geographical location, industry dynamics, vibrant export markets, carbon credit, and Government's policy initiatives. India, being a tropical country, receives sufficient solar radiation which is one of the primary enablers for generation of solar energy. Most of the regions in the country receive 4 kWh-7 kWh of solar radiation per square metre per day depending on the location, with the average solar insolation (a measure of solar radiation energy received on a given surface area in a given time) in a city like Mumbai being about twice that in New York, Berlin or Tokyo.

The industry dynamics in India is also likely to fuel the PV market, going forward. The key enablers under this category are expected to be the perennial power deficit faced by India, the increasing demand for off-grid PV applications, declining prices of raw materials and rise in polysilicon manufacturing in the country. With the country facing chronic power shortage – estimated at 10%, with a peak deficit of 17% – the source of electricity generation from any additional source is always welcome. This has and will continue to lead to increased use of solar power generation, especially from captive sources. With a large section of the population, particularly those living in rural areas and hinterland having limited or no access to electricity, and given the decentralised form of power generation from solar cells, demand for PV application in rural areas is likely to witness a strong growth. In addition, there are other off-grid PV applications which have huge scope in India such as off-grid lighting system, irrigation pump, backup power for telecom, roof based solar PV, building integrated PV systems, billboard application, residential backup application and solar home lighting systems, all of which will fuel demand for the PV sector.

The year 2009 saw a significant decline in the major raw material price for the PV industry, viz. silicon. While global polysilicon prices fell by 80%, silicon wafer prices declined by 50%, and crystalline module prices dropped by 38%, thereby resulting in reduction in cost of power generation from the PV technology. The drop in price of polysilicon continued in 2010 and reached a 4-year low of US$ 52.5/kg in March 2010 before recovering marginally to US$ 56.1/kg in August 2010 , largely due to short term demand from the German, Italian, French and Czech markets, where there is a rush to build PV projects, before incentives are reduced in the latter half of 2010. The prices are likely to remain subdued in 2010 and 2011, which is likely to reduce operating expenses and the cost of generating solar photovoltaic energy, rendering the technology more cost effective and thereby stimulating demand for PV applications. Further, Indian companies are also planning to foray into the production and processing of polysilicon so as to reduce their reliance on imports – currently, India imports about 4,000 tonnes per annum of polysilicon and wafers. This would also play a catalytic role for the PV industry as proximity to raw material will encourage companies to enter the PV domain.

India has performed exceedingly well as far as exports of PV panels/modules are concerned, increasing by more than six-fold in just a matter of 4 years between 2004 and 2008. Further, a large share of PV cells and modules averaging almost two-third of domestic production is being exported annually from India. With global electricity generation capacity from photovoltaics projected to nearly double from 7.2 GW in 2009 to 13.7 GW by 2014 (moderate projections by EPIA), they would act as a key driver of exports of PV cells and modules and as a corollary would fuel the domestic PV industry as also encourage new market entrants.

Carbon credits and its trading are also likely to stimulate the domestic PV industry by enhancing the cost competitiveness of PV projects. When a firm in India invests in a renewable energy source like solar photovoltaic, it will be able to acquire carbon credits which can be traded in the international markets generating income for the owner of the credits. Carbon credits, which are issued to organizations based on their efforts to limit climate change, and renewable energy projects are intricately linked in India. The Clean Development Mechanism under the Kyoto Protocol allows developing countries like India to generate emission credits (CERs) for industrialized countries by GHG emission reduction projects such as solar PV. The sale of CERs would tend to accelerate solar power development in India. For example, India could set up (currently) high cost solar power plants and reap the economic advantages obtained by saving emissions and earning money from trading emissions so saved. The cost of carbon saved when switching from a coal based power plant to solar power station is estimated to be US$ 107 per ton of carbon (Table 17). It is equally important to note that such an economic environment would help to bolster the market for solar PV technologies.

The last but among the most important enabler of PV industry in India would be the Government's policy initiative, which is discussed separately in the following section.

Select Government Initiatives and Policies

Various policy initiatives have been taken by the Government recognizing the significance of the PV industry and its potential. The main Government departments working towards the development of photovoltaic energy and other new renewable sources of energy include the Ministry of New and Renewable Energy (MNRE), Indian Renewable Energy Development Agency (IREDA), and Solar Energy Centre (Exhibit 42). These agencies have undertaken various measures with a view to create an enabling environment for the PV industry in India. At a broad-level, such policies include: the National Action Plan for Climate Change (NAPCC), Jawaharlal Nehru National Solar Mission (JNSM), and Semi-Conductor Policy. Specific to the PV industry, there are capital investment subsidies, generation-based incentives (similar to that of feed-in-tariffs) for grid interactive solar PV generation projects, and support for R&D in PV technologies.

The Government of India announced the JNSM in late 2009 which proposes to provide significant incentives to the solar PV industry. The Mission aims to achieve volume production at a

Table 17: Cost of Carbon Saved When Switching from a Coal Based Power Station to a Solar Power Station

Cost Item	Coal-based power station	Solar power station
Carbon emissions*	260C/kwh	0 gmC/kwhr
Capital cost	US$ 1653/kw	US$ 2185/kw
Annual Operating/maintenance cost	US$ 47/kw	US$ 8.8/kw
Fuel cost (assuming coal cost is US$2/GJ)	US$ 0.02/kwh	US$ 0.00/kwh
Total electricity cost, at 0% cost of capital**	US$ 0.034/kwh	US$ 0.047/kwh
Cost of saved carbon ***	US$ 48/tonC	
Total electricity cost, at 10% cost of capital	US$ 0.05/kwh	US$ 0.118/kwh
Cost of saved carbon	US$ 107/tonC	

Notes:
* Assuming coal has 29.3 MJ/kg and 75% carbon, coal plant efficiency is 35.1%
** Assuming 85% capacity factor for coal, 25% capacity factor for solar, and a 30 year lifetime.
*** Cost of saved carbon is defined as net present value of costs (at specified discount rate) divided by total carbon saved.
Source: Centre for Science & Environment, New Delhi

Exhibit 42 : Major Government Bodies Involved with Renewable Energy Development in India

Ministry of New & Renewable Energy (MNRE)

- Chief body concerned with new and renewable energy
- Responsible for the implementation of Programmes which include
  - Rural lighting, cooking and motive power
  - Use of renewable energy in urban, industrial and commercial applications
  - Development of alternate fuels and applications

Indian Renewable Energy Development Agency

- Under the administrative control of MNRE
- Promotes, develops, extends financial assistance for renewable energy and energy efficiency projects
- It is notified as a Public Financial Institution under section 4 of the Companies Act, 1956 and registered as a Non-Banking Finance Corporation

Solar Energy Centre

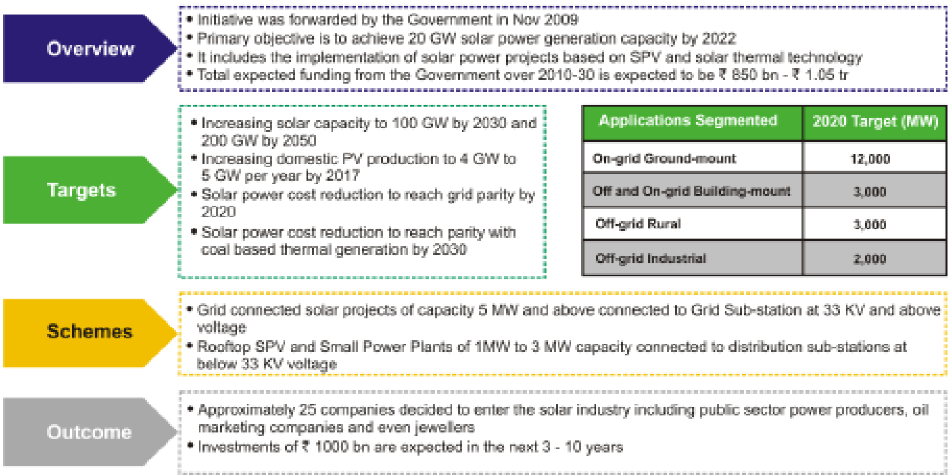
- A unit of MNRE
- Works towards the development of solar energy technologies and promotes its applications
- Undertakes activities related to design, development, testing, standardization, consultancy, training and information dissemination in the field of Solar Energy

scale which leads to cost reduction and rapid diffusion and deployment of solar technologies both at centralized and decentralized levels across India in 3-phased manner spread across 12 years (Table 18). The first phase (up to 2013) will focus on capturing the low-hanging options in solar thermal; on promoting off-grid systems to serve populations without access to commercial energy and modest capacity addition in grid-based systems. In the second phase, after taking into account the experience of the initial years, capacity will be aggressively ramped up to create conditions for up scaled and competitive solar energy penetration in the country. A schematic outline of JNSM has been provided in (Exhibit 43).

Table 18: Road Map of JNSM

Application segment	Target: Phase I (2010-13)	Cumulative Target: Phase 2 (2013-17)	Cumulative Target: Phase 3 (2017-22)
Utility grid solar power incl. roof top	1,100 MW	4,000 MW	20,000 MW
Off-grid applications (incl. rural solar lights)	200 MW	1,000 MW	2,000 MW
Solar collectors	7 million sq metres	15 million sq metres	20 million sq metres

Exhibit 43: Jawaharlal Nehru Solar Mission – An Overview



Source : Reliance Industries Ltd. "Recent Trends in Solar Power", Oct. 2009

In order to facilitate these planned capacity additions, MNRE, through IREDA would provide a generation based incentive (GBI) of ₹12 per unit of solar PV. The policy has been unique as compared to previous renewable energy polices in the sense that it provides financial support on the actual output and not on the capital, thereby avoiding a big drain on the exchequer since PV deployment is highly capital intensive. A schematic representation of the salient features of GBI is presented in Exhibit 44.

To promote solar power for off-grid applications for photovoltaic, the Government is also offering financial support through a combination of 30% subsidy and/or 5% interest bearing loans for companies in the business. The guidelines on off-grid and decentralised solar applications released by MNRE to meet the targets set by the JNSM lays down the funding pattern for such projects. The funding pattern under the scheme would be in project mode and the total project cost would be financed through a mix of debt and incentives where the promoters' equity contribution would be at least 20%. Under the scheme, off-grid solar PV systems up to a maximum capacity of 100 kWp per site and off-grid and decentralised solar thermal applications would be eligible. For mini-grids for rural electrification applications up to a maximum capacity of 250 kW per site would be considered. For 2010-11, the benchmark price for PV systems with battery back-up is considered as ₹300 per Wp. In case of systems not using storage battery such as water pump systems, the installed PV system cost will be at a maximum of ₹210 per Wp. The guidelines also envisage soft loans for projects, including a component for working capital, to be

Exhibit 44: Generation Based Incentives in India

Generation Based Incentive (GBI)

Government Authorities supporting the Generation Based Incentive Scheme (GBI)

* Ministry of New and Renewable Energy will extend support to the grid connected solar PV projects across India
* Indian Renewable Energy Development Agency (IREDA) will help MNRE in fund handling, monitoring and other related activities.

Objectives of the Scheme

* To promote and develop the technical performance of grid connected solar power generation across India
* Reduce the cost of grid connected solar systems in India and also to minimize the cost of overall solar power generation in the country

Eligibility Criteria and Benefits

* Minimum installed capacity for grid interactive solar PV plant should be 1MWp
* Any project developer can set up grid interactive PV power generation projects up to a maximum of 5 MWp capacity in the country
* It will provide financial assistance of ₹12/kWh in case of solar PV plant with a capacity of 1 MWp and above

made available to SME manufacturers of solar thermal systems and balance of systems manufacturers for solar PV (excluding battery manufacturers) through re-finance facility implemented through IREDA. Capital subsidy of 90% of the benchmark cost would be available for special category States - North-East, Sikkim, Jammu & Kashmir, Himachal Pradesh and Uttarakhand. In addition, it will be extended for setting up solar power plants/packs (both PV/ thermal) in remote difficult areas such as Lakshadweep, Andaman & Nicobar Islands, and districts on the country's international border. However, for funding solar thermal systems in these areas, the subsidy would be limited to 60% for all categories of beneficiaries. The interest subsidy under the scheme would be made available to NBFCs and scheduled commercial banks (excluding Regional Rural Banks) by way of re-finance from IREDA.

JNSM has proposed to define a policy framework and provide an incentive structure, to attract large capital investments, encourage technical innovation, and lower the cost to grid parity, and thereby achieve the targets set for the capacity augmentation. The incentive framework proposed would be a combination of three elements, viz., setting of Feed-in-Tariff; 10-year tax holiday, customs duty and excise duty exemption on capital equipment and critical materials. JNSM has estimated a fund requirement of ₹85,000 crore to ₹105,000 crore over the 30-year period, starting with ₹5000 crore to ₹6000 crore (including cost of demonstration plants) in the Eleventh Five Year Plan. JNSM proposes to generate the funds through taxing the fossil fuels and fossil-fuel based power generation, and distribute through a non-lapsable Solar Fund. Levy of cess is also proposed on usage of some conventional fuel at the rate of 10 paisa / Kcal, and 5 paisa / kWh on thermal power generation. JNSM also envisages to launch a major R&D programme in solar energy, which will focus on improving efficiency in existing applications and reducing costs of Balance of Systems (for e.g. batteries) as also focus on research in areas such as development of new materials, processes, systems, production and testing equipment for solar cells and modules, and electronics used in PV systems, supporting the indigenous production capabilities.

The Government has also been promoting the semiconductor industry – key components of PV panels/modules – by announcing the special incentive package scheme, under which, manufacturers of semiconductor wafer fabrication facility and other units related to semiconductor (which include solar photovoltaic) are entitled to a subsidy of 20% of the capital expenditure for a unit in special economic zone (SEZ) and 25% for non-SEZ unit. The policy has facilitated setting up of semiconductor manufacturing facilities, which in turn has stimulated the domestic PV industry. Other select initiatives of the Government are schematically presented in Exhibit 45.

Several recent Government announcements and policy measures suggest that PV adoption may be entering a phase of major expansion. The states of Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Punjab, Rajasthan, Tamil Nadu and West Bengal have announced their own solar PV projects, policies, plans, and incentive packages in recent months, including those for grid-connected

Exhibit 45: Select Government Initiatives to Support Domestic PV Industry

FISCAL INCENTIVES	* 10 year tax holiday is given to SPV players for photo voltaic projects set up by them by 2020 * No Central Excise duty is levied on specific capital equipment, critical materials and project imports. * Customs duty on equipment for SPV projects is very low at 5%. * Loans are also offered at very low rates
SPECIAL INCENTIVE PACKAGE (SIP)	* In September 2007, GOI announced the SIP. One of the purpose was to encourage players to make investments in solar PV sector —> Under SIP, GOI will provide 20% subsidy for SPV project in a SEZ while 25% subsidy will be provided in case of a non SEZ —> In case State Govt. provides incentives then it would be over and above this amount
REMOTE VILLAGE LIGHTING PROGRAMME	* MNRE has taken an initiative to electrify rural areas through renewale energy resources * 6,431 villages covered under this scheme have been electrified through solar PV technology * 95% of the villages have been provided with solar PV home lighting system
AKSHAY URJA SHOPS	* In order to make solar energy products easily available MNRE along with IREDA is setting up Akshay Urja Shops in major cities in India * A total of 297 such shops have been sanctioned which have either been set up or are under development in 28 cities/UTs across India * Individuals or companies can avail a loan of up to INR 1 mn from the designated banks at an interest rate of 7% to set up such shops

generation. MNRE, Government of India has targeted grid connected PV generation capacity of 50 MW by 2012, which is expected to be achieved well in time.

The various states in India are slowly realizing their potential and are creating policies to enhance investments in this sector in their respective states. After the introduction of feed-in-tariff by the Government of India, to the maximum of ₹15/kWh in case of grid-connected systems, in March 2008, West Bengal became the first state to declare feed-in-tariff at ₹11/kWh. Government of Gujarat launched its new 'Solar Power Policy' plan, including incentives for the development of at least 500 MW solar PV power. Gujarat, with between 1800 hours and 2200 hours of sun each year, is putting together a plan to develop at least 50 MW of PV power plants. The potential for solar PV in Rajasthan, with its vast area of sunny desert, is also significant.

Outlook for PV Market in India

Renewable resources, in the forms of solar, wind, hydroelectric, biomass, and geothermal sources, provide energy while addressing environmental concerns. Of these technologies, solar photovoltaic energy provides the most reliable, scalable, and long-term economically viable solution with the least environmental impact. Moreover, solar energy generation profiles match usage patterns well (i.e. high energy is consumed when the sun is at peak). It may be mentioned that over two-third of India's population is involved in agriculture and other rural-based activities. Around 500 million Indians are estimated to be having no access to grid electricity, and an estimated 80,000 villages are not connected to the grid. This segment presents significant opportunities for PV industry.

The usage of photovoltaic technology in India is critical given the power shortages that the country faces and the potential the photovoltaic industry may play in mitigating this gap. It is useful for providing grid quality, reliable power in rural areas where the line voltage is low and insufficient to cater to connected load. Solar photovoltaic modules are uniquely suited for small-scale off-grid applications such as rural electrification projects. Installations can be as small as 100 kW, panels and equipment are easy to transport and install in remote locations, and facilities require little space. Another area of growth is in the irrigation sector, especially installation of solar irrigation pumps. Telecom sector offers significant growth opportunities for PV industry; cellular telephone base stations and towers are growing across the country, which could install solar PV systems than using diesel generators. The use of PV systems in urban areas is also increasing, with growth in building integrated PV, use of PV for billboards, development of street and traffic lighting solutions, and highway lighting. In the industrial sector, the PV power generation plants could replace diesel based captive power generation.

The grid parity situation will open up opportunities for new business models, such as the leasing of solar energy systems. This could remove the hurdle facing private households of making an initial solar system investment. A new type of energy company could emerge from this, where one owns the PV system on the customer's roof and sells the solar electricity generated per kWh to the homeowner. With a number of companies taking the inorganic growth path and diversifying into the PV industry, the prospects for PV industry in India remain fairly bright.

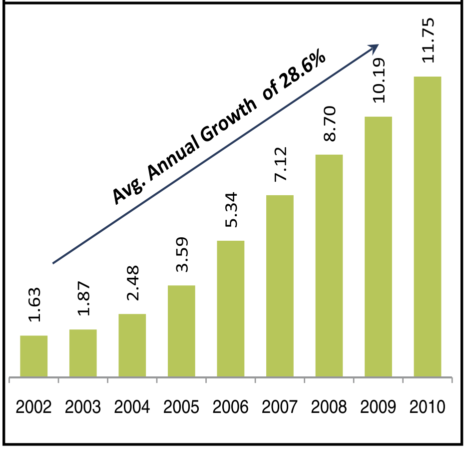
WIND ENERGY

India, with a large peninsular belt, and two-season monsoon, has significant potential in generating wind energy. Apart from onshore generation, India also has potential for tapping offshore belts for wind energy. Although offshore generation of power is an expensive proposition under present technologies, with the required capital averaging between US$ 2 million and US$ 3 million per MW, offshore wind farms enjoy much higher plant load factors. Also, as demand increases and technology improves, cost will come down.

The Domestic Wind Energy Market

Power generated from wind energy has witnessed a steady increase in the Indian market. According to the Centre of Wind Energy Technology (an autonomous R&D institution under MNRE), total installed capacity reached 11.75 GW as at end March 2010, up from 1.63 GW in 2002, thereby registering a healthy average annual growth of 28.6%. The country added 1564.7 MW to the installed capacity in 2009-10 as against 1484.0 MW in 2008-09. Although high in itself, this is only a small percentage of the estimated potential – the onshore gross potential that can be harnessed from wind energy in India is estimated at about 48.5 GW with Karnataka, Gujarat and Andhra Pradesh offering the maximum potential of 11.5 GW, 10.6 GW and 8.9 GW, respectively[35] (Table 19).

Exhibit 46: Cumulative Installed Wind Energy Capacity in India (GW) - end March



Source: C-WET, MNRE, Exim Bank Analysis

Table 19: Estimated Wind Power Potential in India

State	Gross Potential (MW)
Karnataka	11531
Gujarat	10645
Andhra Pradesh	8968
Tamil Nadu	5530
Rajasthan	4858
Maharashtra	4584
Madhya Pradesh	1019
Orissa	255
Kerala	1171
Total	48561

Source: MNRE Annual Report 2009-10

[35]Source: MNRE Annual Report 2009-10; gross potential is based on the assumption of 1% of land availability in potential areas for setting up wind farms @12 ha/MW in sites having wind power density greater than 200 W/sq. m at 50 m height

However, in terms of actual installed capacities, wind power is concentrated mainly in the southern state of Tamil Nadu, with an installed capacity of 4875.9 MW (as at end March 2010), representing 41.5% of India's total installed wind energy capacity. According to MNRE, India has wind electric generators of diverse unit sizes, ranging from 225 KW to 1.65 MW. These installations have cumulatively fed over 54 billion units of electricity to the state electricity grids; of which, the installations in Tamil Nadu alone have contributed over 32 billion units of electricity. Notwithstanding this, the geographic dispersion of wind farms in India has been gradually witnessing a shift. With increasing interests in renewables, the dominance of Tamil Nadu has been gradually declining as other states, including Maharashtra (2071.6 MW), Gujarat (1864.6 MW), Karnataka (1506.9 MW) and Rajasthan (1091.7 MW) have started to catch up (Table 20).

Specific policies have been introduced by the state Governments (through the State Electricity Regulatory Commissions) to encourage setting up of wind power projects. The policies cover regulations pertaining to types of investments, as also the buy-back of power at a contracted rate. The state level policies for wind power projects is highlighted in Table 21. It may be noted that most states mentioned in Table allow open access transactions and third party sale.

India also manufactures wind electric generators through (a) joint ventures or under licensed production; (b) subsidiaries of foreign companies under licensed production; (c) Indian firms with indigenous technology. An indigenization level of 50%-80% has been achieved in machines. A few manufacturers have started manufacturing wind electric generators without any foreign collaboration. The annual production capacity of

Table 20: State-wise Annual Wind Power Installed Capacity

No.	State	Annual Installed Capacity Addition (MW)					Cumulative Capacity (MW)
		2005-06	2006-07	2007-08	2008-09	2009-10	
1	Tamil Nadu	860.7	570.5	392.7	423.7	598.3	4875.9
2	Maharashtra	545.1	483.6	276.1	181.1	134.1	2071.6
3	Gujarat	84.6	329	580.1	313.6	296.2	1864.6
4	Karnataka	170.9	264.8	187	322.4	154.4	1506.9
5	Rajasthan	74.5	111.8	70.5	199.6	350	1091.7
6	Madhya Pradesh	11.2	17.5	69.3	25.1	16.6	167.5
7	Andhra Pradesh	0.9	0.8	-	-	13.6	140.4
8	Kerala	-	-	8.7	18.6	1.5	31.2
9	Others	0.25	0.5	-	-	-	2.1
	ALL INDIA	**1748.2**	**1778.3**	**1584.3**	**1484.0**	**1564.7**	**11752.8**

Source: C-WET, MNRE, Wind Energy Generator Manufacturers, Exim Bank Analysis domestic wind turbine was about 3000 MW in 2009-10. The trend in recent installations indicates a shift towards better aerodynamic design, use of lighter and larger blades, higher towers, direct drive, and variable speed gearless operation using advanced power electronics typically to suit moderate wind regime and weak local grid network. The manufacturing of wind turbines with latest technology like permanent magnet generator has also started in the country. The wind energy industry has taken up indigenised production of blades, gearboxes, yaw components and controllers etc. It may be mentioned that import component has been at greater level in higher capacity machines, and an indigenous level of upto 70% has been achieved in machines of unit sizes of upto 500 KW.

Table 21: Policies by State Governments for Setting-up of Wind Power Projects

State	Wheeling[a]	Banking[b]	Buyback[c]	RPS[d]	Others
Andhra Pradesh	5% of energy	Not allowed	₹ 3.5 / kWh frozen for 10 years	--	Industry status granted
Haryana	2% of energy	Allowed	₹ 4.08 / kWh with escalation	--	
Karnataka	5% of energy	2% p.m. for 12 months	₹ 3.40/kWh fixed for 10 years	3%	Exemption from electricity duty
West Bengal	₹ 0.30 / unit which may be revised	6 months	To be decided on case to case basis	--	
Madhya Pradesh	Allowed: 2% of energy + charges	Allowed	₹ 4.03 / kWh, reducing @ 17 paisa/year	--	Exemption from electricity duty
Maharashtra	2% of energy + charges	12 months	₹ 3.50 / kWh with escalation clause	--	Subsidy for power evacuation arrangement
Rajasthan	10% of energy	3 months	₹ 3.67 - ₹ 3.71/kWh	--	Exemption from electricity duty
Tamil Nadu	5% of energy	12 months	₹ 2.90 / kWh	--	--
Gujarat	4% of energy	Monthly settlement	₹ 3.37 / kWh fixed for 20 years	--	Exemption from electricity duty
Kerala	5% of energy	9 months	₹ 3.14 / kWh for 20 years	--	--
Punjab	2% of energy	Allowed	₹ 3.66 / kWh with five annual escalation	--	--

Source: MNRE, State Policies

[a]Wheeling: Charges imposed on entities using power for captive consumption at their sites routed through the state grid

[b]Banking: Storage of power generated by producers with the State Electricity Boards which can be drawn for future use

[c]Buyback guarantee from State Electricity Grids for purchase of wind power generated

[d]Renewable Portfolio Standard – State utilities have to purchase a certain portion of their energy from green sources

Table 22: India's Foreign Trade in Wind & Related Goods – Major Partners

Major Export Destinations (US$ mn)						Major Import Sources (US$ mn)					
Country	2004	2005	2006	2007	2008	Country	2004	2005	2006	2007	2008
World	302	451	965	1144	1809	World	731	1014	1165	1537	2224
USA	30	79	419	314	355	China	66	100	161	398	639
Brazil	3	4	4	66	156	Germany	216	315	403	444	600
Australia	6	5	15	90	139	Italy	31	33	63	91	129
Spain	1	5	16	12	107	USA	40	62	70	79	121
Portugal	0	0	19	16	87	Japan	63	69	71	80	106
UAE	37	37	32	48	70	S. Korea	20	31	34	40	76
Germany	14	24	23	44	53	Belgium	9	15	9	32	74
Oman	2	16	19	16	49	Malaysia	4	11	6	9	56
Turkey	3	0	2	1	40	Denmark	70	84	51	35	45
Nigeria	2	9	14	25	36	France	22	27	24	32	39
Others	204	272	402	512	717	Others	190	267	273	297	339

Source: Derived from UN Comtrade Database

India's International Trade in Wind Energy and Related Products

India's international engagement with regard to trade in a broader set of wind energy and related components has been on the rise. The country's total trade in wind energy and related products aggregated US$ 4.0 bn in 2008 – an impressive average annual increase of 40.9% during the 2004-2008 period. Out of the total trade figure of US$ 4.0 bn in 2008, the country's exports amounted to US$ 1.8 bn while imports aggregated US$ 2.2 bn, thereby resulting in a negative trade balance. In fact, India has been in trade deficit for wind energy and components for each of the past 5 years (2004-2008) (Table 22).

USA was India's main export destination of wind energy products in 2008 with exports amounting to US$ 355 mn (19.6% share). Other major export markets included Brazil (US$ 156 mn; 8.6% share), Australia (US$ 139mn; 7.7%), Spain (US$ 107 mn; 5.9%) and Portugal (US$ 87 mn; 4.8%). In terms of imports, China and Germany were by far, the two biggest sources with imports amounting to US$ 639 mn and US$ 600 mn, respectively. Together, these two countries accounted for 55.7% of India's total imports of wind energy and related components in 2008. China overtook Germany in 2008 to become the largest source of import for India. The other major sources of imports in 2008 included Italy (US$ 129 mn; 5.8% share), USA (US$ 121 mn; 5.4%), and Japan (US$ 106 mn; 4.8%).

In terms of commodity composition, the encouraging aspect form the point of view of data analysis and interpretation thereof was the fact that wind turbines (HS 850231) – the key single use item identified as being used exclusively for the production of wind energy –

was the single largest item exported from India not only in 2008 but also in the preceding two years (i.e. 2007 and 2006). Wind turbine was also the single largest product traded by India in the wind energy sector in 2008 with total trade aggregating US$ 653 mn, implying that almost the entire amount being traded in 2008 was for the purpose of exports with only a negligible amount being imported (Table 23). Other major categories of wind energy and related products traded by India in 2008 included parts of electric motors, generators, generating sets and rotary converters (HS 850300), towers and lattice masts (HS 730820), gears and gearing, other than toothed wheels, chain sprockets and other transmission elements presented separately; ball or roller screws; gear boxes and other speed changers, including torque converters (HS 848340) and liquid dielectric transformers: having a power handling capacity exceeding 10,000 kVA (HS 850423).

As mentioned earlier, the key single use exclusive item identified for the wind energy sector was wind turbines (HS 850231). An analysis of the trading pattern of wind turbines reveals that its exports from India have grown at a phenomenal pace – from a mere US$ 1 mn in 2004 to as much as US$ 651 mn in 2008 – a stupendous average annual growth of 885.1%. This growth has been fuelled primarily by India's robust exports to USA which shot up from US$ 22 mn in 2005 to US$ 203 mn in 2008, placing it as the largest export destination for wind turbines from India

Table 23: India's Foreign Trade in Wind & Related Goods – Major Products

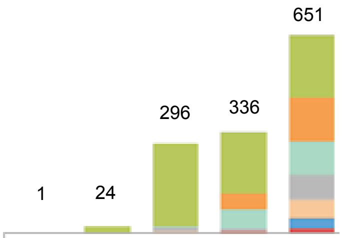
EXPORTS (US$ mn)						IMPORTS (US$ mn)					
HS Code	2004	2005	2006	2007	2008	HS Code	2004	2005	2006	2007	2008
Total	302	451	965	1144	1809	Total	731	1014	1165	1537	2224
850231	1	24	296	336	651	850300	257	401	426	407	477
850423	45	70	108	141	255	848340	105	125	161	248	424
730820	48	71	126	171	253	730820	11	5	3	181	299
850300	30	53	143	117	164	848210	83	119	130	137	169
848340	15	25	36	44	59	850423	9	18	12	20	157
848220	28	36	36	42	58	848280	32	42	68	85	105
850421	9	15	39	59	58	848230	40	60	68	81	105
850422	9	9	28	36	48	848220	27	41	50	59	90
848210	29	25	28	30	44	850431	24	37	56	59	66
841290	14	17	22	32	34	841290	27	27	36	41	57
Others	74	106	103	136	185	Others	116	139	155	219	275

Note: Product descriptions corresponding to respective HS codes are given in Annexure 1.

Source: Derived from UN Comtrade Database

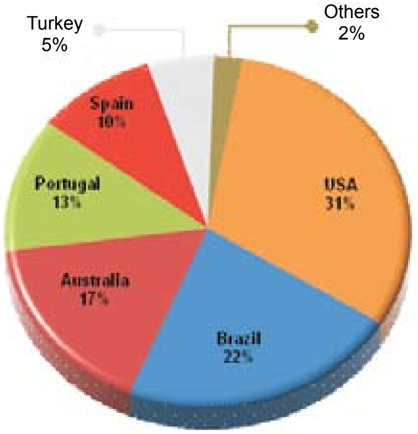
Exhibit 47 : India's Exports of Wind Turbines (HS 850231)

Trends in India's Exports of Wind Turbines (US$ mn)



	2004	2005	2006	2007	2008
USA	0	22	274	205	203
Brazil	0	0	0	53	145
Australia	0	0	1	62	109
Portugal	0	0	15	10	81
Spain	0	0	2	0	63
Turkey	0	0	0	0	35

India's Exports of Wind Turbines in 2008: Major Markets (Total: US$ 651 mn)



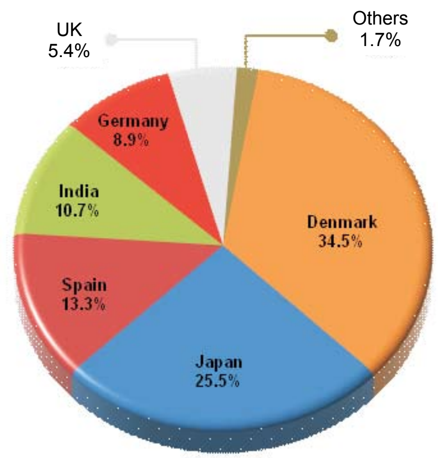
Source: Derived from UN Comtrade Database

(a share of 31%). The other major export destinations for wind turbines in 2008 included Brazil (US$ 145 mn; 22% share), Australia (US$ 109 mn; 17%), Portugal (US$ 81 mn; 13%), Spain (US$ 63 mn; 10%) and Turkey (US$ 35 mn; 5%).

Considering that USA is the largest market for India's exports, some analysis of its importing pattern of wind turbines could provide valuable insights. The US wind turbine imports increased substantially after 2005, peaking in 2008 and declining slightly in 2009. This trend mirrored the one seen in India's exports to the US market – a sudden spurt in exports from US$ 22 mn in 2005 to US$ 274 mn in 2006, although in the subsequent two years, export declined marginally. Since US imports of wind turbines and related products is available at a far more disaggregated level, through the provision in the Harmonized Tariff Schedule of the United States (HTS) at 10 digit level, analysis would be more precise than the one carried out in the earlier chapter for the world as a whole or in this chapter for India. Following the HTS classification, US imports of wind-powered generating sets (HTS 8502.31.0000) – that includes nacelles and, if they are imported with the nacelle, other components – leapfrogged from US$ 482.5 mn in 2005 to US$ 2.5 bn in 2008, and then marginally decreased to US$ 2.3 bn in 2009. Denmark was the leading source of imports in 2009, accounting for 34.5% of imports. Japan accounted for 25.5%, Spain 13.3%, India 10.7%, and Germany 8.9% (Exhibit 48). Similarly, U.S. imports in the HTS provisions that include towers and blades increased from 2005 to 2008, and then declined in 2009.

Imports of other parts of generators and other engines and motors, which include wind turbine blades and other components such as hubs, increased from US$ 562.7 mn in 2005 to US$ 1.8 bn in 2008, then declined to US$ 1.3 bn in 2009. The top five sources of these imports in 2009 were Brazil (21.2% of imports), Mexico (17.5%), Germany (14.1%), India (8.6%), and Denmark (8.1%). Imports of towers and lattice masts, the HTS classification that includes wind turbine towers, increased from US$102.7 mn in 2005 to US$ 944.4 mn in 2008, but declined thereafter to US$ 612.2 mn in 2009. Since 2007, there has been a shift in the sourcing of US tower imports from Europe to Asia, with the share of imports from five Asian countries (China, India, Indonesia, Korea, and Vietnam) increasing from 31% to 81%

Exhibit 48: US Imports of Wind Powered Generating Sets in 2009 (Total: US$ 2.3 bn)



Source: USITC, Exim Bank Analysis

of imports. US imports of wind-powered generating sets, blades, towers, gearboxes, and generators accounted for approximately 38% of the market in 2008 (which was estimated at US$ 14.9 bn) and 36% in 2009 (US$ 12.5 bn).

Given the trends in US imports of wind turbines and related components, the market appears to be offering vast opportunities for Indian companies, both in terms of trade as also in terms of setting up of wind turbine manufacturing units so as to reduce logistic costs. However, analysis of India's export direction of wind turbines reveals that the market, like PV panels/ modules, is very narrow, dictated to a large extent by the demands in the US market, thereby necessitating a need for market diversification as an export strategy which could be sustainable over the long run.

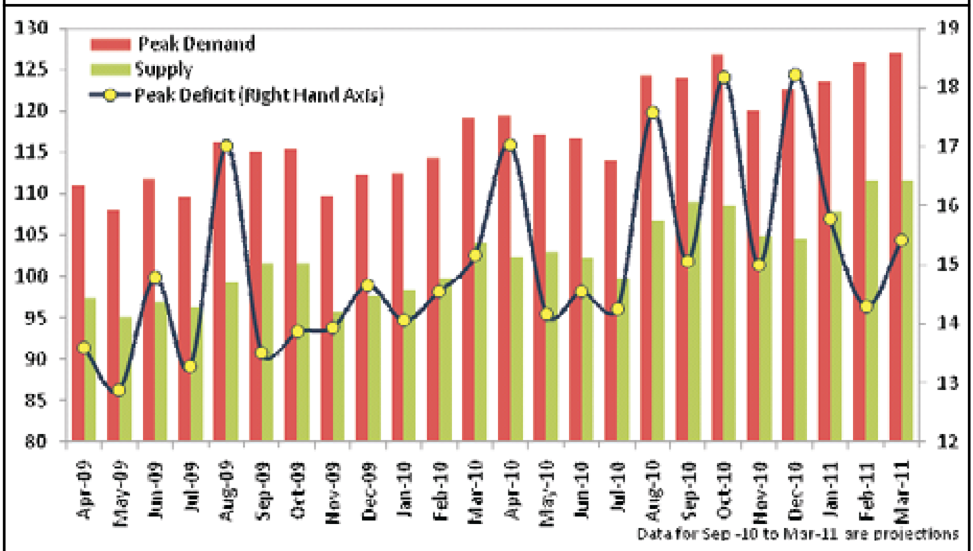
Wind Energy – The Key Demand Drivers

The robust growth in the Indian wind energy industry has been largely driven by the incentives provided by the Central and State governments. These incentives have been discussed separately in the following section. The growth in the market for wind energy would also continue to be driven by a host of other factors including existing and projected gaps in the electricity supply, growing carbon credit markets, future cost competitiveness and global shift in the movement towards generation of clean energy.

The perennial power deficit faced by India has led to exploration of alternate sources of energy other than fossil fuels like coal. While the peak power deficit averaged 14.3 GW during 2009-10, it is projected to average 15.8 GW during 2010-11 (Exhibit 49). With power deficit projected to increase further in the foreseeable future, it is expected to drive the market for renewables like wind energy.

The Clean Development Mechanism under the Kyoto Protocol is likely to provide a strong impetus to the wind energy sector in India. The sale of Carbon Emission Reduction (CERs) will continue to help accelerate wind power development in India. The revenue from the CERs for wind power projects has the potential of meeting the annual operation and maintenance (O&M) cost. Based on this, the equipment manufacturers are developing the concept of a free annual maintenance contract (AMC) for the private companies who need not spend money on the annual O&M costs. In turn, the private companies shall authorise the equipment manufacturers to develop CDM projects and earn CER credits for their wind farms. Since wind power capacities have witnessed a rising trend, and the plant load factor (PLF) has also been increasing with more efficient machines, generation of wind energy is likely to increase significantly, thereby providing more headroom for earnings from carbon credit trading. Because of the peculiar environmental-friendly characteristics of the industry, many countries are investing in wind energy projects to earn carbon credits under the Kyoto Protocol's Clean Development Mechanism (CDM). It may be mentioned that India and China

Exhibit 49: Power Demand and Supply Situation in India (GW)



Source: Central Electricity Authority, Exim Bank Analysis are expected to earn significant carbon credits due to wind energy development in these two countries. According to UNEP, there are around 1062 CDM wind energy projects that are in the pipeline, with more than 43,500 MW of expected wind power generation. Of this, 435 projects with expected installed capacity of 6981 MW are to be established in India, positioning it as the second largest country after China, both in terms of number of projects and also in terms of amount of MW expected to be installed (Table 24).

Cost competitiveness of wind energy vis-à-vis traditional forms of energy is likely to be strengthened, if viewed from a long term perspective. The key elements that determine the basic costs of wind energy are the upfront investment costs (mainly the turbines). Approximately three-fourth of the total cost of energy for a wind turbine is related to upfront costs such as the cost of the turbine, foundation, electrical equipment, and grid-connection. Unlike natural gas or coal power production (where fuel costs can make up the majority of total project life costs), variable fuel input costs for wind are zero, since wind is a natural phenomenon involving no expenses to generate it. However, due to high capital cost and low capacity utilization factor, the cost of wind energy is high initially, but quite low subsequently. On the contrary, the cost of fossil fuel based energy is low initially, but rises perpetually due to (inevitable) increase in cost of fuel and O&M expenses. British Wind Energy Association estimates an average generation cost for wind power at about £ 32 per MW while American Wind Energy Association estimates it at approximately US$ 56 per MW. In India the capital cost of a wind farm ranges between ₹ 6 cr to ₹ 6.5 cr per MW and the average estimated cost of wind power generation works out to ₹ 3000 to ₹ 4000 per MW. Comparative estimates

Table 24: Wind CDM Projects in Pipeline (by country)

Country	No. of Projects	MW	Share (by no. of projects)	Share (by MW)
China	540	31191	50.8%	71.6%
India	435	6981	41.0%	16.0%
Mexico	16	1925	1.5%	4.4%
South Korea	12	351	1.1%	0.8%
Brazil	12	723	1.1%	1.7%
Chile	7	274	0.7%	0.6%
Morocco	6	444	0.6%	1.0%
Cyprus	6	261	0.6%	0.6%
Egypt	4	406	0.4%	0.9%
Others	24	1016	2.3%	2.3%
Total	1062	43572	100.0%	100.0%

Source: UNEP Risoe Centre (http://www.cdmpipeline.org/cdm-projects-type.htm), Exim Bank Analysis suggest that the most cost efficient wind power – onshore production in coastal (i.e., good wind) areas – becomes competitive with traditionally generated power even at moderate fossil fuel prices once environmental, security of supply, and other usually non-monetized externalities are accounted for. Allocating a price on carbon emissions – one way of internalizing part of these externalities – is therefore likely to be a major additional growth driver for wind energy in the future. Similarly, the establishment of official renewable energy targets and the resulting expansion of feed-in tariff or renewable portfolio standards rules in power supply will continue to offer strong demand support for wind energy.

A transition of the energy markets towards renewable sources like wind is being witnessed across the globe – a trend which is likely to be strengthened in the foreseeable future. The global energy demand is increasing at a rapid pace and the solutions to generating low emission power such as those from wind energy, is the need of hour. Wind turbines cause virtually no emissions during their operation, and very little during their manufacture, installation, maintenance and removal, thereby increasingly becoming the desired technology for many countries across the world. As part of the global push for clean energy, India is aiming to rely more on renewable sources in coming years which will boost the development of the country's renewable energy sector including wind energy. The Government's stated target is for renewable energy to contribute 10% of total power generation capacity and have a 4% - 5% renewables share in the electricity mix by 2012. This means that renewable energy sources, particularly wind energy would grow at a faster rate than conventional power generation, accounting for around 20% of the total added capacity planned during the 11th Five Year Plan. There are other measures as well from both the Central and State Government which are likely to act as a catalyst for the wind energy market in India. Some of these are highlighted in the next section.

Select Government Initiatives

The Government of India has been supportive of the wind energy industry, creating an enabling environment through various initiatives and has been issuing guidelines for wind power development, since 1995, with the objective of bringing balanced growth in this sector. A package of fiscal and financial incentives has been made available, which includes accelerated depreciation, concessional customs duty on specific items, sales tax exemption, and income tax exemption, among others, along with the provision of support for research and development. The Union Government, under the support scheme for renewable energy programme, extends financial assistance to an extent of ₹ 3 crore for setting up of grid interactive wind power projects in special category states (viz. North Eastern states, Jammu & Kashmir, Himachal Pradesh, Uttarakhand), and ₹ 2.5 crore for other states. The

Table 25: Tax Incentives for the Wind Energy Sector

Description of Goods		Rates
INDIRECT TAXES		
I.	Wind operated electricity generators upto 30 kW and wind operated battery chargers upto 30 kW	5%
II.	Parts of wind operated electricity generators for manufacturer of wind operated electricity generators, namely	
	a. Special bearing	5%
	b. Gear Box	5%
	c. Yaw Components	5%
	d. Wind turbine controllers	5%
	e. Parts of the goods specified at (a) to (d) above	5%
	f. Sensor	25%
	g. Brake hydraulics	25%
	h. Flexible coupling	25%
	i. Brake callipers	25%
III.	Blades for rotor of wind operated electricity generators for the manufacturers or the manufacturers of wind operated electricity generators.	5%
IV.	Blades for rotor of wind operated electricity generators for the manufacturers or the manufacturers of wind operated electricity generators.	5%
V.	Raw materials for manufacturer of blades for rotor of wind operated electricity generators	5%
VI.	Customs Duty on Permanent magnets for Wind Operating Electricity Generators	5%
DIRECT TAXES		
I.	80% Accelerated Depreciation on specified Non-conventional Renewable Energy devices/systems (including wind power equipment) in the first year of installation of the projects.	
II.	Tax Holiday on Power Projects.	

Source: Exim Bank Research

Union Government announced the Generation Based Incentive (GBI) scheme in December 2009 to promote efficiency in power generation from wind energy. The main objectives of the GBI scheme include incentivising higher efficiencies, facilitating entry of large independent power producers and broadening the investor base by creating a level playing field between various classes of investors. Under the GBI scheme, MNRE has announced an incentive of ₹ 0.50 per unit (kWh) of electricity fed into the grid for a period not less than 4 years and not more than ten years. A total incentive upto a maximum of ₹ 6.2 mn per MW would be available as GBI with the total disbursement in a year not exceeding one-fourth of the maximum limit, i.e.₹1.55 mn per MW. The scheme would be applicable for a maximum of 4000 MW of capacity during the remaining period of the Eleventh Five Year Plan (2007-12), and for those power producers (having minimum installed capacity of 5 MW) who do not avail of accelerated/enhanced depreciation benefits under the Income Tax Act. The specific incentives provided by the government for the wind energy sector in terms of tax concessions have been highlighted in Table 25.

The Government of India has also floated a scheme for 'Small Wind Energy and Hybrid Systems', for promotion of technology development in this field. The Centre for Wind Energy Technology

(C-WET) which serves as a focal point for wind power development has been established by the Government. C-WET is involved with R&D activities such as improvement in performance of existing wind turbine installations; research support for wind resource assessment; technology support for wind power industry; research and advanced technology development; and manpower and training in R&D. The R&D unit of C-WET focuses on innovations in development of components, as well as sub-systems of wind turbines, in association with other R&D institutions and industry.

The National Action Plan on Climate Change has proposed for a national renewable energy-trading scheme, which would be based on a National Renewable Portfolio Standard. Under this scheme, states would be encouraged to promote the production of renewable power to exceed the national standard. They would then receive certificates for this surplus power, which would be tradable with other states, which fail to meet their renewable standard obligations. Since only grid-connected electricity would be eligible for this scheme, this would particularly benefit the wind power industry. In terms of financial support, the Indian Renewable Energy Development Agency provides funding for setting up of wind power projects, brief outline of which is presented in Table 26.

The Eleventh Five Year Plan has proposed various measures such as targets for installed capacity and extensive Research, Design and Development (RD&D) work to make wind energy technologies more reliable, long-life and cost effective. The Plan has also acknowledged the need for making products as per international standards, specifications and performance parameters which would require adoption of standards and setting up of testing facilities. MNRE, Government of India will aim to provide a package of fiscal and financial incentives to encourage (a) setting up of world class testing facilities; (b) obtain international product certifications; (c) raise investment level in RD&D in new and renewable energy industry to make products of international standards, specifications, and performance parameters. With regard to wind energy, the Eleventh Five Year Plan proposes to undertake:

- Design, development and manufacturing capability for MW-scale Wind Electric Generators (WEGs) for low wind-regimes;
- Design, development and manufacturing capability for small WEGs upto 25 kW capacity for low wind-regimes;
- RD&D on materials used in MW scale WEG systems; and
- RD&D on high efficiency electronics for protecting, controlling, optimizing performance, power management & conversion and establishing connectivity with the grid to export and/or import power.

Box 9 : Grid Connected Systems

The Electricity Act, 2003, and the National Tariff Policy, 2006 provide for both Central Electricity Regulatory Commission, and the State Electricity Regulatory Commissions (SERCs) to prescribe a certain percentage of total power purchased by the grid from renewable based sources. It also prescribes that a preferential tariff may be followed for renewable based power. Further, the National Action Plan on Climate Change of the Government of India proposes the following measures to help enhance mainstream renewable-based sources in the national power system.

A Dynamic Minimum Renewable Purchase Standard (DMRPS) may be set, with escalation in each year till a pre-defined level is reached, at which time the requirements may be revisited. It is proposed that starting 2009-10, the national renewable standard may be set at 5% of total grid purchase, to increase by 1% each year for 10 years. SERCs may get higher percentages than this minimum at each point in time.

Central and State Governments may set up a verification mechanism to ensure that the renewable-based power is actually procured as per the applicable standard. Appropriate authorities may also include certificates that procure renewable-based power in excess of the national standard. Such certificates may be tradable, to enable utilities falling short to meet their renewables standard obligations. In the event of some utilities falling short, penalties as may be allowed under the Electricity Act 2003, and the Rules there under, may be considered.

Procurement of renewable-based power by the State Electricity Boards / other power utilities should be based on competitive bidding, without regard to scheduling, or the tariffs of conventional power. Further, renewable-based power may, over and above the applicable renewables standard, be enabled to compete with conventional generation on equal basis, without regard to scheduling. Other things being equal, the renewable-based power should be preferred to the competing conventional power.

Source: National Action Plan on Climate Change

Outlook

The progress of the wind energy industry in India has been admirable over the last few years. India is currently among the major producers of wind energy and was ranked the 5th largest market in the world, both in terms of cumulative installed capacity and capacity addition in 2009. While the expansion of wind power in India may look impressive on a standalone basis, it pales out when

Table 26: IREDA Financing Norms for Wind Power Projects

Financing for	Interest Rate	Max. repayment period	Min. promoters contribution	Lending norms	Remarks
Development and setting up of wind farms (including off - shore wind projects)	11.25% to 11.90%	10 years	30%	Upto 70% of total project cost	Projects set up by manufacturers or their subsidiaries with minimum capacity of 5 MW, may avail additional loan up to 15%, secured by Bank Guarantee/FDR and generation guarantee is provided for entire loan period to the Borrowing Company and the same is assigned to IREDA.
Manufacturing of equipments and parts for wind energy	12.75%	10 years	30%	Upto 70% of total project cost	Maximum moratorium of 2 years
Market Development Programme for Wind: SPV hybrid system	12.75%	10 years	20%	Upto 80% of total project cost	Maximum moratorium of 1 year. MNRE may also provide interest subsidy.

Source: IREDA

compared to the growth in China. China, with an installed wind power capacity of 1.3 GW in 2005, was ranked the 6th largest market as against India, which was ranked 4th with an installed capacity of 4.4 GW. Compared to this, by the end of 2009, China leapfrogged to the 2nd position with an installed capacity of 25.8 GW vis-à-vis 10.9 GW for India, in the process relegating India to the 5th position. However, with the European Union charting out a strategy to ensure 20% of its energy requirements come from renewable energy sources by 2020, avenues for cooperation in the wind generation

Table 27: Targets for Wind Energy under the Eleventh Five Year Plan

Heading	Target
Grid interactive wind power generation	10500 MW
Outlay for grid interactive wind power generation	₹ 75 crore (for demo only)
Off-grid wind/wind-hybrid/hydro/bio power	950 MW
Outlay for off-grid wind/wind-hybrid/hydro/bio power	₹ 1900 crore
Outlay for Research, Design and Development of wind power	₹ 200 crore

Source: Planning Commission, Government of India

Box 10: Indian Wind Atlas

Government of India is preparing an ‘Indian Wind Atlas’, which would identify windy locations across the country, and thereby, enable better harnessing of resources by project developers in the country. A realistic reassessment of potential will be possible, once the wind atlas is available. A wind atlas basically makes it possible to transfer detailed information about the mean wind climate from one location (the predictor site) to another (the predicted site).

The methodology for preparation of ‘wind atlas’ for India, in general, was on the basis of the methodology adopted in preparation of European Wind Atlas. At present, the wind atlas methodology has been employed in about 105 countries and territories around the world. National wind atlases already exist for about 30 countries.

While much of the wind capacities are focused on India’s eastern coastline and parts of the Western Ghats, the wind atlas is aimed at harnessing more wind potential areas, including the North East Region, and the northern Himalayan zone, besides offshore locations along the coastline. In order to have preliminary idea of the offshore wind resources, parts of the sea surrounding the country are also being included in the project.

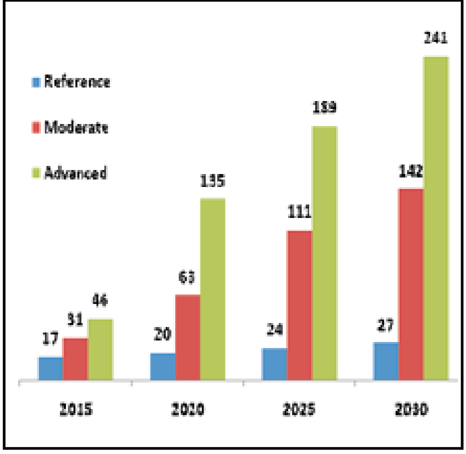
At present, under the country’s National Wind Monitoring Programme, wind data is obtained from 54 coastal locations. While the Gujarat coastline has reasonable potential, it is also prone to cyclonic conditions. So far, two locations at Rameshwaram in Tamil Nadu, and Mundra at Gulf of Kutch have shown good potential, where wind power density of about 350 watt -500 watt per sq.mt has been recorded.

It may be mentioned that all over the world, the capital cost of producing wind turbines has been falling steadily over the past 20 years because (a) manufacturing techniques have been optimized; (b) turbine design has been largely concentrated on three-bladed upwind model with variable speed and pitch regulation; and (c) mass production and automation have resulted in economies of scale.

segment are set to grow. This provides immense opportunities for firms in India to explore the EU market, although, it may be noted that the competition would be stiff due to significant emphasis on quality and timely delivery. It is also important to note that the current world ranking of India (5th) in installed wind power capacity might go down further by 2012, owing to a widening gap between the world's projected cumulative installed capacity of 275.8 GW by 2012, as compared to India's projected cumulative installed capacity of around 17 GW, as at the end of 11th Five Year Plan (which envisages to add additional installed capacity of 10.5 GW during the Plan period). This might bring down India's share in world-installed capacity of wind power to around 6% by 2012 as compared to around 7% in 2009. Hence, in order to maintain its position, if not improve it, there is a need for the country to provide renewed vigour in setting higher targets for capacity additions, and creating new opportunities and strategies so as to achieve them.

A reflection of the various possibilities of the future of wind power in India has been undertaken by GWEC, depending on various policy measures implemented by the Government during the projected period. Accordingly, three different scenarios have been developed, viz. Reference, Moderate and Advanced. The Reference scenario is based on the International Energy Agency's (IEA) predictions for the power mix in India in 2030, resulting in a rather modest increase in wind power during

Exhibit 50: Projected Cumulative Capacity of Wind Power in India under 3 Scenarios (GW)



Source: GWEC, Exim Bank Analysis

this time frame from 17 GW in 2015 to 20 GW in 2020, and further to 27 GW in 2030. Depending on the demand side developments, the penetration of wind energy in India in this scenario is projected to decrease from 3.3% in 2010 to 2.4% - 2.7% in 2030. The Moderate scenario takes into account all policy measures to support renewable energy either already enacted or in the planning stages and also assumes that the targets set by the Government are successfully implemented. Under the Moderate scenario, cumulative wind power capacity is projected to increase from 31 GW in 2015 to 63 GW in 2020, and further to 142 GW in 2030. The Advanced version examines the extent to which this industry could grow in a best case wind energy vision. The assumption here is that all policy options in favour of renewable energy have been selected and the political will is there to carry them out. Under this scenario, wind power capacity is projected to shoot up from 46 GW in 2015 to 135 GW in 2020 and further to 241 GW in 2030. The advanced scenario is a vision statement of the future considering the enormous capacity of power demand of India and possible untapped wind resource. The potential of off-shore is not even estimated but one cannot play down the 7000 km of coastline. Re-powering with larger turbines will add to reaching such capacities. The outlook for India upto 2030 is a projection that is achievable, provided suitable policy measures are put in place.

The wind energy industry has been and is likely to continue to be on an upward strategic move, as highlighted in the preceding paragraphs. With the fundamental drivers (such as growing energy demand, relatively low generation cost, government initiatives, technology and the ever expanding carbon market) for Indian wind energy sector remaining strong, India would be in a position to capitalize the opportunity, not only in promoting wind energy for the cause of mitigating climate change, but also to use this window of opportunity to meet the growing power demand faced by the country. Investment in wind energy is also likely to result in saving of foreign exchange earnings of the country. The new GBI scheme is also expected to provide a significant incentive for new entrants into the Indian wind market, and it is expected that a minimum of 2,200 MW of new wind power capacity will be installed in India in the financial year 2010-2011. Thus, the outlook for the wind energy sector in India is likely to remain fairly bright.

BIOMASS

Biomass is an important energy source for power generation especially in developing countries like India. For the last 15 years, biomass power has become an industry attracting annual investment of over ₹1000 cr, generating more than 9 billion watts of electricity per year and creating employment opportunities in rural areas. Biomass energy projects also bring in significant socio-economic and environmental benefits both at local and global level. Indian climatic conditions offer an ideal environment for biomass production. The country produces a huge quantity of biomass material in its agricultural, agro-industrial and forestry operations. Biomass in India basically includes solid biomass (organic, non-fossil material of biological origins), biogas (principally methane and CO_2 produced by anaerobic digestion of biomass and combusted to produce heat and/or power), liquid biofuels (bio-based liquid fuel from biomass transformation, mainly used in transportation applications), and municipal waste (wastes produced by the residential, commercial and public services sectors and incinerated in specific installations to produce heat and/or power).

India has approximately 141 million hectares of arable land and agricultural output is around 800 million tonnes. Further, this vast agricultural potential

Exhibit 51: Benefits of Energy from Biomass

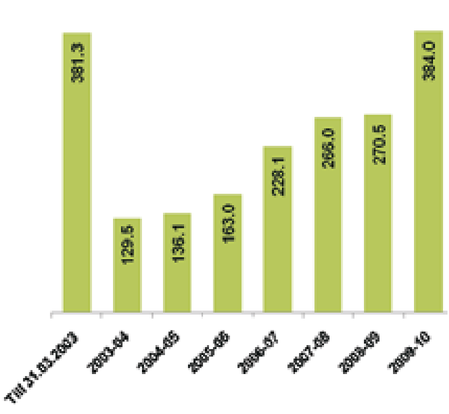
Socio-Economic Benefits	Capacity Builiding	Environmental Benefits
• Illumination and safe drinking water • Cooking gas (biogas) supply for all the households • Water supply for irrigation purposes • Establishment of agro-industry units, generation of employment and incomes • Empowerment • Reduction in drudgery for women and children	• Development of village level institutions • Capacity building of village communities, NGOs, entrepreneurs, researchers • Evolution of appropriate bio-energy policy • Awareness creation on bioenergy among rural communities, NGOs, bankers and policy makers.	• CO_2 reduction through fossil fuel substitution • Land reclamation through forestry through development of biomass on about 3000 hectares of forest, community and farm lands through various models • Biomass conservation to reduce pressure on trees and forests

makes available huge agro-residues to meet the energy needs. With an estimated production of about 460 million tonnes of agricultural waste every year, biomass is capable of supplementing coal to the tune of about 260 million tonnes. This can result in a saving of about ₹250 billion, every year. Crop residues which are not used as animal fodder, such as cane trash, paddy straw, coconut stalks, branches and mustard waste, are estimated to total around 75 million tonnes per annum. Mill residues such as bagasse, rice husk, groundnut husk, corn cobs, saw mill waste and de-oiled cake, are estimated at around 150 million tonnes per annum. Horticultural waste adds another 75 million tonnes of waste per annum. Forest waste could also be another major source of biomass waste. The cost of biomass fuel is considerably lesser than other sources. The cost of power from a diesel generator is upwards of ₹12 per unit while the cost of biomass power can be around a third of that amount. At the same time, the approximate capital cost of biomass energy is ₹4 cr per MW. The cost of setting up a coal-based power plant, on the other hand, is between ₹ 5 cr and ₹ 6 cr per MW.

The Domestic Biomass Market and Potential

Bio-energy has remained critical to India's energy mix. Blessed with ample sunshine and rains, India offers an ideal environment for biomass production. A target for addition of 1,700 MW capacity, consisting of 500 MW of biomass power projects and 1,200 MW of bagasse cogeneration projects has been proposed during the 11th Plan period (2007-12). In addition, 400 MWe energy power from industrial and municipal waste and 100 MWe of

Exhibit 52: Commisioned Biomass Power/Cogeneration Projects in India (MW)



Source: MNRE, Exim Bank Analysis

distributed renewable generation for power and heat has been proposed which include biomass resources. An estimated employment of about 17 million mandays per annum is likely to be generated in various States during 11th Plan period, as a result of deploying biomass projects. These facts reinforce the idea of a commitment by India to develop these resources of power production.

By June 2010, the cumulative biomass power/ bagasse cogeneration based power capacity had reached 2312.6 MW, which comprised 901.1 MW of biomass power projects and 1411.5 MW of bagasse cogeneration projects. The year 2009-10 witnessed a significant increase in biomass power/ bagasse cogeneration capacity addition of 384 MW (125 MW biomass projects and 259 MW bagasse cogeneration projects).

A cumulative biomass power potential of about 18,000 MWe from the surplus agro residues have been estimated in India. This has been stated in the National Biomass Resource Atlas prepared by Indian Institute of Science, Bangalore, under a project sponsored by the Ministry. The Atlas has been designed in order to map and tap the biomass potential using satellite data as input for geographical information systems. According to MNRE, with the present utilization pattern of crop residues, the amount of surplus biomass materials is about 150 million tonnes, which could generate about 18,000 MWe of power. The States of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal have potential for setting up biomass based power projects of 100 MW or above. The biomass power potential in the identified districts of the above States ranges from 10 MW to 100 MW. Sugar mills having crushing capacity of 2500 tonnes of cane crushed per day in the states of Maharashtra, Uttar Pradesh, Tamil Nadu, Karnataka, Andhra Pradesh, Bihar, Gujarat, Punjab and Haryana have an estimated potential of about 5000 MW surplus power generation through optimum bagasse based cogeneration. With the setting up of new sugar mills and the modernization of existing ones, the potential of bagasse cogeneration is estimated at 5,000 MW.

India's Foreign Trade in Biomass

India's international trade in biomass and related products has witnessed a steady increase over the past few years with the best performance being exhibited in the latest year, viz. 2008, although imports in 2008 were almost double that of exports. The analysis of trade figures during the period 2004 to 2008 reveals that exports of biomass and related goods increased at an average annual growth of 23.8% (from US$ 131 mn in 2004 to US$ 285 mn in 2008), while imports averaged 18.4% (from US$ 312 mn in 2004 to US$ 596 mn in 2008).

India's major export items under this segment was the products under HS code 841182 (other gas turbines, of a power exceeding 5,000 kW) and

Table 28: India's Trade in Biomass & Related Goods – Major Products

EXPORTS (US$ mn)						IMPORTS (US$ mn)					
HS Code	2004	2005	2006	2007	2008	HS Code	2004	2005	2006	2007	2008
841182	65	18	9	37	93	382490	81	112	160	211	257
382490	24	43	48	55	89	840682	14	25	80	87	86
847920	13	19	20	20	31	841182	46	26	32	30	64
380210	8	15	16	18	28	220720	112	139	24	13	58
841940	9	9	20	11	11	841940	4	18	11	33	33
840682	2	1	3	4	9	840681	16	15	1	19	28
220710	1	2	9	7	7	847920	9	6	6	8	27
840681	6	4	2	4	6	841620	8	12	12	19	15
841280	0	0	1	1	4	380210	8	7	9	10	13
220720	1	18	6	10	3	841280	5	10	8	10	12
841620	1	1	3	4	3	841931	6	2	22	3	3
841931	1	1	2	2	1	220710	3	4	0	0	0
Total	131	131	139	173	285	Total	312	376	365	443	596

Note: Product descriptions corresponding to respective HS codes are given in Annexure 1.

Source: Derived from UN Comtrade Database

Table 29: India's Trade in Biomass & Related Goods – Major Partners

EXPORTS (US$ mn)						IMPORTS (US$ mn)					
Country	2004	2005	2006	2007	2008	Country	2004	2005	2006	2007	2008
World	131	131	139	173	285	World	312	376	365	443	596
Bangladesh	3	3	1	2	32	China	13	29	53	74	86
UAE	2	3	3	6	28	USA	54	39	49	83	84
USA	14	11	11	12	28	Japan	11	18	38	47	70
Turkey	1	3	5	37	27	Germany	26	41	50	47	68
Oman	0	1	1	3	14	Brazil	110	135	0	0	57
Others	111	110	118	113	156	Others	98	114	175	192	231

Source: Derived from UN Comtrade Database

HS Code 382490 (other chemical products and preparations of the chemical or allied industries, including those consisting of mixtures of natural products, not elsewhere specified or included: other), both of which together constituted almost two-thirds of India's exports from the biomass segment in 2008 (Table 28). In terms of major markets, these were fairly diversified with major export destinations in 2008 being Bangladesh, UAE, USA and Turkey.

Import of biomass and related goods was dominated by HS Code 382490 (other chemical products and preparations of the chemical or allied industries-including those consisting of mixtures of natural products), which accounted for 43.1% of India's imports of renewables related products in 2008. Other major imports were HS Code 840682 (steam turbines and other vapour turbines, of an output not exceeding 40 W) and HS Code 841182 (other gas turbines, of a power exceeding 5,000 kW). Like export destinations, India's major import sources were also spread across the world with China and Japan from Asia, Germany from Europe, and Brazil from Latin America, apart from USA being the chief sourcing countries (Table 29).

Select Biomass Technologies in use in India

Biomass could be described as an important source of energy in the Indian context, with considerable energy being produced from it. Various technologies such as combustion, gasification and cogeneration are used in India for the conversion of biomass materials into electric power.

1. Combustion

Combustion is a well-established commercial technology with applications in most industrialized and developing countries. Biomass combustion is a process which burns biomass for fuel in a specially designed boiler, furnace or wood stove. These combustion chambers can be specifically designed to reduce emissions and airborne particulate. Biomass fuels, typically

Table 30: Select Technologies for Conversion of Biomass Energy to Utilities

Technology	Scale of Use	Utility
Biogas	Small	Electricity (local pumping, milling, lighting, communications, refrigeration, etc. and possible distribution via utility grid)
Producer Gas	Small to Medium	Cooking Heating
Ethanol	Medium to Large	Vehicle Transportation Cooking
Steam Turbine	Medium to Large	Electricity (for industrial processing and grid distribution) Industrial Process Heat
Gas Turbine	Medium to Large	Vehicle Transportation

used for combustion, normally originate from forest and agricultural residues such as bark, branches, straw, sawdust, wood chips or pellets. The advantage is that the technology used is similar to that of a thermal plant based on coal, except for the boiler. The cycle used is the conventional ranking cycle with biomass being burnt in high pressure boiler to generate steam and operating a turbine with generated steam. The exhaust of the steam turbine can either be fully condensed to produce power, or used partly or fully for another useful heating activity. The latter mode is called cogeneration. In India, cogeneration route finds application mainly in industries.

The devices used for direct combustion of solid biomass fuels range from small domestic stoves (1 kW to 10 kW) to the largest boilers used in power and Combined Heat and Power (CHP) plants (>5 MW). Intermediate devices cover small boilers (10 kW to 50 kW) used in single family house heating, medium-sized boilers (50 kW to 150 kW) used for multi-family house or building heating, and large boilers (150 kW to over 1 MW) used for district heating. Co-firing in fossil fired power stations enables the advantages of large size plants (>100 MWe) that are not applicable for dedicated biomass combustion due to limited local biomass availability.

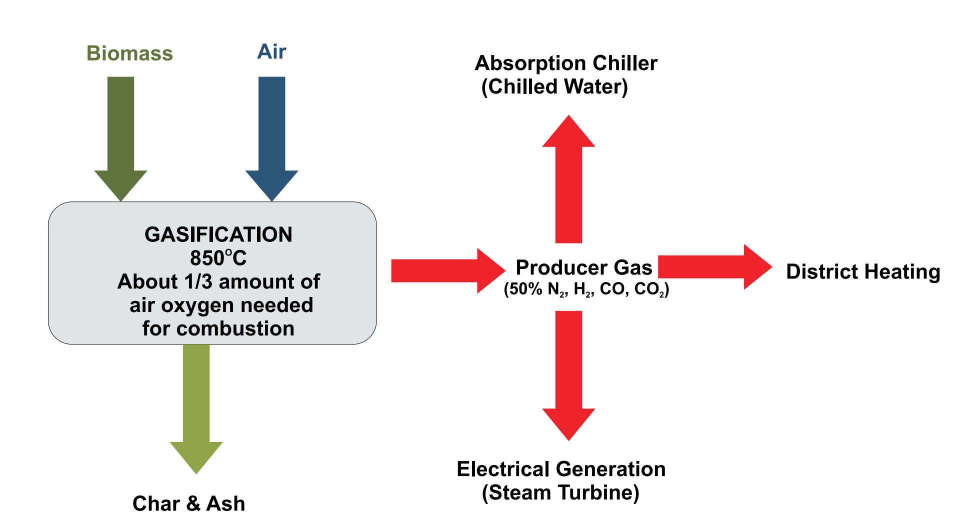
Combustion technology is better suited to be set up in a rural area where biomass procurement is easy. Setting up the plant in a city will entail transportation of biomass and, therefore, add to costs. The power generated in the rural area can be transmitted to where it is needed using the State's transmission /distribution system, under the open access regime set up by the Electricity Act, 2003.

2. Biomass Gasification

Biomass gasification is a process of converting biomass into a combustible gas in a reactor, known as gasifier, under controlled conditions. The combustible gas, known as producer gas has a composition of approximately 19% CO (Carbon Monoxide), 10% CO_2 (Carbon Dioxide), 50% N_2 (Nitrogen), 18% H_2 (Hydrogen) and 3% CH_4 (Methane). This gas, which has a calorific value of 4.5 - 5.0 MJ/cubic metre is then cooled and cleaned prior to combustion . The gas can be used for generation of motive power either in dual fuel engines along with diesel or in 100% gas engines. The gas can also be used directly for heating and cooking. A wide range of biomass in the form of wood or agro residue can be used in the gasifier. These include:

- ❖ Any biomass that has a density of more than 250 kg per cubic meter can be used for gasification;
- ❖ Wood from trees such as eucalyptus, casuarina, acacias, albizzias, cassia siamea and many other species;
- ❖ Agricultural residues like coconut shell, husk, fronds, corn cobs, corn

Exhibit 53: Gasification Procedure



stalks, mulberry stalks, briquetted biomass of saw dust, coffee husk, groundnut husk, rice husk etc.

However, due to high toxicity of carbon monoxide, extensive safety provisions are a must for domestic applications which perhaps explains the reason for lack of individual use of this system.

The estimated cost of gasifier systems is about ₹10,000 to ₹ 15,000 per kWh for thermal applications and ₹30,000 to ₹45,000/- per kWe for mechanical and electrical applications. The estimated cost of village electrification projects with biomass gasification systems is about ₹50,000 to ₹80,000 per kWe in capacity range of 5 KW to 50 KW including the cost of land, civil works, distribution lines and development. The biomass gasification systems have necessary versatility for use in a diverse range of applications in rural areas. Apart from use as a cooking fuel and for electricity generation, the gas can be used for heating applications in village industries. Some biomass gasifiers have also been exported to the USA, South Asia, Europe and Latin America.

The erstwhile Ministry of Non-Conventional Energy Sources (now Ministry of New and Renewable Energy) has implemented a National Biomass Gasifier Programme for mechanical, electrical, thermal heating applications and village electrification since mid 1980s. Financial incentives for installation of gasifier systems are provided under the programme. Biomass gasifiers in the capacity range of 5 kW to 1 MW equivalent electric capacity have been developed indigenously and are being manufactured by around 15 manufacturers in the country. The systems being proposed for village electrification applications are based on 100% producer gas.

3. Bagasse-based Cogeneration

Bagasse is a by-product of the sugar industry and is produced from crushing sugarcane waste. Sugar industry has been traditionally practicing cogeneration by using bagasse as a fuel. Since India is amongst the leading sugarcane producers of the world, it offers considerable potential for the production of bagasse-based generation, estimated at close to 5000 MW. On the other hand, cogeneration is a process in which waste energy (includes garbage, bagasse, sewerage gas, and other industrial, agricultural, and urban refuse) can be used to produce electricity. Thus, in the case of the sugarcane industry, cogeneration is the use of a single fuel to produce more than one form of energy in sequence.

With the advancement in the technology for generation and utilization of steam at high temperature and pressure, sugar industry in India can potentially produce electricity and steam for its own requirement. It can also produce significant surplus electricity for sale to the grid using same quantity of bagasse. For example, if steam generation temperature/pressure is raised from 400^0C/33 bar[36] to 485^0C/66 bar, more than 80 KWh of additional electricity can be produced for each ton of cane crushed. The sale of surplus power generated through optimum cogeneration would help a sugar mill to improve its viability, apart from adding to the power generation capacity of the country.

USE OF BIOMASS GENERATED POWER

Biofuels for Transportation

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels called biofuels for a variety of transportation needs like cars, trucks, buses, airplanes, and trains. A wide range of biofuels can be produced through one or a combination of the following processes, viz. cold pressing, extraction, refining, fermentation, distillation, hydrolysis, synthesis, digestion, CO_2/H_2O removal, steam reforming, gasification, hydro cracking, pyrolysis, supercritical gasification etc. Some of the conventional biofuels are: straight vegetable oil, biodiesel from seeds, biodiesel from waste (oil/fats), ethanol from sugar crops, ethyl tertiary butyl ether (ETBE), Substitute Natural Gas from biogas, hydrogen from biogas etc. Some of the advanced biofuels are: Fischer-Tropsch (FT) diesel, Methanol, methyl tertiary butyl ether (MTBE), alcohols from synthetic gas, hydrogen form synthetic gas, ethanol from celluloses, pyrolysis-diesel, hydrogen from wet materials etc. Ethanol, for instance, is used as fuel additive to bring down vehicle's carbon monoxide and smog causing emissions. Also, gasoline-ethanol mixtures with ethanol up to 85% are being used in some fuel flexible vehicles. Biodiesel, for

[36] 1 bar ≡ 100,000 Pa = 100 kPa = 0.1 MPa (bar is an unit of pressure and is roughly equal to the pressure of the earth at sea level); Pa = Pascal

example, is made by transesterification of straight vegetable oil or by refining and transesterification of waste oils/ fats. Biodiesel is used as an additive to reduce vehicle emissions (typically 20%) or in its pure form as a renewable alternative fuel for diesel engines. As one of the long-term alternatives, biomass derived fuels may be used for transportation in India.

Biopower for Electricity Generation

Biopower is the use of biomass to generate electricity through direct burning or converting it into gas or into oil. There are six major types of biopower systems - direct-fired, co-firing, gasification, anaerobic digestion, pyrolysis, and small, modular systems. Most of the biopower plants in the world use direct-fired systems, which burn feedstock directly and produce steam, which in turn run turbine to produce electricity. When a part of this steam is used for manufacturing processes or heat buildings, then it is called combined heat and power facilities. For instance, wood waste is often used to produce both electricity and steam in paper mills. Co-firing is a process in which coal firing is supplemented by bioenergy feedstock in high efficiency boilers in order to significantly reduce sulphur-dioxide emissions. Gasification systems use high temperatures and an oxygen-starved environment to convert biomass into a gas called 'Producer Gas', which is a mixture of hydrogen, carbon monoxide, and methane. The gas is either used in gas turbines or in internal combustion engines to generate captive power. Composition, water content and morphological properties of the material to be gasified, guide the selection of gasification route based on technical feasibility and economic viability of conversion. For instance, cow-dung, which is rich in water content, is ideal for biological conversion. Whereas solid biomass such as wood and rice husk, which have low moisture content, are thermo-chemically gasified to producer gas - a low energy yield gas.

Anaerobic digestion involves using bacteria to decompose organic matter in the absence of oxygen, whereas methane gas is produced as landfill gas. Oils are produced from biomass through pyrolysis – a process, which occurs when biomass is heated in the absence of oxygen. The resulting liquid called pyrolysis oil can be burned like petroleum to generate electricity with a capacity of 5 megawatts or less. This system is designed for use at the small town level or even at the consumer level. For example, farmers can use the waste from their livestock to provide their farms with electricity.

Bioproducts through Biorefinery

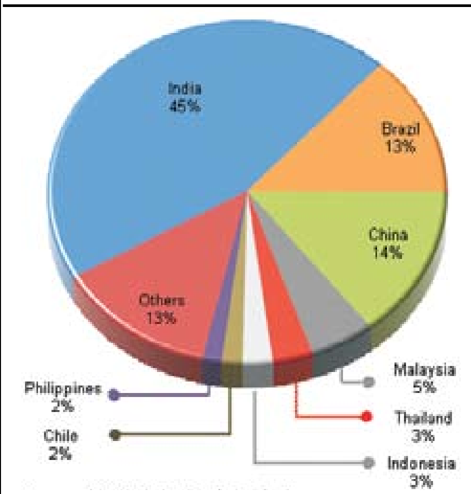
Products that are typically made from fossil fuels can be made from biomass. Bioproduct is the result of converting biomass into chemicals through biorefinery concepts and making products such as antifreeze, plastics, glues, artificial sweeteners, and gel for toothpaste. When biomass is heated in the presence of small amount of oxygen, carbon monoxide and hydrogen are produced. The mixture is called biosynthesis gas and this gas is used to make plastics and acids, which can be used in making photographic films, textiles, and synthetic fabrics. When biomass is heated in the absence of oxygen, it forms pyrolysis oil from which phenol can be extracted. Phenol is used to make wood adhesives, moulded plastic, and foam insulation.

Biomass Industry and Carbon Credits

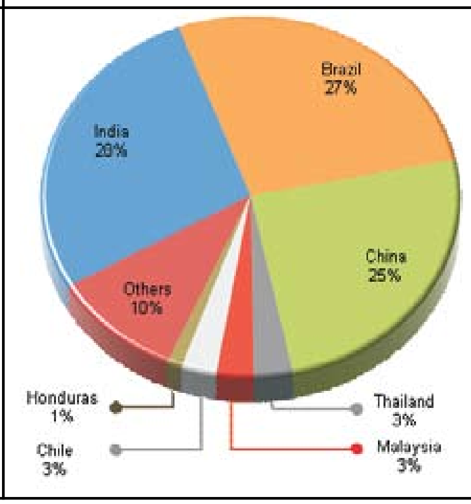
Carbon credits are a key component of national and international attempts to mitigate the growth in concentrations of greenhouse gases. One Carbon Credit is equal to a tonne of carbon. Asia is the leading supplier of Certified Emission Reductions in the global carbon market, holding approximately 77 % of the share. Over 3,714 projects are developed under the Clean Development Mechanism all over Asia. Most of these are the future-installed power projects, which will have a capacity of around 58 GW in hydro, wind, biomass, geothermal, biogas, landfill gas, solar, tidal, energy efficiency-based own generation, and coal bed/coal mine methane sectors. Developing countries like India have favoured carbon trade, as it offers a win-win situation for both entrepreneurs and the broader society. While innovative companies that help reduce emissions are provided with carbon credits, which they can encash to boost viability or earn profits, the gains to society accrue in the form of a smaller destabilising impact on the environment. CDM projects in India contribute towards sustainable development. In the agricultural sector, utilisation of biomass waste, for power generation as well as in the transport sector reduces consumption of conventional fuel and also eliminates methane formed by its decay.

Exhibit 54: Country-wise Biomass CDM Projects in Pipeline

By Number (Total: 705)



By Capacity (Total 9,233 MW)



Source: UNEP, Exim Bank Analysis

As far as biomass related CDM projects are concerned, there are 705 such projects in pipeline in the world with total energy capacity of 9233 MW. India, with 318 projects and a capacity of 2558 MW in pipeline accounts for the largest share, both in terms of number of projects as also in terms of biomass energy capacity. The other major biomass CDM players include Brazil, China, Malaysia, Thailand and Chile (Exhibit 54). The larger gains made by the biomass segment in India compared to elsewhere is explained by its long history. The renewable energy programmes initiated in the 1970s promoted various programmes like its direct utilisation of fuel, conversion of woody biomass into fuel and methane gas reclamation. The biomass segment gained greater attention and popularity with the coming of bio-fuel projects like bio-diesel. The high fuel price scenario has helped India integrate its energy security strategies with more environment-friendly projects in segments like biomass and wind.

Carbon offsets from solid waste projects, are on rise. At present, the Indian solid waste management market is witnessing tremendous growth. Currently the solid waste management market is valued at around US$ 156 million (₹ 728 crore) and is expected to grow at a rate of around 20% - 25% in the next 3 to 5 years. In biomass energy, the state that ranked at the top was Uttar Pradesh with 52 projects, followed by Andhra Pradesh (40), Maharashtra (37), and Karnataka (34).

Table 31: Select Government Incentives for Biomass Power Generation

ITEM	DESCRIPTION
Accelerated Depreciation	80% depreciation in the first year can be claimed for the following equipment required for co-generation systems: 1. Back pressure, pass -out, controlled extraction, extraction –cum -condensing turbine for co-generation with pressure boilers 2. Vapour absorption refrigeration systems 3. Organic rankine cycle[37] power systems 4. Low inlet pressures small steam turbines
Income Tax Holiday	Ten years tax holidays.
Customs Duty	Concessional customs and excise duty exemption for machinery and components for initial setting up of projects.
General Sales Tax	Exemption is available in certain States

Source: MNRE

[37]The Rankine cycle is a thermodynamic cycle which converts heat into work. The heat is supplied externally to a closed loop, which usually uses water as the working fluid. This cycle generates about 80% of all electric power used throughout the world.

Government Initiatives

The promotion of biomass-based power generation in the country is encouraged through conducive policies, both at the State and Central levels. The Government has been encouraging the promotion of biomass based off-grid small power projects for meeting unmet demand of electricity in electrified / un-electrified villages in the country under various programmes such as Village Energy Security Programme (VESP), Remote Village Electrification Programme (RVEP) and Biomass Gasifier programme. The RVEP aims to provide basic facilities of lighting / electricity in those remote, un-electrified census villages and remote un-electrified hamlets of electrified census villages, where grid connectivity is either not feasible or not cost effective, through various renewable energy sources, including biomass.

MNRE has recently launched a new initiative on biomass cooking stoves, with the primary aim of enhancing the availability of clean and efficient energy for the energy deficient and poorer sections of our society. Apart from this, the Government of India has a well-framed national policy with objectives to promote biomass power generation systems. Requisite clauses have been inserted in the Electricity Act, 2003. The Act provides that co-generation and generation of electricity from nonconventional sources would be promoted by the respective State Electricity Regulatory Commissions (SERC) by providing suitable measures for connectivity with the grid and sale of electricity from such sources – starting from 2009-10, the national renewable standard has been set at 5% of total grid purchase, which is to be increased by 1% each year for 10 years. SERCs could get higher percentages than this minimum at each point in time.

Recently, India has decided to start research on production of biofuels for the aviation industry. The Department

Table 32: Capital subsidy For Bagasse/Biomass Cogeneration Projects

	Special Category States (NE Region, Sikkim, J&K, HP and Uttarakhand)	Other States
	Biomass Based Projects	
Biomass Power Projects	₹ 25 lakh X (Capacity in MW)^ 0.646	₹ 20 lakh X (Capacity in MW)^ 0.646
Bagasse Cogeneration	₹ 18 lakh X (Capacity in MW)^ 0.646	₹ 15 lakh X (Capacity in MW) ^ 0.646
Bagasse Cogeneration projects by cooperative/public/joint sector (max. support Rs 8 cr/project)		
40 bar and above	₹ 40 lakh per MW*	₹ 40 lakh per MW*
60 bar and above	₹ 50 lakh per MW	₹ 50 lakh per MW
80 bar and above	₹ 60 lakh per MW	₹ 60 lakh per MW
Biomass Power using Advanced Technologies	₹ 1.2 crore X (Capacity in MW)^ 0.646	₹ 1.0 crore X (Capacity in MW) ^ 0.646

*For new sugar mills subsidies shall be one-half of the level mentioned above

Box 11: National Biomass Resource Atlas

Use of biomass for thermal energy is age-old but the use of "modern biomass" (implying clean combustion process) is more recent. In the last three decades, with several developments in the country, more particularly with funded research and development, at the instance of MNRE, extensive meetings and discussions between the researchers and manufacturers have led to a condition of India being considered a leader in the development of biomass gasification systems meant for high grade heat or power. In these developments, Combustion, Gasification & Propulsion Laboratory-CGPL, IISc is at the forefront bringing its knowledge on advanced combustion processes of handling solid biomass fuels to address power packages up to couple of megawatts. Apart from this there has been a realization of the commercial sector in putting larger power plants from the conventional thermal-steam route to size them at 10MWe - 15 MWe. In this context it is necessary that the assessment of biomass availability is made taking account of the present usages in the existing traditional practices and socially essential needs such as fodder, domestic fuel, thatching and manure.

This project was taken up to develop a software package to estimate the power generation potential augmenting the site suitability studies for biomass based power plants. CGPL, IISc took up the role of (National Focal Points) for the purpose of evaluating the data and its integration. In this context, a set of Taluk and District Level surveys were instituted by MNRE to get some of the field specific data and most importantly, the local trend in the usage of the biomass. The surveys were conducted by set of consultants monitored by organizations that included TERI, Anna University, ASCII and ORG as Apex Institutions. Each phase of the survey studies helped to improve upon the quality of data collection and in building up a database to be used for the Biomass Resource Atlas. The survey reports have given a good option in validating and consolidating Crop Yields, Crop to Residue Ratio and the usage factors of the biomass. The calorific value of the biomass is estimated based on its ash and moisture content and this data for the different biomass residues are consolidated and built in to the database.

Source: MNRE

of Science and Technology (DST) signed an agreement with Canada to undertake various science and technology projects. The Sustainable Aviation Fuel Group, a global industry consortium, expects airlines to use 600 million gallons of biofuel a year by 2015. The Government has also sponsored a project on "National Biomass Resource Atlas" which is being undertaken by the Indian Institute of Science, Bangalore and is already in place.

SUM UP

This chapter envisaged to highlight the tremendous potential the country has in the renewable energy sector. India, which is already succumbing under energy crisis with large parts of the country still surviving without electricity, renewable energy may act as a panacea to much of its problems. Given the available potential in all the three nascent and new renewable energy technologies (PV, wind and biomass) so discussed, and utilizing it to the utmost, India can become self reliant and self sufficient in power generation in the years to come.

Apart from the domestic opportunity available to harness the three nascent renewable energy technologies, there also exists tremendous potential for trade in key components that are used in these sectors. However, amongst these three key technologies, two main single use items that can be considered for India's exports are PV panels/modules for solar energy (HS 854140), and wind turbines that are used in generation of energy from wind (HS 850231 - wind powered electric generating sets). The key markets for India's exports of these components has also been analysed in detail in this chapter. It may be noted that in both these commodities (HS 850231 and HS 854140), India has been doing well and there exists a good opportunity for India to exploit the existing potential by venturing into markets where import demand exists and is growing rapidly.

On the whole, India is suitably positioned to capitalize from this sector both domestically – by capacity creation, and internationally – by catering to the renewable energy technology component market abroad, which is growing by leaps and bounds.

Table 33: Tariffs by the State Electricity Regulatory Commissions for Biomass (As on 30.09.2008)

State	Participation	Wheeling	Banking	Buy Back	Third Party Sale	Other Incentives
A.P.**	Pvt.	28.4% + ₹0.5/kwh	Allowed at 2% for 8-12 months	₹2.63 per unit, (05-06) @1% for 5 years	Not Allowed	--
Chattisgarh	Pvt.	6%	Not allowed	₹3.05 to ₹.3.71	Allowed	As to other industry; Electricity Duty Exempted for 1st five year
Gujarat##**	Pvt.	4% of energy	Allowed 12 months	₹3.00/unit, No escalation	Allowed	--
Haryana **(RPS-3%-07-08)	Pvt.	2% of energy	Allowed	BM-₹4.00/unit, BC-3.74/unit 2% escalation (base year07-08)	Allowed	--
Karnataka**	Pvt.	5% surcharge ₹1.13/unit	Allowed at 2% charge on monthly basis	@ ₹2.74 per unit, (cogeneration)@₹2.85 per unit(04-05) 2% on base tariff	Allowed (Cogeneration)	Subsidy @ ₹25 lakhs/MW for co-gen. only
Kerala	Pvt.	5% of energy	Allowed 4 months	₹2.80 per unit, escalated at 5% for five years (2000-01)	Allowed	50% cost of power evacuation line to be borne by KSEB.
Maharashtra**	Pvt./Coop.	7% of energy	Allowed	₹3.05 per unit (Comm yr.) (Cogen) @ ₹3.04 - 3.43 (13 yrs.) @1% (biomass)	Allowed	50% cost of power evacuation line to be borne by MSEB.
M.P.	Pvt.	Yet to be decided	Allowed	₹3.33 to ₹5.14 paise for 20 yrs. With escl of 3- 8 paise	Allowed	--
Punjab	Pvt.	2% of energy	Allowed 12 months	₹3.49 per unit, (06-07) escalated at 3% - cogen. & for 5% - BM	Allowed	As to other industry
Rajasthan	Pvt.	10% of energy	Allowed 12 months	₹3.60 per unit, (07-08)-water cooled and ₹3.96- air cooled condenser in 1st year of operation with escalation	Allowed	--
Tamil Nadu	Pvt.	2% - 10%	Allowed at 2% charge	₹3.15 per unit, fixed for 3 Years	Not allowed	--
U.P. **	Pvt.	12.5%*	Allowed 24 months	₹2.86 per unit, for existing and ₹ 2.98 for new with escalated at 4 paise/year	Allowed*	--

* Not allowed for Co-generation
** SERC Policy announced
Govt. Resolution No. REP-102000-502-B dated 27th September, 2001 ~~Not allowed for co-generation. For Biomass only.

5. RENEWABLE ENERGY: A FUNDING PERSPECTIVE

One of the major hurdles in exploiting the potential of renewable energy is the availability of capital. Limited ability of obtaining finance by firms for renewable energy projects have often been seen as a strong deterrent to investments in renewable energy technologies in many countries around the world, including India. The main hurdle in investment in renewable energy remains the high up-front costs, particularly for installing equipment. To some degree, strengthening capacity building, promoting enabling environment, developing policy frameworks, and improving demands for renewable energy technologies (RET) can help in mitigating the steep transaction costs in underdeveloped markets. However, despite such initiatives, the up-front investment costs of renewable energy projects still remain higher than those of conventional technologies. Nevertheless, such initiatives, if undertaken over prolonged periods of time, are expected to reduce the cost of investments in the renewable energy sector.

In the context of India, a well constructed policy support mechanism by the Governments, both at the centre

Table 34: Comparable Cost of Renewable Energy Technologies in India - 2006

Technology	Capital Costs (US$ Mn / MW)	Unit Costs (Cents / KWH)
Small Hydropower	1.27-1.53	3.8-6.4
Wind Power	1.02-1.27	5.1-7.6
Biomass Power	1.02	6.4-8.9
Bagasse co-generation	0.89	6.4-7.6
Bagasse gasifier	0.48-0.51	6.4-8.9
Solar PV	0.66-0.69	38.2-50.9
Waste-to-energy	0.64-2.55	6.4-19.1

Source: Integrated Energy Policy, Report of the Expert Committee, Planning Commission and at the state level, including fiscal incentives, is equally crucial for the success of renewable energy programs. Such mechanisms are required to help support shifting the investment paradigm of energy sector away from the typically undervalued investment costs of fossil fuels. Given the barriers, innovative finance mechanisms can lead the way to increase the demand for investments in renewable energy technologies, and generate a sustainable market for the deployment of RET.

From the discussions in the preceding chapters, it is amply clear that the success of the usage and the proliferation of RET will only be possible through a two pronged strategy – a sound financial support mechanism and a constructive policy initiatives enabling enhanced investment into the sector, both of which needs to exist in tandem.

FINANCIAL SUPPORT MECHANISM

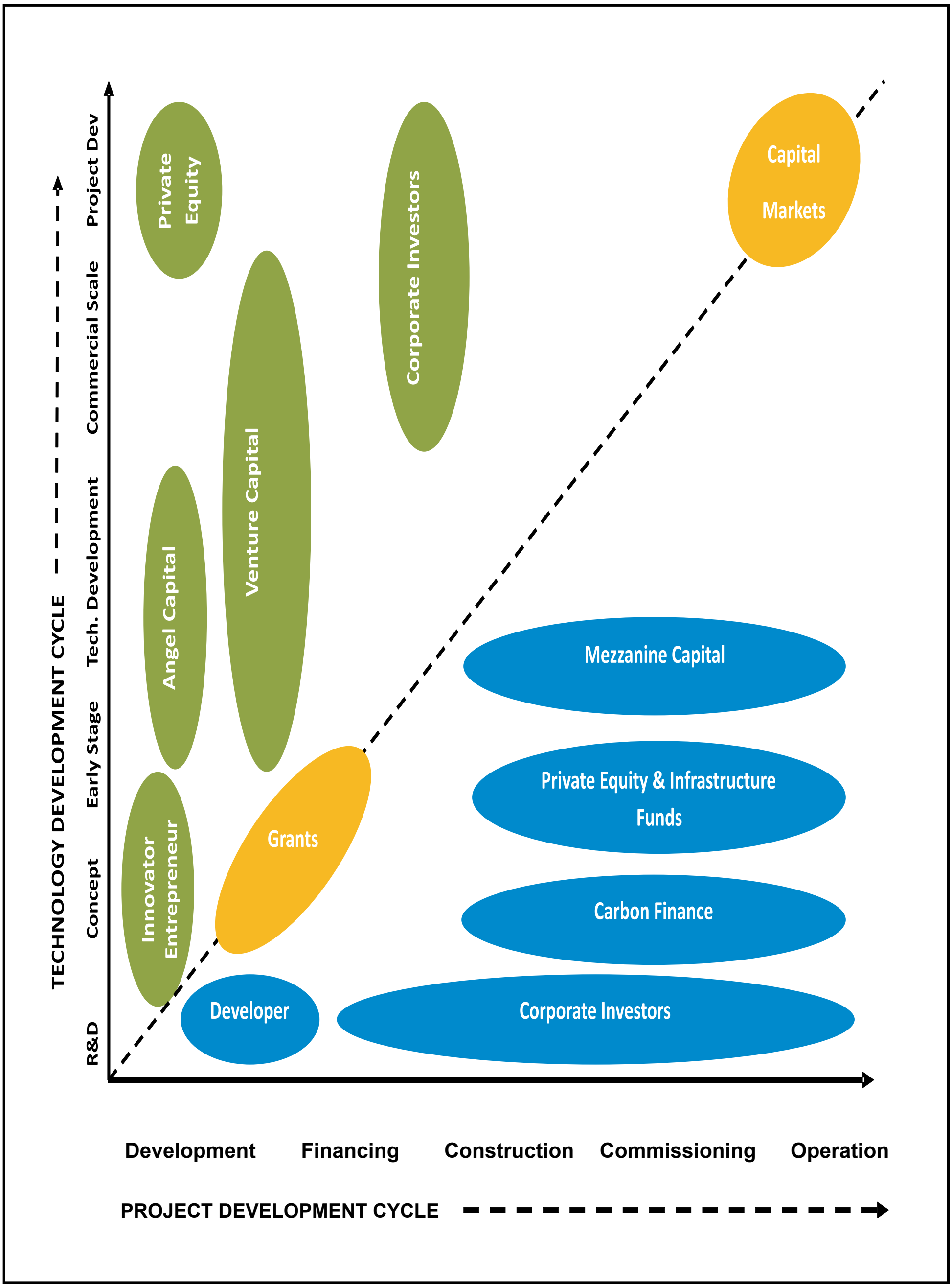
Financing of renewable energy, which was at a very nascent stage in the early 90's, has of late, become a mainstream financing activity with various financing modes introduced at different stages of the evolution of the RET, from concept to its commercial mass scale use. Financing methods in the RET sector have mostly been conventional debt and equity products.

RET is an expensive affair both for developing and making the technology commercially viable – as significant costs are incurred at both the stages. Financing development of such technologies, especially when they are largely at their nascent stage with their commercial utilization still uncertain becomes a risky proposition. Equipment manufacturers, construction contractors, integrators/assemblers (those who bundle technologies together into an integrated package) and service providers are all critical players in the RET sector. Their innovations, expertise and performance are crucial in making RET a commercially viable technology. In spite of these deterrents players have been successful in devising means and mechanisms to finance their growth, at the various stages of the technology and project development cycle.

Exhibit – 55 illustrates the investor groups, and their possible interventions at various stages of technology development and the project development cycles, of the renewable energy sector.

Understandably, RET firms are required to undertake a lot of R&D activities, and mostly the initial concept has an entrepreneurial genesis who may be called as an ***'innovator entrepreneur'***. R&D finds solution to specific technical problems and applies them to new technologies. After a lot of R&D, the 'innovator entrepreneur' conceptualizes it and then takes it from the nascent stage forward with the help of other modes of financing to the next level. In most countries, including India, business incubators have been set up, which are playing a crucial role in the clean energy sector in stimulating innovations in the laboratories, fostering

Exhibit 55: Renewable Energy Technology Development: Life Cycles and Funding Sources



Source: Exim Bank Analysis

firm-level growth, and aiding in the path towards commercialisation. Led by academic and research foundations, organizations incubating clean energy companies are usually affiliated with universities, government facilities, subsidiaries of large corporations and charitable organizations.

There are ***developers*** in the project development stage, who seek to deploy their ideas / innovations once the fundamental technical barriers have been resolved and the commercial potential of a technology has been established. They basically undertake such ventures by bringing in infrastructure projects by going in for a mass scale production and utilization, thereby playing an important role.

Once the R&D is done in the technological development stage, and the commercial viability of the project is established, venture capital and angel capital comes into the forefront. ***Angel investors*** are typically high net worth individuals that provide early stage capital to businesses, usually filling the capital gap between initial funding provided by developers/entrepreneurs and venture funds and other sources of capital. The principal difference between Angel Capital and Venture Capital funds has traditionally been that angel investors usually invest their own funds while venture funds are managed-pools of funds. Angel investors may support clean energy infrastructure projects if an appropriate conduit can be found to match investors with appropriately prepared projects and returns can thereby be secured. According to the Centre for Venture Research, University of New Hampshire, angel investors are the largest providers of seed capital and startup capital to entrepreneurial ventures in the US, focusing primarily on technology investments.

Venture capital (VC) invests in a relatively larger amount as compared to angel capital. VC funds provide both equity and risk capital to new entrepreneurial ventures. Fundamentally, venture capitalists look for investments with significant growth opportunity and focus primarily on technology related investment. They are also involved actively with the management (prefer a high level management role). VCs have played a significant role as enablers in commercializing RETs across the globe.

On the other hand ***private equity*** firms prefer to enter the renewable energy sector late in the technological or the project development cycle with a time horizon of around 3 years to 5 years. The term ‘private equity’ refers to the manner in which funds are raised, the defining feature being that the fund is not listed in the market. These firms invest large chunk of capital and play an active role in management and focus traditionally on operating businesses that require expansion capital or a ‘turnaround’ that shows good prospects of an exit in the short period.

By their nature, ***infrastructure funds*** are focused on investments in infrastructure assets and generally finance essential services which offer concessions to operate the infrastructure. While infrastructure funds have made some investments in clean energy infrastructure projects, most notably in wind energy, majority of these investments have been made into projects in OECD countries. Infrastructure funds are well suited to renewable energy infrastructure investments but tend to enter at a later stage. However, a relatively low investment in the sector through such infrastructure funds remains a possible hurdle, especially in India's context.

Mezzanine capital generally refers to unsecured or subordinated, high-yield debt or preferred stock. Mezzanine finance bridges the gap between equity and bank debt. The objective of using mezzanine capital is to minimize the equity commitment of the project sponsor, reduce the potential impact of dilution, and optimize the capital structure and weighted average cost of capital of the company. Mezzanine capital has traditionally been used to fund growth opportunities such as acquisitions or plant expansions. In contrast to conventional lenders, mezzanine lenders look favourably on stable, profitable mid-market companies, which, due to their lack of hard assets, require a cash-flow lending approach. Part of the attraction for such financing is the fact that it can be arranged fairly quickly. Moreover, because mezzanine capital is subordinated to the senior bank financing on the borrower's balance sheet, the company is able to optimize the amount of total leverage. Mezzanine financing has a number of advantages for companies compared to the other traditional financing methods. These include:

- Less expensive than equity financing;
- Avoids dilution of equity: Shareholders continue to operate more independently than would be the case if additional investors had rights to the capital;
- Cash flow based (as opposed to collateral based);
- Ideal for smaller-size companies who have limited access to financing;
- Easy to implement and quick to execute which makes it attractive for smaller-size companies.

Carbon Financing is another mode of financing (which has been dwelt upon in Chapter 2). Creation of trade in carbon credits has given rise to a number of carbon currencies. The two most important being Certified Emission Reductions (CERs) from CDM projects, and Emission Reduction Units (ERUs) from JI projects. In many instances, these credits are sold forward from projects that are yet to start operations and therefore have material risks of non-delivery (planning, construction, and operations going wrong). These are known as "primary CERs" and "primary ERUs". Credits that have either been generated and approved by the UN or backed by a high grade financial institution are known as "secondary" CERs (sCERs) and "secondary" ERUs (sERUs). Though pCERs have been traded since 2005, sCERs are being

Table 35: Traditional Financing Mechanisms undertaken by Corporate Investors

Corporate financing	Involves the use of the internal company capital to finance a project directly, or the use of internal company assets as collateral to obtain a loan from bank or other lenders.
Project Financing	This refers to financing structures wherein the lender has recourse, only or primarily to the assets of the project, and depends on the cash flows of the project for repayment. Such financing model will be "limited recourse" financing, when besides the project cash flows, the lender has some recourse to the balance sheet of the promoter by way of issuance of corporate guarantees. 'Non-recourse finance, is used when there is no recourse to the balance sheet of the promoter and therefore the lender takes a higher interest and/or put stricter norms in place.
Lease Financing	Lease financing involves the supplier of an asset financing the use and possibly also the eventual purchase of the asset, on behalf of the project sponsor. Assets which are typically leased include land, buildings, and specialized equipment. A lease may be combined with a contract for operation and maintenance of the asset.

traded since 2007. As the carbon market matures, carbon funds would play an increasingly important role in pricing carbon credits, in terms of providing a greater certainty to the project's future income streams.

The most common and conventional mode of renewable energy funding is however by the corporate investors. They are generally present at all stages of the project development cycle. Historically, corporate investors have concentrated activity on conventional energy transactions. Of late, they have evinced increasing interests in RET projects, with few of them having a dedicated team looking after the requirements of this sector. However, corporate investors investing in RET tend to be selective, undertaking a project development risk, with most of them expressing their interests for projects only after commissioning.

Raising capital is a strategic priority and role of capital markets has assumed far greater importance and urgency. As firms either in the technology development cycle or in the project development cycle matures, they have the option of entering the capital market for raising funds by issuing shares and going ahead with their expansion plans. However, firms entering the capital market generally do so at advanced stages with the main objective of diversification and liquidity. They generally require an operating track record too. Countries like India today have a well developed capital market providing enormous opportunity for renewable and energy efficiency projects. As many as 19 IPOs across

Box 12 : Some Innovative Financing Models

Dealer-Credit Model (or Dealer Sales Model): Here the dealer is provided support through access to business financing and sells the RE system to the end user, which can be some times on credit. In the case of Bangladesh, International Finance Corporation, the private sector arm of the World Bank, provided loan to the dealer, Grameen Shakti, under their Small and Medium Scale Enterprise Program. The Grameen Shakti, in turn, extended credit to customers to purchase RE system.

The Consumer Credit Model: In this mechanism, local finance institutions provide loans to users to buy the RE system. The RE enterprise in this case transacts on commercial basis with the users. In Sri Lanka, this model is practiced through Sarvodaya, a micro finance organization, which in turn borrows from commercial financers.

The Supplier Credit Model: In which a RE enterprise provides a short term (3 months to 12 months) credit to the end user to purchase the RE equipment/ system.

The Energy Service Company Model: The Energy Service Company Model (or Fee-for-Service model), in which the customers pay for the energy service that is provided to them by an energy service company (ESCO). It makes the energy affordable and minimizes the long-term risks for the customers as the ownership and maintenance of the equipment lies with the energy service company. The World Bank used this model in Argentina, Benin, Togo, Dominican Republic and Cape Verde.

various sectors were launched till end August in the Indian capital markets raising over Rs.50 billion in the first five months of the fiscal 2010-11.

POLICY INITIATIVES

Policy initiatives are the backbone to the success of RET. As the sector requires huge amount of capital, a conducive policy oriented ambience is necessary to encourage greater investments into the sector. In a country like India, which is a highly value-conscious mass market, public is unlikely to pay substantial premiums for goods/ services tagged “clean”, at the lease in the near future. In such a scenario, clean energy projects cannot sustain without Government support primarily in the form of capital infusion.

This could be done in a number of ways, from sanctioning grants (reduces initial investment costs), introducing tax credits (to reduce capital or operating costs), including low interest loans and grants (lowers capital recovery requirements), to introducing green purchasing targets (which may help to create a market pull by committing to buy green power for their operations) in the country (Exhibit - 56)

Grants

A grant is an amount of money provided by a party to a project, person or an organisation that contributes to furthering the objectives of the party. Grants may be convertible to loans or equity, if the project achieves commercial success (if so, this will be stated in the terms and conditions of the grant). Grants are typically provided by Government organizations, although cover only a portion of the project costs.

Over the years a number of programs related to grant have been introduced across the world including in India. However, under the American Recovery and Reinvestment Act, 2009, the US Government announced a US$ 3 billion "Payments for Specified Energy Property in Lieu of Tax Credits" grant which facilitate speedy disbursement of grants. Under the new program, companies would forgo the tax credits in favour of an immediate reimbursement of 30% of certain project expenses, expediting availability of funds. Here, cheques are deposited into a company's bank account within 60 days after receiving an eligible application. Each project is expected to receive an average of US$ 600,000, but there is no cap on how much a company can get or a limit on the total funds that will be available. Previously, energy companies would file for a tax credit to cover a portion of the costs of a renewable energy project. This program had played a key role in encouraging private sector capital to invest in clean energy development during the period of recession.

Investment Incentives

Investment Tax Credit

Investment tax credits are an important source of renewable energy financing, especially when these credits are given for performing certain actions, such as installing solar panels or windmills to generate electricity. Investment tax credits for renewable energy directly reduce the cost of investing in renewable energy systems and reduce the level of risk by allowing investors to reduce their tax liability in direct proportion to the amount of tax credit they have earned. For businesses, tax credits may be in the form of no taxes for a specific number of years or a certain percentage of tax offset, making this money available for investment into renewable energy projects instead.

In USA, tax credits are offered for both individuals and businesses that choose to make a switch to renewable energy sources, helping to lower the cost of energy projects that do not use fossil fuels. Apart from this, businesses in the US that installed renewable energy systems prior to 2007 were eligible for a corporate tax credit amounting to 30% of installed cost until 2007, and 10% after that. This credit is applicable to solar space heating, solar water heat, solar thermal electric, solar thermal process heat, photovoltaics, geothermal electric, fuel cells, solar hybrid lighting, direct use geothermal (10% only), and microturbines (10% only).

Exhibit 56: Various Policy Mechanisms in Renewable Energy Promotion

Source: Exim Bank Analysis

Instead of tax exemptions for renewables, some Governments have implemented energy taxes on fossil fuels. Similar taxes are emission-related taxes, such as CO_2 or SO_2 taxes. These taxes are meant to correct a market failure that does not incorporate the external costs of fossil energy sources in the heat and electricity sectors. A similar tax was introduced by the Indian Government in the 2010-11 Budget whereby Rs 50/tonne (around US$1) was levied on production/import of coal and the amount so collected was to be used for funding research and innovation projects though the 'National Clean Energy Fund'. Such taxes make it easier for (usually somewhat more expensive) energy from renewables to compete in the marketplace, and tax revenues so generated could also be used to support renewable energy technologies.

The only country having a substantial wind power installed capacity in Latin America is Brazil (606 MW), which added 264 MW of wind energy in the year 2009 (an increase of over 180% as compared to 2008). Brazil's PROFINA programme supports the uptake of renewable energy sources in the Brazilian energy mix. There have been additional positive signs for the wind industry, with some Federal and State Tax relief measures designed to stimulate investment, including moves to eliminate import taxes for wind equipment. It may also be noted that 90% of Brazil's vehicles are running on hybrid fuels (Brazil is amongst the largest producers of ethanol).

Table 36: Policy Interventions for Energy Efficiency and Renewable Energy

Policy area	Energy efficiency and demand-side management interventions	Renewable Energy Interventions	Barriers Addressed
Economywide	Removal of fossil-fuel subsidies; Tax (fuel or carbon tax); Quantitative limits (cap-and-trade).		Environmental externalities not included in the price; Regressive or demand-augmenting distortions from subsidies for fossil fuels.
Regulations	Economywide energy-efficiency targets; Energy-efficiency obligations; Appliance standards; Building codes; Industry energy-performance targets; Fuel economy standards.	Mandatory purchase, open and fair grid access; Renewable portfolio standards; Low-carbon fuel standards; Technology standards; Interconnection regulations.	Lack of legal framework for renewable independent power producers; Lack of transmission access by renewable energy; Lack of incentives and misplaced incentives to save; Supply-driven mentality; Unclear interconnection requirements.
Financial incentives	Tax credits; Capital subsidies; Profits decoupled from sales; Consumer rebates; Time-of-use tariffs; Fuel taxes; Congestion tolls; Taxes based on engine size; Insurance or tax levies on vehicle miles traveled; Taxes on light trucks, SUVs.	Feed-in tariff, net metering; Green certificates; Real-time pricing; Tax credits; Capital subsidies.	High capital costs; Unfavorable pricing rules; Lack of incentives for utilities and consumers to save.
Institutional arrangements	Utility; Dedicated energy-efficiency agencies; Independent corporation or authority; Energy service companies (ESCOs).	Utility; Independent power producers.	Too many decentralized players.
Financing mechanisms	Loan financing and partial loan guarantees; ESCOs; Utility energy-efficiency, demand-side management program, including system benefit fund.	System benefit fund; Risk management and long-term financing; Concessional loans.	High capital cost, and mismatch with short-term loans; ESCOs' lack of collateral and small deal size; Perceived high risks; High transaction costs; Lack of experience and knowledge.
Promotion and education	Labeling; Installing meters; Consumer education;	Education about renewable energy benefits.	Lack of information and awareness; Loss of amenities.

Source: Adapted from World Development Report, 2010

The Chinese established the "Medium and Long-Term Development Plan for Renewable Energy" in 2007, to establish a basic system of renewable energy technologies. As a foundation for the development of a large-scale domestic manufacturing capability, China has provided strong support to the wind energy sector through the introduction of a number of regulations and incentives to support domestic manufacturing capabilities. As early as 2003, the Chinese authorities mandated local content requirements, amounting to 40% in the context of the concession programme, and subsequently raised to 70%, and extended to all new wind installations, including those applying for financing under the Clean Development Mechanism (CDM). Apart from this, in 2001, the VAT for wind power was cut in half (from 17 to 8.5 %); there was also a shift in customs policy. Initially, imported wind power equipment was exempted from customs duties in order to promote technology transfer. Subsequently, as the focus increasingly shifted to the development of a domestic wind power manufacturing base, the Government issued graduated customs duty rates that favoured the import of components over complete turbines. In April 2008, China announced the removal of all tax breaks on imported wind turbines below 2.5 MW. At the same time, the Government announced a VAT rebate on imported "key components and raw materials" if they were used by domestic manufacturers to develop and manufacture large systems (1.2 MW and above). The returned taxes were to be used to support "new product development and innovation capacity building". In August 2008, China issued a second financial incentive package aimed at promoting domestic wind power equipment manufacturers. The policy rewards domestic manufacturers with 600 RMB per kW for each of the first 50 turbines of over 1 MW, if they have been tested and certified by the Chinese authorities, put into operation and connected to the grid. Only those turbines qualify that use domestically produced components. This policy is expected to have a significant impact on the future promotion of China's technology innovation by domestic industry, thereby improving competitiveness and building domestic branding in the long run.

Accelerated Depreciation

Accelerated depreciation allows renewable energy investors to receive their tax benefits sooner than under standard depreciation rules. It allows investors in renewable energy facilities to record depreciation in plant and equipment at a faster rate, thereby reducing stated income for purposes of income taxes. Since renewables other than biomass are generally more capital intensive than other forms of electricity production, accelerated depreciation has a significant effect on post-tax profitability of renewable investment. The effect of accelerated depreciation is similar to that of investment tax credits. In the United States, businesses can recover investments in solar, wind, and geothermal property by depreciating them over a period of five years, than the 15 years to 20 years depreciation period of conventional power investments.

India's accelerated depreciation policy allows 100% depreciation in the first year of operation. However, this policy may lead to large investments without sufficient regard to long-term operating performance and maintenance, and thereby may result in excess capacity. Due to this apprehension, production-based incentives are preferable to investment tax credits and accelerated depreciation.

Production Based Incentives

Production tax credits (PTC) provide investors with a tax credit based on the amount of electricity actually produced from renewable energy sources and fed into the electric grid. They increase the rate of return and reduce the payback period for renewable energy projects, while rewarding producers for actual generation of energy.

However, it is to be noted that PTC are long term initiatives and any inconsistency and uncertainty created by the Government in dealing with the extensions of the PTC, results in inconsistent and uneven growth in the renewable energy sector. US too has a Renewable Electricity Production Tax Credit (PTC) programme, which has been providing a per kWh tax credit for electricity generated by qualified wind, closed-loop biomass, or poultry waste resources. This program has helped USA in driving significant capacity expansion in the RET sector. The PTC programme renewed in December 2009, after it had expired in 2008 (this tax incentive package assumed significance as the US has traditionally seen drastic decline in wind installations on expiry of these credits and sharp pick up in volumes upon extensions).

Mandated Market Share

One strong measure a Government can take to develop RE markets is through mandated market share (MMS) policies, which require that a certain quantity or proportion of a country's energy be generated from renewable energy sources by instituting a purchase obligation or creating strong incentives for renewable energy at some point along the energy supply. Mandated market shares for renewable energy can be created by instituting one of the following three policies, or a combination of them:

❖ Renewable Portfolio Standards, whereby the government requires that all electricity carriers produce a certain amount of renewable energy annually, or buy tradable credits for that amount of energy. For example, many countries, including USA, have adopted Renewable Portfolio Standards (RPS), which enables electricity utility organisations or providers to supply a certain quantity of their delivered energy from renewable energy sources such as PV. In June 2009, the US House of Representatives

Box 13: The Financial Crisis Offers Opportunities for Efficient and Clean Energy

The financial crisis brought both challenges and opportunities to clean energy. Sharply falling fossil-fuel prices discourage energy conservation and make renewable energy less competitive. The weak macro-economic environment and tight credit have led to lower demand and declining investment, and renewable energy is hard hit because of its capital-intensive nature (renewable energy is characterized by high up-front capital costs but low operating and generation costs). By the last quarter of 2008, clean energy investments dropped by more than half from their peak at the end of 2007.

Yet, the financial crisis should not be an excuse to delay climate-change action, for it offers opportunities to shift to a low-carbon economy. First, stimulus investments in energy efficiency, renewable energy, and mass transit can create jobs and build an economy's productive capacity. Second, falling energy prices provide a unique opportunity to implement programs to eliminate fossil-fuel subsidies in emerging economies and adopt fuel taxes in advanced economies in ways that are politically and socially acceptable.

Source: Adapted from World Development Report, 2010

passed the American Clean Energy and Security Act, which contains a 20% RES by 2020. Currently, in India, there are 18 states which are having a RPS policy of between 2% and 10%, dictating the percentage of power purchased by distribution companies from renewable sources. The state of Maharashtra fined distribution companies who did not meet the 5% RPS in 2008, the first penalty of its kind in India.

- Feed-in Tariffs allow the Government to set the price of renewable energy and guarantee that all renewable energy produced will be purchased and fed to the grid at the specified price for a specific period of time. Italy offers a very attractive support scheme, under which the PV system owner can valorise the electricity he produces himself at the same price as the electricity he consumes traditionally from the grid. If, over a time period, there is an excess of electricity fed into the grid, the PV system owner gets a credit (unlimited in time) for the value of the excess of electricity. This measure is very attractive for the residential, public and commercial sectors. On top of the valorisation of the electricity itself, the PV system owner also gets a premium FiT on the total electricity produced by the PV system. Under the present FiT scheme valid until the end of 2010, EPIA expects continuous growth of the Italian PV market.

- ❖ Tendering systems are a combination of the previous two policies, which allows energy suppliers to competitively bid for renewable energy obligations.

In general, production incentives are preferable to investment incentives because they promote the desired outcome—generation of electricity from renewable energy. In addition, production incentives are most likely to encourage investors to purchase the most reliable systems available, or to maintain them and produce as much energy with them as possible. Thus, production incentives are more likely to lead to optimum performance of the installed systems and a sustained industry.

Property taxes are generally based on the installed cost of the improvements to the property. Therefore, if taxed at the same rate as conventional facilities, renewable energy systems, which have higher investment costs, but no (or very low) fuel costs, would pay higher property taxes. Over 40 states in United States have property tax incentives for renewable energy. These are generally implemented in any of the three ways: a) renewable energy property is partially or fully excluded from property tax assessment; b) renewable energy property value is capped at the value of an equivalent conventional energy system providing the same service; and c) tax credits are awarded to offset property taxes.

Malaysian Government, through the Pusat Tenaga Malaysia (PTM) is promoting Building Integrated Photovoltaic Programme (BIPV). As a showcase of BIPV project, PTM has developed the 'zero energy office building', concept that incorporates the features of energy efficiency with renewable energy. The Suriya 1000 programme provides assistance to residential and commercial end-user segments to install BIPV systems on their existing or new buildings.

MULTILATERAL FINANCING MECHANISMS

It may be noted that much before commercial banks took interests in this sector, many multilateral financial institutions across the globe have taken steps to facilitate investments and promote renewable energy by providing special credit lines and funds. There are several multilateral programmes of cooperation that aim at increasing the utilization of renewable sources of energy in the context of climate change mitigation (Table 38).

Today, all major multilateral agencies are incorporating environmental consideration in their programmes. Although the share of financial assistance from the institutions is not as big as bilateral aid or private sector investment, they can play a pivotal role in promoting international cooperation in the new emerging mechanism. Demand is increasing for multilateral financing because these institutions offer loans for a longer period (Islamic Development Bank (IDB)) offer loans with maturities of up to 15 years), while a typical commercial bank would offer a loan with a maturity of no more than 5-7 years.

Box 14 : Climate Education in School Curricula

Education is an important aspect of understanding the repercussions of climate change and GHG in the atmosphere. A more specific and perceptible change can be noticed by introducing subjects on climate change in the early stages of schooling. This will not only help in educating the public at large but also bring about a consciousness towards the environment, through community actions, and its challenges, and how to overcome the same.

There are already a number of countries that have taken steps in the right direction by introducing courses in the regular curriculum. In the Philippines, a National Environmental Awareness and Education Act (of 2008) has been enacted, which promotes the integration of climate-change education in school curricula at all levels. The 1998 education reforms in Lebanon incorporated environmental studies, including climate change, into science, civic, and geography classes. In 2006, the U.S. Environmental Protection Agency created a climate-change-based educational resource for high school students, allowing them to calculate emissions inventories. In 2007, Canadian Provinces committed to include climate change in their school curricula. Under Australia's Third National Communication on Climate Change, the Government provides support and develops material to promote climate change education, such as a school resource kit developed by the Australian Greenhouse Office.

Source: Exim Bank Analysis

Box 15: Exim Bank's Support to Renewable Energy Sector

Export-Import Bank of India, the country's premier export finance institution, has signed an agreement for a long term loan of Euro 150 million equivalents with a tenor of upto 15 years with European Investment Bank (EIB) in 2008. The purpose of the EIB loan to Exim Bank of India is for supporting projects that contribute to climate change mitigation and to enhance EU presence in India through FDI, transfer of technology or know-how from Europe. The borrowings under this facility will enable the Bank to on-lend for import of equipment for projects including renewable energy projects (eg. wind, solar, biomass etc.), energy efficiency enhancement (eg. fuel switching, plant modernisation etc.) as well as projects that would reduce greenhouse gas emissions, clean environment, afforestation.

Table 37 : Select Countries with National Plans or Proposals for Energy & Climate Change

Country	Climate change	Renewable energy	Energy efficiency
European Union	20 % emission reduction from 1990 to 2020 (30 % if other countries commit to substantial reductions); 80 % reduction from 1990 to 2050	20 % of primary energy mix by 2020	20 % energy savings from the reference case by 2020
United States	Emission reduction to 1990 levels by 2020; 80 % reduction from 1990 to 2050	25 % of electricity by 2025	
Canada	20 % reduction from 2006 to 2020		
Australia	15 % reduction from 2000 to 2020		
China	National Climate Change Plan and White Paper for Policies and Actions for Climate Change, a leading group on energy conservation and emission reduction established, chaired by the prime minister	15 % of primary energy by 2020	20 % reduction in energy intensity from 2005 to 2010
India	National Action Plan on Climate Change: per capita emissions not to exceed that of developed countries; an advisory council on climate change created, chaired by the PM	23 gigawatts of renewable capacity by 2012	10 gigawatts of energy savings by 2012
South Africa	Long-term mitigation scenario: emissions peak in 2020 to 2025, plateau for a decade, and then decline in absolute terms	4 % of the power mix by 2013	12 % energy-efficiency improvement by 2015
Mexico	50 % emission reduction from 2002 to 2050; national strategy on climate change: intersecretariat commission on climate change set up for coordination	8 % of the power mix by 2012	Efficiency standards, cogeneration
Brazil	National plan on climate change: reducing deforestation 70 % by 2018	10 % of the power mix by 2030	103 terawatt hours of energy savings by 2030

Table 38 : Renewable Energy Finance Programs of Select Multilateral Financial Institutions

FINANCIAL INSTITUTION	COMMITMENTS / KEY FEATURES
The World Bank *Climate Investment Funds (CIF)*	Climate Investment Funds (CIF): The World Bank's CIF is the umbrella vehicle that distributes multilateral contributions to two trust funds and their programmes: - The Clean Technology Fund, which is open to projects and programmes that contribute to demonstration, deployment and transfer of low-carbon technologies with a significant potential for long-term GHG emissions savings. The energy sector, particularly renewable energy and energy efficiency in generation, transmission and distribution, figures prominently among the Fund's thematic priorities.

	- The Strategic Climate Fund, which contains the recently approved Programme for Scaling up Renewable Energy in Low Income Countries, aims to shift generation of energy from conventional fuels, such as oil and coal, to renewable fuels.
ADB *Energy Efficiency Initiative (EEI)* *Clean Energy Financing Partnership Facility (CEFPF)*	ADB has launched the Energy Efficiency Initiative (EEI) in July 2005 to identify new renewable energy and energy efficiency projects, with the objective of boosting investments in clean energy. This initiative is intended to catalyze investments in renewable energy and energy efficiency segments, needed to fill the investment requirement of US$ 240 billion over 10 years for emerging Asia. In 2007, ADB set up the Clean Energy Financing Partnership Facility (CEFPF) to help improve energy security in developing member countries and decrease the rate of climate change. The CEFPF is made up of three funds: a) the multi-donor Clean Energy Fund supported by the Governments of Australia, Norway, Spain, and Sweden; b) the single donor Asian Clean Energy Fund supported by the Government of Japan; and c) the newly established Carbon Capture and Storage Fund supported by the Global Carbon Capture and Storage Institute of the Government of Australia. CEFPF resources are also intended to finance policy, regulatory, and institutional reforms that encourage clean energy development. Potential investments include: • Deployment of new clean energy technology; • Projects that lower the barriers to adopting clean energy technologies; • Projects that increase access to modern forms of clean and energy efficient sources for the poor; • Technical capacity programs for clean energy. During the period January - May 2010, CEFPF has allocated about US$16.2 million to 19 projects, raising the cumulative total to about US$ 44.7 million to 56 projects. In 2009, CEFPF allocated about US$ 14.1 million to 19 projects, raising the cumulative total to about US$ 28.5 million to 37 projects. Recently, the ADB launched a US$ 9 billion solar power initiative to develop projects generating 3,000 megawatts by 2012. ADB will provide US$ 2.25 billion in direct financing, expecting to leverage another US $ 6.75 billion in private financing for the projects.

AfDB *FINESSE program (ended in 2008)*	Financed by the Dutch Government with US$5.3 million, the Financing Small Scale Energy Users (FINESSE) Program is assisting countries in Africa to work through the AfDB in mainstreaming renewable energy and energy efficiency (RE&EE) projects and programs. The objectives of the FINESSE program were: • Increasing capacity of Bank staff to deal with renewable energy and energy efficiency projects and proposals; • Establishing RMCs' ownership and commitment to renewable energy and energy efficient projects and programs; • Operationalising renewable energy and energy efficiency projects and programs in the Bank; and • Identifying and preparing renewable energy and energy efficiency projects for the Bank's portfolio.
GEF *South Asia Clean Energy Fund (SACEF)*	Global Environment Facility Trust Fund (GEF) has set up a South Asia Clean Energy Fund (SACEF), with Global Environment Fund (US Private Equity firm); and equity contribution from ADB. SACEF is raising a US$ 300 million growth capital fund – for investing in clean energy opportunities across the region.
The Global Environmental Facility's (GEF) Trust Fund	Under its Climate Change focal area, finances projects to promote the adoption of renewable energy by assisting Governments to remove barriers and reduce implementation costs to make renewables more attractive. It has projects, including several of them focusing on rural areas, in a number of developing countries viz., Argentina, Bangladesh, Bolivia, Botswana, Burkina Faso, Cambodia, Chile, China, the Democratic People's Republic of Korea, Ecuador, Egypt, Ghana, Guinea, Honduras, India, the Lao People's Democratic Republic, Lesotho, Mali, Mexico, Mongolia, Nicaragua, Nigeria, Peru, the Philippines, Senegal, Sri Lanka, Uganda, the United Republic of Tanzania, Viet Nam and Yemen.
CAF	Latin American Carbon Program (PLAC) was established in 1999. Have previously worked together with KfW. With carbon emissions market as a starting point, CAF is now interested in EE/RE opportunities both in CDM project development, and beyond.

Source : Websites of respective finanical institutions

SUM UP

Climate change presents humanity with a significant challenge. At the same time, investments in clean energy and low carbon alternatives, present business and capital with an opportunity, which could potentially emerge as one of the largest commercial opportunities of our time.

The electricity generated from renewable energy sources accounted for 25% of global power capacity, and 18% of global power production in 2009. During the same year, renewable energy sources accounted for 60% of newly installed power capacity in Europe, and more than 50% in the USA. The increasing trend is sustainable energy investment, including generation from renewable sources and energy efficiency projects, indicates the determination of countries across continents, including the developing countries, to transform the financial and economic crisis into an opportunity for green investment. It is estimated that the newly-installed capacity from renewable sources in the world as a whole could increase by over 50% in a couple of years. This could be achieved through innovative financing and incentive mechanisms. Favourable policies are already in place in more than 100 countries; however, to maintain the upward trend in renewable energy growth, policy efforts need to be taken up to a higher level in these countries, and need to be introduced in the remaining countries, thereby encouraging massive scale up of renewable technologies.

Apart from this, companies should be encouraged to report their carbon footprint. Something on this line could also be worked out in coordination with International Accounting Standards Board to develop a universal accounting standard on carbon emissions reporting. India could also devise a domestic renewable energy reporting system, perhaps in collaboration with Institute of Chartered Accountants of India.

Innovation is another key factor for the growth of the renewable energy sector.

It may be noted that financial instruments that reward risk taking, rather than rewarding only the winners, may encourage risk taking skills among innovators, Technological solutions from unexpected quarters or from new business models that traditional R&D subsidy programs may tend to overlook. Tata Group, for example, has recently announced a program, first of its kind in India, to reward people who have tried to do something innovative, but finally could not achieve success. As part of the failure award process, the teams explain what they are trying to accomplish and what went wrong. The interviews are recorded, with the results published in a book and shared as case studies open to the public on the Tata Group's website. Such initiatives in the renewable energy sector by corporate and academic institutions will go a long way in fostering lateral thinking.

Examples such as the small group of US-based NRIs having set up a rice husk-based power-generating units in the West Champaran district in India, lighting up some 500-700 households spread over 20 villages in the district, and changing the profile of the cluster altogether.

India has been at the forefront of renewable energy technology with the country being amongst the first in the world to have a full fledged Ministry catering to this niche sector. However, the success level is relatively low as compared to China, who has moved ahead within a short span of time. India is strategically placed with both the demand and supply of renewable energy co-existing in the country. With almost 500 million people with limited access to electricity, renewable energy could act as a potential source to mitigate this yet unmet demand. On the supply side, India, unlike many countries in Europe, has a distinct advantage of generating energy from all the three emerging renewable energy technology fields – photovoltaic, wind, and biomass – which need to be leveraged suitably so as to harness their potential. Appropriate mechanisms could be created to overcome barriers at the early stage of project development, while simultaneously creating enhanced deal flow for later stage private and foreign institutional investors.

Annexure 1

6-digit HS Codes for Goods related to New Renewable Energy Sector - Global Exports

(US $ mn)

S. No.	HS Code	Product Description (for 6-Digit HS Code)	2004	2005	2006	2007	2008
1	854140	Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes	12980	15692	20359	27427	43189
2	382490	Other chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products), not elsewhere specified or included: other	20253	21782	24854	29237	39042
3	850440	Static converters	19887	21892	26678	32981	37398
4	850300	Parts of electric motors, generators, generating sets and rotary converters	10158	12220	14093	17170	20060
5	848340	Gears and gearing, other than toothed wheels, chain sprockets and other transmission elements presented separately; ball or roller screws; gear boxes and other speed changers, including torque converters	7950	9346	10531	13167	16734
6	848210	Ball bearings	8127	8905	9572	10895	12277
7	841989	Other machines and mechanical appliances for the treatment of materials by a process involving a change of temperature: other	4780	5122	5785	6624	7939
8	841182	Other gas turbines, of a power exceeding 5,000 kW	4897	5530	5670	6773	7933
9	841990	Other machines and mechanical appliances for the treatment of materials by a process involving a change of temperature: parts	3443	4161	4759	6619	7026
10	900190	Other (including lenses & mirrors)	4733	5324	5873	6340	6394
11	850423	Liquid dielectric transformers: having a power handling capacity exceeding 10,000 kVA	1640	2077	2623	3983	6339
12	850431	Electric transformers, having a power handling capacity less than 1 kVA	3875	3752	4329	5281	5567
13	220710	Undenatured ethyl alcohol	1336	2022	3422	3269	5489

S. No.	HS Code	Product Description (for 6-Digit HS Code)	2004	2005	2006	2007	2008
14	850231	Wind-powered electric generating sets	1097	1914	3191	3909	5341
15	850164	AC generators (alternators): of an output exceeding 750 kVA	1158	1394	1924	2758	4806
16	841290	Other engines and motors: parts	1652	2234	2703	3134	4657
17	848220	Tapered roller bearings	2363	2717	3074	3662	4648
18	730820	Towers and lattice masts	728	1101	1276	1946	3700
19	850239	Other generating sets: other	1688	1570	2112	2766	3630
20	711590	Other articles of precious metal or of metal clad with precious metals, other	1206	1414	2079	2527	2872
21	848230	Spherical roller bearings	1386	1576	1827	2315	2833
22	848250	Other cylindrical roller bearings	1193	1377	1577	2029	2692
23	841919	Instantaneous or storage water heaters, nonelectric	935	1093	1372	1668	2287
24	850434	Electric transformers, having a power handling capacity exceeding 500 kVA	581	688	1048	1592	2138
25	841940	Distilling or rectifying plant	515	747	753	1058	1913
26	902830	Electricity meters	1034	1065	1062	1448	1721
27	850421	Liquid dielectric transformers: having a power handling capacity not exceeding 650 kVA:	726	832	1151	1613	1706
28	848280	Other ball or roller bearings	928	960	1184	1495	1650
29	850422	Liquid dielectric transformers: having a power handling capacity of 650 kVA -10,000 kVA	469	517	843	1273	1632
30	900290	Other optical elements (including mirrors)	1510	1560	1629	1652	1606
31	903039	Other instruments and apparatus for measuring or checking voltage, current or resistance, with a recording device	1739	1911	2021	1448	1573
32	732290	Radiators for central heating, air-heaters, hot air-distributors non-electric, other	845	947	1050	1153	1191
33	841280	Other engines and motors	342	452	521	566	1182
34	850433	Electric transformers, having a power handling capacity of 16 kVA - 500 kVA	465	534	674	901	1116
35	890790	Other	399	506	649	1036	1104
36	220720	Ethyl alcohol and other spirits	276	395	661	962	1090
37	848240	Needle roller bearings	709	737	825	929	1087
38	841620	Other furnace burners, including combination burners	587	648	794	923	1061

S. No.	HS Code	Product Description (for 6-Digit HS Code)	2004	2005	2006	2007	2008
39	380210	Activated carbon	491	572	678	845	1037
40	850161	AC generators (alternators): of an output not exceeding 75 kVA (kilovolt ampere)	505	570	685	848	946
41	840682	Steam turbines and other vapour turbines, of an output not exceeding 40 W	382	434	641	820	890
42	700991	Glass mirrors, unframed	571	603	674	780	888
43	700992	Glass mirrors, framed	500	584	632	775	796
44	847920	Machinery for the extraction or preparation of animal or fixed vegetable fats or oils	374	426	445	617	782
45	840681	Steam turbines and other vapour turbines, of an output exceeding 40 MW	479	520	484	509	760
46	850432	Electric transformers, having a power handling capacity of 1 kVA -16 kVA	343	389	467	584	648
47	850162	AC generators (alternators): of an output exceeding 75 kVA	386	384	488	580	621
48	903020	Cathode-ray oscilloscopes	203	213	221	375	563
49	903031	Multi-meters	467	518	520	532	505
50	841931	Dryers: for agricultural products	182	202	277	333	498
51	850163	AC generators (alternators): of an output exceeding 375 kVA	206	203	249	298	436
52	830630	Photograph, picture or similar frames, mirrors; and parts thereof	412	405	439	471	411
53	900580	Other instruments	305	314	341	344	376
	TOTAL		**134396**	**153051**	**181789**	**223240**	**284780**

Source : Data derived from UN Comtrade Database, Exim Bank Analysis

Glossary of Terms

Assigned Amount Unit (AAU): Allowances issued to Annex I countries which have a cap on their emissions under the Kyoto Protocol. Each AAU grants the country the right to emit one tonne of greenhouse gases during a commitment period.

Cap and trade: Cap and trade schemes set a desired maximum ceiling for emissions (or cap) and let the market determine the price for keeping emissions within that cap. To comply with their emission targets at least - cost, regulated entities can either opt for internal abatement measures or acquire allowances or emission reductions in the carbon market, depending on the relative costs of these options.

Carbon Dioxide Equivalent (CO_2e): The universal unit of measurement used to indicate the global warming potential of each of the six greenhouse gases regulated under the Kyoto Protocol. Carbon dioxide – a naturally occurring gas that is a by-product of burning fossil fuels and biomass, land-use changes, and other industrial processes - is the reference gas against which the other greenhouse gases are measured, using their global warming potential.

Certified Emission Reductions (CERs): A unit of greenhouse gas emission reductions issued pursuant to the Clean Development Mechanism of the Kyoto Protocol, and measured in metric tons of carbon dioxide equivalent. One CER represents a reduction in greenhouse gas emissions of one metric ton of carbon dioxide equivalent.

Clean Development Mechanism (CDM): The mechanism provided by Article 12 of the Kyoto Protocol, designed to assist developing countries in achieving sustainable development by allowing entities from Annex I Parties to participate in low-carbon projects and obtain CERs in return. Annex I Parties include the industrialized countries that were members of the OECD in 1992, plus countries with economies in transition, including the Russian Federation, the Baltic States, and several Central and Eastern European States.

Emission Reductions (ERs): The measurable reduction of release of greenhouse gases into the atmosphere from a specified activity, and a specified period of time.

Emission Reduction Units (ERUs): A unit of emission reductions issued pursuant to Joint Implementation. One ERU is awarded for a reduction in greenhouse gas emissions equivalent in impact to one tonne of carbon dioxide.

European Union Emission Trading Scheme (EU ETS): The EU Emissions Trading Scheme commenced on 1 January 2005, creating the world's first multi-country emissions trading system and the largest scheme ever implemented. The EU ETS runs in three phases: 2005-2007 (Phase I), 2008-2012 (Phase II) and 2013-2020 (PhaseIII).

Greenhouse Gases (GHGs): Both natural and anthropogenic, greenhouse gases trap heat in the earth's atmosphere, causing the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases. The emission of greenhouse gases through human activities (such as fossil fuel combustion or deforestation) and their accumulation in the atmosphere is responsible for contributing to climate change. The Kyoto Protocol regulates six GHGs: CO_2, CH_4, and N_20, as well as hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride (SF6).

Joint Implementation (JI): Mechanism provided by Article 6 of the Kyoto Protocol, whereby entities from Annex I Parties may participate in low-carbon projects hosted in Annex I countries and obtain Emission Reduction Units in return.

Kyoto Mechanisms (KMs): The three flexibility mechanisms that may be used by Annex I Parties to the Kyoto Protocol to fulfil their commitments. Those are the Joint Implementation (JI, Art. 6), Clean Development Mechanism (CDM, Art. 12) and International Emissions Trading (Art. 17).

Kyoto Protocol: Adopted at the Third Conference of the Parties to the United Nations Convention on Climate Change held in Kyoto, Japan in December 1997, the Kyoto Protocol commits industrialized country signatories to collectively reduce their greenhouse gas emissions by at least 5.2% below 1990 levels on average over the period 2008–12, while developing countries can take no regret actions and participate voluntarily in emission reductions and removal activities through the CDM. The Kyoto Protocol entered into force in February 2005.

Offsets: Carbon credits earned for a reduction in emissions from projects or activities sources that are not subject to a cap on emissions. Emission reductions are usually calculated by reference to a business as usual baseline.

Primary CERs (pCER): CERs which are issued to or bought directly from a CDM project. In general, the buyer of primary CERs is exposed to the project risks.

Secondary CERs (sCER): CERs which are bought from a market intermediary on a “guaranteed delivery” basis, i.e. the seller insulated the buyer from project risks by guaranteeing to make good any shortfall from the projects in its portfolio.

Source: World Bank, European Climate Exchange

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