EAI
Energy Alternatives India

India Renewable Energy Advisor for Foreign Investors

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Preface

The Indian growth story is well known; what is not as well-known is the Indian renewable energy growth story, which has been putting in impressive performances last few years. This guide from EAI provides the highlights of renewable energy in India.

India has had a significant contribution from the large hydro power sector since its independence, with almost 20% of its total installed power capacity still coming from this sector. Its progress on utilizing the rest of the renewable energy sources has however been relatively recent, with wind power being the most prominent face of the renewable energy sector for the past decade.

Since 2010, there have been significant activities in a few other Indian renewable energy sectors as well, most notably solar. With the announcement of the ambitious National Solar Mission in 2010 and the subsequent implementation of the initial stages of the mission, the Indian government has shown its eagerness in harnessing the significant potential that solar presents for India. Other renewable energy sectors showing significant progress are small hydro and biomass power. Some segments that show little activity currently - like wave, tidal and geothermal, for instance – have the potential for significant growth in future.

This wide spectrum growth in the Indian renewable energy sector implies significant opportunities for companies from India and abroad. As many of the renewable energy sectors are nascent, there is significant need and eagerness from Indian corporates – for technology transfer from companies who are at the cutting edge of clean technology. This is where foreign companies, especially those from developed countries could play a significant role.

The *India Renewable Energy Advisor for Foreign Investors* from EAI is a ready reference for those foreign companies keen on entering the renewable energy industry. The *Advisor* comprises the first comprehensive compilation of data on critical parameters for all the important sectors of the Indian renewable energy industry. This guide was last revised in August 2011.

EAI is India's leading consulting and business intelligence firm, with a dedicated focus on renewable energy and clean technology. Our work has benefitted over a hundred Indian and foreign companies exploring the Indian renewable energy segment. One of our divisions specializes in advising foreign companies to explore and enter the Indian renewable energy sector. More about us can be known from www.eai.in

I hope you find this guide useful in your efforts to explore and participate in the exciting Indian renewable energy industry.

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India Renewable Energy &Cleantech Highlights

- ✓ Over 400 million Indians living in about 60,000 villages have no access to electricity
- ✓ Between 2005 and 2010, investments in renewable energy in India grew almost 500%
- ✓ Even at today's high costs for solar, power from solar costs less than power from diesel gensets (22 cents per kWh vs. 29 cents per kWh)
- ✓ Solar based industrial heating and drying can save up to 4.5 million T of oil per year
- ✓ Fewer than 1% of India's power plants use biomass as a fuel
- ✓ Under optimal conditions, biomass power plants could have payback periods of fewer than 3 years
- ✓ Investments in small hydro grew by over 200% between 2007 and 2009
- ✓ Seven of the top ten global wind turbine manufacturers have manufacturing facilities in India
- ✓ Many energy efficiency programs present attractive payback periods of less than one year!
- ✓ Biofuels contribute less than 0.5% to the total transport fuel consumption in India

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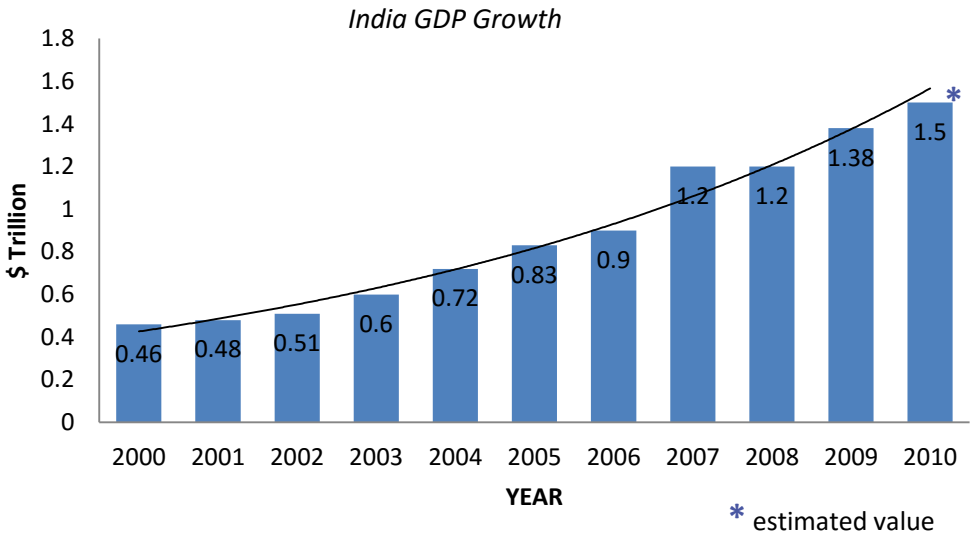
1. The India Story

1.1 Surging Economy

1.1.1 India GDP Growth

India's GDP is expected to have a growth rate of about 9% for the next five years or more, and its GDP is expected to be over $3 trillion by 2020, making it one of the top five economies of the world. In spite of its size and growth, India is still a low-wage economy, making it attractive for many foreign firms to set up factories. In purchasing power parity (PPP) terms, India is currently the fourth largest economy, and will become the third largest by 2015.



1.1.2 Strong Domestic Market

- The market, rather than the government, has beenthedriver ofthe Indian economy in the past two decades, with the stateplaying a supporting role.
- Large, growing urban middle class that has increasing purchasing power.
- Insulation from global downturns and less volatility as a result of the large domestic market

1.1.3 Vibrant Private Sector

- Over 100 Indian companies have market capitalization of over US$ 1 billion
- Over 1000 Indian companies have received foreign institutional investment
- Over 125 Fortune 500 companies have R&D facilities in India

1.1.4 Fundamental Advantages

- Scale of domestic consumption is higher in India than in many other developing countries
- Qualified, skilled and low wage labor is available in plenty
- Rule of law (most of the time!)

1.2 Growth Drivers for India (Compared with East and South East Asia)

India	East & SE Asia
Domestic Market	Exports Market
Services Oriented	Manufacturing Oriented
Consumption Based	Investment Based
Medium to High Tech Products	Low to Medium Tech Products

1.3 Increasing Energy Demand

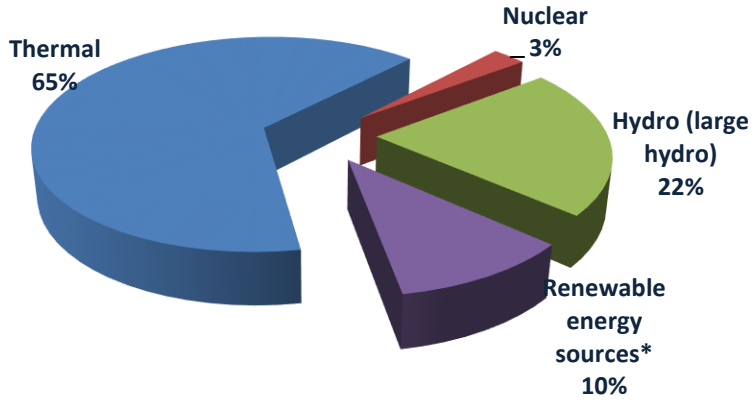
All the above factors imply that India's needs for energy would increase at a hectic pace. These substantial increases in energy demand will require a different portfolio of energy sources in future.

2. Potential and Status of Indian Renewable Energy

2.1 India's Overall Energy Scenario

2.1.1 Electricity

Total Electricity Installed Capacity: 176.9 GW (Jun2011)



*Source: CEA; *: excluding large hydro*

2.1.2 Liquid Fuels

Consumption of petroleum products during 2009-10 was about 138 million T, while domestic production was about 33.7 million T. *Thus, over 75% of all crude was imported, resulting in a large import bill.*

Diesel is one of the main liquid fuels used in India. In addition, about 1200 MW of the grid connected electricity generation capacity in India is fueled by diesel. A significant portion of captive power (off-grid) plants in the country (8648 MW) are also powered by diesel. With the widely fluctuating price of diesel and question on security of supply in India,industries are increasingly looking at renewable sources to offset their diesel requirements.

Biofuels constitute a negligible percentage of liquid fuels used today, at about 0.40 million T (both ethanol and biodiesel together), less than 0.5% of the total transport fuels used.

2.1.3 Natural Gas

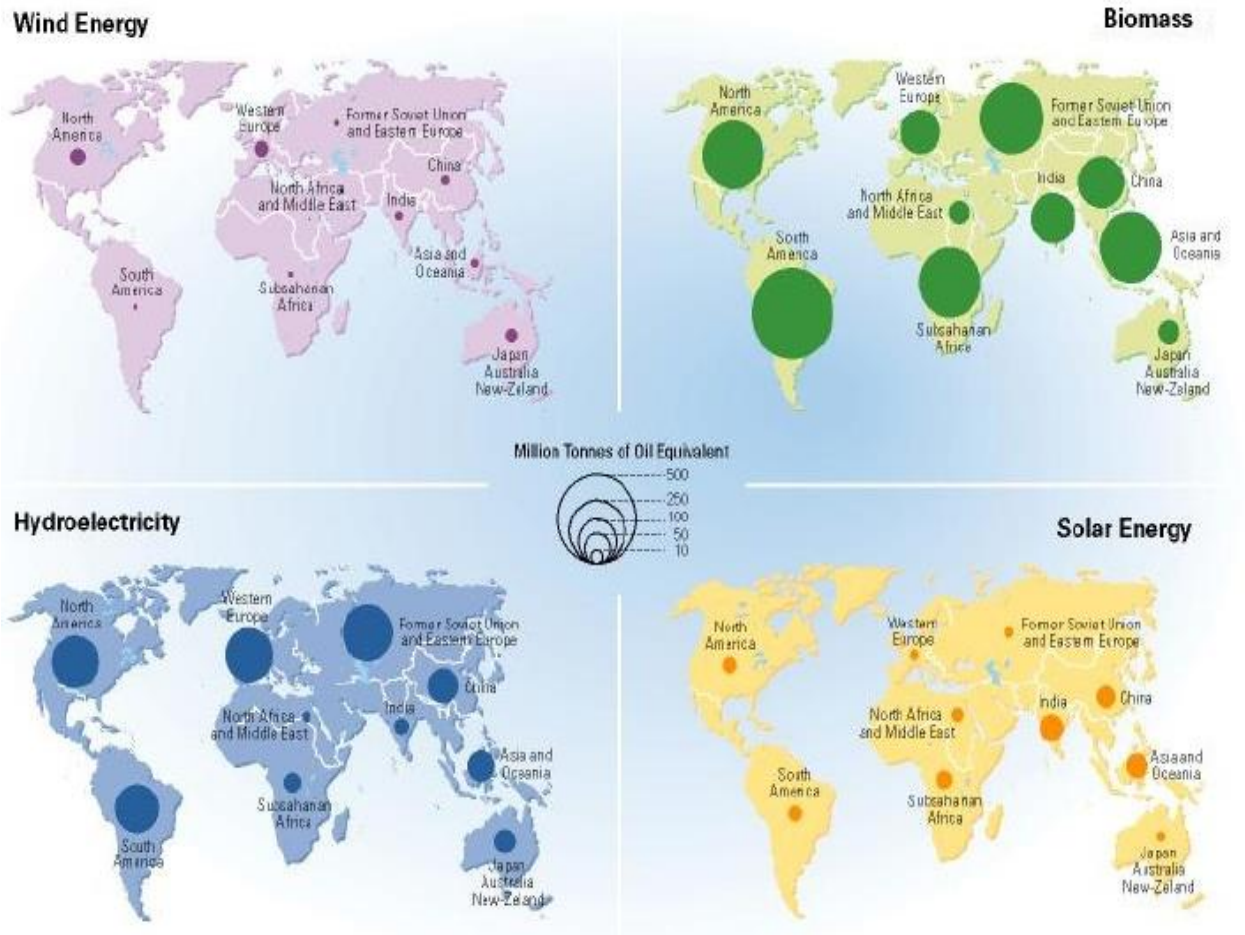
India produced about 1.62 trillion cu ft of natural gas in 2010 and consumed about 2.27 trillion cu ft during that year. Thus, imports constitute about 28% of the total consumption. *India started becoming a net importer of natural gas starting 2004*. By 2014, India is forecast to consume 3.96 trillion cu ft of natural gas and have a domestic production of 2.52 trillion cu. ft., the share of imports thus rising to about 36%.

2.2 The India Renewable Energy Story

2.2.1. Relative Potential for Renewable Sources

The map below provides an idea of the potential India has for various renewable energy sources, relative to the rest of the world.

Renewable energy potential- India vs. Global

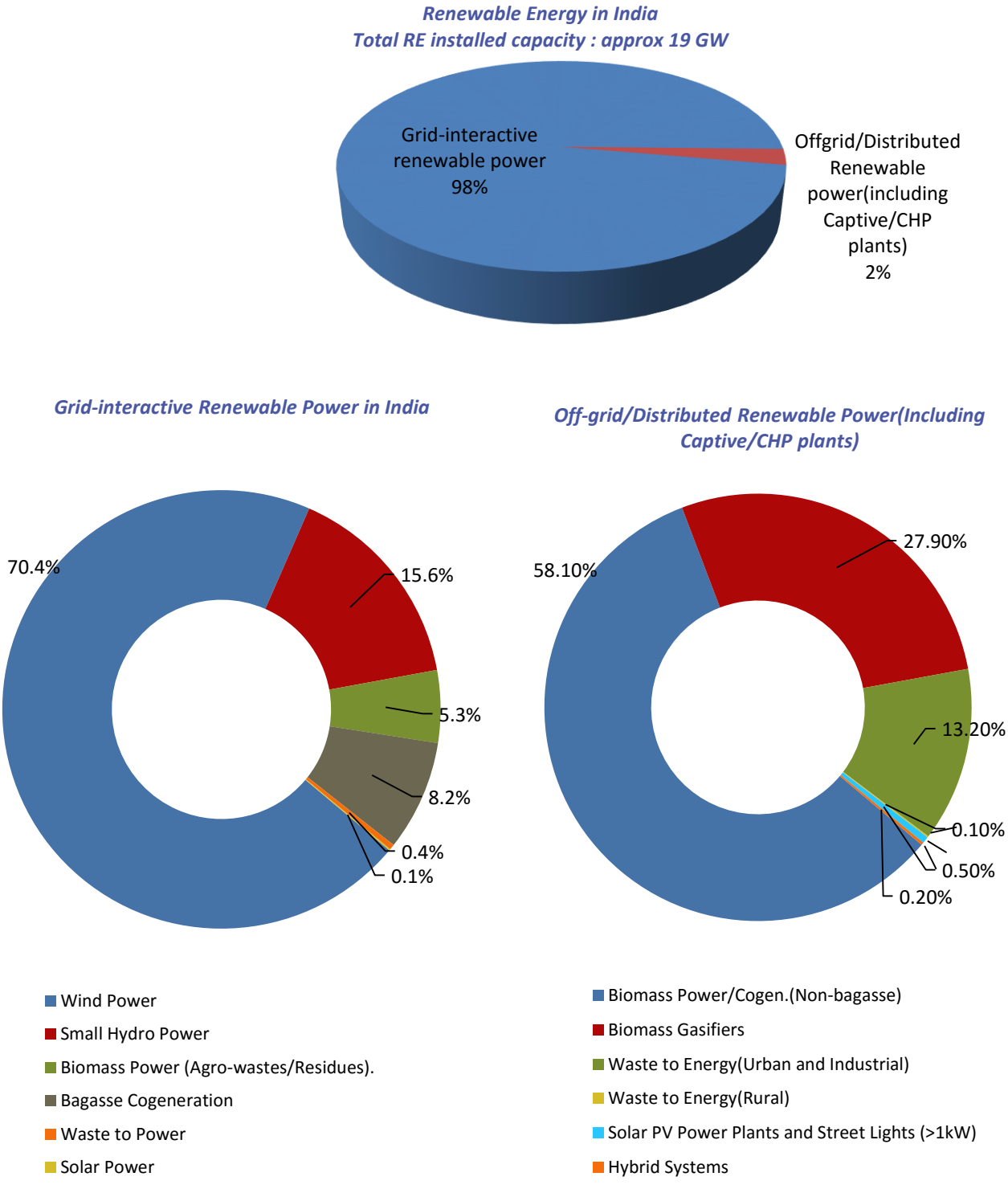


Source: World Resources Institute

- **The flagship of the Indian renewable energy sector is the wind energy sector** whose growth over the past few years has spurred the development of other renewable energy based power generation systems. This, in spite of the fact that India's total wind energy potential is not in the highest bracket when compared to those in some other regions in the world.
- The geographic **location of the country lends itself to receiving a high amount of solar insolation** – this can be a catalyst for the exponential growth of solar power.
- **Being a country founded on an agrarian base, there is significant potential in the field of biomass based energy generation**. A large portion of this sector is yet to be exploited in the country, with current investments mainly coming from sugar companies and rice mills.

- There is significant potential for hydro power in India. Most of the primary power production is from large scale hydro installations. While the overall potential for small hydro is an order of magnitude less than that for large hydro power, small hydro has distinct strengths and advantages that will propel its growth.

2.2.2. India's Renewable Energy Status



Source: MNRE (as on Jul 2011)

2.3 India's Energy Needs, and Drivers for Renewable Energy

Though rich in coal deposits, India otherwise has low hydrocarbon reserves (0.4% of world's total). More than 35% of the country's primary energy needs are met through imports.At the same time, the country is rich in renewable energy sources – especially solar, wind, hydro, and bio-energy. These two complementary factors set the stage for the growth of renewable energy in India.

The key drivers for the growth of renewable energy in India are the following:

- *High growth rate in overall energy needs* - The expansion of the overall energy demand-supply gap is due to the increase in the population's standard of living. The demand-supply gap in power is currently at 10.3% and is one of the key drivers of renewable energy.

- *Increasing reliance on imports for fossil fuels* - In 2009-10, the country imported about 80% of its domestic crude oil consumption;over 30% of the country's total imports bill typically goes towards oil imports. In a similar vein, the growth of electricity generation in India has been hindered by domestic coal shortages and as a consequence, India's coal imports for electricity generation increased by 18% in 2010.

- *Need for a viable solution for rural electrification* - A program of grid extension and strengthening of the rural electricity infrastructure was initiated in 2005 to benefit the 400 million Indians who lack access to electricity. While the government had planned ambitious grid expansion programs, concerns have been expressed, questioning in particular the long term financial and technical sustainability of the programs.

- *Electricity peak demand-supply* - The CEA predicts that the electricity shortfall for the current fiscal year (2011-2012) will be 10.3% with a peak shortage of 12.9%. The southernregion is expected to bear the brunt of the deficit.

- *Pressure on industry and polity to abate GHG emissions* - India's strategy for tackling climate change is set out in its 'National Action Plan on Climate Change' (NAPCC), released in 2008. It includes a target to reduce the emissions intensity of India's economy (per unit of GDP) by 20% between 2007/08 and 2016/17.

2.4 Potential and Status of Renewable Energy in India

Details on potential and status are provided for the following renewable energy sources:

1. Solar
   - Solar PV
   - Solar CSP
   - Solar Thermal for Heating
2. Wind
3. Biofuels
   - Biodiesel
   - Ethanol
4. Biomass Power
5. Hydro
   - Small Hydro
   - Large Hydro
6. Waste to Energy
7. Geothermal
8. Wave and Tidal

2.4.1 Solar

2.4.1.1 Solar PV

Solar photovoltaic (PV) systems are characterized by conversion of solar radiation to direct current (DC) electricity using semiconductors – which in PV systems are represented by the solar modules. The direct current generated by the system can be converted to usable alternating current (AC) using inverters before consumption.

Total available potential	Total theoretical potential – over 5000 trillion kWh annually. This represents about 25% of the world's current total annual consumption of electricity!
Exploited potential	Exploited potential is less than 150 MW, and of that only about 38-45.5MW is grid-connected. (as of Jul 2011)
Projected capacity	For solar CSP and PV together, the National Solar Mission attempts to reach the followingcumulativeinstalled capacity: ✓ By 2013: 1-2 GW ✓ By 2017: 4-10 GW

	✓ By 2022: 20 GW Industry experts foresee a much higher installed capacity by 2022. EAI predicts that this could be much higher than 20 GW, at about 75 GW. KPMG has predicted that the total solar power installation in the country could be as high as 68 GW by 2022.
Government incentives	The National Solar Mission incentives are available through Ministry of New and Renewable Energy (MNRE) and State renewable energy agencies. The incentives vary, depending on whether it was proposed by the central or state governments. Overall, incentives include a feed-in-tariff in the range of 27 to 40 cents per kWh for grid connected power plants, depending on the size of the power plant.
Investments	Government is expected to spend $19 billion until 2022, of which $1 billion has already been allocated. The government has earmarked $335 million for investment in solar energy related projects over the next two years.
Challenges	✓ High capital costs of solar PV systems ✓ Land scarcity for large solar plants near locations of high population density ✓ Technology obsolescence concerns and lack of clarity on which of the two technologies – crystalline or thin film – would predominate in future ✓ Difficulty in raising finance from banks
Cost of power generation	Current cost of production – 22 to 26 cents/kWh. This includes O&M, amortized/depreciated capital costs, loan repayment costs, and other expenses such as insurance.

2.4.1.2 Solar CSP

Concentrated solar power (CSP) systems use mirrors or lenses to concentrate a large area of sunlight, or solar thermal (heat) energy, onto a small area. The concentrated light is converted to heat which drives a heat engine (usually a steam turbine) connected to an electrical power generatorfor generating electricity.

Total available potential	Total theoretical potential – over 5000 trillion kWh annually.

Exploited potential	Negligible. The National Solar Mission has already allocated 500 MW to Indian corporates for solar CSP based power plants; these plants are currently in the process of achieving financial closure.
Projected capacity	50:50 allocations for Solar PV/CSP under the National Solar Mission (explained under solar PV) – thus, installed capacity may follow a similar trendin the future.
Government incentives	The National Solar Mission incentives available throughMNRE and State renewable energy agencies are applicable for solar CSP as well. The incentives vary, depending on whether it was proposed by the central or state governments. Overall, incentives comprise a feed-in-tariff in the range 22 to 31 cents per kWh for grid connected power plants.
Investments	Inclusive of the CSP allocations under the National Solar Mission, in all investments for about 1000 MW of solar CSP power plants are afoot.
Challenges	✓ High capital costs ✓ Need for scale (minimum 50 MW)and the resulting high capital investment ✓ Technology still evolving and not as well established as Solar PV – a lack of clarity about which of the four competing CSP technologies would predominate in future.
Cost of power generation	20 to 24 cents/kWh. This includes O&M, amortized/ depreciated capital costs, loan repayment costs, and other expenses such as insurance. A 15% investment cost reduction can be expected in developing countries due to lower labor costs. This implies that leaders in CSP equipment could find India to be an attractive manufacturing base.

2.4.1.3 Solar Thermal for Heating Purposes

Solar thermal refers to the direct use of the sun's heat for heating, drying (and in some cases, cooling). This source has significant potential in India.

Solar Thermal for Industrial Heating/Drying

Outside of water heating, studies have shown that energy from solar thermal can also be used *for industrial heating and drying*(both for heating and pre-heating), and has the potential to save up to 4.5 million tons of furnace oil or diesel per year. In a market assessment report[1], the potential areas for solar heating in industries were classified as follows:

- Boiler Feed Water Heating
- Process Heating
- Process Cooling (through VAM[2])
- Comfort Cooling (through VAM)
- Hot Air Generation

Specific industries that could find solar heating and drying applicable are food and beverages, transport, textiles and chemicals. Studies by EAI indicate significant growth potential for this segment, as the payback periods are attractive (sometimes fewer than 3 years).

Specific challenges are present for solar thermal based heating in the context of industrial uses where the temperature requirements are very high (beyond 400^{o}C) while solar thermal (without the use of concentrators) can produce only much lower temperatures.

Solar Water Heating

One well known sector in India that has used solar thermal in a significant way is the solar water heating segment.

The total potential in India for solar water heatingis about 140 million sq. meters. Of this, the total installed capacity is about 3.5 million sq. meters. Every year, over 20,000 solar water heaters are installed across India, according to some estimates. Given the attractive payback periods for solar water heaters and the financial incentives (soft loans and accelerated depreciation etc), it is expected this segment will experience significant growthin the near future.

The solar thermal incentives offered by the government fall under the subsidy scheme of the National Solar Mission. An incentive of $65 to $135 per square meter of installation is being offered depending on the technology.

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[1]***Market Assessment of Solar Water Heating Systems in Industrial Sectors*, ABP Infrastructure Advisory (available at:** http://www.mnre.gov.in/pdf/Report-Market-Assessment-of-SWH-in-Industrial-Sector.pdf)

[2]**VAM – Vapor Absorption Machines**

The National Solar Mission targets to install 20 million square meters of solar water heating systems by 2022.

- ✓ ***Solar PV – Potential for short and medium term growth: High***
- ✓ ***Solar CSP – Potential for short and medium term growth: Short term: Medium, Medium term: High***
- ✓ ***Solar Thermal for Heating and Drying – Potential for short and medium term growth: High***

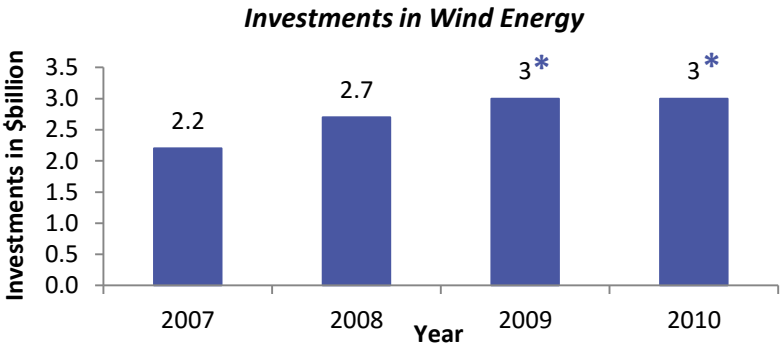
2.4.2 Wind Energy

India has the fifth largest installed wind power capacity in the world. Wind power accounts for 8% of India's total installed power capacity.

Wind power can be broadly categorized into onshore and offshore wind power. India is yet to exploit any offshore wind resources.

Total available potential	While the official estimates put the total potential at 48,000 MW, EAI estimates, done after consultation with technical and industry experts, suggest the potential for onshore wind in India alone could be over 100,000 MW. This higher potential is possible owing to significant technological improvements in the turbines.
Exploited potential	Total installed capacity is 14,157 MW (Jun 2011)
Projected capacity	Estimates from the *EAI Wind Research* team project India having a total wind installed capacity of over 50,000 MW by 2020, implying an addition of about 3500 MW on average every year until 2020.
Government incentives	Feed-in-tariffs are available for wind for each state; these range from 8 cents to over 12 cents per kWh. Over and above the FiT, wind power developers can avail accelerated depreciation benefits or generation based incentives.

investments



* Over $3 billion each year (EAI estimate)

Challenges

- ✓ Incentive Challenges – FiT needs to be wind zone based, not state based
- ✓ Transmission Challenges – connectivity to grid and evacuation infrastructure is poor
- ✓ Efficiency Challenges – small wind efficiency low; efficiency of MW wind varies significantly from one location to another

Cost of power generation

6 to 8 cents/kWh – this includes amortized capital costs, O&M expenses, insurance, and loan repayment costs.

Wind – Potential for short and medium term growth: High

2.4.3 Biofuels

Biofuel refers fuel derived from biomass.

2.4.3.1 Biodiesel

Biodiesel refers to any diesel-equivalent biofuel made from renewable biological materials such as vegetable oils, animal fats or from other biomass such as algae. To a large extent, biodiesel can replace diesel in most applications.

Using the vegetable oil from feedstock such as oilseeds as the source, biodiesel is produced by a chemical reaction called *transesterification*, in which vegetable or waste oil is reacted with a low molecular weight alcohol, such as ethanol and methanol.

Total available potential	India has up to 60 million hectares of non-arable land but only 17 million hectare is suitable for any kind of farming to produce biodiesel from second generation crops such as Jatropha
Exploited potential	90,000 T versus an installed capacity of over 1.2 million T (2010)
Projected capacity	Largely dependent on the extent of mechanization introduced in the collection and extraction stages
Government incentives	✓ 20% of fuel used should be biofuels by 2017 (National Policy on Biofuels, 2008) though RFS (Renewable Fuel Standards) is a mere indication of government preference and not a mandate ✓ Mandatory 5% blending for ethanol and biodiesel (Nov 2009) ✓ Biodiesel is exempt from excise duty (no other central taxes and duties are proposed to be levied) ✓ Government agreed on a price of about 76 cents per liter of biodiesel purchase by oil companies (Nov 2009). This price is however said to be insufficient for biodiesel producers to turn in reasonable profits.
Investments	The largest investment seen so far was made by BP, in TATA's 8000 acre Jatropha acreage in Andhra Pradesh – $9.4 million invested. Bharat Petroleum, one of India's four national oil companies, announced a venture, Bharat Renewable Energy, which seeks to produce one million T of biodiesel from Jatropha by 2015.
Challenges	✓ Supply of feedstock security, as availability of Jatropha seeds and oil is poor ✓ Price fluctuations for feedstock ✓ Lack of confidence due to delay in implementation of the government biodiesel policy ✓ Lack of seed collection / oil extraction infrastructure ✓ No minimum support price for seeds ✓ Lack of optimal policy framework which had rendered the price of biodiesel unsustainable
Cost of fuel production	Biodiesel production cost stands at about 90 cents per liter

2.4.3.2 Ethanol

Bioethanol (also referred to as ethanol) is an alcohol made by fermenting the sugar components of plant materials. It is made mostly from sugar and starch crops, and is a potential substitute for petrol (gasoline).

As ethanol can be produced domestically in most countries, it helps reduce the dependence on foreign sources of oil.

Total available potential	✓ India produces about 495 million tons of crop residues annually; this translates to about 145 million T of ethanol per annum ✓ India's total crude oil import is about 115 million T per annum, thus cellulosic ethanol has a theoretical potential to completely replace India's crude oil imports
Exploited potential	Fuel Ethanol – 95 million gallons in India (EAI estimate) vs. 23 billion gallons worldwide in 2010 (0.4% of global production)
Projected capacity	If India is to move to a 5% blending of ethanol with gasoline, that alone will require a consumption of 159 million gallons; a 20% target will require 625 million gallons
Government incentives	✓ 20% biofuels by 2017 (National Policy on Biofuels, 2008) ✓ Mandatory 5% blending for ethanol and biodiesel (Nov 2009) ✓ Government of India announced a purchase price of 60 cents per liter for ethanol (Apr 2010)
Investments	✓ Most ethanol in India is produced from sugar mills, and there are typically few investments outside of the sugar industry ✓ Many isolated, small investments have happened in this industry ✓ Tata commissioned India's first sweet sorghum based ethanol plant back in 2008, in which an initial investment of $10 million for prototype development, and there were plansto follow it by $150 million over the subsequent 3 - 4 years
Challenges	✓ Since ethanol is also used in chemical industries and for potable alcohol, there is price pressure on ethanol used for fuel production ✓ Low sugarcane yield per acre due to poor farming practices

	✓ Lack of utilization of advanced technology in ethanol manufacture
Cost of fuel production	45 to 56 cents/liter

- ***Biodiesel – Potential for Short Term Growth: Short Term - Low, Medium Term – High***
- ***Ethanol – Potential for Short Term – Medium, Medium Term Growth: High***

2.4.4 Biomass-based Power

Biomass can be used instead of fossil fuels such as coal, oil or natural gas – as the feedstock to produce electricity. India being an agrarian country, there is easy availability of agricultural biomass which can be used to generate energy.

There are multiple ways to produce power from biomass. The three primary routes are: Combustion, Gasification and Anaerobic Digestion.

- **Combustion** is easy to understand – instead of using coal or other fossil fuel, use biomass to produce steam that runs a turbine. Combustion of biomass for power could either be in the form of co-firing (when it is burned along with coal) or pure play biomass based combustion.
- In the case of **gasification**, the biomass is first gasified into a mixture of organic gases, and this gas turn produces power in a gas engine.
- **Anaerobic digestion** is usually applied to biomass that have a high amount of water in them (anaerobic digestion is most used for treating organic waste such as kitchen waste and sewage waste into energy). Under this route, microorganisms (bacteria) act upon the organic matter present in the biomass under anaerobic (absence of air) and convert it into biogas, which comprises predominantly methane.

Total available potential	23.7 GW (EAI estimates peg it at about 25-30 GW) – cogeneration 7-10 GW, agro-residues – 17 GW
Exploited potential	✓ Biomass Direct - Combustion 800 MW (approx) ✓ Biomass Direct - Gasification 120 MW (approx) ✓ Bagasse Cogeneration – 1466 MW installed ✓ The total installed capacity is 2,673 MW (Jun 2011)

Projected capacity	EAI Estimates suggest India could have a total biomass installed capacity of over 10,000 MW by 2022, with growth coming from both cogenerationand agro residues.
Government incentives	✓ Customs duty exemption/reduction on parts of biomass operated electricity generator ✓ Excise duty exemption on parts of biomass operated Electricity generator ✓ Exemption in central sales tax ✓ 100 % accelerated depreciation ✓ Income tax holiday for ten years (can be availed within 15 years). ✓ Power sector reforms have encouraged investment in grid-connected biomass projects.
Investments	In the current Five Year Plan period (2007 to 2012), the government's target for biomass power capacity is 1780 MW, with 500 MW from cogeneration plants
Challenges	✓ Feedstock supply and price security ✓ Channeling of sugarcane bagasse for alternative uses such as paper production ✓ Barriers in obtaining land for biomass cultivation for large scale applications (competition with food grain production)
Cost of power generation	Cost of electricity production – 7 to 9 cents/kWh. This includes all costs, including capital depreciation, O&M, insurance and interest costs. This cost could increase over the years as the cost of biomass increases

Biomass Power in India – Now and Future

Parameter	Now (2011)	Future (2020)
Distributed electricity generation	Biomass Power (agro-wastes/residues) has a minor contribution of 5.3% of the total grid connected renewables while it contributes to nearly 86% of off-grid power.	Estimates of potential in the future for power from biomass in India varies from about 18,000 - 50,000 MW
Use in co-firing in power plants	Fewer than 1% of power plants use biomass	A much larger proportion of plants will be powered by biomass
Use of feedstock	Primarily waste biomass and assorted	Dedicated energy crops
Related revenue streams	Some additional revenue streams already present	A more established end user market for co-products
Standalone renewable power source?	Primarily standalone mode	Will be used in conjunction with other renewable electricity sources

Biomass Power – Potential for short and medium term growth: High

2.4.5 Hydro Power

2.4.5.1 Small Hydro

Small hydro is the second largest renewable energy contributor to electricity production in India (after wind). From about 1500 MW end of 2002, by end of 2010 the installed capacity had grown to about 2800 MW, growing at a CAGR of about 8% for the period.

Total available potential	Estimated potential - 15,000 MW Identified 15,384 MW through 5718 sites (Average 2.7 MW per site)
Exploited potential	Installed capacity is 3043 MW (20% of total) as of Jun 2011

Projected capacity	Target capacity addition in 11th plan (2007-12): 1488 MW Installed capacity grew from 1693 MW in 2005 to 2403 in 2009. (CAGR of 9.2%). Expected to grow even faster, at 13% for 2010-15.
Government incentives	✓ PPAs with attractive tariffs ✓ Capital subsidies ✓ Exemptions from taxations and duties ✓ No techno-economic clearance is required for projects up to $40 million investment ✓ 17 States have so far announced their policies to invite private sector to set up SHP projects. ✓ Over 2600 MW capacity SHP sites offered/allotted to private sector by the States to set up SHP projects ✓ MNRE has created special facilities for SHP performance testing
Investments	Small hydro investment in India grew significantly since 2008 - $550 million in 2009 and $600 million in 2010 (about 15% of total RE investments), compared to just $140 million in 2007
Challenges	✓ Delays and long timelines for approvals ✓ Long distances between generation stations and consumption centers lead to poor efficiency of transmission and distribution ✓ Geological and social uncertainties ✓ Regulatory challenges
Cost of power generation	5 to 7 cents/kWh. This cost includes O&M costs, insurance, depreciation, and loan repayment costs

Small Hydro – Potential for short and medium term growth: High

2.4.5.2 Large Hydro

Total available potential	India is endowed with economically exploitable large hydro-power potential to the tune of 148,700 MW of installed capacity.
Exploited potential	The total installed capacity in India is 38,106 MW (Jun 2011)

Projected capacity	15,627 MW is planned to be added in the 11th five year plan (2007-2012)
Incentives	Hydro Policy 2008 has stated an objective of overcoming the problems experienced with respect to tariff based bidding for hydro power plants
Amount of investments	Major part of the investment is government dominated. Investment in the 11th five year plan (2007-12) is $6.2 billion.
Challenges	✓ High capex ✓ Large project gestation periods ✓ Geological surprises during project implementation ✓ Societal and environmental impacts ✓ Inter-state and inter-regional disputes ✓ Uneven distribution of hydro resources and possible demand-supply mismatch
Cost of power generation	Generation cost in the first ten years could be about 5 to 7 cents/kWh but it decreases after that, and could be very low later, given that these projects have a lifespan of well over 50 years.

Large Hydro – Potential for short and medium term growth: Medium

2.4.6 Geothermal

Geothermal energy is energy extracted from heat stored in the earth. This energy originates from the original formation of the planet, from radioactive decay of minerals, and from solar energy absorbed at the surface. It has been used for space heating and bathing since ancient times, but is now known for both heating as well as for generating electricity.

There are three main methods to exploit geothermal sources:

1. *Direct use of hot water* from geothermal hot water reservoirs
2. *Electricity from geothermal energy* – Geothermal power plants are generally built where geothermal reservoirs are located within a mile or two of the surface, and use the reservoir heat for generating steam, which runs a turbine to produce electricity.
3. *Ground source heat pumps / geothermal heat pumps* – These heat pumps use the stable temperature under the ground, and the consequent temperature difference between the surface and underground, to heat or cool buildings.

The Indian government has done little so far to exploit geothermal energy. Unlike in the sectors of wind and solar energy, few benefits or incentives have been formulated or announced to attract investment in geothermal energy.

Total available potential	Claimed to be 10,000 MW but experts are confident only to the extent of 100 MW
Exploited potential	None
Projected capacity	No projections yet
Government incentives	10 year tax break, incentive package still evolving
Investments	Companies that have started exploring this field include LNJ Bhilwara, Tata Power (5MW plant in Gujarat), Thermax (3MW plant in Ladakh) and Geosyndicate Power (25MW in Andhra Pradesh)[3]
Challenges	✓ Long gestation periods involved in site prospecting, getting licenses and testing ✓ Unproven in India ✓ Lack of clear policy and incentive package from the government ✓ Manpower and expertise for R&D and operations unavailable in India
Cost of power generation	Global estimates put the price of generation at about 6 to 7 cents/kWh (no Indian cost estimates available).

Geothermal – Potential for short and medium term growth: Low

[3] **NEDCAP Announcement (available at:** http://www.nedcap.gov.in/PDFs/Geo-thermal-News.pdf)

2.4.7 Wave & Tidal Energy

India is yet to make any significant progress in exploiting wave and tidal energy sources.

2.4.7.1 Tidal

Total available potential	Total identified potential: about 9000 MW *West Coast* ✓ Gulf of Cambay (7000 MW) ✓ Gulf of Kutch (1200 MW) *East Coast* ✓ The Ganges Delta in the Sunderbans in West Bengal for small scale tidal power development.
Exploited potential	None
Projected capacity	No clear projections, but there is a 3.75 MW project coming up in the Sunderbans (West Bengal).
Government incentives	None at the moment, but India's Ministry of New and Renewable Energy said in Feb 2011 that it may provide financial incentives for as much as 50 percent of the cost for projects seeking to demonstrate tidal power.
Investments	✓ Negligible, currently ✓ In Jan 2011, the state of Gujarat announced plans to install Asia's first commercial-scale tidal current power plant; the state government approved the construction of a 50 MW project in the Gulf of Kutch.
Challenges	✓ Long development timescales (some technologieshave remainedat the development stage for decades) ✓ High capital cost ✓ Lack of infrastructure for connection of the system to the grid ✓ Environmental issues arising out of the cable laying and other construction works ✓ Intermittent supply – tidal power plants provide power for only around 10 hours each day – when the tide is actually moving in or out ✓ Regional limitations – tidal power plants require a basin or gulf that has mean tidal amplitude of 7m or above for efficient generation

Cost of power generation	Global estimates put the price of generation at 13 to 15 cents/kWh (no Indian estimates available)

2.4.7.2 Wave Energy

Total available potential	The potential along the 6000 Km of India's coast is estimated to be about 40,000 MW – these are preliminary estimates. This energy is however less intensive than what is available in more northern and southern latitudes.
Exploited potential	None
Projected capacity	No commercial projects
Government incentives	None
Investments	Negligible; some preliminary efforts being made in the state of Gujarat.
Challenges	✓ Lack of clarity about the potential ✓ Technology immaturity ✓ High costs ✓ Lack of clear policy and incentive package from the government ✓ Low energy density
Cost of power generation	Global estimates put the price of generation at 15 to 17 cents/kWh (no Indian cost estimates available)

- ***Wave Power – Potential for Short and Medium Term Growth: Low***
- ***Tidal Power – Potential for Short and Medium Term Growth: Low***

2.4.8 Waste to Energy

Any organic waste from urban and rural areas, and industries, is an energy resource. Wastes hold the potential to create renewable energy through the adoption of waste-to-energy technologies.

In the context of energy generation, waste can be broadly classified into municipal solid waste, sewage waste, industrial waste and agro/crop waste. Each of this waste feedstock have different characteristics and present varying potential and challenges for energy generation.

Total available potential	There exists a potential for generating an estimated 1500 MW from municipal solid waste, and about 225 MW from sewage waste. A further 1050 MW of energy could be recovered from industrial wastes. Potential for agro waste is traditionally included under biomass power potential.
Exploited potential	Indian Renewable Energy Development Agency (IREDA) estimates indicate that India has so far realized only 2% of its waste-to-energy potential. Over 35 waste-to-energy projects have been completed as of 2010, with an aggregated installed capacity of over 70 MW. (Jun 2011)
Projected capacity	There are no reliable estimates for projected capacity addition for waste to energy projects.
Government incentives	MNRE has been promoting waste to energy plants – refuse derived fuel, biomethanation, biogas, and gasification. The subsidy is in the range of $333,000 to $867,000 per MW, depending on the processes and feedstock used.
Investments	Investments have been made into waste-to-energy projects to aggregate a total installed capacity of 72MW (June, 2011)
Challenges	✓ Lack of segregation is a key challenge for municipal solid waste to energy efforts. ✓ Waste to energy is a poorly understood topic, because there are many different types of waste and many different energy conversion processes for each type of waste. ✓ Lack of institutional and financial capability ✓ Lack of viable business models in the sector, ✓ Some of the technology options proposed are not yet proven, either technically or economically ✓ High capital costs
Cost of power generation	Depending on the technology and processes used, waste to energy projects cost between $2 million and $2.9 million per MW. If one factors government incentives, the cost of generating power from waste varies between 8 and 13 cents per kWh.

Waste to Energy – Potential for Short and Medium Term Growth: Medium

Summary of Renewable Energy Sources Growth Potential in India

Renewable Energy Source	Short Term Growth Potential	Medium Term Growth Potential
High Potential		
Solar PV	High	High
Solar CSP	Medium	High
Solar Thermal for Heating/Drying	High	High
Wind	High	High
Biomass Power	High	High
Small Hydro	High	High
Biofuels - Ethanol	Medium	High
Medium Potential		
Large Hydro	Medium	Medium
Biofuels – Biodiesel	Low	High
Waste to Energy	Medium	Medium
Low Potential		
Geothermal	Low	Low
Wave	Low	Low
Tidal	Low	Low

2.5 Regions with Potential for Renewable Energy

1. **Solar PV/CSP -** The southern states of Andhra Pradesh, Karnataka, Tamil Nadu and states in north western India such as Gujarat, MP and Rajasthan have the best solar radiation in the country. States such as Arunachal Pradesh, Haryana, Jharkhand, Kerala, Orissa, Punjab, Uttar Pradesh and West Bengal also have reasonable potential.

2. **Wind** - Wind farms are predominantly present in the states of Tamil Nadu, Maharashtra, Karnataka and Gujarat. Other states such as Andhra Pradesh, Rajasthan, Kerala and Madhya Pradesh and Jharkand have good potential.

3. **Biomass/biofuels -** While most states in India have select regions that are rich in biomass availability, Rajasthan, Punjab, Maharashtra, Uttar Pradesh, Tripura, Tamil Nadu, Punjab, Orissa and Haryana are states with the highest potential for biomass power, followed by Andhra Pradesh, Assam, Bihar, Chhattisgarh, Madhya Pradesh, Manipur, Meghalaya, Mizoram and Nagaland. For biofuels, the most attractive states are those that are large-scale sugar producers (for ethanol) and those that have a high potential for Jatropha cultivation (for biodiesel). The top sugar producing states in the country are Uttar Pradesh and Maharashtra, followed by Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. States with good potential for Jatropha cultivation are Andhra Pradesh, Chhattisgarh, Gujarat, Maharashtra and Rajasthan.

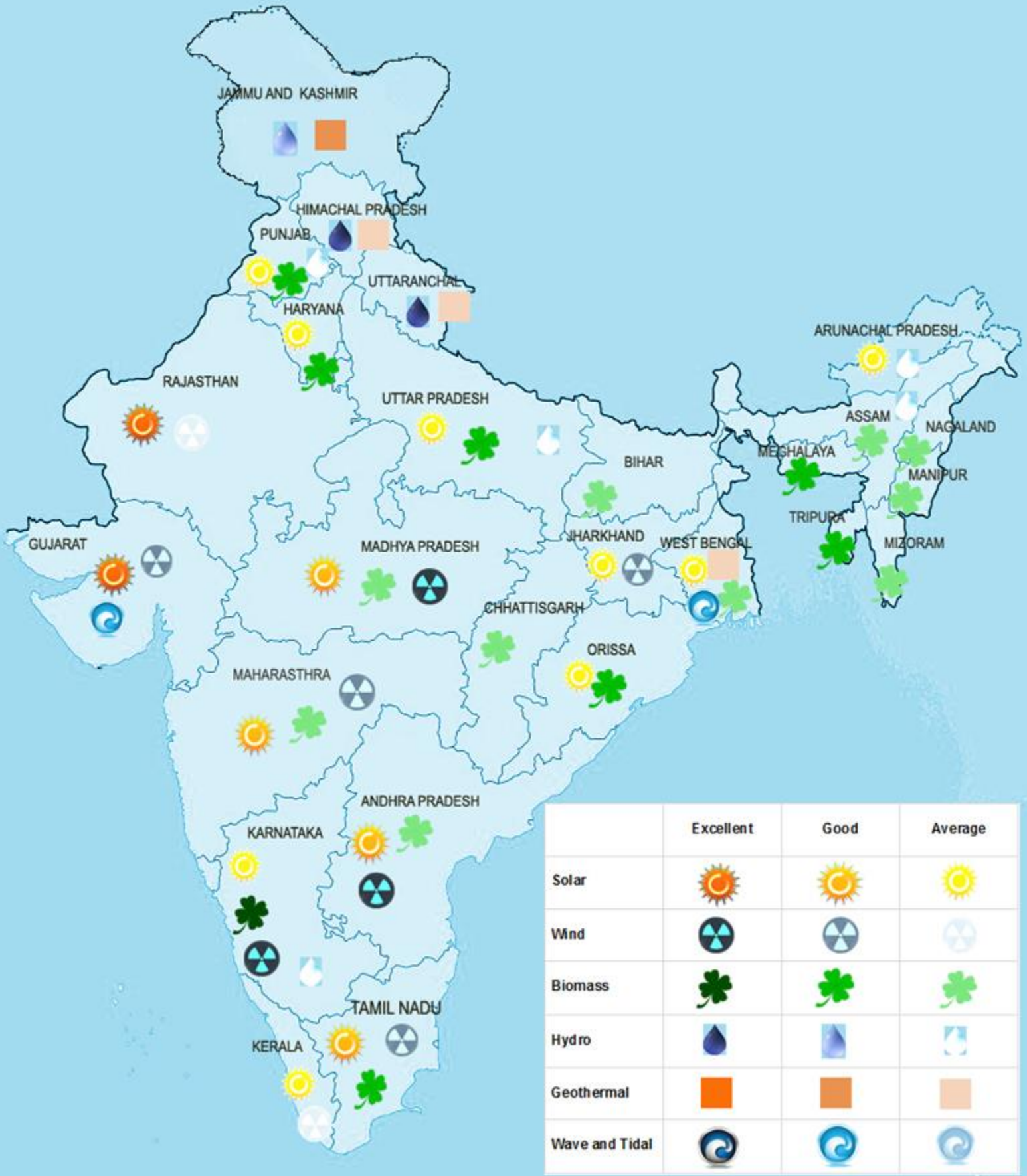
4. **Small hydro power** - Potential for run-of-river schemes exist mainly in hilly areas of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, West Bengal, Uttaranchal, Karnataka, Punjab and North Eastern states.

5. **Geothermal** - Geothermal potential is dependent on geotectonic, geological and structural conditions. Potential states include Jammu & Kashmir, Himachal Pradesh, Uttaranchal and West Bengal.

6. **Energy crops** - The states with high potential are Andhra Pradesh, Chhattisgarh, Karnataka, Tamil Nadu, Rajasthan and Maharashtra.

7. **Wave and tidal** - The most attractive locations are the Gulf of Cambay and the Gulf of Kutch on the west coast. The Ganges Delta in the Sunderbans in West Bengal also has good locations for small scale tidal power development.

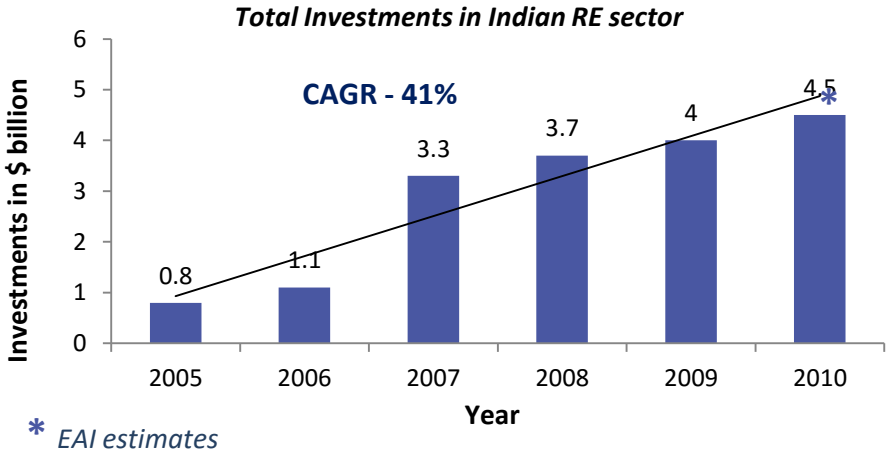
States and Regions with Potential for Renewable Energy



3. Investments in Indian Renewable Energy

3.1 Details of Investments in Indian Renewable Energy

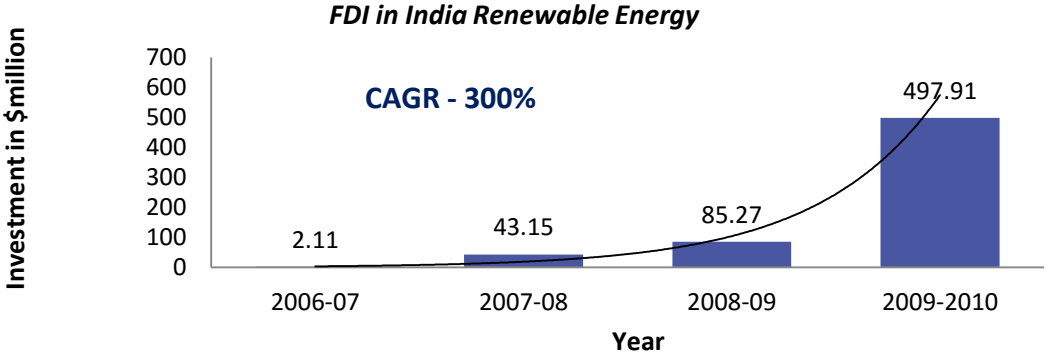
Over the next decade, India is projected to increase its renewable energy generating capacity to 91GW, over five timesthatof thecurrent installed capacity. According to KPMG, the top five countries for renewable energy investments are the USA (selected by 53% of the respondents), China (38%), India (35%), Germany (34%), and the UK (33%).



* *EAI estimates*

3.2 FDI in Indian Renewable Energy

From almost negligible FDI in 2006-07, India's FDI in renewableenergy increased to about $500 million in 2009-10 – a CAGR of an astonishing 300% for the period 2006-10. While wind energy is currently the fastest growing renewable energy sector for both domestic and foreign investments, solar (especially solar PV) is expected to contribute to a large share of FDI within the next few years.



3.3 List of Prominent European Renewable Energy Companies in India

Name	Sector invested in	Joint venture partners/ Subsidiary	Corporate website
Abengoa Solar	Solar CSP (CSP technology transfer, Solar)	Maharishi Renewable Energy (MREL)	www.abengoasolar.com/corp/web/en
Centrotherm Photovoltaics AG	Solar PVC (Polysilicon processing factory).	SREI Infrastructure Finance Ltd, Environ Energy Deck Services (together 50% stake) and Perseus (35%)	www.centrotherm.de
Mola Solaire Produtions GmbH,	Solar PVC (Five-year contract to supply 125 MW of multi-crystalline solar wafers to XL Telecom & Energy Ltd).	Data not available	www.mola-solaire-international.com
Germany's IBC SOLAR and India's Refex Energy	Solar PVC (Signed a MOU with State energy and petrochemical department for setting up a 50 MW solar PV power plant in Gujarat).	IBC Solar (exclusively foreign partnership)	www.refexenergy.com
TATA-BP solar	Solar PVC (Solar cell manufacturing).	Tata & British Petroleum (JV)	www.tatabpsolar.com
SunTechnics	Solar PV/Wind (Installation of small scale PV/wind hybrid in north India).	Indian subsidiary - SunTechnics India	www.suntechnics.com
eSolar	Solar CSP	ACME Group	www.esolar.com
Vestas	Wind (Factory at Sriperumbudur near Chennai to make turbine blades and wind turbines).	Indian subsidiary – Vestas India	www.vestas.com
Gamesa	Wind (Indian subsidiary, to produce 850KW wind turbines, with an initial production capacity of 200MW a year, in the Red Hills area next to the city of Chennai).	Indian subsidiary - Gamesa Wind turbines	www.gamesa.es/en

Siemens	Wind (Wind turbine factory in India by 2012.)	Indian subsidiary – Siemens India	www.siemens.com/entry/in/en
Enercon India	Wind (Total installed capacity of wind turbines in India exceeds 2900 MW)	Mehra Group	www.enerconindia.net
BP	Biodiesel (Project to demonstrate the feasibility of producing bio-diesel from Jatropha)	The Energy and Resources Institute (TERI)	www.bp.com/bodycopyarticle.do?categoryId=1&contentId=7052055
Biogas Nord	Biogas (Efficient biogas plants based on a flow-storage process, to convert bagasse to biogas).	Local sugar factories	www.biogas-nord.com

3.4 List of Prominent US Renewable Energy Companies in India

Name	Sector invested in	Joint venture partners/ Subsidiary	Corporate website
First Solar	Solar PV (manufacture of thin film PV modules, turn-key PV power plants)	Supplied modules for Moser Baer installations	www.firstsolar.com
Signet Solar	Solar PVC (MOU with Tamil Nadu to manufacture 300 MW of thin-film PV modules).	Indian subsidiary	www.signetsolar.com
Solfocus	Concentrated solar PV systems	Moser Baer (technology partner)	www.solfocus.com
SunPower	Solar PV (manufacture of PV modules. Signed a deal with Mahindra for supply of solar panels)	Mahindra (JV)	www.sunpowercorp.com

SPG Solar	Solar PV (turn-key solar power plant solution provider)	No data available	www.spgsolar.com
SunEdison	Solar PV (polysilicon and wafer manufacturer)	Subsidiary of MEMC	www.sunedison.com
SolarWorld	Solar PV (manufacture of solar panels)	No data available	www.solarworld-usa.com
Spire Corporation	Solar PV (turn-key solar power generation systems. Announced setting up of a manufacturing line in Jaipur)	Rajasthan Electronics & Instruments (JV). Indian subsidiary – Spire Solar India	www.spirecorp.com
REC Solar	Solar PV (EPC)	No data available	www.recsolar.com
General Electric	Wind, Solar PV (wind turbine manufacture, thin film panel manufacture)	Indian subsidiary – GE India	www.ge-energy.com

3.5 List of Prominent Indian Renewable Energy Companies

Name	Sector invested in	Joint venture partners/ Subsidiary	Corporate website
Indosolar	Solar PV (multi-crystalline solar cell manufacturing)	Data not available	www.indosolar.co.in
Titan Energy Systems Ltd.	Solar PV (manufacture of solar PV modules)	Enfinity Belgium (JV)	www.titan-energy.com
TATA-BP solar	Solar PV (solar cell manufacturing).	Tata & British Petroleum	www.tatabpsolar.com
XL Energy Limited	Solar PV (module manufacturing)	Corning, Kyocera Wireless, Axesstel (partners)	www.xlenergy.com

Moser Baer Solar Limited	Solar PV (thin film module manufacturing, turn-key solutions)	Subsidiary of Moser Baer Group	www.moserbaersolar.com
KotakUrja	Solar PV and Solar Thermal (manufacture of modules, BIPV, inverters, solar thermal systems etc.)	Subsidiary of Kotak Group	www.kotakurja.com
Azure Power	Solar power plant developers and operators	Data not available	www.azurepower.com
RRB Energy	Wind(turbine manufacture)	Free Breeze Energy Systems (UK)	www.rrbenergy.com
ReGen Powertech	Wind (turbine manufacture, plant at Kukudwad, Maharashtra in association with Bhilwara Energy)	Vensys Energy AG, LM Wind Power Blades (partners)	www.regenpowertech.com
Pioneer Wincon	Wind (turbine manufacture)	Wincon (Denmark)	www.pioneerwincon.com
Suzlon	Wind (turbine manufacture, turn-key solutions)	REpower (Germany)	www.suzlon.com
CLP India	Wind energy (wind power project developers)	Subsidiary of CLP Holdings	www.clpindia.in
AllGreen Energy India Pvt. Ltd.	Biomass (proposes to setup integrated biomass resources at various locations in India)	Indian subsidiary – Allgreen Energy Pte. Ltd.	www.allgreenenergy.net
Praj	Biofuels (fuel production system manufacture)	Qtreos (JV)	www.praj.net

Nandan Biomatrix	Biofuels (Jatropha cultivation across various states)	Alphakat GmbH (JV)	www.nandanbiofuels.com
Orient Green Power Company Ltd.	Biomass, Wind and Small Hydro power plant developer	Belongs to the Shriram EPC Group	www.orientgreenpower.com
Green Infra Ltd.	Wind, Hydro, Solar and Biomass power plant developer	Promoted by IDFC Private Equity	www.greeninfralimited.in
RamkyEnviro Engineers Ltd.	Waste management and waste to energy systems (operates hazardous waste and MSW management facilities across the country)	Subsidiary of Ramky Group	www.ramkyenviroengineers.com

4. Incentives Provided by the Indian Government for Renewable Energy

In the early 1980s, the Indian government established the Ministry of New and Renewable Energy (MNRE) to encourage diversification of the country's energy supply and satisfy the increasing energy demand of a rapidly growing economy. The MNRE issued guidelines to all state governments to create an attractive environment for the export, purchase, wheeling and banking of electricity generated by renewable power projects.

The following is the framework of incentives available:

- Feed-in-tariffs
- Up to 80 percent accelerated depreciation for renewable energy investments
- Relief in customs duty, excise duty and sales tax
- Exemption from Central Sales Tax, and customs duty concessions on the import of material, components and equipment used in renewable energy projects
- Soft loans
- Government policies covering wheeling, banking, buy-back, and third-party sale of power
- Income tax exemption for any single 10 year period in the first 15 years of a wind farm

(Please note that all incentives may not be applicable to every renewable energy source)

In addition to the above government incentives, most renewable energy projects can increase their monetization through the carbon credits trading under the Clean Development Mechanism (CDM).

Many states in India have introduced renewable purchase obligations (RPO/RPS) for utilities. Renewable Energy Certificates (REC) mechanism has also been introduced, using which utilities that do not have access to sufficient renewable energy sources could purchase credits from those utilities / companies that generate green power. The RPO acts as the driver for the use of RECs and in turn, RECs provide the support required to implement the RPOs.

Details of state-specific RPOs are provided in a later section.

4.1 Incentives for Each Renewable Energy Source

4.1.1 Solar PV, Solar CSP & Thermal

PV & CSP

The "National Solar Mission", formally adopted by Prime Minister Manmohan Singh's special panel on climate, envisages the creation of a statutory solar authority that would make it mandatory for states to buy some solar power, according to a draft of the plan. The plan pledges to boost output of solar energy from near zero to 20 GW by 2022. The goal is to have 1000-2000 MW of capacity by 2013, 4000-10000 MW cumulative during the period 2013-2017 and then on to a total of 20,000 MW by 2022. The targets have an equal emphasis for both PV and CSP, thus each is expected to have a 50% share of the total target.

As part of this plan, in Jun 2010, the MNRE announced the final guidelines for implementing off-grid and small solar PV power plants. In July 2010, similar guidelines for larger, grid-connected power plants were released. As of Jun 2011, 500 MW of solar CSP and 200 MW of solar PV grid-connected projects have already been allocated. An additional 300 MW solar PV is expected to be allocated soon.

The National Solar Mission also has the following additional objectives:

- To create favorable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
- To promote programs for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022.
- To achieve 15 million sq. meters solar thermal collector area by 2017 and 20 million by 2022.
- To deploy 20 million solar lighting systems for rural areas by 2022.

Under the plan, incentives vary, depending on whether the project is off-grid or grid-connected.

1. *Grid connected solar projects* – these systems are typically supported by high feed-in-tariff. The first phase of the solar mission saw the tariffs being decided by a reverse bidding process. The rates quoted by the winners were in the range of 24 to 28 cents/kWh for solar PV and 23 to 27 cents/kWh for CSP.
2. *Off-grid solar projects* – for solar PV projects that are off the grid, incentives have been provided primarily in the form of capital subsidies (30% for non-priority regions and 90% for priority regions), accelerated depreciation and in some cases, access to soft loans (5% interest rate).

Outside of the central schemes under the National Solar Mission, several state governments have announced their own incentive schemes for solar PV.

State Schemes

Many Indian states are firming up their individual state schemes under the National Solar Mission. Of these, only Gujarat, Rajasthan and Karnataka have so far announced their schemes formally. A furtherfive states are expected to come out with their plans by end 2011.

Thermal

Incentives for Solar Thermal for Industrial Purposes

- A subsidy of up to 30% is available from MNRE on solar furnace components
- 80% Accelerated Depreciation is available
- IREDA provides soft loans for solar thermal projects under 2 different schemes
    - Direct User Scheme
    - Intermediary Scheme
- For solar water heaters, soft loans at interest rates of 2%, 3% and 5% are provided to domestic, institutional and commercial users respectively.
- SNAs (State Nodal Agencies) can be approached for capital subsidies of $43 for domestic, $40 for institutional and $32 for commercial establishments, per sq. meter of installed solar water heating.

4.1.2 Wind Energy

- 10 year tax holiday
- Low customs duty on imported components
- Accelerated Depreciation (AD) benefits
- In June 2008, the MNRE announced a national generation based incentive scheme for grid connected wind power projects under 49 MW, providing an incentive of about 1 cent per kWh in addition to the existing state incentives.
- A developer can go for either of two benefits - Accelerated Depreciation (AD) or Generation Based Incentive scheme (GBI).
- States such as Maharashtra have recently announced feed-in-tariffs based on wind zones; this tariff structure is more closely aligned with the total amount of electricity production possible. This framework has the potential to significantly increase the returns for wind farm owners in India, making this sector even more attractive than it is presently.

4.1.3 Biomass Power

Biomass Power Production

Biomass based power plants in India can avail the following:

- Capital subsidies (30%)
- Accelerated depreciation (80% in first year)
- Exemption from Central Sales Tax and customs duty concessions on the import of material, components and equipment used
- Preferential feed-in-tariff (varies from state to state)

Biofuels

India has a Biofuel Policy with an emphasis on biodiesel production from Jatropha and ethanol production from sugarcane molasses. In 2004, it was decided, as a first step, to mandate 5% blending of petrol with ethanol. An MOU between the Indian Sugar Mills Association and Indian Oil Corporation is designed to ensure uninterrupted supplies of ethanol for the program.The target was a 20% blend by the year 2011-12, though this target will most likely not be achieved, going by the trends available until Jun 2011.

A National Bio-diesel Board has been created to promote, finance and support organizations that are engaged in the field of oilseed cultivation and oil processing leading to bio-diesel production. India's Bio-diesel Purchase Policy prescribes that public sector oil marketing companies should purchase bio-diesel of prescribed specification from authorized suppliers at a uniform price that will be reviewed every six months.

State incentives for biodiesel
Incentives are usually provided through the respective state renewable energy development agency. A reduced VAT @ 4% is provided in most states.

Support price of oil seeds
The government has fixed remunerative support prices for purchase of different oil seeds suitable for production of biofuels.

Incentives for raising commercial plantations
For raising commercial plantations, different categories of cultivators can avail different forms of financial assistance (subsidy, soft loans) under back ended credit linked subsidy program of National Oilseed and Vegetable Development (NOVOD) Board under the Ministry of Agriculture, Government of India.

Subsidy given for planting material

50% subsidy will be provided on cost of planting material for biofuels crops such as Jatropha. Subsidies available to agro-processing industry will be extended to bio-fuel and bio-diesel extraction plants.

Credits and finance resources

Financial institutions shall be roped in to support the activities by providing timely financial assistance for bio-fuel plantations establishment of expelling units, storage sheds, refineries etc.

4.1.4 Small Hydro

- Tax incentives such as enhanced capital allowances
- IREDA provides low interest rate loans for hydel power stations up to 25MW
- State specific capital subsidies are provided as given below
    - Special Category States (NE Region, J&K, H.P and Uttarkhand) - $446 per kW for installations up to 1MW (for private projects), $446,390 for 1st MW followed by $66,950 for each additional MW
    - Other States – $268 per kW for installations upto 1MW (for private projects), $268,895 for the 1st MW followed by $44,650 for each additional MW
- Incentives for detailed survey and investigation
- Incentives for Detailed Project Report (DPR) preparation
- Interest subsidy for commercial projects
- Financial support for renovation, modernization and capacity up-rating of old SHP stations
- Financial support for development / up-gradation of water-mills

Other incentives include: Ability for power wheeling and banking, buy-back arrangement by state electricity boards, ability to sell to third (private) parties and electricity duty exemption. As electricity is a state subject in India, the incentives for each of the above are different for different states.

4.2 Renewable Purchase Obligations State-wise

S.No.	State	RE Source	2010-11	2011-12
1	Gujarat	Wind	4.50%	5.00%
		Solar	0.25%	0.50%
		others	0.25%	0.50%
		Total	**5%**	**6%**
2	Maharashtra	Solar	0.25%	0.25%
		Non-solar	5.75%	6.75%
		Total	**6%**	**7%**
3	Uttaranchal	Solar	0.25%	0.50%
		Non-solar	3.75%	4.50%
		Total	**4%**	**5%**
4	Manipur	Solar	0.25%	0.25%
		Non-solar	1.75%	2.75%
		Total	**2%**	**3%**
5	Mizoram	Solar	0.25%	0.25%
		Non-solar	4.75%	5.75%
		Total	**5%**	**6%**
6	Jammu & Kashmir	**Total**	**1%**	**3%**
7	Uttar Pradesh	Solar	0.25%	0.50%
		Non-solar	3.75%	4.50%
		Total	**4%**	**5%**
8	Tripura	Solar	0.10%	0.10%
		Total	1%	1%
9	Jharkhand	Solar	0.25%	0.50%
		Non-solar	1.75%	2.50%
		Total	**2%**	**3%**
10	Himachal Pradesh	Solar	0%	0.10%
		Non-solar	10%	11%
		Total	**10.10%**	**11.1**
11	Orissa	Solar		0.10%
		Non-solar	1.00%	1.20%
		Co-gen	3.50%	3.70%
		Total	**4.50%**	**5%**
12	Assam	Solar	0.05%	0.10%
		Total	**1.40%**	**2.80%**
13	Tamil Nadu		14%	

14	Delhi		1%	
15	Andhra Pradesh		5%	
16	Karnataka		11%	
17	West Bengal		10%	
18	Rajasthan		9.50%	9.50%
19	Madhya Pradesh		10%	
20	Punjab		4%	
21	Haryana		10%	

4.3 State-wise Feed-in-tariffs for Wind Power

Table: Comparison of Tariffs and Policies for Wind Power in Key States

States	Tariff rates (cents per KWh)	Annual tariff escalation	Percentage Renewable Portfolio Standard for Wind
Andhra Pradesh	8	Constant for 10 years for the PPAs to be signed during 01-05-09 to 31-03-2014	5% for all RE(2011/2012)
Gujarat**	8	No escalation for 25 years of project life	5% (2011/2012) 5.5% (2012/2013)
Haryana	9	With 1.5% per year for 5th years	10% (2010/2011) for all RE
Karnataka*	8	No escalation for 10 years	7-10% (2010/2011) for all RE
Kerala	8	No escalation for 20 years of project life	3% (2011/2012 &2012/2013) for all RE
Madhya Pradesh**	10	No escalation for 25 years of project life	6% (2011/2012)
Maharashtra	Wind Zone I - 11 Wind Zone II - 10 Wind Zone III - 8 Wind Zone IV - 8	No escalation for 13 years	7% (2011/2012) 8% (2012/2013) for all RE
Orissa	12	No escalation for 13 years	5% for all RE (2011/2012)
Punjab	8	With base year 2006/07 with 5 annual escalation @5% up to 2011/12	4% for all RE (2011/2012)
Rajasthan**	8 & 9	No escalation for 25 years of project life	7.5% (2011/2012)

		8 cents for Jalsalmer, Jodhpur & Balmer districts while 9 cents for other districts	
Tamil Nadu	8	No escalation for 20 years of project life	14% for all RE (2010/2011)
Uttarakhand	Wind Zone I-11* Wind Zone II-10* Wind Zone III-8 * Wind Zone IV-7*	13 cents for first 10 years & 8 cents for 11th year onward 11 cents for first 10 years & 7 cents for 11th year onward 9 cents for first 10 years & 6 cents for 11th year onward 8 cents for first 10 years & 5 cents for 11th year onward	4.53% for all RE (2011/2012)
West Bengal*	11	No escalation for 10 years	3% for all RE (2011/2012)
*RPS for Bengaluru Electricity Supply Company Ltd (BESCOM), Mangalore Electricity Supply Company Ltd (MISCOM), Calcutta Electricity Supply Company Ltd (CISCOM) is 10% while for HebM Electricity Supply Company Ltd (HESCOM) and Hukari, it is 7%			
**RPS specific only for Wind			

Source:MNRE

4.4 State-wise Feed-in-tariffs for BiomassPower

Table: Comparison of Tariffs and Policies for Biomass and Cogeneration Power in Key States

States	Tariff rates (cents per KWh)	Annual tariff escalation	Percentage Renewable Portfolio Standard for Biomass and Cogeneration
Andhra Pradesh	10 (BM) 8 (Cogen)	No escalation	Minimum of 3.75%
Chattisgarh	9 (BM)	No escalation	5%
Gujarat	9 (with AD) (BM) 10 (with AD) (Cogen)	No escalation	10%
Haryana	9 (BM) 8 (Cogen)	With base year 2007/08, annual escalation @ 3%	1%
Karnataka	8 (PPA signing date) to 9 (10th year) (BM) 8 (PPA signing date) to 9 (10th year) (Cogen)	No escalation	Minimum 10%

Kerala	6 (BM)	With base year 2000/01, annual escalation @ 5% for five years	3%
Maharashtra	11 (BM) 10 (Cogen)	No escalation	6%
Madhya Pradesh	7 to 11 for 20 years	Annual escalation of less than 1 cent	0.8%
Punjab	11 (BM) 10 (Cogen)	Annual escalation @ 5% for both BM and Cogen	Minimum of 3%
Rajasthan	10 (water cooled BM) 11 (air cooled BM)	No escalation	1.75%
Tamil Nadu	10 - 11 (BM) 9 - 10 (Cogen)	Annual escalation @ 2%	Minimum of 13%
Uttaranchal	7 (BM) 7 (Cogen)	No escalation	9%
Uttar Pradesh	10 (existing) 10 (new)	With base year 2006, annual escalation at 1 cent/year	4%
West Bengal	10	Fixed for 10 years	4%
Bihar	9 (BM) 9 (Existing cogen) 10 (New cogen)	No escalation	1.5%
Orissa	9	No escalation	
BM – Biomass Power Cogen – Cogeneration Plants			

Source: MNRE

5. Summary of Renewable Energy Costs & Returns

This section provides a summary of costs and returns for the various renewable energy sources in India. These data will aid a prospective investor in doing a preliminary evaluation of the economic feasibility for investments.

5.1 Levelized Cost of Electricity (LCoE) of Electricity Sources

The following list provides EAI's estimates of the Levelized Cost of Electricity (LCoE)

Energy Source	Levelized cost of electricity production* (US cents/kWh)
Coal / natural gas	5-6
Wind	7-9
Biomass	6-10
Solar PV	25-30
Solar CSP	22-26
Small hydro	6-7
Large hydro	6-7
Diesel generator sets	30

*: Levelized cost denotes the total cost, after taking into account all direct and indirect variable expenses such as insurance, and depreciation of capital costs. All investments assume a 70:30 debt:equity split.

5.2 Costs of Renewable Energy Sources

Indicative Capital and Operational Expenses of Renewable Energy Sources

All estimates are India-specific

	Capex ($ million/MW, unless mentioned otherwise)	Opex (US cents per kWh, unless mentioned otherwise)	Tariff (cents /kWh, unless mentioned otherwise)	Equity IRR (%)	Payback Period (years)
Solar PV	3.5	1.4	30-40	14-20[(1)]	5-7[(1)]
Solar CSP	2.75	2	25-30	14-20[(1)]	5-7[(1)]
Biomass Power[(2)]	$1.2	2.2 (excluding cost of biomass)	10	20-25	4-5
Solar Thermal for Heating / Drying	$200/sq m[(3)]	1 cent/thermal kWh	NA	20-25	4-5
Ethanol	$0.3/annual liter	Cellulosic: 40 cents/liter Corn: 16 cents/liter	60 cents/liter	• Corn: 13 • Sweet sorghum :19	7 years reported for a case of solid substrate fermentation, ethanol from sweet sorghum
Biodiesel	$0.25 / annual liter	12 cents/liter	75 cents/liter	Currently, equity IRRs for biodiesel projects fall in a wide range of 5 – 20 owing to the diverse feedstocks and processes.	Consequent to a wide range for the equity IRRs, the payback period estimates also fall in a wide range of 4-15 years.

Small Hydro	1.25	1.5	5-6	17-20	5-6
Large Hydro	1.75-2.5	0.5-2[4]	5	10-14	7-9
Wind	1.25	1	6-7	17	6
Geothermal	1.1-1.8[5]	1.7	6	17-20	5-6
Wave	3.3	2.75-3	NA	8-9[6]	11-13[6]
Tidal (stream)	2.75	3	NA	10-12[6]	9-10[6]

(1) Varies, depending on the incentive structures provided; 20%, under the National Solar Mission incentives

(2) Data provided as a representative data for both biomass combustion and gasification; combustion has less IRR and higher payback periods than does gasification

(3) 1 sq m produces about 400 thermal kWh per year

(4) High Opex in the initial years, owing to high maintenance and setting up costs, Opex decreases significantly over years

(5) $1.1 million/MW for flashed steam technology, and $1.8 million/MW is for binary technology

(6) Preliminary estimates made with limited empirical data