

# EAI

## India Renewable Energy Advisor

Highlights of Indian Renewable Energy  
Industry for Investors



**EAI**  
Energy Alternatives India

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Feasibility Studies • Strategic Consulting • Market Intelligence



## Preface

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The Indian growth story is well known; what is less well known is the Indian renewable energy growth story. 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. 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.

Outside of solar and wind, there are other renewable energy sectors are showing significant progress - notably small hydro and biomass power. Some of the segments that show little activity now – 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 in India. In addition, the large and fast-growing Indian domestic market and the increasing need for electricity and transport fuels, imply large markets for energy project developers, OEMs and component manufacturers.

The *India Renewable Energy Advisor* from Energy Alternatives India (EAI) is a ready reference for those companies in India that are keen on entering the renewable energy industry and also provides concise data and insights on key parameters related to the sector. This guide was last revised in July 2011.

EAI is India's leading consulting and business intelligence firm, with a dedicated focus on renewable energy and clean technology. More about us can be known from [www.eai.in](http://www.eai.in)

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

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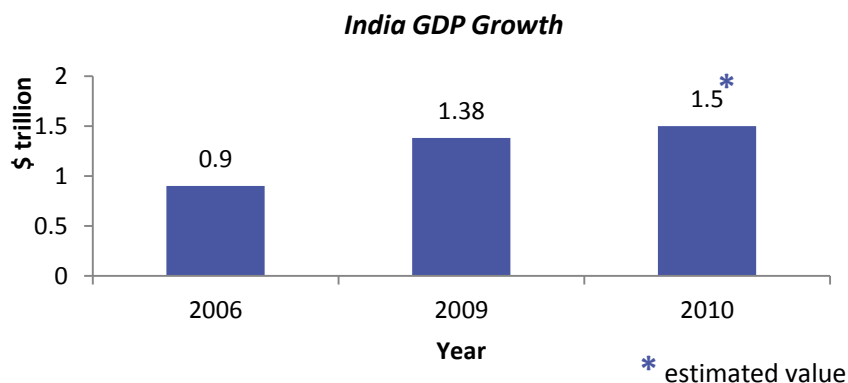
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# 1. The India Story

## 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 5 years or more, and its GDP is expected to be over \$3 trillion by 2020, making it one of the top 5 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 been the driver for the Indian economy in the past two decades, with the state playing 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-Medium Tech Products

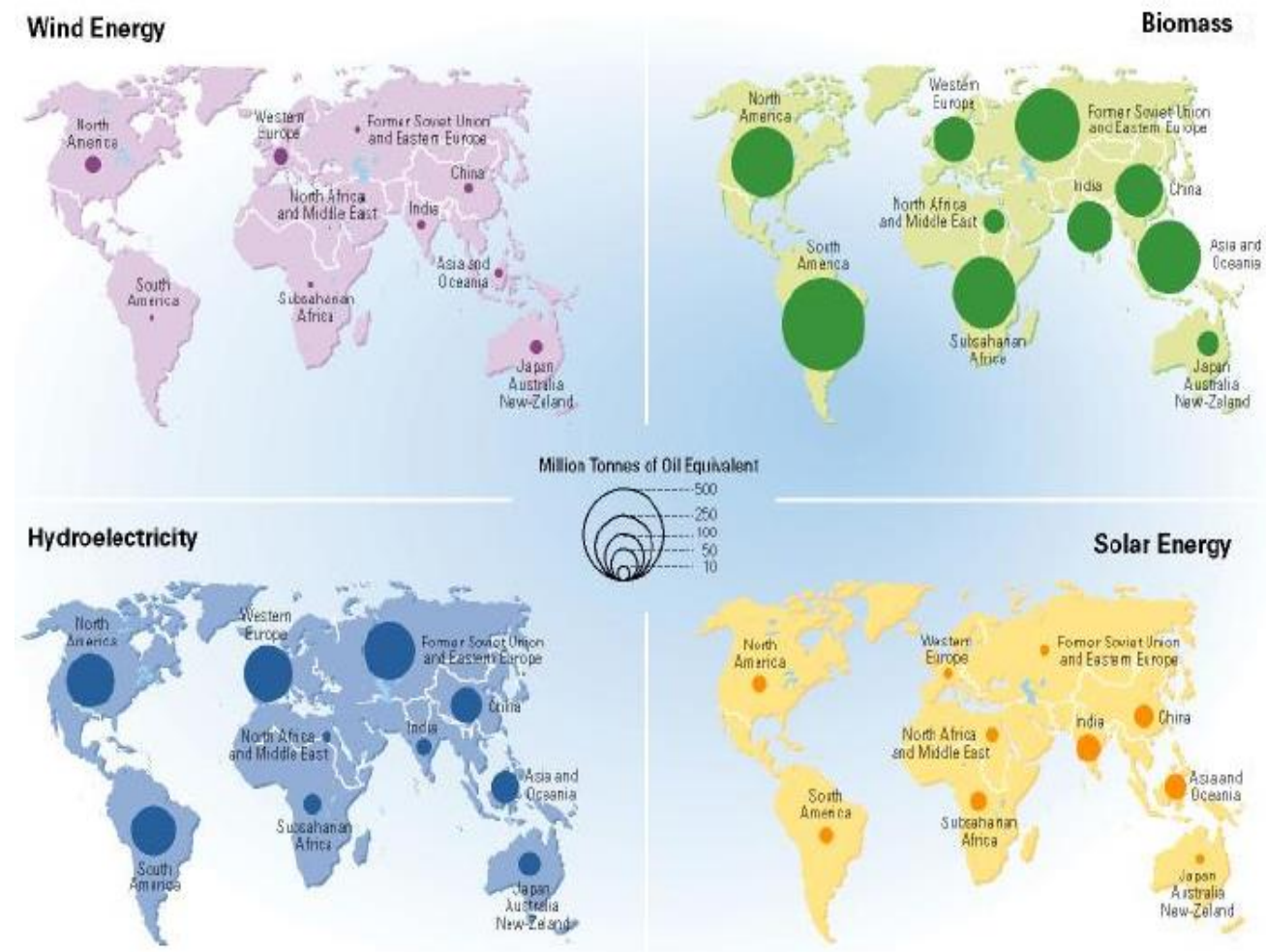
## 1.3 Why Should You Invest in India's Renewable Energy Sector Now?

- To get an early mover advantage in one of the fastest growing renewable energy markets
- To take advantage of a number of attractive government incentives
- To obtain business partnerships and joint ventures with prominent Indian companies that might not be available later
- To go up the learning curve during the next few years, so that your company is well positioned to benefit from opportunities when the market starts growing at an exponential rate

## 2. Potential and Status of Indian Renewable Energy

### 2.1 India's Overall Energy Scenario

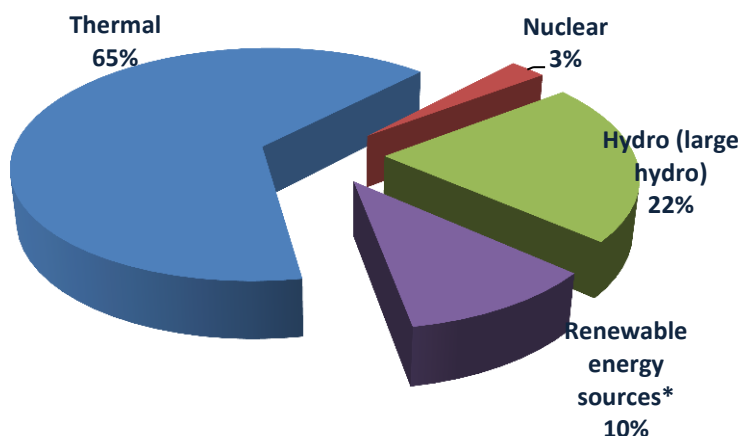
*Renewable energy potential- India vs. Global*



- 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 some other regions in the world.
- 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.
- 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 production.
- There is significant potential for hydro power in India. Most of the primary power production is from large scale hydro installations. With an increase in government funding and subsidies, the small scale hydro projects in India are gathering momentum.

### 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 0.25 million T (both ethanol and biodiesel together), less than 0.5% of the total transport fuels used.*

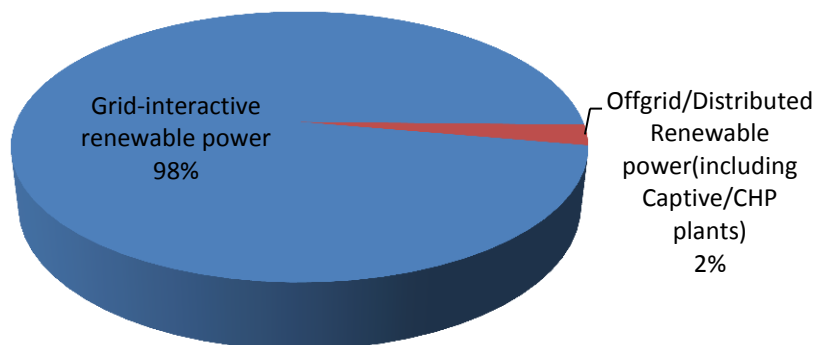
### 2.1.3 Natural Gas

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 cc ft., the share of imports thus rising to about 36%.

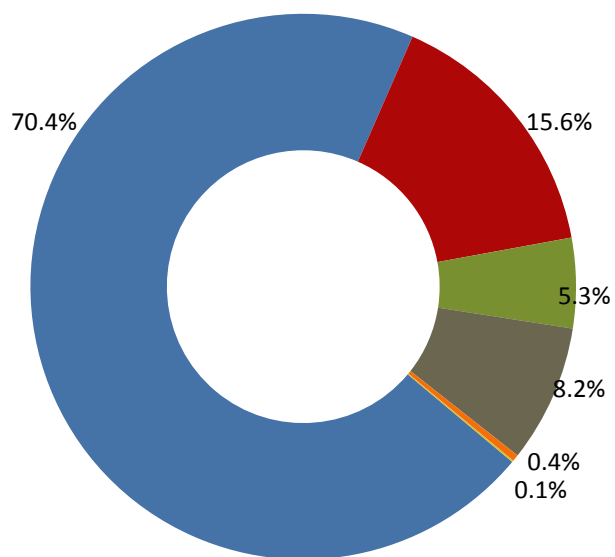


## 2.2 The India Renewable Energy Story

*Energy in India*

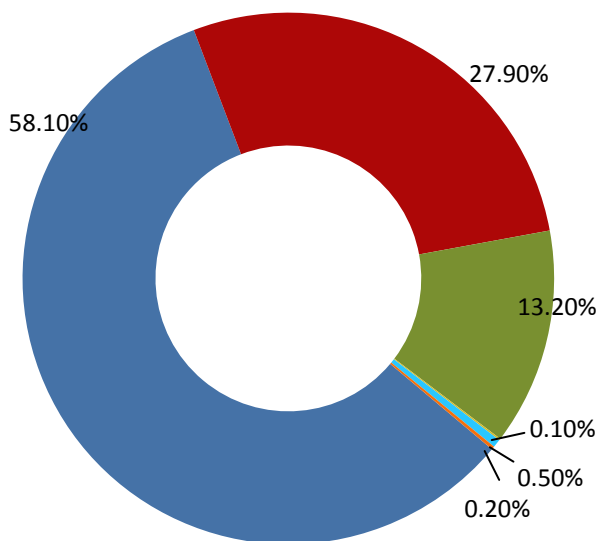


*Grid-interactive Renewable Power in India*



- Wind Power
- Small Hydro Power
- Biomass Power (Agro-wastes/Residues).
- Bagasse Cogeneration
- Waste to Power
- Solar Power

*Off-grid/Distributed Renewable Power (Including Captive/CHP plants)*



- Biomass Power/Cogen. (Non-bagasse)
- Biomass Gasifiers
- Waste to Energy (Urban and Industrial)
- Waste to Energy (Rural)
- Solar PV Power Plants and Street Lights (>1kW)
- Hybrid Systems

Source: MNRE (as on Dec 2010)

## 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 import. But the country is rich in renewable energy sources – especially solar, wind, hydro, and bio-energy.

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

- *High growth rate in overall energy needs*

The expansion of the overall energy demand-supply gap 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 in the country.

- *Increasing reliance on imports for fossil fuels*

In 2009-10, the country imported 159.26 million tonnes of crude oil which amount to 80% of its domestic crude oil consumption; 31% of the country's total imports are oil imports. 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 has been initiated in 2005 to benefit the 400 million Indians who lack access to electricity. However, real benefits for newly connected rural households may be severely restricted unless the ambitious grid expansion plans are accompanied by similarly ambitious distribution reforms and de-politicization of tariffs. Concerns have been expressed, questioning in particular the long term financial and technical sustainability of the program.

- *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 southern region 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. This fact is also articulated in the Eleventh Five Year Plan (2007-2012).

## 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. Geothermal
7. Wave and Tidal

### 2.4.1 Solar

#### 2.4.1.1 Solar PV

##### *Total available potential*

Total theoretical potential –over 5000 trillion kWh annually.

##### *Exploited potential*

Exploited potential is less than 150 MW, and of that only about 20 MW is grid-connected. (as of Jul 2011)

##### *Projected Capacity*

For solar CSP and PV together, the National Solar Mission attempts to reach the following installed capacity:

- ✓ By 2013: 1-2 GW
- ✓ By 2017: 4-10 GW
- ✓ By 2022: 20 GW

Reputed industry experts foresee a much higher installed capacity by 2022. EAI predicts that this could be even higher, at about 75 GW. KPMG, for instance, 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 Rs 12-18 per kWh for grid connected power plants, depending on the size of the power plant.

#### *Amount of investments*

Government is expected to spend Rs. 84,000 crores until 2022, Rs. 4,400 crores of which has already been allocated. The government has earmarked Rs. 1,500 crores 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 – Rs 10-12/kWh. This includes O&M, amortized/depreciated capital costs, loan repayment costs, and other expenses such as insurance.

### **2.4.1.2 Solar CSP**

#### *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 corporate; these CSP plants are currently being commissioned.

#### *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 trend in the future.

#### *Government incentives*

The National Solar Mission incentives available through MNRE 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 Rs 10-14 per kWh for grid connected power plants.

#### *Amount of 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*

Rs 9-11/kWh. This includes O&M, amortized/ depreciated capital costs, loan repayment costs, and other expenses such as insurance.

### 2.4.1.3 Solar Thermal for Heating Purposes

#### ***Solar Heating / Drying for Industries***

Solar thermal (heating and drying) energy has significant potential in India.

Studies have shown that energy from solar thermal used for industrial heating and drying (both for heating and pre-heating) can save up to 4.5 million tons of furnace oil or diesel per year. In a market assessment report<sup>1</sup>, the potential areas for solar heating in industries were classified as follows:

- Boiler Feed Water Heating
- Process Heating
- Process Cooling (through VAM<sup>2</sup>)
- 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.

#### ***Solar Water Heating***

The total potential in India for solar water heating is 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 growth in the near future.

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<sup>1</sup> **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> )

<sup>2</sup> VAM – Vapor Absorption Machines

The solar thermal incentives offered by the government fall under the subsidy scheme of the National Solar Mission. An incentive of Rs. 3000 to Rs. 6000 per square meter of installation is being offered, depending on the technology.

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 6% of India's total installed power capacity, and it generates 1.6% of the country's power. It is estimated that 6,000 MW of additional wind power capacity will be installed in India by 2012.

India is fast moving towards complete indigenization of components required for wind turbine manufacturing, and the government is keen on promoting this indigenization with a number of incentives. This has resulted in significant opportunities for a number of companies.

*Total available potential* 100,000 MW

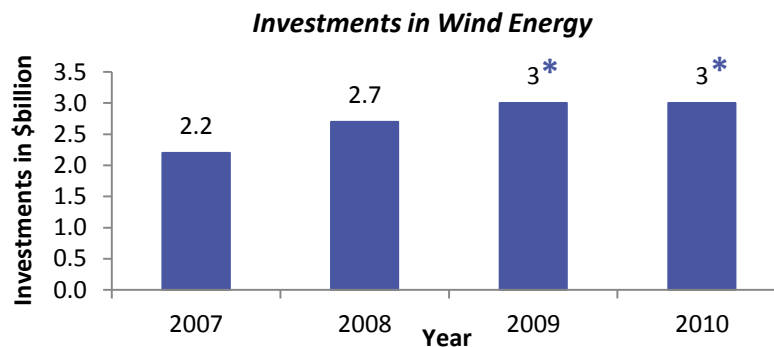
*Exploited potential* Approximately 14,000 MW (Jun 2011)

*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 Rs 3.39 to over Rs 5/kWh. Over and above the FiT, wind power developers can avail of accelerated depreciation benefits or generation based incentives.



### Amount of investments



\* Over \$3 billion each year (EAI estimate)

### Challenges

- ✓ Incentive Challenges – FIT needs to be wind zone based, not state based (being corrected, Jun 2011)
- ✓ 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

Rs 2.75-3.5 /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

### 2.4.3.1 Biodiesel

#### 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 34 rupees 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.

#### *Amount of investments*

The largest investment seen so far was made by BP, in TATA's 8000 acre Jatropha acreage in Andhra Pradesh – Rs. 41.5 crore 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 feedstocks
- ✓ 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 power generation*

Biodiesel production cost stands at about Rs. 40 per liter

### **2.4.3.2 Ethanol**

#### *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 – 360 million liters in India (EAI estimate) vs. 87 billion liters 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 600 million liters; a 20% target will require 2400 million liters

#### *Government incentives*

- ✓ 20% biofuels by 2017 (National Policy on Biofuels, 2008)
- ✓ Mandatory 5% blending for ethanol and biodiesel (Nov 2009)

#### *Amount of investments*

- ✓ Government recently announced a purchase price of Rs 27 per liter (60 cents/liter) for the public oil companies for ethanol (Apr 2010)
- ✓ 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, in which an initial investment of \$10 million for prototype development will be followed by \$150 million over the subsequent 3 - 4 years.

#### *Challenges*

- ✓ Ethanol is also used in industries and for potable alcohol, and hence 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 power generation*

Rs 20-25 per 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

Being an agrarian country, there is easy availability of agricultural biomass which can be used to generate energy.

#### *Total available potential*

22 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; 1591 MW under implementation (2009)
- ✓ Total of about 2505 MW of biomass power installed

#### *Projected capacity*

EAI Estimates suggest India could have a total biomass installed capacity of over 10,000 MW by 2022, growth coming from both cogen as well as from 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.

### *Amount of investments*

In the current Five Year Plan period (2007 to 2012), the government's target for biomass power capacity is 1200 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)
- ✓ High wheeling and open access charges in some states

### *Cost of power generation*

Cost of electricity production – Rs 2.5-4/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 renewable while it contributes to nearly 86% of off-grid power. Capacity of biomass based power in India was 2,500 MW in 2010.	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 10,265 MW through 4278 sites (Average 2.5 MW per site)

#### *Exploited potential*

Approximately 2953 MW (20% of total), as of Feb 2011

#### *Projected capacity*

Target capacity addition in 11<sup>th</sup> plan (2007-12): 2000 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 Rs. 250 crores (\$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

#### *Amount of investments*

Small hydro investment in India grew significantly since 2008 - Rs. 2425 crore in 2009 and Rs. 2645 crore in 2010 (about 15% of total RE investments), compared to just Rs. 617 crore in 2007

#### *Challenges*

- ✓ Delays & long timelines for approvals
- ✓ Poor efficiency of transmission and distribution because of lack of

- local customers, as often these are in remote regions
- ✓ Geological and social uncertainties
- ✓ Regulatory challenges

*Cost of power generation*

Rs 2.25-3/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 148700 MW of installed capacity.

*Exploited potential*

The total installed capacity of India is 37367 MW (Feb 2011)

*Projected capacity*

15,627 MW is planned to be added in the 11th five year plan (2007-2012)

*Government 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 Rs 28,000 crores (\$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 Rs 2.25-3.25 per unit 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

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.

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

**Geothermal – Potential for short and medium term growth: Low**

<sup>3</sup> 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

<i>Total available potential</i>	<p>Total identified potential: about 9000 MW</p> <p><i>West Coast</i></p> <ul style="list-style-type: none"> <li>✓ Gulf of Cambay (7000 MW)</li> <li>✓ Gulf of Kutch (1200 MW)</li> </ul> <p><i>East Coast</i></p> <ul style="list-style-type: none"> <li>✓ The Ganges Delta in the Sunderbans in West Bengal for small scale tidal power development.</li> </ul>
<i>Exploited potential</i>	None
<i>Projected capacity</i>	No clear projections, but there is a 3.75 MW project coming up in the Sunderbans (West Bengal).
<i>Government incentives</i>	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.
<i>Amount of investments</i>	<ul style="list-style-type: none"> <li>✓ Negligible, currently</li> <li>✓ 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.</li> </ul>
<i>Challenges</i>	<ul style="list-style-type: none"> <li>✓ Long development timescales (some technologies remain at the development stage for decades)</li> <li>✓ High capital cost</li> <li>✓ Lack of infrastructure for connection of the system to the grid</li> <li>✓ Environmental issues arising out of the cable laying and other construction works</li> <li>✓ Intermittent supply-tidal plant provides power for only around 10 hours each day, when the tide is actually moving in or out</li> <li>✓ Regional limitations – tidal power plants require a basin or gulf that has mean tidal amplitude of 7m or above for efficient generation</li> </ul>



*Cost of power generation*

Tidal 13-15 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

*Amount of 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 estimate: Wave 15-17 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**

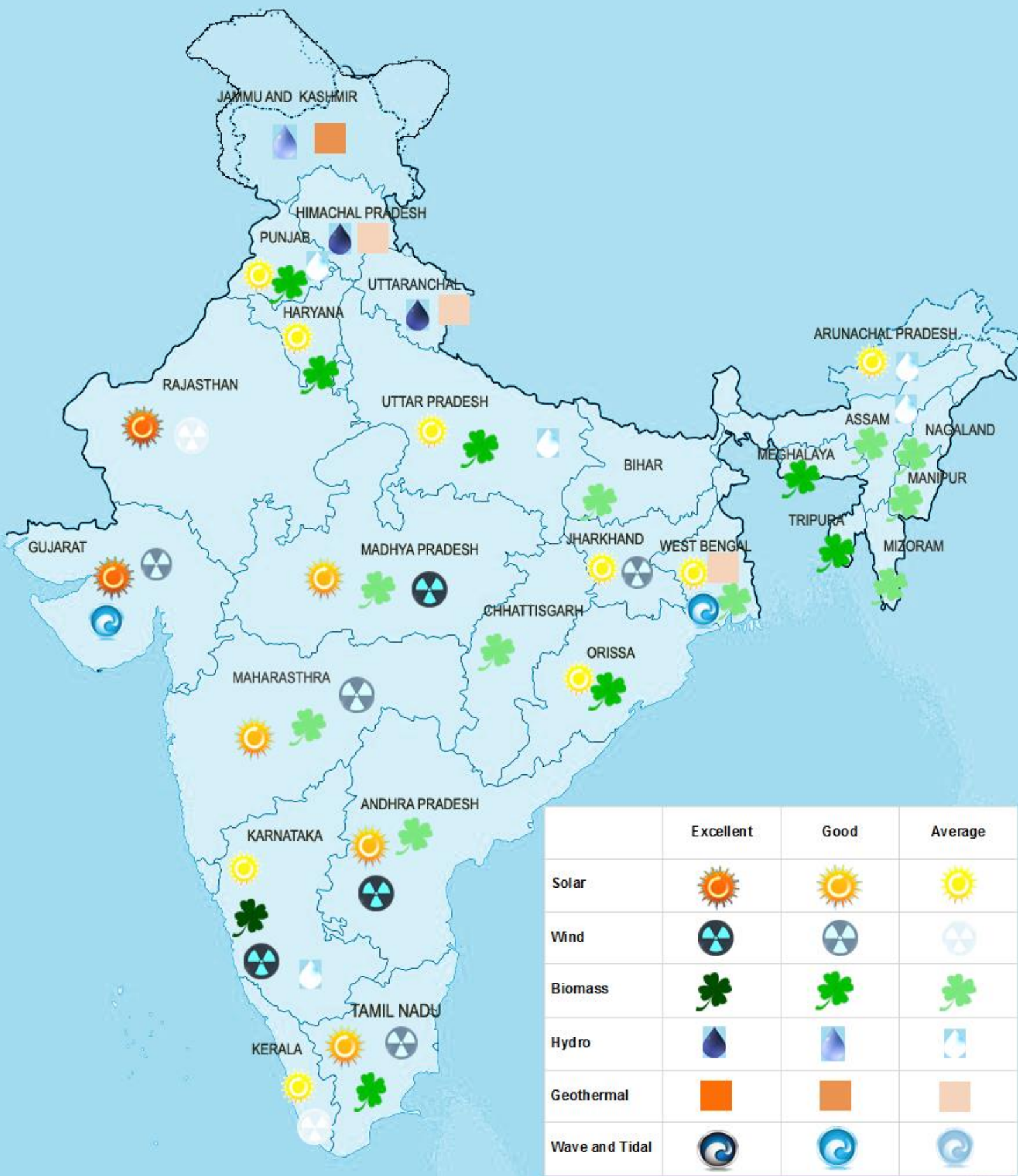
***Summary of Renewable Energy Sources Growth Potential in India***

Renewable Energy Source	Short Term Growth Potential	Medium Term Growth 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
Large Hydro	Medium	Medium
Biofuels – Ethanol	Medium	High
Biofuels – Biodiesel	Low	High
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 Jharkhand 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, Uttarakhand, 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, Uttarakhand 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.

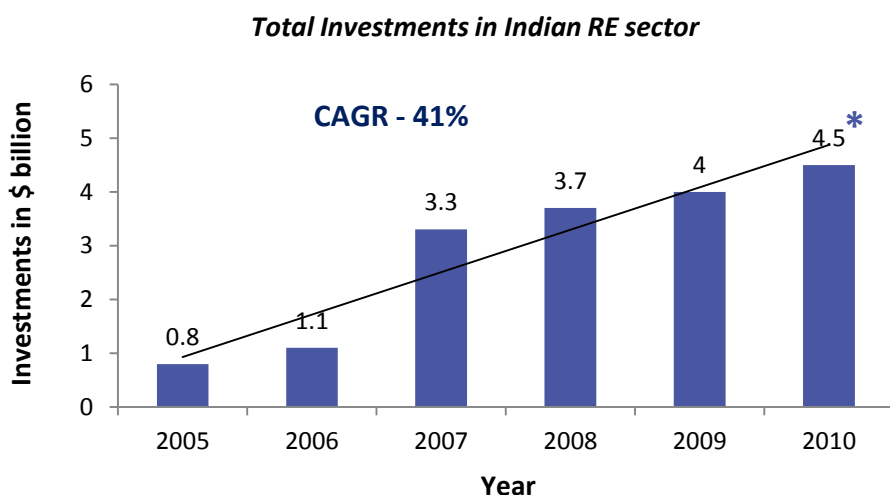
# States and Regions with Potential for Renewable Energy



## 3. Investments in Indian Renewable Energy

### 3.1 Details of Investments in Renewable Energy and Clean Technologies

Over the next decade, India is projected to increase its renewable energy generating capacity to 91 GW, five times of the current 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 %).

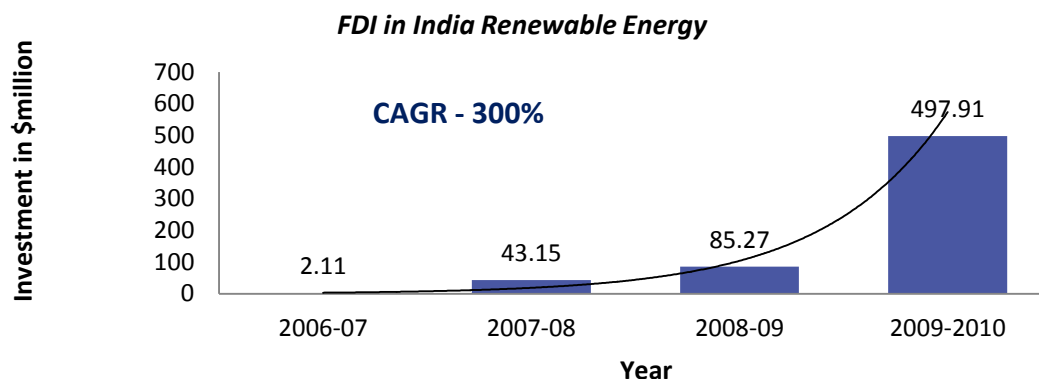


\* EAI estimates

### 3.2 FDI in Indian Renewable Energy

From almost negligible FDI in 2006-07, India's FDI in renewable 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
<b>Abengoa Solar</b>	Solar CSP (CSP technology transfer, Solar)	Maharishi Renewable Energy (MREL)	<a href="http://www.abengoasolar.com/corp/web/en">www.abengoasolar.com/corp/web/en</a>
<b>Centrotherm Photovoltaics AG</b>	Solar PVC (Polysilicon processing factory).	SREI Infrastructure Finance Ltd, Environ Energy Deck Services (together 50% stake) and Perseus (35%)	<a href="http://www.centrotherm.de">www.centrotherm.de</a>
<b>MolaSolaireProduktions GmbH,</b>	Solar PVC (Five-year contract to supply 125 MW of multi-crystalline solar wafers to XL Telecom & Energy Ltd).	Data not available	<a href="http://www.mola-solaire-international.com">www.mola-solaire-international.com</a>
<b>US-based Signet Solar</b>	Solar PVC (MOU with Tamil Nadu to manufacture 300 MW of thin-film PV modules).	Indian Subsidiary	<a href="http://www.signetsolar.com">www.signetsolar.com</a>
<b>Vestas wind</b>	Wind (Factory at Sriperumbudur near Chennai to make turbine blades and wind turbines).	Indian Subsidiary - VestasIndia	<a href="http://www.vestas.com">www.vestas.com</a>
<b>Gamesa</b>	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	<a href="http://www.gamesa.es/en">www.gamesa.es/en</a>

<b>eSolar</b>	Solar CSP (ACME will be the master licensee of eSolar's modular, scalable technology).	ACME Group	<a href="http://www.esolar.com">www.esolar.com</a>
<b>Siemens</b>	Wind (Wind turbine factory in India by 2012.)	Indian Subsidiary – Siemens India	<a href="http://www.siemens.com/entry/in/en">www.siemens.com/entry/in/en</a>
<b>Germany's IBC SOLAR and India's Reflex Energy</b>	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)	<a href="http://www.refexenergy.com">www.refexenergy.com</a>
<b>TATA-BP solar</b>	Solar PVC (Solar cell manufacturing).	Tata & British Petroleum (JV)	<a href="http://www.tatabpsolar.com">www.tatabpsolar.com</a>
<b>BP</b>	Biodiesel (Project to demonstrate the feasibility of producing bio-diesel from Jatropha)	The Energy and Resources Institute (TERI)	<a href="http://www.bp.com/bodycopyarticle.do?categoryId=1&amp;contentId=7052055">www.bp.com/bodycopyarticle.do?categoryId=1&amp;contentId=7052055</a>
<b>Enercon India</b>	Wind (Total installed capacity of wind turbines in India exceeds 2900 MW)	Mehra Group	<a href="http://www.enerconindia.net">www.enerconindia.net</a>
<b>Biogas Nord</b>	Biogas (Efficient biogas plants installed by Biogas Nord are based on a flow-storage process, and convert bagasse to biogas).	Local sugar factories	<a href="http://www.biogas-nord.com">www.biogas-nord.com</a>
<b>SunTechnics</b>	Solar PVC/Wind (In Northern India, the installation of photovoltaic-wind-hybrid plants with a total capacity of 50 kilowatts is being realized).	Indian Subsidiary - SunTechnics India	<a href="http://www.suntechnics.com">www.suntechnics.com</a>

### 3.4 List of Prominent US Renewable Energy Companies in India

Name	Sector invested in	Joint venture partners/ Subsidiary	Corporate website
<b>First Solar</b>	Solar PV (manufacture of thin film PV modules, turn-key PV power plants)	Supplied modules for Moser Baer installations	<a href="http://www.firstsolar.com">www.firstsolar.com</a>
<b>Solfocus</b>	Concentrated solar PV systems	Moser Baer (technology partner)	<a href="http://www.solfocus.com">www.solfocus.com</a>
<b>General Electric</b>	Wind, Solar (wind turbine manufacture, thin film panel manufacture)	Indian Subsidiary – GE India	<a href="http://www.ge-energy.com">www.ge-energy.com</a>

### 3.5 List of Prominent Indian Renewable Energy Companies

Name	Sector invested in	Joint venture partners/ Subsidiary	Corporate website
<b>Indosolar</b>	Solar PV (multi-crystalline solar cell manufacturing)	Data not available	<a href="http://www.indosolar.co.in">www.indosolar.co.in</a>
<b>Titan Energy Systems Ltd.</b>	Solar PV (manufacture of solar PV modules)	Enfinity Belgium (JV)	<a href="http://www.titan-energy.com">www.titan-energy.com</a>
<b>TATA-BP solar</b>	Solar PV (Solar cell manufacturing).	Tata & British Petroleum	<a href="http://www.tatabpsolar.com">www.tatabpsolar.com</a>
<b>XL Energy Limited</b>	Solar PV (module manufacturing)	Corning, Kyocera Wireless, Axesstel (partners)	<a href="http://www.xlenergy.com">www.xlenergy.com</a>
<b>Moser Baer Solar Limited</b>	Solar PV (thin film module manufacturing, turn-key solutions)	Subsidiary of Moser Baer Group	<a href="http://www.moserbaersolar.com">www.moserbaersolar.com</a>

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

<b>NandanBiomatrix</b>	Biofuels (Jatropha cultivation across various states)	Alphakat GmbH (JV)	<a href="http://www.nandanbiofuels.com">www.nandanbiofuels.com</a>
<b>Orient Green Power Company Ltd.</b>	Biomass, wind and Small Hydro power plant developer	Belongs to the Shriram EPC Group	<a href="http://www.orientgreenpower.com">www.orientgreenpower.com</a>
<b>Green Infra Ltd.</b>	Wind, Hydro, Solar and Biomass power plant developer	Data not available	<a href="http://www.greeninfralimited.in">www.greeninfralimited.in</a>
<b>Ramky Enviro Engineers Ltd.</b>	Waste management and waste to energy systems (operates hazardous waste management facilities across the country)	Subsidiary of Ramky Group	<a href="http://www.ramkyenviroengineers.com">www.ramkyenviroengineers.com</a>



## 4. Incentives Provided by the Indian Government for Renewable Energy

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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 and Renewable Energy Certificates (REC) 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

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 programmes 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 typically are supported by a high feed-in-tariff, which for the National Solar Mission. 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 Rs 10.9-12.7/kWh for solar PV and 10.49 to 12.24/kWh for CSP.
2. *Offgrid 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 further five states are expected to come out with their plans by end 2011.

### **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 Rs 1900 for domestic, Rs 1750 for institutional, and Rs 1400 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 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 0.5 rupees per kWh in addition to the existing state incentives. A developer can go for either of two benefits - Accelerated Depreciation (AD) and 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 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 25 MW
- State specific data for capital subsidies are provided as given below
  - Special Category States (NE Region, J&K, H.P and Uttarkhand) - Rs. 20,000 per kW for installations up to 1 MW (for private projects), Rs. 2 crores for 1<sup>st</sup> MW followed by Rs. 30 lakhs for each additional MW
  - Other States – Rs. 12,000 per kW for installations upto 1 MW (for private projects), Rs. 1.2 crores for 1<sup>st</sup> MW followed by Rs. 20 lakhs 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%
		<b>Total</b>	<b>5%</b>	<b>6%</b>
2	Maharashtra	Solar	0.25%	0.25%
		Non-solar	5.75%	6.75%
		<b>Total</b>	<b>6%</b>	<b>7%</b>
3	Uttaranchal	Solar	0.25%	0.50%
		Non-solar	3.75%	4.50%
		<b>Total</b>	<b>4%</b>	<b>5%</b>
4	Manipur	Solar	0.25%	0.25%
		Non-solar	1.75%	2.75%
		<b>Total</b>	<b>2%</b>	<b>3%</b>
5	Mizoram	Solar	0.25%	0.25%
		Non-solar	4.75%	5.75%
		<b>Total</b>	<b>5%</b>	<b>6%</b>
6	Jammu & Kashmir	<b>Total</b>	<b>1%</b>	<b>3%</b>
7	Uttar Pradesh	Solar	0.25%	0.50%
		Non-solar	3.75%	4.50%
		<b>Total</b>	<b>4%</b>	<b>5%</b>
8	Tripura	Solar	0.10%	0.10%
		<b>Total</b>	<b>1%</b>	<b>1%</b>
9	Jharkhand	Solar	0.25%	0.50%
		Non-solar	1.75%	2.50%
		<b>Total</b>	<b>2%</b>	<b>3%</b>
10	Himachal Pradesh	Solar	0%	0.10%
		Non-solar	10%	11%
		<b>Total</b>	<b>10.10%</b>	<b>11.1</b>
11	Orissa	Solar		0.10%
		Non-solar	1.00%	1.20%
		Co-gen	3.50%	3.70%
		<b>Total</b>	<b>4.50%</b>	<b>5%</b>

12	Assam	Solar	0.05%	0.10%
		<b>Total</b>	<b>1.40%</b>	<b>2.80%</b>
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 per KWh	Annual tariff escalation	Percentage Renewable Portfolio Standard for Wind
Andhra Pradesh	Rs. 3.50	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**	Rs. 3.56	No escalation for 25 years of project life	5% (2011/2012) 5.5% (2012/2013)
Haryana	Rs. 4.08	With 1.5% per year for 5th years	10% (2010/2011) for all RE
Karnataka*	Rs. 3.70	No escalation for 10 years	7-10% (2010/2011) for all RE
Kerala	Rs. 3.60	No escalation for 20 years of project life	3% (2011/2012 & 2012/2013) for all RE
Madhya Pradesh**	Rs. 4.35	No escalation for 25 years of project life	6% (2011/2012)
Maharashtra	Wind Zone I-Rs. 5.07 Wind Zone II-Rs. 4.41 Wind Zone III-Rs. 3.75 Wind Zone IV-Rs. 3.38	No escalation for 13 years	7% (2011/2012) 8% (2012/2013) for all RE
Orissa	Rs. 5.31	No escalation for 13 years	5% for all RE (2011/2012)
Punjab	Rs. 3.49	With base year 2006/07 with 5 annual escalation @5% up to 2011/12	4% for all RE (2011/2012)
Rajasthan**	Rs. 3.87 & Rs. 4.08	No escalation for 25 years of project life Rs. 3.87 for Jaisalmer, Jodhpur & Balmer districts while Rs. 4.08 for other districts	7.5% (2011/2012)
Tamil Nadu	Rs. 3.39	No escalation for 20 years of project life	14% for all RE (2010/2011)
Uttarakhand	Wind Zone I-Rs. 5.15* Wind Zone II-Rs. 4.35*	Rs. 5.65 for first 10 years & Rs. 3.45 for 11 <sup>th</sup> year onward Rs. 4.75 for first 10 years & Rs. 3.00	4.53% for all RE (2011/2012)

	Wind Zone III-Rs. 3.65* Wind Zone IV-Rs. 3.20*	for 11 <sup>th</sup> year onward Rs. 3.95 for first 10 years &Rs. 2.55 for 11 <sup>th</sup> year onward Rs. 3.45 for first 10 years &Rs. 2.30 for 11 <sup>th</sup> year onward	
<b>West Bengal*</b>	Rs. 4.87	No escalation for 10 years	3% for all RE (2011/2012)
*RPS for Bangaluru 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			

## 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* (Rs. /kWh)
Coal / natural gas	2.2 – 2.6
Wind	2.75–3.5
Biomass	2.5 – 4.0
Solar PV	10 – 12
Solar CSP	9 – 10
Small hydro	2.2 – 3
Large hydro	2.3 – 3.2
Diesel generator sets	13 - 15

\*: 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 (Rs.crores/MW, unless mentioned otherwise)	Opex (Paise per kWh, unless mentioned otherwise)	Tariff (Rs./kWh, unless mentioned otherwise)	Equity IRR (%)	Payback Period (years)
<b>Solar PV</b>	15	60	10.50 – 17.90	14-20 <sup>(1)</sup>	5-7 <sup>(1)</sup>
<b>Solar CSP</b>	12	90	11 – 15	14-20 <sup>(1)</sup>	5-7 <sup>(1)</sup>
<b>Biomass Power<sup>(2)</sup></b>	5.5	100 (excluding cost of biomass)	3.50 – 5	20-25	4-5
<b>Solar Thermal for Heating / Drying</b>	Rs. 9000/sq m <sup>(3)</sup>	45/thermal kWh	NA	20-25	4-5
<b>Ethanol</b>	Rs.13 /annual liter	Cellulosic: Rs.17/liter Corn: Rs.7/liter	Rs. 27/liter	<ul style="list-style-type: none"> <li>• Corn: 13</li> <li>• Sweet sorghum :19</li> </ul>	7 years reported for a case of solid substrate fermentation, ethanol from sweet sorghum
<b>Biodiesel</b>	Rs 10-11/ annual liter	Rs. 5–6/ liter	Rs. 34/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.
<b>Small</b>	5.5	60	2.20 –2.60	17-20	5-6

<b>Hydro</b>					
<b>Large Hydro</b>	7.5	25	2.50	10-14	7-9
<b>Wind</b>	6	45	3.70 - 5	17	6
<b>Geothermal</b>	4.8– 7.9 <sup>(5)</sup>	75	NA	17-20	5-6
<b>Wave</b>	14.5	Rs 1.20 to Rs. 1.30/kWh	NA	8-9 <sup>(6)</sup>	11-13 <sup>(6)</sup>
<b>Tidal (stream)</b>	12	Rs. 1.30/kWh	NA	10-12 <sup>(6)</sup>	9-10 <sup>(6)</sup>

- (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



## 6. About EAI

EAI is a boutique research and consulting firm in renewable energy technologies. Our expertise ranges from Solar PV and Wind Energy to Algae fuels and Jatropha biodiesel. Our work has been sought after by some of the largest corporate and multilateral organizations in the world such as The Bill and Melinda Gates Foundation, Reliance Industries, World Bank, PepsiCo, iPLON, Vedanta Group, Accenture, Boston Consulting Group, [and more](#).

Our range of services include –

- Developer/IPP Assistance
- Assisting Industrial consumers go green
- Diversification into/within renewable energy
- Market entry for international firms
- Research and Publications
- Renewable energy catalysis

To hear more on how we can help your organization procure power, write to us at [consult@eai.in](mailto:consult@eai.in).

### 6.1. Replacing Diesel with Solar Report

Looking to save on diesel by moving to captive solar power? EAI's **Replacing Diesel with Solar** report is a one-stop resource for all the information you will need to assess, implement, and profit from substituting diesel with solar. Within this report you will find

- Captive solar PV technology and components
- Constraints in replacing diesel with solar
- Government incentives and regulations
- Inputs on capital and operational costs and financial scenario analysis
- Case studies for those businesses that already use solar for captive power
- Financing options
- Vendors, component suppliers, and system integrators
- List of solar PV captive power plant systems all over India

Please click [here](#) for detailed contents, critical questions answered, and a free preview of the report.