

# Renewable energy sources

## Summary

There exists immense potential regarding development of renewable sources of energy in India; however, it has a long way to catch up. Power generation from municipal solid waste, with total potential of 3,366 MW of installed capacity, can solve the dual problem of waste disposal and meeting power demand. Small hydropower with currently 2,430 MW of capacity has the potential to reach 14,305 MW. In spite of huge potential, solar energy continues to remain insignificant. Blending of biofuel remains below target due to inadequate availability of ethanol and biodiesel. Absence of strong winds coupled with huge unexploited onshore potential has resulted in zero development of offshore wind farms in India.

Revenue from carbon credit has resulted in additional stream of revenue for companies in India and other developing countries. However, there prevails ambiguity of existence or replacement of the Kyoto Protocol post 2012.

## Annual Review

October 2009



## Contents

### Immense potential; however, long way to catch up

Executive summary	1
Carbon credit	3
Power generation from municipal solid waste	17
Wind energy	35
Small hydropower	53
Solar energy	63
Biofuels	79
Glossary	109
Abbreviations and acronyms	117

# Contents

## Sections

Executive summary	1
1.0 Carbon credit	3
- Summary	3
- An introduction	3
- The Kyoto Protocol	4
- Clean Development Mechanism (CDM)	5
- Global scenario	9
- Methodologies for calculating CERs	11
- Annexure	14
2.0 Power generation from municipal solid waste	17
- Summary	17
- Introduction	17
- Annexure	31
3.0 Wind energy	35
- Summary	35
- Introduction	35
- Offshore wind farms development across the world	37
- Regulations: Fiscal incentives have aided growth	41
- Global scenario	43
- Annexure	47
4.0 Small hydropower	53
- Summary	53
- Introduction	53
- Process of power generation	55
5.0 Solar energy	63
- Summary	63
- Introduction	63
- Annexure	73

Continued...

...continued

## Sections

6.0	Biofuels	79
-	Summary	79
-	Ethanol	79
-	Introduction	79
-	Supply scenario	80
-	Player profile	81
-	Global scenario	83
-	Annexure	86
-	Biodiesel	93
-	Introduction	93
-	Supply	94
-	Global scenario	98
-	Annexure	99
7.0	Glossary	109
8.0	Abbreviations and acronyms	117

## Charts

<u>1.0</u>	<u>Carbon credit</u>	
01	CDM project registration process	6
02	Certified emission reductions	14
<u>2.0</u>	<u>Power generation from municipal solid waste</u>	
01	Classification of municipal solid waste	17
02	Present status of waste disposal	18
03	Ideal way of waste disposal	18
04	Process of power generation from municipal solid waste	21
<u>3.0</u>	<u>Wind energy</u>	
01	Offshore wind farm	36
02	Wind energy generator components	47
03	Power transmission process from windmill	48
<u>4.0</u>	<u>Small hydropower</u>	
01	Classification of hydropower plant	54
<u>5.0</u>	<u>Solar energy</u>	
01	Working of photovoltaic cell	75
02	Schematic of a concentrated solar thermal trough power plant with storage	78

continued...

...continued

## Charts

<u>6.0</u>	<u>Biofuels</u>	
01	Molecular structure of ethanol	86
02	Production process of ethanol by sugarcane route	89
03	Production of biodiesel using Jatropha as feedstock	104
04	Transesterification process	104
05	Transesterification reaction	104
06	State-wise biofuel plantation potential and status	107

## Figures

<u>1.0</u>	<u>Carbon credit</u>	
01	CERs expected by India	7
02	Region-wise breakup of CER issued until date	9
03	Project-wise breakup of CER expected by 2012	10
04	Surplus/deficit of carbon emissions by European countries in 2008	10
05	CER rates since January 2008	11
<u>2.0</u>	<u>Power generation from municipal solid waste</u>	
01	Waste generated in the 59 cities covered by Central Pollution Control Board	19
02	Cost of supply across different fuels	28
<u>3.0</u>	<u>Wind energy</u>	
01	Breakup of capital cost for offshore and onshore wind farms	37
02	Installed capacity of different renewable sources of energy as of March 2009	40
03	Global cumulative installed wind power capacity 1997-2008	44
<u>4.0</u>	<u>Small hydropower</u>	
01	Small hydropower plant installed capacity	57
02	Region-wise breakup of identified potential SHP sites and capacity	58
<u>5.0</u>	<u>Solar energy</u>	
01	Cumulative installed PV power	
01	Cumulative installed PV power capacity in Germany	71
03	Cumulative installed PV power capacity in Spain	71
04	Cumulative installed PV power capacity in Japan	72
05	Cumulative installed PV power capacity in USA	73
<u>6.0</u>	<u>Biofuels</u>	
01	Year-wise cultivation of Jatropha saplings in Chhattisgarh	95
02	Global biodiesel production	98

continued...

## Tables

<u>1.0</u>	<u>Carbon credit</u>	
01	Evolution of carbon credit	4
02	Global warming potential	5
03	Few Indian companies eligible for carbon credit	8
04	Different categories of CDM projects for computation of CERs	12
05	List of Annex I countries	14
06	List of non-Annex I countries	15
<u>2.0</u>	<u>Power generation from municipal solid waste</u>	
01	Waste generated in 59 cities	20
02	Financial assistance by the Government	22
03	Power projects based on municipal solid waste	22
04	Potential power generation capacity from municipal solid waste	24
05	MSW-based power plant across the world	25
06	Sensitivity analysis of PLF and tariffs to equity IRR and project IRR	26
07	Sensitivity analysis of PLF and capital cost to Equity IRR and Project IRR	26
08	Sensitivity analysis of PLF and CER rates to Equity IRR and Project IRR	27
09	Sensitivity analysis of PLF and fuel cost to Equity IRR and Project IRR	27
10	State-wise installed capacity of biomass-based power as of March 2009	29
11	State-wise potential installed capacity for bagasse-based power co-generation in India	29
12	Capital subsidy for bagasse/biomass cogeneration projects	30
13	Fiscal incentives for biomass power generation	30
14	Financial support by MNRE for biomass-based power projects	31
15	Financial support by MNRE for biomass gasifier projects	31
16	Impact of steam generation pressure/temperature on power generation capacity in a typical 2,500 TCD sugar mill	32
17	Producer gas composition	33
<u>3.0</u>	<u>Wind energy</u>	
01	Year-wise installed capacity of offshore wind farms	38
02	Offshore wind capacity target	39
03	State-wise gross onshore wind potential and installed capacity	40
04	State-wise installed capacity of wind power	41
05	Incentives provided by various state governments	42
06	State-wise potential wind power	42
07	New capacity addition in 2008	44
08	USA - cumulative installed wind power capacity	45
09	Germany - cumulative installed wind power capacity	45
10	Spain - cumulative installed wind power capacity	46
11	Chain - cumulative installed wind power capacity	46

continued...

...continued

## Tables

<u>4.0</u>	<u>Small hydropower</u>	
01	Requirements for small hydropower plant	55
02	State-wise installed SHP capacities as of March 2009	57
03	SHP projects in private sector as of March 2009	58
04	State policies for private sector small hydropower projects	59
05	Sensitivity analysis of PLF and capital cost of plant to tariff	61
06	Sensitivity analysis of long-term interest rate and PLF to tariffs	61
07	Sensitivity analysis of free power to states and PLF to tariffs	62
<u>5.0</u>	<u>Solar energy</u>	
01	State-wise grid-connected installed capacity	64
02	Programme-wise achievement	64
03	Existing player's expansion and new entrants in the industry	65
04	Tariff across different states	68
05	Top 10 countries with installed PV power capacity	69
06	Cumulative installed PV power as at the end of 2008	70
<u>6.0</u>	<u>Biofuels</u>	
01	Potential ethanol demand	80
02	Demand-supply of alcohol	80
03	Status of ethanol blending across different states	81
04	Shree Renuka Sugars Ltd - Profit and loss account	82
05	Bajaj Hindustan Ltd - Profit and loss account	83
06	Annual World Ethanol production by country	84
07	Ethanol production statistics	85
08	Country-wise production of ethanol in the EU	85
09	Production capacity as of August 2009	86
10	Properties of petrol and ethanol	87
11	Comparison of cane and sugar beet	90
12	Comparison of sugarcane with other feedstock	91
13	Diesel consumption and forecast	94
14	Biodiesel demand at various blending levels	94
15	Plantation area required in hectares	95
16	State-wise distribution of waste lands under National Mission on biodiesel for 96 Jatropha plantations in India	96
17	Biodiesel price economics	97
18	Landed costs of import of edible oils	97
19	Acreage of oilseeds over a 5-year period	97
20	Feedstock used for biodiesel production	98
21	European biodiesel production capacity	99
22	Biodiesel - physical properties	100
23	Properties of different methyl esters in comparison with diesel fuel	100
24	Typical oil extraction from 100 kg of oil seeds	105
25	Standards for biodiesel	106