Department of Industrial and Management Engineering
Indian Institute of Technology Kanpur

Forum of Regulators

5th Capacity Building Programme for Officers of Electricity Regulatory Commissions
18 – 23 Oct., 2012

Renewable Energy Tariffs: Regulations and Design

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Renewable Energy (RE) policies

Policy Mechanisms to promote RE

- Grants and Rebates
- Tax Credits
- Competitive Tenders and Auctions
- Tradable Renewable Energy Certificates
- Renewable Portfolio Standards and Quota systems
- Net Metering
- Feed-In Tariff (FIT)
- Competing or combining policies

FITs are the most widely used policy mechanism globally

Feed-In-Tariff Definition

Feed-in Tariff (FIT):

- A renewable energy policy that offers a guarantee of payment to renewable energy developers for the electricity they produce.

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Feed-in tariffs go by many names

- Advanced Renewable Tariffs
  - A system of feed-in tariffs (prices or payments) for different technologies
- Renewable Energy Payments
  - Because the “tariffs” are a payment per kilowatt-hour of electricity generated
- Standard Offer Contracts
  - Feed-in tariffs use “standard contracts” and “standard offers”
  - “offers” may differ by technology (one price for solar, another for wind)
- Also called fixed-price policies, minimum price policies, feed laws, feed-in laws, renewable and energy dividends

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Access to the grid: Interconnection

Connectivity should be:

- Guarantee and on priority
- Simple, timely, and at reasonable cost

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Priority Purchase

- Renewable energy must be first priority
  - Must run status
  - Take or pay contracts
- Producer must be assured that the electricity they produce is purchased
- Only exception is “system emergencies”

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Contract Length

- Tariff levels are usually guaranteed for a longer period
  - 20 years or more
  - Longer contracts = lower initial tariff
  - Shorter contracts = higher initial tariffs
- Standardized Contract (Model PPA)

In this way FiT provides long-term certainty about receiving financial support, which is considered to lower investment risks

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Specific Tariff Design

- Differentiated by technology
  - wind, solar, biomass, hydro, etc.
- Differentiated by project size
  - higher prices for small projects
  - lower prices for large projects
- Differentiated by resources qualities
- Differentiated by application
  - higher prices for rooftop solar , BIPV
- Differentiated by project location

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Ancillary Design Elements

- Pre determined tariff degression
- Responsive tariff degression
- Annual inflation adjustment
- Front-end loading (i.e., higher tariffs initially, lower tariffs later on)
- Time of delivery (coincidence with demand to encourage peak shaving)

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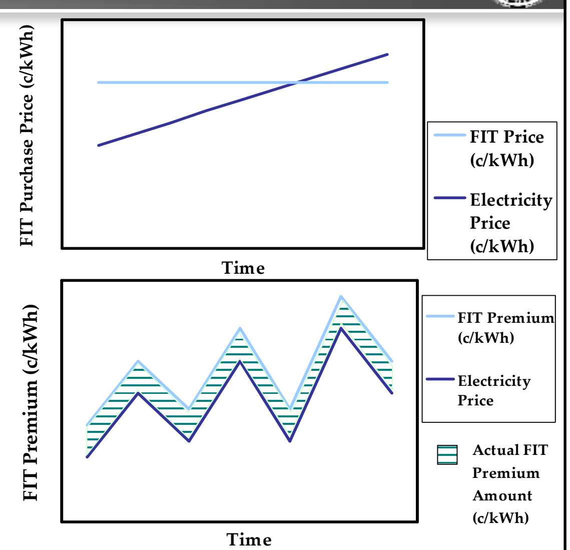
Fundamental FIT Payment Choice

(1) Fixed Price FIT Payment

Fixed Price FITs most common

(2) Premium FIT Payment (above market price)



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Front loading payment stream

- Instead of having a constant tariff level for the complete support duration, it can be considered to increase tariffs for the first years of a project while decreasing tariffs in the last years.
- It can help to reduce financing cost without increasing the total sum of financial support,.

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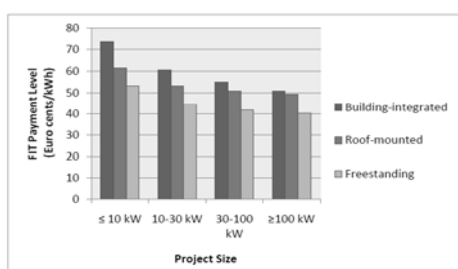
Differentiation by Project Size

(i.e., kW or MW Capacity)

- Lowest payment level is typically offered to the largest plants
- Reflecting the gains that result from economies of scale
- Differentiating FiT payments by project size is another means of offering FiT payments that reflect actual project costs

- E.g.: France, Germany, Switzerland, and Italy provide the highest tariff amounts for the smallest PV installations



Source: SFOE 2010

Switzerland's solar PV payment

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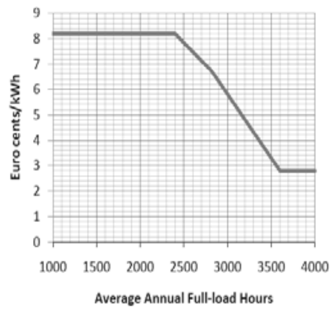
Differentiation by Resource Quality

- Different payments to projects in areas with a different cost of production
  - to encourage development in a wider variety of areas, which can bring a number of benefits both to the grid and to society
  - to match the payment levels as closely as possible to RE generation costs
  - For e.g. areas with a high-quality wind resource will produce more electricity from the same capital investment, all else being equal, leading to a lower levelized cost (FIT)

Denmark, France, Germany, Portugal, and Switzerland have implemented resource adjusted payment levels



On Shore wind farm FIT Payment Level
(10 to 15 Years)
Source: France 2006, NREL 2010

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Differentiation by Project Location

- Varied payments to projects mounted in different physical locations (without regard to resource quality)
  - To encourage project development in particular applications,
  - To encourage multi-functionality (e.g. solar PV),
  - Target particular owner types such as homeowners,
  - To meet a number of other policy goals

System Location	Payment Level (€ cents/kWh)
BIPV on recently constructed[42] residential buildings, schools, & health facilities	58
BIPV (on other recently constructed buildings)	50
Simplified BIPV	42
Freestanding PV (>250 kW)[43]	31.4
Source: France 2010a	

France FIT Payment Differentiation by Location for PV Systems (2010)

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Predetermined Tariff Degression

- Used to keep tariffs in line with evolving cost realities through decreases in the payment level, at either specific points in time, or as capacity targets are reached
- Fixed annual percentage declines, or According to a "responsive" formula that allows the rate of degression to respond to the rate of market growth
  - Degression rates will be greater for rapidly evolving RE technologies such as PV
  - Degression creates greater investor security by removing the uncertainty associated with annual program revisions and adjustments

Tariff Degression for Landfill Gas Facilities in Germany (Germany RES Act 2008)

Project Size	Payment levels (€ cents/kWh) Based on an annual degression of 1.5% — In-Service Year					
	2009	2010	2011	2012	2013	2014
0-500 kW	9.00	8.87	8.73	8.60	8.47	8.34
500 kW-5 MW	6.16	6.07	5.98	5.89	5.80	5.71

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FIT: Responsive Degression

- Degression is adjusted according to the rate of market growth (Germany RES Act 2008)
- In Germany's case, if the annual installed PV capacity in a given year exceeds a certain amount, the percentage rate of annual degression is increased by 1%; if it falls short of a certain annual installed capacity, the degression rate is decreased by 1%

German Responsive Degression Rates

Year	Market Condition (this year)	Next year's annual degression rate
2009:	< 1,000 MW installed	Declines 1% (e.g. 8% to 7%)
	Between 1,000-1,500 MW installed	No change
	1,500+ MW installed	Increases 1% (e.g. 8% to 9%)
2010	< 1,100 MW installed	Declines 1% (e.g. 8% to 7%)
	Between 1,100-1,700 MW installed	No change
	1,700+ MW installed	Increases 1% (e.g. 8% to 9%)
2011	< 1,200 MW installed	Declines 1% (e.g. 8% to 7%)
	Between 1,200-1,900 MW installed	No change
	1,900+ MW installed	Increases 1% (e.g. 8% to 9%)

Source: Adapted from Jacobs and Pfeiffer 2009; see also Germany 2008 and 2010

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Inflation Protection

- Feed-In Tariffs are index linked to the Retail Prices Index (RPI), which means the tariff is subject to inflation
  - Protects invested capital
- Higher protection = lower initial tariffs
- Prices adjusted periodically
  - For new projects
  - Inside existing contracts
- Inflation indexing often less than 100%
  - France & Spain: 50% to 70% indexing

Greater protection offered on the value of project revenues, adjusting FITs for inflation can reduce the perceived risk of the policy for investors

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Periodic Review

Reviews every 2-5 years enables to:

- Determines if targets being met
- Allows price adjustment
  - If profits are too high
  - If targets are not being met
- Allows addition of new technologies

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Fiscal and other support incentives

- Direct production incentives/Generation Based Incentive
- Investment subsidies
- Low-interest loans
- Loan guarantees
- Flexible/accelerated depreciation schemes
- Investment or production tax exemptions

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Advantages of FIT Policies

- Offer a secure and stable market for investors
- Stimulate significant and quantifiable growth of local industry and job creation
- Only cost money if projects actually operate (i.e. Fits are performance-based)
- Provide lower transaction costs
- Can secure the fixed-price benefits of RE generation for the utility's customers by acting as a hedge against volatility

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Advantages of FIT Policies

- Settle uncertainties related to grid access and interconnection
- Enhance market access for investors and participants
- Predictable revenues : Enable traditional financing
- Encourage technologies at different stages of maturity, including emerging technologies
- Customize the policy to support various market conditions, including regulated and competitive markets

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Other benefits are that FIT policies

- Have a measurable impact on RE generation and capacity
- Tailor the policies using a range of design elements that will achieve a wide range of policy goals
- Are compatible with RPS mandates
- Can help utilities meet their RPS mandates
- Can provide a purchase price to renewable energy generators that is not linked to avoided costs
- Demonstrate a flexible project-specific design that allows for adjustments to ensure high levels of cost & efficiency

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Disadvantages of FIT Policies

- FITs can lead to near-term upward pressure on electricity prices, particularly if they lead to rapid growth in emerging (i.e., higher-cost) RE technologies
- FITs may distort wholesale electricity market prices
- FITs do not directly address the high up-front costs of RE technologies – instead, they are generally designed to offer stable revenue streams over a period of 15-25 years, which enables the high up-front costs to be amortized over time

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Disadvantages of FIT Policies

- Due to the fact that RE investments are generally limited to citizens with disposable (i.e. investable) income, as well as with property on which to install RE systems, FITs may exclude lower-income individuals from participating because these individuals are generally required to share the cost burden via higher bills, this can create or exacerbate social inequity
- FITs do not encourage direct price competition between project developers

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Disadvantages of FIT Policies

- It may be difficult to control overall policy costs under FIT policies, because it is difficult to predict the rate of market uptake without intermediate caps or capacity-based degression
- It can be challenging to incorporate FITs within existing policy frameworks and regulatory environments
- FITs are not "market-oriented," primarily because FITs often involve must-take provisions for the electricity generated, and the payment levels offered are frequently independent from market price signals

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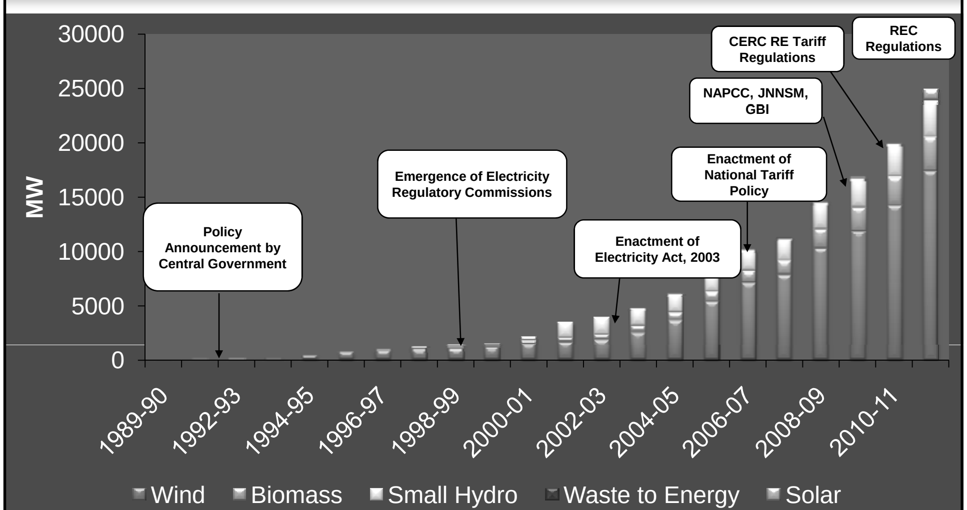
Renewable Energy Generation Capacity Growth in India



Spurt in growth of Renewables after enactment of the Electricity Act, 2003 26

Regulatory Intervention

- Renewable Purchase Obligation (RPO)
- Preferential Tariff
- Facilitative Framework for Grid Connectivity
- Market Development (Tradable Renewable Energy Certificates)

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Regulatory Instrument for promotion of RE in India

- RPO along with Preferential tariff was the main instrument until 2010
- RPO with Preferential tariff and Renewable Energy Certificate (REC) are the instrument s for promotion of RE in India

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REGULATORY INITIATIVE:

PREFERENTIAL TARIFF

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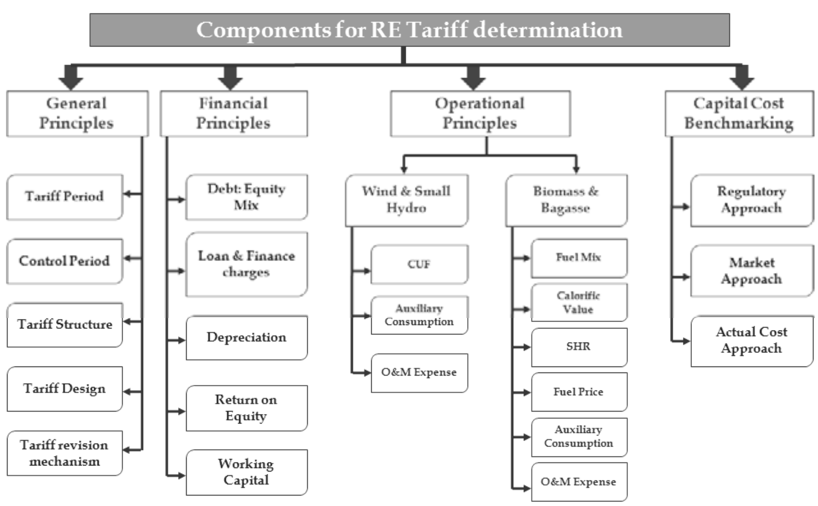
CERC RE Tariff Regulations



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Levellised tariff

- Generic tariff on levellised basis for the Tariff Period
- RE technologies having fuel usage :
  - Single part tariff with two components: Fixed and variable
  - Tariff shall be determined on levellised basis for fixed cost component
  - While the fuel cost component shall be specified on year of operation basis
- For the purpose of levellised tariff computation, the discount factor equivalent to Post Tax weighted average cost of capital
- Levellisation to be carried out for the 'useful life'

A balanced approach vis a vis concerns of front loaded tariff, back loaded tariff etc.

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Generic v/s Project specific tariff

- Provision for project specific tariff on case to case basis, for new RE technologies like:
  - Municipal Solid Waste to Energy Projects
  - Hybrid Solar Thermal Power plants
  - Hybrid options (i.e. renewable–renewable or renewable–conventional sources)
  - Any other new renewable energy technologies as approved by MNRE

The financial norms specified for determination of Generic Tariff except for capital cost, would be ceiling norms while determining the project specific tariff

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Tariff Period

- Wind, Biomass, Bagasse based cogeneration projects:13 years

> - **Regulatory support during the 13 year tariff period will provide certainty to the project developer to meet its debt service obligations**
> - **After this period, the competitive procurement of RE will ensure that power is procured at most reasonable rate, and benefit passed on the consumer**

- Small hydro projects below 5 MW: 35 years
- Solar PV and Solar thermal power projects: 25 years
- Biomass Gasifier and Biogas based power projects: 20 years

> - **Longer duration of tariff support in view of smaller size/nascent technologies**

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Capital Cost Benchmarking

- Various approaches are evaluated for development of benchmark capital cost for different RE technologies
  - **Regulatory Approach:** Norms as approved by various SERCs are most simple and easy to follow
  - **Market Based Approach:** Project awarded through competitive tender process carried out by public and private entities
  - **Actual Project Cost Approach: Information furnished by developers as a part of project appraisal requirements to various financial institutions/banks to avail** loan or to UNFCCC for registering the project to avail CDM benefits
  - **International Project Cost based Approach**

> **Subsequently suitable indexation mechanism devised to consider the year on year variation for the underlying capital cost parameters**

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Financial Principles

- **Debt : Equity Ratio** considered at 70 : 30. For project specific tariff,
  - In case of equity funding in excess of 30%, to be treated as normative loan.
  - In case of equity funding lower than 30%, actual equity to be considered.
- **Return on Equity**
  - Value base at 30% of capital cost or actual equity (whichever is lower).
  - Pre-tax ROE: 19% p.a. for first 10 years and 24% p.a. from 11th year onwards.
- **Loan Terms**
  - Tenure of loan considered as 12 years.
  - Interest rate : SBI Base rate + 300 basis points
- **Depreciation**
  - 'Differential depreciation' approach over loan period & 'Straight Line' method over the remaining useful life.
  - Allowed upto 90% of capital cost considering salvage value as 10%.
  - On SLM basis at 5.83 % p.a. for first 12 years and remaining depreciation to be spread over balance useful life of asset.

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Financial Principles

Useful Life

- Wind Energy : 25 years
- Biomass power / cogeneration : 20 years
- Small hydro power : 35 years
- Solar PV and Solar thermal : 25 years

Sharing of CDM benefits

- Share of developer to be 100% for 1st year after COD.
- Share of beneficiary to be 10% in second year to be increased progressively at 10% per year till it reaches 50%.
- Thereafter, sharing shall be on equal proportion basis.

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Financial Principles

Working Capital

Technology	O&M expense	Receivables	Maintenance spares	Fuel cost
Wind/ Small Hydro/ Solar	1 Month	2 Month	15% of O&M expense	
Biomass/ Non-fossil Fuel Co-generation	1 Month	2 Month	15% of O&M expense	4 months of fuel stock at normative PLF

- Interest rate equivalent to average SBI Base rate plus 350 basis points

TECHNOLOGY SPECIFIC PARAMETERS

Wind Energy

Eligibility Criteria :

- New Wind energy projects

Capital Cost:

- Rs 575 Lakh/MW for first year of Control Period (FY 2012-13)
- Linked to indexation mechanism over Control Period

O&M expense:

- Rs 9 Lakh/MW for first year of Control Period (FY 2012-13 with escalation at 5.72% / annum

Capacity Utilization Factor :

Annual Mean Wind Power Density (W/m^2)	CUF
Up to 200	20%
201-250	22%
251300	25%
301-400	30%
> 400	32%

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Small Hydro Projects

S. No.	Particular	Unit	Description
1.	**Capital cost**		
	Himanchal Pradesh and Uttarakhand (Below 5 MW)	Rs Lakh/ MW	770
	Himanchal Pradesh and Uttarakhand (5 MW to 25 MW)	Rs Lakh/ MW	700
	Other States (Below 5 MW)	Rs Lakh/ MW	600
	Other States (5 MW to 25 MW)	Rs Lakh/ MW	550
2.	**Capacity Utilisation Factor (CUF)**		
	Himanchal Pradesh and Uttarakhand	%	45%
	Other States	%	30%
3.	**O&M cost**		
	Himanchal Pradesh and Uttarakhand (Below 5 MW)	Rs Lakh/ MW	25
	Himanchal Pradesh and Uttarakhand (5 MW to 25 MW)	Rs Lakh/ MW	18
	Other States (Below 5 MW)	Rs Lakh/ MW	20
	Other States (5 MW to 25 MW)	Rs Lakh/ MW	14
4.	Auxiliary Consumption	%	1%

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Biomass Power Projects

Eligibility Criteria:

- Biomass power projects based on Rankine cycle technology and using biomass fuel sources, provided use of fossil fuel is restricted only to 15% of total fuel consumption on annual basis.

S. No.	Particular	Unit	Description
1	Capital Cost	Rs Lakh/MW	450
2	Plant Load Factor		
	1st yr during stabilization	%	60%
	remaining period of the 1st yr	%	70%
	Next year onward	%	80%
3	Auxiliary Consumption	%	10
4	Station Heat Rate	kCal/kWh	4000
5	O&M Expenses	Rs Lakh/MW	24

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Non- Fossil Fuel Based Co-generation

S. No.	Particular	Unit	Description
1.	Capital Cost	Rs Lakh/MW	420
2.	Auxiliary Consumption	%	8.5
3.	Station Heat Rate	kCal/kWh	3600
4.	O&M Expenses	Rs Lakh/MW	15
5.	Plant Load Factor	Operating days	PLF
	Uttar Pradesh and Andhra Pradesh	180 days	45%
	Tamil Nadu and Maharashtra	240 days	60%
	Other States	210 days	53%
6..	GCV	kCal/kg	2250

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Solar PV & Solar Thermal

S. No.	Particular	Unit	Solar PV	Solar Thermal
1.	Technology Aspect		crystalline silicon or thin film etc.	Concentrated solar power (CSP) technologies viz. line focusing or point focusing
2.	Capital cost	Rs Lakh/ MW	1000	1300
3.	CUF	%	19%	23%
4.	O&M cost	Rs Lakh/ MW	9.0	13
5.	Auxiliary Consumption	%	NA	10%

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RE Tariff Order 2012-13 35/2012 (suo-moto)

Wind

	Annual Mean WPD (W/m2) at 50 mtr HH	CUF	2009-10 ` /kWh	2010-11 ` /kWh	2011-12 ` /kWh
Zone-1	200-250	20%	5.63	5.07	5.33
Zone-2	250-300	23%	4.90	4.41	4.63
Zone-3	300-400	27%	4.70	3.75	3.95
Zone-4	> 400	30%	3.75	3.38	3.55
	WPD at 80 mtr		2012-13 ` /kWh		
Zone-1	Upto 200	20%	5.96		
Zone-2	200-250	22%	5.42		
Zone-3	250-300	25%	4.77		
Zone-4	300-400	29%	3.97		
Zone-5	> 400	32%	3.73		

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Small Hydro Power

	09-10	10-11	11-12	**12-13**	Diff.
HP, Uttarakhand and NE States (Below 5MW) ` /kWh	3.90	3.59	3.78	**4.14**	0.36
HP, Uttarakhand and NE States (5MW to 25 MW) ` /kWh	3.35	3.06	3.22	**3.54**	0.32
Other States (Below 5 MW) ` /kWh	4.62	4.26	4.49	**4.88**	0.39
Other States (5MW to 25 MW) ` /kWh	4.00	3.65	3.84	**4.16**	0.32

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Biomass Power Project

Biomass Tariff Capital Cost: ` 4.26 Crore/MW (FY11-12) Capital Cost: ` 4.45 Crore/MW (FY12-13)			Difference
	2011-12 ` /kWh	2012-13 ` /kWh	` /kWh
Andhra Pradesh	3.78	**5.18**	1.40
Haryana	4.97	**5.65**	0.68
Maharashtra	4.31	**5.74**	1.43
Punjab	4.94	**5.83**	0.89
Rajasthan	4.28	**5.16**	0.88
Tamil Nadu	4.58	**5.12**	0.54
Uttar Pradesh	4.06	**5.24**	1.18
Others	4.41	**5.42**	1.01

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Non-Fossil Fuel based Cogeneration

Bagasse based Co-generation: ` /kWh Capital Cost: ` 4.21 Crore/MW (FY11-12) Capital Cost: ` 4.20 Crore/MW (FY12-13)					Difference
States	09-10 ` /kWh	10-11 ` /kWh	11-12 ` /kWh	12-13 ` /kWh	` /kWh
Andhra Pradesh	4.93	4.23	4.51	**5.06**	0.55
Haryana	5.78	4.86	5.21	**5.73**	0.52
Maharashtra	4.80	4.05	4.34	**5.42**	1.08
Punjab	5.75	4.84	5.19	**5.30**	0.11
Tamil Nadu	5.10	4.29	4.60	**4.61**	0.01
Uttar Pradesh	5.21	4.45	4.76	**5.35**	0.59
Others	5.17	4.38	4.68	**5.20**	0.52

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Solar PV & Thermal

Technology	2009-10 ` /kWh	2010-11 ` /kWh	2011-12 ` /kWh	2012-13 ` /kWh	Diff. ` /kWh
Solar PV CC: ` 14.42 Cr/MW (FY11-12) CC: ` 10 Cr/MW (FY12-13)	18.44	17.91	15.39	**10.39**	-5.00
Solar Thermal CC: ` 15 Cr/MW (FY11-12) CC: ` 13 Cr/MW (FY12-13)	13.45	15.31	15.04	**12.46**	-2.58

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Biomass Gasifier and Biogas

State	Levellised Fixed Cost (`/kWh)	Variable Cost (FY 2012-13) (`/kWh)	Applicable Tariff Rate (FY 2012-13) (`/kWh)	Benefit of Accelerated Depreciation (if availed) (`/kWh)	Net Levellised Tariff (upon adjusting for Accelerated Depreciation benefit) (if availed) (`/kWh)
Biomass Gasifier Power Project					
Andhra Pradesh	2.29	3.22	**5.51**	0.11	5.40
Haryana	2.34	3.66	**6.00**	0.11	5.89
Maharashtra	2.35	3.74	**6.09**	0.11	5.98
Punjab	2.36	3.83	**6.19**	0.11	6.08
Rajasthan	2.29	3.19	**5.48**	0.11	5.37
Tamil Nadu	2.28	3.16	**5.44**	0.11	5.33
Uttar Pradesh	2.29	3.27	**5.56**	0.11	5.45
Others	2.32	3.44	**5.76**	0.11	5.65
Biogas based power project					
Biogas	3.06	3.38	**6.44**	0.21	6.23

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COMPETITIVE BIDDING FOR TARIFF DISCOVERY

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Reverse bidding experience : Solar

Bid discount from reference tariff (CERC determined Tariff)

- Target for Phase I (2013): 1000 MW
- Batch –I : 620 MW capacity tied up through Competitive bidding
  - 37 bidders selected through reverse bidding auction
  - 470 MW Solar Thermal & 150 MW Solar PV
    - Solar Thermal: Rs. 10.49 to 12.24/kWh
    - Solar PV: Rs. 10.95 to 12.75/kWh
- Batch – II : 345 MW Solar PV capacity tied up through Competitive bidding
  - 26 bidders selected through reverse bidding auction: Discount offered in CERC tariff
    - Solar PV: Rs. 7.49 to 9.39/kWh

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Issues and Way Forward

- Issues
  - Competitive procurement of renewable energy
    - Whether competitive bidding the right strategy for infirm RE technologies ?
  - Should FiT co-exist with REC
- Way Forward
  - Bidding Guidelines being issued
  - REC mechanism being reviewed

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Thank You

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TECHNOLOGY SPECIFIC NORMS: WIND ENERGY

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Wind - Capital Cost

Wind

Capital Cost

CUF

O & M Cost

RE Tariff Regulations-2009

Year	Date of Regulations/Order	Capital cost ` Lacs/MW
2009-10	17.09.2009	515.00
2010-11	26.02.2010	467.13
2011-12	09.11.2010	492.52

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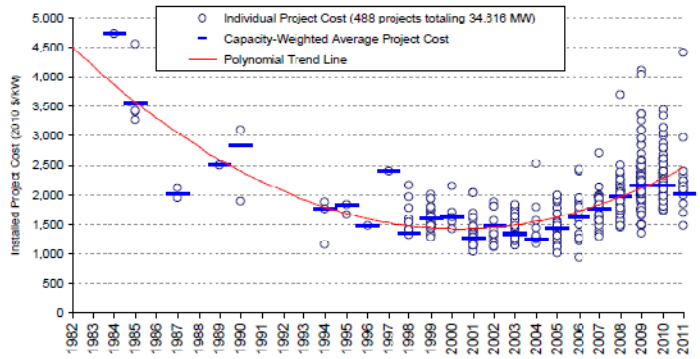
Wind - Capital Cost

Wind

- Capital Cost
- CUF
- O & M Cost

International Trend: Installed Project Cost - USA



Note: 2011 data represent preliminary cost estimates for a sample of 17 projects totaling 1.1 GW that have either already been or will be built in 2011, and for which reliable cost estimates were available.
Source: Berkeley Lab (some data points suppressed to protect confidentiality)

U.S. Department of Energy's report on "2010 Wind Technologies Market Report": June - 2011 prepared by the Lawrence Berkeley National Laboratory (LBNL)

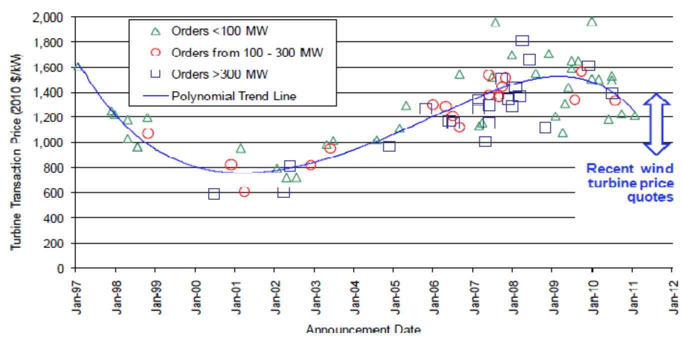
- 1 GW of capacity that either have been or will be built in 2011 suggests that average installed costs may decline in 2011

Wind - Capital Cost

Wind

- Capital Cost
- CUF
- O & M Cost

International Trend: Turbine Cost - USA



Source: Berkeley Lab

U.S. Department of Energy's report on "2010 Wind Technologies Market Report": June - 2011 prepared by the Lawrence Berkeley National Laboratory (LBNL)

- **In US total Project costs which were bottomed out in 2001-04; rose by $850/kW on average through 2009; held steady in 2010 at around $2,160/kW and appear to be dropping in 2011 at around $2000/kW**

Wind - Capital Cost

Wind

Capital Cost

CUF

O & M Cost

Capital Cost considered by other SERCs

Name of the Commission	Date of Order/Regulation	Capital cost ` Lacs/MW
CERC (2009-10)	17.09.2009	515.00
KERC	11.12.2009	470.00 (inc. evacuation cost)
CERC (2010-11)	26.02.2010	467.13
MPERC	14.05.2010	500.00 (inc. evacuation cost)
OERC (FY 10-11 to12-13)	14.09.2010	467.13 (As per CERC)
CERC (2011-12)	09.11.2010	492.52
MERC (2010-11)	29.04.2011	489.53 (As per CERC)

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Wind - Capital Cost

Wind

Capital Cost

CUF

O & M Cost

Capital Cost:

Source	No. of Projects	MW	Weighted Average Capital Cost ` Cr./ MW
IREDA (FY 10-11)	10	570	5.90
IREDA (FY 11-12)	4	220	5.90
UNFCCC (FY 09-10)	14	137	5.23
UNFCCC (FY 10-11)	5	84	5.47
Tender (FY 10-11)	5	34	6.00
Total	38	1045	

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Wind - Capital Cost

Wind

- Capital Cost
- CUF
- O & M Cost

2.1 MW-S88		
Component Breakup	**% cost**	**Net Cost**
SUPPLY OF WTG WITHOUT TT	58%	33265546
SUPPLY OF BLADE	9%	5284916
SUPPLY OF TT	12%	6761086
SUPPLY OF TRANSFORMER	1%	751232
ERECTION	2%	974985
COMMISSIONING	0%	108272
MEDA CHARGES	1%	315517
MEDA Application Fees	0%	5259
ZP Road charges	0%	210345
CIVIL WORKS	5%	2925897
ELEC LINE & SUPPLY	4%	2299406
LAND	3%	1442365
EVACUATION	5%	3155174
	100%	57,500,000

Wind: Capacity Utilisation Factor

Wind

- Capital Cost
- CUF
- O & M Cost

RE Tariff Regulations-2009

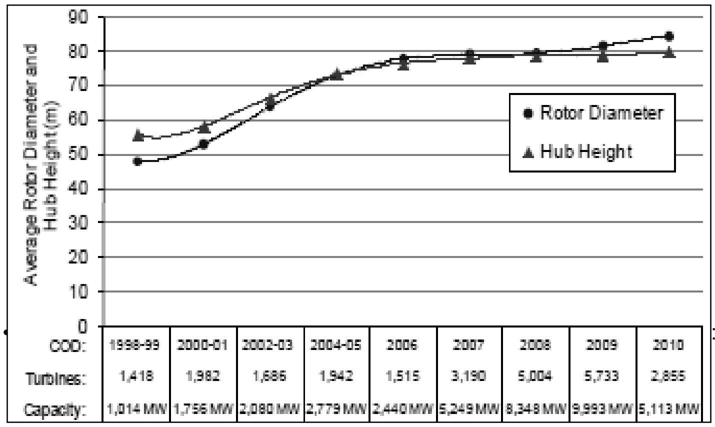
Annual Mean Wind Power Density (W/m2) at 50 mtr hub height	CUF
200-250	20%
250-300	23%
300-400	27%
> 400	30%

- ... basis of
- C-WET
  - Published Indian Wind Atlas in February 2010
- **MNRE Circular dated 1.08.2011: No restriction will exist for WPD criteria as far the development of wind power project is concerned**

Historical Increase in Hub Height & Rotor Diameter: USA

Wind

- Capital Cost
- CUF
- O & M Cost



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Wind Energy Installation: FY 10-11

Wind

- Capital Cost
- CUF
- O & M Cost

Developer / State	MAH	KAR	TN	RAJ	MP	GUJ	AP	Total	%	Hub Height
Suzlon	107.2	93.95	191.55	333.5	42.6	183.1		951.9	**40.48**	65 75 78 80
Enercon	31.2	116	112	103.2		78.4	63.2	504	**21.43**	50 56 57 65
Vestas		39.6	115.5			20.4		175.5	**7.46**	70 78 80
Maruti Windfarm	21.15							21.15	**0.90**	
RS Windfarm	41.25							41.25	**1.75**	
TS Windfarm	25							25	**1.06**	
Sriram EPC	1		25			2.5		28.5	**1.21**	41
Vestas RRB			99					99	**4.21**	65
Gamesa			213.35			14.45		227.8	**9.69**	
Regen		4.5	96			7.5		108	**4.59**	75 85
SWPL					6	0.45		6.45	**0.27**	45
GWL			31.93			3		34.93	**1.49**	
Pioneer Wind	2.25		28			2		32.25	**1.37**	50
WinWind			29					29	**1.23**	70
Cwel			14.03					14.03	**0.60**	
INOX			2					2	**0.09**	80
Kenersys	10		2					12	**0.51**	80
Shiva Wind			1.5					1.5	**0.06**	50
TTG			0.25					0.25	**0.01**	
LeitWind			36.3					36.3	**1.54**	65
IWPL						1		1	**0.04**	
TOTAL	**239.05**	**254.05**	**997.41**	**436.7**	**48.6**	**312.8**	**63.2**	**2351.81**	**100**	
%	**10.16**	**10.80**	**42.41**	**18.57**	**2.07**	**13.30**	**2.69**	**100.00**	**84.46**	

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LBNL : Reassessing Wind Potential Estimates for India:

Wind

- Capital Cost
- CUF
- O & M Cost

Wind Power Class	50 m		80 m			100 m			120 m		
	WPD	WS	CF	WPD	WS	CF	WPD	WS	CF	WPD	WS
1	0-200	0-5.6	-	0 - 200	0-5.6	-	0-200	0-5.6	-	0-200	0-5.6
1a	*NA*	*NA*	*20%*	*200 -251.3*	*5.6 -6.0*	*20.0%*	*200-220*	*5.6-5.7*	*20.0%*	*200-237.9*	*5.6-5.9*
1b	*NA*	*NA*	*NA*	*NA*	*NA*	*21.6%*	*220-276.5*	*5.7-6.2*	*23.3%*	*237.9-299*	*5.9-6.3*
2	200 -300	5.6-6.4	25%	251.3 - 375.1	6.0 -6.9	27.0%	276.5-412.7	6.2-7.1	29.0%	299-446.3	6.3-7.3
3	300 -400	6.4-7.0	32%	375.1 - 490.8	6.9-7.5	34.0%	412.7-540	7.1-7.7	35.5%	446.3-583.9	7.3-7.9
4	400 -500	7.0 - 7.5	36%	490.8 - 603.6	7.5-8.0	37.5%	540-664.2	7.7-8.3	39.0%	583.9-718.2	7.9-8.5
5	500 -600	7.5-8.0	39%	603.6 - 732.6	8.0 -8.6	40.5%	664.2-806.1	8.3-8.8	42.0%	718.2-871.6	8.5-9.1
6	600 -800	8.0 - 8.8	42%	732.6 - 975.1	8.6-9.4	43.5%	806.1-1,072.9	8.8-9.7	45.0%	871.6-1,160.1	9.1-10

Source : LBNL

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Wind: Capacity Utilisation Factor (CUF)

Wind

- Capital Cost
- CUF
- O & M Cost

RE Tariff Regulations-2009

	Annual Mean WPD (W/m2) at 50 mtr HH	CUF
Zone-1	200-250	20%
Zone-2	250-300	23%
Zone-3	300-400	27%
Zone-4	> 400	30%

RE Tariff Regulations-2012

	WPD at 80 mtr	
Zone-1	Upto 200	20%
Zone-2	200-250	22%
Zone-3	250-300	25%
Zone-4	300-400	29%
Zone-5	> 400	32%

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Wind: Operation & Maintenance Cost

Wind

- Capital Cost
- CUF
- O & M Cost

RE Tariff Regulations-2009

- Normative O&M expenses for the first year of the Control Period (i.e. FY 2009-10) : ` 6.5 Lakh/ MW.
- Escalation Rate: 5.72% per annum over the tariff period to compute the levellised tariff.
- FY 2010-11: ` 6.87 Lakh/ MW, FY 2011-12: ` 7.26 Lakh/ MW

❑ **O&M agreement being signed between the wind farm developers and investors are in the range of ` 7 to 10 lakh/MW.**

❑ **Now Forecasting cost would be additional cost**

RE Tariff Regulations-2012

- Commission considered 5.72% annual escalation over the normative Operation and Maintenance Cost allowed for FY 11-12 along with additional insurance cost was considered at 0.25% of capital cost as well as forecasting cost: FY 2012-13 Rs. 9 Lakh/MW with 5.72% Esc.

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TECHNOLOGY SPECIFIC NORMS:

Biomass Based Power Projects with Rankine Cycle Technology

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Capital Cost

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

RE Tariff Regulations-2009

Year	Date of Order/Regulation	Capital cost ` Lacs/MW
2009-10	17.09.2009	450.00
2010-11	26.02.2010	402.54
2011-12	09.11.2010	426.30

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Capital Cost

Capital Cost Approved by the SERCs

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

SERCs	Capital Cost ` Cr./MW	Indexation Mechanism	Order/ Regulation	Remark
RERC	5.40 : Water Cooled 5.85 : Air Cooled	As per Formula	Regulation 23/01/2009	
GERC	4.25	Not provided	Order No.5 of 2010: 17.05.2010	Common for water and Air cooled condenser
UERC	4.50	Not provided	Regulation Dated 06.07.2010	As per CERC
MERC	4.03 (2010-11)	As per CERC	Regulation 07.06.2010	As per CERC
KERC	4.87 Incl. Trans. costs	Not provided	Order No.5 of 2010	Took note of CERC specified CC for 2009-10
JSERC	4.50	Not provided	Reg. 27.01.2010	As per CERC
HERC	4.50	Not provided	Order dated 27.5.2011	As per CERC

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Capital Cost

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

Actual Project Cost Approach

Source	FY2009-10			FY2010-11			FY2011-12		
	No of Projects	Cap. MW	WA CC Rs. Cr/MW	No of Projects	Cap. MW	WA CC Rs. Cr/MW	No of Projects	Cap. MW	WA CC Rs. Cr/MW
IREDA	-	-	-	2	20	4.79	1	10	5.00
UNFCCC	4	36.8	4.74	2	24.5	5.39			
Total	4	36.8	4.74	4	44.4	5.12			

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Capital Cost

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

IREDA Benchmark for financing biomass projects for FY 2011-12

Pressure Configuration (ata)	Biomass Power (` Crore/MW)		
	6 MW	7.5 MW	10 MW
44	4.03	3.93	3.79
66	5.38	5.19	5.03
86	5.59	5.37	5.15
102	5.93	5.77	5.61
110	6.05	5.89	5.72

Basis for Formulation of Capital Cost Benchmark:

- Normative capital cost of Rs 4.45 Cr./MW (with Water Cooled Condenser and with out Transmission lines) is proposed for first year of the Control Period

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Biomass Price

RE Tariff Regulations-2009

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

State	Biomass price (Rs/MT) 2009-10	Biomass price (Rs/MT) 2010-11	Biomass price (Rs/MT) 2011-12
Andhra Pradesh	1301	1,342.81	1,460.75
Haryana	2168	2,237.67	2,434.21
Maharashtra	1801	1,858.87	2,022.14
Madhya Pradesh	1299	1,340.74	1,458.50
Punjab	2092	2,159.23	2,348.88
Rajasthan	1822	1,880.55	2,045.72
Tamil Nadu	1823	1,881.58	2,046.84
Uttar Pradesh	1518	1,566.78	1,704.39
Other States	1797	1,854.75	2,017.65

Biomass Price

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

Comments received:

State	As proposed in draft Regulation FY12-13 (` /MT)	Comments received (` /MT)
Andhra Pradesh	2315	e- auction coal price
Haryana	2635	-
Maharashtra	2116	3000-3800
Madhya Pradesh	1507	2864-3000
Punjab	2756	3000
Rajasthan	2300	2415-3215
Tamil Nadu	2277	2500
Uttar Pradesh	2355	-
		Karnataka: 3200, Gujarat 3000, Orissa: 3000

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Biomass Price

Biomass

Capital Cost
Biomass Price
O & M Cost
Station Heat Rate
Gross Calorific value
Auxiliary Consumption

State	Draft Regulation	Biomass Price	Rationale
Andhra	2315	2315	APERC norms escalated with 5% to bring at FY 2012-13
Haryana	2635	2635	HERC norms escalated with 5% to bring at FY 2012-13
Maharashtra	2116	2695	As reviewed by MERC
Madhya	1507	2476	Shifted to other state category
Punjab	2756	2756	PSERC norms escalated with 5% to bring at FY 2012-13
Rajasthan	2300	2300	As proposed in the draft
Tamil Nadu	2277	2277	As proposed in the draft
UP	2355	2355	As proposed in the draft
Other States	2283	2476	Average of the above States

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Biomass Price : Escalation

Biomass

Capital Cost
Biomass Price
O & M Cost
Station Heat Rate
Gross Calorific value
Auxiliary Consumption

Proposal: Fuel price Indexation formula or 5% escalation

Comments received

- Most of the stakeholders suggested that normative escalation factor of should be 10% -11% annum instead of 5% annually escalation.
- Some of the stakeholders have suggested that biomass price/tariff should be fixed annually.

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Biomass Price : Escalation

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

Year	WPI for all Commodities	WPI of HSD	WPI for non coking coal	20% of WPI	20% of WPI of HSD	60% of WPI of Non Cocking coal	Composite Series
1999	76.79	44.29	64.77	15.358	8.858	38.862	63.078
2000	81.59	60.49	67.07	16.318	12.098	40.242	68.658
2001	85.8	69.88	80.19	17.16	13.976	48.114	79.25
2002	87.92	72.65	81.38	17.584	14.53	48.828	80.942
2003	92.6	81.71	85.31	18.52	16.342	51.186	86.048
2004	98.72	95.34	96.5	19.744	19.068	57.9	96.712
2005	103.37	115.39	102.6	20.674	23.078	61.56	105.312
2006	109.59	129.68	102.5	21.918	25.936	61.5	109.354
2007	114.94	125.62	104.01	22.988	25.124	62.406	110.518
2008	124.92	135.66	112.7	24.984	27.132	67.62	119.736
2009	127.86	130.33	116.53	25.572	26.066	69.918	121.556
2010	140.08	147.91	131.2	28.016	29.582	78.72	136.318
2011	152.93	160.37	160.91	30.586	32.074	96.546	159.206
			13 years CAGR				8.02%
			10 Years CAGR				7.81%

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Review of Biomass Fuel prices for the projects commissioned in the earlier control period

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

Proposal:

- The biomass base price shall be revised at the end of the control period for the next Control Period and same shall also be applicable to project commissioned under this Control Period.

Comments received

- Most of the stakeholders suggested that the prices need to be revised every quarterly or half yearly or annually instead of at the end of the Control Period.

RE Tariff Regulations-2012

- The biomass price shall be reviewed in the third year of the control period in order to capture the volatility in the biomass fuel market as well as more realistic prices.

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Operation & Maintenance Cost

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

Proposal in Draft Regulations

- 24 Lakh/MW for FY 2012-13 (which are determined by applying annual escalation factor of 5.72% per annum on the O&M cost norm applicable for FY 2011-12)

Comments received

- Separate norm for project with water-cooled and air-cooled condensers
- Separate norm for smaller biomass power plant
- 6.5% to 9.39% of the Capital cost
- Suggestions received in the range of ` 32 .4 Lakh /MW to ` 50 Lakh/MW
- Annual escalation factor should be 7%

RE Tariff Regulations-2012

- Retained the norm as provided in the draft Regulations

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Station Heat Rate

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

- **RE Tariff Regulations-2009:** 3800 Kcal/kWh
- **Proposal in draft RE Tariff Regulations-2012:** 4000 Kcal/kWh
- **Comments received:**
  - Some of the stakeholders suggested that SHR of 4200kCal/kWh and 4400kCal/kWh should be considered for project with water-cooled condensers and air-cooled condensers
  - Some of the stakeholders requested to consider the SHR as 4500kCal/kWh as per CEA study
  - Station Heat Rate of 4400 kcal/kwh for paddy straw fired biomass power plant should be considered
  - Dalkia Energy Services has recommended to consider SHR as 4100, 4400 and 4150kCal/kWh for rice husk based (> 5MW), straw based and other fuel based biomass power plants.

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Station Heat Rate

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

- **MNRE recommendation on SHR for different technology :**

Biomass Source	IPP (> 5 MW)	Tail End (< 2 MW)
Rice Husk	4100	5200
Straw	4400	5500
Others	4150	5200

- **National Productivity Council** conducted a field study for MEDA for assessment of heat rate of commissioned biomass power plants in Maharashtra.

Project with Boiler Type	Station Heat Rate kCal/KWh
AFBC	4000 – 4100
Traveling Grate	4150 - 4250

- **RE Tariff Regulations-2012:** Station Heat Rate at 4000 kCal/kWh

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Gross Calorific value

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

RE Tariff Regulations-2009: State wise GCV specified, Average GCV was 3462 kCal/kg

Proposal in draft RE Tariff Regulations-2012: 3300 kCal/kg

Comments received

- CEA, National Productivity Council and MNRE recommended GCV have not considered degradation in GCV of these seasonal fuels over the non-seasonal period.
- Due to the rains, storage, contamination by fuel suppliers and inherent mud in agricultural residues there is a significant reduction in GCV of biomass fuels.
- Actual GCV in rice husk is between 3000-3100 kCal/kg.
- GCV of cotton stalk available in Gujarat is around 3600-3700 kcal/kg and average GCV of the biomass would be around 3500.
- Some of the stakeholders suggested that average GCV should be taken as 3000 kCal/kg considering loss during storage

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Gross Calorific value

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

MNRE Recommendation

- MNRE also mentioned that there are other losses which are being encountered during the storage and handling of biomass due to land settlement, loss of fuel during sand storm,
- GCV loss due to decaying of biomass. MNRE referred a recent survey has been carried out by DESL under mandate from Rajasthan Renewable Energy Corporation Ltd. (RREC) to assess such losses which are in the range of 3.2 to 3.5%.
- MNRE recommended that there should be provision of loss of fuel during storage at around 2%.
- MNRE recommended following general principles can be adopted for the GCV as under:

Biomass	GCV (kCal / kg)
Rice husk	3200
Straw/Stalks/Other husks	3300
Plantation	2800

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Gross Calorific value

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

- The National Productivity Council (NPC) in its study mentioned that based on the fuel analysis report from the different plants, GCV & moisture variation found as under:

Biomass	GCV (kCal / kg)	Variation in Moisture (%)
Rice husk	3000-3200	12-18
Maize Bhutia	3500	21
Cotton Stalk (Air Dried Basis)	3250	8

RE Tariff Regulations-2012

- Normative GCV of biomass at 3300 kCal/kg
  - Use of 15% of coal (average coal GCV at 3600 kCal/kg) and 85% uses of Biomass fuel of 3200 kCal/kg.
  - The weighted average GCV works out to around 3300 kCal/kg.

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UNFCCC: FIFTH MONITORING REPORT
Biomass in Rajasthan – Electricity Generation from Mustard Crop Residues

Electricity Exported & Fuel Consumed:

Sl. no	Month	Gross Generation (Kwh)	Auxiliary Consumption* (Kwh)	Net Export to Grid (Kwh)	Power Import (Kwh)	Net Export (After Deduction of Power Import) (Kwh)	Biomass Fuel Consumed (MT)	Fossil Fuel Used (MT)
1	Apr - 08	5398157	490532	4907625	3600	4904025	7023	0
2	May - 08	4753965	487740	4266225	21975	4244250	6342	0
3	Jun - 08	5081085	502785	4578300	8850	4569450	6782	0
4	July-08	3926579	378329	3548250	35700	3512550	4992	0
5	Aug- 08	5133753	494103	4639650	7950	4631700	6413	0
6	Sep - 08	4882806	449931	4432875	7275	4425600	6007	0
7	Oct – 08	2439300	224100	2215200	48750	2166450	3144	0
8	Nov - 08	5614229	458579	5155650	225	5155425	6822	0
9	Dec – 08	5382093	418143	4963950	10200	4953750	6781	0
10	Jan – 09	5401171	421396	4979775	6900	4972875	7026	0
11	Feb - 09	4781205	384555	4396650	7050	4389600	6177	0
12	Mar – 09	5442503	447953	4994550	5625	4988925	6995	0
	Total	**58236846**	**5158146**	**53078700**	**164100**	**52914600**	**74504**	0

As per above data SFC: 1.27 kg/kWh

As per our proposal SHR 4000 kCal/kWh GCV : 3200 Kcal/kg: SFC: 1.25 kg/kWh

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Auxiliary Consumption

Biomass

- Capital Cost
- Biomass Price
- O & M Cost
- Station Heat Rate
- Gross Calorific value
- Auxiliary Consumption

- **RE Tariff Regulations-2009:** 10%
- **Proposal in draft RE Tariff Regulations-2012:** 10%

Comments received

- Many stakeholders have suggested to increase the same which are ranges from 11.5% to 14%
- Separate norm for projects with water cooled and air cooled condensers
- Higher auxiliary consumption during stabilisation period
- Separate norm for straw fired plants, Auxiliary Consumption should be considered at 14% for Water Cooled Condenser and 16% for Air Cooled Condenser

RE Tariff Regulations-2012: 10%

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