



# ANALYSIS OF COST & FINANCIAL ASPECTS OF RICE STRAW BASED POWER PLANT IN INDIA

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## ABSTRACT

The pollution effects of open field burning of rice straw are well known. The harmful effects due to this field burning and its mitigation cost are to be borne by the society and the world at large. Biomass power projects accrue many social benefits (non-monetary), like employment to locals, extra income to farmers, rural area development and renewable power generation etc., but every business needs to be seen from techno-commercial viability and return on investments, if it is to be scaled up for investment. Though Government of India, through Central Electricity Regulatory Commission, and States through their own regulatory commissions, are trying to provide good tariff for promoting biomass based power projects, only 2-3% of theoretical potential has been harnessed so far, in last many decades in India. Thus it becomes important to understand the attractiveness of investment in this field through detailed study on financial aspects. Through this paper, an attempt has been made to understand the revenue and the various expenditures along with government regulatory aspects, associated with rice straw based power plants in one of the states i.e. Punjab, India. The cost part includes the fuel cost of rice straw (raw material, land lease for fuel storage, transportation, cutting/chopping, degradation, protection from weather, feeding, insurance etc.) and operation and maintenance (O&M) cost besides fixed cost (interest on loan, depreciation, interest on working capital and taxes). The biomass power is a state subject and tariff provided by various states is feed-in-tariff (generic tariff decided by regulatory commissions of various states), thus the economics would be worked out with this as basis. The way forward to make this sector attractive has also been discussed in the paper.

**Keywords:** Cost of energy from biomass, sale tariff for biomass power projects, rice straw as fuel for power plants, regulatory policies for biomass power projects

## INTRODUCTION

For sustainable development of the economy, power generation through new and renewable energy resources is desirable. Biomass is renewable as it is an organic material in form of plants and grows from sun energy. Biomass contains chemical energy which in turns can be converted into heat energy for producing steam to generate electricity.

Biomass is one of the resources which can be used to produce energy either through small capacity gasification power plants (50 KW to 500 KW) or through higher capacity steam based thermal power projects (5 MW to 15 MW). Most of the biomass gasifier based projects are de-centralized distribution generation type projects, which caters electricity to remote un-electrified villages where electricity couldn't reach even till 2015 in India. On other side, higher capacity biomass projects were allocated through memorandum of understanding routes till 2010 by various states to produce electricity for rural India and these plants were grid connected.

There was less experience both with private and government organizations because stability or scalability of power generation through biomass were yet to be seen in India.

The tariff i.e. rate at which electricity is to be procured by utility is fixed by state electricity regulatory commissions (SERC's) for their states. However, central electricity regulatory commission (CERC) keep releasing guiding documents and notifications based on feedbacks from Industry experts and other bodies which are generally accepted by SERC's.

Gross calorific value (GCV) is amount of heat energy released from unit mass of biomass during complete combustion. The calorific value is different for all types of fuel i.e. coal, gas, oil, biomass and other materials. This is measured in Kcal/kg.

Station heat rate (SHR) is an efficiency of power plant to generate electricity. More the efficiency less is SHR which results in fuel saving. Big thermal projects based on coal as fuel has SHR in the range of (2200 -2600 kcal/kWh). However, biomass based power projects have SHR almost two times than big thermal projects.

The fuel consumption in biomass is almost 65%-75% of total expense thus GCV and SHR plays equally important role for viability of any project.

For techno-commercial viability of 100% rice straw based biomass projects, a study is made to understand the ground reality 12 MW project located in Punjab which is only one operational project in India so far, as a case study for expenses and revenues. Way forward for improvement have been discussed.

## LITERATURE REVIEW

There is a general perception that cost of generation by fossil fuels is cheaper than renewable sources like biomass, however, in rural areas, where villagers use diesel generators, power from biomass gasifiers (very small plants) are considerable cheaper. (J.Jenil Gavaskar et. al. 2012).

In 2009, fossil fuel combustion for electricity in US was 37% of all GHG emissions and coal contributes around 81% of GHG (USEPA, 2011). Because biomass is considered as carbon neutral feedstock, co-firing biomass and coal has the potential to decrease GHG from coal. Biomass can be co-fired in existing coal plant with no retrofits (Bain, Overend & Craig, 1998).

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Co-firing biomass decrease in ash, dust, SO<sub>2</sub> and NO<sub>x</sub> emissions over coal firing alone, depending on the feedstock and co-firing method (IEAGHG and ECOFYS, 2011).

However, In India, NTPC is planning to blend biomass in its existing coal based power plants which have total capacity of around 40000 MW.

As per New and Renewable Source of Energy (NRSE) policy released by government of Punjab in year 2006, the power potential from biomass or agri-waste was estimated to be around 1500 MW and target was set to harness the same by 2020. Some promotional efforts like exemption of VAT & octroi and leasing of land on nominal rates were also mentioned for promoting renewable plants in the state. Punjab Energy Development Agency (PEDA) was made as nodal agency to promote renewable projects. The tariff for biomass projects was declared as Rs 3.49/Kwh with 5% escalation. There was no separate tariff category for rice straw based biomass power projects. (NRSE Policy Dated 24<sup>th</sup> Nov, 2006).

Punjab State Energy Regulatory Commission (PSERC) has mentioned in their policy released in 2014 that tariff for rice straw based biomass power projects would be Rs 7.90/Kwh and for other biomass projects it would be Rs 6.95/Kwh. CERC has also issued guidelines for adopting these tariff by various states. (PSERC order dated 15<sup>th</sup> Sep, 2014 and CERC order dated 15<sup>th</sup> May, 2014)

Logistics of biomass fuel supply is complex because it has intrinsic feedstock characteristics, such as limited period of availability and the scattered distribution. (Antio C. Caputo, Palumbo, Pelagagge and Scacchia, 2005).

## **RESEARCH OBJECTIVE**

- To study in detail the cost and financial aspects of 100% rice straw based power project in the State of Punjab which is only operational project in India.
- To analyze and discuss attractiveness in today scenario for such plants for private sector investment.

## **RESEARCH METHODOLOGY**

The approach is based upon case study, which is both quantitative and quality in nature and is based on case of 12 MW rice straw based power plant being operated by M/s Punjab Biomass Power Company Limited located in the state of Punjab. This rice straw based power project is only/single operational project in India. Review of various papers and policies have been carried out for understanding the regulatory and techno-commercial aspects. The pollution from rice straw burning can be controlled if proper utilization of rice straw is done for energy as well as ethanol production.

An exploratory and descriptive detailed study was carried out by conducting an interviews with senior officials of M/s PBPL, boiler manufacturer i.e. M/s Cheema Boiler, Turbine and auxiliary suppliers, farmers for understanding fuel cost, fuel traders, members of regulatory commission for tariff understanding, MNRE officials for benefits to promote rice straw base power plants and officials of Punjab energy development agency.

## **BACKGROUND**

Punjab Government set up one 100% rice straw base power project in 1990 but it couldn't succeed even after commissioning due to various issues mainly techno-commercial aspects. The technical aspects were related to fuel feeding system, boiler height because of low ash infusion temperature of rice straw and chopping of rice straw as it all cutters are required to re-grinded after every 12 hours. However, M/s Punjab Biomass Power Limited signed an memorandum of understanding and got allocation of 12 MW rice straw based power project in year 2006 at an initial tariff of Rs 3.49/Kwh. This project was commissioned in 2009-10 and is in operation from last 6-7 years but is also not successful because of again techno-commercial aspects. However, there are learnings and state and center have acknowledged that for promoting such plants many improvements are still required for keeping its viability so that scalability can be achieved in years to come. As rice straw burning is nuisance for health problems thus it become imperative for scholars to do brain storming to highlight good things, bring out issues and suggest way forward.

There are many examples that developer's signs an agreement and once they start the power projects they found that the ground realities are different and issues and challenges are much more than were assumed at the time of bidding or investment. However, it is always worthwhile to learn and improve the things so that corrections can be made in the technical aspects or policies or wherever needed including project management.

The cost and financial aspects of rice straw based biomass power project does not include benefits like reduction in particulate matters i.e. Particulate matter (PM) 2.5 and PM10, reduction in GHG emissions or any social benefits like farmers income, rural employment etc. as these have not be monetized.

In spite of very low capacity size of biomass power plant (12 MW) in comparison to coal based power plant (say 1000 MW), the technical aspects are quite similar i.e. involvement of supply chain management for fuel, fuel feeding system, fuel storage, boiler, cooling towers, electro static precipitator, steam turbine, generators and transmission lines etc.

Thus the expense involved at each and every activity particularly fuel supply, fuel management, fuel feeding, operation and maintenance or ash handling etc. would be analyzed. The other expense are simple which are related to finance like interest on loan, depreciation, return on investment, taxes etc.

The revenue considered is only revenue received from Discom/ utility as per power purchase agreement.

### **Issues In 100% Rice Straw Based Power Project**

There are many issues in rice straw based power project thus no new projects are coming up. There is a need to understand the issues and find out the ways to resolve the problem. The major issues are as below;

- The boiler required for 100% rice based power project is still under research and technology. In India there is only one manufacturers who have supplied boiler for

such plant i.e. M/s Cheema Boiler, Punjab. He has carried out many experiments at existing 12 MW power project to improve the efficiency and viability. Some of the improvements are extending water walls of boiler, adding pneumatic spreaders for uniform spray of rice straw on travelling grate and underground fuel feeding system.

- Limited supply of rice straw due to open field burning of rice straw and there is very limited window of 45-60 days when rice straw can be cut and stored because farmers are to make their fields ready for next crops i.e. Rabi crops
- The capital expenditure of rice straw based power project is high in comparison to normal biomass based power projects
- Rice straw is corrosive in nature and difficult to handle as a fuel. It contains high silica and chlorine which erode pressure parts of boiler and deteriorate boiler in short span.
- As there is no rice straw based power plant in India which is economically viable project thus banks are not ready to finance. However, only one operational project is there and so detailed studies have been carried out and presented in this paper.
- Due to rains and self-ignition problem of rice straw, the weather protection and fire protection is must

In the way forward, the suggestions have been provided to overcome the issues and these projects are now techno-commercially viable projects.

**Costing Aspects of Rice Straw Biomass Power Plant**

There are two kind of costs

- A. Fixed cost of electricity ( related to capital expenditure)
  - B. Variable cost of Electricity ( fuel Cost, O&M variable cost)
- A. Fixed Cost

For investing in any biomass power project, the following studies and risks are required to be assessed;

- Availability of rice straw as a fuel
- Cost of transportation
- Storage centers for fuel and protection from weather and fire
- Rice straw biomass based power technologies
- Financing arrangements
- Experience and Project Management for operating rice straw based power projects
- State policies and regulations

All these studies are taken up during the preparation of any detailed project report. Punjab is abundant state with respect to availability of rice straw. Around 10% of total rice straw produced in India is in the state of Punjab only.

Boiler of rice straw power plant is of more height (> 35 meters) than normal biomass plant which has boiler height of (approx. 25 meter). The pressure and temperature of steam turbine in rice straw based power plant is 60 bar and 435<sup>0C</sup> against 80 bar and 485<sup>0C</sup>. The more is the temperature and pressure the turbine efficiencies are better. Thus the economics of rice straw based power plant is poorer than normal biomass and further because of higher height of boiler, as mentioned above and due to complex fuel feeding system, capital expenditure of rice straw based power project is more by 20% in comparison to normal biomass plant.

Details of project cost of 12 MW rice straw biomass power project

The tentative costs of various items involved is as under. This cost include freight, taxes and erection and commissioning charges .The time frame for completion of project is around two years, thus interest during construction will also be a part of project cost. The price level is FY16-17

**Table-1: Project cost for 12 MW Rice straw based power project, Source: detailed project cost of M/s Punjab Biomass Power project is base and discussions with manufacturers for updation.**

(INR in Mn)

S.No	Description of Item	Amount
1	Preliminary and Pre-operative expense	10.00
2	Detail Engineering	15.00
3	Land and Site Development	40.00
4	Civil and Structural work	100.00
5	Mechanical Items	
	a) Water Plant	10.00
	b) Boiler and Aux	120.00
	c) Turbine Generator & Aux.	100.00
	d) Cooling Tower & Compressed Air System	15.00
	e) Ash Handling system	05.00

	f) Fuel Handling System & equipment's	80.00
	g) Pollution control equipment's	10.00
	h) Other Piping & Misc. works	60.00
	Sub Total	<b>400.00</b>
6	Electrical & Instrumentation	
	a) Switchyard and Transformers	30.00
	b) HV/LV switchgears	15.00
	c) DC System, Earthing, Illumination etc.	05.00
	d) Bus duct, Cabling, transmission etc.	30.00
	e) DCS, Instruments, Plant communication system etc.	20.00
	Sub Total	<b>100.00</b>
	Total ( 1 to 6)	<b>665.00</b>
8	IDC	50.00
9	Contingency	20.00
	<b>Grand Total</b>	<b>745.00</b>
	<b>Cost per MW ( Rs in Mn/MW)</b>	<b>62.00</b>

Now regulatory commission has approved the project cost of Rs 59 Mn/ MW (year 14-15). However, there is not much increase in the cost of civil works or electro-Mechanical works in India since 2010. Thus the cost of project for 100% rice straw based power project was around Rs 50 Mn/MW in 2010.

**Table-2: Tariff as per state regulatory orders in the state of Punjab**

Year	Tariff In Rs/Kwh
2001	3.01
2006	3.49
2012	5.00
2014	790*

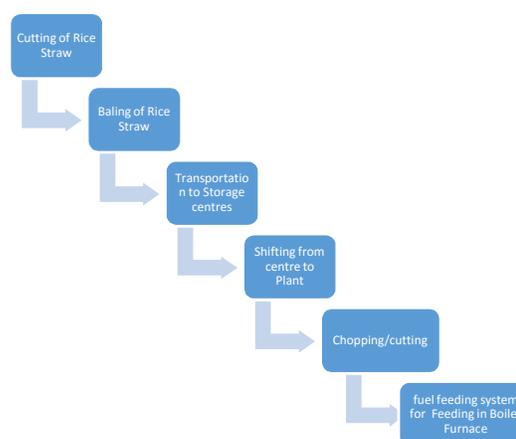
\*Applicable from prospective and for new projects only, rice straw projects got special distinction by CERC. On the other hand, the existing plants couldn't get the enhanced benefits of tariff due to regulations and thus most of plants either rice straw based or general biomass plants are in losses. However, new investor always look at the existing plants before investment, thus one of the factor that in-spite of good tariffs by state governments, investment couldn't take up on scale.

**B. Variable Cost**

Assured long term fuel supply of rice straw or other biomass at low cost and as a sustainable source of fuel supply is must for economics of rice straw based power plant. The fuel cost can be very low for a fuel which is to be disposed off anyway like rice straw. Operation and maintenance cost makes significant difference while computing variable part of cost of electricity. (International Renewable Energy Agency-IRENA, 2012)

**i. Fuel Cost Computations**

100% rice straw can be used in power project which has been designed for the same. However, cane trash to an extent of 10% or any other agri waste can also be used in the same biomass plant. On the other side, if plant is not designed for rice straw, it is difficult to use the rice straw in that power plant, as rice straw contains high alkali content and requires special fuel cutters and fuel feeding systems.



**Fig. 1: Process involved during fuel collection, storage and its usage. Source: Rice straw based power plant**

Rice straw is fuel for the 100% rice straw base power project and its cost analysis for the cost up to boiler tip is as below. This study has been carried out based on inputs from farmers, traders, fuel suppliers and employees of fuel team of M/s Punjab biomass power project.

**Table-3: Fuel Cost Analysis – Rice Straw (30US\$/Ton)**

Description	Cost Per Ton (in INR)
Basic Price	750.00
Salary & Wages	85.03
Security Charges	58.88
Labor Charges	60.66
Depot Establishment Cost	58.38
Fuel shifting charges from storage Centre	336.93
Fuel Chopping charges	300.00
Admin Expenses	13.85
Repair & Maintenance - Fuel Equipment	25.89
Degradation & Transit Loss	130.76
Twine ( Thread) charges	150.00
Lease Rent	43.15
Insurance	2.92
Cost of fuel at boiler tip	2016.44

Source: Farmer, traders, fuel suppliers, employees of M/s PBPL

Calorific value of the rice straw is around 2800- 3200 kcal/kg and station heat rate of boiler is around 4600- 4800 kcal/Kwh (based on past performance of 8 years of M/s PBPL). The specific fuel consumption (SFC) i.e. amount of fuel required to produce one unit of electricity is around 1.5 and it goes up to 2 in rainy season due to wet fuel.

Fuel cost per kg will vary from Rs 3.00/Kg Per kg. Approx. after adding interest cost on working capital required for fuel plus. The processed rice straw fuel (already cut and dried fuel) can also be procured from market for mixing with rice straw, this fuel also cost around Rs 2.75/Kg

Specific Fuel Consumption of rice straw based power project = 4800 /3200 = 1.5 (varies due to moisture content of fuel and many other variables including number of shutdowns etc.) Thus cost of fuel to produce one unit of electricity is around Rs 4.50/Kwh

ii. Operation and maintenance cost on annual basis of the rice straw power plant

Rice straw plant is highly labor oriented plant. The staff requirement is of around 100 people for managing 12 MW plant and this includes maintenance team for fuel collection equipment's, maintenance teams for Boiler, Turbine, Water System and Instrumentation etc. The other functions like HR, Admin, Accounts, and Management etc. are part of system. There are regular operational problems in biomass plant which can't be ignored, these problems occur mainly in travelling grate, fuel conveyor belts, Boiler tubes, Ash handling system etc. Annual shut downs are planned during rainy season for complete checkup of plant. The spares are required to be maintained at plant which are planned as per criticality, wear and tear or based on experience. The annual O&M cost for 12 MW plant is as under;

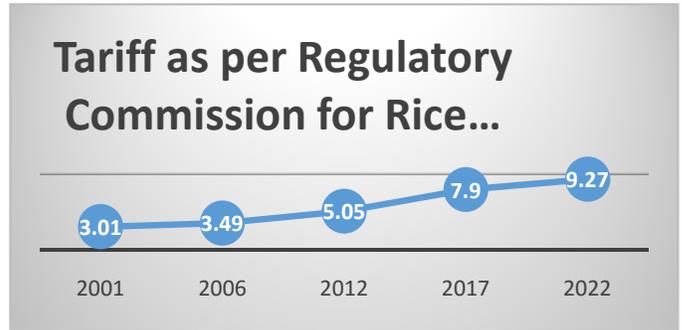
**Table-4: O&M cost of 12 MW rice straw based power project**

S.No.	Description	Amount (in Mn)	Remarks
1	Maintenance	20.00	Equipment's & Consumables
2	Administrative & Insurance	05.00	Electricity & Security etc.
3	Salaries and Wages	25.00	Employees and contractual staff
	Total Per Annum	50.00	Mn/Annum

Source: M/s PBPL and other biomass plants in state of Punjab

**Regulatory Aspects of Rice Straw Based Plant in the State of Punjab**

Below is the representation of tariff hike given in biomass sector by State and Central Regulatory commissions (Fig. 2) to promote the rice straw based biomass energy sector. In spite of almost 300% hike in tariff rates given by regulatory commission in last 2 decades, there are no investors in this sector, thus investors are required to understand the economic benefits in this sector.



**Fig. 2: Tariff in past 18 years – Source- Computations based on CERC Tariff Orders**

From above it is very clear that government of India and government of Punjab have recognized that the rice straw based power plants need to be put under special category and tariff should be Rs 7.90/Kwh as on 2017 (price level, as per state regulatory commission orders). However, the new plants are still not coming up in spite of good commercial sense because there is no marketing efforts on promotion of such plants. Independent power producers still feel that the operation of the plant is very challenging or technology doesn't exist or there is no return on investment. On the other side technology is well proved and with ample of rice straw available all across the State, the investor lobby should invest in this sector. National Green Tribunal, Punjab and High Court and Hon. Supreme Court all have banned the open field burning thus biomass power being techno-commercially viable need promotional efforts.

Tariff computation Sheet (Annexure-I) for 12 MW biomass plant (as per central electricity regulatory commission norms, 2014) as well as sensitivity analysis based on experience of M/s PBPL plant is attached herewith for reference.

**Way forward**

Following points are likely improve the techno commercial viability of the rice straw based power projects:

- The present tariff provided by state regulatory commissions are highest tariff in the power sector and independent power producers should confidently invest in this sector.
- Fuel cost will further come down as there are subsidies on procurement of cutters, balers and trolleys which will be used for rice straw baling. As per recent order, GoI has provided lot of funds to curb field burning to both Haryana and Punjab.
- Due to complete and strict ban on open field burning farmers are trying to sell the rice straw waste at very low rates
- Direct bale feeding installation on the right side or left side of the boiler will increase the efficiency of fuel feeding and reduce the chopping/ cutting cost substantially
- Once through cooling system instead of cooling towers will improve the efficiency. Moreover, it will also reduce the dependency on the ground water requirement. Recently government has allowed once through system.

**CONCLUSION AND RECOMMENDATIONS**

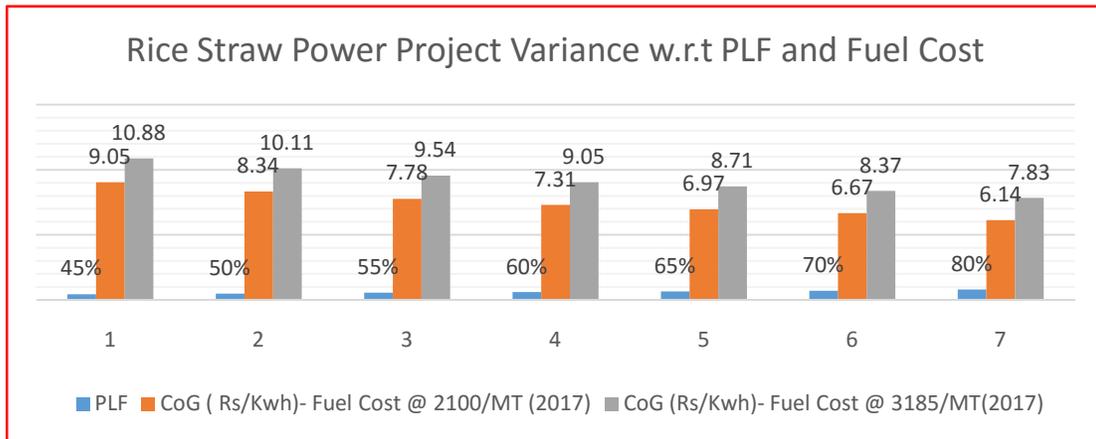
The Tariff provided by CERC or PSERC to new plants is very attractive and Techno-commercially viable. The rice straw cost can be highly optimized because Centre and State Governments have started providing subsidies to farmers to procure Balers and thus on supply of rice straw to power plants. The fuel cost can be easily reduced to 30% to 50% from the CERC/PSERC approved fuel cost, if proper measures are taken.

The Plant load factor of 80% is considered by CERC/PSERC while computing tariff and it is very high and may be almost impossible to achieve for rice straw power projects, considering 2-3 months rainy season and breakdowns of plant

etc. The realistic Plant load factor with good project management for 10% rice straw based power projects should be 55% to 65%. For other Biomass power projects the same can be 80%. The sensitivity analysis as per CERC norms for Cost of Generation (with RoE) vis-a-vis PLF and 30% reduction in fuel cost as Fig. 3.

**ACKNOWLEDGEMENT**

This case is based upon the study of an only operational rice straw based power project of India. The business context is real and the feedback is from senior management officials of M/s PBPL and M/s Punjab Energy Development Agency (PEDA).



**Fig. 3: Impact on Cost of generation with PLF at reduced fuel cost**

*Source: CERC order 2014 and operational rice straw based power project*

**Table-5: Assumptions for rice straw based power plant- Source CERC order 2014**

Annexure-1

**Tariff Computation Sheet for 12 MW Rice straw Power Project as Per Regulatory Norms**

Project Capacity	12	MW
Plant Load Factor	80%	2nd Year onwards, 70% for Ist
Aux Consumption	10%	2 <sup>nd</sup> year , 11% for Ist Year
Useful Life	20	years
Project Cost	59	Mn/MW
Debt : Equity	70:30 %	
RoE ( post tax)	20% & 24%	For Ist 10 years and after 10 yrs.
Rate of interest	11%	
Discount Rate	9.78%	
Corporate Tax	34%	18% MAT for first 10 yrs.
O&M (2017)	4.8	Mn/year/MW and 5.72% Esc.
Working Capital		
O&M	1	Month
Maintenance Spare	15%	of O&M
Receivables	2	Month Electricity Revenue
Interest rate on WC	12%	Per Annum
Station Heat Rate	4200	Kcal/Kwh
GCV of Fuel	3100	Kcal/Kg
Biomass Price (2014)	2751	Rs/MT
Biomass Cost (2017)	3184.63	Rs/MT
Escalation in fuel price	5%	Per Annum
Depreciation	5.83%	for 12 years and 2.51% thereafter

Tariff Computation for 12 MW Rice Straw Based Power Project

12 MW Rice Straw Plant Tariff as Per Regulatory Commission								
			2017	2018	2019	2020	2021	2022
	Years-	1.00	2.00	3.00	4.00	5.00	6.00	7.00
Installed Capacity	MW	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Gross generation	MU	73.58	84.10	84.10	84.10	84.10	84.10	84.10
Aux. Consumption	MU	8.09	7.36	7.36	7.36	7.36	7.36	7.36
<b>Saleable Energy</b>	MU	65.49	76.74	76.74	76.74	76.74	76.74	76.74
<b>Variable Cost</b>								
Biomass Requirement	000*MT	100	114	114	114	114	114	114
Biomass Price	Rs/MT	3,184	3,344	3,511	3,687	3,871	4,065	4,268
Biomass Cost	Rs in Mn	318.00	381.00	400.00	420.00	441.00	463.00	487.00
<b>Variable Tariff</b>	Rs/Kwh	4.86	4.96	5.21	5.47	5.75	6.03	6.35
<b>Fixed Cost</b>								
O&M expense	Rs in Mn	56.71	59.95	63.38	67.01	70.84	74.89	79.17
Depreciation	Rs in Mn	41.28	41.28	41.28	41.28	41.28	41.28	41.28
Interest on loan	Rs in Mn	52.24	47.70	43.16	38.62	34.07	29.53	24.99
Interest on WC	Rs in Mn	25.01	28.92	30.18	31.48	32.87	34.31	35.84
Return on Equity	Rs in Mn	42.48	42.48	42.48	42.48	42.48	42.48	42.48
Total FC		217.72	20.33	220.48	220.87	221.54	222.49	223.76
<b>Fixed Tariff</b>	Rs/Kwh	3.32	2.87	2.87	2.88	2.89	2.90	2.92
<b>Total Tariff</b>	Rs/Kwh	8.18	7.83	8.08	8.35	8.64	8.93	9.27
Discount Factor		1.00	0.91	0.83	0.76	0.69	0.63	0.57
Variable Tariff (2017)	4.96	Rs/Kwh						
Fixed Tariff (levelized)	3.03	Rs/Kwh						

The authors acknowledges the information shared by M/s Punjab Biomass Power Project limited, 12 MW plant located in District Patiala, Punjab, officials state agencies, manufactures and fuel suppliers. Information is also available on public domain because of tariff related matters with state regulatory commission for most of existing biomass power projects. The authors are grateful to all for providing useful suggestions to improve the quality of this article.

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