

Explanatory Memorandum  
for  
Draft Terms and Conditions for  
Determination of Tariff  
for  
Renewable Energy Sources  
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**Central Electricity Regulatory Commission**  
**(CERC)**  
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## 1. Background

In exercise of powers conferred under Section 61 read with Section 178 (2) (s) of the Electricity Act, 2003 (36 of 2003) (herein after “the Act”), the Commission had issued the Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2009 dated 16.09.2009. The Control Period specified under these regulations was three years ending on 31.03.2012. Thereafter the Commission issued the Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2012 dated 06.02.2012. The Control Period specified under these regulations is five years ending on 31.03.2017. CERC (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations for 17.9.2009 to 31.3.2012 along with statement of reasons was issued vide notification no. L-7/186(201)/2009-CERC on 16th September 2009 and is available on website<sup>1</sup>. The CERC (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2012 for period 1.4.2012 to 31.3.2017 was issued vide notification No. L-1/94/CERC/2011 dated 6th February, 2012<sup>2</sup>

India is a land bestowed with tremendous potential of renewable energy sources based on its strategic geographical location and has envisaged a journey of capacity addition using renewable energy based sources through several programmes both at Central and State levels for promoting renewable energy. Capacity additions have increased using all available renewable energy technologies, Government of India’s commitment of at least 40% of its electricity generation from non-fossil sources by 2030 at Conference of Parties (CoP 21) in November 2015 at Paris, ratified in October 2016 and ambitious target addition of 175 GW of renewable energy based installed capacity by 2022, to name a few. Through the advent of public-private partnership along with incentives offered by various State Governments, the total installed capacity of grid interactive renewable energy in India stood at 50,017.97 MW as on 31<sup>st</sup> December 2016, with the largest share of wind energy at 28,700.44 MW followed by solar energy at 9,012.66 MW<sup>3</sup> (Source: MNRE). The share of grid interactive renewable capacity in the total generation capacity mix is over 16% as on 31<sup>st</sup> December 2016.

During the Control Period 2012 – 2017, renewable energy technologies have matured and have reduced the gap between the cost of generation using conventional sources of energy and renewable energy sources. In addition, India is ranked 4th in the Global Wind Power Installed Capacity Index by the Global Wind Energy Council (GWEC) in December 2016. It follows China (1,45,362 MW), USA (74,471 MW) and Germany (44,947 MW). On the other hand, sun has been bright during the control period as more than 50 competitive bids have been successfully conducted across the country for over 18,000 MW of capacity. The

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<sup>1</sup> [http://www.cercind.gov.in/Regulations/CERC\\_RE-Tariff-Regualtions\\_17\\_sept\\_09.pdf](http://www.cercind.gov.in/Regulations/CERC_RE-Tariff-Regualtions_17_sept_09.pdf)

<sup>2</sup> [http://www.cercind.gov.in/2012/regulation/CERC\\_RE-Tariff-Regualtions\\_6\\_2\\_2012.pdf](http://www.cercind.gov.in/2012/regulation/CERC_RE-Tariff-Regualtions_6_2_2012.pdf)

<sup>3</sup> Source: Ministry of New and Renewable Energy, [www.mnre.gov.in](http://www.mnre.gov.in)

country is expected to be the third largest market for solar power in 2017 based on estimates by leading consulting agencies.

In accordance with the regulations issued from time to time as aforesaid, the Commission has been determining the generic tariff of the grid interactive power projects based on renewable energy sources through transparent and participative process. The said Regulations also state that the Commission shall undertake the exercise of revision in Regulations for the next Control Period at least six months prior to the end of the first Control Period. Hence, the Commission has initiated the exercise of framing the RE Tariff Regulations for the next control period.

Representations have been received from Ministry of New and Renewable Energy incorporating suggestions as follows:-

1. Generic tariff for Small Hydro be applied only up to 5 MW projects. For Projects higher than 5 MW project specific tariff should be fixed unless tariff is determined through open transparent bidding
2. MNRE subsidy is not taken by every developer, nor is the AD benefit taken by all the developers. This should not be automatically deducted from the tariff whether generic or otherwise. This may be deducted only from those who take the benefit and to the extent benefit is taken.

Representation has also been received from National Solar Energy Federation of India (NSEFI). NSEFI have requested not to determine the benchmark Capital Cost and Tariff for Solar PV Projects owing to procurement of solar power through competitive bidding in most states and provisions made in Tariff Policy.

## **2. Scope of RE Tariff Regulations**

### **2.1 Applicability of Regulations**

In accordance with Section 79 read with Section 62 of the Act, the Commission is required to determine the tariff for the central sector generating stations or the generating stations with composite scheme for sale of electricity to more than one State. Accordingly, it is proposed that RE Tariff Regulations shall be applicable in all cases where tariff for a generating station or a unit thereof is based on renewable sources of energy, and are covered under section 79(1)(a) & (b) read with section 62 of the Act. Further, in cases of Wind, Small Hydro projects, Biomass power based on Rankine cycle, non-fossil fuel based cogeneration projects, Solar PV, Solar Thermal power projects, Biomass gasifier, Biogas, Municipal Solid Waste, Refuse Derived Fuel based power projects and other emerging technologies, these Regulations shall apply subject to the fulfilment of eligibility criteria as

specified under the Regulations. Para 6.4 (3) of Tariff Policy<sup>4</sup> notified on 28.01.2016 empowers the Commission to lay down the guidelines for pricing of non-firm power. The Para 6.4 (3) reads as under,

*“The Central Commission should lay down guidelines for pricing intermittent power, especially from renewable energy sources, where such procurement is not through competitive bidding. The tariff stipulated by CERC shall act as a ceiling for that category.”*

CERC RE Tariff Regulations are also a guiding factor for the State Electricity Regulatory Commissions in terms of Section 61(a) of the Act and the aforesaid provision of the Tariff Policy.

## 2.2 Eligibility Criteria

The tariff determined under these Regulations shall be applicable in respect of RE technologies meeting specific Eligibility Criteria. The Commission proposes to retain the Eligibility Criteria as specified in RE Tariff Regulations 2012 and its subsequent amendments for the Small Hydro, Biomass power project based on rankine cycle technology, Non-fossil fuel based co-generation, Biomass gasifier, Biogas based projects, Municipal Solid Waste based projects, Refuse Derived Fuel based projects, Solar PV and Solar Thermal Power projects.

The National Institute of Wind Energy (NIWE) has published the India Wind Atlas which estimates the country's wind power potential at 100 metres level as over 300 GW. With change in wind turbine technology and better efficiency for wind energy projects, even the lower wind power zones are being exploited by project developers. The Commission has also observed that a few developers have envisaged and are constructing wind projects with over 100 meters hub height to exploit higher wind power at greater heights and gaining greater amount energy generation. Considering the same, the Commission proposes eligibility criteria for wind projects accordingly.

Eligibility Criteria for the next Control Period (2017-2020) are as under:-

- a) Wind power project – using new wind turbine generators, located at the sites approved by State Nodal Agency/ State Government (only for zoning purpose).
- b) Small hydro project – located at the sites approved by State Nodal Agency/ State Government using new plant and machinery, and installed power plant capacity to be lower than or equal to 25 MW (or as approved by relevant Ministry) at single location.

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<sup>4</sup> National Tariff Policy notified by the Ministry of Power on 28.01.2016  
[http://powermin.nic.in/sites/default/files/webform/notices/Tariff\\_Policy-Resolution\\_Dated\\_28012016.pdf](http://powermin.nic.in/sites/default/files/webform/notices/Tariff_Policy-Resolution_Dated_28012016.pdf)



- c) Biomass power project based on Rankine cycle technology – Biomass power projects using new plant and machinery based on Rankine cycle technology and using biomass fuel sources, without use of fossil fuel.
- d) Non-fossil fuel based co-generation project: The project shall qualify to be termed as a non-fossil fuel based co-generation project, if it is using new plant and machinery and is in accordance with the definition and also meets the qualifying requirement outlined below:

TOPPING CYCLE MODE OF CO-GENERATION – Any facility that uses non-fossil fuel input for the power generation and also utilizes the thermal energy generated for useful heat applications in other industrial activities simultaneously. Provided that for the co-generation facility to qualify under topping cycle mode, the sum of useful power output and one half the useful thermal output be greater than 45% of the facility's energy consumption, during season.

Explanation- For the purposes of this clause,

- (1) 'Useful power output' is the gross electrical output from the generator. There will be an auxiliary consumption in the cogeneration plant itself (e.g. the boiler feed pump and the FD/ID fans). In order to compute the net power output it would be necessary to subtract the auxiliary consumption from the gross output. For simplicity of calculation, the useful power output is defined as the gross electricity (kWh) output from the generator.
  - (2) 'Useful Thermal Output' is the useful heat (steam) that is provided to the process by the cogeneration facility.
  - (3) 'Energy Consumption' of the facility is the useful energy input that is supplied by the fuel (normally bagasse or other such biomass fuel).
  - (4) 'Topping Cycle' means a co-generation process in which thermal energy produces electricity followed by useful heat application in industrial activities.
- e) Solar PV and Solar Thermal Power Project – Based on Technologies approved by MNRE.
  - f) Biomass Gasifier based Power Project – using new plant and machinery and having a Grid connected system that uses 100% producer gas engine, coupled with gasifier technologies approved by MNRE.
  - g) Biogas based power project - using new plant and machinery and having grid connected system that uses 100% Biogas fired engine, coupled with Biogas technology for co-digesting agriculture residues, manure and other bio waste as may be approved by MNRE.

- h) Municipal Solid Waste based power project - using new plant and machinery based on Rankine cycle technology and using municipal solid waste as fuel sources.
- i) Refuse derived fuel based power project - using new plant and machinery based on Rankine cycle technology and using refuse derived fuel as fuel sources.

### **2.3 Approach for Development of Tariff Norms**

While determining the tariff norms, the following approaches have been considered:-

- a) Detailed review of the Tariff Orders / Regulations notified by various SERCs and the approaches considered in determining the norms for tariff for a specific RE technology.
- b) Review and analysis of the actual project cost details and information about performance parameters in respect of existing RE projects based on information received from financial institutions, public agencies and other State Electricity Regulatory Commissions.
- c) Comparative analysis of project cost and performance parameters in respect of similar RE technology applications in the international context.
- d) Feedback/views/comments of the various stakeholders received on the RE Tariff Regulations – 2012 and its subsequent amendments in the subject matter.

The tariff norms have been categorized broadly under three sections, namely General Principles, Financial Principles and Technology Specific Principles. On the basis of RE technologies covered under the Regulations, the Explanatory Memorandum has been divided into the following sections:

- I. General Principles
- II. Financial Principles
- III. Technology specific Principles: Wind Energy
- IV. Technology specific Principles: Small Hydro Power
- V. Technology specific Principles: Solar PV
- VI. Technology specific Principles: Solar Thermal
- VII. Technology specific Principles: Biomass based generation with Rankine Cycle technology
- VIII. Technology specific Principles: Non-fossil fuel based co-generation
- IX. Technology specific Principles: Biomass Gasifier based power generation

- X. Technology specific Principles: Biogas based power generation
- XI. Technology specific Principles: Municipal Solid Waste based power generation based on Rankine Cycle technology
- XII. Technology specific Principles: Refuse derived fuel based power generation based on Rankine Cycle technology

The comprehensive approach adopted for development of norms for the purpose of tariff determination of tariff for power in respect of various RE technologies has been presented below and the same has been elaborated under subsequent sections.

### **3. General Principles**

Under this section, the general principles for RE tariff determination such as Control Period, Tariff Period, Tariff Structure, Tariff Design, Tariff Review Mechanism etc. have been discussed.

#### **3.1 Control Period**

In RE Tariff Regulations – 2012, Control Period of five (5) years was specified.

While specifying the same, the Commission had considered the maturity level of non-solar technologies. The Commission was of the view that the benchmark capital cost for Solar PV and Solar Thermal projects be reviewed annually.

During the 2nd Control Period (2012-17), the maturity level of solar technologies has grown significantly. In addition, majority of the capacity addition through Solar PV technology have come through the competitive bidding route. Moreover, utilisation of the competitive bidding route for other RE technologies is on the anvil. Waste to Energy projects have been selected through competitive bidding in Andhra Pradesh and Scheme for setting up of 1,000 MW ISTS-connected Wind Power Projects is underway by Solar Energy Corporation of India (SECI).

The reducing prices of equipment and discovery of lower tariff regimes through competitive bidding has enabled the Commission to review the advantages and disadvantages of specifying short duration of Control Period of 3 years and long duration of Control Period of 5 years.

Considering the long term certainty of regulatory principles and in order to avoid a situation where the validity of underlying tariff parameters is questioned, the Commission now proposes to keep the third Control Period at three (3) years i.e. 2017-2020, based on

dynamics of the market and the maturity level of renewable energy technologies at present. The tariff determined for the RE projects commissioned during the Control Period, shall continue to be applicable for the entire duration of the Tariff Period.

The Commission also proposes that the revision in Regulations for next Control Period would be undertaken six months prior to the end of the present Control Period and in case Regulations for the next Control Period are not notified until commencement of next Control Period, the tariff norms as per these Regulations shall continue to remain applicable until the notification of the revised Regulations subject to adjustments as per revised Regulations.

### **3.2 Tariff Period**

In the RE Tariff Regulations 2012, it is specified that Tariff Period for Renewable Energy power projects except in case of Small Hydro Projects below 5 MW, Biomass based projects with rankine cycle technology, Biomass Gasifier, Non fossil-fuel co-generation, Biogas based projects, Solar PV and Solar Thermal power projects shall be thirteen (13) years. In case of Small Hydro projects below 5 MW, the tariff period shall be thirty five (35) years. For Solar PV and Solar Thermal projects, the Tariff Period shall be twenty five (25) years. In case of Biomass, Biomass Gasifier, Non fossil-fuel co-generation projects, Biogas based projects, Municipal Solid Waste and Refuse Derived Fuel based projects the tariff period shall be twenty (20) years.

Based on the provisions of the Act and Tariff Policy, the Commission has taken a balanced approach which outlines preferential treatment to renewable energy projects till such time that the RE technologies are able to compete in the market. The Commission has also considered that the regulatory support during the 13 year tariff period will provide certainty to the project developers to meet their debt service obligations and after this period, the competitive procurement of renewable energy will ensure that power is procured at most reasonable rate, and benefit passed to consumer.

The Commission proposes to retain the Tariff period as specified for the above technologies in RE Tariff Regulations 2012 for the next Control Period (2017-2020).

### **3.3 Tariff Structure**

The RE Tariff Regulations-2012 specified that the tariff for renewable energy technologies not having fuel cost component shall be single part tariff consisting of the following fixed cost components:

- i. Return on equity;

- ii. Interest on loan capital;
- iii. Depreciation;
- iv. Interest on working capital;
- v. Operation and maintenance expenses.

For renewable energy technologies having fuel cost component, like biomass power projects and non-fossil fuel based cogeneration, single part tariff with two components, i.e. fixed cost component and fuel cost component, was specified. The Commission considered that single part tariff structure for RE technologies involving no fuel cost component is the simplest method to operationalize considering number of projects and unit size of each project and the same has been in practice for RE technologies for long time.

In case of RE technologies involving fuel cost components, single part tariff with two components representing fixed cost component and variable cost component was specified. Any generation beyond threshold PLF shall also receive same tariff since risk and cost associated with project sizing, project location etc. is expected to be borne by project developer.

The Commission proposes to continue with the same tariff structure for the next Control Period (2017-2020).

### 3.4 Tariff Design

In the RE Tariff Regulations-2012, it was specified that the tariff would be determined on levellised basis for all RE technologies for the tariff period. While specifying the same, the Commission considered that Levellised tariff approach is a balanced approach amongst various tariff determination mechanisms like front loaded tariff, back loaded tariff etc.

The Commission also considered that Levellised tariff with appropriate discount rate representing weighted average cost of capital on the basis of normative debt-equity ratio as specified in the Regulations. The discount rate used for renewable energy tariff determination was the pre-tax Weighted Average Cost of Capital (WACC). The WACC was computed as under:

Post Tax WACC = Cost of Debt + Cost of Equity

Where,

Cost of Debt = Normative Debt X (Normative Rate of Interest) X (1-Corporate Tax Rate)

Cost of Equity= Normative Equity X (Post Tax Return on Equity)

For the technologies mentioned in the subsequent para, no annual generic tariff shall be determined.

### 3.5 Project Specific Tariff

RE Tariff Regulations – 2012 specified that the project specific tariff would be determined by the Commission on case to case basis for new RE technologies such as:

Municipal Solid Waste and Refuse Derived Fuel based power projects (if a project developer opts for project specific tariff);

Solar PV and Solar Thermal (if a project developer opts for project specific tariff);

Hybrid Solar Thermal Power Projects;

Other Hybrid projects including renewable- renewable or renewable-conventional sources, for which renewable technology is approved by MNRE;

Biomass project other than that based on Rankine Cycle technology application with water cooled condenser;

Any other new renewable energy technologies approved by MNRE;

It was also specified in the RE Tariff Regulations 2012, that the financial norms as may be specified except for capital cost, would be the ceiling norms while determining the project specific tariff.

During the Control Period (2012-17), it has been observed that no petition for determination of project specific tariff was submitted. Further, no projects which are based on inter-state sale of renewable energy have been set-up in the country, though such plants are expected in near future.

Solar Technologies, especially Solar PV have registered a significant growth during the Control Period (2012-17). More than 18,000 MW have been auctioned since 2013 and the installed capacity is over 9,000 MW as on 31<sup>st</sup> December 2016 (Source: MNRE). Projects which have been set-up are mainly for consumption within the respective States and have come up primarily through the competitive bidding route. The recent trends of tariff discovered amongst various auctions conducted across the country have yielded competitive tariff in per unit terms. The Commission has observed that projects which shall sell electricity using inter-state transmission network are under pre-development stage and shall be online during the next Control Period (2017-2020).

Similarly, competitive bidding route is also in-effect for enhancing the wind energy capacity of the country. Scheme for setting up of 1,000 MW ISTS-connected Wind Power Projects is underway through SECI.

Technologies involving the use of biomass gasifier and biogas projects have registered a growth during the Control Period 2012-17. However, more emphasis and promotion of these technologies is required to meet the dual purpose of energy generation and waste management.

Emerging technologies in the area of renewables have been gradually arriving in the Indian landscape. Proposals have been invited by SECI for solar-battery storage technology based projects. Globally such adoption has gained momentum with renewable rich countries adopting these technologies through competitive route and feed-in-tariff.

As per para 6.4 (3) Tariff Policy 2016, the Central Commission should lay down guidelines for pricing intermittent power especially from renewable energy sources, where such procurement is not through competitive bidding.

*“The Central Commission should lay down guidelines for pricing intermittent power, especially from renewable energy sources, where such procurement is not through competitive bidding. The tariff stipulated by CERC shall act as a ceiling for that category.”*

Based on the above mentioned provision and to promote the renewable energy based projects to be set-up on inter-state sale basis, the Commission proposes to adopt the project specific tariff approach for the following technologies for the next Control Period (2017-2020).

- 1) Solar PV and Solar Thermal;
- 2) Wind Energy (including on-shore and off-shore);
- 3) Biomass Gasifier based projects;
- 4) Biogas based projects;
- 5) Municipal Solid Waste and Refuse Derived Fuel based projects with Rankine cycle technology;
- 6) Hybrid Solar Thermal Power Projects;
- 7) Other Hybrid projects including renewable-renewable sources, for which renewable technology is approved by MNRE;
- 8) Biomass project other than that based on Rankine Cycle technology application with water cooled condenser;
- 9) Any other new renewable energy technologies approved by MNRE;

No annual generic tariff shall be determined for the above mentioned technologies. Financial and Operational norms as may be specified would be the ceiling norms while determining the project specific tariff.

The determination of project specific tariff shall be in accordance with the Regulation 8 of RE Tariff Regulations and subsequent amendments issued from time to time.

### **3.6 Scheduling of Renewable Energy**

In the RE Tariff Regulations 2012, it was specified that all renewable energy power plants including Municipal Solid Waste and Refuse Derived Fuel based power projects except for biomass power plants with installed capacity of 10 MW and above, non-fossil fuel based cogeneration plants shall be treated as 'MUST RUN' power plants and shall not be subjected to 'merit order despatch' principles. For the biomass power generating station (rankine cycle technology) with an installed capacity of 10 MW and above and non-fossil fuel based co-generation projects, it was specified that such projects be subjected to scheduling and despatch code as specified under Indian Electricity Grid Code (IEGC) and Central Electricity Regulatory Commission (Unscheduled Interchange and related matters) Regulations, 2009 including amendments thereto.

In view of the large scale integration of Renewable Energy sources in future, the IEGC-2010 specifies the technical and commercial aspects for integration of the renewable sources into the grid. While specifying the philosophy and responsibilities for planning and operation of Indian power system, the Indian Electricity Grid Code (IEGC) -2010 has specified specific provisions for proper scheduling and despatching of power from the renewable energy sources for grid discipline and same is required to be followed.

As regards scheduling of biomass power, the Commission is of the view that it is a firm power as compared to wind and solar energy and amenable to scheduling for day-to-day operations. Such projects with installed capacity of lower than 10 MW, in view of their smaller size and complexities of ensuring visibility at SLDC are not amenable to scheduling and despatch requirement unlike their counterparts with installed capacity in excess of 10 MW.

In accordance with the IEGC -2010, solar generating plants with capacity of 5 MW and above and connected at the connection point of 33 KV level and above shall be subjected to scheduling and despatch code as specified under Indian Electricity Grid Code (IEGC) Regulations -2010.

The Commission has also introduced the Framework for Forecasting, Scheduling and Imbalance Handling for Variable Renewable Energy Sources (Wind and Solar) in August 2015 which is applicable for regional entities and subsequent amendments facilitating the



framework have been incorporated in IEGC 2010 through the Central Electricity Regulatory Commission (Indian Electricity Grid Code) (Third Amendment) Regulations, 2015 (Notification No. 1/14/2015-Reg.Aff.(FSDS)(i)/CERC dated 07.08.2015) and Central Electricity Regulatory Commission (Deviation Settlement Mechanism and related matters) (Second Amendment) Regulations, 2015 (Notification No. 1/14/2015-Reg.Aff.(FSDS)(ii)/CERC dated 07.08.2015).

On similar lines, model regulations and enabling framework for forecasting, scheduling and deviation settlement for intra-state RE generating stations have been endorsed by the Forum of Regulators (FOR). Several States published the final versions of their Regulations and few have issued Draft Regulations for comments and views of stakeholders.

IEGC 2010 and its subsequent amendments specify that the wind and solar generators shall mandatorily provide the technical specifications at the start and upon any change including the data relating to power system and weather related data as applicable to the concerned RLDC.

Forecasting shall be done by wind and solar generators which are regional entities as well as the concerned RLDC. The concerned RLDC may engage forecasting agency(ies) and prepare a schedule for such generating stations. The forecast by the concerned RLDC shall be with the objective of ensuring secure grid operation. The forecast by the wind and solar generator shall be generator centric. The wind and solar generators which are regional entities will have the option of accepting the concerned RLDC's forecast for preparing its schedule or provide the concerned RLDC with a schedule based on its own forecast.

The schedule by wind and solar generators which are regional entities (excluding collective transactions) may be revised by giving advance notice to the concerned RLDC, as the case may be. Such revisions shall be effective from 4<sup>th</sup> time block, the first being the time-block in which notice was given. There may be one revision for each time slot of one and half hours starting from 00:00 hours of a particular day subject to maximum of 16 revisions during the day.

Scheduling of wind and solar energy shall be governed as per the aforesaid provisions of Central Electricity Regulatory Commission (Indian Electricity Grid Code) (Third Amendment) Regulations, 2015 and Central Electricity Regulatory Commission (Deviation Settlement Mechanism and related matters) (Second Amendment) Regulations 2015 as amended from time to time.

## **4. Financial Principles**

Under this section, the financial principles such as Benchmarking of Capital Cost, Debt: Equity, Loan and Finance Charges, Depreciation, Return on Equity, Interest on Working Capital have been discussed.

### **4.1 Capital Cost**

For development of benchmark capital cost in respect of different RE technologies, the Commission considered inter alia, the capital cost norms as approved by various SERCs in last three years. Such capital cost norm approved by SERCs varied from State to State.

The Commission also compared capital cost for installation of renewable energy projects awarded through competitive bidding route in last three years by public entities particularly, solar energy projects. Information about capital cost through this route reflects real cost of capacity addition and does not project any notional cost assumed under regulated approach. Under the high demand and interest shown by project developers in the auctions, market based approach is likely to reflect the influence of financial capabilities and interests of the project developers rather than underlying costs.

The Commission also collected capital cost information for RE projects as provided by Power Finance Corporation (PFC), Indian Renewable Energy Development Agency (IREDA) and Rural Electrification Corporation (REC). Further, capital cost and other performance parameters submitted by Solar Energy Corporation of India (SECI) for solar projects awarded under various modes are also considered.

In addition to the above, the Commission also gathered market information from various stakeholders to arrive at technology parameters for various RE technologies.

The analysis for benchmark capital cost formulation for each RE Technology has been elaborated separately under Technology specific section.

### **4.2 Capital Cost Indexation Formula**

The Commission in its RE Tariff Regulations 2012 specified capital cost indexation formula to consider the year on year variation for the underlying capital cost parameters for each RE technology except Solar PV and Solar Thermal.

During the Control Period 2012-17, the maturity levels of RE technologies have increased with total RE installations at over 50,000 MW as on 31<sup>st</sup> December 2016 (Source: MNRE). Further with the announcement of renewable energy capacity addition, it is expected that

energy efficient technologies shall also be deployed by project developers resulting in cost savings and greater energy generation.

Considering the downward trend in energy generation equipment and factoring the market response, the capital cost indexation formula based on site independent factors mainly plant and machinery and site specific parameters such as land/civil works, erection and commissioning and finance cost and interest during construction are not providing the market sentiment and has resulted in a gap between regulatory assumptions and actual project parameters.

The Commission proposes to review the capital cost for all RE technologies every year based on market information.

### **4.3 Debt-Equity Ratio**

The Commission in its RE Tariff Regulations-2012 specified that the generic tariff to be determined based on suo-motu petition; the debt equity ratio shall be 70:30.

For Project specific tariff, it was specified that if the equity actually deployed is more than 30% of the capital cost, equity in excess of 30% shall be treated as normative loan and where equity actually deployed is less than 30% of the capital cost, the actual equity shall be considered for determination of tariff. CERC RE Tariff Regulations-2012 also provided for normative debt-equity ratio of 70:30 for Generating Company/licensee.

It is proposed to continue with the debt to equity ratio of 70:30 in line with RE Tariff Regulations-2012 for the determination of renewable energy tariff in the next Control Period (2017-2020).

### **4.4 Loan and Finance Charges**

#### **4.4.1 Loan Tenure**

In the RE Tariff Regulation-2012, the Commission after considering the suggestions from stakeholders specified a normative loan tenure of 12 years for the purpose of determination of tariff.

Upon review of the information submitted by the financial institutions like PFC, IREDA, REC; the tenure of the loans extended by them to RE project developers is in the range of 10-15 years.

The Commission is of the view that since most of the RE technologies have achieved maturity level, it should be possible for the developers to secure loan from lenders /financial institution for longer duration of say 12 years or more.

Considering the same, the Commission now proposes the normative loan tenure of thirteen (13) years for the purpose of determination of tariff for the next Control Period (2017-2020).

#### 4.4.2 Interest Rate

As the risk profile of renewable energy projects is perceived higher as compared to conventional power projects, the Commission in its RE Tariff Regulations 2012, had proposed normative interest rate of three hundred (300) basis points above the average State Bank of India (SBI) Base Rate prevalent during the first six months of the previous year of the relevant year of the Control Period for the determination of tariff.

With effect from 01.04.2016, SBI replaced the Base Rate regime with the new regime of Marginal Cost of Funds based Lending Rate (MCLR) which are pegged on loan tenor basis and are updated on monthly basis. There has been a decreasing trend in the interest rates based on changes in monetary policy announcement by the Reserve Bank of India. The monthly data for the last available six months from State Bank of India monthly press releases is as below:

Month	Tenor-wise MCLR Rates (Source: SBI Monthly Press Releases)				
	3 years (%)	2 years (%)	1year (%)	6 Months (%)	Overnight (%)
September 2016	9.25	9.20	9.10	9.05	8.85
October 2016	9.20	9.15	9.05	9.00	8.80
November 2016	9.05	9.00	8.90	8.85	8.65
December 2016	9.05	9.00	8.90	8.85	8.65
January 2017	8.15	8.10	8.00	7.95	7.75
February 2017	8.15	8.10	8.00	7.95	7.75
<b>Avg. for last Available 6 months</b>	<b>8.81</b>	<b>8.76</b>	<b>8.66</b>	<b>8.61</b>	<b>8.41</b>

Accordingly, to incorporate an approach which aligns closer with the market dynamics and reflects the prevalent interest rates, the Commission proposes to review and take into

consideration the State Bank of India MCLR (One year Tenor) for the last available six months to the notification of the order.

The Commission took note of the interest rates charged by PFC, IREDA and REC to various renewable energy projects. The interest rate charged was dependent on the type/technology of project, loan tenure and the risk profile of the borrower. Based on the classification, the interest rates charged ranges from 10% to 13.7% depending upon the renewable energy technology. The interest rates trends reveal that the rates have been reducing over the past year and are expected to reduce further in the next year.

In view of the above, the Commission proposes normative interest rate of two hundred (200) basis points above the average State Bank of India MCLR (One year Tenor) prevalent during the last available six months of the relevant year of the Control Period for the determination of tariff.

#### 4.5 Depreciation

In the RE Tariff Regulations-2012 the Commission specified depreciation per annum based on 'Differential Depreciation Approach' over loan tenure and beyond loan tenure over useful life computed on 'Straight Line Method'. The depreciation rate specified for the first 10 years of the Tariff Period was 5.83% per annum and the remaining depreciation shall be spread over the remaining useful life of the project from 11<sup>th</sup> year onwards.

While specifying the same, the Commission had considered the concern of the investors/lenders about debt service coverage needs, as more renewable energy capacity is envisaged to be funded by way of non-recourse finance basis.

The Commission is of the view that since most of the RE technologies have achieved maturity level, it would be possible for the developers to secure loan from lenders /financial institution for longer duration of say 12 years or more. The longer duration of loans has also been observed in the project information gathered from financial institutions. Following the 'Differential Depreciation Approach over the loan tenure and beyond loan tenure over useful life computed on 'Straight Line Method', the Commission now proposes depreciation rate of 5.28% per annum for first 13 years and remaining depreciation to be spread during remaining useful life of the RE projects considering the salvage value of the project as 10% of project cost.

#### 4.6 Return on Equity

In the RE Tariff Regulations 2012, the Commission specified the normative Return on equity of pre-tax 20% per annum for first 10 years and pre-tax 24% per annum from 11<sup>th</sup> year onwards. It was further specified that the value base for the equity shall be 30% of the

capital cost or lower, in case of actual equity is less than 30% of the capital cost (in case of project specific tariff determination)

The Commission while specifying the Return on Equity of pre-tax 20% per annum for the first 10 years had considered tax holiday benefit available under the Section 80-IA of Income Tax Act, 1961. Renewable energy project developers are exempted from income tax on all earnings generated from the project for any 10 year consecutive assessment year during the first 15 years of the project life and the Minimum Alternate Tax (MAT) would be applicable on book profit of such undertaking.

The Commission has reviewed the norms on Return on Equity followed by various SERCs.

	<b>Gujarat (MYT Regulation 2011)</b>	<b>Madhya Pradesh (2016)</b>	<b>Tamil Nadu (2016)</b>	<b>Rajasthan (2016)</b>	<b>Karnataka (2015)</b>
RoE Norm	14% Return on Equity plus the applicable tax payment for conventional and renewable power projects	@20% pre-tax per annum during the life of the project	14% Post Tax Return on Equity for conventional fuel based generating stations	16% on equity base of 30% of Capital Cost	16%. Any tax paid on the RoE is allowed as a pass through

The Commission also reviewed the 10 yr G-Sec rates for the past six months. The yield data for last available six months from Reserve Bank of India's monthly bulletin is as under:

<b>Month</b>	<b>10 yr G-Sec yield (Source: Monthly RBI Bulletin)</b>
June 2016	7.51
July 2016	7.27
August 2016	7.13
September 2016	6.81
October 2016	6.83
November 2016	6.30
<b>Average for Last Available 6 Months</b>	<b>6.97</b>

The Commission had undertaken an exercise to determine Return on Equity using the Capital Asset Pricing Model (CAPM) principles.

As per CAPM Methodology;

Return on Equity = Risk Free Rate +  $\beta$  (Market Rate – Risk Free Rate)

Where;

Risk Free Rate – Average of last available six months yield of G-Sec (June 2016 – November 2016) – 6.97%;

$\beta$  – Calculated for BSE Power Index for the period (01.01.2016 – 30.12.2016) as 1.004;

Market Rate – CAGR of last 20 years BSE Sensex values (1996 - 2016) calculated as 11.38%;

Return on Equity = 6.97% + 1.004 (11.38% - 6.97%)

Return on Equity = 11.40%

Considering the market realities and norms proposed by various SERCs, the Commission proposes to give a market premium of seven hundred (700) basis points over the prevailing average G-Sec rates prevalent during the last available six months of the relevant year of the Control Period for the determination of tariff.

Accordingly, the Commission proposes to consider Return on Equity of 14% (post tax) for the next Control Period (2017-2020). Going forward, Minimum Alternate Tax/ Corporate Tax are expected to be lowered and the Commission has observed that the effective tax rate is lower than the Corporate Tax rate. Hence, for the certainty of regulatory principles, it is proposed that the return on equity shall be grossed up by Minimum Alternate Tax prevailing as on 1<sup>st</sup> April of the previous financial year for the entire useful life of the project.

#### 4.7 Interest on Working Capital

The Commission in its RE Tariff Regulations 2012 have specified the norms for Working Capital for the renewable energy generation projects as under:

The Working Capital requirement in respect of Wind Energy projects, Small Hydro Power, Solar PV and Solar Thermal power projects are proposed to be computed in accordance with the following:

##### **Wind Energy / Small Hydro Power /Solar PV / Solar Thermal**

- A. Operation & Maintenance expenses for one month;
- B. Receivables equivalent to 2 (Two) months of energy charges for sale of electricity calculated on the normative CUF;
- C. Maintenance spare @ 15% of operation and maintenance expenses.

The Working Capital requirement in respect of Biomass power projects with rankine cycle technology, Non-fossil fuel based Co-generation projects, Biomass Gasifier based power projects, Biogas based power projects, Municipal Solid Waste and Refuse Derived Fuel based projects are proposed to be computed in accordance with the following clause:

**Biomass Power (with Rankine Cycle technology), Non fossil fuel based Co-generation, Biomass Gasifier based power project, Biogas based power projects, Municipal Solid Waste and Refuse Derived Fuel**

- A. Fuel costs for four months equivalent to normative PLF
- B. Operation & Maintenance expenses for one month;
- C. Receivables equivalent to 2 (Two) months of energy charges for sale of electricity calculated on the normative CUF;
- D. Maintenance spare @ 15% of operation and maintenance expenses.

The Commission proposes to continue with the above-said norms for Working Capital requirements for renewable energy generation projects for the next Control Period (2017-2020).

The Commission in its RE Tariff Regulations 2012 specified the interest on Working Capital at interest rate equivalent to the average State Bank of India Base rate prevalent during the first six months of the previous year plus three hundred fifty (350) basis points.

To incorporate an approach which aligns closer with the market dynamics and reflects the prevalent interest rates, the Commission proposes to review and take into consideration the State Bank of India MCLR (One year Tenor) for the last available six months to the notification of the order.

In addition, the Commission notes that the term of working capital loans being short, the interest rate would be higher than the interest rate chargeable for long term loans. However, the interest rates trends reveal that the rates have been reducing over the past year and are expected to reduce further in the next year.

Considering the above, the Commission proposes normative interest rate of three hundred (300) basis points above the average State Bank of India MCLR (One year Tenor) prevalent during the last available six months of the relevant year of the Control Period for the determination of tariff.

#### **4.8 Operation and Maintenance Expenses**

The Commission in its RE Tariff Regulations 2012, specified that the O&M Expenses for various RE Technologies. The O&M expenses comprise of employee expense, A&G expense and repairs and maintenance expense. While the RE project developers such as biomass



power, small hydro project have their own establishments, wind energy project developers have adopted different model of outsourced O&M activity with WTG supplier or wind-farm developer offering O&M services. Similar case is observed for Solar projects where EPC Contracting companies also offer O&M services. Even in case of biomass projects the fuel procurement, storage and handling activities are outsourced to limited extent.

The O&M Expenses were specified in Rs lakhs/MW and an annual escalation rate of 5.72% was specified for the entire Control Period in its RE Tariff Regulations 2012.

The Commission has reviewed the O&M Escalation Factor for Thermal Generating Stations, Hydro Generating Stations and Transmission system specified in the Terms and Conditions for Tariff Regulations 2014.

An exercise, as shown below, has also been conducted based on the WPI (60% weightage) and CPI Index (40% weightage) for the last five (5) years to arrive at a normative rate of escalation for the next Control Period (2017-2020).

WPI	
Average 2011-12 to 2015-16	4.36%
Weightage of WPI	60%
<b>Effective Value of WPI</b>	<b>2.61%</b>
CPI	
Average 2011-12 to 2015-16	8.09%
Weightage of CPI	40%
<b>Effective Value of CPI</b>	<b>3.24%</b>
<b>Estimated Inflation rate 2011-12 to 2015-16</b>	<b>5.85%</b>

As calculated above, the inflation rate 2011-12 to 2015-16 is estimated to be 5.85%. However, the Commission has proposed to retain the normative escalation rate of 5.72% keeping in view the current industry trend for the next Control Period (2017-2020).

#### 4.9 Subsidy and Incentive

Regulation 22 of the RE Tariff Regulations 2012, specifies that the Commission shall take into consideration any incentive or subsidy offered by the Central or State Government,

including accelerated depreciation benefit if availed by the generating company, for the renewable energy power plants while determining the tariff.

It also provide principles to be considered for ascertaining income tax benefit on account of accelerated depreciation, if availed, for the purpose of tariff determination which is reproduced as under:

*i) Assessment of benefit shall be based on normative capital cost, accelerated depreciation rate as per relevant provisions under Income Tax Act and corporate income tax rate.*

*ii) Capitalization of RE projects during second half of the fiscal year. Per unit benefit shall be derived on levlised basis at discount factor equivalent to weighted average cost of capital.*

The Commission proposes that the tariff determined under these Regulations is exclusive of taxes (other than corporate tax and minimum alternate tax) and duties as may be levied by the appropriate Government.

Provided that the taxes (other than corporate tax and minimum alternative tax) and duties levied by the appropriate Government shall be allowed as pass through on actual incurred basis.

The Commission has proposed to retain the above-said norm for the next Control Period (2017-2020).

## **5. Technology Specific Norms: Calculation of CUF/PLF**

Under this section, technology specific parameter Capacity Utilisation Factor/Plant Load Factor for Small Hydro Power projects, Solar PV and Solar Thermal projects, Wind Energy Projects, Biomass Power (with Rankine Cycle technology), Non fossil fuel Co-generation, Biomass gasifier based power project, Biogas based power projects, Municipal Solid Waste and Refuse Derived Fuel based projects have been discussed.

The Commission in its computation of Generic Tariff for the Control Period 2012-17 has considered the total number of hours in a year as  $24\text{hours} \times 365\text{ days} = 8760$ . However, going forward, the additional numbers of hours available during a leap year are also proposed to be factored in tariff determination.

A similar principle has been observed in wind energy modelling softwares which are used to determine the estimated energy generation for the Tariff Period. The number of hours considered in the software modelling is 8766 in a year, i.e. factoring for the 24 hours additional generation during the leap year across the consecutive four years.

Further, SECI has also proposed specified the calculation of CUF for leap year to be considered using 8784 hours instead of 8760 in its bidding documents for Design, Engineering, Supply, Construction, Erection, Testing, Commissioning and O&M of Solar PV Plants across the country.

The Commission proposes to consider the number of hours for generation in a year for determination of gross generation using various RE Technologies as 8766 hours for the next Control Period (2017-2020).

## 6. Technology Specific Norms: Small Hydro Power

Under this section, technology specific parameters such as Capital Cost Norm, Capacity Utilisation Factor, Auxiliary Consumption and O&M Expenses for Small Hydro Power projects have been discussed.

### 6.1 Capital Cost

The Commission in its RE Tariff Regulations 2012 specified normative capital cost for Small Hydro Power (SHP) projects during first year of Control Period (FY 2012-13). Capital Cost for subsequent years to be determined on the basis of indexation formula as outlined in the Regulation 29 of the RE Tariff Regulations 2012. In line with the indexation mechanism, the Commission determined the normative capital cost for FY 2012-13 (vide Order No. 35/2012 (Suo-Motu) dated 27.03.2012), FY 2015-16 (vide Order No. SM/004/2015 dated 31.03.2015) and FY 2016-17 vide Order No. SM/03/ dated 29.4.2016) as shown below:

Region	Project Size	Capital Cost FY 2012-13 (Rs lakhs/MW)	Capital Cost FY 2015-16 (Rs lakhs/MW)	Capital Cost FY 2016-17 (Rs lakhs/MW)
Himachal Pradesh, Uttarakhand & North-Eastern States	Below 5 MW	770	829.62	830.00
	5 MW to 25 MW	700	754.20	754.55
Other States	Below 5 MW	600	646.45	646.76
	5 MW to 25 MW	550	592.58	592.86

The Commission specified Capital Cost norms for SHP projects below 5 MW higher than the Capital Cost Norms for SHP between 5 MW to 25 MW as small size hydro projects below 5 MW have higher capital cost and higher operating cost due to their small size, remote locations, grid connectivity issues etc.

### 6.1.2 Costs considered by the State Regulatory Commissions

During the Control Period 2012-17, various SERCs have notified the Small Hydro Tariff Regulations/Order. These orders are based on the SHP potential available in the State and the type and design of the SHP projects going to be set up in the control period of this order. Details of the Capital Cost specified are as under:

Project Cost (Rs lakhs/MW)	Gujarat (2016)	Jammu & Kashmir (2016)	Tripura (2015)	Manipur /Mizoram (2015)	Madhya Pradesh (2013)
Below 5 MW	820.00	798.41	850.00	808.73	650.00
5 MW to 25 MW	748.00	725.83	775.00	735.21	635.00

### 6.1.3 Actual Project Cost Approach

Capital Cost information for 3 Small Hydro Projects (which translates into 29 MW) as provided by PFC and REC for the projects lent during the Control Period (2012-17) as well as capital cost information submitted by IREDA have been analysed under this approach.

Source	No. of Projects	Capacity (MW)	Project Cost (Rs Crores/MW)	Project Location
PFC	36	8	7.87	Other States
REC	2	21	6.15 – 7.05	Other States

Capital Cost information submitted by IREDA is as under (January 2015 – November 2016)

Capital Cost Component	Average Cost (Rs lakhs/MW)
Land Site Development	12.66
Civil Works and H&M works	400.64
Electro-mechanical Equipment, Engg. & Consultancy & Installation	205.41
Transmission Line	36.36
Preliminary & Pre-operative Cost / Project Mgmt.	43.90
Contingencies and Taxes & Duties	17.70

<b>Total Project Cost without IDC</b>	<b>716.67</b>
Interest during Construction	107.70
<b>Total Project Cost with IDC</b>	<b>824.37</b>

#### 6.1.4 Capital Cost Formulation for Small Hydro

The Commission has studied the SHP costing Benchmark Report prepared by IIT, Roorkee for MNRE. The Commission has also examined the cost of the SHP projects lent by different agencies and the capital cost related data for SHP of various SERCs.

To determine the Capital Cost for FY 2017-18 for SHP Projects, Capital Cost Indexation Mechanism as per Regulation 29 of RE Tariff Regulation 2012 was applied over the Capital Cost determined for SHP Projects in the Generic Tariff Order 2016-17 (Order No. SM/03/2016 dated 29.04.2016).

Capital Cost of Indexation for Small Hydro Power projects (FY 2017-18)

<b>Indexation Formulation</b>
$CC(n) = P\&M(n) * (1 + F1 + F2 + F3)$
$d(n) = (a * (SI(n-1)/SI(0)) - 1) + b * (EI(n-1)/EI(0)) - 1) / (a + b)$
$P\&M(n) = P\&M(0) * (1 + d(n))$

<b>Variables</b>	<b>Description</b>	<b>Value</b>
a	Weightage for Steel Index	0.6
b	Weightage for Electrical Machinery Index	0.4
F1	Factor for Land and Civil Work	0.16
F2	Factor for Erection and Commissioning	0.1
F3	Factor for IDC and Financing	0.14

<b>Month/Year</b>	<b>Electrical Machinery</b>		<b>Steel</b>	
	<b>2016</b>	<b>2011</b>	<b>2016</b>	<b>2011</b>
Jan-16	138.30	125.10	122.60	118.60

Feb-16	138.00	125.10	123.90	113.00
Mar-16	138.00	126.40	123.90	113.00
Apr-16	139.40	127.20	123.90	113.00
May-16	139.20	127.60	123.90	113.00
Jun-16	138.90	128.00	125.90	119.60
Jul-16	138.80	128.70	125.20	126.20
Aug-16	138.70	129.20	125.20	126.20
Sep-16	138.60	130.90	125.20	126.20
Oct-16	138.70	130.60	125.20	126.20
Nov-16	138.80	130.80	125.20	126.20
Dec-16	138.90	131.00	125.20	126.20
<b>Average</b>	<b>138.692</b>	<b>128.383</b>	<b>124.608</b>	<b>120.617</b>

Parameters	Description	HP/Uttarakhand/NE		Other States	
		SHP <5 MW	5 MW – 25 MW	SHP <5 MW	5 MW – 25 MW
CC(0) (RsL/MW)	Capital Cost for the Base Year	770.00	700.00	600.00	550.00
P&M(0) (Rs L/MW)	Plant & Machinery Cost for the Base Year	550.00	500.00	428.57	392.86
d(n)	Capital Cost escalation Factor	5.197%	5.197%	5.197%	5.197%
P&M(n) (Rs L/MW)	Plant & Machinery Cost for the nth Year (FY 2017-18)	578.59	525.99	450.84	413.28
CC(n) (Rs L/MW)	Capital Cost for the nth Year (FY 2017-18)	810.02	736.38	631.18	578.59

Based on the above the following scenario emerges:-

Region	Project Size	Capital Cost FY 2016-17 (Rs lakhs/MW)	Capital Cost in line with Indexation Mechanism (Rs lakhs/MW)
Himachal Pradesh, Uttarakhand & North- Eastern States	Below 5 MW	830.00	810.02
	5 MW to 25 MW	754.55	736.38
Other States	Below 5 MW	646.76	631.18
	5 MW to 25 MW	592.86	578.59

Energy from Small Hydro power projects is the oldest and reliable renewable energy source and the potential of this source is still under-utilised. Therefore, to promote development of small hydro power projects in the country, the Commission proposes the Capital Cost for SHP Projects for FY 2017-18 as under:

Region	Project Size	Capital Cost FY 2017-18 (Rs lakhs/MW)
Himachal Pradesh, Uttarakhand & North-Eastern States	Below 5 MW	830
	5 MW to 25 MW	755
Other States	Below 5 MW	647
	5 MW to 25 MW	593

## 6.2 Capital Cost Indexation Mechanism

The Capital Cost for Small Hydro Power as specified for the first year of the Control Period will remain valid for the entire Control Period (2017-2020) unless reviewed earlier by the Commission based on market information.

## 6.3 Capacity Utilisation Factor

The RE Tariff Regulations -2012 specified that Capacity Utilization Factor (CUF) for the small hydro projects located in Himachal Pradesh, Uttarakhand and North Eastern States shall be 45% and for other States, CUF was 30%. It was further specified that the normative CUF is net of free power to the home State if any, and any quantum of free power if committed by the developer over and above the normative CUF shall not be factored into the tariff. The above norms for CUF were derived on the basis of CUF considered by the SERCs while approving the tariff for small hydro projects in their respective States. The CUF considered by various SERCs during the period 2012-2017 are as follows:

	Gujarat (2016)	Jammu & Kashmir (2016)	Tripura (2015)	Manipur /Mizoram (2015)	Madhya Pradesh (2013)
CUF	42%	45%	45%	45%	30%

Accordingly, the Commission proposes to retain the Capacity Utilization Factor norm of 45% for SHP Projects located in Himachal Pradesh, Uttarakhand and North Eastern States and CUF of 30% for SHP Projects located in Other States as specified in the RE Tariff Regulations-2012 for the next Control Period (2017-2020).

#### 6.4 Auxiliary Consumption Factor

The Commission in its RE Tariff Regulations-2012 specified the Normative Auxiliary Consumption for the small hydro projects of 1.0% for the determination of tariff. While specifying the above norm, the Commission considered that a typical SHP project has very few auxiliaries and pumping units as compared to large size hydro projects. The Auxiliary Consumption considered by various SERCs are as under:

	Gujarat (2016)	Jammu & Kashmir (2016)	Tripura (2015)	Manipur /Mizoram (2015)	Madhya Pradesh (2013)
Auxiliary Consumption	1%	1%	1%	1%	1%

Accordingly, the Commission proposes to retain the normative auxiliary consumption including transformation losses of 1% for the next Control Period (2017-2020).

#### 6.5 Operation and Maintenance Expenses

The Commission in its CERC RE Tariff Regulations-2012 specified the normative O&M expenses for the first year of the Control period (i.e. FY 2012-13). While specifying the above norm the Commission considered the operation and maintenance expense norm of 2 % of Capital cost specified in the CERC (Terms and Conditions for Tariff) Regulations, 2009 for new large size hydro projects. It was further considered that the cost of insurance shall be included in the prescribed cost.



Region	Project Size	O&M Expenses FY 2012-13 (Rs lakhs/MW)
Himachal Pradesh, Uttarakhand & North-Eastern States	Below 5 MW	25
	5 MW to 25 MW	18
Other States	Below 5 MW	20
	5 MW to 25 MW	14
Escalation Rate		5.72%

Upon review of the CERC (Terms and Conditions for Tariff) Regulations, 2014, O&M costs for Hydro Generating Stations is 4% of project cost for stations having installed capacity up to 200 MW and 2.50% for installed capacity more than 200 MW.

The Commission also reviewed the norms prescribed by various SERCs for small hydro projects during the Control Period 2012-17. The O&M Costs considered by various SERCs are as under:

O&M Cost	Gujarat (%age of Capital Cost) (2016)	Jammu & Kashmir (Rs lakhs/MW) (2016)	Tripura (Rs lakhs/MW) (2015)	Manipur /Mizoram (Rs lakhs/MW) (2015)	Madhya Pradesh (%age of Capital Cost) (2013)
Below 5 MW	3.3% of CC	29.54	30.00	27.94	3% of CC
5 MW to 25 MW	2.5% of CC	21.27	21.60	20.12	
Escalation Rate	5.72%	5.72%	5.72%	5.72%	5.72%

Therefore, the Commission proposes the following O&M expenses norm for the first year of Control Period (i.e. FY 2017-18) which is determined by applying annual escalation factor of 5.72% per annum on the O&M cost norm applicable for FY 2016-17:

Region	Project Size	O&M Expense FY 2016-17 (Rs lakhs/MW)	O&M Expense FY 2017-18 (Rs lakhs/MW)
Himachal Pradesh, Uttarakhand & North-Eastern States	Below 5 MW	31.23	33.02
	5 MW to 25 MW	22.49	23.78
Other States	Below 5 MW	24.98	26.41
	5 MW to 25 MW	17.49	18.49

## 7. Technology Specific Norms: Solar PV

Under this section, technology specific parameters such as Capital Cost Norm, Capacity Utilisation Factor, Auxiliary Consumption and O&M Expenses for Solar PV power projects have been discussed.

### 7.1 Technology Aspect

Norms for Solar Photovoltaic (PV) power would be applicable for grid connected PV systems that directly convert solar energy into electricity and are based on the technologies such as crystalline silicon or thin film etc. as may be approved by MNRE.

Over the course of the control period, Solar PV technology has registered the maximum growth and stands at over 9,000 MW as on 31<sup>st</sup> December 2016 (Source: MNRE). The project developers have been exhibiting keen interest and the competitive bidding results have yielded near grid parity tariffs.

### 7.2 Capital Cost Benchmarking

The Commission proposes to determine only Project Specific Capital Cost and Tariff based on the prevailing market information for Solar PV Projects for the next Control Period (2017-2020). Hence, no Capital Cost is specified for Solar PV projects for FY 2017-18.

### 7.3 Capacity Utilisation Factor

The Commission in its RE Tariff Regulations-2012 specified the Capacity Utilisation Factor for Solar PV project at 19%. Subsequently, the Commission has reviewed the RE Generic Tariff Orders notified by various SERCs and have also reviewed the bidding documents issued by various agencies including SECI for competitive bidding and inviting project Developers and Engineering, Procurement and Construction (EPC) companies to setup and construct solar PV projects.

The summary of CUF prescribed by various SERCs is as under:

	<b>Rajasthan (2016)</b>	<b>Madhya Pradesh (2016)</b>	<b>Jammu &amp; Kashmir (2016)</b>	<b>Tamil Nadu (2016)</b>	<b>Uttarakhand (2016)</b>	<b>Gujarat (2015)</b>
CUF	20% with deration factor of 0.50% from 2 <sup>nd</sup> year onwards	19%	18%	19%	19%	19%

In addition, the summary of CUF prescribed in various Bidding Documents issued by State Agencies including SECI is as under:

Agency	Prescribed CUF (%)
SECI (BDL, Telangana; THDCIL, Kerala and Paradip Port Trust, Odisha)	16 - 19
TANGEDCO (Jan 2017)	17 - 19
UPNEDA (April 2016)	20% for first year. 0.8% degradation from 2 <sup>nd</sup> yr onwards

Considering the above, the Commission proposes benchmark CUF of 19% for the next Control Period (2017-2020). The Commission also proposes to study the variation of CUF across the country and identify zones.

#### 7.4 Auxiliary Consumption

The Commission in its RE Tariff Regulations 2012, did not prescribe any auxiliary consumption for Solar PV projects for the Control Period.

A photovoltaic power plant consumes minimal energy for auxiliary purposes. Auxiliary power may be required for air-conditioning in inverter and control rooms, cleaning water softening and pumping system, security night lighting and general office lights and fans. The Commission has reviewed the Tariff Orders of various SERCs issued for the period 2015-16 and 2016-17 as under:

	Rajasthan (2016)	Madhya Pradesh (2016)	Jammu & Kashmir (2016)	Tamil Nadu (2016)	Gujarat (2015)	Karnataka (2015)
Auxiliary Consumption	Nil	0.25%	Nil	Nil	0.25%	0.25%

The Commission is of the view that some equipment in the plant shall require supply to be consumed. In order to promote these technologies, an auxiliary consumption of 0.25% of gross generation is allowed for the next Control Period (2017-2020).

## **7.5 Operation and Maintenance Expenses**

The Commission proposes to determine only Project Specific O&M Expenses based on the prevailing market information for Solar PV Projects for the next Control Period (2017-2020). Hence, no Operation and Maintenance Expenses are specified for Solar PV projects for FY 2017-18.

## **8. Technology Specific Norms: Solar Thermal Technologies**

Under this section, technology specific parameters such as Capital Cost Norm, Capacity Utilisation Factor, Auxiliary Consumption and O&M Expenses for Solar Thermal power projects have been discussed.

Concentrating Solar Power (CSP) technologies use systems of mirrored concentrators to focus direct beam solar radiation to receivers that convert the energy to high temperature for power generation. There are four main configurations that are commercially available- Parabolic Trough, Linear Fresnel Reflector, Parabolic Dish and Central Receiver Tower – with Parabolic Trough being the most prevalent.

Typically, this heat is transformed to mechanical energy through a steam turbine and then to electricity. CSP has advantages compared to photovoltaic as it can readily incorporate thermal energy storage and/or hybridization to provide dispatchable power. The use of relatively 'low tech' manufacturing methods for solar collector fields, together with the use of available steam turbine technologies, makes the prospect of CSP capacity quite feasible to get rapidly scaled up.

### **8.1 Capital Cost**

The Commission proposes to determine only Project Specific Capital Cost and Tariff for Solar Thermal Projects for the next Control Period (2017-2020) based on the prevailing market information. Hence, no Capital Cost is specified for Solar Thermal projects for FY 2017-18.

### **8.2 Capacity Utilisation Factor**

The Commission in its RE Tariff Regulations 2012 has prescribed a Capacity Utilisation Factor of 23% based on solar field size of 5804 square metres per MW with an energy dump of 9%. The Commission has reviewed the CUF prescribed by various SERCs in their Generic Tariff Orders during the Control Period 2012-17. A summary of the CUF prescribed by SERCs is as under:

	<b>Rajasthan (2016)</b>	<b>Madhya Pradesh (2016)</b>	<b>Jammu &amp; Kashmir (2016)</b>	<b>Tamil Nadu (2016)</b>	<b>Gujarat (2015)</b>
CUF	23% with deration factor of 0.25% from 4 <sup>th</sup> year onwards	23%	23%	23%	23%

Considering the above, the Commission proposes CUF for Solar Thermal projects at 23% for the next Control Period (2017-2020).

### 8.3 Operation and Maintenance Expenses

The Commission proposes to determine only Project Specific O&M Expenses based on the prevailing market information for Solar Thermal Projects for the next Control Period (2017-2020). Hence, no O&M Expenses are specified for Solar Thermal projects for FY 2017-18.

### 8.4 Auxiliary Consumption

In RE Tariff Regulations 2012, the Commission specified the auxiliary consumption factor for solar thermal plants without storage at 10%.

The Commission has reviewed the norms for Auxiliary Consumption considered by various SERCs as under:

	<b>Rajasthan (2016)</b>	<b>Madhya Pradesh (2016)</b>	<b>Jammu &amp; Kashmir (2016)</b>	<b>Tamil Nadu (2016)</b>	<b>Gujarat (2015)</b>	<b>Karnataka (2015)</b>
Auxiliary Consumption	6.5%	6.5%	10%	10%	10%	8%

Considering the above, the Commission proposes auxiliary consumption for Solar Thermal projects at 10% for the next Control Period (2017-2020).

## 9. Technology Specific Norms: Wind Energy

Under this section, technology specific parameters such as Capital Cost norm, Capacity Utilization Factor (CUF), O&M Expenses for wind energy projects have been discussed.

## 9.1 Capital Cost

The Commission proposes to determine only Project Specific Capital Cost and Tariff for Wind Power Projects for the next Control Period (2017-2020), based on the prevailing market information. Hence, no Capital Cost is specified for Wind projects for FY 2017-18.

## 9.2 Capacity Utilisation Factor (CUF)

Regulation 26 of the RE Tariff Regulations for the control period 2012-17 specify norms for Capacity utilization Factor (CUF) for Wind Energy. The CUF was categorized in 5 groups of annual wind power density range at 80 meter hub height:

Wind Zone	Annual Mean Wind Power Density (W/m <sup>2</sup> )	CUF
Wind Zone - 1	Up to 200	20%
Wind Zone - 2	201 -250	22%
Wind Zone - 3	251 - 300	25%
Wind Zone - 4	301 - 400	30%
Wind Zone - 5	Above 400	32%

With changing trends in the wind turbine technology, large numbers of turbine models with hub height higher than 80m and with larger rotor diameter are available in the market. The general trend is towards steadily growing hub heights, with major wind turbine manufacturers now routinely offering turbines with hub heights around 100 meters. The National Institute of Wind Energy (NIWE), under the direction of MNRE has assessed India's wind power potential at 100m hub height as 302 GW.

It is also essential to understand the impact of increase in turbine height from 80 meters to 100 meters on the wind speed which rationally defines capacity factor of wind turbine. CERC has done an in-house study to understand the impact of increase in turbine height on the CUF.

As the Commission recognizes that the technical parameters like, air density, wind speed, shear factor etc. are site specific, the below exercise has been done based on standard conditions/parameters

For the 5 identified wind zones, their corresponding wind speeds have been calculated for Air Density of  $1.225 \text{ kg/m}^3$  (International Standard Atmosphere Condition) shown as below:

Zones	Annual Mean WPD ( $\text{W/m}^2$ )	Calculated Annual Mean Wind Speed (m/s)
Wind Zone 1	Up to 200	Up to 6.89
Wind Zone 2	201 - 250	6.9 - 7.42
Wind Zone 3	251 - 300	7.43 - 7.88
Wind Zone 4	301 - 400	7.89 - 8.68
Wind Zone 5	Above 400	Above 8.68

Wind speeds for 100m hub height were calculated using the Power Law Formula:

$$V_1/V_2 = (H_1/H_2)^\alpha$$

Where,  $\alpha$  is 1/7 or 0.143 for Neutral Stability condition

H1 is Hub Height at 80m

H2 is Hub Height at 100m

V1 is Wind Speed at 80m Hub Height

	80m Hub Height		100m Hub Height
Zones	Annual Mean WPD ( $\text{W/m}^2$ )	Calculated Annual Mean Wind Speed (m/s)	Calculated Annual Mean Wind Speed (m/s)
Wind Zone 1	Up to 200	Up to 6.89	Up to 7.11
Wind Zone 2	201 - 250	6.9 - 7.42	7.12 - 7.66

Wind Zone 3	251 - 300	7.43 - 7.88	7.67 - 8.14
Wind Zone 4	301 - 400	7.89 - 8.68	8.15 - 8.96
Wind Zone 5	Above 400	Above 8.68	Above 8.96

V2 is Wind Speed at 100m Hub Height

For all the wind zones, their corresponding WPDs were calculated at 100m hub height for Air Density of  $1.225 \text{ kg/m}^3$  (ISA Condition) as shown in below table:

	80m Hub Height		100m Hub Height	
Zones	Annual Mean WPD ( $\text{W/m}^2$ )	Calculated Annual Mean Wind Speed (m/s)	Calculated Annual Mean Wind Speed (m/s)	Calculated Annual Mean WPD ( $\text{W/m}^2$ )
Wind Zone 1	Up to 200	Up to 6.89	Up to 7.11	Up to 220
Wind Zone 2	201 - 250	6.9 - 7.42	7.12 - 7.66	221 - 275
Wind Zone 3	251 - 300	7.43 - 7.88	7.67 - 8.14	276 - 330
Wind Zone 4	301 - 400	7.89 - 8.68	8.15 - 8.96	331 - 440
Wind Zone 5	Above 400	Above 8.68	Above 8.96	Above 440

To calculate the CUF at 100m hub height, Weibull distribution approach is adopted which is well accepted in wind industry and is the basis for all high end wind flow modelling softwares. It gives a good representation of the variation in hourly mean speed over a year at many typical sites. It indicates fraction of time for which wind is at a given velocity V and is characterized by two parameters - “scale parameter” and “shape parameter”. Standard power curves of wind turbines, available in India having 100m hub heights are considered for CUF calculation.



Capacity Factor Analysis	
Air Density	1.225 kg/m <sup>3</sup>
Shape Factor k*	2 (Assumption)
Scale Factor	(WS/Gamma (1+1/k))

*\*k is the Weibull shape parameter. It specifies the shape of a Weibull distribution and takes on a value of between 1 and 3. A small value for k signifies very variable winds, while constant winds are characterized by a larger k. For the purpose of this exercise, k has been considered as 2.*

Below table shows an example of Weibull distribution of number of hours against wind speed bin of 1m/s for Wind Zone 1 at 80m & 100m hub height:

Zone 1	80m Hub Height	100m Hub Height
	WS = 6.89m/s	WS = 7.11m/s
Wind Speed	No. of Hours	No. of Hours
0	0	0
1	320	301
2	892	843
3	1283	1222
4	1438	1389
5	1376	1353
6	1161	1168
7	880	909

8	605	645
9	380	419
10	218	251
11	115	138
12	56	70
13	25	33
14	10	15
15	4	6
16	1	2
17	0	1
18	0	0
19	0	0
20	0	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0

The standard power curve of turbines is applied as input along with frequency distribution for determination of gross electricity generation/Capacity Utilization Factor (CUF) estimation at 80m & 100m hub-heights. The Net generation/CUF is determined by considering suitable discounting factors to the gross generation/CUF.

An increase of 6 – 8% in terms of CUF has been observed from 80m hub height to 100m hub height. After rounding off, the Commission proposes the following WPD and CUF for 100m hub height of wind projects for the next Control Period (2017-2020):

Zones	Proposed at 100m Hub Height	
	Annual Mean WPD (W/m <sup>2</sup> )	CUF
Wind Zone 1	Up to 220	22%
Wind Zone 2	221 - 275	24%
Wind Zone 3	276 - 330	28%
Wind Zone 4	331 - 440	33%
Wind Zone 5	Above 440	35%

### 9.3 Operation and Maintenance (O&M) Expenses

The Commission proposes to determine only Project Specific O&M Expenses for Wind Power Projects for the next Control Period (2017-2020), based on the prevailing market information. Hence, no O&M expenses are specified for Wind projects for FY 2017-18.

## 10. Technology Specific Norms: Biomass Projects Rankine Cycle

Under this section, technology specific parameters such as capital cost norm, capital cost indexation mechanism, plant load factor, auxiliary consumption, station heat rate, gross calorific value, biomass fuel price, biomass fuel price indexation mechanism and O&M Expenses, for biomass based power projects with Rankine cycle technology have been discussed.

## 10.1 Capital Cost

In line with the indexation mechanism, specified in Regulation 35 of the RE Tariff Regulations, the normative capital cost for FY 2016-17 for Biomass Projects has been determined considering capital cost specified in the RE Tariff (First Amendment) Regulations for FY 2013-14 as base year capital cost, average WPI for Steel and average WPI for Electrical Machinery prevalent for calendar year 2015 considered for SI (n-1) and EI (n-1) respectively. Average WPI for Steel and average WPI for Electrical Machinery that are prevalent for year 2012 for SI (0) and EI (0) respectively. Accordingly, the Commission determined normative capital cost for FY 2016-17 for Biomass Projects as under:

Biomass Rankine Cycle Projects	Capital Cost (FY 2016-17) (Rs Lakhs/MW)
Project [other than rice straw and juliflora (plantation) based project] with water cooled condenser	559.03
Project [other than rice straw and juliflora (plantation) based project] with air cooled condenser	600.44
For rice straw and juliflora (plantation) based project with water cooled condenser	610.8
For rice straw and juliflora (plantation) based project with air cooled condenser	652.2

### 10.1.1 Regulatory Approach

Various SERCs have issued the Tariff Orders for biomass based generation projects. The latest cost data approved by the various States Commissions is analyzed and is as under:

Name of the Commission	Gujarat (2013)		Madhya Pradesh (2013)	Tamil Nadu (2016)	Rajasthan (2015)		Maharashtra (2016)
Capital Cost (Rs Lakh / MW)	Water Cooled - 468	Air Cooled - 498	463.336	550	Water Cooled – 540.79	Air Cooled – 575.85	500.88

Based on the above analysis of the cost considered by various SERCs, it is observed that capital cost specified by SERCs is much lower than the CERC benchmark. Therefore, the Commission proposes the benchmark capital cost for FY 2017-18 to be same as that of capital cost of 2016-17 for determination of tariff.

Biomass Rankine Cycle Projects	Capital Cost (FY 2017-18) (Rs Lakhs/MW)
Project [other than rice straw and juliflora (plantation) based project] with water cooled condenser	559.03
Project [other than rice straw and juliflora (plantation) based project] with air cooled condenser	600.44
For rice straw and juliflora (plantation) based project with water cooled condenser	610.8
For rice straw and juliflora (plantation) based project with air cooled condenser	652.2

## 10.2 Capital Cost Indexation Mechanism for Biomass Projects

The Capital Cost for Biomass projects as specified for the first year of the Control Period (2017-2020) will remain valid for the entire duration of the Control Period, unless reviewed earlier by the Commission.

### 10.3 Plant Load Factor (PLF)

Regulations 36 of the RE Tariff Regulations 2012 specify the plant load factor for Biomass power projects with Rankine cycle technology and has been specified as under:

Period	PLF
During stabilization (6 months)	60%
During remaining period of the first year (after stabilization)	70%
Second year onwards	80%

#### 10.3.1 Regulatory Approach

The PLF specified by various SERCs have been analyzed and is summarized below:

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2012)	Tamil Nadu (2016)	Rajasthan (2015)	Maharashtra (2016)
PLF	70% for First Year 80% from Second Year onwards	During stabilization - 60% During remaining period of the first year (after stabilization) - 70% Second year onwards - 80%	80%	During stabilization (6 months) - 60% During remaining period of the first year (after stabilization) - 70% Second year onwards - 75%	During stabilization - 60%  During remaining period of the first year (after stabilization) - 70% Second year onwards - 80%

Based on the review of orders of various SERCs, the Commission proposes to retain the norm specified earlier for Plant Load Factor for determining tariff for the next Control Period (2017-2020).

Period	PLF
During stabilization (6 months)	60%
During remaining period of the first year (after stabilization)	70%
Second year onwards	80%

## 10.4 Auxiliary Power Consumption

Regulations 37 of the RE Tariff Regulations 2012 specify the auxiliary power consumption for Biomass power projects with Rankine cycle technology as under:

- a) For the project using water cooled condenser:
  - I. During first year of operation: 11%
  - II. From 2nd year onwards: 10%
- b) For the project using air cooled condenser:
  - I. During first year of operation: 13%
  - II. From 2nd year onwards: 12%

### 10.4.1 Regulatory Approach

Auxiliary power consumption from orders of various SERCs have been analyzed and is summarized below:

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2012)	Tamil Nadu (2016)	Rajasthan (2015)	Maharashtra (2016)
Auxiliary Power Consumption	10%	10%	10%	a) For the project using water cooled condenser: <ol style="list-style-type: none"> <li>I. During stabilization (6 Months): 10.5%</li> <li>II. After Stabilization: 10%</li> </ol> b) For the project using air cooled condenser: <ol style="list-style-type: none"> <li>I. During stabilization (6 Months): 12.5%</li> <li>II. After Stabilization: 12%</li> </ol>	10%

Based on the review of orders of various SERCs, the Commission proposes to retain the norm specified in 2016-17 for Auxiliary Power Consumption for determining tariff for the next Control Period (2017-2020).

Therefore, proposed Auxiliary Power Consumption for FY 2017-18:

- a) For the project using water cooled condenser:
  - I. During first year of operation: 11%
  - II. From 2nd year onwards: 10%
- b) For the project using air cooled condenser:
  - I. During first year of operation: 13%
  - II. From 2nd year onwards: 12%

## 10.5 Station Heat Rate

The Station Heat Rate (SHR) specified under Regulations 33 of the RE Tariff Regulations 2012 (as amended from time to time) for biomass projects are as under for year 2016-17:

- a) For projects using travelling grate boilers: 4126 kCal/kWh
- b) For projects using AFBC boilers: 4063 kCal/kWh

### 10.5.1 Regulatory Approach

Station Heat Rate specified by various SERCs have been analyzed and is summarized below:

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2013)	Tamil Nadu (2016)	Rajasthan (2015)	Maharashtra (2016)
<b>Station Heat Rate (SHR)</b>	a) For the project using water cooled condenser: 3800 kCal/kWh b) For the project using air cooled condenser: 3950 kCal/kWh	3800 kCal/kWh	3840 kCal/kWh	a) For the project using water cooled condenser: I. During stabilization: 4300 kCal/kWh II. After stabilization: 4200 kCal/kWh b) For the project using	4200 kCal/kWh



				air cooled condenser: I. During stabilization: 4540 kCal/kWh II. After stabilization: 4440 kCal/kWh	
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Based on the review of orders of various SERCs, the Commission proposes to retain the Station Heat Rate values same as that for 2016-17 for determining tariff for the next Control Period (2017-2020).

Proposed Station Heat Rate for FY 2017-18:

- a) For projects using travelling grate boilers: 4126 kCal/kWh
- b) For projects using AFBC boilers: 4063 kCal/kWh

## 10.6 Gross Calorific Value (GCV)

Regulation 43 of the RE Tariff (Third Amendment) Regulations 2015, provides the calorific value of biomass fuel used for determination of tariff shall be at 3174 kCal/kg.

### 10.6.1 Regulatory Approach

Gross Calorific Value (GCV) notified by various SERCs have been analyzed and is summarized below:

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2013)	Tamil Nadu (2016)	Rajasthan (2015)	Maharashtra (2016)
Gross Calorific Value (GCV)	Biomass: 3400 kCal/kg Coal: 3632 kCal/kg	3600 kCal/kg	3200 kCal/kg	3400 kCal/kg	3611 kCal/kg

Based on the above orders, the Commission proposes to retain the Gross Calorific Value (GCV) values same as that for FY 2016-17 for determining tariff for the next Control Period (2017-2020).

Gross Calorific Value (GCV) for FY 2017-18: 3174 kCal/kg

## 10.7 Use of Fossil Fuel

On the issue of usage of fossil fuel in Biomass based power projects, the Commission would like to emphasize that the prime objective of the Regulations are to promote usage of biomass for energy generation. Therefore, by allowing usage of fossil fuel, the very objective of using alternate fuel is defeated.

Thus, considering the necessity to promote the usage of biomass as fuel in power projects, the Commission proposes to not allow the usage of fossil fuel in biomass based power projects for the next Control Period (2017-2020).

## 10.8 Fuel Price

The Commission, in terms of Regulation 44 of the RE Tariff Regulations 2012, has specified the biomass fuel price applicable during the period 2012-13 and has specified fuel price indexation mechanism, in case developer wishes to opt, for the remaining years of the control period. With respect to the indexation, the biomass fuel price applicable for FY 2016-17 is as below:

State	Andhra Pradesh	Haryana	Maharashtra	Punjab	Rajasthan	Tamil Nadu	Uttar Pradesh	Other States
<b>Biomass price (Rs/tonne)</b>	2807.74	3195.86	3268.62	3342.6	2789.54	2761.64	2856.25	3003.01

### 10.8.1 Regulatory Approach

Fuel Prices from various SERCs have been analyzed and is summarized below:

State	Maharashtra (2016)	Rajasthan (2015)	Tamil Nadu (2016)	Karnataka (2015)	Gujarat (2013)	Madhya Pradesh (2013)
<b>Biomass price (Rs/tonne)</b>	4186.35 with escalation of 5%	2613.39	2892.03 with 5% Escalation	2100 with 5.72% escalation	2726 with 5% Escalation	2653 with 5% escalation

### 10.8.2 Fuel Price Indexation Mechanism

The Commission specified the following fuel price indexation formulae in the RE Tariff Regulations-2012 in order to take care of variation in prices of raw fuel, labour charges for storage and handling and transportation cost for the remaining year of the control period:

$$P(n) = P(n-1) * \{a * (WPI(n)/WPI(n-1)) + b * (1+IRC)(n-1) + c * (Pd(n)/Pd(n-1))\}$$

Where

P(n) = Price per ton of biomass for the nth year to be considered for tariff determination

P(n-1) = Price per ton of biomass for the (n-1)th year to be considered for tariff determination.

a = Factor representing fuel handling cost

b = Factor representing fuel cost

c = Factor representing transportation cost

IRC(n-1) = Average Annual Inflation Rate for indexed energy charge component in case of captive coal mine source (in %) to be applicable for (n-1)th year, as may be specified by CERC for 'Payment purpose' as per Competitive Bidding Guidelines

Pd n = Weighted average price of HSD for nth year.

Pd n-1 = Weighted average price of HSD for (n-1)th year.

WPI n = Whole sale price index for the month of April of nth year

WPI n-1 = Wholesale price index for month of April of (n-1)th year.

Where a, b & c will be specified by the Commission from time to time. In default, these factors shall be 0.2, 0.6 & 0.2 respectively.

Variable Charge for the nth year shall be determined as under:

$$VC_n = VC_1 \times (P_n / P_1) \text{ or}$$

$$VC_n = VC_1 \times (1.05)^{(n-1)} \text{ (optional)}$$

where,

VC1 represents the Variable Charge based on Biomass Price P1 for FY 2009-10 and shall be determined as under:

$$VC_1 = \frac{\text{Station Heat Rate (SHR)}}{\text{Gross Calorific Value (GCV)}} \times \frac{1}{(1 - \text{Aux Consum. Factor})} \times \frac{P_1}{1000}$$

In the above formula the various components of base price of the biomass fuel have been linked to indices such as average 'Annual Inflation Rate' for domestic coal to be notified by the CERC from time to time, 'Wholesale Price Index' and 'Weighted Average Price of High Speed Diesel' to take care of fuel cost, fuel handling cost and transportation cost respectively.

Accordingly, the fuel price indexation is applied on FY 2016-17 values and the new values are as below:

State	Andhra Pradesh	Haryana	Maharashtra	Punjab	Rajasthan	Tamil Nadu	Uttar Pradesh	Other States
<b>Biomass price (Rs/tonne)</b>	2873.22	3270.39	3344.85	3420.56	2854.60	2826.05	2922.86	3073.05

Based on the review of various SERCs and the Fuel Price Indexation Mechanism, the Commission proposes the fuel prices determined by indexation mechanism as the fuel prices for determination of tariff for FY 2017-18.

Alternatively, for each subsequent year of the Tariff Period, the Commission proposes the normative escalation factor of 5% per annum at the option of the developer.

Proposed Fuel Prices for FY 2017-18 are as under:-

State	Andhra Pradesh	Haryana	Maharashtra	Punjab	Rajasthan	Tamil Nadu	Uttar Pradesh	Other States
<b>Biomass price (Rs/tonne)</b>	2873.22	3270.39	3344.85	3420.56	2854.60	2826.05	2922.86	3073.05

The fuel cost for Biomass projects as specified for the first year of the Control Period (2017-2020) will remain valid for the entire duration of the Control Period, unless reviewed earlier by the Commission.

## 10.9 Operation & Maintenance Expenses

Regulation 39 of RE Tariff (First Amendment) Regulations 2014 provides that the normative O& M expenses for biomass based projects for the year 2013-14 shall be Rs 40 Lakh per MW and which shall be escalated at the rate of 5.72% per annum over the tariff period for determination of the levelled tariff. Accordingly, the Commission has considered O&M cost norm for biomass power as Rs 47.26 lakhs/MW for FY 2016-17.

### 10.9.1 Regulatory Approach

O&M expenses from various SERCs have been analysed and are summarized below:

State	Maharashtra (2016)	Rajasthan (2015)	Tamil Nadu (2016)	Karnataka (2015)	Gujarat (2013)	Madhya Pradesh (2013)
<b>O&amp;M Expenses</b>	Rs 27.08 Lakhs/MW	a) Water Cooled: Rs 37.72 Lakhs/MW with escalation of 5.85% per year b) Air Cooled: Rs 40.223 Lakhs/MW with an escalation of 5.85% per year	5% on 85% of Capital Cost & 0.9% on 15% of Capital Cost with escalation of 5.72% from 2 <sup>nd</sup> year	Rs 30 Lakhs/MW with an escalation of 5.72% per year	5% of Capital Cost with 5.72% Escalation	4% of Capital Cost with 5.72% Escalation

Based on the review of O&M Expenses of various SERCs, the Commission proposes the O&M cost for biomass power as Rs. 40.00 lakhs/MW, which is about 6% of the Capital Cost of biomass projects (Rankine Cycle), for FY 2017-18 with escalation of 5.72% per annum from second year onwards.

## 11. Non-Fossil Fuel Based Co-Generation (Bagasse)

### 11.1 Technology Aspect

The project may qualify to be termed as a co-generation project, if it is in accordance with the definition and also meets the qualifying requirement outlined below:

Topping cycle mode of co-generation – Any facility that uses non-fossil fuel input for the power generation and also utilizes the thermal energy generated for useful heat applications in other industrial activities simultaneously.

For the co-generation facility to qualify under topping cycle mode, the sum of useful power output and one half the useful thermal outputs be greater than 45% of the facility's energy consumption, during the season.

### 11.2 Capital Cost Benchmarking

The Commission, in Regulation 47 of RE Tariff Regulations 2012 has specified the normative capital cost for the Non-Fossil Fuel Based Cogeneration Projects as Rs 420 lakhs/MW for FY 2012-13 which shall be linked to the indexation mechanism specified under Regulation 48 of the RE Tariff Regulations 2012.

In accordance with the above referred Regulations, the Commission determined the normative capital cost of Non-Fossil Fuel based Cogeneration power projects at Rs 452.75 lakhs/MW for FY 2016-17.

#### 11.2.1 Regulatory Approach

Various SERCs have issued tariff orders for Non-fossil fuel based co-generation projects. The cost data approved by them are as under:

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2013)	Tamil Nadu (2016)	Maharashtra (2016)	Karnataka (2015)
Capital Cost (Rs Lakh / MW)	457	436	520	495.51	475

Based on the review of capital cost of various SERCs, the Commission proposes to continue with the benchmark capital cost of Rs 452.75 lakhs/MW for FY 2017-18, same as that of FY 2016-17.

### 11.3 Capital Cost Indexation Mechanism

The capital cost for Non-Fossil Fuel Based Co-Generation (Bagasse) projects as specified for the first year of the Control Period (2017-2020) will remain valid for the entire duration of the Control Period unless reviewed by the Commission.

### 11.4 Plant Load Factor (PLF)

Regulation 49 of the RE Tariff Regulations 2012 stipulates the plant load factor for Non-fossil Fuel based Co-generation projects as under, computed on the basis of plant availability for number of operating days considering the operations during crushing season and off-season and load factor of 92%. The number of Operating days for different States as specified in the Regulation 49(2) is as under:

States	Operating Days	PLF
Uttar Pradesh and Andhra Pradesh	120 days (crushing)+ 60 days (off-season) = 180 days	45%
Tamil Nadu and Maharashtra	180 days (crushing)+ 60 days (off-season) = 240 days	60%
Other States	150 days (crushing) + 60 days (off-season) = 210 days	53%

#### 11.4.1 Regulatory Approach

PLF notified by various SERCs are summarized below:

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2013)	Tamil Nadu (2016)	Maharashtra (2016)	Karnataka (2015)
PLF	60%	53%	55%	60%	60%

Based on the review of PLF notified by various SERCs, the Commission proposes to retain the PLF of FY 2016-17 for FY 2017-18.

Proposed Plant Load Factor (PLF) for FY 2017-18 - Based on the above reviews, the Commission proposes the following PLF:

States	Operating Days	PLF
<b>Uttar Pradesh and Andhra Pradesh</b>	120 days (crushing)+ 60 days (off-season) = 180 days	45%
<b>Tamil Nadu and Maharashtra</b>	180 days (crushing)+ 60 days (off-season) = 240 days	60%
<b>Other States</b>	150 days (crushing) + 60 days (off-season) = 210 days	53%

## 11.5 Auxiliary Consumption

Regulation 50 of the RE Tariff Regulations 2012 stipulates the auxiliary consumption for Non-fossil Fuel based Co-generation projects as 8.5% for determination of tariff.

### 11.5.1 Regulatory Approach

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2013)	Tamil Nadu (2016)	Maharashtra (2016)	Karnataka (2015)
<b>Auxiliary Consumption</b>	8.50%	8.50%	8.50%	8.50%	9%

Auxiliary consumption adopted in the Orders of various commissions is as below:

Based on the review of Auxiliary consumption adopted by different SERCs, the Commission proposes to retain the previous determined Auxiliary consumption of 8.5% for FY 2017-18.

## 11.6 Station Heat Rate

The Station Heat Rates (SHR) specified under Regulations 51 of the RE Tariff Regulations 2012 for non-fossil fuel based co-generation projects is 3600 kCal/kWh.



### 11.6.1 Regulatory Approach

SHR considered by various SERCs have been summarized below:

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2013)	Tamil Nadu (2016)	Maharashtra (2016)	Karnataka (2015)
Station Heat Rate (SHR)	3600 kCal/kWh	3600 kCal/kWh	3240 kCal/kWh	3600 kCal/kWh	3600 kCal/kWh

Based on the review of SHR adopted by different SERCs, the Commission proposes to retain the previous determined SHR of 3600 kCal/kWh for FY 2017-18.

### 11.7 Gross Calorific Value (GCV)

The Gross Calorific Value for Bagasse for FY 2016-17 has been considered as 2250 kCal/kg.

#### 11.7.1 Regulatory Approach

The GCV considered by various SERCs have been summarized below:

Name of the Commission	Gujarat (2013)	Madhya Pradesh (2013)	Tamil Nadu (2016)	Maharashtra (2016)	Karnataka (2015)
Gross Calorific Value (GCV)	2250 kCal/kg	2250 kCal/kg	2300 kCal/kg	2250 kCal/kg	2250 kCal/kg

Based on the review of GCV adopted by different SERCs, the Commission proposes to retain the previous determined GCV of 2250 kCal/kWh for FY 2017-18.

### 11.8 Fuel Price

The Commission, in terms of Regulation 53 of the RE Tariff Regulations 2012, has specified the price of bagasse applicable during the period 2012-13 and has specified fuel price indexation mechanism, in case developer wishes to opt, for the remaining years of the

control period. The price of bagasse (for non-fossil fuel based co-generation projects) applicable for FY 2016-17 is summarized in the table below:

State	Andhra Pradesh	Haryana	Maharashtra	Punjab	Tamil Nadu	Uttar Pradesh	Other States
Bagasse price (Rs/tonne)	1585.19	2254.67	2221.93	1984.22	1707.69	1768.33	1919.93

### 11.8.1 Regulatory Approach

Analysis of the bagasse price and that specified by different SERCs in establishing the tariff for bagasse power plant are shown as under:

State	Maharashtra (2016)	Tamil Nadu (2016)	Gujarat (2016)	Madhya Pradesh (2013)	Karnataka (2015)
Bagasse price (Rs/tonne)	2443.18	1788 with 5% escalation from 2nd Year	1804 for Bagasse 2912 for Coal	1583	1600

### 11.8.2 Fuel Price Indexation Mechanism

Based on the Fuel Price Indexation Mechanism as explained in Section 10.7.2, below are the fuel prices determined for various states.

State	Andhra Pradesh	Haryana	Maharashtra	Punjab	Tamil Nadu	Uttar Pradesh	Other States
Bagasse price (Rs/tonne)	1622.16	2307.26	2273.75	2030.49	1747.51	1809.57	1964.71

Based on the review of various SERCs and the Fuel Price Indexation Mechanism, the Commission proposes the fuel prices determined by indexation mechanism as the fuel prices for determination of tariff for FY 2017-18.

Alternatively, for each subsequent year of the Tariff Period, the Commission proposes the normative escalation factor of 5% per annum at the option of the developer. The Proposed Fuel Prices for FY 2017-18 are as under:

State	Andhra Pradesh	Haryana	Maharashtra	Punjab	Tamil Nadu	Uttar Pradesh	Other States
Bagasse price (Rs/tonne)	1622.16	2307.26	2273.75	2030.49	1747.51	1809.57	1964.71

The fuel cost for Non-Fossil Fuel Based Co-Generation (Bagasse) projects as specified for the first year of the Control Period (2017-2020) will remain valid for the entire duration of the Control Period, unless reviewed by the Commission.

## 11.9 Operation and Maintenance Expenses

As per Regulation 55 of RE Tariff Regulations 2012, the normative O&M Expenses for non-fossil fuel co-generation projects for the year 2012-13 has been specified as Rs 16 Lakh per MW which shall be escalated at the rate of 5.72% per annum over the tariff period for determination of the levelled tariff. Accordingly, the Commission has considered O&M cost norm for non-fossil fuel based co-generation as Rs 19.99 lakhs/MW for FY 2016-17.

### 11.9.1 Regulatory Approach

The O&M cost considered by various SERCs in their Tariff Orders is summarized below:

State	Maharashtra (2016)	Tamil Nadu (2016)	Gujarat (2013)	Madhya Pradesh (2013)	Karnataka (2015)
O&M Expenses	3.54% of Capital Cost for Base year (2015-16), escalated to indexation mechanism	Rs 18.91 Lakhs/MW with an escalation of 5.72% from 2nd year onwards	3% of Capital Cost with Escalation at 5.72%	3% of Capital Cost with Escalation at 5%	3% of Capital Cost with an escalation of 5.72%

Based on the review of O&M expenses of various SERCs O&M Expenses, the Commission proposes to escalate the O&M expenses by 5.72% on existing value of 2016-17 for determining tariff for the next Control Period (2017-2020).

Accordingly, the Commission proposes O&M cost for Non-fossil fuel based power projects as Rs 21.13 lakhs/MW for FY 2017-18 with escalation of 5.72% from second year onwards.

## 12. Biomass Gasifier Technology

### 12.1 Capital Cost

The Commission under Regulation 66 of RE Tariff Regulations 2012 has specified the normative capital cost for the Biomass Gasifier power projects based on Rankine cycle to be Rs 550.00 lakhs/MW for FY 2012-13. After taking into account capital subsidy of Rs 150.00 lakhs/MW, net project cost of Rs 400.00 lakhs/MW was determined for FY 2012-13 (linked to the indexation mechanism specified under Regulation 67 of the RE Tariff Regulations 2012).

In accordance with the above referred Regulation, the Commission determines normative Capital Cost of Biomass gasifier power projects at Rs 592.88 lakhs/MW for FY 2016-17. After taking into account capital subsidy of Rs 150.00 lakhs/MW, net project cost determined was Rs 442.88 lakhs/MW for FY 2016-17.

#### 12.1.1 Regulatory Approach

Capital Cost norms by various SERCs are summarized below:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Jharkhand (2016)	Bihar (2016)
Capital Cost	Rs 458.13 Lakhs/MW for FY 2016-17, after taking into account the capital subsidy of Rs 150 Lakhs/MW from MNRE	Same as CERC	Project Specific	Rs 593 Lakhs/MW (Draft Order)	Rs 441.25 Lakhs/MW for FY 2016-17 after taking into account the capital subsidy of Rs 150 Lakhs/MW from MNRE

Based on the analysis of approved/draft capital cost of various SERCs, the Commission has proposed to keep the Capital Cost of FY 2017-18 similar to that of FY 2016-17. Accordingly, proposed capital cost for FY 2017-18: Rs 442.88 lakhs/MW after taking into account capital subsidy of Rs 150.00 lakhs/MW from MNRE.

## 12.2 Specific Fuel Consumption

Regulation 70 of the RE Tariff Regulations 2012 stipulates that the normative specific fuel consumption shall be 1.25 kg per kWh for Biomass Gasifier based power generating stations for FY 2016-17.

### 12.2.1 Regulatory Approach

Specific fuel consumption for various SERCs have been summarized below:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Jharkhand (2016)	Bihar (2016)
Specific Fuel Consumption	1.25 kg/kWh	Same as CERC	Project Specific	1.25 kg/kWh (Draft Order)	1.25 kg/kWh

Based on the analysis of different SERCs specific fuel consumption values, the Commission has proposed to retain specific fuel consumption value to 1.25 kg per kWh for FY 2017-18.

## 12.3 Auxiliary Power Consumption

Regulation 69 of the RE Tariff Regulations 2012 stipulate the auxiliary power consumption factor as 10% for Biomass Gasifier projects.

### 12.3.1 Regulatory Approach

The auxiliary power consumption specified by various SERCs is summarized below:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Jharkhand (2016)	Bihar (2016)
Auxiliary Consumption Factor	10%	Same as CERC	Project Specific	10% (Draft Order)	10%

Based on the analysis of various SERCs regarding their auxiliary consumption factor, the Commission has proposed to retain the auxiliary consumption factor as 10% for FY 2017-18.

## 12.4 Plant Load Factor (PLF)

Regulation 68 of the RE Tariff Regulations 2012 (which is amended time to time) specified the plant load factor for Biomass Gasifier based renewable energy generating stations as 85%.

### 12.4.1 Regulatory Approach

The PLF considered by various SERCs have been summarized in below table:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Jharkhand (2016)	Bihar (2016)
Plant Load Factor (PLF)	85%	Same as CERC	Project Specific	85% (Draft Order)	85%

Based on the analysis of various SERCs of their plant load factor, the Commission has proposed to retain the PLF as 85% for FY 2017-18.

## 12.5 O&M Expenses

Regulation 71 of the RE Tariff Regulations 2012 specified the normative O&M expenses for biomass gasifier power projects shall be Rs. 40 lakhs/MW for the first year of operation, which shall be escalated at the rate of 5.72% per annum over the tariff period for determination of the levelled tariff. Accordingly, the Commission has considered O&M cost norm for biomass gasifier based power plant as Rs. 49.97 lakhs/MW for FY 2016-17.

### 12.5.1 Regulatory Approach

The O&M cost specified by various SERCs have been summarized in the below table:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Jharkhand (2016)	Bihar (2016)
O&M Cost	Rs 50.035 Lakhs/MW with escalation of 5.85%	Same as CERC	Project Specific	Rs 50 Lakhs/MW (Draft Order)	Rs 49.97Lakh/MW for FY 2016-17

Based on the review of various SERCs O&M Expenses, for the FY 2017-18, the Commission proposes to escalate the O&M Expenses of biomass gasifier projects by 5.72% on existing value of 2016-17

Accordingly, the Commission proposes O&M cost for Biomass Gasifier power projects as Rs 52.83 lakhs/MW for FY 2017-18 with escalation of 5.72% per annum for second year onwards.

## **12.6 Biomass Fuel Price**

The Commission proposes that the biomass fuel price suggested for the biomass based power plant with rankine cycle technology would be applicable for the biomass gasification based power plant for the next Control Period (2017-2020)

## **13. Technology Specific Norms: Biogas Plants Technology**

Grid connected biogas based power projects that use 100% Biogas fired engine, coupled with Biogas technology for co-digesting agriculture residues, manure and other bio waste (as may be approved by the Ministry of New and Renewable Energy) qualify for tariff determination under clause 4 of the RE Tariff Regulations.

### **13.1 Capital Cost**

The Commission under Regulation 76 of RE Tariff Regulations 2012 has specified the normative capital cost for Biogas based power projects to be Rs 1100.00 lakhs/MW for FY 2012-13. After taking into account of capital subsidy of RS 300.00 lakhs/MW, net project cost is Rs 800.00 lakhs/MW for FY 2012-13 (which is linked to the indexation mechanism). In accordance with the above referred Regulation, the Commission determines the normative capital cost of Biogas based power projects at Rs 1185.76 lakhs/MW for FY 2016-17. After taking into account of capital subsidy of Rs 300.00 lakhs/MW, net project cost is Rs 885.76 lakhs/MW for FY 2016-17.

#### **13.1.1 Regulatory Approach**

The capital cost specified by various SERCs has been summarized as below:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Madhya Pradesh (2015)	Jharkhand (2016)	Haryana (2015)
<b>Capital Cost</b>	Rs 1185.36 Lakhs/MW, After taking into account the capital subsidy of Rs 300 Lakh/MW, net capital cost works out to Rs 885.36 Lakh/MW for FY 2016-17	Same As CERC	Project Specific	Rs 925 lakhs/MW after net of subsidy and including power evacuation	Rs 1190 Lakhs/MW (Draft order)	Project Specific

Based on the analysis of specified capital cost for Biogas based projects of various SERCs, the Commission has proposed to retain the capital cost of FY 2016-17 as that for FY 2017-18.

Accordingly, the proposed capital cost for biogas based projects for FY 2017-18 is Rs 1185.76 lakhs/MW (excluding any subsidy).

## 13.2 Specific Fuel Consumption

The Regulation 81 of the RE Tariff Regulations 2012 stipulates that the normative specific fuel consumption shall be 3 kg of substrate mix per kWh for Biogas based power generating stations.

### 13.2.1 Regulatory Approach

Specific fuel consumption defined by various SERCs is given in the below table:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Madhya Pradesh (2015)	Jharkhand (2016)	Haryana (2015)
<b>Capital Cost</b>	3 Kgs/kWh	Same As CERC	Project Specific	10.7 Kgs./kWh	3Kgs/kWh (Draft Order)	Project Specific

Based on the analysis of various SERCs for their specific fuel consumption, the Commission has proposed to retain the values of FY 2016-17 for FY 2017-18.



Proposed Specific Fuel Consumption for Biogas project for FY 2017-18 is 3 kg of substrate mix per kWh.

### 13.3 Feedstock Cost

The Commission, in terms of Regulation 82 of the RE Tariff Regulations 2012, has specified the feed stock price during first year of the Control Period (i.e. FY 2012-13) at RS 990/MT (net of any cost recovery from digester effluent) and has specified fuel price indexation mechanism for the Biogas project developer. The price of fuel applicable for the biogas based power plant for FY 2016-17 after adjusting to the fuel price index was RS 1200.72/MT (net of any cost recovery from digester effluent).

#### 13.3.1 Regulatory Approach

Feed stock prices defined by various SERCs are given in the below table:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Jharkhand (2016)	Haryana (2015)
Feed Stock Price	Rs 1209.04 per MT	Same As CERC	Project Specific	Rs 1200 per MT (Draft Order)	Project Specific

#### 13.3.2 Fuel Price Indexation Mechanism

Based on the Fuel Price Indexation Mechanism as explained in Section 10.7.2, the feed stock price determined is Rs 1228.72/MT.

Based on the analysis of feed stock prices for various SERCs and the price determined from Indexation Mechanism, the Commission has propose the values determined by indexation mechanism as the feed stock price for FY 2017-18.

Accordingly, the proposed feed stock price for biogas projects is Rs 1228.72/MT for FY 2017-18.

### 13.4 Auxiliary Power Consumption

Regulations 79 of the RE Tariff Regulations 2012 stipulate the auxiliary power consumption factor for biogas projects as 12% for FY 2016-17.

#### 13.4.1 Regulatory Approach

Auxiliary power consumption specified by various SERCs is summarized in the below table:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Madhya Pradesh (2015)	Jharkhand (2016)	Haryana (2015)
Auxiliary power Consumption	12%	Same As CERC	Project Specific	10%	12% (Draft Order)	Project Specific

Based on the analysis of auxiliary power consumption notified by various SERCs, the Commission has proposed to retain the values of FY 2016-17 as that for FY 2017-18.

Accordingly, the proposed auxiliary power consumption for biogas projects is 12% for FY 2017-18.

### 13.5 Plant Load Factor (PLF)

Regulations 78 of the RE Tariff Regulations 2012 specify the plant load factor for Biogas based projects as 90%.

#### 13.5.1 Regulatory Approach

PLF considered by various SERCs is summarized in the below table:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Madhya Pradesh (2015)	Jharkhand (2016)	Haryana (2015)
Plant Load Factor (PLF)	85%	Same As CERC	Project Specific	10%	12% (Draft Order)	Project Specific

Based on the analysis of various SERCs for their PLF, the Commission has proposed to retain the PLF for FY 2017-18 as 90%.

### 13.6 O&M Expenses

Regulation 80 of the RE Tariff Regulations 2012 specified the normative O&M expenses for biogas at be Rs 40 lakhs/MW for the first year of operation, which shall be escalated at the rate of 5.72% per annum over the tariff period for determination of the levellised tariff. Accordingly, the Commission has considered O&M cost norm for biogas based power plant as Rs 49.97 lakhs/MW for FY 2016-17.

#### 13.6.1 Regulatory Approach

The O&M cost specified by various SERCs is summarized in the below table:

Name of the Commission	Rajasthan (2016)	Punjab (2016)	Maharashtra (2016)	Madhya Pradesh (2015)	Jharkhand (2016)	Haryana (2015)
O&M	Rs 50.035 Lakhs/MW with escalation of 5.85%	Same As CERC	Project Specific	4% of capital cost for 1st year. Escalation of 5.72% from 2 <sup>nd</sup> yr	Rs 50 Lakhs/MW with Escalation of 5.72% (Draft order)	Project Specific

Based on the review of various SERCs regarding O&M Expenses, for the FY 2017-18, the Commission proposes to escalate the O&M Expenses by 5.72% on existing value of 2016-17 for FY 2017-18.

Accordingly, the Commission proposes O&M cost for Biogas power projects as Rs 52.83 lakhs/MW for FY 2017-18 with escalation of 5.72% per annum from second year onwards.

## 14. Technology Specific Norms: Waste to Energy viz Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF)

The Commission notified the Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) (Fourth Amendment) Regulations, 2015, on 7.10.2015 wherein, various technical norms of Waste to Energy (viz Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) were specified. The Commission in the Tariff Order FY 2016-17 has decided to issue the Tariff Order for MSW / RDF projects separately, and till such time the tariff as per order dated 7.10.2015 shall continue to be in force.

### 14.1 Capital Cost

The Commission proposes to determine only Project Specific Capital Cost and Tariff for Municipal Solid Waste and Refuse Derived Fuel Projects for the next Control Period (2017-2020), based on the prevailing market information. Hence, no Capital Cost is specified for Municipal Solid Waste and Refuse Derived Fuel Projects for FY 2017-18.

### 14.2 Plant Load Factor

Regulation 33C of the RE Tariff Regulations 2012 specifies the Plant Load Factor (PLF) for the Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) power projects as below:

PLF	MSW	RDF
During Stabilisation	65%	65%
During the remaining period of the first year (after stabilization)	65%	65%
From 2nd Year onwards	75%	80%

#### 14.2.1 Regulatory Approach

The PLF specified by various SERCs has been summarized below:

Name of the Commission	Chhattisgarh (2016)	Telangana (2016)	Madhya Pradesh (2016)	Jharkhand (2016)	Haryana (2016)
PLF	MSW – 75% RDF – 80%	MSW: First Year – 65% Second Year onwards – 75%  RDF: First Year – 65% Second Year onwards – 80%	MSW: First Year – 65% Second Year onwards – 75%	MSW: First Year – 65% Second Year onwards – 75%  RDF: First Year – 65% Second Year onwards – 80% (Draft Order)	MSW: First Year – 65% Second Year onwards – 75%  RDF: First Year – 65% Second Year onwards – 80%

Based on the analysis of PLF for municipal solid waste (MSW) and refuse derived fuel (RDF) projects of various SERCs, the Commission has proposed to retain the PLF of FY 2016-17 as that for FY 2017-18.

Accordingly, the proposed PLF for Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) power projects for FY 2017-18 shall be as under:

PLF	MSW	RDF
During Stabilisation	65%	65%
During the remaining period of the first year (after stabilization)	65%	65%
From 2nd Year onwards	75%	80%

### 14.3 Auxiliary Consumption

The Regulation 33D of the RE Tariff Regulations 2012 specified the Auxiliary Consumption for the Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) power projects as 15%.

#### 14.3.1 Regulatory Approach

The Auxiliary Consumption specified by various SERCs has been summarized below:

Name of the Commission	Chhattisgarh (2016)	Telangana (2016)	Madhya Pradesh (2016)	Jharkhand (2016)	Haryana (2016)
<b>Auxiliary Consumption</b>	MSW – 15% RDF – 15%	MSW - 12% RDF - 11%	MSW - 15%	MSW - 15% RDF - 15% (Draft Order)	MSW – 15% RDF – 15%

Based on the analysis of Auxiliary Consumption for Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) power projects specified by various SERCs, the Commission has proposed to retain the PLF of FY 2016-17 as that for FY 2017-18.

Accordingly, the proposed Auxiliary Consumption for Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) power projects for FY 2017-18 shall be as 15%.

#### 14.4 Station Heat Rate

The Regulation 33F of the RE Tariff Regulations 2012 specified the Station Heat Rate for the Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) power projects as 4200 Kcal/kWh.

##### 14.4.1 Regulatory Approach

The Station Heat Rate specified by various SERCs has been summarized below:

Name of the Commission	Chhattisgarh (2016)	Telangana (2016)	Jharkhand (2016)	Haryana (2016)
<b>Station Heat Rate</b>	4000 Kcal/kWh for both MSW and RDF	4000 Kcal/kWh For RDF only	4200 Kcal/kWh for both MSW and RDF (Draft Order)	4200 Kcal/kWh for both MSW and RDF

Based on the analysis of Station Heat Rate for Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) power projects specified by various SERCs, the Commission has proposed to retain the Station Heat Rate of FY 2016-17 as that for FY 2017-18.

Accordingly, the proposed Station Heat Rate for Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) power projects for FY 2017-18 shall be as 4200 Kcal/kWh.

## 14.5 Calorific Value

The Regulation 33G of the RE Tariff Regulations 2012 specified the Calorific Value for the Refuse Derived Fuel (RDF) as 2500 kcal/kg.

### 14.5.1 Regulatory Approach

The Calorific Value specified by various SERCs have been summarized below:

Name of the Commission	Chhattisgarh (2016)	Telangana (2016)	Jharkhand (2016)	Haryana (2016)
Calorific Value	2500 kcal/kg for both MSW and RDF	2500 kcal/kg for both MSW and RDF	2500 kcal/kg for RDF (Draft Order)	2500 kcal/kg for RDF

Based on the analysis of Calorific Value for Refuse Derived Fuel (RDF) projects of various SERCs, the Commission has proposed to retain the Calorific Value of FY 2016-17 as that for FY 2017-18.

Accordingly, the proposed Calorific Value for Refuse Derived Fuel (RDF) for FY 2017-18 shall be as 2500 kcal/kg. GCV for MSW projects is not relevant in the present context as no fuel charge is applicable for such plants.

## 14.6 Fuel Cost

The Regulation 33H of the RE Tariff Regulations 2012 specified the Fuel Cost for the Refuse Derived Fuel (RDF) based projects. The price for FY 2016-17 has been considered as Rs 1,800 per MT.

For each subsequent year of the Tariff Period, the normative escalation factor of 5% per annum shall be applicable at the option of the refuse derived fuel (RDF) project developer.

No fuel cost shall be considered for determination of tariff for the power projects using Municipal Solid Waste (MSW).

#### 14.6.1 Regulatory Approach

The Fuel Cost specified by various SERCs for RDF based projects has been summarized below:

Name of the Commission	Chhattisgarh (2016)	Telangana (2016)	Jharkhand (2016)	Haryana (2016)
<b>Fuel Cost</b>	Rs 1890/Tonne for first year with escalation of 5% per annum for subsequent year	Rs 1800/Tonne for first year with escalation derived as per formula	Rs 1800/Tonne for first year with escalation of 5% per annum for subsequent year (Draft Order)	Rs 1800/Tonne for first year with escalation of 5% per annum for subsequent year at the option of project developed

Based on the analysis of Fuel Cost for Refuse Derived Fuel (RDF) projects of various SERCs, the Commission has proposed to retain the Fuel Cost of FY 2016-17 as that for FY 2017-18.

Accordingly, the proposed Fuel Cost for Refuse Derived Fuel (RDF) for FY 2017-18 shall be as Rs 1,800 per MT with escalation of 5% per annum.

No Fuel cost is considered for MSW based projects.

#### 14.7 Operation and Maintenance (O&M) Expenses

The Commission proposes to determine only Project Specific O&M Expenses for MSW and RDF based projects for the next Control Period (2017-2020), based on the prevailing market information. Hence, no O&M expenses have been specified for MSW and RDF based projects for FY 2017-18.

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