Renewable Energy Tariff and Financial Analysis Tool

User Guide

Prayas Energy Group, Pune

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Introduction

Electricity Regulatory Commissions in India determine feed-in-tariffs for different renewable energy technologies. In addition to feed-in-tariffs, renewable energy certificates (RECs) is another regulatory mechanism for deployment of renewables - essentially to overcome geographical resource availability. Apart from these, off-grid systems are deployed in areas where it is techno-economically infeasible to extend the grid.

This Excel-based tool provides a convenient way to perform tariff calculations based on *Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) (First Amendment) Regulations, 2014* (hereafter referred to as CERC Guidelines) as well as to compare costs of off-grid and grid extension projects.

The tool takes user input on up to 64 variables that are used to determine the tariff and internal rate of return (IRR) for a particular technology. In addition, the tool calculates delivered costs of off-grid and grid extension projects based on 7 inputs (without IRR as it is not applicable to off-grid projects). The tool also allows for sensitivity analysis in which the user can vary a few select inputs and observe graphically how the variation affects tariff. Default values are provided based on the technology. More information about the default values is provided later in this guide.

This tool can be used by anyone who wishes to study the financial aspects of renewable energy projects including but not limited to civil society groups, regulators, project developers, financiers and policy analysts. Some knowledge of renewable energy and financial terminology is useful to make best use of the tool.

The renewable technologies currently supported for feed-in-tariff and REC calculations are Solar Photovoltaic (PV) and Solar Thermal, Wind, Small Hydro, Biogas, Bagasse Cogeneration, Biomass Gasifier and Biomass Rankine Cycle. The technologies supported for off-grid projects are Solar PV, Small Hydro and Biomass Gasifier.

The tool runs in Microsoft Excel with a combination of Excel formulas and Visual Basic for Applications (VBA) code.

Revisions

Version	Date	Comments
1.0	April 30, 2012	Initial version. • Supports Solar PV/Thermal, Wind, Biogas, Bagasse Co-generation, Biomass Gasifier and Biomass Ranking Cycle Projects. Bagasse Co-generation option can be used for all non-fossil fuel co-generation projects. • Incorporates basic sensitivity analysis to study affect of changes in the inputs – capital expenditure, O&M expenses, capacity utilization, interest rate, discount rate, return on equity and fuel – on tariff.
2	September 5, 2014	• Delivered cost for off-grid and grid extension projects ○ Includes generation and distribution costs • Support for REC with state-specific APPC • Ability to specify a Feed-in-tariff and compare returns • Support for additional loan • Support for foreign loan

Intended audience

The tool can be used by anyone who wishes to study the financial aspects of a renewable energy project including but not limited to civil society groups, regulators, project developers, financiers and policy analysts. Some knowledge of renewable energy and financial terminology is useful to make best use of the tool. This guide and the tool referred to are written with the expectation that the users of this tool are familiar with basic use of Microsoft Excel.

Disclaimer

While every effort has been made to make the tool user friendly, error-free and accurate, it is possible that it can be improved further. We are open to suggestions and constructive feedback on improving the tool.

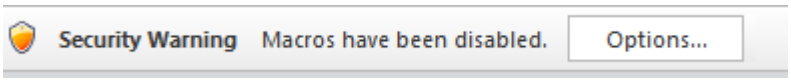
The tariff tool is provided on as 'as-is where-is' basis and only as a guide. Appropriate professional help should be sought before any commercial decisions are made. PRAYAS accepts no liability from the use of the results from this tool.

System Requirements

1. Machine: At least 512 MB RAM, 600MHz CPU
2. Operating System: Windows XP and above
3. The tool works best with Microsoft Office 2007 and above. It works with Microsoft Office 2003 as well with the exception of some minor features such as tab navigation. The tool does not work with LibreOffice or OpenOffice. This is because the tool has a lot of macros that are written in Visual Basic for Applications (VBA).
4. The font Calibri is used through the Excel workbook, hence viewing is optimal if the font is installed.

Instructions

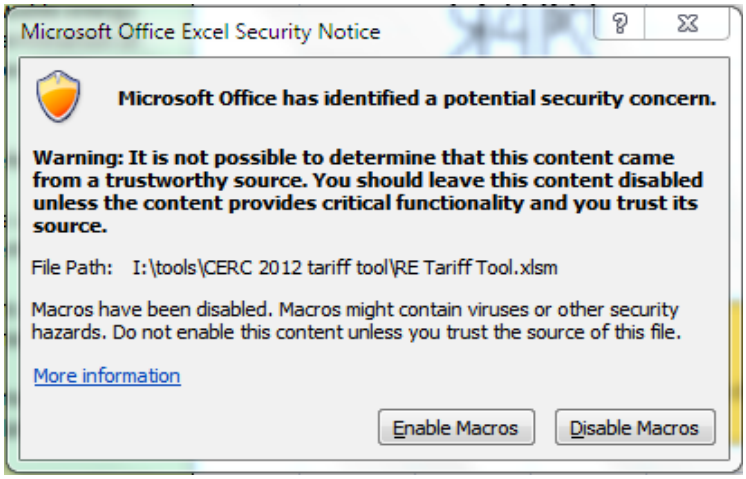
1. Excel Security Options need to be verified on the machine on which the tool is run. Depending on the security options, macros may need to be enabled. If macros are disabled by default, when the workbook is opened, a security warning may show up in the following two ways:
   i. A security warning shows up in the toolbar at the top of the spreadsheet that looks like the following:



When the button titled “Options...” is clicked, the following dialog box appears:

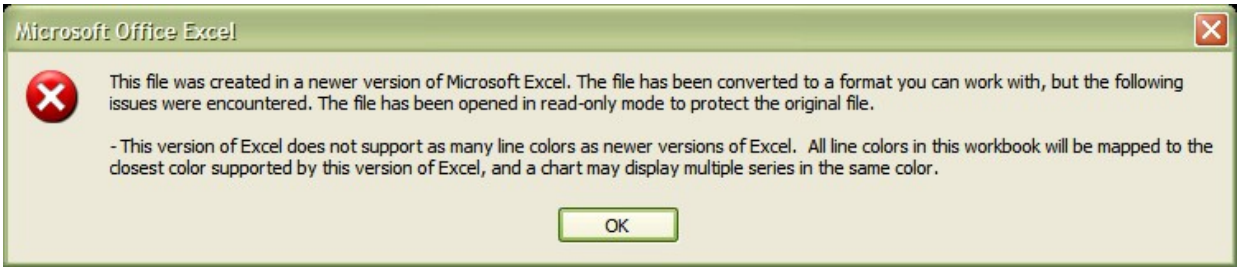
The “Enable this content” radio box needs to be checked and the “OK” button clicked in order for the tool to run.

   ii. Alternatively, the following popup may show up. The “Enable Macros” button needs to be clicked for the tool to run.

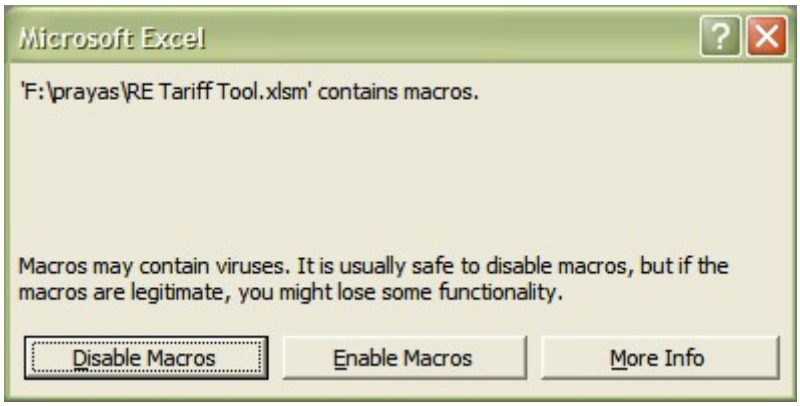


Note: this version of the popup has been observed only in some instances.

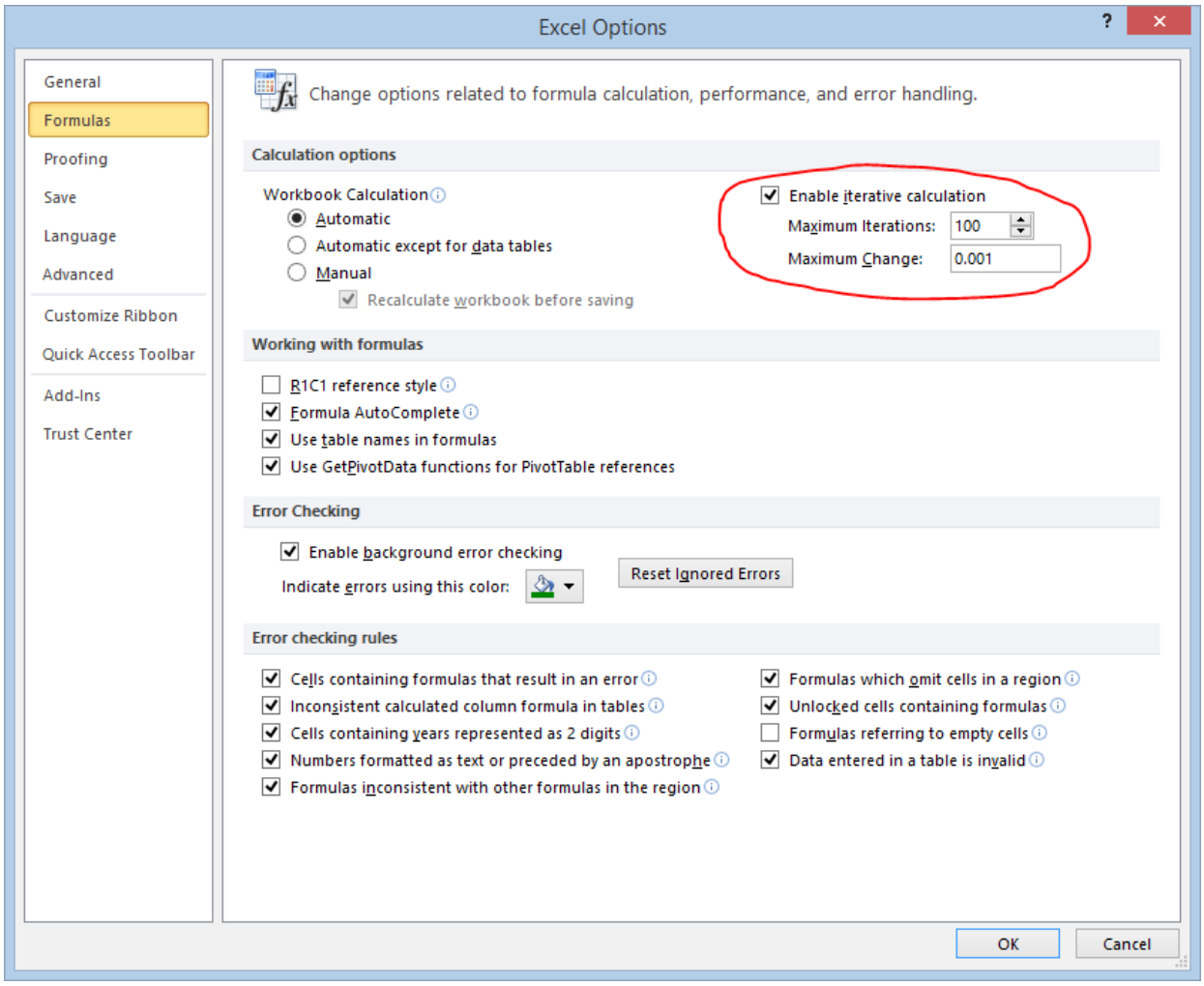
iii. When opening the spreadsheet in Office 2003 running with the Microsoft Office Compatibility Pack, the popup appears as below.



When "OK" button is clicked in the above dialog box, the following popup appears. "Enable Macros" button needs to be clicked.

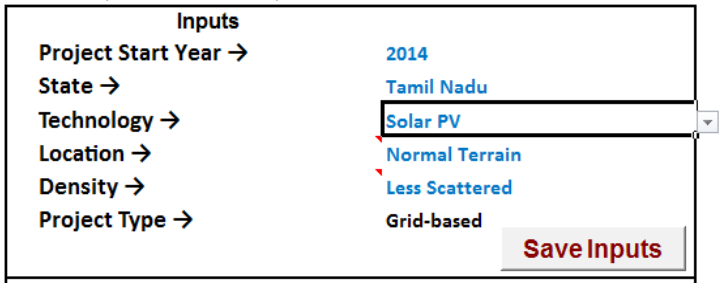


2. The tool has circular dependencies for which iterative calculations need to be enabled in Excel. This should automatically be enabled. In case this doesn't happen, open Excel options by clicking File→Options. Select the Formulas tab and check "Enable iterative calculation" as shown in the image below.



3. After enabling macros at startup, the user is taken to the Introduction sheet. It is recommended that the instructions on this page are read before running the tool the first time. After reading the instructions, the "Go to Tool" button on the Introduction sheet can be clicked to run the tariff tool.

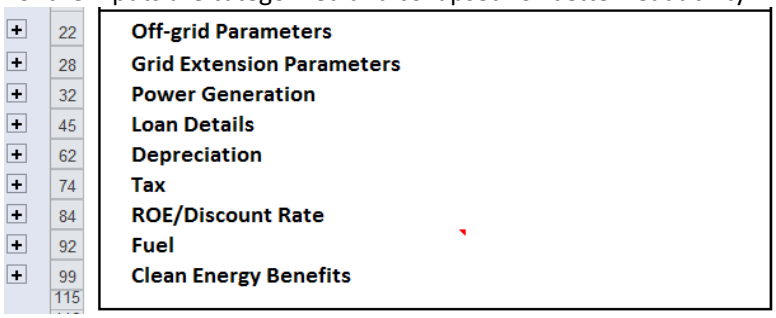
4. When the "Go to Tool" button is pressed, the "Inputs&Summary" sheet is activated. This sheet shows the inputs fed to the tool to the left and some important outputs from the tool to the right.
5. The inputs are self explanatory. At the outset, the technology and the state can be chosen using drop down menus that show up when the respective cell is selected.



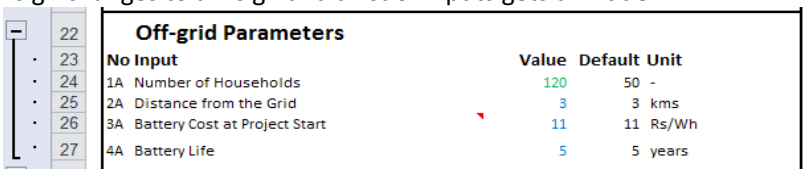
6. One of 11 technologies can be selected, 8 of which are grid-based and the remaining three off-grid. The

project type automatically changes according to the technology selection.

7. For off-grid projects, the location and density of the projects can also be input. The location and density properties do not impact grid-based projects.
8. Start year of the project can be chosen. This impacts REC calculations.
9. The remainder of the inputs are categorized and collapsed for better readability.



In order to expand each category, the + sign to left of the category title needs to be clicked. When clicked, the + sign changes to a – sign and a list of inputs gets unhidden.



To collapse the category back, the – sign next to the category title needs to be clicked.

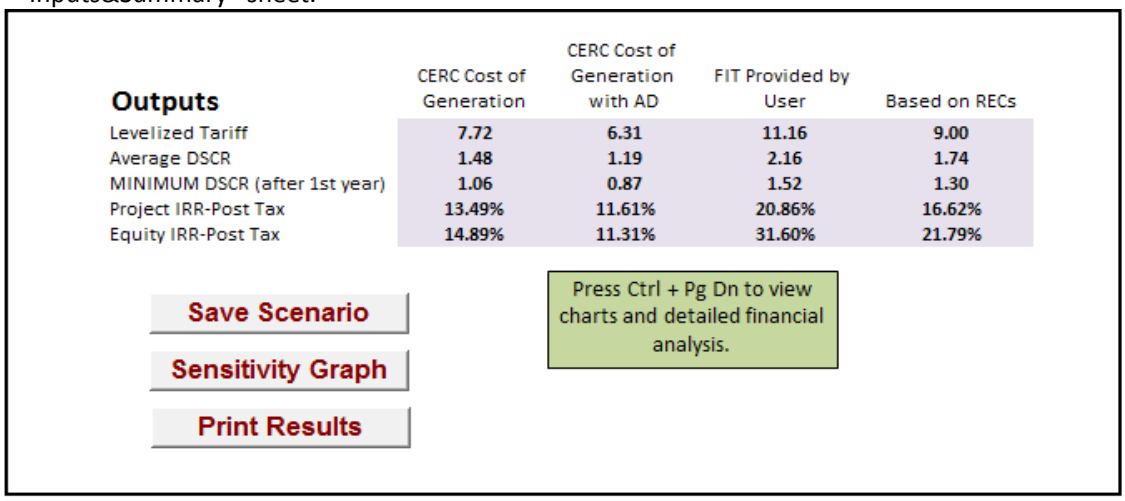
10. The first two categories - “Off-grid Parameters” and “Grid Extension Parameters” - apply only to off-grid projects. The remaining inputs apply to all projects.
11. The worksheets have been protected to avoid inadvertent changes that may impact calculations. However, the cells containing inputs to the tool can be modified. The text in these cells is blue in colour as shown in the snapshot of the off-grid parameters shown above. Please note that some of the cells in blue contain formulas. If these are overwritten, reverting back to the formula
12. Although the category titles are mostly self-explanatory, brief descriptions of each of the categories can be found below:
    i. The “Power Generation” category consists of plant capex, opex and operation details such as installed capacity, capital cost, PLF, auxiliary consumption and operation & maintenance (O&M) costs of the plant.
    ii. The “Loan Details” category consists of financial loan details. The tool supports up to 2 loans. The second loan is included by providing a non-zero input in the “Loan 2 Principal” field. This amount is deducted from the debt amount (based on the “Debt Fraction”) and the result is the amount of the first loan. The second loan can be a foreign loan and this is indicated by providing a “Loan 2 Currrency Conversion Factor” other than 1. The currency conversion factor changes over time using the “Currency Conversion Escalation Rate” input. This factor is a fixed escalation or de-escalation rate (depending on the sign). If a different type of trajectory needs to be provided, or to enumerate the exchange rate for each month, the “Currency Conversion” table at the bottom of “Term Loan 2” worksheet can be changed. The loan payment structure can be either fixed monthly installments (when EMI is set to 1) or fixed principal payments (when EMI is set to 0). The “Term Loan 1” and “Term Loan 2” worksheets provide more insight into calculations related to the loan repayment.
    iii. The “Depreciation” category, as the name suggests, is about capital depreciation. Three types of depreciation are used in the tool – book depreciation, straight-line method and accelerated depreciation. There is also plant and machinery depreciation as well which is used for tax purposes in the non-accelerated depreciation case. The “Depreciation” worksheet has more details.
    iv. The next category is “Tax” consisting of inputs related to tax rate, minimum alternate tax (MAT), MAT set off and tax holidays. More details can be found in the “Profit Loss” worksheet.
    v. The next category – “ROE/Discount Rate” – groups miscellaneous parameters including return on

equity (ROE) expected for the project, discount rate calculated based on the post-tax ROE and associated annuity factor.

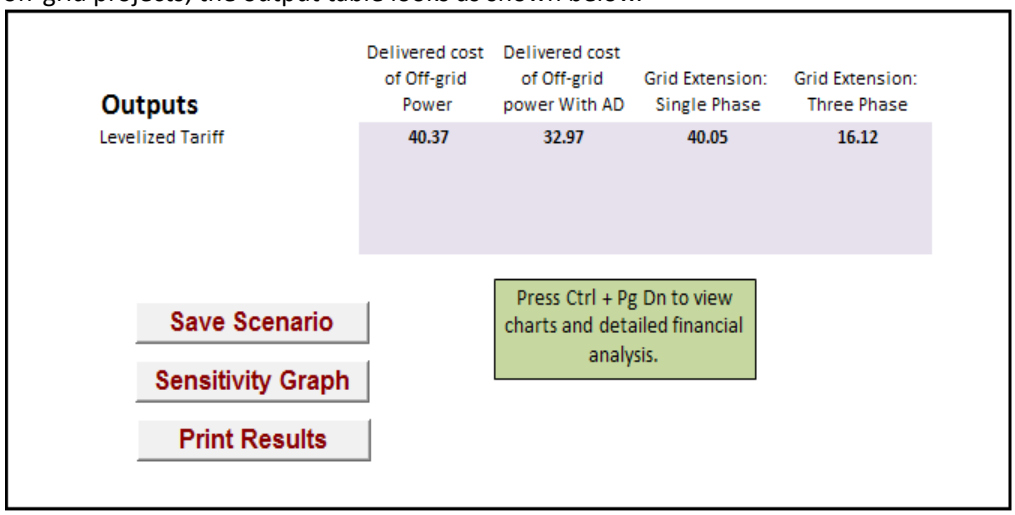
vi. The "Fuel" category only applies to biomass-based projects, i.e., biogas, bagasse and biomass gasifier. This includes fuel requirement, fuel cost and fuel cost escalation. In addition, there are a couple of parameters – "Duration of initial CUF" and "CUF for subsequent years" – for biomass rankine cycle projects which have a lower CUF in the first two years.

vii. The last category – "Clean Energy Benefits" – lists inputs related to the financial incentives available to clean energy projects. This includes REC, feed-in tariffs and carbon trading incomes.

13. Finally the "Save Inputs" button can be used to save the current set of inputs for the selected technology. This may not be useful if the default values provided are used as inputs, but if any of the inputs are changed, they can be saved off so that when the same technology is used next time, those inputs are filled in.
14. As mentioned earlier, important outputs from the tool are displayed to the right of the "Inputs&Summary" sheet.

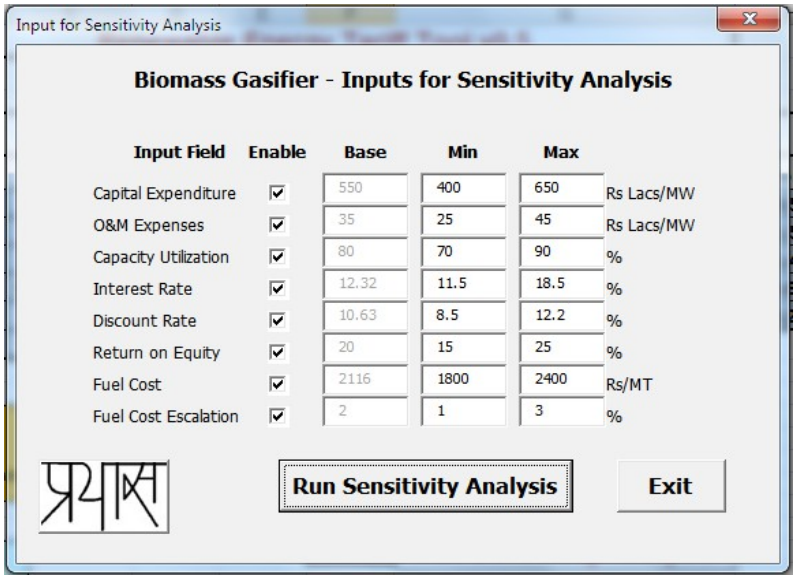


15. For grid-based projects, the output table looks like the picture above. The outputs provided here are tariff, average debt service coverage ratio (DSCR), minimum DSCR, project and equity IRR computed based on post-tax returns. The outputs are provided for four cases – one each for tariff calculated based on CERC guidelines with and without accelerated depreciation, one in which financials are computed based on the user-provided feed-in-tariff and one where income from sale of renewable energy certificates (RECs) is considered.
16. For off-grid projects, the output table looks as shown below.

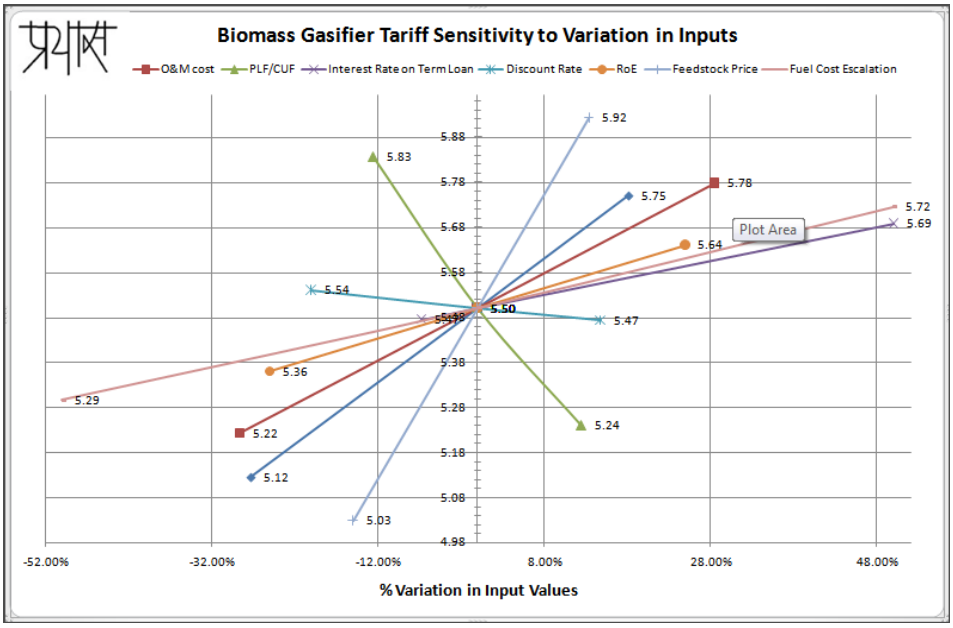


Here, the first two columns show the delivered per-unit cost of the off-grid project including generation, distribution and maintenance costs. These numbers are influenced by the number of households and terrain of the region served. The next two columns show estimated electricity tariffs for single phase and three phase grid extension to that region. A three phase grid connection is expected to support increased productive load; hence the per unit tariff would be lower.

17. As can be seen, there are 3 additional buttons in the output box – “Save Scenario”, “Sensitivity Graph” and “Print Results”. These are described below.
18. “Save Scenario” saves most of the inputs and outputs from the current run. Upto 10 runs can be saved. The runs are saved in the “Scenarios” sheet. The user is prompted to enter a scenario index (1-10) and accordingly the inputs and outputs are saved in the corresponding column in the “Scenarios” sheet.
19. The “Tariff Chart” displays a graph depicting the different components of the tariff resulting from the provided inputs. The levelized tariff with and without accelerated depreciation is also shown in this graph. Another view of the same is shown in the “Tariff breakup Chart”.
20. Preliminary sensitivity analysis can be done by clicking the “Senstivity Graph” button. Sensitivity analysis allows the user to vary a few select inputs and observe graphically how the variation affects the tariff.
    For Large Renewable Energy Projects : Each of the inputs selected for sensitivity analysis is varied while the rest of the inputs stay constant at the base values, i.e., values chosen through the main tariff tool form. When this button is clicked, the following form shows up:

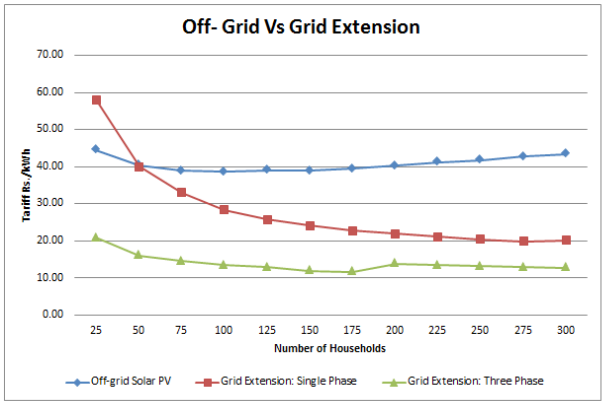


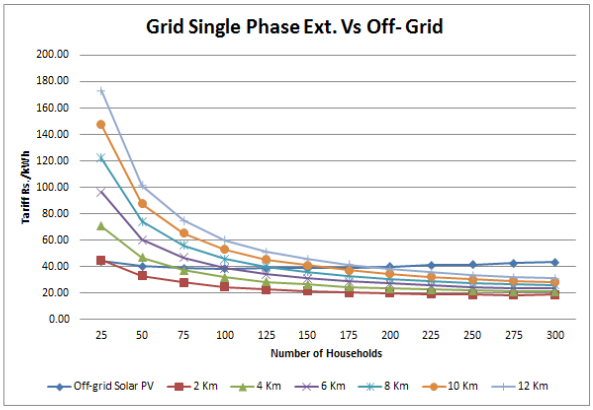
The title of the Sensitivity Analysis form reflects the technology last chosen in the main tariff tool. As can be seen above, a few of the inputs chosen in the tariff tool are presented for sensitivity analysis. Each of these inputs can be enabled or disabled (for sensitivity analysis purposes). The base values chosen for these values are shown and the range of values can be provided by the user. After the necessary ranges are provided, the “Run Sensitivity Analysis” button can be clicked to do the analysis. Once the tariffs are computed for the different ranges of inputs, the Sensitivity chart gets activated, snapshot of which is shown below.



The vertical axis shows the tariff and the horizontal axis shows the % variation in the inputs.

For Off-grid Energy Projects: When the sensitivity analysis button is clicked the following graphs appear.





The graph on the left shows the sensitivity of delivered costs in gird extension and off-grid projects to change in number of households. The graph on the right shows the variation in delivered costs with change in distance from the grid.

Some suggested ranges of the different inputs with respect to Sensitivity Analysis have been provided in the next section.

21. The rest of the sheets show profit/loss calculations, cash flows, balance sheet and intermediate calculations.
22. The “Print Results” button can be used to print a subset of the output from the tool. Clicking on this button prints the “Summary Results”, the “Scenarios” sheet, the “Tariff Chart” and the sensitivity graphs.

Assumptions

For Large Renewable Energy Projects

Default Values

1. The default capacity utilization factor (CUF also referred to as plant load factor, PLF) for Wind has been taken as 25% in the tool. Per CERC Guidelines Regulation 26(1), the following CUF values are recommended based on the wind power density of the project. It is left to the user to enter the appropriate CUF.

Annual Mean Wind Power Density (W/m2)	**CUF**
Upto 200	20%
201-250	22%
251-300	25%
301-400	30%
> 400	32%

2. The default capital cost for small hydro projects (SHP) has been taken as Rs 700 lacs/MW. Per CERC Guidelines Regulation 28(1), the following capital costs are recommended based on the host state/region and capacity of the hydro power project. It is left to the user to enter the appropriate capital cost based on the following table:

Region	**Project Size**	**Capital Cost (Rs Lacs/MW)**	**CUF**	**O&M Expenses (Rs Lacs/MW)**
Himachal Pradesh, Uttarakhand and North Eastern States	Below 5 MW	770	45.00%	25
	5 to 25 MW	700	45.00%	18
Other States	Below 5 MW	600	30.00%	20
	5 to 25 MW	550	30.00%	14

3. The default CUF for small hydro projects provided in the tool is 45%. According to CERC Guidelines Regulation 30, the normative CUF is 45% for Himachal Pradesh, Uttarakhand and North Eastern States and 30% for other states. In addition, the CERC Guidelines state 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 user needs to enter the appropriate CUF based on this regulation.
4. Likewise, default O&M expense for small hydro projects is taken as Rs 25 Lakhs/MW. The O&M expenses need to be modified according to above table.
5. With reference to biomass rankine cycle projects, CERC Guidelines Regulation 41 states this: "The use of fossil fuels shall be limited to the extent of 15% of total fuel consumption on annual basis." However, the tool does not have a provision to enter a fossil fuel input. This will be considered for a future update of the tool.
6. According to the CERC Guidelines Regulation 44 (updated for 2014-15 as per Suo Motu order 354), state-wise normative feedstock prices for biomass (gasifier and rankine cycle) projects are as follows. The tool picks these value based on the selected state.

State	Biomass Price Rs/tonne
Andhra Pradesh	2747.59
Haryana	3127.4
Maharashtra	3198.61
Punjab	3271.01
Rajasthan	2729.79
Tamil Nadu	2702.49
UP	2795.07
Other States	2938.69

7. The default fuel requirement for biomass rankine cycle projects is 1.331 kg/kWh. This is calculated from the normative values of Station Heat Rate of 4125 kCal/kWh for projects using AFBC boiler and Calorific value of 3100 kCal/kg as per 1st Amendment to the CERC regulation, 2014. Earlier recommended values were 4000 kCal/kWh (Regulation 38) and 3300 kCal/kg (Regulation 43) respectively which translate to a fuel requirement 1.212 kg/Kwh.
8. For co-generation projects, a default CUF of 53% has been used. The normative values provided in the CERC Guidelines are as follows:

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

9. For co-generation projects, the default fuel requirement is 1.6 kg/kWh. This is calculated from the normative values of Station Heat Rate (Regulation 51: 3600 kCal/kWh) and Calorific Value (Regulation 52: 2250 kCal/kg) provided in the CERC Guidelines.
10. The default fuel escalation rate for biomass rankine cycle, bagasse co-generation and biomass gasifier projects is 5% as per CERC Guidelines - Regulations 44, 53 and 73. Please note that this results in errors in IRR calculations by Excel (please see point #3 in the Calculations section below).
11. For biomass gasifier and biogas projects, capital subsidy has been assumed in the default capital cost values provided by the tool. These can be modified according to CERC Guidelines Regulations 66 and 76 if capital subsidy is not applicable to the project.

Calculations

1. Discount Rate is equal to the post-tax weighted average cost of capital. It is calculated using the following formula:

```
Discount Rate = Debt % * Term Loan Interest Rate * (1-Corporate Tax Rate)
                + Equity % * (Post-tax ROE)
```

2. Annuity Factor, used to calculate levelized tariff, is calculated using the following formula:

$$\text{Annuity Factor} = \frac{((1 + d)^n - 1)}{(d * (1 + d)^n)}$$

where d = Discount Rate and n = Plant Life

3. For , the Project and Equity IRR shown in the Summary Results Sheet can be displayed as "#NUM!" or "#DIV/0!".

   "#NUM!" shows up in cases where multiple solutions are found for the IRR. No guess is provided to the IRR function in Excel, since the expected IRR can vary depending on the inputs provided. In the absence of a guess, the solver cannot choose between the solutions computed, hence it returns a "#NUM!" result.

   "#DIV/0!" can occur if the IRR solver in Excel finds no root or returns an extraordinarily high value.

   The Goal Seek tool in Excel (available under Data → "What-If Analysis" → "Goal Seek" in Excel 2007 and later or under Tools → "Goal Seek" in Excel 2003) can be used to further analyze both issues.

4. Where applicable, for biomass projects, fuel requirement is derived from the normative station heat rate and biomass calorific value provided by CERC Guidelines.

$$\text{Fuel requirement (kg/kWh)} = \frac{\text{station heat rate (kCal/kWh)}}{\text{calorific value (kCal/kg)}}$$

Suggested Ranges for Sensitivity Analysis

Input	**CUL/ PLF**	**Capex (w/o subsidy)**	**Feedstock Price**	**Debt Fraction**	**Interest Rate**	**Term Loan Duration**	**ROE**	**Emission Factor**	**CER Price**
Source	%	Rs Lacs/MW	Rs/ton	%	%	years	%	tons of CO_2/MWh	$/ton
Solar PV	15-25	900-1100	Not Applicable	60-80	5-15	7-20	10-25	0.8-1.1	10-20
Solar Thermal	20-40	1100-1400							
Wind	15-35	450-650							
Small Hydro	25-50	450-750							
Biogas	60-90	~1000	~1000						
Bagasse	40-70	350-500	1000-2000						
Biomas Gasifier	60-80	500-600	1500-3000						
Biomas Rankine Cycle	60-80	400-500	1500-3000						

For Off-grid Renewable Energy Projects

(These assumptions have been derived from independent project locations a user is free to change the assumptions to suit his/her requirement)

Load Profile

These are a set of assumptions that have been used to determine the load profile for villages. The load profile is further used to calculate the required plant size to meet the load. However the load profile can be adjusted by every user to suit, meet their requirements. The numbers used here as mere assumptions used by the developers to set pace for the further calculations.

Load Profile	**Assumptions/Calculations**
No. of users using lights (type 1)	Households / Service connections
No. of users using lights (type 2) and Mobile charger	50% Households / Service connections
No. of users using fan	10%Solar Insolation >5.5 30% , 10%
No. of users using mixer	0 for very remote, else 20%0 for very remote, else 20%
No. of users using TV set	20% for moderate, 30% for normal
No. of light points (type 1) per service connection	2% for remote, 4% for moderate, 5% for
No. of light points (type 2) per service connection	1 for remote,2 for moderate, 3 for normal
Computer	1 for HH >75, 2 for HH >200
No. of street lights	1 light for 5 HH

Hours of Usage

In order to arrive at the peak demand of power for the required load, the following set of assumptions have been made for the hours of usage of each electrical equipment. The assumptions are based on experiences from villages belonging to typical setups.

Hours of Use	**Assumptions**
Day time usage of fan	4 hrs for zones 1 to 4, 2hrs for zones 5 and 6
Day time usage of TV set	1 hr for remoteness 1, 2hrs for remoteness 2 and 3
Night time usage of light points (type 1 or 2)	3 hrs for remoteness 1, 5 hrs for remoteness 2 and 3
Night time usage of fan	3 hrs for zones 1 to 4, 0 hrs for zones 5 and 6
Night time usage of TV set	3 hrs for remoteness 1, 4 hrs for remoteness 2 and 3
Water pump sizing based on assumptions: 80 liters water per person, water for irrigation of 1 acre land per household, 10000 liters water requirement per acre per week, water head = 30 m, pump efficiency = 50%	
Flour mill sizing based on assumptions: 5 kg flour requirement per person per month, flour mill operates for 4 hrs per day and for 20 days per month, flour mill output = 10 kg/hr per kW capacity	

Off-grid Generation and Distribution

The tool is currently capable of calculating the energy generation costs and distribution costs for three types of technology including Solar PV, Biomass Gasifier and Micro Hydro Systems. The table enlists the calculation methodology and the assumption made during the calculations. Each technology uses a different calculation for arriving at the optimum size of the system required to meet the expected demand.

The details are segregated into plant sizing, equipment required for plant installation, plant operation and maintenance parameters and distribution network extension equipment.

Plant Sizing	**Solar PV**	**Biomass Gasifier**	**Micro Hyrdo**
Day time energy demand in kWh	Summation of (no. of users x no. per user x Wattage x day time usage hours) of all utilities / 1000		
Night time energy demand in kWh	summation of (no. of users x no. per user x Wattage x night time usage hours) of all utilities / 1000		
Maximum day time usage	Usage hours of utility which runs for maximum hrs in the day time		
Maximum night time usage	Usage hours of utility which runs for maximum hrs in the night time		
Average demand	Total energy demand in kWh / Generator On hrs		
Total connected load in kW	summation of entire electrical load		
Maximum demand	Maximum loading on Generator, calculated with assumption: load factor = demand factor		
Optimum Plant Size (kWp/ kW): Can be fed in by the user as there are no standard procedures to define the micro grid sizes.	Optimum solar PV size based on assumptions: system efficiency = 83% at day time and 77% at night time, guaranteed PV capacity after 25 years = 80% of rated capacity, actual	11 kW or 25 kW or 32 kW or 70 kW, immediate next capacity available to (maximum demand x safety factor)* Safety Factor = 1.1	Optimum Micro Hydro size is assumed to be : Maximum Demand x Safety Factor (where safety factor =1.1)
Optimum Battery Size (kWh)	Optimum battery size based on assumptions: system efficiency = 77%, designed for night time load, depth of discharge = 50%, autonomy = 1 day	There is no requirement of batteries in Biomass Gasifier sets , although diesel generator sets are used for start up. But the consumption of diesel for this process is negligible.	There is no requirement of batteries in Micro hydro Systems.
Phase	System phase selection based on assumption: Single phase system for PV size < =15 kWp, three phase system for PV size > 15 kWp	All biomass gasifiers are designed to provide three phase power hence the phase is always at 415 V	All micro hydro projects are designed to provide three phase power hence the phase is always at 415 V
Voltage	Generation Voltage = 230 V for single phase, 415 V for three phase		
PLF	Is accounted as a factor of total energy demand and plant size		

Equipment Details	Assumption
Equipment + Mounting structure - per Wp or kW	These are fixed cost assumptions for each project type referenced from different sources and from on ground projects. These costs would vary depending on developer, site
Inverter / PCU - basic per Wp or kW	
Battery bank - per Wh	
Miscellaneous (Junction box, AC power distribution box, cables, switches, meters, earthing, LA etc) - fixed	
Miscellaneous (Junction box, AC power distribution box, cables, switches, meters, earthing, LA etc) - variable per Wp	
Civil work - fixed per Wp or kW	
Civil work - variable per Wp or kW	
Material transportion - per trip	
Installation - per man day	
Project development	
Equipment + Mounting structure - per Wp or kW	

Plant Operation and Maintenance	Assumptions
Battery/ Plant maintenance - one visit of technician	Rs. 6000 for remoteness = 1, Rs. 4500 for remoteness = 2, Rs. 3000 for remoteness = 3
Miscellaneous plant maintenance - two visits of technician	Rs. 12000 for remoteness = 1, Rs. 9000 for remoteness = 2, Rs. 6000 for remoteness = 3
Miscellaneous material cost for maintenance	1% of material and transportation cost
Plant operator & project administration by trained villager	Rs. 6000 for remoteness = 1, Rs. 12000 for remoteness = 2, Rs. 24000 for remoteness = 3
Land rent & security	Rs. 6000 for remoteness = 1, Rs. 12000 for remoteness = 2, Rs. 24000 for remoteness = 3
Plant Insurance (fire, theft)	0.25% of solar PV, mounting structure, PCU and battery cost

Distribution Equipment	Assumptions
Material transportation cost per trip	Rs. 15000 for remoteness 1, Rs. 12000 for remoteness 2, Rs. 8000 for remoteness 3 1, Rs. 12000 for remoteness
Installation cost per pole	Rs. 7000 for remoteness 1, Rs. 6000 for remoteness 2, Rs. 5000 for remoteness 3 1, Rs. 6000 for remoteness
Connections per pole based on village population density and no. of service connections	
No. of poles	Connections per pole x no. of service connections
Type of pole	RSJ for remoteness 1, PSC for remoteness 3, RSJ for remoteness 2 and poles <10, PSC for remoteness 2 and poles >10 1, PSC for remoteness
Length of conductor based on assumption: distance between two poles	50 meter
Maximum current flowing through the conductor is based on PV size, no. of phases and phase voltage	
% Power loss for different conductors is based on maximum current flowing through the conductor, length and resistance of conductor	
Type of conductor	ACSR 30 mmsq if power loss < 7% for 30 mmsq, ACSR 50 mmsq if power loss > 7% for 30 mmsq and < 7% for 50 mmsq, ACSR 80 mmsq otherwise

Pole ans stay unit cost	RSJ or PSC pole cost + LT stay unit cost
Conductor cost for any type is based on length of conductor and no. of phases	
Hardware cost	Cost per pole x no. of poles
Grouting and earthing cost	Cost per pole x no. of poles
Material transportation cost	Rs. 15000 per trips, Maximum 20 poles per trips
Installation cost	No. of poles x cost per pole x factor, factor 1.2 for poles <10, 1.1 for poles <20, 1.0 for poles >20 1.2 for poles <
Total cost	summation of material, installation, transportation costs
Power distribution cost per pole	Total cost / no. of poles
Cable and supporting GI wire cost	Rs. 800 x no. of service connections
Energy meter cost	Rs. 1200 x no. of service connections
MCB / switch, mounting board, earthing cost	Rs. 1500 x no. of service connections
Installation cost	Rs. 600 x no. of service connections
Total service connection cost	summation of material, installation costs
Service connection cost per connection	Total cost / no. of service connections

Distribution Line Length and Pole configurations	**Assumptions**
Connection per pole is a factor of density of village (Highly Scattered,Medium Scattered, Less Scattered)and number of households	Highly scattered, Connections (0-25) 1.5 Highly scattered, Connections (25-50) 2 Highly scattered, Connections (50-75) 2.5 Highly scattered, Connections (75-125) 3 Highly scattered, Connections (>125) 3.5 Medium scattered, Connections (0-25) 2.5 Medium scattered, Connections (25-50) 3 Medium scattered, Connections (50-75) 3.5 Medium scattered, Connections (75-125) 4.5 Medium scattered, Connections (>125) 5 Less scattered, Connections (0-25) 3.5 Less scattered, Connections (25-50) 4 Less scattered, Connections (50-75) 5 Less scattered, Connections (75-125) 6 Less scattered, Connections (>125) 7
No of poles	Total households/ Connections per pole
Type of pole (1 for RSJ, 2 for PSC)	Chosen depending on location of installation between metal and concrete poles.
Length of conductor (meters) - one way	Total number of poles -1 * 50 (meters between 2 poles)
Type of ACSR conductor (1 for 30 mmsq, 50 mmsq, 80 mmsq)	Depending on capacity of power plant, power generation from plant and losses over line.

Grid Extension Calculations

The tool allows the user to compare the delivered cost of power using an off-grid system vs. the grid. The table here details the set of assumptions used to arrive at a total cost of grid extension to the village which is derived from benchmark costs of each equipment referenced from the CEA cost estimates.

Grid Extension parameters	**Assumptions**
Total 3 Phase Demand	Derived from load profile
Total 1 Phase Demand	Derived from load profile
Length of 11k V line	Distance from grid

Length of LT line	Derived from distribution calculation for off- grid setup
Number of DTE Transformers	As a factor of load and phase
Number of Service Connections	Number of 3 phase+ Single Phase connections
Unit Cost of each (11 kV line, LT line, DTE, Service Connections)	Referenced from CEA benchmark costs
Annual operation and Maintenance Costs	Assumed to be 5% , which can be changes as per user discretion
Cost of Power Purchase	An aggregate of average power purchase cost over time of project

Known Issues

Although reasonable checks are in place, the tool has not been tested to ensure that it works error-free when extreme values are input. Following issue is known at the time of release of this version.

1. Accelerated depreciation (AD) calculations in the tool don't match CERC's calculations. We are investigating this.

Future Enhancements

1. Better help text for guidance in entering the input data.
2. Formulation of the financial model used in the tool.

Additional features may be implemented based on feedback received for the current version of the tool.

The spreadsheet and macros have been protected in order to prevent inadvertent changes that can cause the tool to become unusable. If anyone is interested in the unprotected version of the tool, they can contact the developers at the email address provided below.

This Renewable Energy Tariff tool was developed by Prayas Energy Group, Pune. Any questions can be directed to energy@prayaspune.org or to +(91) 20-25420720/65205726 Monday-Friday 10:00am – 6pm.