



## The Calculation of 3-Months Tariff for Solar Rooftop Model.

The plant independent standardized tariff is calculated based on the equating NPVs of each annual cashflow to eliminate the cost dependency of each plant on its maturity.

The capital cost of all the plants on the system are varied using the cost variation equation given in Appendix B.

<i>Variable</i>	Description
<i>C</i>	Capital cost
<i>DER</i>	Debt, equity ratio-debt portion
<i>N</i>	Loan Period
<i>M</i>	Project Period
<i>d</i>	Plant efficiency depreciation rate
<i>AWPLR</i>	Average Weighted Prime Lending Rate
<i>TBR</i>	Treasury Bond Rate
<i>P<sub>L</sub></i>	Investment premium for debt
<i>P<sub>E</sub></i>	Investment premium for Equity
<i>INF</i>	Inflation
<i>pf</i>	Plant factor
<i>k<sub>OM</sub></i>	O&M escalation rate
<i>m<sub>OM</sub></i>	O&M percentage
<i>SMC<sub>DP,day,i-1</sub></i>	System Marginal cost of the day-time dispatchable generators
<i>AVGC<sub>base,i-1</sub></i>	Average Cost of base load generators
<i>p<sub>c</sub></i>	Capital escalation factor

### 1.1. Calculation of the Weighted Average Cost of Capital (WACC) and the discounting rate

Weighted Average cost of capital (WACC) can be calculated as,

$$WACC_i = (1 - DER)(TBR_i + p_E) + DER(AWPLR_i + p_L) \quad (1)$$

And the depreciation factor when corrected for the capital escalation is,

$$k = \frac{1 + p_{c,j}}{1 + WACC_i} = \frac{1 + p_{c,j}}{1 + 0.4(TBR_i + p_E) + 0.6(AWPLR_i + p_L)} \quad (2)$$

The capital escalation factor  $p_{c1}$  as calculated in Appendix B is used here to compensate for the civil cost escalation to be brought to real terms. individual cost components are as follows,

### 1.2. Loan Premium

The loan portion of the capital in a simple payback loan will be paid in equal installments over the total loan period.

Therefore,

$$Ln\_Prm_i = \frac{DER \times C_i}{N} \quad (3)$$

### 1.3. Loan Interest

The interest on the loan is assumed to be in equal interest terms converted to net present value using the discounting rate for the particular year. This can be calculated using the equation;

$$EQIR = IR \left[ \frac{N+1}{N} - \frac{1}{N(1-k)} + \frac{k^N}{1-k^N} \right]$$

Now the loan interest component for the particular year can be calculated as,

$$Ln\_Int_i = DER \times C_i \times EQIR$$

Where the interest rate  $IR$  is given by,

$$IR = AWPLR + p_L$$

Therefore,

$$Ln\_Int_i = DER \times C_i \times (AWPLR + p_L) \left[ \frac{N+1}{N} - \frac{1}{N(1-k)} + \frac{k^N}{1-k^N} \right] \quad (4)$$

### 1.4. Profit on Equity

Profit on equity is calculated based on the TBR and a risk premium such as

$$PROF_i = C_i(1 - DER)(TBR + p_E) \quad (5)$$

### 1.5. Operation and Maintenance cost

The operation and maintenance cost of the plant is calculated as a percentage from the capital cost. The capital cost is estimated every year based on the market rates and therefore, the annual maintenance cost also will be subjected to the same inflation. There will be an increase in the annual maintenance cost due to the aging of certain plants. This needs to be accounted for the total plant operational period. Therefore, the Operation and Maintenance cost of the plant can be written as;

$$OM_i = C_i m_{OM,1} \left[ \frac{1-\beta}{1-\alpha} \right] \left[ \frac{1-\alpha^M}{1-\beta^M} \right] \quad (6)$$

Where,

$$\alpha = (1 + k_{OM})k$$

and

$$\beta = k$$

Let

$$\left[ \frac{1-\beta}{1-\alpha} \right] \left[ \frac{1-\alpha^M}{1-\beta^M} \right] = \gamma$$

Then

$$OM_i = C_i m_{OM,1} \gamma$$

### 1.6. Rate Adjustment

The adjustment of rates will be carried out as a correction to the rates. Therefore, the adjustment of rates would be.

$$ADJ_i = \begin{cases} (AVGC_{base,i-1} - R_{i-1,Solar\ Rooftop}), & R_{i-1,Solar\ Rooftop} < AVGC_{base,i-1} \\ 0, & AVGC_{base} < R_{Solar\ Rooftop} < k_{SMC}SMC_{DP,day} \\ -(R_{i-1,Solar\ Rooftop} - k_{SMC}SMC_{DP,day,i-1}), & R_{i-1,Solar\ Rooftop} > k_{SMC}SMC_{DP,day,i-1} \end{cases} \quad (7)$$

If the paid rate for the previous year,  $R_{i-1}$  is more than  $k_{SMC}$  percentage of the System Marginal Cost of the dispatchable generators for day time in that year,  $SMC_{DP,day,i-1}$ , or less than the Average Cost of the based load generators in that year,  $AVGC_{base,i-1}$ , then an adjustment of the rate paid above or below the price cap, if any will be corrected from the next year tariff rates.

The percentages of the price cap are as shown in table below.

Item No	Item Description	Variable	Rooftop Solar			
			0-20	20-100	100-500	>500
1	Percentage of the System Marginal Cost at day time used as the upper price ceiling	$k_{SMC}$	95%	95%	95%	95%

### 1.7. Total annual energy generation

The total energy generation is calculated as the average generation over the total operational period if the plant depreciation factor of  $d$ , as calculated in Appendix A.3,

$$E_i = 8760pf \left\{ 1 - d \left( \frac{k}{1-k} + \frac{Mk^M}{1-k^M} \right) \right\} \quad (8)$$

### 1.8. Calculation

Now the tariff can be calculated using equations (2), (3), (4), (5), (6), (7), (8), (9) as,

$$R_{Solar\ Rooftop} = \frac{Ln\_Prm_i + Ln\_Int_i + PROF_i + OM_i}{E_i} + ADJ_i \quad (9)$$

$$R_{Solar\ Rooftop} = \frac{C_i}{E_i} \left\{ \frac{DER}{N} + DER(AWPLR + p_L) \left[ \frac{N+1}{N} - \frac{1}{N(1-k)} + \frac{k^N}{1-k^N} \right] \right. \\ \left. + (1-DER)(TBR + p_E) + m_{OM,1Y} \right\} + ADJ_i \quad (10)$$

Hence,

$$R_{i,Solar\ Rooftop} = \begin{cases} AVGC_{base,i-1}, & R_{Solar\ Rooftop} < AVGC_{base,i-1} \\ R_{Solar\ Rooftop,i-1}, & AVGC_{base} < R_{Solar\ Rooftop} < k_{SMC}SMC_D \\ k_{SMC}SMC_{DP,day,i-1}, & R_{Solar\ Rooftop} > k_{SMC}SMC_{DP,day} \end{cases}$$

**Appendix B - Estimation model for the capital escalation used to estimate the capital cost for Rooftop Solar model.**

This cost estimation will be carried out in every year for the Rooftop Solar plants under Net Accounting, Net Plus & Net Plus Plus schemes.

The total capital of a project comprises of six items, as given in table B.1.

No	Item	Variable	Percentage from the total cost
1	Foreign Machinery	$F$	$p_F$
2	Local transport	$T$	$p_T$
3	Civil Construction	$CC$	$p_{cc}$
4	Installation	$I$	$p_I$
5	Overheads	$O$	$p_O$
Table B.1			

$$C_j = (1 + K_{IDC})[F_j + T_j + CC_j + I_j + O_j]$$

The capital cost estimation will not be applicable for long periods. Usually, linear cost estimation models are applicable for less than 5 years in technology specific cost estimations and will be obsolete when a significant technology development takes place. Therefore, this estimation formula may be used only for short window of period. The index  $i$  is used here to denote the particular year within that window of estimation and index  $o$  is used to denote the initial year of the window. Once the formula is seen to deviate from the actual costs due to technology maturity or any other factor which we have not captured, then a new window of cost calculation shall be started with a new  $C_0$ .

The independent variables used for the calculation of the price variation are listed below in table B.2.

No	Item	Variable	Source
1	Accumulated change in the Producer Price Index of US	$PPIUS_{i,ACC}$	Federal Reserves Bank
2	Accumulated change in the Sri Lankan Consumer Price Index	$SLCPI$	CBSL
3	Accumulated Inflation	$INF_{i,ACC}$	CBSL
4	Fuel cost	$FL$	CBSL
5	Dollar conversion rate	$D$	CBSL

6	Percentage of fuel in transport	$k_f$	SLSEA
7	Percentage of fixed cost in construction	$k_{c0}$	SLSEA
8	Percentage of Concrete in civil cost	$k_{c1}$	SLSEA
9	Percentage of Steel in civil cost	$k_{c2}$	SLSEA
10	Percentage of Labor in civil cost	$k_{c3}$	SLSEA
11	Percentage of Fuel in civil cost	$k_{c4}$	SLSEA
12	Cost of Concrete Cubic Meter	$P_C$	ICTAD
13	Cost of Steel Ton	$P_S$	ICTAD
14	Labour index	$P_L$	ICTAD
Table B.2			

### Accumulated Inflation Rates

The accumulated inflation rates shall be calculated as a series of inflations of each year multiplied through the complete period as shown below.

$$INF_{j,ACC} = \prod_{k=1}^i (1 + INF_k) - 1$$

$$PPIUS_{j,ACC} = \prod_{k=1}^i (1 + PPIUS_k) - 1$$

### Foreign Cost

Foreign Cost component of the project capital comprising of the machinery imported is considered to vary by accumulated producer price index of US and the Dollar conversion rate as shown below

$$F_j = F_0 \left( \frac{PPIUS_{i,ACC}}{PPIUS_0} \right) \frac{D_j}{D_0}$$

### Transport Cost

The transport cost of the imported machinery is considered to vary by the fuel cost and labor cost as shown below.

$$T_j = T_0 \left[ k_f \frac{FL_j}{FL_0} + (1 - k_f)(1 + INF_{j,ACC}) \right]$$

### Civil Construction Cost

Civil construction cost is considered to vary by the cost of concrete, cost of steel, cost of labor and cost of fuel as shown below.

$$CC_j = CC_0 \left[ k_{C0} + k_{C1} \frac{P_{Cj}}{P_{C0}} + k_{C2} \frac{P_{Sj}}{P_{S0}} + k_{C3} \frac{P_{Lj}}{P_{L0}} + k_{C4} \frac{FL_j}{FL_0} \right]$$

### Installation Cost

Installation cost is considered to vary by the variation of labour cost as shown below.

$$I_j = I_0 \frac{P_{Lj}}{P_{L0}}$$

### Overheads

Overheads are considered to vary by the accumulated inflation.

$$O_j = O_0 (1 + INF_{j,Acc})$$

### Interest During Construction

Interest during construction is calculated as an enhancing factor of the capital as.

$$K_{IDC} = 0.1AWPLR_{j-2} + 0.6AWPLR_{j-1}$$

### Price Calculation

$$C_j = (1 + K_{IDC}) [F_j + S_j + T_j + CC_j + I_j + O_j]$$

$$C_j = (1 + 0.1AWPLR_{j-2} + 0.6AWPLR_{j-1}) \left[ F_0 \left( \frac{PPIUS_{j,Acc}}{PPIUS_0} \right) \frac{D_j}{D_0} \right. \\ \left. + T_0 \left\{ k_f \frac{FL_j}{FL_0} + (1 - k_f)(1 + INF_{j,Acc}) \right\} \right. \\ \left. + CC_0 \left\{ k_{C0} + k_{C1} \frac{P_{Cj}}{P_{C0}} + k_{C2} \frac{P_{Sj}}{P_{S0}} + k_{C3} \frac{P_{Lj}}{P_{L0}} + k_{C4} \frac{FL_j}{FL_0} \right\} + I_0 \frac{P_{Lj}}{P_{L0}} + O_0 (1 + INF_{j,Acc}) \right]$$

This equation is used to calculate the capital cost of 1kW of a particular RE technology corresponding to a particular year.

### Price escalation

Price escalation factor can now be calculated using the same equation as shown below.

$$p_C = \frac{C_j - C_0}{C_0} = \left[ \frac{1 + K_{IDC,j}}{1 + K_{IDC,0}} \right] \left[ \frac{F_j}{C_0} + \frac{T_j}{C_0} + \frac{CC_j}{C_0} + \frac{I_j}{C_0} + \frac{O_j}{C_0} \right] - 1$$

$$p_C = (1 + 0.1AWPLR_{j-2} + 0.6AWPLR_{j-1}) \left[ p_F \left( \frac{PPIUS_{j,Acc}}{PPIUS_{0,Acc}} \right) \frac{D_j}{D_0} \right. \\ \left. + p_T \left\{ k_f \frac{FL_j}{FL_0} + (1 - k_f)(1 + INF_{j,Acc}) \right\} \right. \\ \left. + p_{CC} \left\{ k_{C0} + k_{C1} \frac{P_{Cj}}{P_{C0}} + k_{C2} \frac{P_{Sj}}{P_{S0}} + k_{C3} \frac{P_{Lj}}{P_{L0}} + k_{C4} \frac{FL_j}{FL_0} \right\} + p_I \frac{P_{Lj}}{P_{L0}} + p_O (1 + INF_{j,Acc}) \right] \\ - 1$$



The price escalation coefficient for short term project without considering the IDC is as shown below which is used for Rooftop Solar price calculation.

$$p_{C1} = p_F \left( \frac{PPIUS_{i,Acc}}{PPIUS_{0,Acc}} \right) \frac{D_j}{D_0} + p_T \left\{ k_f \frac{FL_j}{FL_0} + (1 - k_f)(1 + INF_{j,Acc}) \right\} \\ + p_{CC} \left\{ k_{C0} + k_{C1} \frac{P_{Cj}}{P_{C0}} + k_{C2} \frac{P_{Sj}}{P_{S0}} + k_{C3} \frac{P_{Lj}}{P_{L0}} + k_{C4} \frac{FL_j}{FL_0} \right\} + p_I \frac{P_{Lj}}{P_{L0}} + p_O (1 + INF_{j,Acc}) \\ - 1$$

Typical figures for the cost participatory factors and cost factors are as shown below in table B.3 and table B.4.

No	Item	Coef.	Value							
			Roof Top Solar	Ground Mounted Solar	Floating Solar	Wind	Mini Hydro	Bio Mass	Agri/Indu Waste	Waste to energy
1	Percentage of foreign cost out of total project cost	$p_F$	80%	70%	70%	70%	62%	59%	59%	59%
2	Percentage of Transport cost out of total project cost	$p_T$	2%	2%	5%	3%	3%	6%	6%	6%
3	Percentage of Civil Construction cost out of total project cost	$p_{CC}$	0%	10%	7%	10%	21%	21%	21%	21%
4	Percentage of Labour cost out of total project cost	$p_I$	12%	12%	12%	11%	8%	8%	8%	8%
5	Percentage of Overhead cost out of	$p_O$	6%	6%	6%	6%	6%	6%	6%	6%

	total project cost									
Table B.3.										

No	Item	Coef.	Value
6	Percentage of fuel in transport	$k_f$	80%
7	Percentage of fixed cost in construction	$k_{c0}$	15%
8	Percentage of Concrete in civil cost	$k_{c1}$	30%
9	Percentage of Steel in civil cost	$k_{c2}$	20%
10	Percentage of Labor in civil cost	$k_{c3}$	30%
11	Percentage of Fuel in civil cost	$k_{c4}$	5%
Table B.4.			