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## Training on

# Grid Connected Rooftop PV Systems Technical & Economic Fundamentals

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Dr. Sudhir Kumar

# G RTPV Financial Analysis

# Solar Rooftop User Categories

S.No.	Category	Holding	Capacity
1	<b>Domestic</b>	<b>Small house</b>	<b>1-2 kW</b>
2	<b>Domestic</b>	<b>Lower middle class</b>	<b>3-5 kW</b>
3	<b>Domestic</b>	<b>Higher middle class</b>	<b>5-10 kW</b>
4	<b>Domestic</b>	<b>Lavish Bungalow</b>	<b>10-15 kW</b>
5	<b>Commercial</b>	<b>Hotels/ Shopping malls</b>	<b>100-500 kW</b>
6	<b>Industrial</b>	<b>Factories</b>	<b>500-1000 kW</b>

**Note: Normally more than 1 MW rooftop is not considered under net-metering regulation.**

# Rooftop Business Models

CAPEX	OPEX*
Project owned by roof owner/consumer	Project owned by project developer/supplier
Roof owner/consumer responsible for O&M of system after initial 1-2 year period	Roof owner/consumer not responsible for O&M; O&M is responsibility of project developer
Can't be converted to OPEX model at a later date	Can be converted into CAPEX at a pre-decided date (option to buy back)
Power to be used for captive consumption; surplus power can be sold to distribution utility	Power can be sold to roof owner; Power can be sold to distribution utility; Power can be sold to third party**

CAPEX – **Prosumers** (Produce + Consume)

\* OPEX – Mostly RESCOs

\*\* Some states do not allow 3<sup>rd</sup> party sale

# Typical Project Cost of 1 MW

Ground Mounted 1 MW Power Project		
Component	Rs in lakhs	(% of total cost)
PV module	220	44
Civil and General Work	30	6
Mounting Structure	45	9
Cables, Transformers and other misc.	5	1
Power conditioning unit	120	24
Preliminary and pre-operative expenses including IDC and contingency	40	8
Land cost (16 Lakh/ MW)	10	2
Switchyard and transmission line	30	6
<b>Total capital cost of 1 MW</b>	<b>500</b>	<b>100</b>

Rooftop Solar 1 MW Power Project		
Component	Rs in lakhs	(% of total cost)
PV module	250	50
Civil and General Work	30	6
Mounting Structure	55	11
Cables and other misc.	25	5
Power conditioning unit	130	26
Preliminary and pre-operative expenses and contingency	10	2
Land cost (16 Lakh/ MW)	0	0
Switchyard and transmission line	0	0
<b>Total capital cost of 1 MW</b>	<b>500</b>	<b>100</b>

# CAPEX BUSINESS MODEL

# Capex: Pay Back Period

- ❖ It is the length of time required to recover the cost of an investment.
- ❖ Longer payback periods are typically not desirable for investment decisions. e.g.
- ❖ Project cost or initial investment = Rs. 10, 000/-
- ❖ Pay back period is 2 years

	Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6
Cash Outflow	- <b>10000</b>						
Cash Inflow	<b>0</b>	<b>5000</b>	<b>5000</b>	3000	2000	0	-2000

- ❖ “Simple Payback” Term used only for rough idea
- ❖ Does not consider time value of money
- ❖ Hence “**Discounted Payback Period**” is more realistic

# Payback: Residential Rooftop Solar

Discounted Cash Flow calculated as  $CF_n / (1+r)^n$  where n: year,  
 CF<sub>n</sub>: Cash Flow in n<sup>th</sup> year, r: Discount Rate %

CF1	CF2	CF3	CF4		
$(1+r)^1$	$(1+r)^2$	$(1+r)^3$	$(1+r)^4$		

Assumptions	
Capacity kW	10
Cost (Rs.)/kW	-60000
Tariff Escalation	5%
Tariff Rs. per unit	8
Saving 1st Year	116800
Generation Solar Units/kW/day	4
Discount Rate	10%

Simple Payback Period Calculation		
Year	Cash Flow	Balance
0	-600000	-600000
1	116800	-483200
2	122640	-360560
3	128772	-231788
4	135211	-96577
5	141971	45394
6	149070	194463
7	156523	350987
8	164349	515336
9	172567	687903
10	181195	869098
<b>Simple Payback Years</b>		<b>4.32</b>

Discounted Payback Period			
Year	Cash Flow	PV	Balance
0	-600000	-600000	-600000
1	116800	106182	-493818
2	122640	101355	-392463
3	128772	96748	-295715
4	135211	92351	-203364
5	141971	88153	-115211
6	149070	84146	-31065
7	156523	80321	49256
8	164349	76670	125926
9	172567	73185	199111
10	181195	69859	268970
11	190255	66683	335653
<b>Discounted Payback Years</b>			<b>6.61</b>



# Payback: Commercial Rooftop Solar

Assumptions	
Capacity kW	100
Cost (Rs.)/kW	-55000
Tariff Escalation	5%
Tariff Rs. per unit	12
Saving 1st Year	1752000
Solar Generation Units/kW/day	4
Discount Rate	10%

Simple Payback Period Calculation		
Year	Cash Flow	Balance
0	-5500000	-5500000
1	1752000	-3748000
2	1839600	-1908400
3	1931580	23180
4	2028159	2051339
5	2129567	4180906
6	2236045	6416951
7	2347848	8764799
8	2465240	11230039
9	2588502	13818541
10	2717927	16536468
<b>Simple Payback Years</b>		<b>2.01</b>

Discounted Payback Period			
Year	Cash Flow	PV	Balance
0	-5500000	-5500000	-5500000
1	1752000	1592727	-3907273
2	1839600	1520331	-2386942
3	1931580	1451225	-935718
4	2028159	1385260	449542
5	2129567	1322294	1771836
6	2236045	1262189	3034025
7	2347848	1204817	4238842
8	2465240	1150053	5388895
9	2588502	1097778	6486672
10	2717927	1047879	7534551
11	2853823	1000248	8534799
<b>Discounted Payback Years</b>			<b>3.32</b>

# Payback: Industrial Rooftop Solar

Assumptions	
Capacity kW	1000
Cost (Rs.)/kW	-45000
Tariff Escalation	5%
Tariff Rs. per unit	8
Saving 1st Year	11680000
Solar Generation Units/kW/day	4
Discount Rate	10%

Simple Payback Period Calculation		
Year	Cash Flow	Balance
0	-45000000	-45000000
1	11680000	-33320000
2	12264000	-21056000
3	12877200	-8178800
4	13521060	5342260
5	14197113	19539373
6	14906969	34446342
7	15652317	50098659
8	16434933	66533592
9	17256680	83790271
10	18119514	101909785
<b>Simple Payback Years</b>		<b>3.40</b>

Discounted Payback Period			
Year	Cash Flow	PV	Balance
0	-45000000	-45000000	-45000000
1	11680000	10618182	-34381818
2	12264000	10135537	-24246281
3	12877200	9674831	-14571450
4	13521060	9235066	-5336384
5	14197113	8815290	3478906
6	14906969	8414595	11893501
7	15652317	8032114	19925615
8	16434933	7667018	27592632
9	17256680	7318517	34911149
10	18119514	6985857	41897006
11	19025489	6668318	48565324
<b>Discounted Payback Years</b>			<b>4.39</b>

# OPEX BUSINESS MODEL

# IRR (Internal Rate of Return)

- ❖ Internal rate of return (IRR) is the discount rate at which the net present value of an investment becomes zero.
- ❖ PV of future cash flows – Initial Investment = 0

$$\left[ \frac{CF1}{(1+r)^1} + \frac{CF2}{(1+r)^2} + \frac{CF3}{(1+r)^3} + \frac{CF4}{(1+r)^4} + \dots \right] - \text{Initial Investment} = 0$$

- ❖ Where, r is discount rate; CF1 is the period one net cash inflow; CF2 is the period two net cash inflow, CF3 is the period three net cash inflow, and so on ...

	Year	Cash Flow	NPV at 12% Discount rate	NPV at 14% Discount rate	NPV at 14.10% Discount rate	NPV at 15% Discount rate
<b>Investment (I)</b>	<b>0</b>	<b>213000</b>				
<b>Income year 1</b>	<b>1</b>	<b>65200</b>	<b>58214</b>	<b>57193</b>	<b>57143</b>	<b>56696</b>
<b>Income year 2</b>	<b>2</b>	<b>96000</b>	<b>76531</b>	<b>73869</b>	<b>73739</b>	<b>72590</b>
<b>Income year 3</b>	<b>3</b>	<b>73100</b>	<b>52031</b>	<b>49340</b>	<b>49211</b>	<b>48064</b>
<b>Income year 4</b>	<b>4</b>	<b>55400</b>	<b>35208</b>	<b>32801</b>	<b>32686</b>	<b>31675</b>
<b>Total NPV</b>			<b>221984</b>	<b>213204</b>	<b>212780</b>	<b>209025</b>
<b>NPV-I</b>			<b>-8984</b>	<b>-204</b>	<b>220</b>	<b>3975</b>

\* At 14% discount rate (NPV-I) is almost Zero. Hence IRR for 4 years is 14%.

\* Accept the project if IRR is greater than expected cost of finance

# Debt Service Coverage Ratio (DSCR)

- ❖  $DSCR = (\text{Total Cash Available after Tax and before Interest and Depreciation}) / \text{Payment of Interest and Principle loan repayment}$
- ❖ Key Financial Ratio for Lenders to evaluate and decide a Loan sanction
- ❖ Lenders prefer DSCR more than 1.2 to 1.5 e.g.
- ❖ Average DSCR = 1.31 > 1.2 (Accept)

	Yr 1	Yr2	Yr3	Yr 4	Yr5	Yr6
Cash after tax before int & Dep (A)	11500	12000	13000	13500	14000	14500
Principle and int repayment (B)	10000	10000	10000	10000	10000	10000
DSCR = A/B	1.15	1.2	1.3	1.35	1.4	1.45

- ❖ Solar systems: No more costly or unaffordable
- ❖ Technically matured and unbelievable cost reduction
- ❖ Erstwhile hesitant investors now prefer solar sector
- ❖ Investment in solar rooftop is profitable due to:
  - ❖ high return
  - ❖ hassle free
  - ❖ AD Benefit

# Financial Analysis: 100 KW Rooftop

<b>Assumption Sheet</b>	
<b>Proposal for 0.1MW Project</b>	
<b>Numbers in Lakhs INR Unless Specified</b>	
<b>Project Details</b>	
Technology	Photo Voltaic
Location	Pune
Size (MW)	0.10
Number of MWs	0.10
<b>Generation</b>	
Plant Load Factor	17.70%
Net Expected Generation per MW (Lakhs kWh)	15.51
Transmission Losses	0.00
Auxiliary consumption	0.00%
Estimated losses per year	1.0%
<b>Capital Expenditure and Structure</b>	
EPC Price/MW (Rs. Lakhs)	550.00
Interest During Construction (6 months)	10%
Equity Capital	30%
Total Debt	70%

# Assumption Sheet Continued

Interest Cost ( Debt)	10.00%
<b>Loan Particulars</b>	
	<b>INR Debt</b>
Moratorium Period (years)	0.50
Loan Period (Years)	10.50
Period of Loan Excluding Moratorium(Years)	10.0
<b>Operating Expenses</b>	
O&M Expenses (Rs. Lakhs/MW)	1.00%
Annual escalation in O&M Expenses	3.00%
Insurance Expenses (% of Project Cost)	0.15%
<b>Book Depreciation Rates</b>	
Book Depreciation Rate(1-10 year)	10.00%
Book Depreciation Rate(11-25 year)	0.00%
<b>Income Tax Depreciation Rates</b>	
Civil Structure (Additional Infra 20% 1st year)	40.00%
Plant and Machinery (Additional Infra 20% 1st year)	40.00%
Pre-operative Expenses (Additional Infra 20% 1st year)	40.00%
<b>Tax Rules</b>	
Income Tax Rate	30.00%
Surcharge on Income Tax	5.00%
Education Cess on Income tax and Surcharge	3.00%
Minimum Alternate Tax	18.50%



# Financial Analysis: Output (1)

- For 5 years PPA, Rs.10 per unit with 5% escalation gives project IRR 12%, DSCR 1.7
- For 10 years PPA and user agreeing for Rs. 7 per unit with 5% escalation, results into the project IRR is 12%, DSCR 1.7
- For longer PPA period say for 25 years, even Rs. 4.50 per unit with 5% escalation gives project IRR 12%, DSCR 1.2

## Financial Analysis: Output (2)

- Maharashtra commercial tariff is **Rs.15-20 per unit**
- Any **commercial entity** will happily agree to pay **Rs.10 per unit** without yearly escalation
- In such a case: Project IRR is **16-20%** and DSCR **2.0-2.14**
- Thus investor will have multiple choices
- In our view, 10 years of PPA seems to be the most ideal

# Financial Case Study

**Jai Bhavani Mata Stampings Pvt  
Ltd, Pune, India**

**200 kW Solar Rooftop System**

# Existing Electricity Bill

	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Avg.	Rounded off
Units Consumed	34968	32700	29276	33504	27392	24588	31804	30605	30000
Monthly Bill	303227	293623	307183	349402	293482	259660	321590	304024	300000
Per Unit Rate	8.67	8.98	10.49	10.43	10.71	10.56	10.11	9.99	10.00

# Saving Through Solar

MSEB Tariff Escalation %	3											
Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
MSEB Rate/Unit	10	10.30	10.61	10.93	11.26	11.59	11.94	12.30	12.67	13.05	13.44	13.84
Avg. Consumed Units/Month	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Projected MSEB Monthly Bill (Rs.)	300000	309000	318270	327818	337653	347782	358216	368962	380031	391432	403175	415270
Solar Power Per Month (Units)		24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Solar Cost/Unit		7.5	7.73	7.96	8.20	8.44	8.69	8.96	9.22	9.50	9.79	0
Monthly Solar Power Bill (Rs.)		180000	185400	190962	196691	202592	208669	214929	221377	228019	234859	0
Monthly Saving by Solar (Rs.)		67200	69216	71292	73431	75634	77903	80240	82648	85127	87681	332216
Yearly Saving by Solar (Rs.)		806400	830592	855510	881175	907610	934839	962884	991770	1021523	1052169	3986594
Reduced Monthly MSEB Bill (Rs.)		61800	63654	65564	67531	69556	71643	73792	76006	78286	80635	83054

- ❖ JBMS has huge financial benefit without investment
- ❖ Initially till the PPA period, the yearly saving is Rs.8-10 lakhs in 10 years
- ❖ Thereafter, more than Rs.40 lakhs per year

## SECURITY DEPOSIT

- ❖ On commercial operation date, the Power User will pay to the investor a **security deposit** equal to the estimated cost of the supply of solar power for a period of ..... months estimated cost of power calculated at 17% of the rated capacity
- ❖ The investor will **refund the Security Deposit (free of any interest)** to the Power User upon the termination of this Agreement subject to any deductions made towards compensation payable by the Power User to the investor.

## CORPORATE GUARANTEE

- ❖ On the Effective Date, the Power User will provide a **corporate guarantee** to the investor in the agreed form assuring that he will abide by Agreement's provisions as **approved by his board of Directors**
- ❖ In the event that the Power User becomes liable to pay compensation to the Investor under this Agreement, the investor will be entitled to **invoke the Corporate Guarantee should the Power User fail** to pay such compensation within 30 (thirty) days of the Power User having become liable to pay such compensation

# PPA Legal Framework (3)

## OTHER SALIENT FEATURES

- ❖ The technology provider will commission the plant as per the **technical specifications mandated by MNRE** and will maintain the timeline. He will also be responsible for all **the govt. approvals and SEB clearance for net metering**
- ❖ The **owner** of the roof will **lease the roof area** and **allow unrestricted access** to technology provider and investor till the agreement period. He will also be responsible for on-time payments to the investor and will provide all the collateral needed
- ❖ The **investor** will be solely **eligible owner** of the plant and will **claim accelerated depreciation benefit** any other fiscal benefit to solar system. However, **subsidy will be claimed by the roof owner** as per the govt. norms.



# Review

- ❖ What is OPEX and CAPEX?
- ❖ What is prosumer?
- ❖ Who is final authority for rooftop program?
- ❖ What is capacity cap and transformer cap?
- ❖ What is virtual net metering ?
- ❖ What is simple and discounted payback period?
- ❖ What is IRR?
- ❖ What should be IRR of the project ideally?
- ❖ What is DSCR/
- ❖ What should be DSCR of a project ideally?

**Thank You**