Trending! The SunBurn Test™

'How to Ensure Capturing the Expected Return on Investment on your Project'?

Trending! The SunBurn Test™

Me speak no good english, that's unpossible! Such a statement is hilarious because it proves the contrary of its intended claim. An equally hilarious statement is a one that still alleges that climate change phenomenon is a three-scenario hypothesis: hoax, plausible, or confirmed.

Long story short, it is confirmed, and the scientific evidence is plentiful.

So, the question is now how to deal with climate change related risks and opportunities? A growing market trend is evolving for better climate change related risk and opportunity transparency and it may soon become a regulatory or at least a market enforced good practice requirement where corporations will be required to report climate change related impacts in their financial reporting and disclosure. The disclosure shall cover both current short-term and forward-looking long-term impacts projections.

This article sheds some light on climate change risks in the context of solar PV power plant project financial feasibility health-check and how climate change risks impacts can be modelled through a stress test: **The SunBurn Test™**, or **SBT™** in short.

The proposed test approach is not a scientific research paper but is rather based on a risk management approach that makes use of available or reasonably forecasted scientific data coupled with scenario analysis stress test for a baseline case.

Skin sun burns result from the excessive unprotected exposure to direct sunlight. Such burns can be very painful. In contrast, solar PV power plant welcome such excessive exposure! However, if that sun exposure is reduced or altered from design levels, the solar PV power plant will turn pale along with its Independent Power Producer (IPP) investors! The project forecasted "Internal Rate of Return" **IRR will evaporate,** i.e. fall drastically below forecast level, and the project forecasted "Debt Service Coverage Ratio" **DSCR will condensate**, i.e. breach contracts covenant levels to the point of default. Unfortunately, such a scenario may be possible with climate change risks. **The SunBurn Test™** may help understand such misfortunes of pain or financial loss and thus guide us to mitigate them. One could call it The SunPale Test™, but since climate change risks cause equivalent or even more pain thank skin sun burns, the sun burn analogy fits better!

Simply and concisely put, Solar PV power plant financial feasibility is modelled based on its forecasted Levelized Cost of Electricity (LCOE). Such model is based on the principles of Capital Budgeting in Financial Management. The model uses various specific inputs, generates a cashflow waterfall, discounts it at an appropriate discount factor, and outputs the LCOE and other financial covenants such as Equity IRR, DSCR, PLCR, LLCR, DSRA, MMRA, and many others. Simplified basic financial model for a baseline case is shown in Figure 1.

Furthermore, it is important to understand the impacts of the variance of any input parameter on the resulting output (LCOE). This is done through one-dimensional sensitivity analysis were one input parameter is varied a certain percentage and the resultant LCOE change is plotted in a chart. This is shown in Figure 2.

As expected, the Figure 2 chart helps us visualize the result of an input parameter variance and its material impact on forecasted LCOE. The material impact may be become a dangerously compounding effect when multiple parameters vary simultaneously and whose net variance increase the LCOE.

In other words, if parameters vary and the result increases the forecasted LCOE and if we would like to keep the LCOE constant since we have already signed power purchase agreement and built the project. then we must adjust other input parameters that counter the increase with an equivalent decrease back to baseline LCOE. Post project commercial operation date (PCOD), that counter measure will be the project WACC and thus its Equity IRR, as well as a definite secondary effect of reduced measured DSCR. ***That is no good!***

PV POWER PLANT PROJECT LCOE	
PRE-FEASIBILITY ECONOMIC ANALYSIS	
INPUTS	
General	
Analysis Period (years)	25 & 20
Finance Structure	
Debt Percentage	76.00%
Equity Percentage	24.00%
Debt Interest Rate	3.00%
Return on Equity Rate	7.00%
WACC / Nominal Discount Rate	3.96%
Capital Expenditure	
Overnight EPC Cost ($/kWp)	$700.00
Overnight Development Cost ($/kWp)	$10.00
Total Overnight CAPEX Cost ($/kWp)	$710.00
O&M Expenditure	
Fixed Annual O&M ($/kWp/year)	$8.50
O&M Annual Escalation (%)	1.20%
System	
Power Plant Installed Size (kWp)	1.00
Estimated Annual Specific Yield P50 (kWh/kWp)	2,325.88
Installed Annual Energy Output (kWh)	2,325.88
Annual Energy Degradation Year 1 (%/year)	0.00%
Annual Energy Degradation Year 2 to 25 (%/year)	0.60%
Power Plant Annual Availability (%)	99.60%
Net Annual Energy Output Year 1 (kWh)	2,316.58
Residual Value at End of Service Life	
Salvage % of EPC at Year 25	14%
Salvage % of EPC at Year 20	12%

OUTPUTS - 25 Years		
LCOE Component	Component $ ¢/kWh	Component Percentage
Capex Component	2.073064501	86.20%
Opex Component	0.331940496	13.80%
		Total Percentage Check
		100.00%
LCOE ($ ¢/kWh)	**2.405004997**	

OUTPUTS - 20 Years		
LCOE Component	Component $ ¢/kWh	Component Percentage
Capex Component	2.359810857	88.80%
Opex Component	0.297589947	11.20%
		Total Percentage Check
		100.00%
LCOE ($ ¢/kWh)	**2.657400804**	

Proprietary Model
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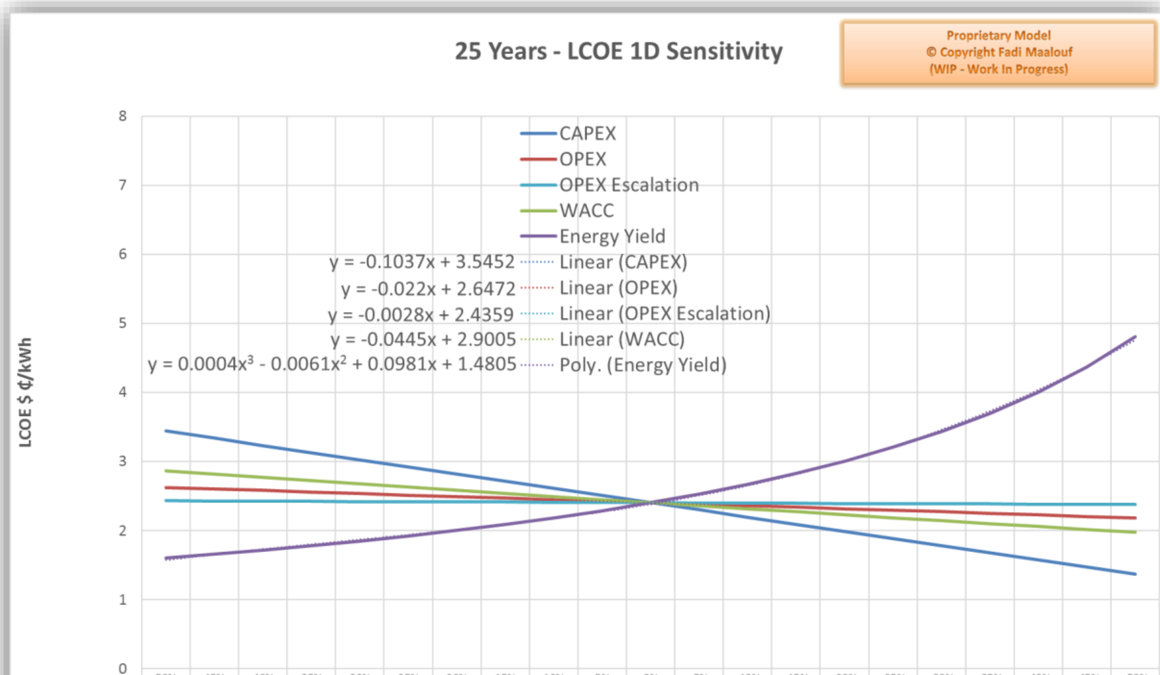
Figure 1 – LCOE Financial Model – Baseline Case



	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%	-5%	-10%	-15%	-20%	-25%	-30%	-35%	-40%	-45%	-50%
CAPEX	3.441537	3.337884	3.234231	3.130578	3.026924	2.923271	2.819618	2.715965	2.612311	2.508658	2.405005	2.301352	2.197699	2.094045	1.990392	1.886739	1.783086	1.679432	1.575779	1.472126	1.368473
OPEX	2.625162	2.603146	2.581131	2.559115	2.537099	2.515084	2.493068	2.471052	2.449036	2.427021	2.405005	2.382989	2.360974	2.338958	2.316942	2.294926	2.272911	2.250895	2.228879	2.206864	2.184848
OPEX Escalation	2.433927	2.430922	2.427942	2.424988	2.42206	2.419156	2.416277	2.413423	2.410593	2.407787	2.405005	2.402247	2.399512	2.3968	2.394111	2.391445	2.388802	2.386181	2.383582	2.381005	2.37845
WACC	2.866979	2.819323	2.771977	2.724948	2.67824	2.631857	2.585806	2.54009	2.494715	2.449685	2.405005	2.360679	2.316713	2.273109	2.229873	2.18701	2.144522	2.102414	2.060689	2.019353	1.978407
Energy Yield	1.603337	1.658624	1.717861	1.781485	1.850004	1.924004	2.004171	2.091309	2.186368	2.290481	2.405005	2.531584	2.672228	2.829418	3.006256	3.206673	3.435721	3.700008	4.008342	4.372736	4.81001

Figure 2 – LCOE Sensitivity Analysis – Baseline Case for 25-Year Term

But, where is the climate change in all of that scary scenario? Climate change results in risks related to the assumed validity (or partial invalidity or accuracy) of the P50 TMY weather file where such historically based data sets file may not represent the true P50 baseline for the next 25 years. Therefore, our estimated P50 energy yield may consistently fall short of forecasts. Additionally, the cousin of our P50 weather file, the P99, may also fall short of estimates. Moreover, climate change has the potential of impacting our forecasted O&M costs significantly, as well as impacting our other LCOE financial model input parameters. All these impacts may compound negatively!

A qualitative and quantitative risk management approach can help us understand climate changes risks and their impacts on our solar PV project forecasted LCOE and hence the Equity IRR and other covenants like DSCR. Climate change related risks may exhibit attributes as shown in Table 1.

SunBurn Test™ Scenario Analysis Model		
Climate Change Risk Register (Extract)		
S.N.	**Qualitative**	**Quantitative**
1	Year 1 Air pollution (PM2.5/10, smog/haze) Not accounted for or fully accounted for in historical P50 TMY weather file and P50 forecasted energy yield report	Decreased solar irradiance, decreased annual energy yield, whilst noting that different PV module technologies get impacted differently according to their light spectrum range
2	Forward looking: Year 2 onwards till plant end of life (PPA term). Continuous percentage increase YoY in air pollution	Continuous percentage decrease YoY in solar irradiance, continuous percentage decrease YoY in annual energy yield
3	Year 1 Higher annual average ambient temperature than forecasted in historical P50 TMY weather file (global warming due to GHG, frequent heat wave events) and hence impacting P50 forecasted energy yield report	Decreased annual energy yield, decrease is proportional to solar module power temperature coefficient
4	Forward looking: Year 2 onwards till plant end of life (PPA term). Continuous percentage increase YoY in annual average ambient temperature, net 2 °C increase in the next 30 years (straight line, slope +0.0666 °C / year)	Continuous percentage decrease YoY in annual energy yield, decrease is proportional to solar module power temperature coefficient
5	Year 1 Extreme weather events Increased frequency of sand storms and/or muddy rain and/or acid rain	Increase in solar modules cleaning frequency (dry and wet), Increase in OPEX Cost (parts & labor & water consumption rate as well as water unit cost rate due to scarcity)
6	Forward looking: Year 2 onwards till plant end of life (PPA term). Consistent extreme and harsh weather events	Accelerated solar module power degradation, higher percentage rate per annum, Decreased energy yield
7	Extreme weather events that result in increased frequency of preventive and corrective maintenance events	Increase in OPEX Cost due to increase MTBF (parts & labor costs)
8	Extreme weather events that result in equipment being out-of-operating-range (high wind speed events for tracking systems, ambient temperature Tmax & Tmin, etc.), and hence plant on temporary curtailment or shutdown	Decrease in power plant annual availability percentage
9	Adverse weather events that result in increased frequency of preventive and corrective maintenance events (hurricanes, floods, landslides, wild fires, etc.) requiring partial or complete power plant shutdown events	Decrease in power plant annual availability percentage
10	Consistent adverse weather events YoY that result in insurance claims (hurricanes, floods)	Increase in OPEX Cost due to increase in insurance costs
11	Catastrophic climate change phenomenon (rising sea levels) that necessitate remedial measures	Increase in CAPEX and OPEX Costs due to protection and fortification measures
12	New & emerging risks attributable to climate change	Ongoing proactive analysis

Table 1 – Climate Change Risk Register (Extract)

The above risks are associated with climate change. This analysis will not be complete without evaluating and noting opportunities that may be associated with climate change. Such opportunities may create an “upside” potential in certain locations. It is important to note that the above risk list is generic. In addition, risks are site specific and not all sites will experience all and the same the risks, but all sites may experience at least a number or risks.

To run the SunBurn Test™, a risk must have Net Value that will impact an input parameter of our LCOE financial model. The Net Risk Value calculation is a two-step approach: First we need to calculate the Gross Risk Value and then the Net Risk Value.

Gross Risk Value = GRV = Risk Value x Probability of Occurrence = RV x PO
Net Risk Value = NRV = Gross Risk Value x Post-Mitigation Correction Factor = GRV x PMCF
NRV = RV x PO x PMCF
PO = 0% to 100%
PMCF = 0 to 1
PMCF examples as follows:
PMCF = 0 is for fully mitigated Gross Risk and hence no residual risk remains (no Net Risk Value)
PMCF = 1 is for fully unmitigated Gross Risk and hence remaining residual risk (NRV) equals GRV
PMCF = 0.7 is for 30% mitigated Gross and hence 70% residual risk remains (NRV)
PMCF = 0.25 is for 75% mitigated Gross Risk and hence 25% residual risk remains (NRV)

<u>Mini Case: Hypothetical Example of SunBurn Test™</u>

Risk A Description: Air pollution resulting in 4% decrease in annual energy yield

RV = P50 Annual Energy Yield Baseline Value x (-0.04)
PO = 75%
PMCF = 1
NRV = P50 Annual Energy Yield Baseline Value x (-0.04x0.75x1)

Risk B Description: Year 2 onwards till plant end of life (PPA term), continuous percentage increase YoY in annual average ambient temperature, net 2.5 °C increase in the next 30 years (straight line, slope +0.0833 °C / year) which result in annual energy yield decrease of 0.0375%

RV = P50 Annual Energy Yield Baseline Value x (-0.000375xN) ; N = Year number -1
PO = 100%
PMCF = 1
NRV = P50 Annual Energy Yield Baseline Value x (-0.000375xN1x1)

Risk C Description: Extreme weather events causing increased frequency of preventive and corrective maintenance events which result in additional annual OPEX of 25%

RV = Annual OPEX Baseline Value x 0.25
PO = 50%
PMCF = 1
NRV = Annual OPEX Baseline Value x (0.25x0.50x1)

Risk D Description: Adverse weather events causing increased frequency of preventive and corrective maintenance events and/or plant-out of-operating-range requiring partial power plant shutdown events, hence plant’s overall annual availability baseline value is reduced by 2%

RV = Plant’s Annual Availability Baseline Value x (-0.02)
PO = 50%
PMCF = 1
NRV = Plant’s Annual Availability Baseline Value x (-0.02x0.5x1)

***Risk E Description: Year 2 onwards till plant end of life (PPA term), consistent extreme and harsh weather events causing* accelerated solar module power degradation, annual degradation rate increases by 20%**

RV = Solar Module Annual Power Degradation Baseline Value x (0.20)
PO = 75%
PMCF = 1
NRV = Solar Module Annual Power Degradation Baseline Value x (0.20x0.75x1)

To stress test our earlier calculated 25 Years LCOE Baseline Case of 2.40 $ ₵/kWh, we apply the five calculated NRV values to our financial model inputs. The resulting Climate Change Risk Weighted LCOE is shown in Figure 3.

PV POWER PLANT PROJECT LCOE

PRE-FEASIBILITY ECONOMIC ANALYSIS

INPUTS	
General	
Analysis Period (years)	25 & 20
Finance Structure	
Debt Percentage	76.00%
Equity Percentage	24.00%
Debt Interest Rate	3.00%
Return on Equity Rate	7.00%
WACC / Nominal Discount Rate	3.96%
Capital Expenditure	
Overnight EPC Cost ($/kWp)	$700.00
Overnight Development Cost ($/kWp)	$10.00
Total Overnight CAPEX Cost ($/kWp)	$710.00
O&M Expenditure	
Fixed Annual O&M ($/kWp/year)	$8.50
O&M Annual Escalation (%)	1.20%
System	
Power Plant Installed Size (kWp)	1.00
Estimated Annual Specific Yield P50 (kWh/kWp)	2,325.88
Installed Annual Energy Output (kWh)	2,325.88
Annual Energy Degradation Year 1 (%/year)	0.00%
Annual Energy Degradation Year 2 to 25 (%/year)	0.60%
Power Plant Annual Availability (%)	99.60%
Net Annual Energy Output Year 1 (kWh)	2,224.52
Residual Value at End of Service Life	
Salvage % of EPC at Year 25	14%
Salvage % of EPC at Year 20	12%

OUTPUTS - 25 Years

LCOE Component	Component $ ¢/kWh	Component Percentage
Capex Component	2.185821159	84.27%
Opex Component	0.408028097	15.73%
		Total Percentage Check
		100.00%
LCOE ($ ¢/kWh)	**2.593849256**	

OUTPUTS - 20 Years

LCOE Component	Component $ ¢/kWh	Component Percentage
Capex Component	2.482820234	87.06%
Opex Component	0.369127085	12.94%
		Total Percentage Check
		100.00%
LCOE ($ ¢/kWh)	**2.851947319**	

Proprietary Model
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The SunBurn Test™ - Stress Test Scenario Analysis Model
Climate Change Risks

Air Pollution - Decrease in Energy Yield	4%
Probability of Occurrence x Post-Mitigation Correction Factor	75%
Ambient Temperature Increase - Decrease Energy Yield Annually, Yr2+	0.0375%
Probability of Occurrence x Post-Mitigation Correction Factor	100%
Extreme Weather Events - Increase OPEX	25%
Probability of Occurrence x Post-Mitigation Correction Factor	50%
Adverse Weather Events - Decrease Annual Availability	2%
Probability of Occurrence x Post-Mitigation Correction Factor	50%
Extreme & Harsh Weather - Increase Annual Module Degradation, Yr2+	20%
Probability of Occurrence x Post-Mitigation Correction Factor	75%
25 Years LCOE Increase from Baseline Case	7.852%
20 Years LCOE Increase from Baseline Case	7.321%

Figure 3 – Climate Change Risk Weighted LCOE

The 25 Years Baseline Case LCOE of 2.40 $ ₵/kWh increased by 7.85%, whilst holding all baseline case inputs constant expect for the five climate change risks adjustments. Hence, climate change risks have a significant impact in this specific case modelling.

Assuming that we have already signed the 25-year power purchase agreement (PPA) and built the project, then we need to hold our 25 Years Baseline Case baseline LCOE value constant at 2.40 $ ₵/kWh.

Keeping the stress test risks in effect, then we calculate resultant Return on Equity (Equity IRR). This is done via iteration, Excel's Goal Seek function, sensitivity analysis (similar to Figure 2), a fancy macro, or an advanced financial model with built-in functionality. The resultant Return on Equity (Equity IRR). is shown in Figure 4 where baseline case LCOE is maintained at 2.40 $ ₵/kWh. A very minor error is noted, 0.037% variance in 25 Years LCOE. This is due to rounding and it can be safely ignored.

Additionally, it is noted that 20 Years LCOE does not set back to baseline case when we optimize for the 25 Years LCOE and this is due to their different cash flow term and common input parameters. If 20 Years is our baseline case term, then solving for Return of Equity can be performed via the same aforementioned techniques on the basis of 20 Years LCOE. The result shown in Figure 5.

PV POWER PLANT PROJECT LCOE

PRE-FEASIBILITY ECONOMIC ANALYSIS

INPUTS	
General	
Analysis Period (years)	25 & 20
Finance Structure	
Debt Percentage	76.00%
Equity Percentage	24.00%
Debt Interest Rate	3.00%
Return on Equity Rate	3.61%
WACC / Nominal Discount Rate	3.15%
Capital Expenditure	
Overnight EPC Cost ($/kWp)	$700.00
Overnight Development Cost ($/kWp)	$10.00
Total Overnight CAPEX Cost ($/kWp)	$710.00
O&M Expenditure	
Fixed Annual O&M ($/kWp/year)	$8.50
O&M Annual Escalation (%)	1.20%
System	
Power Plant Installed Size (kWp)	1.00
Estimated Annual Specific Yield P50 (kWh/kWp)	2,325.88
Installed Annual Energy Output (kWh)	2,325.88
Annual Energy Degradation Year 1 (%/year)	0.00%
Annual Energy Degradation Year 2 to 25 (%/year)	0.60%
Power Plant Annual Availability (%)	99.60%
Net Annual Energy Output Year 1 (kWh)	2,224.52
Residual Value at End of Service Life	
Salvage % of EPC at Year 25	14%
Salvage % of EPC at Year 20	12%

OUTPUTS - 25 Years		
LCOE Component	Component $ ¢/kWh	Component Percentage
Capex Component	2.007320222	83.43%
Opex Component	0.398570164	16.57%
		Total Percentage Check
		100.00%
LCOE ($ ¢/kWh)	**2.405890386**	

OUTPUTS - 20 Years		
LCOE Component	Component $ ¢/kWh	Component Percentage
Capex Component	2.311299393	86.54%
Opex Component	0.359549309	13.46%
		Total Percentage Check
		100.00%
LCOE ($ ¢/kWh)	**2.670848702**	

Proprietary Model
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The SunBurn Test™ - Stress Test Scenario Analysis Model Climate Change Risks	
Air Pollution - Decrease in Energy Yield	4%
Probability of Occurrence x Post-Mitigation Correction Factor	75%
Ambient Temperature Increase - Decrease Energy Yield Annually, Yr2+	0.0375%
Probability of Occurrence x Post-Mitigation Correction Factor	100%
Extreme Weather Events - Increase OPEX	25%
Probability of Occurrence x Post-Mitigation Correction Factor	50%
Adverse Weather Events - Decrease Annual Availability	2%
Probability of Occurrence x Post-Mitigation Correction Factor	50%
Extreme & Harsh Weather - Increase Annual Module Degradation, Yr2+	20%
Probability of Occurrence x Post-Mitigation Correction Factor	75%
25 Years LCOE Increase from Baseline Case	0.037%
20 Years LCOE Increase from Baseline Case	0.506%

Figure 4 – Climate Change Risk Weighted Return on Equity (Equity IRR) – 25 Years

Under the SunBurn Test™ scenario analysis model for a 25-year term, the Return on Equity dropped from 7.00% to 3.61%, a 48.42% decrease. This is a very significant change that will cause considerable financial loss and some painful "evaporation" of IRR value. This is, of course, under the assumed scenario parameters.

PV POWER PLANT PROJECT LCOE				
PRE-FEASIBILITY ECONOMIC ANALYSIS				
INPUTS		**OUTPUTS - 25 Years**		
General		LCOE Component	Component $ ¢/kWh	Component Percentage
Analysis Period (years)	25 & 20	Capex Component	1.995114032	83.37%
Finance Structure		Opex Component	0.397866509	16.63%
Debt Percentage	76.00%			Total Percentage Check
Equity Percentage	24.00%			100.00%
Debt Interest Rate	3.00%			
Return on Equity Rate	3.37%	**LCOE ($ ¢/kWh)**	**2.392980541**	
WACC / Nominal Discount Rate	3.09%			
Capital Expenditure				
Overnight EPC Cost ($/kWp)	$700.00	**OUTPUTS - 20 Years**		
Overnight Development Cost ($/kWp)	$10.00			
Total Overnight CAPEX Cost ($/kWp)	$710.00	LCOE Component	Component $ ¢/kWh	Component Percentage
O&M Expenditure		Capex Component	2.299533489	86.50%
Fixed Annual O&M ($/kWp/year)	$8.50	Opex Component	0.358849459	13.50%
O&M Annual Escalation (%)	1.20%			Total Percentage Check
System				100.00%
Power Plant Installed Size (kWp)	1.00			
Estimated Annual Specific Yield P50 (kWh/kWp)	2,325.88	**LCOE ($ ¢/kWh)**	**2.658382948**	
Installed Annual Energy Output (kWh)	2,325.88			
Annual Energy Degradation Year 1 (%/year)	0.00%			
Annual Energy Degradation Year 2 to 25 (%/year)	0.60%			
Power Plant Annual Availability (%)	99.60%	Proprietary Model		
Net Annual Energy Output Year 1 (kWh)	2,224.52	© Copyright Fadi Maalouf		
Residual Value at End of Service Life		(WIP - Work In Progress)		
Salvage % of EPC at Year 25	14%			
Salvage % of EPC at Year 20	12%			

The SunBurn Test™ - Stress Test Scenario Analysis Model **Climate Change Risks**	
Air Pollution - Decrease in Energy Yield	4%
Probability of Occurrence x Post-Mitigation Correction Factor	75%
Ambient Temperature Increase - Decrease Energy Yield Annually, Yr2+	0.0375%
Probability of Occurrence x Post-Mitigation Correction Factor	100%
Extreme Weather Events - Increase OPEX	25%
Probability of Occurrence x Post-Mitigation Correction Factor	50%
Adverse Weather Events - Decrease Annual Availability	2%
Probability of Occurrence x Post-Mitigation Correction Factor	50%
Extreme & Harsh Weather - Increase Annual Module Degradation, Yr2+	20%
Probability of Occurrence x Post-Mitigation Correction Factor	75%
25 Years LCOE Increase from Baseline Case	-0.500%
20 Years LCOE Increase from Baseline Case	0.037%

Figure 5 – Climate Change Risk Weighted Return of Equity (Equity IRR) – 20 Years

Under the SunBurn Test ™ scenario analysis model for a 20-year term, the Return on Equity dropped from 7.00% to 3.37%, a 51.85% decrease. Again, this is a very significant change that will cause considerable financial loss and some painful "evaporation" of IRR value. Once again, this is under the assumed scenario parameters.

Good financial modelling practice calls for model integrity checks functionality. In other words, what if these seemingly complex adjustments of integrating climate change net risk values (NRV) to baseline financial model have compromised the integrity of the baseline model calculations and formulae? This is a truly valid question.

Therefore, an integrity check for our financial model is necessary.

Advanced financial models shall have built-in or automated integrity checks functionality. The model used in our analysis is a simplified one. Nonetheless, a simple and quick integrity check can be performed by setting the "Probability of Occurrence x Post-Mitigation Correction Factor" of all climate change risks to zero. With all other input parameters held constant, the model LCOE output shall revert to baseline case. This is shown is Figure 6.

PV POWER PLANT PROJECT LCOE				
PRE-FEASIBILITY ECONOMIC ANALYSIS				
INPUTS		**OUTPUTS - 25 Years**		
General		LCOE Component	Component $ ¢/kWh	Component Percentage
Analysis Period (years)	25 & 20	Capex Component	2.073064501	86.20%
Finance Structure		Opex Component	0.331940496	13.80%
Debt Percentage	76.00%			Total Percentage Check
Equity Percentage	24.00%			100.00%
Debt Interest Rate	3.00%			
Return on Equity Rate	7.00%	**LCOE ($ ¢/kWh)**	**2.405004997**	
WACC / Nominal Discount Rate	3.96%			
Capital Expenditure				
Overnight EPC Cost ($/kWp)	$700.00	**OUTPUTS - 20 Years**		
Overnight Development Cost ($/kWp)	$10.00			
Total Overnight CAPEX Cost ($/kWp)	$710.00	LCOE Component	Component $ ¢/kWh	Component Percentage
O&M Expenditure		Capex Component	2.359810857	88.80%
Fixed Annual O&M ($/kWp/year)	$8.50	Opex Component	0.297589947	11.20%
O&M Annual Escalation (%)	1.20%			Total Percentage Check
System				100.00%
Power Plant Installed Size (kWp)	1.00			
Estimated Annual Specific Yield P50 (kWh/kWp)	2,325.88	**LCOE ($ ¢/kWh)**	**2.657400804**	
Installed Annual Energy Output (kWh)	2,325.88			
Annual Energy Degradation Year 1 (%/year)	0.00%			
Annual Energy Degradation Year 2 to 25 (%/year)	0.60%			
Power Plant Annual Availability (%)	99.60%	Proprietary Model © Copyright Fadi Maalouf (WIP - Work In Progress)		
Net Annual Energy Output Year 1 (kWh)	2,316.58			
Residual Value at End of Service Life				
Salvage % of EPC at Year 25	14%			
Salvage % of EPC at Year 20	12%			

The SunBurn Test™ - Stress Test Scenario Analysis Model **Climate Change Risks**	
Air Pollution - Decrease in Energy Yield	4%
Probability of Occurrence x Post-Mitigation Correction Factor	0%
Ambient Temperature Increase - Decrease Energy Yield Annually, Yr2+	0.0375%
Probability of Occurrence x Post-Mitigation Correction Factor	0%
Extreme Weather Events - Increase OPEX	25%
Probability of Occurrence x Post-Mitigation Correction Factor	0%
Adverse Weather Events - Decrease Annual Availability	2%
Probability of Occurrence x Post-Mitigation Correction Factor	0%
Extreme & Harsh Weather - Increase Annual Module Degradation, Yr2+	20%
Probability of Occurrence x Post-Mitigation Correction Factor	0%
25 Years LCOE Increase from Baseline Case	0.000%
20 Years LCOE Increase from Baseline Case	0.000%

Figure 6 – Model Integrity Check with Zero Climate Change Risks

Thus far, our analysis indicated that the assumed climate change risk scenario has a significant impact on baseline case LCOE. The Climate Change Risk Weighted. LCOE has increased. Using our basic financial model, this in turn translated to a significant decrease in the projected Return on Equity Rate when baseline case LCOE is held constant.

But what about the impacts on Debt Service Coverage Ratio (DSCR) and other project finance term sheet covenants?

From a qualitative perspective, a decrease in Return on Equity Rate signifies a decrease in project operating income cashflow (due to operating revenue decrease, everything else held constant) and hence a decrease in Cashflow Available for Debt Service (CFADS). A decreased CFADS implies in a decreased DSCR (DSCR = CFADS / Debt Payment). To quantify the decrease in DSCR, an advanced financial model that factors in the debt structure (type, tenor, T&Cs) will be required. Analysis using advanced financial modelling will be utilized in a future publication. So, stay tuned for Part 2 of this SunBrun Test™ article!

In summary, The SunBurn Test™ (SBT™) key takeaways are:

1. Climate change is a reality. It presents both risks and opportunities, which can be generally categorized as current short-term impacts and forward-looking long-term impacts.
2. A global mega trend is evolving where corporations will be required to report climate change related impacts in their financial reporting and disclosure. Hence corporations are integrating climate related impacts in their corporate strategies.
3. In the context of Independent Power Producers and solar PV power plants, understanding and accounting for climate change related impacts is paramount.
4. SBT™ is stress test technique in which a scenario analysis is applied to health-check the financial feasibility of a solar PV power plant. The stress parameters are derived from climate change related risks.
5. SBT™ is a process that utilizes:
    a. Location specific climate change risks from credible scientific research where historical measured data is modelled to create forward looking climate projections.
    b. Risk Management approach to qualify and quantify climate change related risks.
    c. Resultant risks values form a scenario and are used to stress test a project baseline case financial feasibility model.
    d. The goal is to determine whether the stressed project remains financially viable. For solar PV power plant, the focus is equity IRR, DSCR, amongst other covenants.
    e. Care of not falling in the trap of **GIGO**: **G**arbage **I**n **»** **G**arbage **O**ut. Modelling parameters must neither be artificially low nor doomsday high!
6. A hypothetical stress test with a few selected risks was run. It indicated significant impact on a solar PV power plant project profitability, especially in very competitively priced LCOE's with single digit IRR's.
7. SBT™ is a useful technique. It may help prevent a nasty sun burn!

Sunny Regards.

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