

“NREL SAM – SUNDAT” INTEGRATION AN OVERVIEW

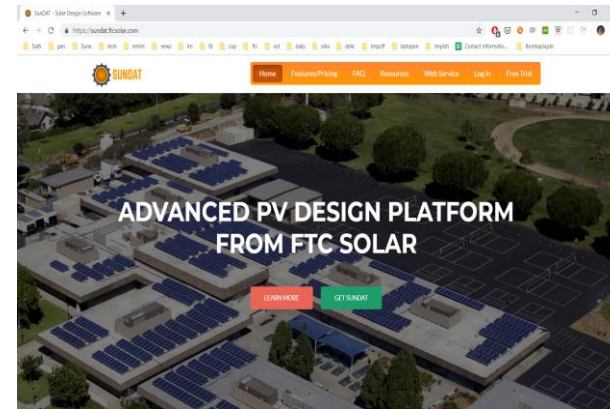
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BRIEF ON SUNDAT

- **Plugin for Sketchup 3D environment for automated and optimized solar design**
- **Allows user to design residential, commercial and utility scale sites based on industry design standards – NO SIZE LIMITS**
- **Automates a major portion of**
 - Shadow simulation
 - Terrain Analysis
 - Module layout with parametric options using Cloud
 - Structural layout
 - Electrical Design
 - Yearly Shade for trackers on Terrain using cloud service
 - Energy modeling with NREL SAM




Yearly Shade % for R_1																								
Month	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Jan	100	100	100	100	100	100	100	100	19.09	35.6	0	0	0	0	0	0.35	64.4	61.94	100	100	100	100	100	100
Feb	100	100	100	100	100	100	100	11.59	1.17	12.06	0	0	0	0	0	0.35	52.46	60.54	100	100	100	100	100	100
Mar	100	100	100	100	100	100	100	22.01	1.05	0	0	0	0	0	0	0.23	1.05	57.61	57.73	100	100	100	100	100
Apr	100	100	100	100	100	100	22.6	27.05	0	0	0	0	0	0	0	0.35	54.8	0.94	100	100	100	100	100	100
May	100	100	100	100	100	100	22.95	27.52	0	0	0	0	0	0	0	0.35	1.41	1.52	20.26	100	100	100	100	100
Jun	100	100	100	100	100	100	22.95	28.57	0	0	0	0	0	0	0	0.35	0.94	1.76	7.61	100	100	100	100	100
Jul	100	100	100	100	100	100	23.19	27.63	0	0	0	0	0	0	0	0.35	1.05	1.76	11.48	100	100	100	100	100
Aug	100	100	100	100	100	100	23.3	27.87	0.82	0	0	0	0	0	0	0.35	55.74	1.17	100	100	100	100	100	100
Sep	100	100	100	100	100	100	100	0.7	1.05	0	0	0	0	0	0	0.35	23.42	59.25	47.31	100	100	100	100	100
Oct	100	100	100	100	100	100	1.17	1.17	0	0	0	0	0	0	0	0.7	61.83	61.71	100	100	100	100	100	100
Nov	100	100	100	100	100	100	100	35.48	9.84	0	0	0	0	0	0.23	29.39	60.54	100	100	100	100	100	100	100
Dec	100	100	100	100	100	100	100	35.48	36.53	0	0	0	0	0	0.12	18.62	66.16	100	100	100	100	100	100	100

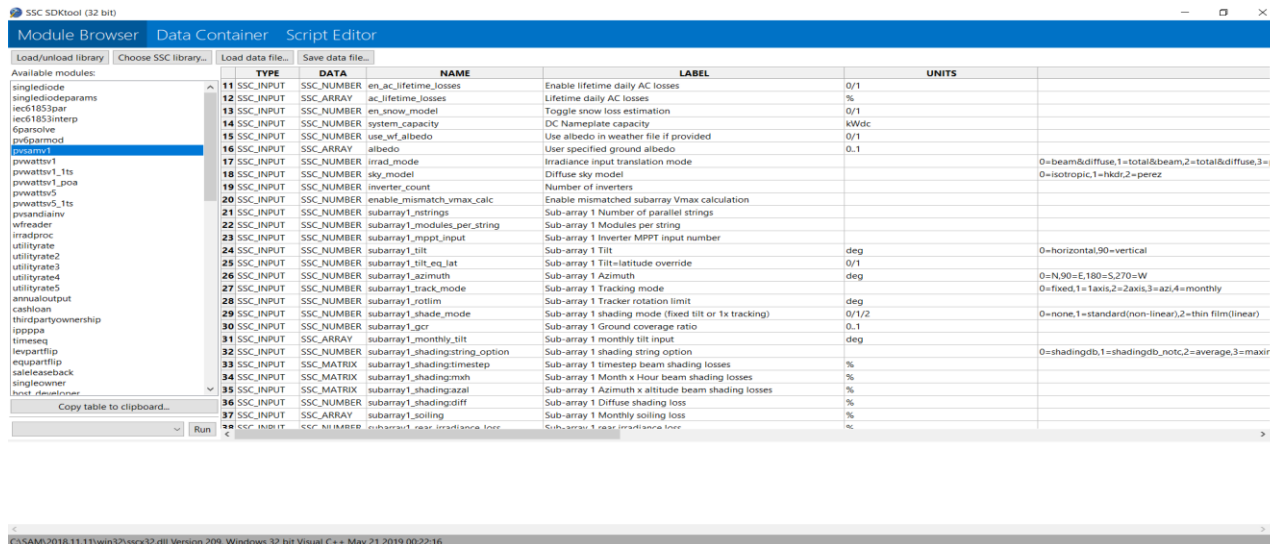
WHY NREL SAM?

- ✓ **SDK Support**
- ✓ **Simple to pack with SunDAT – Just 3 dlls**
- ✓ **Vast Module and Inverter Libraries – Ability to create custom components**
- ✓ **Support for Trackers and Fixed Tilt Tables**
- ✓ **Shade Import Facility**
- ✓ **Weather file library**
- ✓ **Support for weather file formats import**
- ✓ **Fast computation of production and yield**
- ✓ **Computation with numbers rather than whole site**

CHALLENGES

❑ Challenges:

- Ruby SDK support was not there – we used python base to develop Ruby SDK 
- Large number of variables(250), modules and inverters mapping.
- User acceptance on taking SAM simulation values as final when compared to Pvsyst




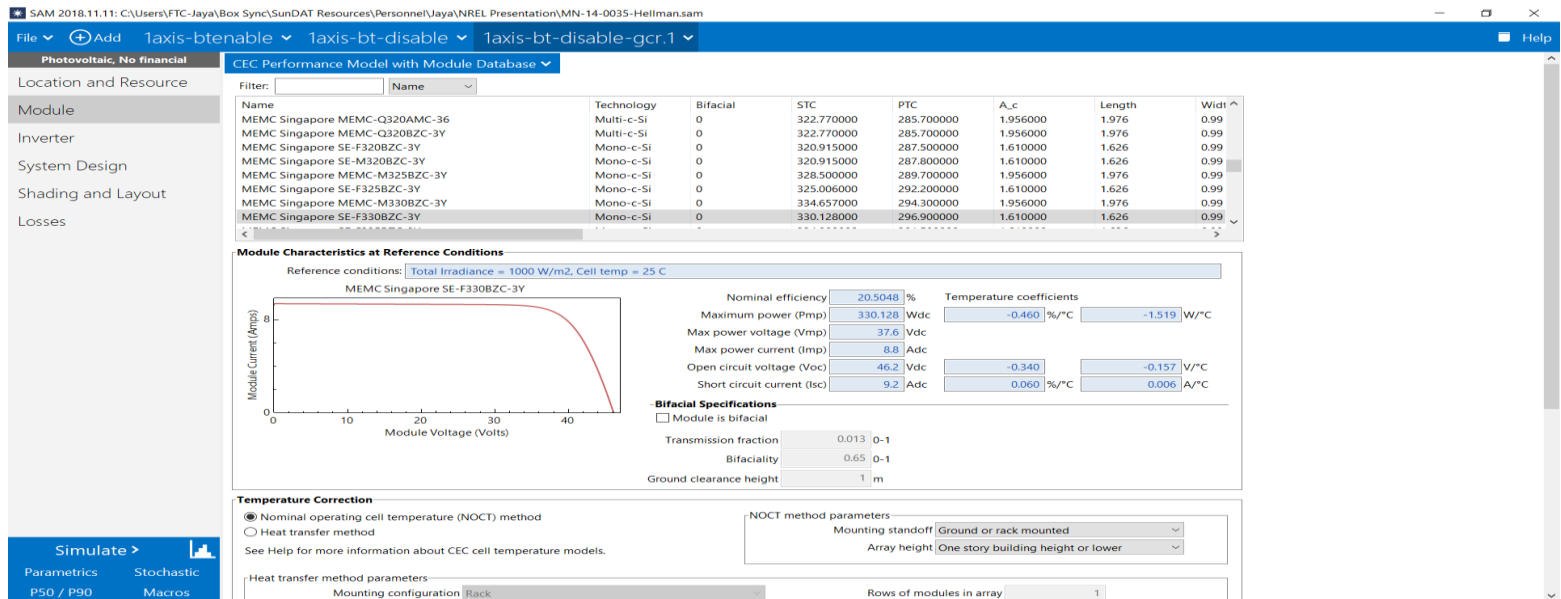
The screenshot shows the SSC SDKtool (32 bit) interface. The main window is titled "Module Browser Data Container Script Editor". Below the title bar, there are tabs for "Load/unload library", "Choose SSC library...", "Load data file...", and "Save data file...". The main area displays a table of available modules and their parameters.

TYPE	DATA	NAME	LABEL	UNITS	
11	SSC_INPUT	SSC_NUMBER	en_ac_lifetime_losses	Enable lifetime daily AC losses	0/1
12	SSC_INPUT	SSC_ARRAY	ac_lifetime_losses	Lifetime daily AC losses	%
13	SSC_INPUT	SSC_NUMBER	en_snow_model	Toggle snow loss estimation	0/1
14	SSC_INPUT	SSC_NUMBER	system_capacity	DC Nameplate capacity	kWdc
15	SSC_INPUT	SSC_NUMBER	use_wf_albedo	Use albedo in weather file if provided	0/1
16	SSC_INPUT	SSC_ARRAY	albedo	User specified ground albedo	0/1
17	SSC_INPUT	SSC_NUMBER	irrad_mode	Irradiance input translation mode	
18	SSC_INPUT	SSC_NUMBER	sky_model	Diffuse sky model	0=beam&diffuse,1=total&beam,2=total&diffuse,3=
19	SSC_INPUT	SSC_NUMBER	inverter_count	Number of inverters	0=isotropic,1=hkdr,2=perez
20	SSC_INPUT	SSC_NUMBER	enable_mismatch_vmax_calc	Enable mismatched subarray Vmax calculation	
21	SSC_INPUT	SSC_NUMBER	subarray1_nstrings	Sub-array 1 Number of parallel strings	
22	SSC_INPUT	SSC_NUMBER	subarray1_modules_per_string	Sub-array 1 Modules per string	
23	SSC_INPUT	SSC_NUMBER	subarray1_mppt_input	Sub-array 1 Inverter MPPT input number	
24	SSC_INPUT	SSC_NUMBER	subarray1_tilt	Sub-array 1 Tilt	deg
25	SSC_INPUT	SSC_NUMBER	subarray1_tilt_eq_lat	Sub-array 1 Tilt=latitude override	0/1
26	SSC_INPUT	SSC_NUMBER	subarray1_azimuth	Sub-array 1 Azimuth	deg
27	SSC_INPUT	SSC_NUMBER	subarray1_track_mode	Sub-array 1 Tracking mode	0=fixed,1=1axis,2=2axis,3=azi,4=monthly
28	SSC_INPUT	SSC_NUMBER	subarray1_rotlim	Sub-array 1 Tracker rotation limit	deg
29	SSC_INPUT	SSC_NUMBER	subarray1_shade_mode	Sub-array 1 shading mode (fixed tilt or 1x tracking)	0/1/2
30	SSC_INPUT	SSC_NUMBER	subarray1_gcr	Sub-array 1 Ground coverage ratio	0,1
31	SSC_INPUT	SSC_ARRAY	subarray1_monthly_tilt	Sub-array 1 monthly tilt input	deg
32	SSC_INPUT	SSC_NUMBER	subarray1_shadingstring_option	Sub-array 1 shading string option	0=shadingdb,1=shadingdb_notc,2=average,3=maxir
33	SSC_INPUT	SSC_MATRIX	subarray1_shadingtimestep	Sub-array 1 timestep beam shading losses	%
34	SSC_INPUT	SSC_MATRIX	subarray1_shadingmsh	Sub-array 1 Month x Hour beam shading losses	%
35	SSC_INPUT	SSC_MATRIX	subarray1_shadingazal	Sub-array 1 Azimuth x altitude beam shading losses	%
36	SSC_INPUT	SSC_NUMBER	subarray1_shadingdiff	Sub-array 1 Diffuse shading loss	%
37	SSC_INPUT	SSC_ARRAY	subarray1_solling	Sub-array 1 Monthly soiling loss	%
38	SSC_INPUT	SSC_NUMBER	subarray1_loss_irradiance_loss	Sub-array 1 loss irradiance loss	%

IMPLEMENTATION

Implementation:

- Picked 'pvsm1' – Photovoltaic (Detailed) with No Financial Model module for automation
- Used SSC SDK Tool for mapping variables to SunDAT variables
- Created a sample sdk script for simulating SunDAT Values by following 
- Converted this implementation to Ruby for SunDAT Simulation



CEC Performance Model with Module Database

Name	Technology	Bifacial	STC	PTC	A_c	Length	Width
MEMC Singapore MEMC-Q320AMC-36	Multi-c-Si	0	322.770000	285.700000	1.956000	1.976	0.99
MEMC Singapore MEMC-Q320BZC-3Y	Multi-c-Si	0	322.770000	285.700000	1.956000	1.976	0.99
MEMC Singapore SE-F320BZC-3Y	Mono-c-Si	0	320.915000	287.500000	1.610000	1.626	0.99
MEMC Singapore SE-M320BZC-3Y	Mono-c-Si	0	320.915000	287.800000	1.610000	1.626	0.99
MEMC Singapore MEMC-M325BZC-3Y	Mono-c-Si	0	328.500000	289.700000	1.956000	1.976	0.99
MEMC Singapore SE-F325BZC-3Y	Mono-c-Si	0	325.006000	292.200000	1.610000	1.626	0.99
MEMC Singapore MEMC-M330BZC-3Y	Mono-c-Si	0	334.657000	294.300000	1.956000	1.976	0.99
MEMC Singapore SE-F330BZC-3Y	Mono-c-Si	0	330.128000	296.900000	1.610000	1.626	0.99

Module Characteristics at Reference Conditions

Reference conditions: Total Irradiance = 1000 W/m2, Cell temp = 25 C

MEMC Singapore SE-F330BZC-3Y

Module Current (Amps) vs Module Voltage (Volts) graph showing a typical solar cell I-V curve.

Temperature Correction

Nominal operating cell temperature (NOCT) method
 Heat transfer method

See Help for more information about CEC cell temperature models.

Heat transfer method parameters:

Mounting configuration: Rack

Rows of modules in array: 1

NOCT method parameters:

Mounting standoff: Ground or rack mounted

Array height: One story building height or lower

Module Characteristics at Reference Conditions

Nominal efficiency: 20.5048 %

Maximum power (Pmp): 330.128 Wdc

Max power voltage (Vmp): 37.6 Vdc

Max power current (Imp): 8.8 Adc

Open circuit voltage (Voc): 46.2 Vdc

Short circuit current (Isc): 9.2 Adc

Temperature coefficients:

Wdc: -0.460 %/°C

Voc: -0.340 V/°C

Isc: 0.006 A/°C

Bifacial Specifications:

Module is bifacial

Transmission fraction: 0.013 0-1

Bifaciality: 0.65 0-1

Ground clearance height: 1 m

LAYOUT RUNS WITH PARAMETRIC INPUT

The screenshot displays the FTCSolar software interface for a solar layout simulation. The window title is "C:\Users\FTC-Jaya\Desktop\Rippe Solar - 7860 Str 062719.skp". The user is logged in as "jrajasekaran@ftcsolar.com".

Configuration Options:

- Regions:** "Choose one or more regions for this layout operation" with a dropdown menu showing "R_01".
- Tables/Blocks:** "Select the tables/blocks to be used" with a checked "Parametric?" option and dropdowns for "Voyager - 28mod str - 385W" and "Voyager - 20 str cmb - 385W - 35GCR".
- Module Alignment:** "Mode of module alignment" with radio buttons for "Uniform" (selected) and "Non-uniform".
- Layout Algorithm:** "Depth of layout algorithm" with radio buttons for "Quick", "Normal", and "Detailed".
- Orientation:** "Azimuth [°]" (175, checked "Parametric?"), "Skew [°]" (180, unchecked "Parametric?"), and "Start Point" (Origin).
- System Size:** "Target System Size" (0 kWDC).
- Spacing:** "North-South Spacing" (3 m, checked "Parametric?") and "East-West Spacing" (7 m, checked "Parametric?").
- Inverter:** "Choose an Inverter (for Energy Analysis)" (SMA_SC_3000-EV, unchecked "Parametric?") and "Target DC/AC Ratio" (1.2, checked "Parametric?").
- Additional Configuration:** "Additional layout configuration" (checked) with "Additional North-South Gap" (4 Rows, 20 m) and "Additional East-West Gap" (None).
- Other Options:** "Fix Inverter Quantity" (unchecked), "Half frequency for first NS Gap?" (unchecked).

Diagram: A 3x3 grid of solar panels is shown with "EW Gap" (East-West Gap) and "NS Gap" (North-South Gap) labels indicating the spacing between panels.

ENERGY VALUES FOR EACH LAYOUT

C:\Users\FTC-Jaya\Desktop\Rippee Solar - 7860 Str - DC Complete 062719.skp

jrjasekaran@ftcsolar.com

PV Layout

Run Results

Group Parametric Results

Version	Region	Generation Type	Tables/Blocks	ns_gap [m]	Add.NS Gap	ew_gap [m]	GCR	pitch [m]	Azimuth	Module	Mod Qty	Size (kW)	Inverter	Inv Qty	DC/AC Ratio	Production (kWh)	Yield (kWh/kWp)	Cost/Watt (\$)	Time Sta
1.0	R_01	Auto	Voyager - 20 str cmb - 385W - 35GCR(400)	3	Every 2 rows with 20m gap	7.47	35	11.492	180	Canadian Solar CS3U- 385MS 1500V	224000	86240	SMA_SC_3000- EV	23	1.25	153045264	1774.644	5974060.456	06/20/20 16:35:48
1.1	R_01	Manual	Voyager - 20 str cmb - 385W - 35GCR(372)	3	Every 2 rows with 20m gap	7.47	35	11.492	180	Canadian Solar CS3U- 385MS 1500V	208320	80203.2	SMA_SC_3000- EV	21	1.27	141776928	1767.722	5556517.759	06/20/20 20:26:52
2.0	R_01	Auto	Voyager - 20 str cmb - 385W - 35GCR(407)	3	Every 4 rows with 20m gap	7.47	35	11.492	180	Canadian Solar CS3U- 385MS 1500V	227920	87749.2	SMA_SC_3000- EV	23	1.27	155153904	1768.152	6078428.029	06/27/20 14:44:56
3.1	R_01	Manual	Voyager - 20 str cmb - 385W - 35GCR(393)	3	Every 4 rows with 20m gap	7.47	35	11.492	180	Canadian Solar CS3U- 385MS 1500V	220080	84730.8	SMA_SC_3000- EV	23	1.23	150808544	1779.855	5869620.475	06/27/20

CUSTOMIZABLE INPUTS 1 – SYSTEM DESIGN

C:\Users\FTC-Jaya\Desktop\Rippe Solar - 7860 Str - DC Complete 062719.skp

jrajasekaran@ftcsolar.com

Customize

Choose Weather Source file (Name | Source | Distance (Km))

USA TX Dallas-fort Worth Intl Ap (TMY3) | TMY3 | 74

Select weather file format to import local file

TMY3

System Design | Shading And Losses | Module Values | Inverter Values

Select region to load values

R_01

Name plate capacity [kWp]

84730.8

Tilt[deg]

0

Azimuth[deg]

180

Tracker Mode

1 Axis

Tracker Rotation Limit[deg]

60

GCR

0.36

Module Orientation

Portrait

Nameplate loss [%]

-0.006

Modules per string

28

Inverter count

23

Strings in region

7860

No of Modules along bottom of row

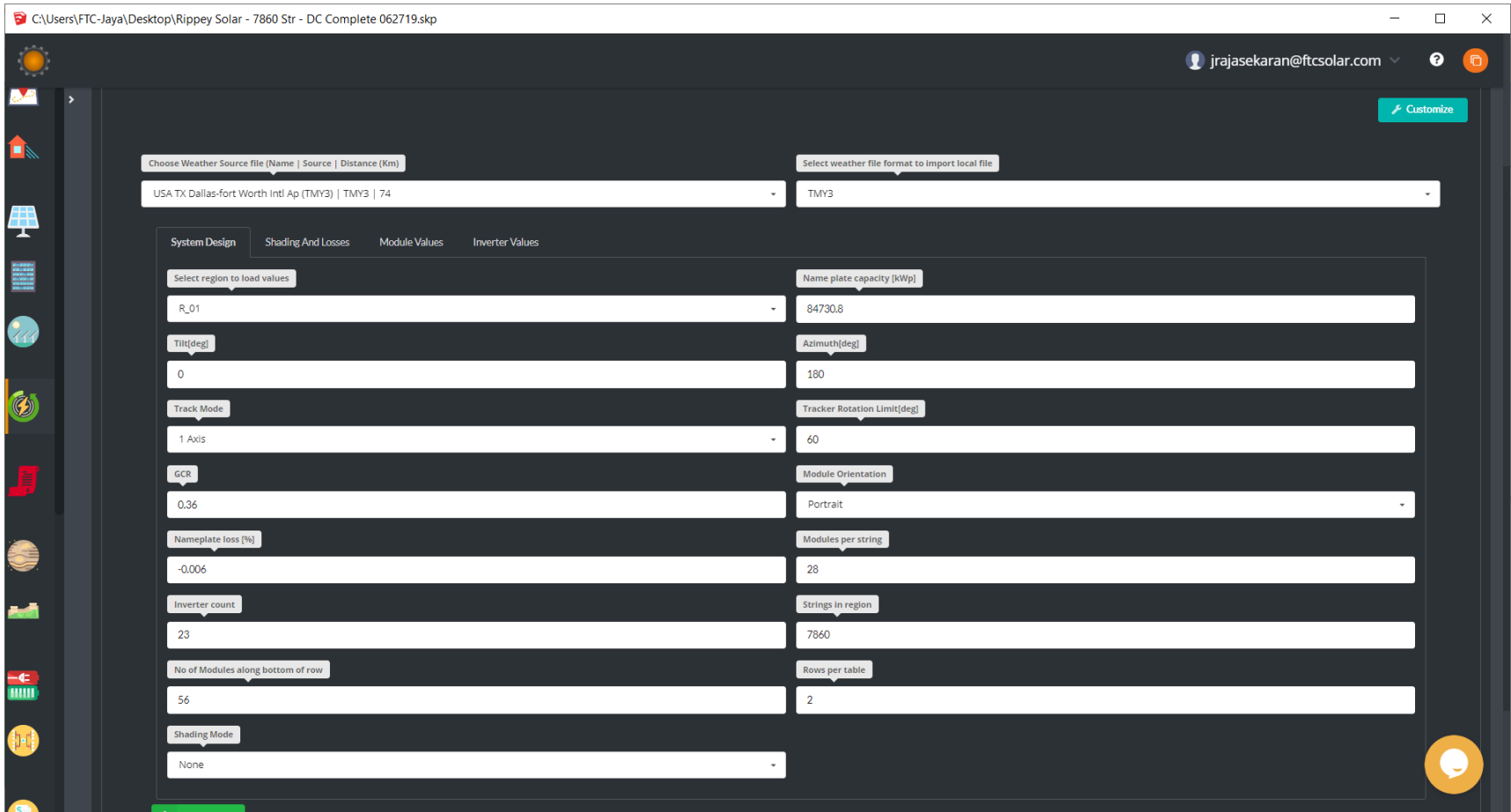
56

Rows per table

2

Shading Mode

None

The image shows a screenshot of a web-based software interface for solar system design. The interface is dark-themed and contains various input fields and dropdown menus for configuring system parameters. At the top, there are fields for weather source file selection and format. Below that, a 'System Design' tab is active, showing a grid of input fields for region, capacity, tilt, azimuth, tracker mode, rotation limit, GCR, module orientation, nameplate loss, modules per string, inverter count, strings in region, modules per row, rows per table, and shading mode. A 'Customize' button is visible in the top right corner. The browser's address bar shows the file path 'C:\Users\FTC-Jaya\Desktop\Rippe Solar - 7860 Str - DC Complete 062719.skp' and the user's email 'jrajasekaran@ftcsolar.com'.

CUSTOMIZABLE INPUTS 2 – SHADING AND LOSSES

C:\Users\FTC-Jaya\Desktop\Rippe Solar - 7860 Str - DC Complete 062719.skp

jrajasekaran@ftcsolar.com

Customize

Choose Weather Source file (Name | Source | Distance (Km))

USA TX Dallas-fort Worth Intl Ap (TMY3) | TMY3 | 74

Select weather file format to import local file

TMY3

System Design

Shading And Losses

Module Values

Inverter Values

Use Albedo in weather file

No

Irradiation mode

Beam and diffuse

Monthly albedo

0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2

Monthly soiling losses[%]

1.0,1.0,6.0,4.0,6.1,0.6,0.4,0.6,0.8,0.8,0.5

Transposition Model

Perez

Mismatch loss [%]

0.5

Diodes and connection loss [%]

0

DC Wiring loss [%]

1.5

Tracking error loss [%]

0.5

DC Power optimizer loss [%]

0

AC wiring loss [%]

0.5

Step-up Transformer loss [%]

1.5

Constant loss [%]

1

Estimate loss from snow coverage

No

CUSTOMIZABLE INPUTS 3 - MODULE VALUES

C:\Users\FTC-Jaya\Desktop\Rippe Solar - 7860 Str - DC Complete 062719.skp

jrajasekaran@ftcsolar.com

Customize

Choose Weather Source file (Name | Source | Distance (Km))
USA TX Dallas-fort Worth Intl Ap (TMY3) | TMY3 | 74

Select weather file format to import local file
TMY3

System Design | Shading And Losses | **Module Values** | Inverter Values

Module Area [m2] 1.984	Temperature coefficient of Isc [A/°C] 0.0053476999999999995
Temperature coefficient of Voc [V/°C] -0.1488	Temperature coefficient of Pmp [%/°C] -0.37
Max power current [Imp] [A] 9.57	
Short circuit current [Isc] [A] 10.09	No of cells in series 72
Nominal operating cell temperature [°C] 43.6	Max power voltage [Vmp] [V] 40.2
Open circuit voltage [Voc] [V] 48	Cell type monoSi
Mounting standoff Ground or rack mounted	Array Height 1 story or less
Bifacial? No	

CUSTOMIZABLE INPUTS 4 – INVERTER VALUES

C:\Users\FTC-Jaya\Desktop\Rippey Solar - 7860 Str - DC Complete 062719.skp

Energy Analysis

Inputs Results

Customize

Choose Weather Source file (Name | Source | Distance (Km))

Select weather file format to import local file

USA TX Dallas-fort Worth Intl Ap (TMY3) | TMY3 | 74

TMY3

System Design Shading And Losses Module Values **Inverter Values**

Max AC Power [Wac]	Max DC Voltage [V]
3000000	1500
Weighted/Peak/Nominal Efficiency [Wdc]	AC Power consumption of night [Wac]
98.8	300
DC Power required to enable the inversion process [Wdc]	DC Input Voltage for Rated AC Power [Vdc]
0	1092
Min mppt voltage [Vdc]	Max Mppt voltage [Vdc]
956	1500

Simulate

REPORTS



SunDAT Production Report

Powered by NREL SAM

Site Details

Name	Rippey
Latitude	33.552701
Longitude	-97.176923
Timezone	-6
Solar North	0
Adjustment	0.478
Location	
Address	965 W Spring Creek Rd, Gainesville, TX 76240, USA
Client	Sterling & Wilson
Country	
Azimuth	180
Tilt	0

Simulation results:

Region Name	R_01
Performance Ratio	0.825%
Capacity Factor	20.258%
Yield	1774.644 kWh/kW
Production	153045264 kWh

Monthly Energy Data:

Month	GHI(kWh/m2)	POA(kWh/m2)	Shaded(kWh/m2)	NamePlate(kW)	Grid(kW)
January	71867	91798	91798	7549451	6772559
February	104255	142247	142247	11801171	10877811
March	134049	173801	173801	14019371	12713738
April	136517	169171	169171	13379958	11866544
May	205236	260492	260492	19734266	18122952
June	165312	204524	204524	15188120	14067438
July	210707	271225	271225	20365885	18770282
August	178391	235437	235437	17529888	16232504
September	137911	174763	174763	13330865	12320579
October	120027	158797	158797	12357664	11381743
November	105409	146826	146826	11674378	10749983
December	88066	123124	123124	10043297	9169133

Simulation parameters

Module	
Name	Canadian Solar CS3U-3850M
Manufacturer	Canadian Solar
Nominal power	385 W
Sub array	
In series	
In parallel	8000
Number of modules	224000
Total Power	86240
Inverter	

Export 8760 values

Select All	<input type="checkbox"/>
Global Horizontal Irradiance	<input checked="" type="checkbox"/>
Beam irradiance	<input checked="" type="checkbox"/>
Diffuse Irradiance	<input checked="" type="checkbox"/>
Wind Speed	<input type="checkbox"/>
Ambient Temperature	<input checked="" type="checkbox"/>
Solar Zenith Angle	<input type="checkbox"/>
Solar Altitude Angle	<input type="checkbox"/>
Solar Azimuth Angle	<input type="checkbox"/>
Sun Up Over Horizon	<input type="checkbox"/>
Absolute Air Mass	<input type="checkbox"/>
Albedo	<input type="checkbox"/>
Subarray 1 Angle of incidence	<input checked="" type="checkbox"/>
Subarray 1 Surface tilt	<input checked="" type="checkbox"/>
Subarray 1 Surface azimuth	<input type="checkbox"/>
Subarray 1 Axis rotation for 1 axis trackers	<input type="checkbox"/>
Subarray 1 Ideal axis rotation for 1 axis trackers	<input type="checkbox"/>
Subarray 1 POA total irradiance (nominal)	<input type="checkbox"/>
Subarray 1 POA total irradiance after shading only	<input type="checkbox"/>
Subarray 1 POA total irradiance after shading and soiling	<input type="checkbox"/>
Subarray 1 POA beam irradiance after shading and soiling	<input type="checkbox"/>
Subarray 1 POA diffuse irradiance after shading and soiling	<input type="checkbox"/>
Subarray 1 Beam irradiance shading factor	<input type="checkbox"/>



QUESTIONS ?



FTCSOLAR 