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SHADOW ANALYSIS FOR SOLAR PV PLANT USING GOOGLE SKETCHUP

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ABSTRACT

Solar Photovoltaic (PV) system is environmentally-friendly which could reduce the consumption of electricity from the non-renewable energy sources. However, the generation of the PV system is highly dependent on weather conditions. More specifically, the shading of PV modules is a common phenomenon which can affect the performance of the PV system. Hence, this paper aims to establish relationship between the distance of a PV plant from a building object and its associated height. To achieve this, the google SketchUp software is used to simulate the shading conditions and estimate the PV system's output. For validity, the data of PV energy, total irradiation, Peak Sun Hour and performance ratio obtained from the simulation were compared with the google SketchUp software. The findings from this research suggest the relative distance of a PV plant should be located in relationship to its nearest building object. It is expected that such findings will provide a good rule-of-thumb for the solar PV system designer in selecting the viable project site.

Keywords :PV system, Shading, Sketchup.

I. INTRODUCTION

India is the world's third largest producer and third largest consumer of electricity. The national electric grid in India has an installed capacity of 382.15 GW as of 31 March 2021. Renewable power plants, which also include large hydroelectric plants, constitute 36.8% of India's total installed capacity. During the fiscal year (FY) 2019-20, the gross electricity generated by utilities in India was 1,383.5 TWh and the total electricity generation (utilities and non-utilities) in the country was 1,598 TWh. The gross electricity consumption in FY2019 was 1,208 kWh per capita. In FY2015, electric energy consumption in agriculture was recorded as being the highest (17.89%) worldwide. The per capita electricity consumption is low compared to most other countries despite India having a low electricity tariff.

II. METHODOLOGY

The three types tools used for designing a model:

a) Large Tool Set bar

b) Views Toolbar

c) Shadows Toolbar

- **LARGE TOOL SET BAR**

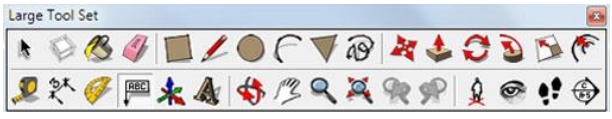

Figure 1: Large Toolset bar.

The "Large Toolset" actually consists of 6 different toolbars.

→ Main Toolbar

→ Drawing Toolbar

→ Modification Toolbar

→ Construction Toolbar

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→ Camara Toolbar

→ Guiding Toolbar

- **VIEWS TOOLBAR**

SketchUp provides several pre-set views, with which we can view the object.

Figure2: Views Toolbar

- **SHADOWS TOOLBAR**

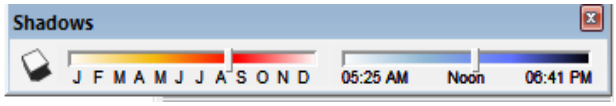

Figure3: Shadow Toolbar

With SketchUp's Shadows feature, you can make your model cast a basic shadow or see how the sun casts shadows on or around a geolocated model.

III. MODELING AND ANALYSIS

Analysis calculations with azimuth (butterfly pattern)

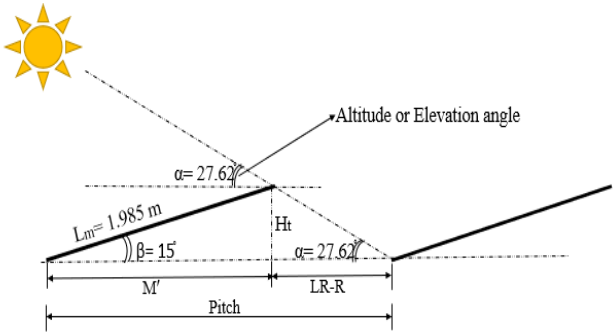

Figure 4: Shading Analysis with Azimuth

Note: Altitude or elevation angle = Height of sun

Azimuth angle = Position of sun

- **Height:**

Sinβ = Ht/Lm

Ht = Sinβ*Lm➔Sin(15°)*1.985 ➔ 0.513755 M

Ht = 0.513755 M

Cosβ = M'/Lm

M' = Cosβ* Lm➔Cos(15°)*1.985 ➔ 1.917362 M

M' = 1.917362 M

- **Module Row Spacing:**

Tanα = Ht/LR-R

LR-R = Ht/Tanα ➔ 0.513755/Tan(27.62) ➔ 0.981887 M

LR-R = 0.981887 M

- **Minimum Module Row**

LR-R(MIN) = LR-R*Cos(φ)

= 0.981887 * Cos(-50.59) ➔ 0.623366 M

LR-R(MIN) = 0.623366 M

Pitch = M' + LR-R(MIN)

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= (1.917362 + 0.623366) M ➔ 2.540728 M

Pitch = 2.540728 M

Obstacle shadow = h/Tan(α

= 4.0/tan(27.62) ➔ 7.644793 M

Obstacle shadow = 7.644793 M

IV. RESULTS AND DISCUSSION

CONDITION-1

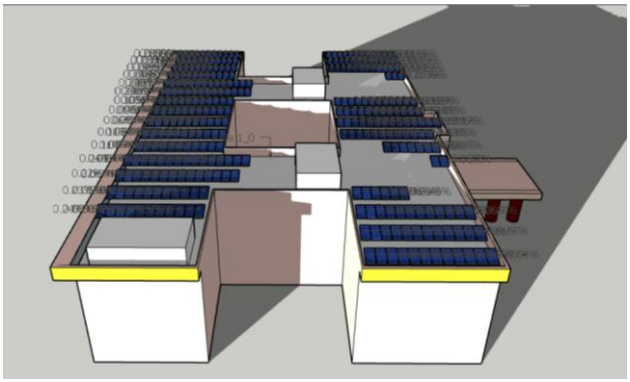
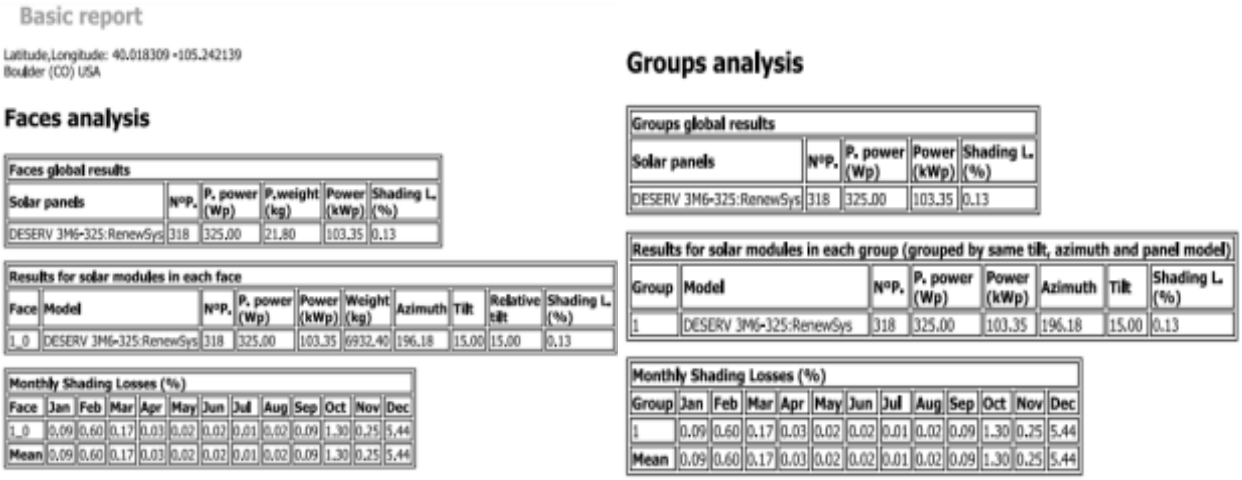


Figure 5: Building layout with solar panels.



Basic report

Latitude,Longitude: 40.018309,-105.242139
Boulder (CO) USA

Faces analysis

Faces global results						
Solar panels	N°P.	P. power (Wp)	P.weight (kg)	Power (kWp)	Shading L. (%)	
DESERV 3M6-325:RenewSys	318	325.00	21.80	103.35	0.13	

Results for solar modules in each face									
Face	Model	N°P.	P. power (Wp)	Power (kWp)	Weight (kg)	Azimuth	Tilt	Relative tilt	Shading L. (%)
1_0	DESERV 3M6-325:RenewSys	318	325.00	103.35	6932.40	196.18	15.00	15.00	0.13

Monthly Shading Losses (%)												
Face	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1_0	0.09	0.60	0.17	0.03	0.02	0.02	0.01	0.02	0.09	1.30	0.25	5.44
Mean	0.09	0.60	0.17	0.03	0.02	0.02	0.01	0.02	0.09	1.30	0.25	5.44

Figure 6: Face analysis of Condition-1

Groups analysis

Groups global results				
Solar panels	N°P.	P. power (Wp)	Power (kWp)	Shading L. (%)
DESERV 3M6-325:RenewSys	318	325.00	103.35	0.13

Results for solar modules in each group (grouped by same tilt, azimuth and panel model)							
Group	Model	N°P.	P. power (Wp)	Power (kWp)	Azimuth	Tilt	Shading L. (%)
1	DESERV 3M6-325:RenewSys	318	325.00	103.35	196.18	15.00	0.13

Monthly Shading Losses (%)												
Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.09	0.60	0.17	0.03	0.02	0.02	0.01	0.02	0.09	1.30	0.25	5.44
Mean	0.09	0.60	0.17	0.03	0.02	0.02	0.01	0.02	0.09	1.30	0.25	5.44

Figure 7: Group analysis of Condition-1

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CONDITION-2

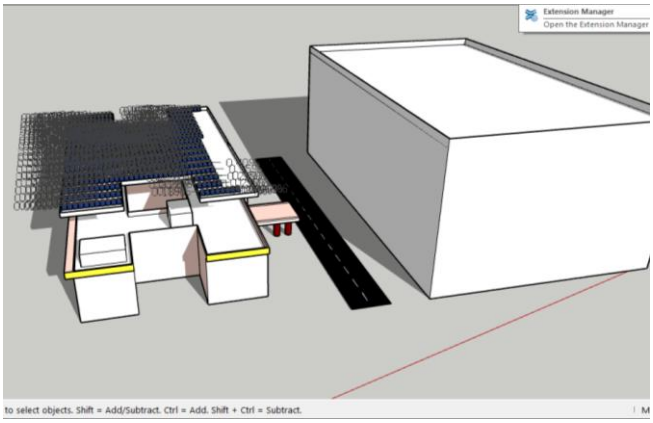

Figure 8: Layout of building (with one side building)

Basic report

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Boulder (CO) USA

Faces analysis

Faces global results

Solar panels	N°P.	P. power (Wp)	P.weight (kg)	Power (kWp)	Shading L. (%)
TATA:TS250 MBZ	419	250.00	19.10	104.75	0.21

Results for solar modules in each face

Face	Model	N°P.	P. power (Wp)	Power (kWp)	Weight (kg)	Azimuth	Tilt	Relative tilt	Shading L. (%)
2	TATA:TS250 MBZ	419	250.00	104.75	8002.90	195.79	15.00	15.00	0.21

Monthly Shading Losses (%)

Face	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	0.45	0.86	0.34	0.05	0.08	0.00	0.06	0.02	0.29	1.22	1.16	7.26
Mean	0.45	0.86	0.34	0.05	0.08	0.00	0.06	0.02	0.29	1.22	1.16	7.26

Figure 9: Face analysis of Condition-2

Groups analysis

Groups global results

Solar panels	N°P.	P. power (Wp)	Power (kWp)	Shading L. (%)
TATA:TS250 MBZ	419	250.00	104.75	0.21

Results for solar modules in each group (grouped by same tilt, azimuth and panel model)

Group	Model	N°P.	P. power (Wp)	Power (kWp)	Azimuth	Tilt	Shading L. (%)
1	TATA:TS250 MBZ	419	250.00	104.75	195.79	15.00	0.21

Monthly Shading Losses (%)

Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.45	0.86	0.34	0.05	0.08	0.00	0.06	0.02	0.29	1.22	1.16	7.26
Mean	0.45	0.86	0.34	0.05	0.08	0.00	0.06	0.02	0.29	1.22	1.16	7.26

Figure 10: Group analysis of Condition-2

CONDITION-3

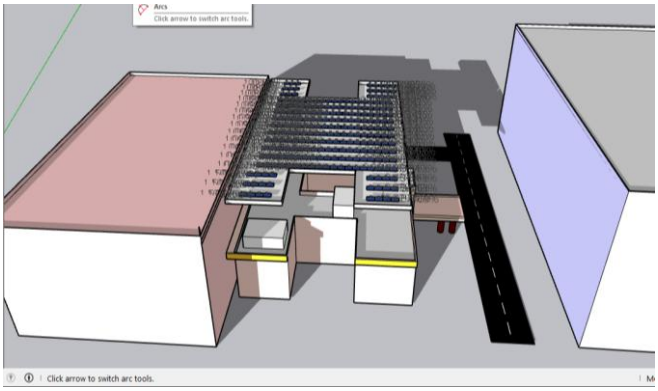

Figure 11: Layout of building (Between two buildings).

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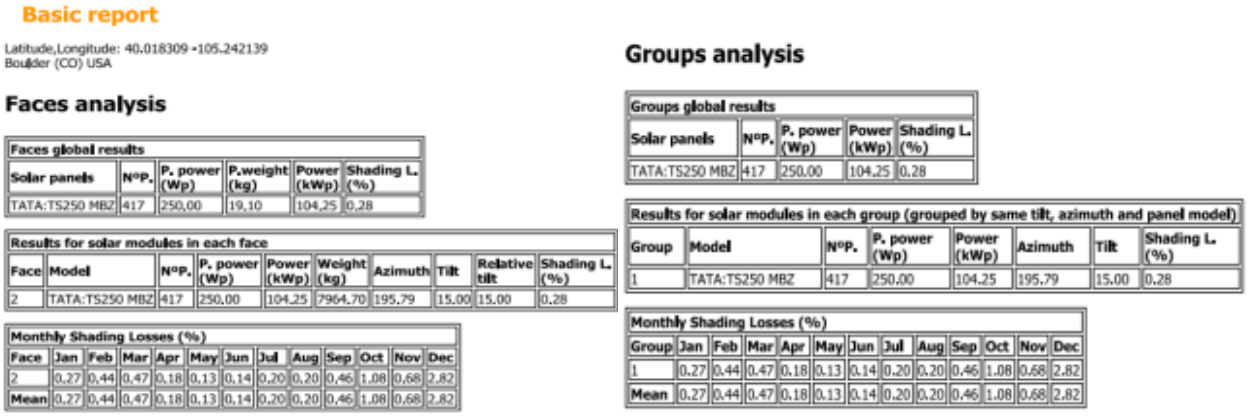

Basic report

Latitude,Longitude: 40.018309 -105.242139
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Faces analysis

Faces global results

Solar panels	N°P.	P. power (Wp)	P.weight (kg)	Power (kWp)	Shading L. (%)
TATA:TS250 MBZ	417	250,00	19,10	104,25	0,28

Results for solar modules in each face

Face	Model	N°P.	P. power (Wp)	Power (kWp)	Weight (kg)	Azimuth	Tilt	Relative tilt	Shading L. (%)
2	TATA:TS250 MBZ	417	250.00	104.25	7964.70	195.79	15.00	15.00	0.28

Monthly Shading Losses (%)

Face	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	0,27	0,44	0,47	0,18	0,13	0,14	0,20	0,20	0,46	1,08	0,68	2,82
Mean	0,27	0,44	0,47	0,18	0,13	0,14	0,20	0,20	0,46	1,08	0,68	2,82

Groups analysis

Groups global results

Solar panels	N°P.	P. power (Wp)	Power (kWp)	Shading L. (%)
TATA:TS250 MBZ	417	250.00	104.25	0.28

Results for solar modules in each group (grouped by same tilt, azimuth and panel model)

Group	Model	N°P.	P. power (Wp)	Power (kWp)	Azimuth	Tilt	Shading L. (%)
1	TATA:TS250 MBZ	417	250.00	104.25	195.79	15.00	0.28

Monthly Shading Losses (%)

Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.27	0.44	0.47	0.18	0.13	0.14	0.20	0.20	0.46	1.08	0.68	2.82
Mean	0.27	0.44	0.47	0.18	0.13	0.14	0.20	0.20	0.46	1.08	0.68	2.82

Figure 12: Face analysis of Condition-3

Figure 13: Group analysis of Condition-3

V. CONCLUSION

By completing this project, we have studied and analysed the factors that affect shadow such as latitude of the installing location, nearby buildings, the effect due to trees and passing of clouds etc. Shadows covering PV cells do indeed have an adverse impact on PV output voltage; however, the reduction varies depending on how manycells are included and on the cell'scombinations. The experimental results show that the largest decrease in output voltage of a polycrystalline PV occurs when parallel combinations of a PV cell are covered by shadows. At the same time, the smallest reduction occurred when the cells involved in series connection.

VI. REFERENCES

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