Optimum Tilt and Azimuth angle for Raipur, India

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Abstract

The solar energy is becoming popular to meet the energy requirement of the world. In this situation harnessing the maximum amount of solar energy is very importantto increase the solar plant efficiency. The daily optimal performance of solar plant is affected by the tilt angle and azimuth angle of solar collector. In this paper, the effect of tilt angle and azimuth angle is studied on a particular day and the optimum values of tilt and azimuth angles are found for a location at Raipur.

Keywords*:SPV (Solar Photovoltaic), PV (Photovoltaic), tilt angle, azimuth angle*

I.INTRODUCTION

The angle at which the sun rays incident on solar collector changes with time of the day and with day of the year. In order to harness maximum sunlight the solar collector orientation should also be changing, which is sometimes not preferred due to economical reasons. In this case the optimized value of solar collector tilt angle and azimuth angle are used to find the appropriate orientation of the fixed solar collector installed.

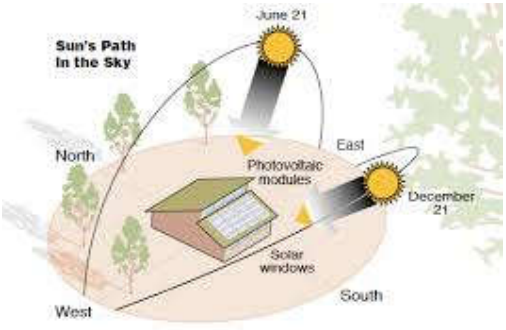

Fig. 1 Sun's path during summers and winters.

Tilt angle of the photovoltaic (PV) array is the key to yield an optimum energy output. Solar panels or PV arrays are most efficient, when they are perpendicular to the sun's rays [1] [2] [3]. In practice as a thumb rule for fixed solar collector installation, the tilt angle of the collector is kept equal to the latitude of the location. The seasonal adjustment of tilt angle increases the plant output further, in summer the tilt angle is equal to the location's latitude minus 15 degree and in winter it is mounted at latitude plus 15 degree. The tilt angle of PV panel is given in fig 2.

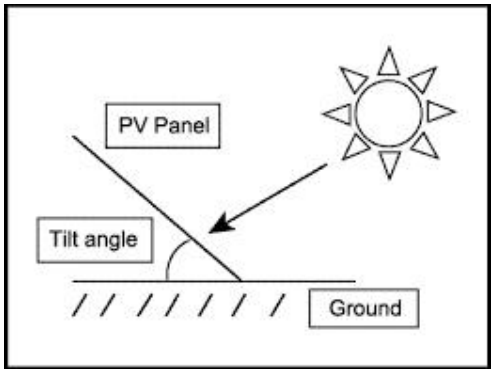

Fig. 2 Tilt angle of PV panel.

Solar azimuth angle is the azimuth angle of the sun; it defines the direction the sun is in [4] [5] [6].The most commonly accepted convention for analysing solar irradiation, e.g. for solar energy applications, is clockwise from due North, thusEast is 90°, South is 180° and West is 270° which is shown in fig 3.

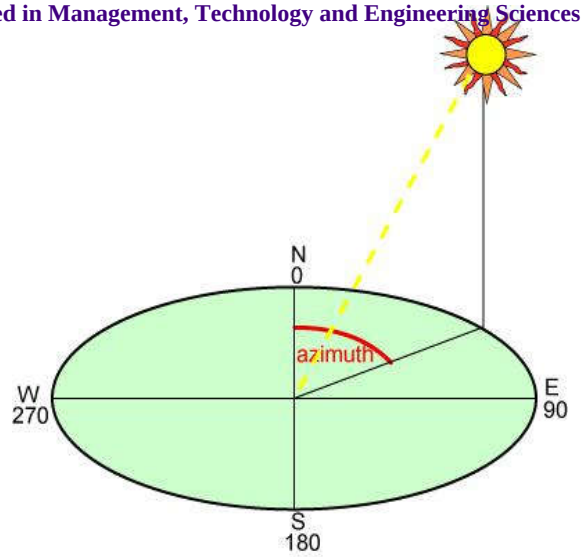

Fig. 3 Azimuth angle of solar panel/array.

The tilt angle and azimuth angle are month as well as location dependent, i.e., every location will have different tilt and azimuth angles for different months of a year.

II. HELIOSCOPE SOFTWARE

Helioscope is the web application designed by Folsom Labs, California in United States. Helioscope does what both PVSyst and AutoCAD do together [8].The following are the steps to create a new project on Helioscope:

1) Create Project
2) Create Design
   i. Create Design (Mechanical)
   ii. Create Design (Electrical)
3) Create Condition Set
4) Run Simulation and View Report

IV.ANALYSIS AND RESULTS

The location used for the analysis is Bhilai Institute of Technology, Raipur. To create project in Helioscope, the project name and address of the location is provided. The software automatically takes up the longitude and latitude of the location. The latitude of Raipur is 21.2514°, and longitude is 81.6296° .The inputs provided to create mechanical and electrical design is given in Table

Mechanical Design	Electrical Design
PV module of 250Wp,	PVS300-8000 ABB Inverter,
Azimuth angle = 180	Combiner poles = 12,
Tilt angle = 8 degrees	String length = 11-21
Horizontal (landscape) orientation,	Stringing along racking.
Fixed tilt racking,	
Row spacing = 3 feet,	
Module spacing = 0.032 feet,	
Setback = 4 feet,	

After creating the mechanical and electrical designs the weather condition set is provided and then the design is simulated.

Study of effect of change in tilt angle on solar PV output

The tilt angle is varied in mechanical design from 8 degrees to 38 degrees in steps of 2 degrees and the monthly and annual AC energy production is noted down as shown in table1.

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Table 1
Monthly and Annual AC Energy Production Report for Various Tilt Angles

Tilt	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°
Jan (kWh)	3553.8	3628.6	3705.7	3814.7	3886.0	3952.1	4024.3	4152.2	4204.6	4342.8	4300.6	4442.2	4514.0	4538.9	4667.0	4719.8
Feb (kWh)	3380.6	3425.3	3472.7	3551.1	3593.5	3631.3	3675.1	3768.4	3793.5	3874.7	3858.3	3943.1	3983.9	3985.7	4079.6	4205.4
March (kWh)	4551.1	4569.0	4592.7	4655.5	4673.2	4685.6	4706.7	4806.7	4802.9	4832.6	4847.4	4883.3	4898.1	4864.3	4940.9	4933.7
April (kWh)	4573.4	4554.8	4544.3	4574.9	4559.3	4538.2	4526.2	4577.2	4538.4	4494.6	4544.3	4505.8	4481.7	4413.5	4445.0	4399.7
May (kWh)	4914.8	4862.5	4817.4	4815.8	4768.9	4716.4	4672.5	4698.2	4625.7	4513.3	4597.7	4489.3	4429.8	4325.2	4316.6	4232.8
June (kWh)	3911.6	3865.4	3823.1	3814.8	3767.1	3716.5	3671.8	3673.7	3609.7	3508.2	3580.3	3481.3	3429.9	3342.6	3330.8	3259.3
July (kWh)	3411.6	3383.1	3356.4	3357.4	3324.8	3288.2	3254.6	3265.9	3218.7	3147.0	3201.4	3133.6	3099.8	3033.9	3037.8	2988.6
Aug (kWh)	3102.5	3088.3	3075.2	3086.1	3067.9	3046.3	3027.3	3049.7	3017.4	2973.0	3012.6	2972.5	2954.1	2904.4	2921.7	2888.0
Sept (kWh)	3120.5	3123.2	3127.6	3158.8	3158.1	3153.6	3152.5	3192.7	3176.6	3167.3	3190.8	3185.4	3181.8	3146.0	3183.1	3165.5
Oct (kWh)	3540.1	3571.8	3606.1	3671.8	3700.6	3724.6	3754.2	3834.7	3845.4	3895.4	3893.5	3949.1	3976.3	3963.3	4041.4	4051.9
Nov (kWh)	2778.3	2823.5	2869.7	2939.5	2980.8	3017.7	3057.5	3139.8	3165.6	3239.8	3221.8	3301.0	3340.1	3345.5	3428.7	3453.8
Dec (kWh)	2905.2	2967.9	3031.5	3120.7	3179.1	3232.1	3288.1	3389.4	3430.6	3537.7	3505.0	3617.7	3673.8	3693.1	3799.0	3838.8
Annual Production (MWh)		**43.86**	**44.02**	**44.56**	**44.66**	**44.70**	**44.81**	**45.55**	**45.43**	**45.53**	**45.75**	**45.90**	**45.96**	**45.56**	**46.19**	**46.04**

Study of effect of change in azimuth angle on solar PV output

The tilt angle of the solar collector is fixed to 36 degree as this gives the highest annual AC energy production. The azimuth angle is now changed from 120 degree to 260 degree in steps of 20 degree in mechanical design. After providing the weather condition set for the location Raipur the design is simulated. The variation of AC energy produced is shown in table2.

Table 2
AC Energy Generated at Various Azimuth Angles Monthly and Annual

Azimuth Angle	120°	140°	160°	180°	200°	220°	240°	260°
Jan (kWh)	3376.2	3926.1	4136.5	4638.9	4552.8	4362.0	4089.0	3428.6
Feb (kWh)	3088.4	3487.9	3611.2	4053.5	4064.9	3977.0	3843.4	3365.7
March (kWh)	3971.1	4349.2	4400.0	4909.7	4969.7	4984.6	4976.0	4521.4
April (kWh)	3896.6	4095.1	4018.7	4416.7	4508.0	4603.9	4754.3	4531.4
May (kWh)	3988.6	4062.3	3921.4	4289.3	4433.2	4716.4	5035.5	4969.8
June (kWh)	3200.0	3214.0	3058.3	3310.8	3409.2	3655.3	3969.2	3999.5
July (kWh)	2876.8	2919.3	2792.9	3020.4	3077.2	3241.7	3465.4	3444.8
Aug (kWh)	2708.2	2784.6	2685.5	2905.8	2948.9	3046.9	3187.9	3096.1
Sept (kWh)	2801.2	2954.5	2899.8	3164.8	3195.9	3244.2	3303.4	3103.1
Oct (kWh)	3222.2	3548.6	3605.5	4016.4	4013.2	3956.9	3882.5	3481.4
Nov (kWh)	2602.6	2945.0	3046.3	3408.4	3377.4	3290.1	3152.3	2731.8
Dec (kWh)	2791.6	3231.6	3387.6	3774.9	3711.7	3560.1	3334.5	2803.7
Annual Energy Production (MWh)	**38.52**	**41.52**	**41.56**	**45.91**	**46.26**	**46.64**	**46.99**	**43.48**

VI.CONCLUSION

Comparing the annual AC energy production for each tilt angle in table1 the optimum value of tilt is found to be 34 degree for the location at Raipur. The optimum value of azimuth angle for this location, found from Table2 is 240 degree from North as this gives the maximum AC energy production.

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