

GUJARAT CHARANKA SOLAR PARK

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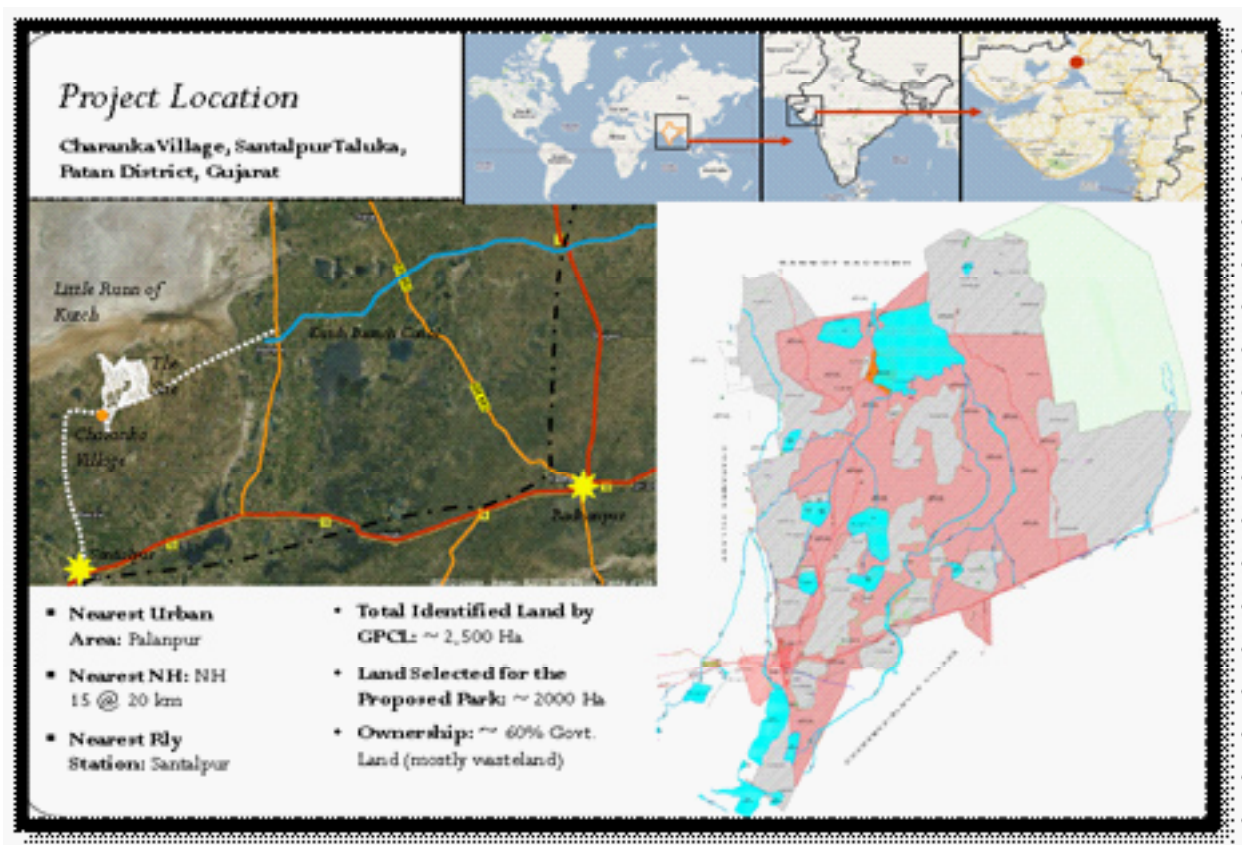
1.Introduction:

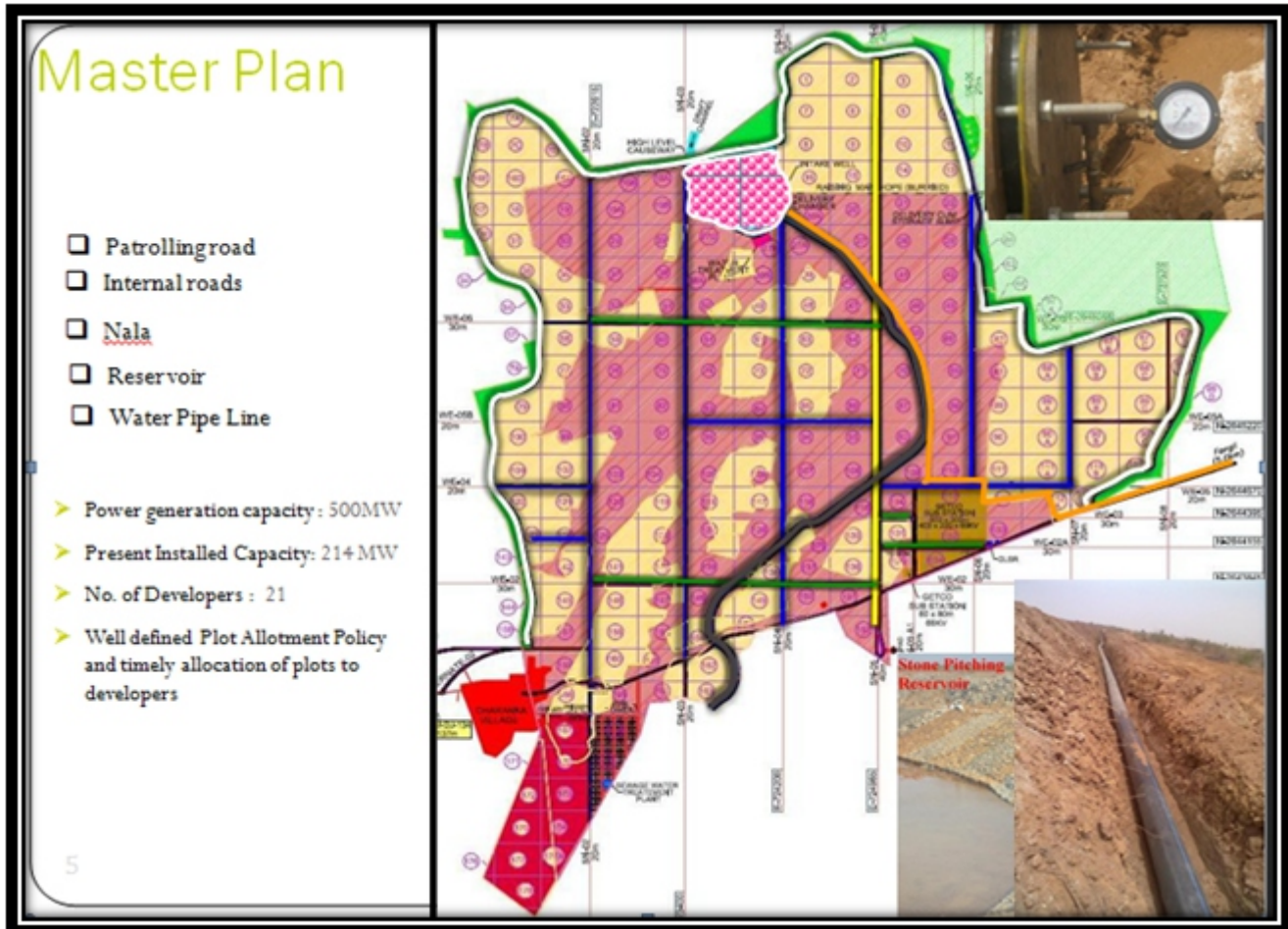
Gujarat Solar Park is the world's first multi developer, multi facility, multi technology and multi beneficiary solar park located in 2,000-hectare (4,900-acre) plot of land near Charanka village in Patan district, northern Gujarat. This is the Asia's largest solar park hub. This project is Honorable Prime Minister Mr. Narendra Modi pet project and because of his initiative in Gujarat the Solar has taken birth in India. The Gujarat Solar Park hosts about 17 different projects by different developers. As on April 2014, a total of 221 megawatts had been commissioned. It also became the world's second largest photovoltaic power station. When fully built out, the Charanka Solar Park will host 500 MW of solar power systems using state-of-the-art thin film and crystalline technology. The investment cost for the Charanka solar park amounts to US\$280 million, the construction began on December 3, 2010. The solar park is expected to save around 8 million tonnes of carbon dioxide from being released into the atmosphere and save around 900,000 tonnes of natural gas per year. The Gujarat government has signed Power purchase agreement

(PPA) with developers for Rs15 (about USD 0.29) per kWh for the first 12 years and Rs 5 (about USD 0.10) per kWh from the 13th to 25th year. The national solar policy has fixed tariffs of Rs17 for photovoltaic and Rs15 for solar thermal for 25 years.

2.Key Features of the solar park:

- First of its kind in the world
- Fastest Implementation
- Multi Developer, Multi Facility, Multi Technology and
- Multi Beneficiary Solar Park
- Integrated hub of Solar power generation
- Unique Integration of Environment benefit, Infrastructure development and Social up gradation
- Benchmark project for other states.
- Hybridization of Wind and Solar
- Up gradation in the standard of living in the rural area
- Utilization of waste lands
- Local employment





3. Infrastructure provided in the solar park:

- Roads
- Raw Water Pipe line
- Rehabilitation of existing reservoir
- Water Treatment Plant
- Water Distribution Network
- Water Tank(GLSR/OHT)
- Sewage Treatment Plant
- 400/220/66KV & 66KV Auxiliary SS
- Auxiliary Power Distribution Network
- Telecom Network
- Fencing (Boundary)
- Compound wall
- Entrance
- Security Towers
- Training Institute
- Common facilities
- Helipad
- Greenbelt / buffer
- Water to meet the irrigation demand
- Landscaping
- Internal (plot) fencing
- Land levelling/Grading
- Fire Station

4. Benefits of Charanka Solar Park:

4.1 Tangible Benefits:

- Basic infrastructure development benefits shared with local villages
- Communication network
- Provision of Irrigation water
- Developer investment of Rs.3600Cr
- Employment generation of about 1500 labours
- Economic upliftment of rural area
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4.2 Intangible Benefits:

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- Increase in Water conservation
- Increase in Vegetation cover
- Reduction in desertification process
- Carbon Emission reduction
- Increase in aesthetic value of area
- Social upliftment

5. List of Project developers in Charanka Solar Park:

S.No	Name of the Party	Capacity (MW)	Module Type	Module Make	Inverter Type	Inverter Make	Tilt
1	GMR Gujarat solar power pvt.ltd	25	Crystalline Si	Canadian Solar	Central Inverter	SMA	Fixed Tilt
2	Sun Clean Renewable pvt.ltd	6	Thin Film	Sharp	Central Inverter	Power - One	Fixed Tilt
3	Emami Cement Ltd	10	Crystalline Si	TATA BP	Central Inverter	ABB	Seasonal Tilt
4	Solarfield Energy Pvt. Ltd.	20	Thin Film	Sharp	Central Inverter	Sharp	Fixed Tilt
5	SEI Solar Power Gujarat pvt.ltd	25	Crystalline Si	Chint/Trina	Central Inverter	Power One	Fixed Tilt
6	GSPC Pipavav Power Company Ltd.	5	Crystalline Si	Suntech	Central Inverter	Bonfiglioli	Fixed Tilt
7	AES Solar Energy Gujarat pvt. Ltd	15	Thin Film	FirstSolar	Central Inverter	Power One	Fixed Tilt
8	Alex Astral Power pvt.ltd	25	Thin Film	FirstSolar	Central Inverter	SMA	Fixed Tilt
9	NKG Infrastructure Ltd	10	Crystalline Si	Solarworld	String Inverter	Delta (String)	Fixed Tilt
10	Palace Solar Energy pvt.ltd	15	Crystalline Si	Canadian Solar	Central Inverter	Power One	Seasonal Tilt
11	Roha Dyechem pvt.ltd	25	Thin Film	Nexpower	Central Inverter	Satcon	Seasonal Tilt
12	Lanco Infratech Ltd.	15	Crystalline Si	C-Sun	Central Inverter	Bonfiglioli	Fixed Tilt
13	Surana Telecom & Power Ltd.	5	Crystalline Si	Surana	Central Inverter	AEG	Fixed Tilt
14	GPCL	5	Crystalline Si	C-Sun	Central Inverter	Bonfiglioli	Seasonal Tilt
15	ZF Steering Gear (India) pvt.ltd	5	Thin Film	Not Available	Central Inverter	Not Available	Seasonal Tilt
16	Yantra eSolar India Pvt.ltd	5	Crystalline Si	Not Available	Central Inverter	Not Available	Fixed Tilt
17	Avatar Solar Pvt. Ltd	5	Crystalline Si	Not Available	Central Inverter	Not Available	Fixed Tilt

Source: Primary Data (Visit to Charanka Solar Park)

6.Charanka Solar Park Generation for the year 2012:

Charanka Solar Park Generation for the Year 2012														
S.No	Name of the Party	Capacity (MW)	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Total	PLF %
1	GMR Gujarat solar power pvt.ltd	25	2318	3584	4066	3396	2557	2290	2901	3806	3415	3481	31813	17%
2	Sun Clean Renewable pvt.ltd	6	695	966	1029	856	638	605	777	970	840	852	8229	19%
3	Emami Cement Ltd	10	1313	1437	1611	1397	1036	944	1189	1528	1344	1357	13157	18%
4	Solarfield Energy Pvt. Ltd.	20	2467	3281	3360	2891	2026	1833	2479	3224	2770	2833	27164	19%
5	SEI Solar Power Gujarat pvt.ltd	25	2342	3849	4001	3414	2548	2392	3070	4027	3603	3601	32847	18%
6	GSPC Pipavav Power Company Ltd.	5	680	694	833	722	506	440	601	782	724	792	6774	19%
7	AES Solar Energy Gujarat pvt. Ltd	15	625	1267	2265	1925	939	694	955	2152	2067	2017	14907	14%
8	Alex Astral Power pvt.ltd	25	2745	3863	4434	3794	2654	2337	3147	4001	3363	3355	33693	18%
9	NKG Infrastructure Ltd	10	1322	1577	1662	1418	1056	992	1245	1615	1450	1465	13803	19%
10	Palace Solar Energy pvt.ltd	15	1800	2467	2525	2210	1617	1380	1776	2300	2239	2334	20649	19%
11	Roha Dyechem pvt.ltd	25	3001	3900	4324	3672	2749	2512	3057	3895	3541	3634	34285	19%
12	Lanco Infratech Ltd.	15	124	857	1265	1589	1020	1182	1608	2138	1974	2057	13814	13%
13	Surana Telecom & Power Ltd.	5	703	735	791	685	485	445	565	742	649	636	6437	18%
14	GPCL	5	264	668	761	642	430	434	568	756	677	708	5908	16%
15	ZF Steering Gear (India) pvt.ltd	5	582		849	717	540	503	640	779	695	714	6018	16%
16	Yantra eSolar India Pvt.ltd	5									579	509	1088	15%
17	Avatar Solar Pvt. Ltd	5												
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Source: Gujarat State Load Dispatch Centre (SLDC)

7.Charanka Solar Park generation for the year 2013:

Charanka Solar Park Generation for the year 2013																
S.No	Name of the Party	Capacity (MW)	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Total	PLF %
1	GMR Gujarat solar power pvt.ltd	25	3700	3559	4229	4075	4214	3168	2443	2798	3317	3838	3445	3640	42426	19%
2	Sun Clean Renewable pvt.ltd	6	885	868	1055	1023	1063	772	590	690	817	902	807	862	10332	20%
3	Emami Cement Ltd	10	1455	1438	1574	1608	1707	1243	989	1117	1246	1466	1382	1420	16644	19%
4	Solarfield Energy Pvt. Ltd.	20	2897	2857	3498	3366	3491	2551	1934	2232	2660	2624	2719	2832	33661	19%
5	SEI Solar Power Gujarat pvt.ltd	25	3799	3715	4397	4090	4162	3079	2345	2764	3244	3812	3568	3793	42768	20%
6	GSPC Pipavav Power Company Ltd.	5	826	764	886	806	872	649	453	569	662	775	741	828	8831	20%
7	AES Solar Energy Gujarat pvt. Ltd	15	2082	2067	2466	2360	2416	1845	1419	1594	1934	2225	1998	2092	24497	19%
8	Alex Astral Power pvt.ltd	25	3808	3491	4284	4330	4490	3324	2515	2895	3365	3839	3384	3599	43324	20%
9	NKG Infrastructure Ltd	10	1556	1494	1780	1704	1748	1298	988	1150	1354	1530	1433	1525	17562	20%
10	Palace Solar Energy pvt.ltd	15	2463	2273	2589	2446	2657	1998	1537	1753	1891	2070	2230	2442	26350	20%
11	Roha Dyechem pvt.ltd	25	3764	3605	4246	4205	4555	3502	2627	2932	3067	3784	3500	3734	43521	20%
12	Lanco Infratech Ltd.	15	2141	2077	2524	2331	2372	1746	1296	1441	1695	1902	1655	1741	22921	17%
13	Surana Telecom & Power Ltd.	5	690	683	808	779	804	578	422	501	587	651	640	652	7797	18%
14	GPCL	5	749	714	841	782	789	579	425	505	606	567	608	688	7853	18%
15	ZF Steering Gear (India) pvt.ltd	5	752	730	899	850	883	653	499	575	688	786	702	694	8711	20%
16	Yantra eSolar India Pvt.ltd	5	613	591	749	741	826	585	433	518	604	667	453	595	7374	17%
17	Avatar Solar Pvt. Ltd	5	-	-	-	541	695	565	449	511	619	699	632	634	5344	12%
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Source: Gujarat State Load Dispatch Centre (SLDC)

8. Charanka Solar park generation for the year 2014:

Charanka Solar Park Generation for the year 2014								
S.No	Name of the Party	Capacity (MW)	Jan-14	Feb-14	Mar-14	Apr-14	Total	PLF %
1	GMR Gujarat solar power pvt.ltd	25	3746	3559	4318	4121	15744	22%
2	Sun Clean Renewable pvt.ltd	6	852	826	1045	1028	3751	21%
3	Emami Cement Ltd	10	1452	1398	1674	1589	6113	21%
4	Solarfield Energy Pvt. Ltd.	20	2764	2678	3409	3296	12147	21%
5	SEI Solar Power Gujarat pvt.ltd	25	3808	3589	4264	4019	15679	21%
6	GSPC Pipavav Power Company Ltd.	5	818	742	872	830	3263	22%
7	AES Solar Energy Gujarat pvt. Ltd	15	2059	1979	2428	2326	8793	20%
8	Alex Astral Power pvt.ltd	25	3607	3464	4322	4233	15625	21%
9	NKG Infrastructure Ltd	10	1538	1459	1738	1712	6447	22%
10	Palace Solar Energy pvt.ltd	15	2390	2175	2545	2369	9480	22%
11	Roha Dyechem pvt.ltd	25	3604	3427	4171	4142	15345	21%
12	Lanco Infratech Ltd.	15	1823	1725	1992	1888	7427	17%
13	Surana Telecom & Power Ltd.	5	667	650	803	770	2890	20%
14	GPCL	5	701	677	831	774	2984	20%
15	ZF Steering Gear (India) pvt.ltd	5	736	637	883	852	3109	21%
16	Yantra eSolar India Pvt.ltd	5	487	596	734	728	2545	17%
17	Avatar Solar Pvt. Ltd	5	649	667	822	765	2903	20%
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Source: Gujarat State Load Dispatch Centre (SLDC)

9. Ranking of various projects at Charanka Solar Park:

Average PLF(%) from March-12 to Apr-14			
S.No	Name of the Party	Average PLF (%)	Ranking
1	GMR Gujarat solar power pvt.ltd	19.42%	9
2	Sun Clean Renewable pvt.ltd	19.92%	4
3	Emami Cement ltd	19.28%	10
4	Solarfield Energy Pvt. Ltd.	19.50%	8
5	SEI Solar Power Gujarat pvt.ltd	19.63%	7
6	GSPC Pipavav Power Company ltd.	20.32%	1
7	AES Solar Energy Gujarat pvt. Ltd	17.4%	14
8	Alex Astral Power pvt.ltd	19.85%	6
9	NKG Infrastructure ltd	20.31%	2
10	Palace Solar Energy pvt.ltd	20.1%	3
11	Roha Dyechem pvt.ltd	19.86%	5
12	Lanco Infratech ltd.	15.6%	17
13	Surana Telecom & Power ltd.	18.38%	12
14	GPCL	18.15%	13
15	ZF Steering Gear (India) pvt.ltd	19.19%	11
16	Yantra eSolar India Pvt.ltd	16.4%	15
17	Avatar Solar Pvt. Ltd	16.0%	16

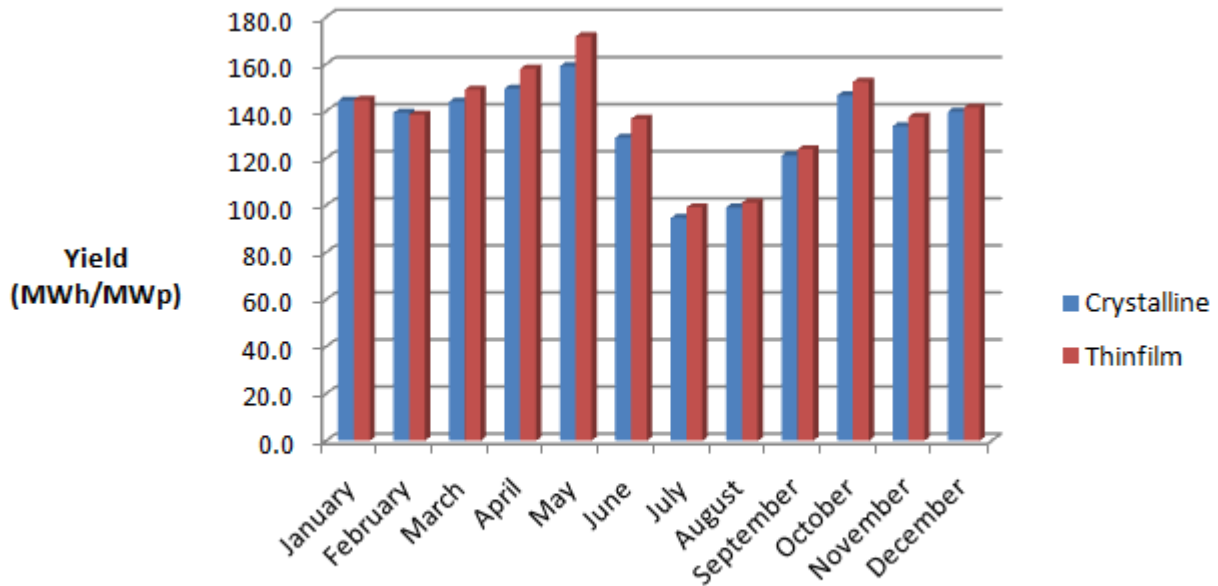
Inference:

- The ranking of the plants considered with the generation data available from March-2012 to April-2014.
- Plant load factor(PLF)= (Actual Generation)/(Capacity of the Project X 365 days X 24 Hrs)
- The energy yield of the plant will depend on the several factors like type of modules, inverters, usage of tracking system, design optimization and build quality.

- The ranking of the plants is based on only the energy yield but did not considered any factors above.
- The first ranking goes to GSPC Pipavav Power Company ltd with a PLF of 20.32%. Lanco Infra was the EPC contractor. Crystalline modules (Make- Suntech), Central inverter(Make- Bonfiglioli) and fixed tilt were used.

10. CRYSTALLINE V/S THINFILM TECHNOLOGY

Technology	January	February	March	April	May	June	July	August	September	October	November	December
Crystalline	144.5	139.3	144.1	149.5	159.1	128.7	94.6	99.1	121.2	146.7	133.6	139.8
Thinfilmm	144.8	138.5	149.2	158.0	171.8	136.7	99.1	101.2	123.9	152.5	137.6	141.4



Inferences:

- Out of 17 projects in the solar park 11 projects have used Crystalline technology and 6 project have used thin film technology.
- While analysing the results, it can be seen that the Thin film modules perform better than the Crystalline modules with an average performance advantage of about 0.77%
- Thin film modules have higher generation than plants using crystalline modules in hotter months

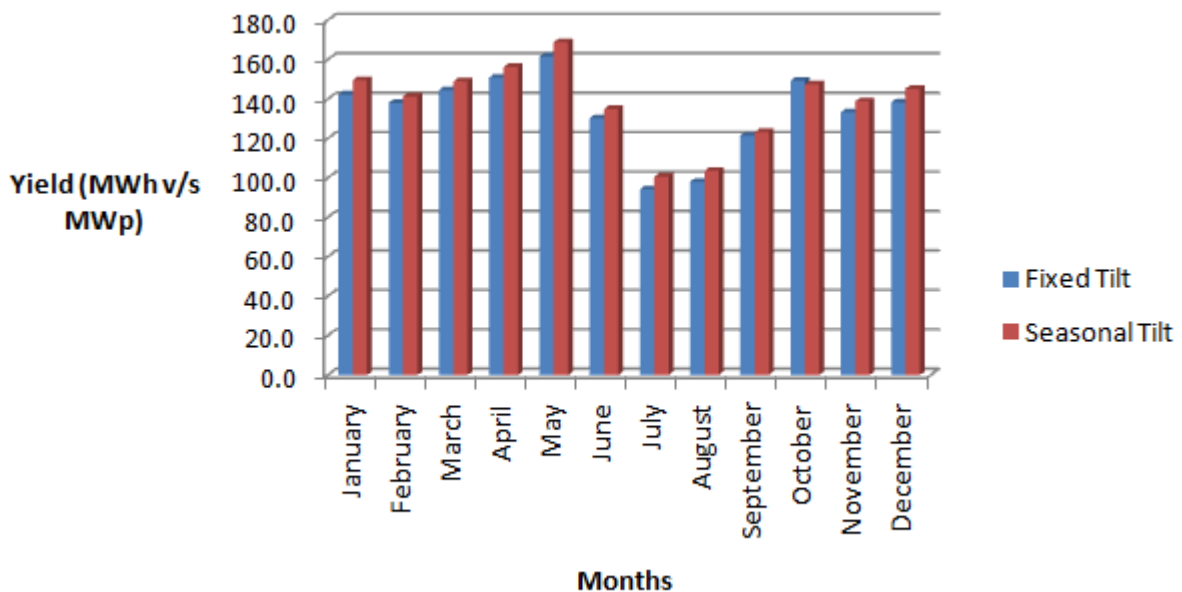
Months

while crystalline modules are with par with thin film in colder months which can be attributed to the lower temperature de-rating coefficient of thin film modules compared to crystalline modules.

- Thin film usually generates more during the initial years and they degrade more within 5-7 years.
- Thin film performs better with diffused radiation.

11. MODULE MOUNTING STRUCTURE: FIXED V/S SEASONAL TILT

Module Mounting Structure	January	February	March	April	May	June	July	August	September	October	November	December
Fixed Tilt	142.4	138.0	144.6	150.9	161.6	130.3	94.2	98.0	121.4	149.4	133.4	138.3
Seasonal Tilt	149.6	141.3	149.0	156.3	168.9	135.0	100.7	103.6	123.3	147.5	138.9	145.2

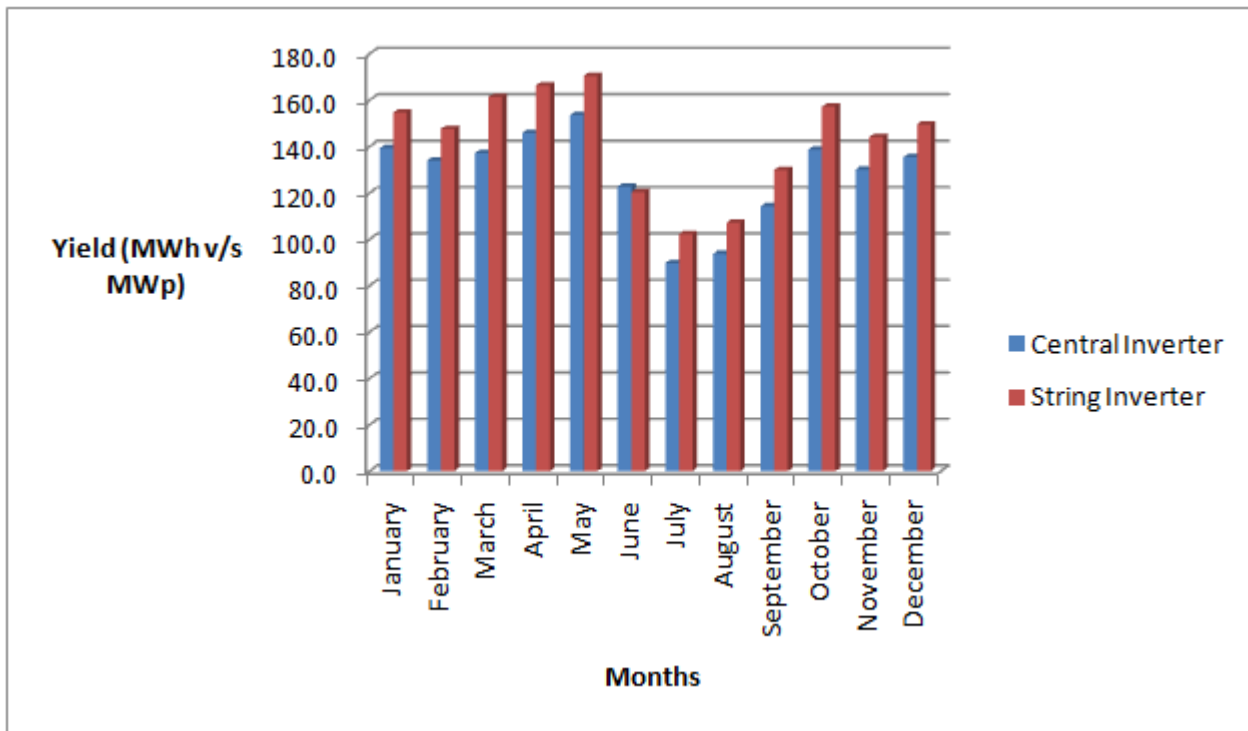


Inferences:

- Except in the month of October, Seasonal tilt module mounting structure generates more than the fixed tilt.
- By using seasonal tilt, the overall generation goes up to 5% with the minimal cost increase as of fixed axis.

12. INVERTERS: CENTRAL V/S STRING INVERTER

Inverters	January	February	March	April	May	June	July	August	September	October	November	December
Central Inverter	139.3	134.0	137.2	145.9	153.5	122.8	89.8	93.7	114.3	138.6	130.2	135.5
String Inverter	154.7	147.6	161.3	166.4	170.5	120.3	102.2	107.1	129.9	157.2	144.2	149.5

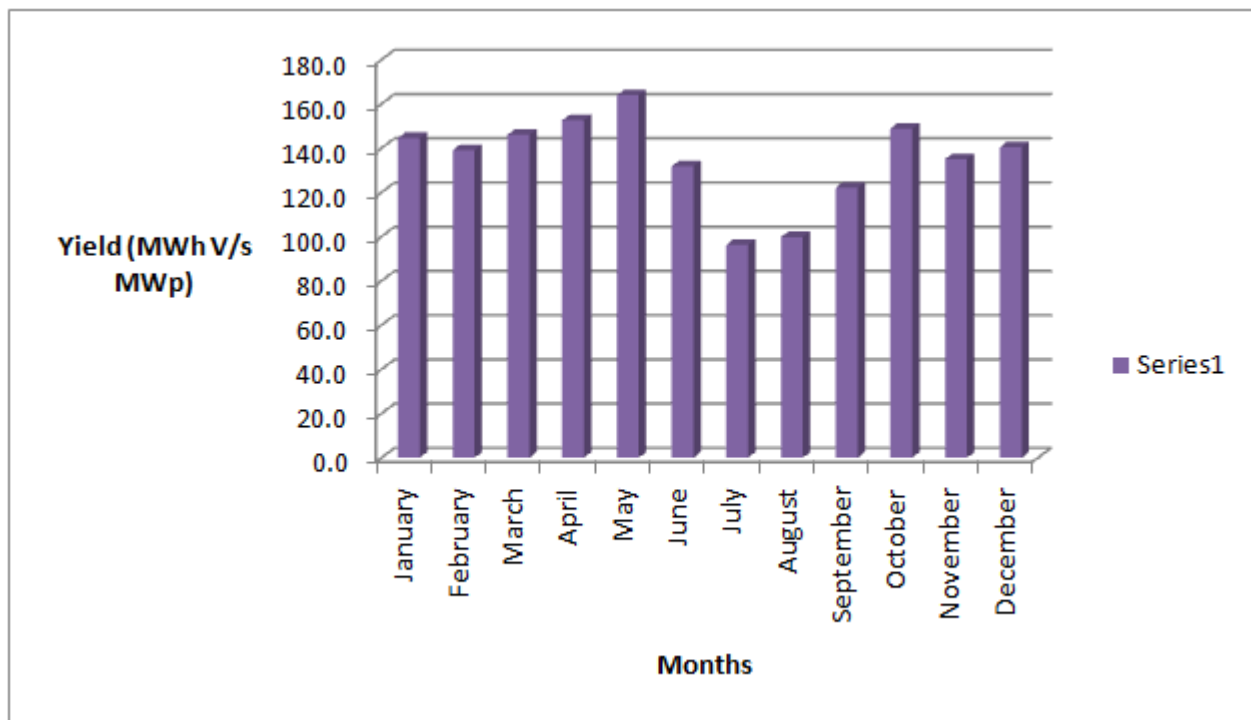


Inferences:

- String inverters offer better performance as opposed to central inverter.
- String inverter has more Maximum Power Point Tracking (MPPT's) and hence a better MPPT window when compared to plants using central inverter.
- By using string inverters optimum utilization of ground area is possible.
- By using string inverters reduced effect of shading is possible.
- Due to high number of independently working inverters the total system output will only be limited affected even if there is a high degree of output variation of modules in your plant.
- By using a string inverter solution you get the flexibility, yield and efficiency expected from a modern day PV system as well as fast and reliable installation and commissioning and a full monitoring solution.

13. AVERAGE GENERATION MONTH WISE:

Months	January	February	March	April	May	June	July	August	September	October	November	December
Generation	144.6	139.0	146.0	152.6	163.9	131.7	96.3	99.8	122.1	148.8	135.0	140.4



Inferences:

- From the table above we can see the maximum generation happens in the month of May
- The secondary peak is seen in the month of April followed by October.
- The lowest generation happens in the month of July followed by August. This is may be due to rainy season.
- Out of all the seasons in summer the generation is very high because of good solar insolation.
- The overall average generation comes to around 16,20,000 units which is around 18.5% plant load factor.

14. Conclusion:

Of the 17 plants for which performance data is available for last 26 months, the annual plant load factor for 76% of the plants is above 18%. The top three plants had plant load factor of more than 20%. One very interesting insight that can be drawn from the performance ranking is that the right components selection is necessary, but not sufficient condition for the optimal performance of the plant. For example one of the plant using C-Sun modules and Bonfiglioli inverter has a plant load factor of 18.15%(GPCL) but another plant using the same configuration of C-Sun modules and Bonfiglioli inverter has a plant load factor of 15.6%(Lanco Infra). One inference that could be drawn is that a developer should pay equal attention to the selection of the balance of system components, ensure design optimization and select the right Engineering Procurement and Construction(EPC) contractor who can ensure build quality and high plant uptimes. Another aspect that

could have an impact on the plant's PLF is operation and maintenance of the plant. A plant that has a very good performance monitoring system (remote monitoring or local SCADA) and is well maintained will obviously lead to higher generation.

In terms of PV module technology selection thin film technology plants are generating more than Crystalline technology plants. In order to draw any conclusion we have to wait for longer term performance of the plants as thin film has tendency to degrade at a faster rate. Comparison between Central and String inverter is difficult to conclude as there is only one plant which is working on string technology. Although we can infer that string technology plant performance is more than the average of central inverter technology plants. In terms of module mounting structure between fixed tilt and seasonal tilt, seasonal tilt plants performance is good but one has to work on the cost economics before taking a decision. To conclude the plant performance data made available by the State of Gujarat has been providing some very valuable insights into the PV plant performance.