

# Sunrise in Gujarat

April 2013-March 2014 in Review



Sunrise  
in Gujarat



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## Executive Summary



## Executive Summary

When Gujarat allotted close to 1 GW of solar projects in 2010, it was hailed as one of the path-breaking initiatives. By the time a majority of these projects were commissioned by March 2012, Gujarat was contributing to more than 75% of the total installed capacity. However, no one would have thought at that time that Gujarat would continue to be the leading solar state in the country 2 years later. At the end of the financial year 2013-14 (March 2014), Gujarat still accounted for more than one-third of the total installed capacity in the country. This is remarkable, considering that Gujarat did not allot any more projects after the initial allotment in 2010.

Apart from its pioneering role in the Indian Solar sector, Gujarat has also contributed immensely to the sector by diligently releasing the plant performance data at the end of each month. The data from these plants have been extremely useful in understanding the performance of the plants under Indian conditions, especially for new developers keen on entering this nascent sector. It has to be pointed out that none of the other states have released plant-wise generation details. The Ministry of New and Renewable Energy (MNRE) releases the performance details of plants under the Jawaharlal Nehru National Solar Mission (JNNSM), but performance data released by MNRE cannot be properly analysed because data for some months are not released, and data is not available for several developers.

Last year, RESolve undertook the task of gathering the performance data for all the operational solar PV plants in Gujarat and providing a comparison of the plants in the form of a whitepaper. The encouraging positive response for the ranking of the performance of the operational plants in Gujarat, motivated us to repeat the exercise this year, and the result is this second edition of the whitepaper. Like the previous edition, this ranking is purely based on the generation data released by the Gujarat SLDC.

One new section has been included in this edition, and in the new section, BKC WeatherSys, one of the leading suppliers of weather monitoring systems for solar PV plants, has shared some very interesting and useful insights on the impact of various weather parameters, especially humidity, on the performance of the solar PV plants. The analysis provides some possible explanations as to why plants in some districts are performing better than others, based on the irradiation, ambient temperature and humidity data.

In this expanded second edition, the total number of plants analysed has increased to 65 plants from 50 in the previous edition. Of the newly added 15 plants, 2 plants are located in Charanka. As in the previous edition, there are 3 rankings – one, an overall ranking, two, ranking of plants within Charanka Solar park, and three, ranking of plants outside Charanka Solar park. Since 48 plants have been operational for more than 2 years, the comparison of performance for each of these 2 years is provided.

The top 3 plants in the previous ranking (Konark, Unity Power and Mono Steel) continued to perform exceptionally well, but Millenium Synergy plant of SunEdison emerged as the number 1 plant with maximum generation. Millenium Synergy's increased electricity generation can be attributed to single axis tracking which was fully operational 2013-14. Similarly, Backbone Enterprises also makes a huge jump from the previous year, and was the 5th largest generation plant, thanks again to its single axis tracking system. As in the previous edition, the details of the module/inverter used,

type of tilt and the EPC contractor are provided in this edition.


At this juncture, we would like to reiterate a point we had made in the first edition of the whitepaper - knowing the module, inverter and EPC details is still not enough to benchmark the plants, because there are other variables that influence the performance of the plant. Some of them include quality of Balance of system components (cables, connectors, etc) and build quality. The more a developer is willing to spend, the better the quality of components will be. In short, what you get is what you pay for. With that in mind, we request you to go through the analysis carefully before drawing any inferences.

We have taken utmost care to verify the authenticity of information, but it is likely that some of the information need to be corrected. In case you come across such information, please let us know and we will be more than happy to correct them.





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# Solar in India

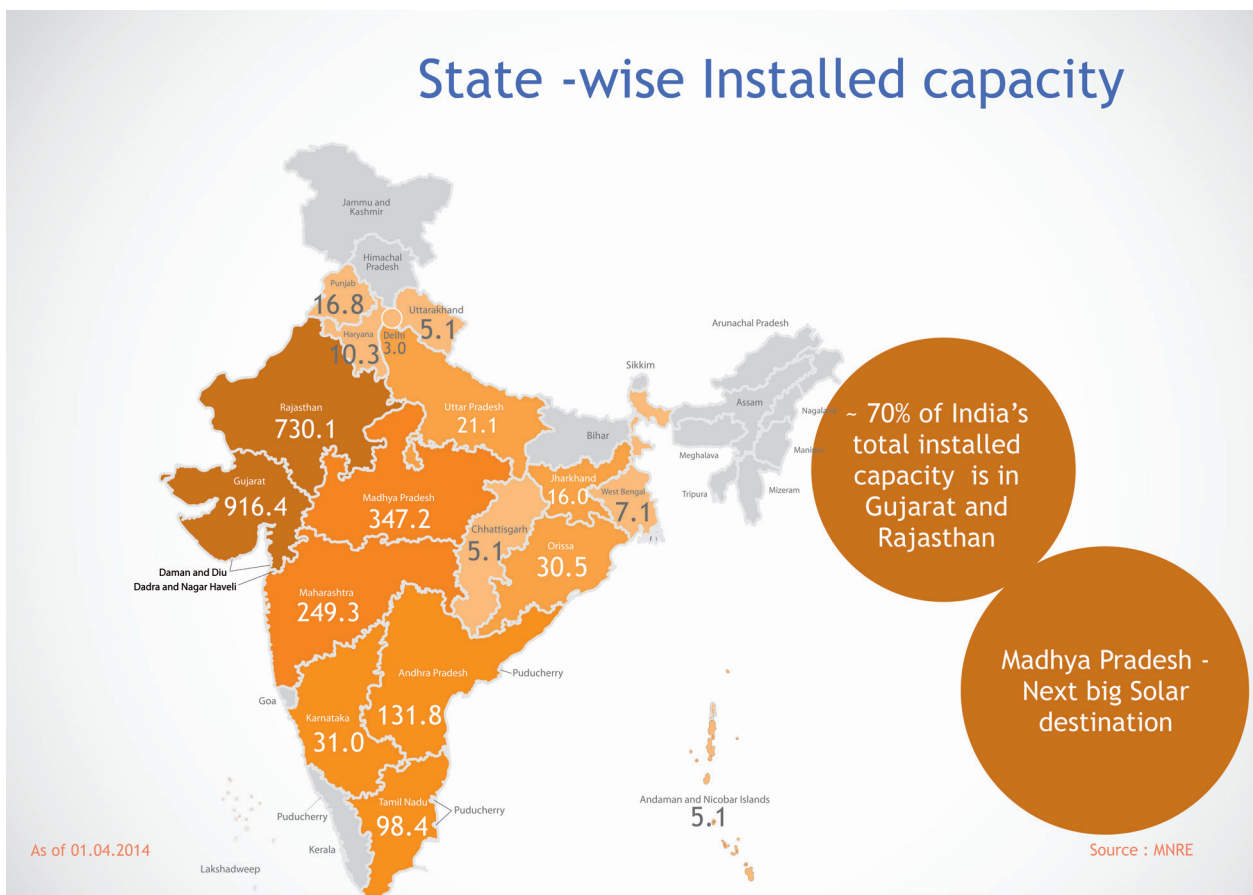


## Overview

As of 31 March 2014, the installed capacity of grid-connected solar stood at 2,632 MW (Source: MNRE). Gujarat continues to be the number one solar state

in terms of installed capacity, with a capacity of 916.4 MW at the end of the financial year 2013-14.

Figure 1 - State - wise Installed capacity

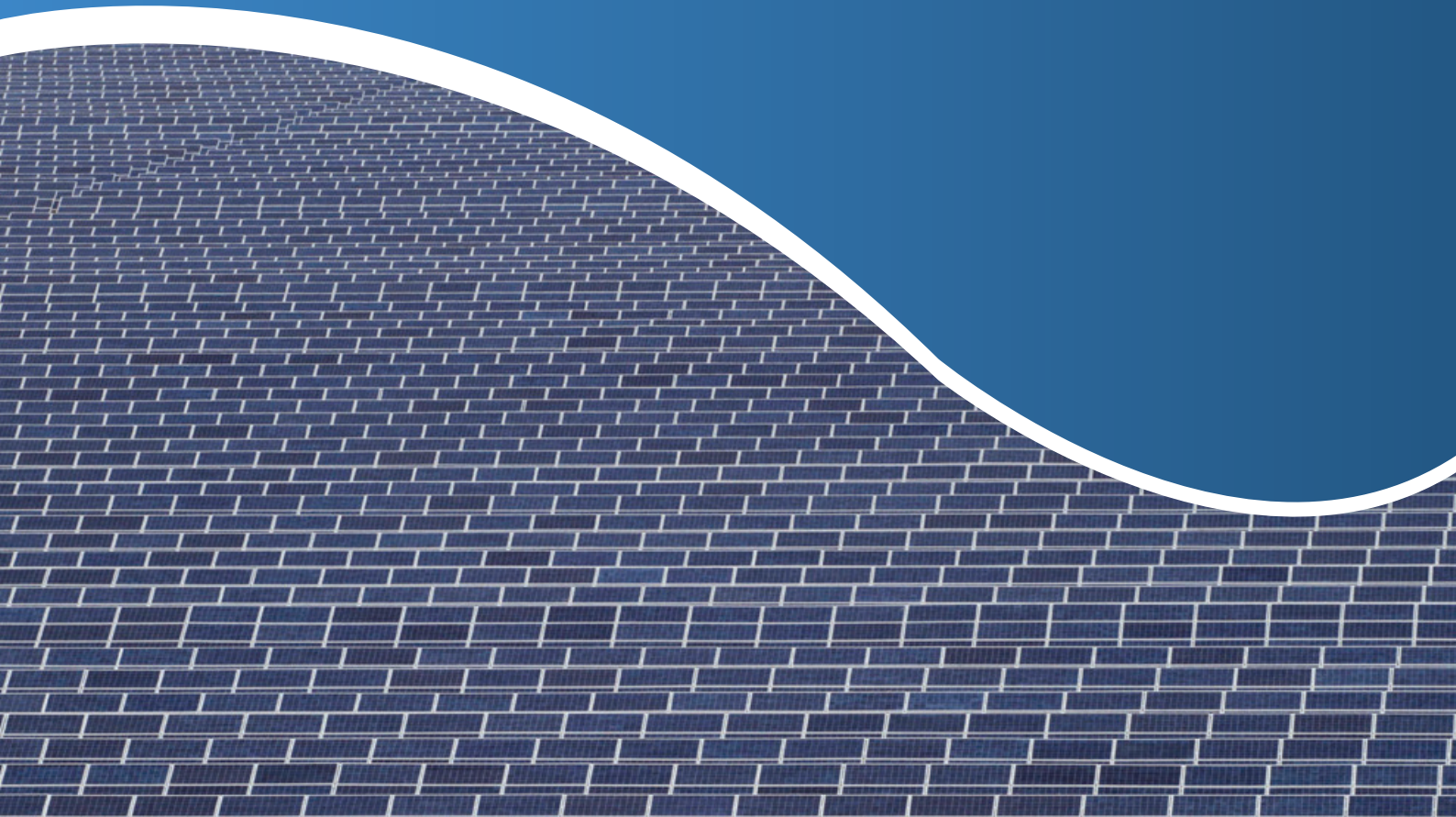




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# Gujarat Solar update



## Gujarat Solar update

Gujarat signed Power Purchase Agreements (PPAs) towards a total 968.5 MW of installed capacity towards end of 2010 and early 2011. The full list of project developers is available in Annexure A.

As of 31 March 2014, 78 projects totalling 857.31 MW were commissioned and operational as per RESolve's research. The complete list of projects is enclosed in Annexure B.

(Note : According to the data released by the Ministry of New and Renewable Energy(MNRE), the installed capacity of Solar in Gujarat stood at 860.4 MW as of 31.03.2014. The Gujarat Energy Development Agency(GEDA) had not released the installed capacity data till 31.03.2014 at the time of release of this whitepaper).

## Charanka Solar Park

The Charanka Solar park is spread over about 2000 Hectares in the wastelands of the Rann of Kutch. The Rann of Kutch is a salt marsh at the edge of Thar Desert, and it borders Pakistan. The total area available can be used

to set up solar plants of a total 500 MW capacity. As of 31.03.2014, a total of 17 plants totalling 221.1 MW are operational in Charanka.

**Note: More details about Charanka Solar Park are available in the first edition of the whitepaper**  
<http://bit.ly/19lwHJO>



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# Solar Plant performance



## Solar Plant performance

The below sections aim to quantify the performance of the solar power plants set up in the state of Gujarat. For the purposes of evaluation, the generation data available from the Gujarat State Load Dispatch Centre (SLDC) has been used. Ranking of the power plants has been done on the basis of the Plant Load Factor (PLF) or Capacity Utilization Factor (CUF). PLF or CUF is calculated as the ratio of actual energy generated (for a given period of time) to the maximum (theoretical) possible generation of a power system. The formula for CUF is as follows.

Capacity Utilisation Factor (CUF) = Energy measured (kWh) / (365\*24\*installed capacity of the plant).

While 78 projects totalling 857.31 MW were operational as of March 31, 2014, the SLDC data is available only for 65 projects totalling 840.31 MW. The list of projects for which data is available is given below. Their generation capacity (MW), total electricity generation (MWh), generation normalised to MW and the CUF for the period April 2013-March 2014 are given in the table below.

Please note that the power plant ratings mentioned here are assumed to be AC ratings. There is a good chance that the actual DC capacity is higher than that of the AC rating mentioned. Most (if not all) solar power plants mentioned in the list is likely to have a higher DC rating (i.e. more solar panel capacity) than the nameplate AC rating mentioned. It is our understanding (based on interactions with industry experts) that many developers have opted for a more “aggressive” DC to AC ratio. We are unable to independently verify the DC to AC ratio of each plant.

## Overall Ranking of Plants operational for at least 1 Year

Rank (2013-14)	Rank (2012-13)	Developer	Capacity (MW)	Total Generation (MWh)	Normalized (MWh per MW per Year)	CUF	Module Type	Module Make	Inverter Make	Tilt	EPC
1	19	Millenium Synergy(Gujarat) pvt. Ltd	10	18581.849	2004.514455	22.88%	Crystalline Si	Trina	SMA	Single Axis	L&T
2	1	Konark Gujarat PV pvt. Ltd	5	9668.27	1933.654	22.07%	Crystalline Si	Vikram Solar	AEG	Seasonal Tilt	Vikram Solar
3	2	Unity Power	5	9401.244	1880.2488	21.46%	Thin Film	Solar Frontier	Power One	Fixed Tilt	Enfinity/ Power Trac
4	3	Mono Steel(India) ltd	10	18321.744	1832.1744	20.92%	Crystalline Si	Waaree	Power One	Seasonal Tilt	Waaree
5	18	BACKBONE Enterprises Ltd.	5	8867.238	1773.4476	20.24%	Thin Film	Nexpower	Siemens	Single Axis	Self
6	11	GSPC Pipavav Power Company Ltd.	5	8786.576	1757.3152	20.06%	Crystalline Si	Suntech	Bonfiglioli	Seasonal Tilt	Lanco
7	6	TATA Power Renewable Energy Ltd.	25	43698.014	1747.92056	19.95%	Crystalline Si	Tata,Canadian Solar, Suntech	ABB + SMA	Seasonal Tilt	Tata
8	7	NKG Infrastructure Ltd	10	17466.545	1746.6545	19.94%	Crystalline Si	Solarworld	Delta(String)		PPS Enviro Power
9	5	Palace Solar Energy pvt.ltd	15	26135.747	1742.383133	19.89%	Crystalline Si	Canadian Solar	Power One	Seasonal Tilt	Etain- Immodo/ Lourex Group
10	21	ESP Urja pvt. Ltd.	5	8675.883	1735.1766	19.81%	Thin Film	Sharp	SMA	Fixed Tilt	L&T
11	10	Roha Dyechem pvt.ltd	25	43379.103	1732.392292	19.78%	Thin Film	NexPower	Satcon	Fixed Tilt	Wipro EcoEnergy
12	16	Welspun Urja Gujarat pvt. Ltd.	15	25973.437	1730.408861	19.75%	Thin Film	First Solar	SMA	Fixed Tilt	Conergy(Sun Technics)
13	4	WAA Solar pvt.Ltd.	10.22	17712.634	1728.061854	19.73%	Thin Film	First Solar	SMA	N/A	Madhav Power
14	13	Alex Astral Power pvt.ltd	25	43133.866	1720.537136	19.64%	Thin Film	First Solar	SMA	N/A	Cirus Solar
15	9	ZF Steering Gear (India) pvt.ltd	5	8586.393	1717.2786	19.60%	Thin Film	N/A	N/A	N/A	N/A
16	8	Sun Clean Renewable pvt.ltd	6	10247.529	1707.9215	19.50%	Thin Film	Sharp	Power-One	Fixed Tilt	L&T

Rank (2013-14)	Rank (2012-13)	Developer	Capacity (MW)	Total Generation (MWh)	Normalized (MWh per MW per Year)	CUF	Module Type	Module Make	Inverter Make	Tilt	EPC
17	24	GMR Gujarat solar power pvt.ltd	25	42560.374	1702.41496	19.43%	c-Si	Canadian Solar	SMA	Fixed Tilt	Indu Projects(Cirus)
18	17	SEI Solar Power Gujarat pvt.ltd	25	42517.669	1700.026749	19.41%	Crystalline Si	Chint/Trina	Power One	Fixed Tilt	L&T
19	NA	Sunkon Energy Pvt.ltd	10	16938.476	1693.8476	19.34%	Thin Film	First Solar	SMA	Fixed Tilt	Moser Baer
20	NA	MI MySolar24 (P) Ltd,	14.99	25326.345	1689.549366	19.29%	Crystalline	REC	N/A	Fixed Tilt	N/A
21	NA	Dreisatz My Solar24 Pvt.Ltd.	14.99	25231.708	1683.236024	19.22%	Crystalline	REC	N/A	Fixed Tilt	N/A
22	34	Gujarat Mineral Development Company Ltd.	5	8401.531	1680.3062	19.18%	Crystalline Si	Tata BP	PowerOne	Fixed Tilt	Tata BP
23	14	Green Infra Solar Energy Ltd.	10	16682.4	1668.24	19.04%	Thin Film	First Solar	SMA	Fixed Tilt	Juwi
24	32	Sand Land Real Estate pvt.ltd	25	41667.099	1666.68396	19.03%	Thin Film	First Solar	SMA	Fixed Tilt	Moser Baer
25	12	AZURE(Hariyana)	10.2	16973.283	1662.417532	18.98%	Crystalline Si	Suntech	N/A	N/A	Self
26	26	Emami Cement Ltd	10	16701.464	1660.185288	18.95%	c-Si	TATA BP	ABB	Seasonal Tilt	Tata BP
27	15	Solarfield Energy Pvt. Ltd.	20	33260.65	1658.058325	18.93%	Thin Film	Sharp	Sharp	Fixed Tilt	L&T
28	23	ICML	9	14786.093	1642.899222	18.75%	Crystalline Si	LDK	IDS	N/A	N/A
29	27	Moser Baer Energy & Development Ltd	15	24654.185	1641.423768	18.74%	Thin Film	First Solar, Moserbaer, Dupont	SMA	N/A	Moser Baer
30	44	AES Solar Energy Gujarat pvt. Ltd	14.92	24349.131	1631.97929	18.63%	Thin Film	First Solar	Power One	Fixed Tilt	Enfinity
31	NA	SunBorne Energy Gujarat One Pvt. Ltd	15	24436.271	1629.084733	18.60%	Crystalline	SolarWorld/ Suntech	SMA	Fixed Tilt	Self
32	NA	Euro Solar Power Pvt. Ltd	5.12	8315.036	1624.030469	18.54%	Crystalline	REC	Bonfiglioli	Fixed Tilt	N/A
33	NA	S J Green Park Energy Pvt.Ltd	5.12	8304.478	1621.968359	18.52%	Crystalline	REC/Canadian Solar	Bonfiglioli	Fixed Tilt	N/A
34	41	Hiraco Renewable Energy pvt.ltd	20	32544.671	1618.33272	18.47%	Crystalline Si	Hanwha Solarone	SMA	Fixed Tilt	Moser Baer
35	28	Precious Energy Services pvt.Ltd	15.2	24526.899	1613.611776	18.42%	Thin Film	First Solar, Moserbaer, Dupont	SMA	N/A	Moser Baer



Rank (2013-14)	Rank (2012-13)	Developer	Capacity (MW)	Total Generation (MWh)	Normalized (MWh per MW per Year)	CUF	Module Type	Module Make	Inverter Make	Tilt	EPC
36	31	Solitaire Energies pvt.Ltd.	15	24010.185	1599.612592	18.26%	Thin Film	First Solar, Moserbaer, Dupont	N/A	N/A	Moser Baer
37	25	GHI Energy pvt. Ltd.	10	15924.483	1592.4483	18.18%	Crystalline Si	Suntech	N/A	N/A	N/A
38	42	Ganeshvani Merchandise Pvt. Ltd	5	8022.438	1591.753571	18.17%	Crystalline Si	Trina	Bonfiglioli	Fixed Tilt	Insolare Energy Pvt. Ltd
39	29	AZURE Power (Gujarat)pvt. Ltd	5	7957.983	1591.5966	18.17%	Thin Film	First Solar	SMA/PowerOne	N/A	N/A
40	47	Solar Semiconductor Power Company	20	31579.057	1578.95285	18.02%	Thin Film	Sunwell	Santerno	Fixed Tilt	N/A
41	37	EMCO Ltd	5	7823.433	1564.6866	17.86%	Crystalline Si	Trina	Ingeteam	N/A	N/A
42	NA	APCA Power Pvt.Ltd	5	7823.367	1564.6734	17.86%	Thin Film	First Solar	N/A	N/A	N/A
43	NA	Chattel Constructions Pvt.Ltd	25.04	39157.237	1563.78742	17.85%	Crystalline	LDK/Trina	Bonfiglioli	Fixed Tilt	N/A
44	38	Visual Percept Solar Projects pvt. Ltd.	25	39020.799	1560.83196	17.82%	Crystalline Si	Hanwha Solarone	PowerOne	Fixed Tilt	Sterling and Wilson
45	33	Gujarat Power Corporation Ltd.	5	7759.117	1551.8234	17.71%	c-Si	C-Sun	N/A	N/A	N/A
46	35	Surana Telecom & Power Ltd.	5	7735.383	1547.0766	17.66%	c-Si	Surana	AEG	Fixed Tilt	Self
47	50	Gangesh Green Energy pvt.ltd	25.08	38733.769	1544.408652	17.63%	Thin Film	First Solar	SMA	Fixed Tilt	N/A
48	20	ACME Solar Technology	15	23037.799	1535.853267	17.53%	Thin Film	First Solar	ABB	Fixed Tilt	M+W
49	30	AEL(Solar)	40	61312.843	1528.617377	17.45%	Thin Film	Sunwell/Sunner Well	SMA	Fixed Tilt	Aries Waaree
50	NA	Ujjawala Power Pvt Ltd	23.06	35084.646	1521.45039	17.37%	Crystalline	Harion/Jinko/JA Solar	Bonfiglioli	Fixed Tilt	N/A
51	NA	Avtar Solar Power Pvt Ltd	4.98	7482.176	1502.44498	17.15%	N/A	N/A	N/A	N/A	Waaree
52	NA	Aatash Power Pvt.Ltd	4.99	7492.413	1501.485571	17.14%	Crystalline	REC	ABB	Fixed Tilt	N/A
53	22	PLG Photovoltaic Ltd	20	30014.692	1500.7346	17.13%	Crystalline Si	PLG/Kyocera	Power One	Fixed Tilt	Zamil Group
54	NA	Yantra eSolar India Pvt.ltd	4.95	7371.303	1489.152121	17.00%	Thin Film	DuPont	N/A	Fixed Tilt	N/A

Rank (2013-14)	Rank (2012-13)	Developer	Capacity (MW)	Total Generation (MWh)	Normalized (MWh per MW per Year)	CUF	Module Type	Module Make	Inverter Make	Tilt	EPC
55	39	Gujarat Industries Power Company Ltd.	5	7418.788	1480.796008	16.90%	Crystalline Si	Titan	ABB	Fixed Tilt	N/A
56	NA	Astonfield Solar(Gujarat) Pvt.Ltd	11.51	16657.661	1447.233797	16.52%	Thin Film	N/A	Schneider Electric	Fixed Tilt	Schneider Electric
57	46	Lanco Infratech Ltd.	15.01	21718.14	1446.911392	16.52%	Crystalline Si	C-Sun	Bonfiglioli	Fixed Tilt	Self
58	NA	Responsive SUTIP Ltd	25.06	35726.135	1425.623903	16.27%	Crystalline	LDK	Bonfiglioli	Fixed Tilt	N/A
59	45	Jaihind Project	5	7051.356	1410.2712	16.10%	Crystalline Si	Nantong	Helofax	Fixed Tilt	Self
60	36	LANCO(BHRD)	5	7036.782	1407.3564	16.07%	Crystalline Si	N/A	Helios Systems	N/A	Lanco
61	40	Louroux Bio Energies Ltd.	25	33224.044	1328.96176	15.17%	Thin Film	Tianwei and Sungen	Siemens	Fixed Tilt	Inspira Martifer
62	38	LANCO(Chandiyana)	15.01	19552.677	1302.643371	14.87%	Crystalline Si and Thin Film	Trina/Dupont/CSUN	Bonfiglioli, Eltek, REFUSol	Fixed Tilt	Self
63	49	Arvali Infrapower Ltd.	5	6497.343	1299.4686	14.83%	Crystalline Si	LDK	Eltek	Fixed Tilt	Moser Baer
64	43	CBC Solar Technologies Pvt.Ltd	10	12128.47	1212.847	13.85%	Crystalline Si	Trina	Bonfiglioli	N/A	Moser Baer
65	N/A	Taxus Infrastructure & Power Project Pvt.Ltd	5	3293.095	658.619	11.29%	N/A	N/A	Bonfiglioli	N/A	Moser Baer
			835.45								

(Note : Plants operational in the Charanka Solar Park are highlighted in yellow)

Note : Data for Taxus Infrastructure & Power Project is available only from August 2013, and the CUF has been calculated for 8 months in the year. The plant has also been excluded from rankings for this reason.

**Table 1 – Solar Power Plant Ranking 2013-14 including Components**

From the above list, it can be seen that Millenium Synergy(Gujarat) Pvt.Ltd (developed by Sun Edison) comes while Konark Gujarat PV pvt. Ltd comes second.

Last year, Konark Gujarat PV was in number one position. However, it must be noted that Millenium Synergy has a single axis azimuth tracking system, whereas Konark Gujarat PV is reported to have fixed tilt mechanism.

A word of caution here – the ranking above is not an indicator of how good or bad a component or EPC is. For example, plant using First Solar modules are among the top ranking projects and low ranking projects. Similarly, some of the projects executed by L&T are among the top as well as in the middle. The CUF will depend on some more factors like build quality, Balance of Systems used(cables, structures, etc) and design optimization.

## Ranking of Plants operational for at least 1 Year (Charanka Solar Park)

Rank (2013-14)	Rank (2012-13)	Developer	Capacity (MW)	Total Generation (MWh)	Normalized (MWh per MW per Year)	CUF	Module Type	Module Make	Inverter Make	Tilt	EPC
1	6	GSPC Pipavav Power Company Ltd.	5	8786.576	1757.3152	20.06%	Crystalline Si	Suntech	Bonfiglioli	Seasonal Tilt	Lanco
2	2	NKG Infrastructure Ltd	10	17466.545	1746.6545	19.94%	Crystalline Si	Solarworld	Delta(String)		PPS Enviro Power
3	1	Palace Solar Energy pvt.ltd	15	26135.747	1742.383133	19.89%	Crystalline Si	Canadian Solar	Power One	Seasonal Tilt	Etain- Immodo/ Lourex Group
4	5	Roha Dyechem pvt.ltd	25	43379.103	1732.392292	19.78%	Thin Film	NexPower	Satcon	Fixed Tilt	Wipro EcoEnergy
5	7	Alex Astral Power pvt.ltd	25	43133.866	1720.537136	19.64%	Thin Film	First Solar	SMA	N/A	Cirus Solar
6	4	ZF Steering Gear (India) pvt.ltd	5	8586.393	1717.2786	19.60%	Thin Film	N/A	N/A	N/A	N/A
7	3	Sun Clean Renewable pvt.ltd	6	10247.529	1707.9215	19.50%	Thin Film	Sharp	Power-One	Fixed Tilt	L&T
8	10	GMR Gujarat solar power pvt.ltd	25	42560.374	1702.41496	19.43%	c-Si	Canadian Solar	SMA	Fixed Tilt	Indu Projects(Cirus)
9	9	SEI Solar Power Gujarat pvt.ltd	25	42517.669	1700.026749	19.41%	Crystalline Si	Chint/Trina	Power One	Fixed Tilt	L&T
10	11	Emami Cement Ltd	10	16701.464	1660.185288	18.95%	c-Si	TATA BP	ABB	Seasonal Tilt	Tata BP
11	8	Solarfield Energy Pvt. Ltd.	20	33260.65	1658.058325	18.93%	Thin Film	Sharp	Sharp	Fixed Tilt	L&T
12	14	AES Solar Energy Gujarat pvt. Ltd	14.92	24349.131	1631.97929	18.63%	Thin Film	First Solar	Power One	Fixed Tilt	Enfinity
13	12	Gujarat Power Corporation Ltd.	5	7759.117	1551.8234	17.71%	c-Si	C-Sun	N/A	N/A	N/A
14	13	Surana Telecom & Power Ltd.	5	7735.383	1547.0766	17.66%	c-Si	Surana	AEG	Fixed Tilt	Self
15	NA	Avtar Solar Power Pvt Ltd	4.98	7482.176	1502.44498	17.15%	N/A	N/A	N/A	N/A	Waaree
16	NA	Yantra eSolar India Pvt.ltd	4.95	7371.303	1489.152121	17.00%	Thin Film	DuPont	N/A	Fixed Tilt	N/A
17	15	Lanco Infratech Ltd.	15.01	21718.14	1446.911392	16.52%	Crystalline Si	C-Sun	Bonfiglioli	Fixed Tilt	Self
		Total	835.45								

In case of Charanka, GSPC Pipavav has the highest CUF, while NKG Infrastructure retains the second position.

**Table 2 – Ranking of Solar Power Plants in Charanka Solar Park (2013-14)**

## Ranking of Plants operational for at least 1 Year (Outside Charanka Solar Park)

Rank (2013-14)	Rank (2012-13)	Developer	Capacity (MW)	Total Generation (MWh)	Normalized (MWh per MW per Year)	CUF	Module Type	Module Make	Inverter Make	Tilt	EPC
1	10	Millenium Synergy(Gujarat) Pvt. Ltd	10	18581.849	2004.514455	22.88%	Crystalline Si	Trina	SMA	Single Axis	L&T
2	1	Konark Gujarat PV pvt. Ltd	5	9668.27	1933.654	22.07%	Crystalline Si	Vikram Solar	AEG	Seasonal Tilt	Vikram Solar
3	2	Unity Power	5	9401.244	1880.2488	21.46%	Thin Film	Solar Frontier	Power One	Fixed Tilt	Enfinity/Power Trac
4	3	Mono Steel(India) ltd	10	18321.744	1832.1744	20.92%	Crystalline Si	Waaree	Power One	Seasonal Tilt	Waaree
5	9	BACKBONE Enterprises Ltd.	5	8867.238	1773.4476	20.24%	Thin Film	Nexpower	Siemens	Single Axis	Self
6	5	TATA Power Renewable Energy Ltd.	25	43698.014	1747.92056	19.95%	Crystalline Si	Tata,Canadian Solar, Suntech	ABB+SMA	Seasonal Tilt	Tata
7	12	ESP Urja pvt. Ltd.	5	8675.883	1735.1766	19.81%	Thin Film	Sharp	SMA	Fixed Tilt	N/A
8	8	Welspun Urja Gujarat pvt. Ltd.	15	25973.437	1730.408861	19.75%	Thin Film	First Solar	SMA	Fixed Tilt	Conergy(Sun Technics)
9	4	WAA Solar pvt.Ltd.	10.22	17712.634	1728.061854	19.73%	Thin Film	First Solar	SMA	N/A	Madhav Power
10	NA	Sunkon Energy Pvt.ltd	10	16938.476	1693.8476	19.34%	Thin Film	First Solar	SMA	Fixed Tilt	Moser Baer
11	NA	MI MySolar24 (P) Ltd	14.99	25326.345	1689.549366	19.29%	Crystalline	REC	N/A	Fixed Tilt	N/A
12	NA	Dreisatz My Solar24 Pvt.Ltd.	14.99	25231.708	1683.236024	19.22%	Crystalline	REC	N/A	Fixed Tilt	N/A
13	22	Gujarat Mineral Development Company Ltd.	5	8401.531	1680.3062	19.18%	Crystalline Si	Tata BP	PowerOne	Fixed Tilt	Tata BP
14	7	Green Infra Solar Energy Ltd.	10	16682.4	1668.24	19.04%	Thin Film	First Solar	SMA	Fixed Tilt	Juwi
15	21	Sand Land Real Estate pvt.ltd	25	41667.099	1666.68396	19.03%	Thin Film	First Solar	SMA	Fixed Tilt	Moser Baer
16	6	AZURE(Hariyana)	10.2	16973.283	1662.417532	18.98%	Crystalline Si	Suntech	N/A	N/A	Self
17	14	ICML	9	14786.093	1642.899222	18.75%	Crystalline Si	LDK	IDS	N/A	N/A

Rank (2013-14)	Rank (2012-13)	Developer	Capacity (MW)	Total Generation (MWh)	Normalized (MWh per MW per Year)	CUF	Module Type	Module Make	Inverter Make	Tilt	EPC
18	16	Moser Baer Energy & Development Ltd	15	24654.185	1641.423768	18.74%	Thin Film	First Solar, Moserbaer, Dupont	SMA	N/A	Moser Baer
19	NA	SunBorne Energy Gujarat One Pvt. Ltd	15	24436.271	1629.084733	18.60%	Crystalline	SolarWorld/ Suntech	SMA	Fixed Tilt	Self
20	NA	Euro Solar Power Pvt. Ltd	5.12	8315.036	1624.030469	18.54%	Crystalline	REC	Bonfiglioli	Fixed Tilt	N/A
21	NA	S J Green Park Energy Pvt.Ltd	5.12	8304.478	1621.968359	18.52%	Crystalline	REC/Canadian Solar	Bonfiglioli	Fixed Tilt	N/A
22	28	Hiraco Renewable Energy pvt.ltd	20	32544.671	1618.33272	18.47%	Crystalline Si	Hanwha Solarone	SMA	Fixed Tilt	Moser Baer
23	17	Precious Energy Services pvt.Ltd	15.2	24526.899	1613.611776	18.42%	Thin Film	First Solar, Moserbaer, Dupont	SMA	N/A	Moser Baer
24	20	Solitaire Energies pvt.Ltd.	15	24010.185	1599.612592	18.26%	Thin Film	First Solar, Moserbaer, Dupont	N/A	N/A	Moser Baer
25	15	GHI Energy pvt. Ltd.	10	15924.483	1592.4483	18.18%	Crystalline Si	Suntech	N/A	N/A	N/A
26	29	Ganeshvani Merchandise Pvt. Ltd	5	8022.438	1591.753571	18.17%	Crystalline Si	Trina	Bonfiglioli	Fixed Tilt	Insolare Energy Pvt. Ltd
27	18	AZURE Power (Gujarat) Pvt. Ltd	5	7957.983	1591.5966	18.17%	Thin Film	First Solar	SMA/PowerOne	N/A	N/A
28	32	Solar Semiconductor Power Company	20	31579.057	1578.95285	18.02%	Thin Film	Sunwell	Santerno	Fixed Tilt	N/A
29	24	EMCO Ltd	5	7823.433	1564.6866	17.86%	Crystalline Si	Trina	Ingeteam	N/A	N/A
30	NA	APCA Power Pvt.Ltd	5	7823.367	1564.6734	17.86%	Thin Film	First Solar	N/A	N/A	N/A
31	NA	Chattel Constructions Pvt.Ltd	25.04	39157.237	1563.78742	17.85%	Crystalline	LDK/Trina	Bonfiglioli	Fixed Tilt	N/A
32	25	Visual Percept Solar Projects pvt. Ltd.	25	39020.799	1560.83196	17.82%	Crystalline Si	Hanwha Solarone	PowerOne	Fixed Tilt	Sterling and Wilson
33	35	Gangesh Green Energy pvt.ltd	25.08	38733.769	1544.408652	17.63%	Thin Film	First Solar	SMA	Fixed Tilt	N/A
34	11	ACME Solar Technology	15	23037.799	1535.853267	17.53%	Thin Film	First Solar	ABB	Fixed Tilt	M+W

Rank (2013-14)	Rank (2012-13)	Developer	Capacity (MW)	Total Generation (MWh)	Normalized (MWh per MW per Year)	CUF	Module Type	Module Make	Inverter Make	Tilt	EPC
	10	Millenium Synergy(Gujarat) Pvt. Ltd	10	18581.849	2004.514455	22.88%	Crystalline Si	Trina	SMA	Single Axis	L&T
35	19	AEL(Solar)	40	61312.843	1528.617377	17.45%	Thin Film	Sunwell/Sunner Well	SMA	Fixed Tilt	Aries Waaree
36	NA	Ujjawala Power Pvt Ltd	23.06	35084.646	1521.45039	17.37%	Crystalline	Harion/Jinko/JA Solar	Bonfiglioli	Fixed Tilt	N/A
37	NA	Aatash Power Pvt.Ltd	4.99	7492.413	1501.485571	17.14%	Crystalline	REC	ABB	Fixed Tilt	N/A
38	13	PLG Photovoltaic Ltd	20	30014.692	1500.7346	17.13%	Crystalline Si	PLG/Kyocera	Power One	Fixed Tilt	Zamil Group
39	26	Gujarat Industries Power Company Ltd.	5	7418.788	1480.796008	16.90%	Crystalline Si	Titan	ABB	Fixed Tilt	N/A
40	NA	Astonfield Solar(Gujarat) Pvt.Ltd	11.51	16657.661	1447.233797	16.52%	Thin Film	N/A	Schneider Electric	Fixed Tilt	Schneider Electric
41	NA	Responsive SUTIP Ltd	25.06	35726.135	1425.623903	16.27%	Crystalline	LDK	Bonfiglioli	Fixed Tilt	N/A
42	31	Jaihind Project	5	7051.356	1410.2712	16.10%	Crystalline Si	Nantong	Helofax	Fixed Tilt	Self
43	23	LANCO(BHRD)	5	7036.782	1407.3564	16.07%	Crystalline Si	N/A	Helios Systems	N/A	Lanco
44	27	Louroux Bio Energies Ltd.	25	33224.044	1328.96176	15.17%	Thin Film	Tianwei and Sungen	Siemens	Fixed Tilt	Inspira Martifer
45	33	LANCO(Chandiyana)	15.01	19552.677	1302.643371	14.87%	Crystalline Si and Thin Film	Trina/Dupont/CSUN	Bonfiglioli, Eltek, REFUSol	Fixed Tilt	Self
46	34	Arvali Infrapower Ltd.	5	6497.343	1299.4686	14.83%	Crystalline Si	LDK	Eltek	Fixed Tilt	Moser Baer
47	30	CBC Solar Technologies Pvt.Ltd	10	12128.47	1212.847	13.85%	Crystalline Si	Trina	Bonfiglioli	N/A	Moser Baer
		Total(MW)	614.59								

**Table 3 – Ranking of Solar Power Plants outside Charanka Solar Park (2013-14)**

## 2 Year comparison of Performance – 2012-13 vs 2013-14

Data for 2 consecutive years are available for 48 plants and a comparison for the two years is given below. Of the 48 plants, 26 plants have registered an increase in energy generation, while 22 plants have shown a decrease.

Plant	Capacity (MW)	Generation		CUF		Generation Difference	CUF Difference
		2013-14	2012-13	2013-14	2012-13		
Gangesh Green Energy pvt.ltd	25.08	1544.41	1074.46	17.63%	12.27%	469.95	5.36%
Millenium Synergy(Gujarat) pvt.Ltd	9.27	2004.51	1687.08	22.88%	19.26%	317.43	3.62%
Solar Semiconductor Power Company	20	1578.95	1310.27	18.02%	14.96%	268.68	3.07%
AES Solar Energy Gujarat pvt. Ltd	14.92	1631.98	1400.54	18.63%	15.99%	231.44	2.64%
Hiraco Renewable Energy pvt.ltd	20.11	1618.33	1478.39	18.47%	16.88%	139.94	1.60%
Gujarat Mineral Development Company Ltd.	5	1680.31	1586.08	19.18%	18.11%	94.23	1.08%
Lanco Infratech Ltd.	15.01	1446.91	1361.28	16.52%	15.54%	85.64	0.98%
Backbone Enterprises Ltd.	5	1773.45	1690.55	20.24%	19.30%	82.90	0.95%
ESP Urja pvt. Ltd.	5	1735.18	1669.17	19.81%	19.05%	66.01	0.75%
Sand Land Real Estate pvt.ltd	25	1666.68	1602.45	19.03%	18.29%	64.24	0.73%
GMR Gujarat solar power pvt.ltd	25	1702.41	1639.35	19.43%	18.71%	63.06	0.72%
Konark Gujarat PV pvt. Ltd	5	1933.65	1872.20	22.07%	21.37%	61.45	0.70%
GSPC Pipavav Power Company Ltd.	5	1757.32	1714.00	20.06%	19.57%	43.31	0.49%
Jaihind Project	5	1410.27	1375.75	16.10%	15.70%	34.52	0.39%
Welspun Urja Gujarat pvt. Ltd.	15.01	1730.41	1697.24	19.75%	19.37%	33.17	0.38%
LANCO(Chandiyana)	15.01	1302.64	1272.22	14.87%	14.52%	30.42	0.35%
Emami Cement ltd	10.06	1660.19	1631.05	18.95%	18.62%	29.14	0.33%
Visual Percept Solar Projects pvt.Ltd.	25	1560.83	1534.36	17.82%	17.52%	26.47	0.30%
Alex Astral Power pvt.ltd	25.07	1720.54	1701.24	19.64%	19.42%	19.30	0.22%
Roha Dyechem pvt.ltd	25.04	1732.39	1715.95	19.78%	19.59%	16.45	0.19%

Plant	Capacity (MW)	Generation		CUF		Generation Difference	CUF Difference
		2013-14	2012-13	2013-14	2012-13		
Unity Power	5	1880.25	1865.71	21.46%	21.30%	14.54	0.17%
TATA Power Reneable Energy Ltd.	25	1747.92	1735.72	19.95%	19.81%	12.20	0.14%
Moser Baer Energy & Development Ltd	15.02	1641.42	1630.45	18.74%	18.61%	10.98	0.13%
EMCO Ltd	5	1564.69	1557.42	17.86%	17.78%	7.26	0.08%
SEI Solar Power Gujarat pvt.ltd	25.01	1700.03	1696.62	19.41%	19.37%	3.40	0.04%
ICML	9	1642.90	1644.72	18.75%	18.78%	-1.82	-0.02%
ZF Steering Gear (India) pvt.ltd	5	1717.28	1719.79	19.60%	19.63%	-2.51	-0.03%
Palace Solar Energy pvt.ltd	15	1742.38	1744.91	19.89%	19.92%	-2.53	-0.03%
Solitaire Energies pvt.Ltd.	15.01	1599.61	1606.69	18.26%	18.34%	-7.08	-0.08%
Precious Energy Services pvt.Ltd	15.2	1613.61	1626.29	18.42%	18.57%	-12.68	-0.14%
Sun Clean Renewable pvt.ltd	6	1707.92	1723.59	19.50%	19.68%	-15.67	-0.18%
AZURE Power (Gujarat)pvt. Ltd	5	1591.60	1615.79	18.17%	18.45%	-24.19	-0.28%
Mono Steel(India) Ltd	10	1832.17	1864.43	20.92%	21.28%	-32.25	-0.37%
Green Infra Solar Energy Ltd.	10	1668.24	1701.23	19.04%	19.42%	-32.99	-0.38%
Surana Telecom & Power Ltd.	5	1547.08	1582.95	17.66%	18.07%	-35.87	-0.41%
Gujarat Power Corporation Ltd.	5	1551.82	1589.53	17.71%	18.15%	-37.70	-0.43%
Solarfield Energy Pvt. Ltd.	20.06	1658.06	1697.41	18.93%	19.38%	-39.36	-0.45%
GHI Energy pvt. Ltd.	10	1592.45	1633.62	18.18%	18.65%	-41.17	-0.47%
AZURE(Hariyana)	10.21	1662.42	1706.06	18.98%	19.48%	-43.64	-0.50%
Gujarat Industries Power Company Ltd.	5.01	1480.80	1525.36	16.90%	17.41%	-44.57	-0.51%
WAA Solar pvt.Ltd.	10.25	1728.06	1806.42	19.73%	20.62%	-78.36	-0.89%
AEL(Solar)	40.11	1528.62	1608.29	17.45%	18.36%	-79.68	-0.91%
ACME Solar Technology	15	1535.85	1678.73	17.53%	19.16%	-142.87	-1.63%
PLG Photovoltaic Ltd	20	1500.73	1657.02	17.13%	18.92%	-156.29	-1.78%
LANCO(BHRD)	5	1407.36	1564.25	16.07%	17.86%	-156.89	-1.79%



Plant	Capacity (MW)	Generation		CUF		Generation Difference	CUF Difference
		2013-14	2012-13	2013-14	2012-13		
Loavuroux Bio Energies Ltd.	25	1328.96	1507.06	15.17%	17.20%	-178.10	-2.03%
CBC Solar Technologies Pvt.Ltd	10	1212.85	1422.53	13.85%	16.24%	-209.68	-2.39%

**Table 4 – Annual Performance Comparison 2012-13 vs 2013-14**

Gangesh Green Energy has experienced a 5.4 percent point increase in CUF(12.23% to 17.63%), and this massive jump can be attributed to below average performance during the previous year in comparison to the current year. The same explanation applies to 3 other plants among the top 5 gainers – Solar Semiconductor, AES Solar and Hiraco. In the case of Millenium Synergy plant, the increase can be attributed to the fact that the tracking system was fully func-

tional during 2013-14 as against the previous year, when there were teething problems.

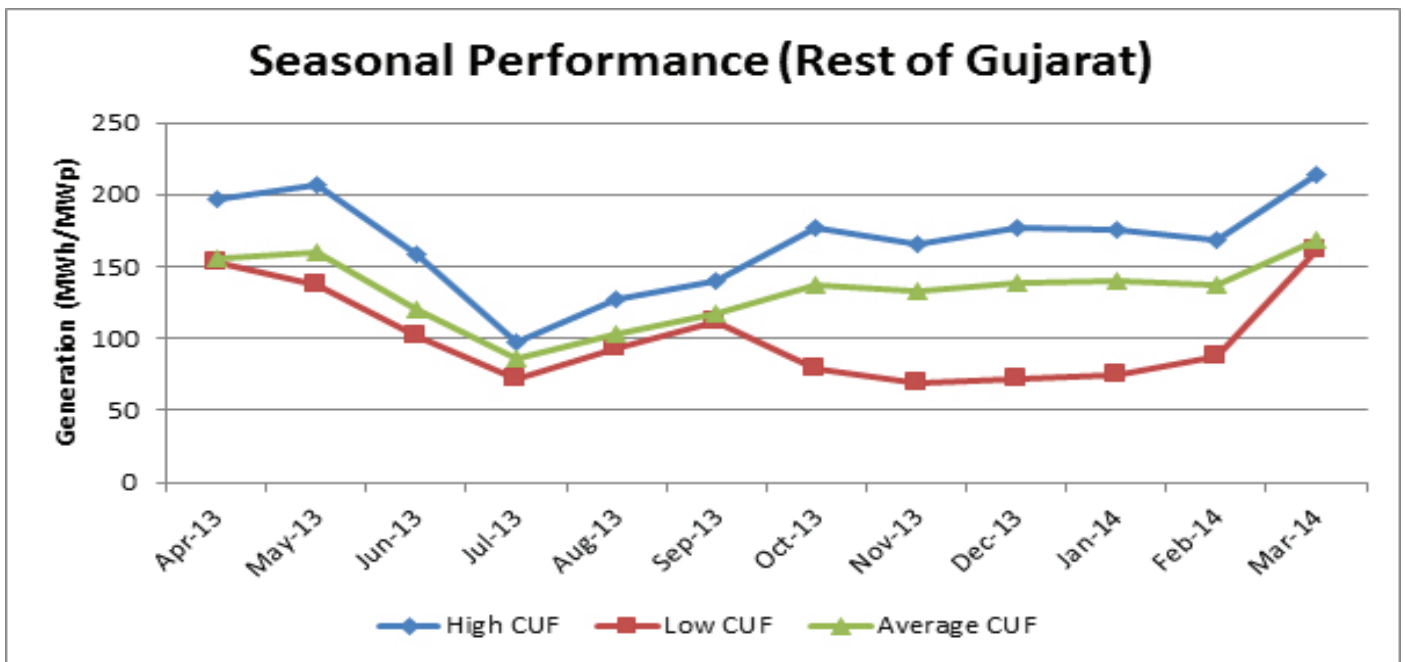
At the other end, the reasons for decrease in the generation are not very clear. The drop could be due to Operation and Maintenance (O&M) related issues.

## Seasonal Characteristics

The seasonal variation graph represented below has been rendered using data from power plants which have completed one year of operation. All numbers in the graph

have been normalized to the total MWh generated per MW of installed capacity.

Figure 2 - Seasonal Performance(Rest of Gujarat)



The plant with the best performance characteristics, Millennium Synergy(Gujarat) Pvt.Ltd, had a peak monthly production of 213.48 MWh/MWp in March 2014. Though this is not a characteristic of all the plants in the sample set, a vast majority had peak production that fell in one of three months – March, April or May.

The highest individual peak generation recorded was 214.69 MWh/MWp by M/s Backbone Enterprises Ltd in the month of May 2013 but the annual production of this plant was lower than the top ranking power plant. Incidentally, the same plant recorded the peak generation seen in a single month in May 2012 (refer RESolve’s

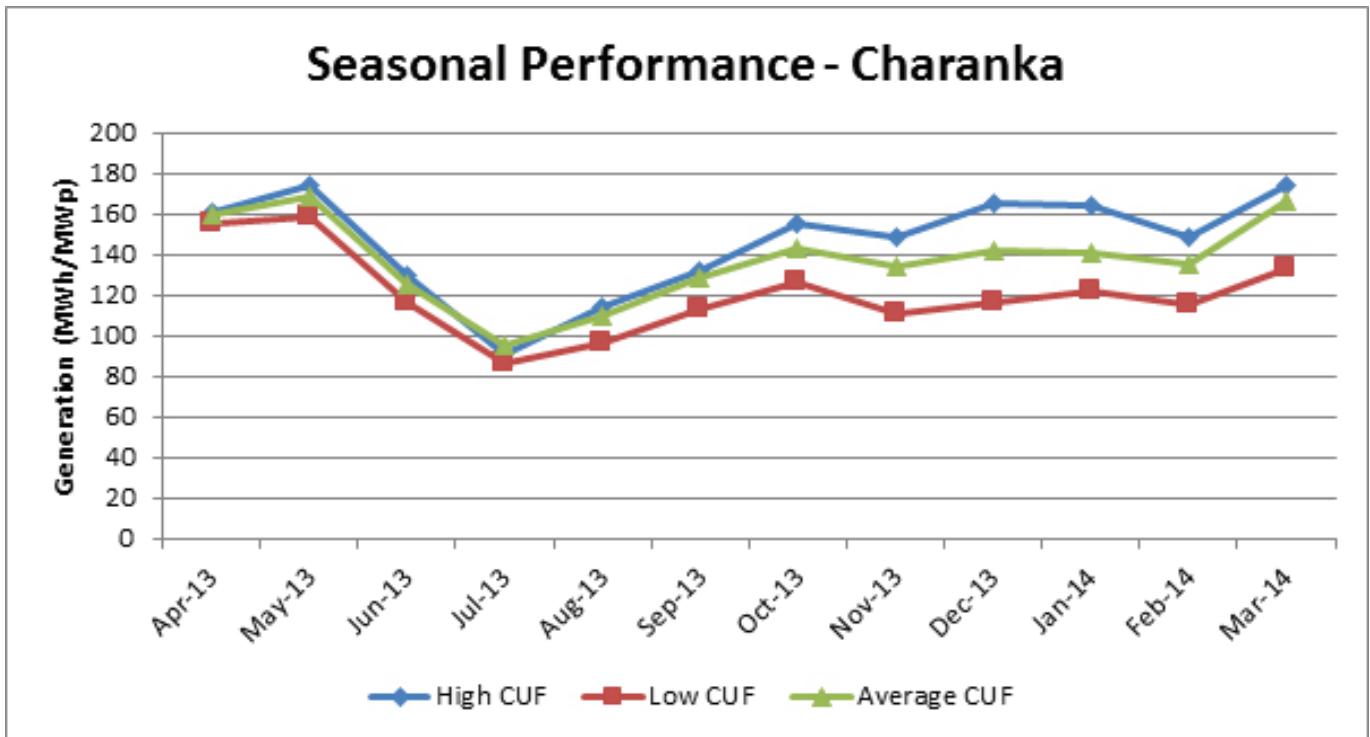
Gujarat Rankings 2012-13).

The lowest generation is merely presented here to provide a representation of the lowest performance and should not be treated as the general performance of power plants in Gujarat. It can be clearly seen that the average performance closely follows the generation characteristic of the best performing power plant in the sample set. The average annual generation is estimated to be 1599.09 MWh/MWp which is up by 17.31 MWh/MWp from last year.

## Seasonal Characteristics – Charanka

The seasonal variation for plants in Charanka is presented below.

Figure 3 - Seasonal Performance - Charanka



The performance of the highest rated power plant can be taken as representative of the performance of all the power plants in the Charanka solar park as the difference between the average value and the highest generation is minimal. Similar to the above scenario, the peak power output for a single month was seen in March 2014. The best performing power plant, GSPC Pipavav Power Company Ltd., had a peak generation of 174.48 MWh/MWp in the month of March 2014 while the highest recorded generation for a given month is 181.92 MWh/MWp generated in May 2013 in the plant owned by Roha Dyechem Pvt. Ltd.

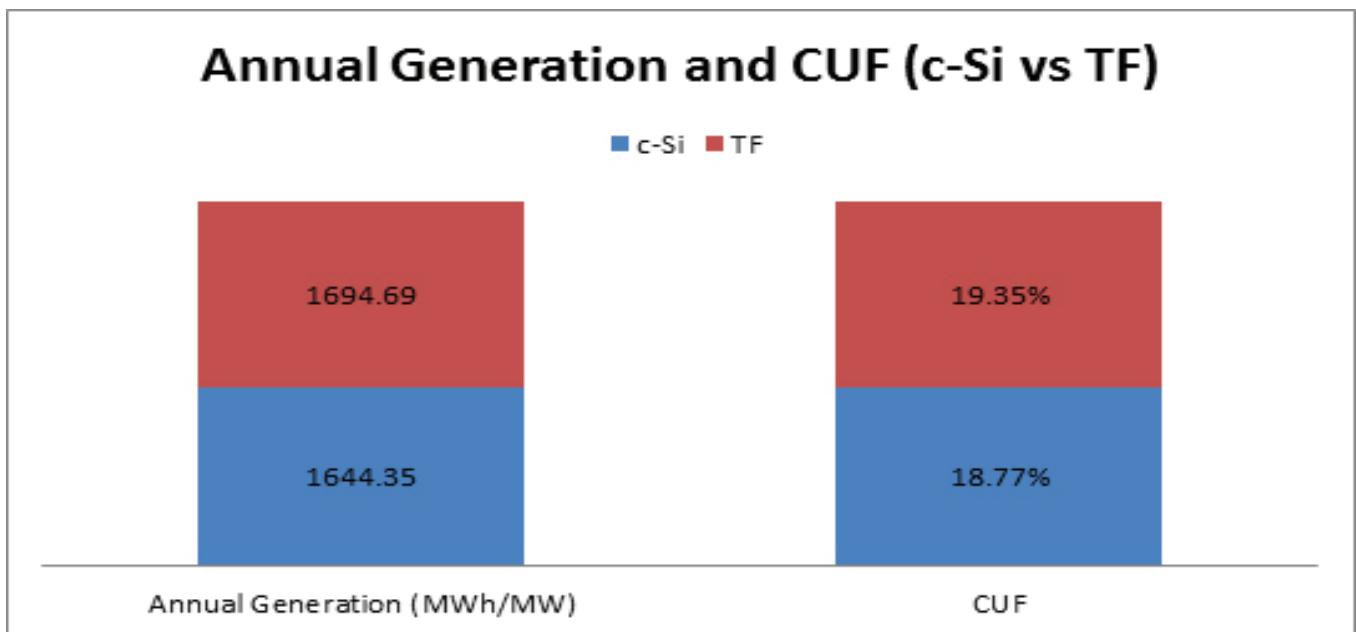
The plant with the lowest CUF for the second year running is the 15 MW plant owned by Lanco Infratech Ltd. Last year, the plant had poor performance in the opening months of operation and we viewed that this was the result of teething issues with the power plant. This year's performance proves that this was indeed the case as the performance of the power plant on a whole was not significantly worse than the average performance (as was witnessed last year). The average yield year is estimated to be about 1647.92 MWh/MWp which is comparatively higher than the average yield seen across the state of Gujarat (non-Charanka average).

## Crystalline Silicon vs. Thin Film Technologies

To identify the difference the choice of the module makes, we looked at the performance of power plants within the same region (only plants in the Charanka Solar Park were chosen) so as to minimize the variations that may be attributed to external factors such as irradiation conditions, grid availability etc. In addition to this, the Charanka solar park has an almost even distribution between c-Si and TF installed capacity.

While analysing the results, it can be seen that the TF modules perform marginally better than the c-Si modules with an average performance advantage of about 0.58%. Last year the difference in performance was about 0.4% in favour of TF modules. It should be noted that the average CUF in both cases (c-Si as well as TF) has increased this financial year compared to last financial year.

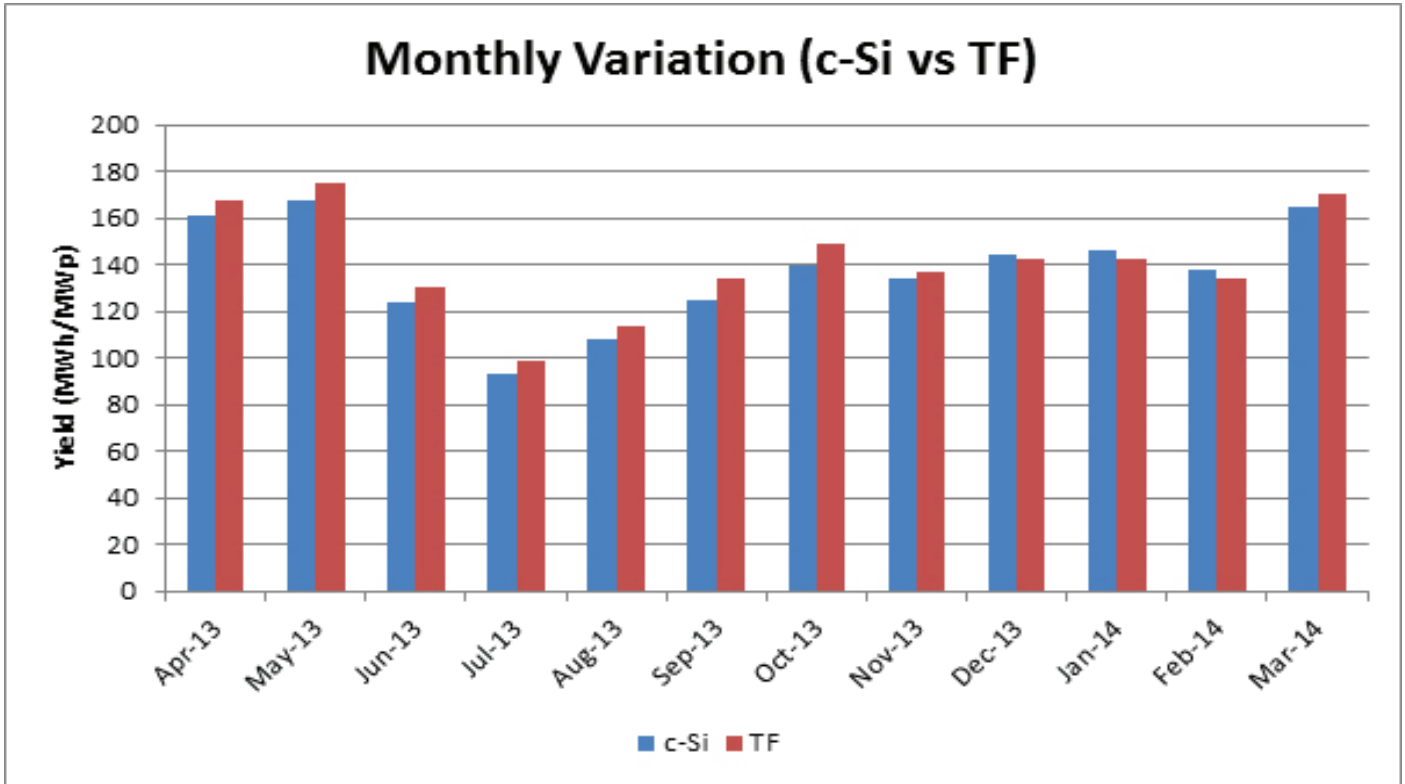
Figure 4 - Annual Generation and CUF (c-Si vs TF)



Looking at the seasonal variation characteristics of the plants (refer graph below), it is easy to spot the difference. Plants using TF modules have higher generation than plants using c-Si modules in hotter months (April to July) while c-Si modules have higher generation in colder

months (Dec to February) which can be attributed to the lower temperature derating coefficient of TF modules compared to c-Si modules (which have a comparatively higher temperature coefficient).

Figure 5 - Monthly Variation (c-Si vs TF)



We would however like to emphasise that the data is not sufficient enough to say one technology is better than the other.

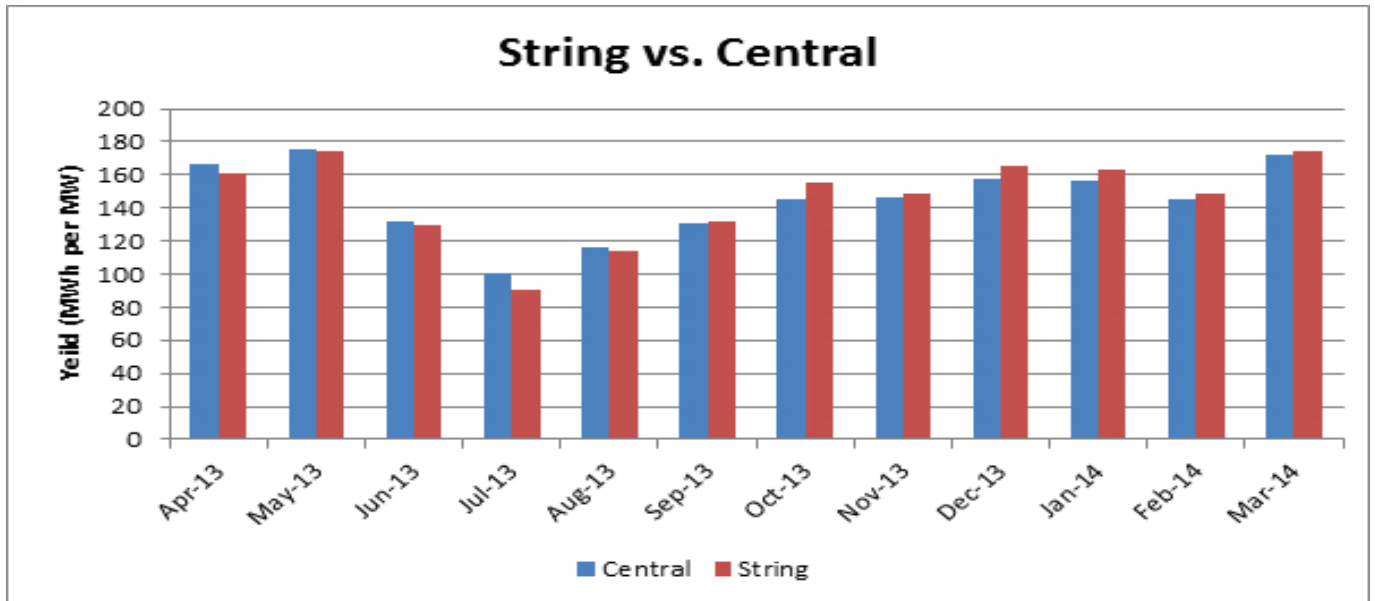
### String inverter vs. Central inverter

Continuing in the similar vein of the TF vs c-Si discussion, we did a brief analysis of the performance of string inverters compared to central inverters. It should be noted that the sample set available for string inverters is minimal and limited to just one in the Charanka solar park.

With this in mind, the average performance of the top central inverter plants was compared to the performance

of the solitary string inverter plant. The only real observation which can be made from this comparison is that the string inverters offer better performance in the winter as opposed to central inverters which can be attributed to the fact that the solar park using string inverters has more MPPTs and hence a better MPPT window when compared to plants using central inverters.

Figure 6 - String Vs Central Inverter



# Correlation of Plant Performance with Solar Irradiation and Meteorological Parameters



## Seasonal Characteristics – Charanka

Plant performance is almost directly dependent on the solar radiation incident on an array. Thus, any estimate of plant performance ought to take into consideration the solar irradiation incident at the tilt of the array, and how efficiently that radiation is converted into energy.

In addition, local environmental conditions like the presence of a water body, dust, relative humidity, wind, and ambient temperature also affect the performance of a solar power plant. We know only too well the effect of dust on power production of solar plants in Rajasthan and the unanticipated costs associated with cleaning of panels. Likewise, high ambient temperatures are not always predictive of high performance and module performance starts to decrease with high temperature depending upon the panel technology as we see in plants in Northern India. Wind also impacts the performance of solar power plants and their impact will come to light with time as data from plants in coastal regions of Tamil Nadu become available.

In India, a large scale analysis of plant performance has not taken into account environmental parameters. Instead, plant performance measures are based on Capac-

ity Utilization Factor (CUF), which is a crude estimate, at best, of a plant's output with respect to the total installed capacity.

Part of the reason for not taking into account weather and environmental parameters is the paucity of accurate solar radiation data (and weather parameters to a smaller extent) in India. Solar radiation maps based on satellite model outputs like the one on page 1 of this report are low resolution and have attendant uncertainties of 15-20%. Ground measurements of solar radiation and weather parameters remain the gold standard of benchmarking plant performance. As India sets up its solar radiation measurement network, estimates of solar resource and energy output will become accurate.

At BKC WeatherSys, we have a growing database of on-site measurements of solar radiation and weather parameters across India, and have developed a solar radiation forecasting model with accuracies in the range of 5-10%. In this white paper, we present an analysis of solar power plant performance in Gujarat with respect to solar radiation and other meteorological parameters using our data sources and forecasting models.

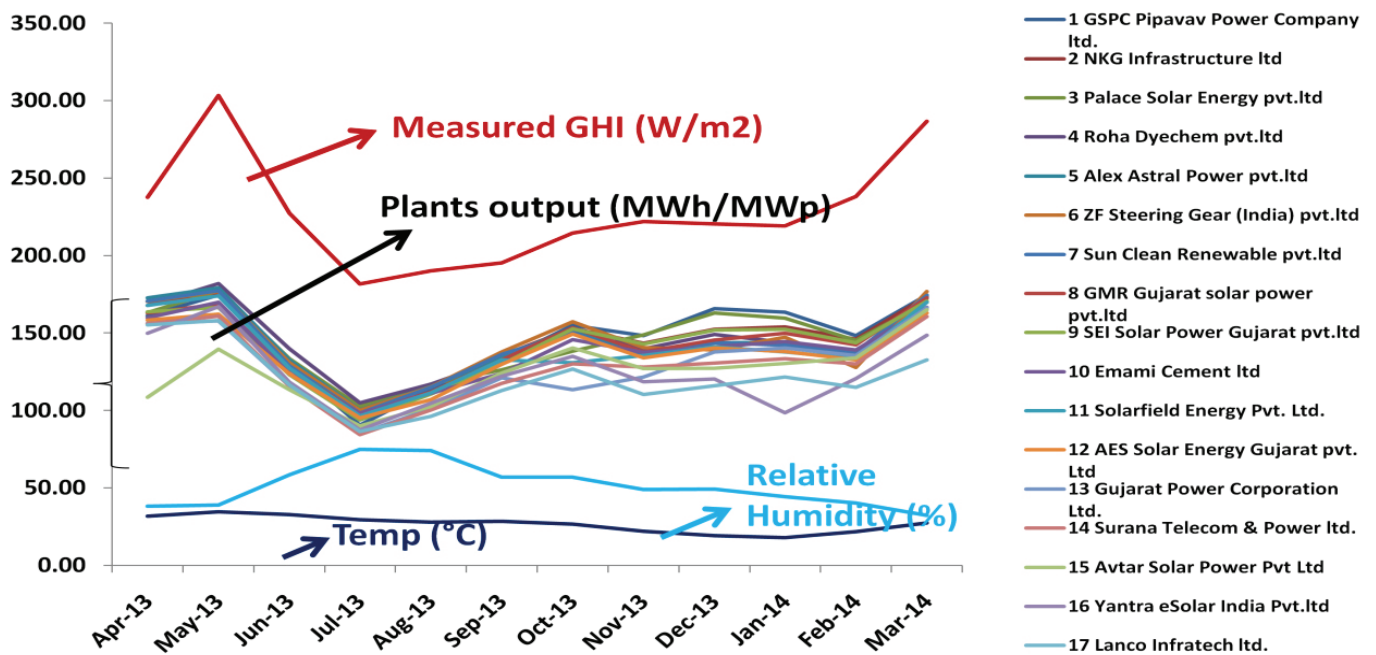
## Performance of Power Plants in Charanka

Plant output from Charanka solar park presents a good data set to evaluate performance as solar radiation and meteorological parameters should be comparable across the sites. We analyzed the performance of 17 plants in

Charanka with respect to ground measurements of Global Horizontal Irradiance (GHI), Ambient Temperature and Relative Humidity for the period between April 2013 to March 2014 (Figure 1). Here are the results:



**Figure 7 - Plant Output versus Solar Irradiance and Other Meteorological Parameters at Charanka**



### A. Energy Production is correlated to Solar Irradiance (GHI)

As is evident from Figure 1, plant output is directly correlated with incoming solar irradiance, with almost all plants showing maximum energy yield in May when the average monthly GHI reached a peak of ~300 W/m2. Inversely, the period of lowest plant output is directly related to lowest average monthly GHI of ~180 W/m2 observed in July.

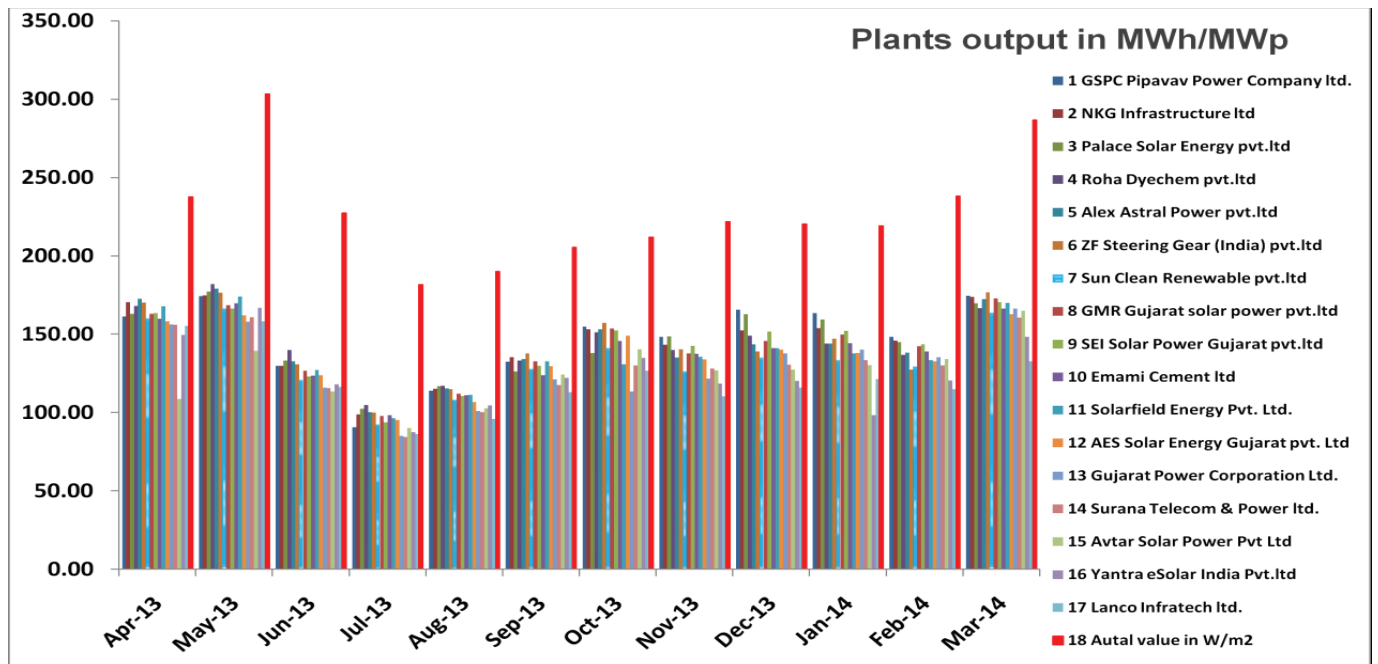
A handful of plants (GMR, SEI, AES, GPCL, and Avtar) show a slightly higher yield in March versus May. This may represent better performance of modules when the ambient temperature is closer to 27 °C, as opposed to 35 °C in May.

### B. Winter Months are the most “Efficient” months for Energy Production

If performance were to be viewed grossly as a percentage of energy production versus solar irradiance, the months of December and January are the most “efficient” months for power production for all plants in Charanka. Almost all plants in Charanka start producing more energy in November, with a second peak in output observed in December and January.

Energy production does not seem to scale proportionally with GHI once ambient temperatures exceed ~25 °C. One reason for this could be that module performance is higher when ambient temperatures are close to or below 20 °C in winter versus ambient temperatures of 27-35 °C during summer.

**Figure 8 - Average Monthly Variation in Solar Irradiance versus Plant Output at Charanka**



**Figure 9 - Measured Solar Irradiance and Other Meteorological Parameters at Charanka.**

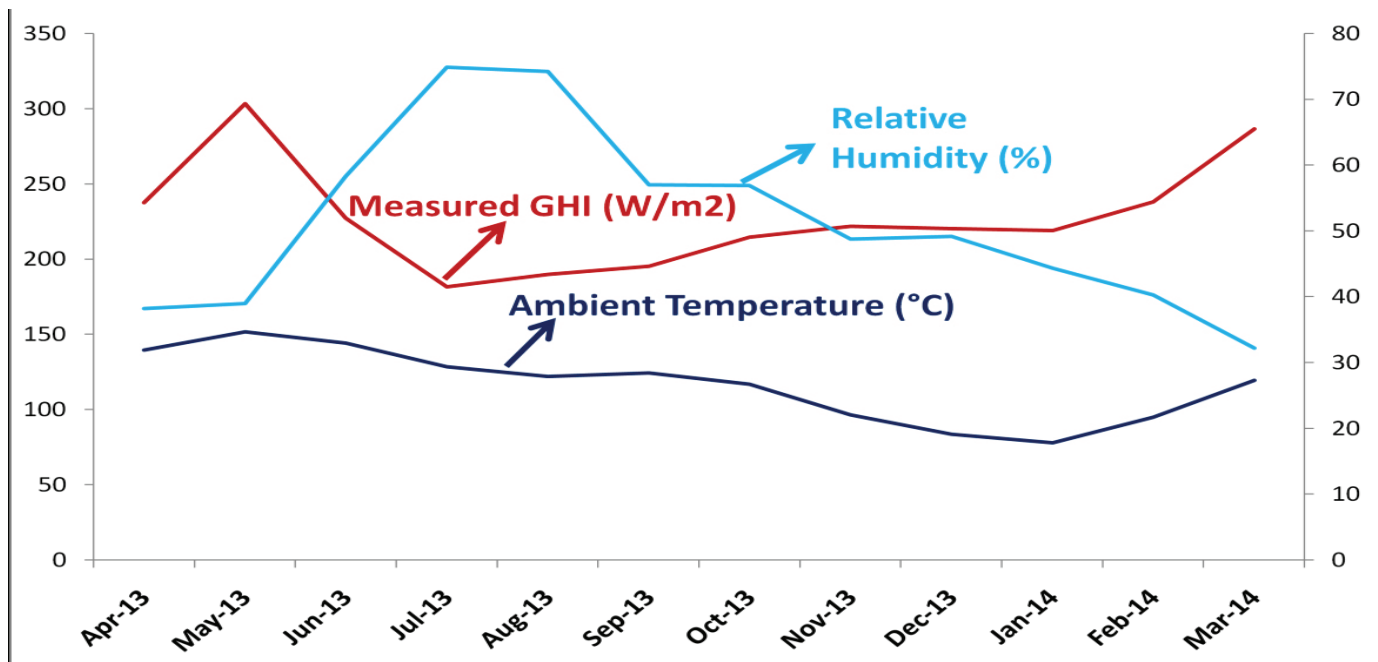


Figure 10 - Plant Output versus GHI and Ambient Temperature at Charanka

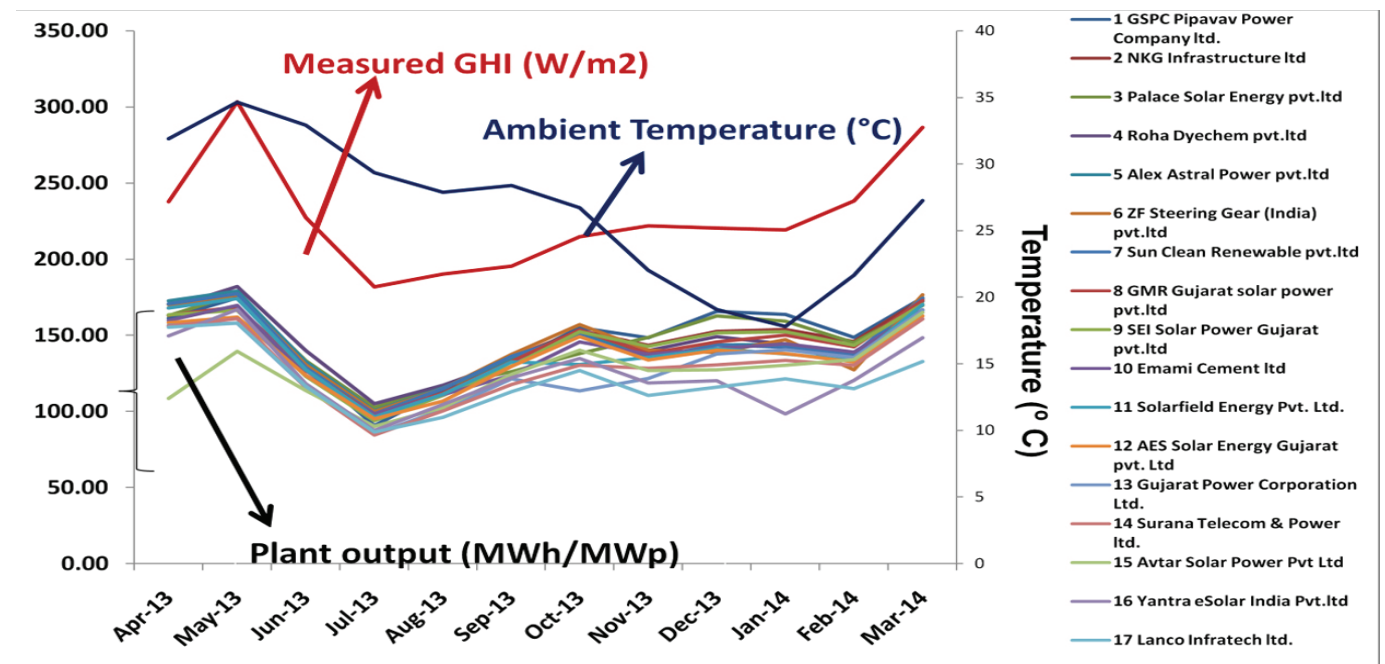
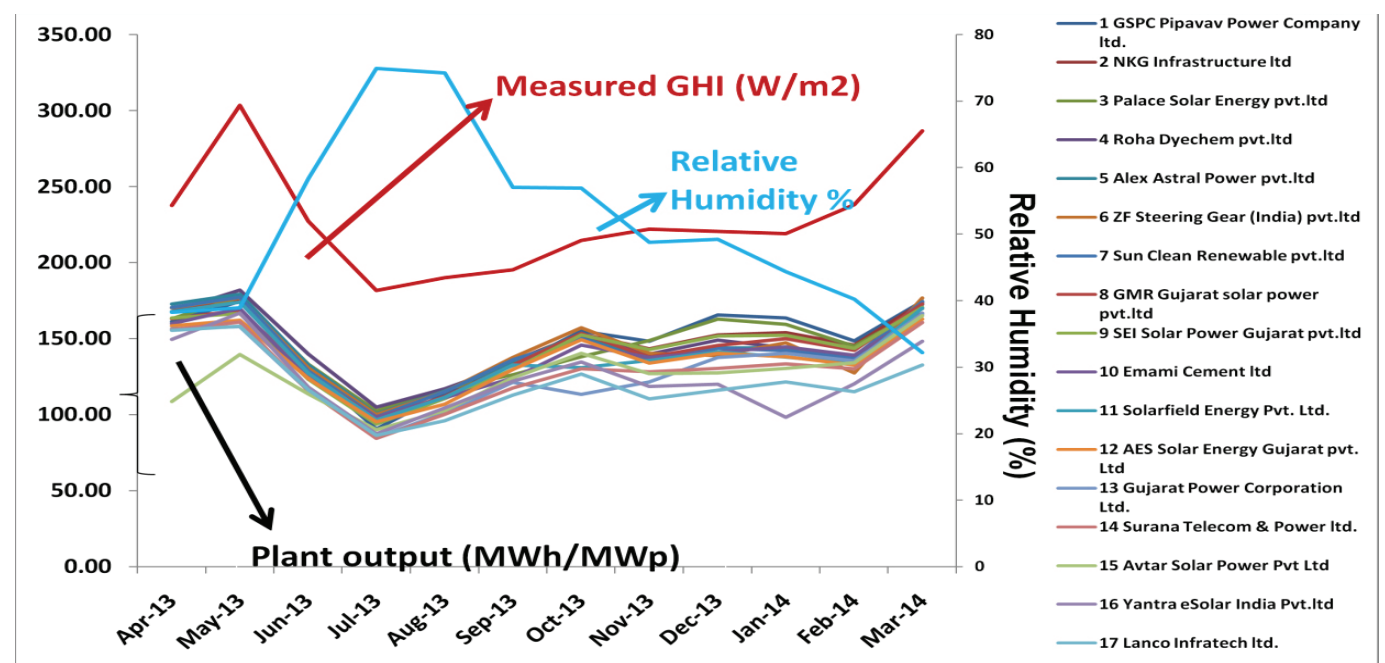


Figure 11 - Plant Output versus GHI and Relative Humidity at Charanka





We have observed that back of module temperatures can be almost 15-18 °C higher than ambient temperature, reducing module efficiency and hence power output. We tried to compare module technologies with respect to performance at different temperatures but no clear conclusions could be made with the data at hand.

A second reason for enhanced “efficiency” during December and Januarys could be that the tilt angle of panels are optimized for the winter season in these plants. Tilt angle data from plants can help refine these results fur-

ther. But with the currently available data, it is clear that the top performing plant (GSPC Pipavav Power Company) appears to have optimal module technology, design, as well as tilt angle for their location. Conversely, plants like 5, 6, 7, perform better in the summer versus winter suggesting there is scope for improved performance in the winter months, perhaps via optimization of the tilt angle. However, we do want to point out that these analyses remain surmises without more specific data on tilt angles and plant design.

### C. High Relative Humidity Reduces Energy Production

The energy output of all solar power plants in Charanka is highest when the relative humidity is below ~38%, and energy production is lowest when the relative humidity exceeds ~75% as seen in June (Figures 1, 3, 5). These data establish that relative humidity directly affects performance of solar power plants in Charanka. Low relative humidity enhances module performance which essentially means that the lower the water vapor in air, higher the

solar flux and consequently energy production. Water vapor and humidity act like dust, affecting solar PV module performance in ways comparable to dust. Periods of high humidity could also be correlated to periods of rain. Unfortunately, in our experience, most solar plants do not measure rainfall, thus leaving out a key parameter in predicting plant performance.

### Regional Variation of Plant Performance with Solar Radiation and Other Meteorological Parameters in Gujarat.

To the best of our knowledge, there hasn't been a published analysis of solar irradiance and local weather conditions within the different regions in Gujarat. As the availability of solar energy is affected by latitude, longitude, elevation, and local weather conditions, we compared irradiation and meteorological parameters for plant sites in five different districts of Gujarat.

We chose the five districts in Gujarat that have the highest number of solar power plants to date: Surendranagar, Kutch, Patan, Rajkot, and Porbander. Modeled GHI, ambient temperature and relative humidity values for sites these five districts have been compared in Figures

Figure 12 - Variation in Solar Irradiance (GHI) at Different Locations in Gujarat

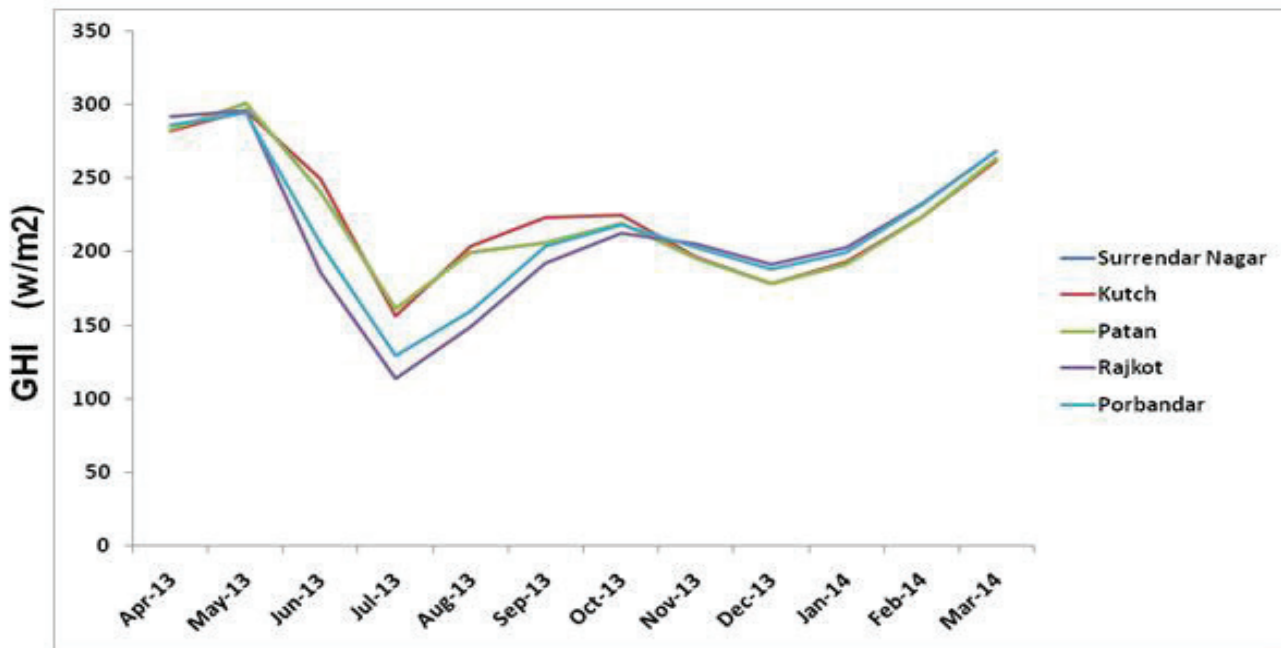
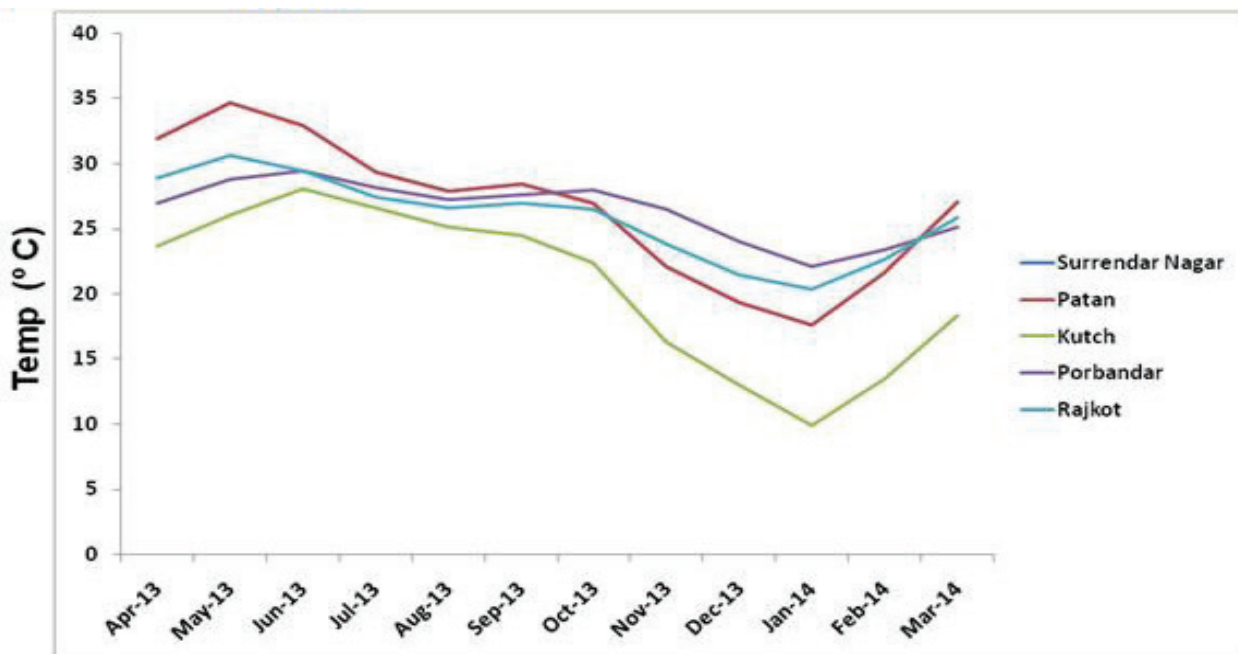
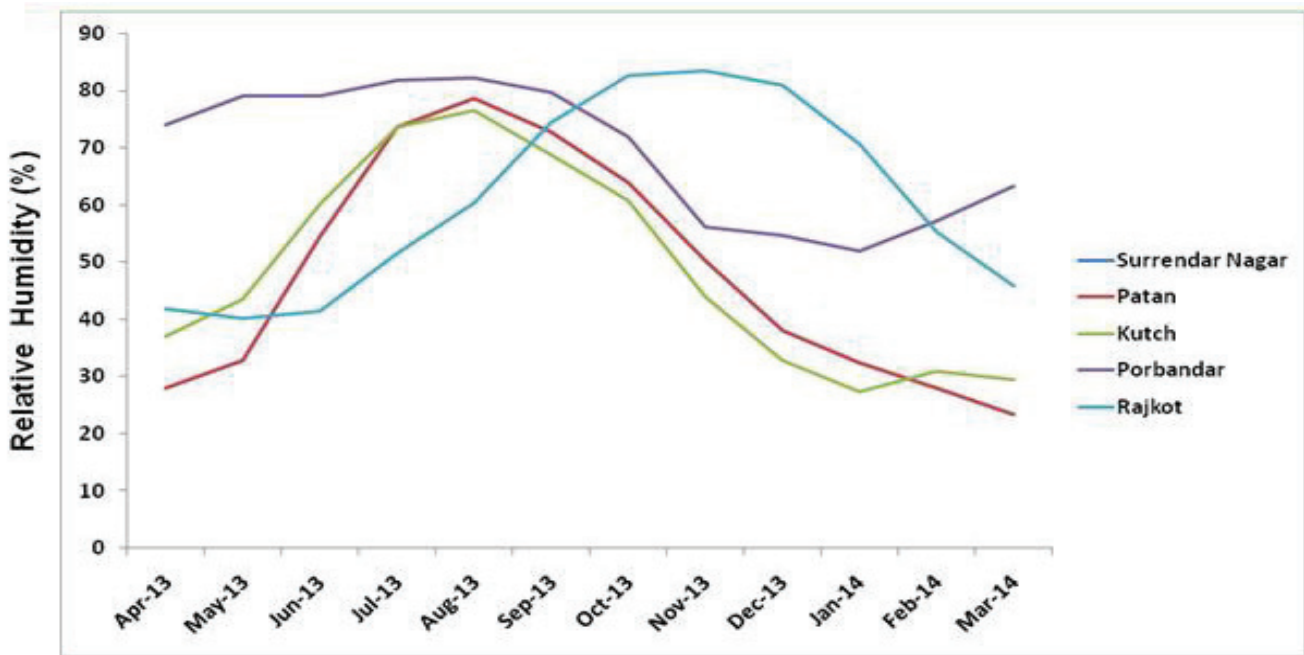


Figure 13 - Variation in Ambient Temperature at Different Locations in Gujarat



**Figure 14 - Variation in Relative Humidity at Different Locations in Gujarat**



Of these five districts, Kutch appears to be the district with optimal environmental conditions for solar power generation: a. GHI values are amongst the highest (Figure 1); b. Ambient temperatures are below 25 °C for almost the entire year, saving the summer months of May, June and July. Even then, temperatures did not exceed the peak of ~27 °C observed in June. These temperatures are close to or within the temperature range of the Standard Test Conditions (STC) specified by most module manufacturers, ensuring high module performance. Lastly, Kutch also appears to have lower values of relative humidity than the other four sites for most of the year. It is no surprise then that 3 of the top five performing plants in this report are in Kutch. While there are multiple contributing factors for performance, local environmental and weather conditions seem to have a significant impact on plant performance.

GHI values are then highest in Surendranagar and Patan. Two of the top ten plants in Gujarat included in this report are in Surendranagar. Porbandar and Rajkot appear

to have relative humidity levels in excess of 75% for a large portion of the year.

This analysis only provides a window into showing how meteorological and local environmental conditions may affect energy production. A limitation of the above analysis is that we have used data for a specific site/lat-long in a district, and single site analysis cannot be extended to covering the larger districts in Gujarat. A report of plant output versus meteorological parameters for each plant location is required to arrive at definitive conclusions regarding design, location and performance. While we have characterized plant outputs against ground measurements of solar and weather parameters at multiple sites across Gujarat (similar to the analyses done for Charanka with ground measurements), these analyses are beyond the scope of this white paper. Nevertheless, in summary, we can safely conclude that energy yields of plants in Gujarat vary not only according to plant design and technology, but local weather and environmental conditions can have significant impact on plant output.



Sunrise  
in Gujarat



## Conclusion



## Conclusion

This year's list has seen the addition of 14 power plants to the rankings bringing the total number to 64 up from 50 we had the previous year. The most encouraging fact is that about 60% of the plants that feature in the list have an average Capacity Utilization Factor (CUF) of over 18% which conforms to the guidelines seen in most bidding documents in the country.

The top performing power plant in this year's list – Millenium Synergy(Gujarat) Pvt. Ltd. has a CUF of about 23% which is close to the upper bound set by most regulators. The primary reason for the high CUF of the top performing plants is that these power plants used some form of tracking mechanism with Millenium Synergy opting to go for a single axis tracking mechanism. The top plants with tracking systems installed have about 2% better CUF compared to the highest ranked non-tracking based plant.

22 of the 48 of the plants (plant's whose performance data is available in full for two years) in the list posted an increase in CUF compared to last year's numbers. The plant that made the biggest gain was Gangesh Green Energy whose CUF increased by 5.36 percentage points. The highest ranking plant - Millenium Synergy posted a CUF gain of 3.62 percentage points – likely because minor issues with their tracking systems have been ironed out.

Similar to last year, Thin Film(TF) based power plants posted a CUF which was slightly (about 0.5 percentage points) higher than c-Si based power plants. It was expected that most TF might post lower numbers this year since TF modules are usually (electrically) overrated and their performance dips during the first year of operations. However, the CUF numbers posted by the TF based power projects this year suggests that this is not really the case as in most scenarios the TF modules posted similar or higher numbers compared to last year with the average CUF of TF plants actually ending up higher (0.6 percentage points higher) than the previous year.

BKC WeatherSys' analysis has provided some insight into how factors such as temperature, relative humidity etc. correlate with energy generation. Their analysis showed that there is a direct correlation between GHI and energy generation (as expected). While the effect of temperature on plant performance was already discussed, this analysis also provided some significant insight on how relative humidity affects plant performance. The conclusion was that the higher the relative humidity in the region, the lower the yield.

One of the findings based on the study of the weather data is that Kutch appears to be the most ideal location for setting up a solar power plant as the ambient temperatures are below 25 °C (almost throughout the entire year) and also because the region has lower levels of relative humidity numbers posted through the year. These are likely to be the reasons which could explain why three of the top five plants in this year's list are located in Kutch.



Annexure A - Details of Solar Power Project Developers who have signed PPA

Table 5 - Project developers in Gujarat

Sl.No.	Name	MW
1	Aatash Power Pvt Ltd	5
2	Abellon Cleanenergy Limited	3
3	ACME Tele power Ltd	15
4	Adani Power Ltd	40
5	AES Solar Energy Gujarat Pvt Ltd	15
6	Alex Astral Power Pvt Ltd	25
7	Ambit Advisory Services Pvt Ltd	5
8	APCA Power Private Limited	5
9	Aravali Infrapower Limited	5
10	Astonfield Renewable Resources	11.5
11	Avatar Solar	5
12	Azure Power (Gujarat) Pvt Ltd	5
13	Azure Power (Haryana) Pvt Ltd	10
14	Backbone Enterprises Limited	5
15	Cargo Motors (Tata)	25
16	Claris LifeScience Ltd	2
17	Common Wealth Business Technologies	10
18	Corner Stone Energy Pvt Ltd	5
19	Driesatz My Solar	15
20	EI Technologies Pvt. Ltd	1
21	Emami Cement Limited	10
22	EMCO Limited	5
23	ESP Urja	5
24	Essar Power Limited	1
25	Euro Solar Private Ltd	5
26	Ganeshvani Merchandise Private Limited	5
27	Ganges Green Energy Private Limited	25
28	GHI Energy Private Limited	10
29	GMR Gujarat Solar Power Pvt. Ltd	25
30	Green Infra Solar Energy Limited	10
31	GSPC Pipavav Power Company Limited	5
32	Gujarat Industries Power Company Limited	5
33	Gujarat Mineral Development Corporation Limited	5
34	Gujarat Power Corporation Limited	5
35	Harsha Engineers Limited	1
36	Hiraco Renewable Energy Pvt Ltd	20

Sl.No.	Name	MW
37	India Solar Ray Power Private Limited	10
38	Industrial Power Infrastructure Limited	25
39	Inspira Solar (Palace)	15
40	Integrated Coal Mining Limited	9
41	Jaihind Projects Limited	5
42	Kemrock Industries and Exports Limited	10
43	Kiran Energy Solar Power Private Limited	20
44	Konark Gujarat PV Pvt. Limited	5
45	Lanco Infratech Ltd	5
46	Lanco Infratech Ltd	15
47	Lanco Infratech Ltd	15
48	Louroux Bio Energies Limited[72]	25
49	MBH Power Private Limited	1
50	Mi My Solar	15
51	Millenium Synergy (Gujarat) Private Limited	10
52	Monnet Ispat & Energy Limited	25
53	Mono Steel (India) Ltd.	10
54	Moser Baer Energy & Development Ltd	15
55	NKG Infrastructure Limited	10
56	PLG Power Ltd	40
57	Precious Energy Services Pvt Ltd	15
58	Rajesh Power Services Private Limited	1
59	Rasna Marketing Services LLP	1
60	Responsive Sutip Limited	25
61	Roha Energy Private Limited	25
62	S J Green Park Energy Private Limited	5
63	Sand Land Real Estates Pvt Ltd	25
64	Saumya Construction Pvt Ltd	2
65	Solar Semiconductor Pvt Ltd	20
66	Solitaire Energies Pvt Ltd	15
67	Som Shiva Impex Limited	1
68	Sun Edison Energy India Private Limited	25
69	SunBorne Energy[87]	15
70	SunClean Renewable Power Pvt. Ltd.	25
71	Sunkon Energy Pvt Ltd	10
72	Surana Telecom & Power Limited	5
73	Tatith Energy	5
74	Taxus infrastructure & Power Project Pvt Ltd	5
75	Toss Financial Services Pvt Ltd	2
76	Ujjawala Power Pvt Ltd	25

Sl.No.	Name	MW
77	Unity Power Pvt Ltd	5
78	Universal Solar System	2
79	Visual Percept Solar Projects Private Limited	25
80	WAA Solar Pvt Ltd	10
81	Welspun Urja India Limited	15
82	Yantra eSolarIndia Private Limited	5
83	Zeba Solar Gujarat Pvt Ltd	10
84	ZF Steering Gear (India) Limited	5

(Source: Gujarat Energy Development Agency - GEDA)

## Annexure B - Gujarat commissioning status

The commissioning of these projects as of 31 March 2014 is given below.

**Table 6 - Solar plants in Gujarat**

Sl.No.	Name	MW
1	Aatash Power Pvt.Ltd	4.99
2	Abellon Clean Energy Ltd.	3
3	ACME Solar Technology	15
4	AEL(Solar)	40.11
5	AES Solar Energy Gujarat pvt. Ltd	14.92
6	Alex Astral Power pvt.ltd	25.07
7	APCA Power Pvt.Ltd	5
8	Arvali Infrapower Ltd.	5
9	Astonfield Solar(Gujarat) Pvt.Ltd	11.51
10	Avtar Solar Power Pvt Ltd	4.98
11	AZURE Power (Gujarat)pvt. Ltd	5
12	AZURE(Hariyana)	10.21
13	Backbone Enterprises Ltd.	5
14	CBC Solar Technologies Pvt.Ltd	10
15	Chattel Constructions Pvt.Ltd	25.04
16	Claris Lifesciences Ltd.	1.99
17	Dreisatz My Solar24 Pvt.Ltd.	14.99
18	EI Technologies Pvt. Ltd.	1
19	Emami Cement Ltd	10.06
20	EMCO Ltd	5
21	ESP Urja pvt. Ltd.	5
22	Essar Power Ltd.	1
23	Euro Solar Power Pvt. Ltd	5.12
24	Ganeshvani Merchandise Pvt. Ltd	5.04
25	Gangesh Green Energy pvt.ltd	25.08
26	GHI Energy pvt. Ltd.	10
27	GMR Gujarat solar power pvt.ltd	25
28	Green Infra Solar Energy Ltd.	10
29	GSPC Pipavav Power Company Ltd.	5
30	Gujarat Industries Power Company Ltd.	5.01
31	Gujarat Mineral Development Company Ltd.	5
32	Gujarat Power Corporation Ltd.	5
33	Gujarat State Electricity Corporation Ltd.-Canal	1.01

34	Gujarat State Electricity Corporation Ltd.-TPS	1
35	Harsha Engineers	1
36	Hiraco Renewable Energy pvt.ltd	20.11
37	ICML	9
38	Jaihind Project	5
39	Konark Gujarat PV pvt. Ltd	5
40	Lanco Infratech Ltd.	15.01
41	LANCO(BHRD)	5
42	LANCO(Chandiyana)	15.01
43	Louroux Bio Energies Ltd.	25
44	MBH Power Pvt. Ltd.	1
45	MI MySolar24 (P) Ltd,	14.99
46	Millenium Synergy(Gujarat) pvt.Ltd	9.27
47	Mono Steel(India) ltd	10
48	Moser Baer Energy & Development ltd	15.02
49	NKG Infrastructure ltd	10
50	Palace Solar Energy pvt.ltd	15
51	PDP-UP-GPCL-GEDA	1
52	PLG Photovoltaic Ltd	20
53	Precious Energy Services pvt.Ltd	15.2
54	Rajesh Power Services Pvt. Ltd.	1
55	Rasna Marketing Services LLP	1
56	Responsive SUTIP Ltd	25.06
57	Roha Dyechem pvt.ltd	25.04
58	S J Green Park Energy Pvt.Ltd	5.12
59	Sand Land Real Estate pvt.ltd	25
60	SEI Solar Power Gujarat pvt.ltd	25.01
61	Solar Semiconductor Power Company	20
62	Solarfield Energy Pvt. Ltd.	20.06
63	Solitaire Energies pvt.Ltd.	15.01
64	Som Shiva (Impex) Ltd.	1
65	Sun Clean Renewable pvt.ltd	6
66	SunBorne Energy Gujarat One Pvt.Ltd	15
67	Sunkon Energy Pvt.ltd	10
68	Surana Telecom & Power Ltd.	5
69	TATA Power Reneable Energy Ltd.	25
70	Taxus Infrastructure & Power Project Pvt.Ltd	5
71	Ujjawala Power Pvt Ltd	23.06
72	Unity Power	5
73	Universal Solar System	2
74	Visual Percept Solar Projects pvt.Ltd.	25

75	WAA Solar pvt.Ltd.	10.25
76	Welspun Urja Gujarat pvt. Ltd.	15.01
77	Yantra eSolar India Pvt.ltd	4.95
78	ZF Steering Gear (India) pvt.ltd	5
	Total	857.31

(Source : Gujarat Energy Development Agency – GEDA and SLDC Gujarat)

## About Us

BKC WeatherSys Pvt. Ltd. is an advanced technology company specializing in solutions for meteorology and environmental monitoring. We offer Turn-key Solutions for Integrated Solar Weather Monitoring across the solar energy project lifecycle: from site assessment to monitoring plant efficiency and forecasting of solar radiation. Our solar radiation and weather monitoring systems are installed and operational in over 60 sites India. We are an ISO 9001:2008 certified company.

## Our Clients

Our clients span the globe and include First Solar, Reliance Energy, Refex, Enfinity, and institutions like India Meteorology Department (IMD), Indian Space Research Organization (ISRO), the Indian Air Force, Indian Army, Indian Navy, National Aeronautics and Space Administration (NASA, USA) and the National Oceanic and Atmospheric administration (NOAA, USA).

## Disclaimer

We have taken the best care to ensure accuracy of the analysis presented in research work. However in the unlikely event of any discrepancy, you are requested to kindly bring it to our notice.

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## About us

RESolve Energy Consultants is a renewable energy advisory firm based in Chennai, India. RESolve has advised clients across the entire PV value chain – PV manufacturing, Balance of Systems, Project development. RESolve has also assisted North American and European companies in their market entry to the Indian solar sector. More details about the company can be found at [www.re-solve.in](http://www.re-solve.in)

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