An Energy Audit on Gujarat Solar Plant Charanka

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Abstract— Global environmental concerns and the escalating demand for energy, coupled with steady progress in renewable energy technologies, are opening up new opportunities for utilization of renewable energy resources. Solar energy is the most abundant, inexhaustible and clean of all the renewable energy resources till date. The power from sun intercepted by the earth is about 1.8 × 1011 MW, which is many times larger than the present rate of all the energy consumption. Photovoltaic technology is one of the finest ways to harness the solar power. This paper reviews the photovoltaic technology, its power generating capability, the different existing light absorbing materials used, its environmental aspect coupled with a variety of its applications. In this paper discuss Gujarat solar plant (Harsha Abakus Solar Private Limited) and energy audit in this plant.
Key words: Solar Energy; Renewable Energy Economics and Policies; Climate Change

I. Introduction

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever evolving technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power.[1] Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy[2]. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air. The large magnitude of solar energy available makes it a highly appealing source of electricity[3]. The United Nations Development Programme in its 2000 World Energy Assessment found that the annual potential of solar energy was 1,575–49,837 exa joules (EJ). This is several times larger than the total world energy consumption, which was 559.8 EJ in 2012. In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits[4]. It will increase countries' energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared"[5].

A. *Advantages of Solar Power*

- Solar energy is a clean and renewable energy source.
- Once a solar panel is installed, solar energy can be produced free of charge.
- Solar energy will last forever whereas it is estimated that the world's oil reserves will last for 30 to 40 years.
- Solar energy causes no pollution.
- Solar cells make absolutely no noise at all. On the other hand, the giant machines utilized for pumping oil are extremely noisy and therefore very impractical.
- Very little maintenance is needed to keep solar cells running. There are no moving parts in a solar cell which makes it impossible to really damage them.
- In the long term, there can be a high return on investment due to the amount of free energy a solar panel can produce, it is estimated that the average household will see 50% of their energy coming in from solar panels.

B. *Disadvantages of Solar Power*

- Solar panels can be expensive to install resulting in a time-lag of many years for savings on energy bills to match initial investments.
- Electricity generation depends entirely on a countries exposure to sunlight; this could be limited by a countries climate.
- Solar power stations do not match the power output of similar sized conventional power stations; they can also be very expensive to build.
- Solar power is used to charge batteries so that solar powered devices can be used at night. The batteries can often be large and heavy, taking up space and needing to be replaced from time to time.

C. *Some of Applications of Solar Energy*

1) *Power Plants*

In conventional power plants non-renewable energy sources are used to boil water and form stream so that turbines can rotate and water to produce electricity. But with application of solar energy heat of sun can boil that water to create steam and rotate turbines. To convert sunlight into electricity solar panels, photoelectric technologies and thermoelectric technologies etc. are used.

2) *Homes*

Use of solar energy is increasing in homes as well. Residential appliances can easily use electricity generated through solar power. Besides this solar energy is running solar heater to supply hot water in homes. Through photovoltaic cell installed on the roof of the house energy is captured and stored on batteries to use throughout the day at homes for different purposes. In this ways expenditure on energy is cutting down by home users.

3) *Commercial use*

On roofs of different buildings we can find glass PV modules or any other kind of solar panel. These panels are used there to supply electricity to different offices or other parts of building in a reliable manner. These panels collect solar energy from sun, convert it into electricity and allow offices to use their own electrical power for different purposes.

4) Ventilation System

at many places solar energy is used for ventilation purposes. It helps in running bath fans, floor fans, and ceiling fans in buildings. Fans run almost every time in a building to control moisture, and smell and in homes to take heat out of the kitchen. It can add heavy amount on the utility bills, to cut down these bills solar energy is used for ventilation purposes.

5) Power Pump

solar power not just help in improving ventilation system at your homes but with that it can also help in circulating water in any building. You can connect power pump with solar power supply unit but you must run it on DC current so that water circulate throughout your home.

6) Swimming Pools

Swimming pools are great joy for kids and adults in all seasons. But during winters it is tough to keep water hot in these pools with minimum power usage. Solar energy can help many in this matter as well. You can add a solar blanket in the pool that will keep the water hot with energy generated from sunlight. Besides this you can install a solar hot water heating system with solar hot water heating panels.

7) Solar Lighting

These lights are also known as day lighting, and work with help of solar power. These lights store natural energy of sun in day time and then convert this energy into electricity to light up in night time. Use of this system is reducing load form local power plants.

8) Solar Cars

It is an electrical vehicle which is recharged form solar energy or sunlight. Solar panels are used on this car that absorb light and then convert it into electrical energy. This electrical energy is stored in batteries used with the car, so that in night time as well we can drive these vehicles.

9) Remote Applications

Remote buildings are taking benefit of solar energy at vast scale. Remote schools, community halls, and clinics can take solar panel and batteries with them anywhere to produce and use electric power.

These are most common applications of solar energy that we get to see in our daily lives. As solar industry grows more diversified applications are expected to be seen in future.

II. GUJARAT SOLAR PLANT CHARANKA

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. This hosts about 19 different projects by different developers. On 19 April 2012, a total of 214 megawatts (287,000 hp) had been commissioned. It also became the world's second largest photovoltaic power station.[47] When fully built out, the Charanka Solar Park will host 500 MW of solar power systems using state of the art thin film technology. The investment cost for the Charanka solar park amounts to some US$280 million. Construction began on 3 December 2010. By 2014, 221 MW had been installed, and 345 MW by March 2017.

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.

III. HARSHA ABAKUS SOLAR

Harsha Abakus Solar is a solar energy solutions providing arm, from the Harsha Engineers Group. With a core philosophy of energizing the society with renewable resources of energy, we are committed to empowering the masses and thereby enlightening the nation. At Harsha Abakus Solar, we understand the energy crisis situation.[49] We understand that innovation holds the key to growing energy demands. Thereby we constantly innovate and bring to you solar energy solutions, which positively impact our society and environment. With this innovation we dream of a day that will never witness energy deficit.

A. About the JV

Harsha Abakus Solar a joint venture between Harsha Solar and Abakus Solar AG aims to bring to you the best of both worlds. Together we bring to you strong engineering and execution skills in addition to in-depth understanding of the Indian renewable energy market along with long standing experience, direct links to production capacities and one-stop project realization know how. Harsha Abakus Solar, therefore jointly, brings more value addition to the Solar Photovoltaic market by playing a prominent role as an end-to-end system integration solution provider. Company's key focus areas include Building Integrated Photovoltaic (BIPV), Grid-tied power plants, Rooftop installations, and Off-grid installations.

B. About Abakus Solar AG

Abakus Solar AG is a single stop solution provider for PV solar energy solutions. Since its inception in 1995, Abakus solar AG is a name to reckon with worldwide in the field of PV turnkey projects. With its in depth understanding and technical expertise, Abakus Solar AG has been successful in helping its customers gain profit from maximum yields through quality of planning, component choice and execution.

10.7 MWp GPCL PLANT DETAILS	
Pitch:- 8 Mtr.	
Module Specification	
Power	305 Wp/ 310 Wp
Module Make	Jinko Solar
Module Qty.	25380+9300=34680 Nos.
Length	1956 mm
Width	992 mm
Height	40 mm
Structure Details	

Structure Configuration	4×5 Landscape Module
Inverter Room-A (Structure Qty.)	460 Nos. (310 Wp Module)
Inverter Room-B (Structure Qty.)	464 Nos. (310 Wp Module)
Inverter Room-C (Structure Qty.)	465 Nos. (305 Wp Module)
Inverter Room-D (Structure Qty.)	345 Nos. (310 Wp Module)
Total Structure	1734 Nos.
Total String (20 Module Per String)	1734 Nos.
Inverter Room Details	
Inverter Qty.	15 Nos.
Inverter Room Qty.	04 Nos.
Control Room Details	
Control Room Qty.	01 Nos.
Plant Details	
Total Plot Area	190846 Sq. Mtr.

Table 1: Harsha Abakus Solar Private Limited Charanka Village, Dist. Patan Gujarat 10.7 MWp GPCL Plant Details

C. Jinko Solar Use in Harsha Abakus Solar

Jinko Solar announced that it has supplied 21.4MW of solar PV modules to Harsha Abakus Solar Pvt. Ltd. ("Harsha Abakus"), a solar energy solutions provider and a subsidiary of Harsha Engineers Group, for a ground mounted solar PV project in Gujarat, India. Located in Charanka, Gujarat, which is one of the highest solar irradiation zones in India, the project deploys seasonal tracking technology to improve plant performance. The project is expected to generate approximately 34.24 million kWh of electricity and remove 30,000 tons of CO2 annually. Once connected to the grid, the solar plant will be one of the first solar parks commissioned under the Jawaharlal Nehru National Solar Mission Phase II Batch I with a fixed PPA rate. The project will be jointly owned by Gujarat State Electricity Corporation Limited and Gujarat Power Corporation Limited.

IV. GUJARAT SOLAR PARK GENERATION REPORT

2013-12	702.3	91,649.723
2013	702.3	867,715.627
2014-01	823.9	108,706.728
2014-02	823.9	108,077.418
2014-03	856.81	127,788.259
2014-04	856.81	123,634.094
2014-05	856.81	128,752.498
2014-06	856.81	97,134.946
2014-07	856.81	70,479.155
2014-08	856.81	82,548.478
2014-09	856.81	95,634.111
2014-10	856.81	109,534.793
2014-11	856.81	104,635.154
2014-12	856.81	110,720.494
2014	856.81	1,267,646.129
2015-01	856.81	110,757.896
2015-02	856.81	108,807.058
2015-03	862.81	132,374.487
2015-04	862.81	132,404.605
2015-05	862.81	130,853.363
2015-06	862.81	112,480.673
2015-07	862.81	89,505.624
2015-08	862.81	93,690.516
2015-09	1000.05	99,140.672
2015-10	1000.05	114,841.173
2015-11	1000.05	106,945.300
2015-12	1000.05	115,440.984
2015	1000.05	1,347,242.350
2016-01	1000.05	119,867.775
2016-02	1000.05	122,643.366
2016-03	1000.05	142,227.550
2016-04	1000.05	142,812.131
2016-05	1000.05	151,267.431
2016-06	1000.05	119,395.042
2016-07	1000.05	91,133.021
2016-08	1000.05	97,582.518
2016-09	1000.05	123,211.648
2016-10	1000.05	141,661.937
2016-11	1000.05	119,838.276
2016-12	1000.05	130,560.415
2016	1000.05	1,502,201.110
2017-01	1024.15	139,319.531
Total		5,161,529.551

Table 2: Gujarat Solar Park Generation Report

V. RESULT

A. Harsha Abakus Solar Private Limited 10.7 MWp GPCL Plant Month Wise Generation

1) Januray Month Generation Data Details (11 JAN 2017)

Fig. 1: Plant Overview

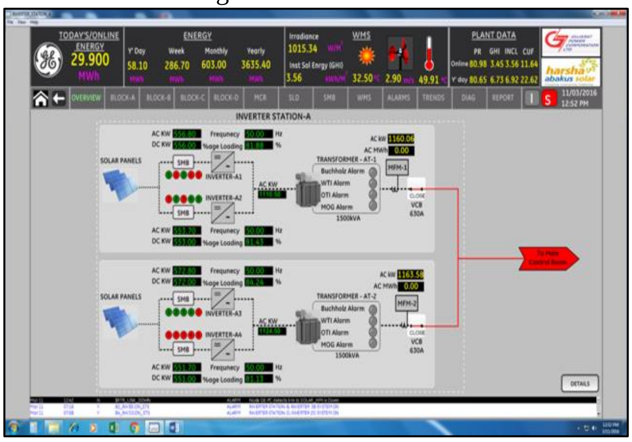

Fig. 2: Inverter Section-A, Block-A

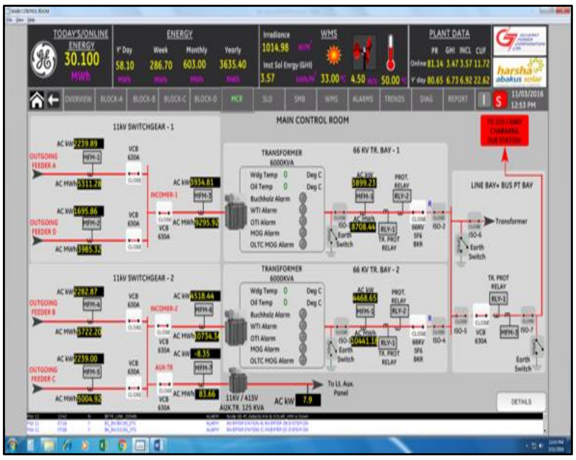

Fig. 3: Main Control Room

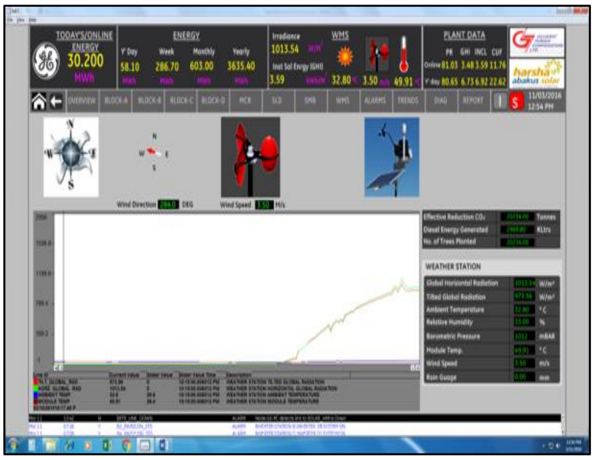

Fig. 6: Weather Measurement System

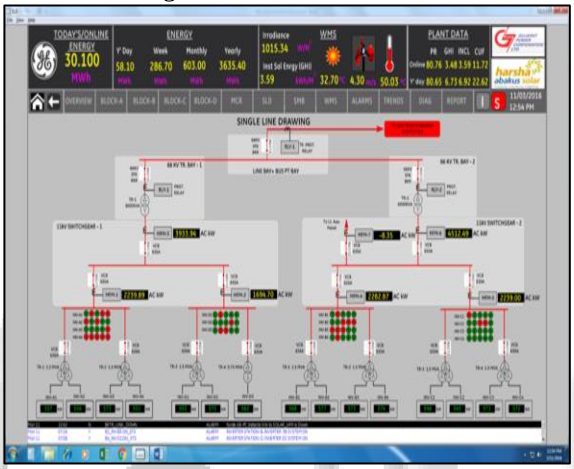

Fig. 4: Single Line Drawing

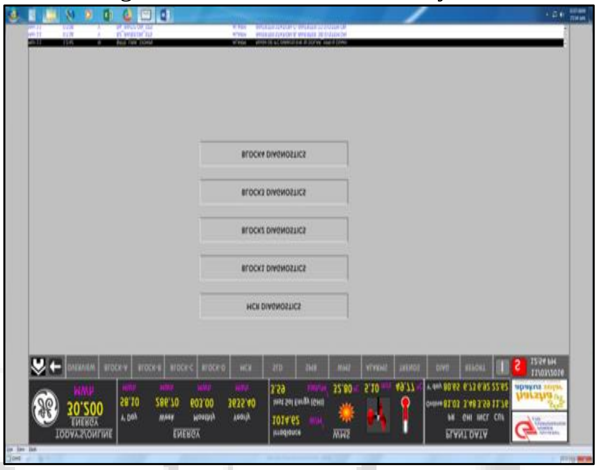

Fig. 7: Block Diagnostics

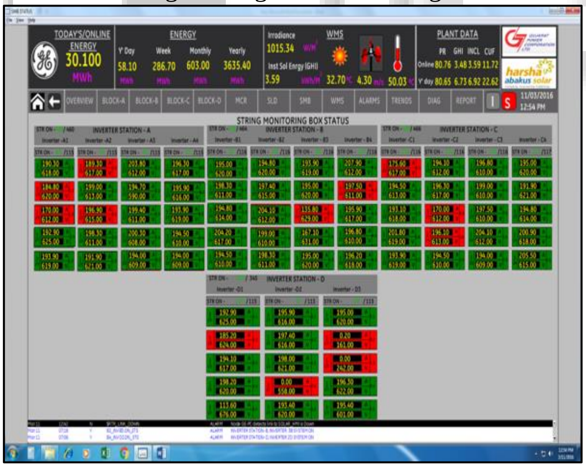

Fig. 5: String Monitoring Box Status

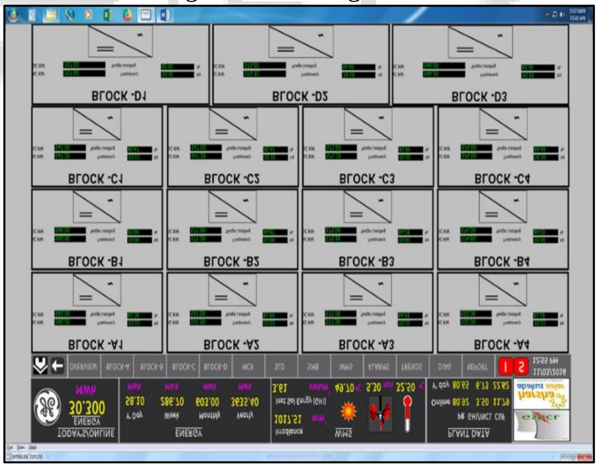

Fig. 8: Report of Plant

VI. Total Energy Audit

A. January Month

S.NO.	DATE	TIME AM/PM	GENERATION(MWh)	IRRADIANCE (W/M2)	AMBIENT TEMPERATURE (˚C)	MODULE TEMPERA TURE (˚C)	WIND SPEED (M/S)
1.	07.01.2017	10:50 AM	19.700	835.36	31.90	48.70	2.60
2.	08.01.2017	02:12 PM	34.900	1000.13	33.10	50.10	2.70
3.	09.01.2017	05:10 PM	48.700	560.80	30.70	47.60	2.90
4.	10.01.2017	03:32 PM	41.600	1012.26	34.20	51.13	2.80
5.	11.01.2017	12:52 PM	29.900	1015.33	32.60	49.88	2.70

Table 3: January Month

S.NO.	DATE	TIME AM/PM	GENERATION (MWh)	IRRADIANCE (W/M2)	AMBIENT TEMPERATURE (˚C)	MODULE TEMPERATURE (˚C)	WIND SPEED (M/S)
1.	24.02.2017	01:13 PM	34.200	1020.48	38.10	55.80	2.80
2.	25.02.2017	03:02 PM	43.500	832.80	38.20	55.10	3.20
3.	26.02.2017	11:47 AM	26.100	932.50	36.80	53.80	2.90
4.	27.02.2017	02:16 PM	39.300	1012.17	40.30	57.10	3.10
5.	28.02.2017	04:25 PM	50.100	555.69	42.80	59.14	2.70

Table 4: February Month

S.NO.	DATE	TIME AM/PM	GENERATION (MWh)	IRRADIANCE (W/M2)	AMBIENT TEMPERATURE (˚C)	MODULE TEMPERATURE (˚C)	WIND SPEED (M/S)
1.	27.03.2017	11:52 AM	29.200	672.90	39.80	56.70	3.90
2.	28.03.2017	01:48 PM	39.700	810.16	40.50	57.40	4.10
3.	29.03.2017	04:02 PM	49.900	827.32	41.10	58.32	4.50
4.	30.03.2017	05:30 PM	56.400	830.70	41.30	58.80	4.70
5.	31.03.2017	02:55 PM	44.700	832.66	42.00	59.28	4.80

Table 3: March Month

VII. Conclusion

Physically, solar energy constitutes the most abundant renewable energy resource available and, in most regions of the world, its theoretical potential is far in excess of the current total primary energy supply in those regions. Solar energy technologies could help address energy access to rural and remote communities, help improve long-term energy security and help greenhouse gas mitigation. The market for technologies to harness solar energy has seen dramatic expansion over the past decade – in particular the expansion of the market for grid-connected distributed PV systems and solar hot water systems have been remarkable. Notably, centralized utility scale PV applications have grown strongly in the recent years; off-grid applications are now dominant only in developing markets. Moreover, the market for larger solar thermal technologies that first emerged in the early 1980s is now gathering momentum with a number of new installations as well as projects in the planning stages. While the costs of solar energy technologies have exhibited rapid declines in the recent past and the potential for significant declines in the near future, the minimum values of levelized cost of any solar technologies, including tower type CSP, which is currently the least costly solar technology, would be higher than the maximum values of levelized costs of conventional technologies for power generation (e.g., nuclear, coal IGCC, coal supercritical, hydro, gas CC) even if capital costs of solar energy technologies were reduced by 25%. Currently, this is the primary barrier to the large-scale deployment of solar energy technologies. Moreover, the scaling-up of solar energy technologies is also constrained by financial, technical and institutional barriers. Various fiscal and regulatory instruments have been used to increase output of solar energy. These instruments include tax incentives, preferential interest rates, direct incentives, loan programs, construction mandates, renewable portfolio standards, voluntary green power programs, net metering, interconnection standards and demonstration projects. However, the level of incentives provided through these instruments has not been enough to substantially increase the penetration of solar energy in the global energy supply mix. Moreover, these policy instruments can create market inefficiencies in addition to the direct costs of requiring more-39 costly electricity supplies to be used. While not discussed in this paper, these indirect impacts need to be considered in assessing the full opportunity cost of policies to expand solar power production. Carbon finance mechanisms, in particular the CDM, could potentially support expansion of the solar energy market. While some changes in the operation of the CDM could increase solar investment, the price of carbon credits required to make solar energy technologies economically competitive with other technologies to reduce GHG emissions would be high. The fundamental barrier to increasing market-driven utilization of solar technologies continues to be their cost. The current growth of solar energy is mainly driven by policy supports. Continuation and expansion of costly existing supports would be necessary for several decades to enhance the further deployment of solar energy in both developed and developing countries, given current technologies and projections of their further improvements over the near to medium term. Overcoming current technical and economic barriers will require substantial further outlays to finance applied research and development, and to cover anticipated costs of initial investments in commercial-scale improved-technology production capacity.

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