The Elements of Design

Solar project design takes into account the design, layout, technology selection and system configuration for each unique project according to their requirements and targets to be met.

Solar photovoltaic systems use PV modules to convert sunlight into electricity, which can be either stored or used directly, fed back into the grid line or combined with one or more other electricity generators. A reliable and clean source of electricity, it is suitable to a wide range of applications.

The development of PV modules is still primarily driven by the idea of economies of scales which leads to unvaried PV modules that are only good for large area installations. These modules are not suitable for the integration into buildings, roof tops or electric devices because of their rigidness and electrical constraints. Even companies which do provide flexible thin-film PV, do not provide customised modules because of the associated set-up times. Thus, it is the aspect of project design that focuses on specific factors such as the local irradiance, weather, soil, wind, and topography to be taken into account for the design, layout, technology selection, and system configuration.

Major system components

Solar PV systems include different components that should be selected according to your system type, site location and applications. The major components for the systems are:

- PV module – converts sunlight into DC electricity.
- Solar charge controller – regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life.
- Inverter – converts DC output of PV panels or wind turbine into a clean AC current for AC appliances or fed back into grid line.
- Battery – stores energy for supplying to electrical appliances when there is a demand.

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- Load – is electrical appliances that connected to solar PV system such as lights, radio, TV, computer, refrigerator, etc.
- Auxiliary energy sources - is diesel generator or other renewable energy sources.

Solar PV System Design

Solar PV system design consists of four steps:

Load estimation: Example - Base condition: Two CFLs (18 watts each), two fans (60 watts each) for six hours a day; is the total energy requirement of the system (total load) i.e Total connected load to PV panel system = No. of units × rating of equipment = 2 × 18 + 2 × 60 = 156 watts, which is further multiplied by the operating hours, i.e total connected load (watts) × operating hours = 156 × 6 = 936 watt-hours.

Estimation of number of PV panels: Actual power output of a PV panel = peak power rating × operating factor = 40 × 0.75 = 30 watt, combined with efficiency is 30 × 0.81 = 24.3 watts (VA) = 24.3 watts. To this, multiply the energy produced by one 40 Wp panel in a day, i.e. actual power output × 8 hours/day (peak equivalent) = 24.3 × 8 = 194.4 watts-hour. Thus, number of solar panels required to satisfy given estimated daily load: = (Total watt-hour rating (daily load)/(Daily energy produced by a panel) =936/194.4 = 4.81 = 5 (round figure).

Estimation of battery bank: Inverter size is to be calculated as: Total connected load to PV panel system = 156 watts and inverter are available with rating of 100, 200, 500 VA, etc; therefore, the choice of the inverter should be 200 VA.

Cost estimation of the system: Here the cost of land, PV modules and panels, controllers, inverters, batteries, auxiliary energy sources will all be taken into consideration along with the cost of development and building, cost of labour and O&M costs.

Logistical Factors & Configurations

A successful project is the outcome of an efficient and effective system design and configuration. Utmost care has to be taken while designing the system because this stage will decide execution/implementation as well as performance outcome. A project design can maximise energy output through different methods such as using higher efficiency solar modules and minimising the loss factors through design optimisation.

According to **Kamlesh Sancheti, Head Project Sales, Racold Thermo Private Limited**, "In-depth, technical understanding of the entire project is important. Depending upon the degree of complexity involved in the project there are various parameters or elements that can be included or omitted to contribute as key success factors for any project."

Meanwhile, **AR Kumar, Head – EPC Operations, Anchor Panasonic**, believes that project design is largely determined by minimum losses and highest efficiency output with right selection of quality components of size and suitability of the project specification.

"Each project design is thus unique at its own. However, the other logistical factors that are taken into consideration include, efficient supply chain management system with closed loop network with manufacturers, selection of nearest port of landing/destination, safety and quality packing of goods for transportation and material handling/storage at site, and environmentally friendly or eco-friendly materials of packing respective to geographical conditions.," he adds.

For configurations, Kumar believes that incorporations such as selection of higher efficiency solar modules, selection of right inverter with appropriate technical specification, shadow analysis and simulation software for system configuration and energy estimation, help ensure success of the projects.

Price-Performance Ratio & Power Tariff

It is said that by applying carefully configurated PV plant parameters, it is possible to ensure that plants deliver maximum financial results.

For Sancheti, while Price-Performance Ratio is not applicable for solar water heaters, the question can be linked to payback period, which is attractive as low as two years, depending upon the type of fuel used, tariff rates, etc. "An efficient design will not only give the desired output, but also save on costs related to maintenance, and auxiliary heating through other conventional methods," he states.

Kumar, on his part agrees that it is possible, subject to precise selection of project components with correct specification and MTBF. "For example, solar inverter is a critical component in the solar system design. This inverter should be capable of performing from 0-60 degree operating conditions with appropriate thermal conditions and cooling system within the committed power de-rating factors. Any change in inverter performance in short term or long term will introduce negative impact on the performance ratio of the project, which will lead to unenviable price-performance ratio," he explains.

On its effect on power tariff Kumar feels that though project design is not directly related to power tariff, it is driven by the cost of raw material/ components available in the international market to match the respective power tariff. "This practice of driving lower cost of solar power plant can substantially affect their quality, considering the plant life of 25 years and also indicative poor returns on investment. By this time the industry should have realised the power tariffs or ROI made out of only financial data are not co-relating to the cash flow of actual plant operations," he opines.

HIT modules perform across temperature and weather conditions

Made in India

For solar water heating products, the progress of Indian manufacturers on the production front has been satisfactory over last decade, but there is huge scope for technological upgradation and innovation through intense efforts in R&D, believes Sancheti. Also, as far as domestic items are concerned, Racold has a prominent set-up supported by a state-of-the-art manufacturing facility located at Pune.

However, Kumar, has a different experience, "there are no challenging or state-of-the-art PV module technologies or R&D facilities available in India. Our country today needs international standard PV manufacturing plants with vertically integrated set up and latest technology."

He adds that while the engineering resources and technical skills are available in abundance in India, module manufacturing units in India are by-and-large operational on semi-automatic or in the form of assembly line. "Majority of the raw materials are dependent on imports and the domestic content of materials is bare minimum. India should draw the advantage of global PV experiences/ examples to draw stringent quality oriented technical standards to ensure realistic returns on investments," he feels.

On domestic manufacturing he states that presently indigenous manufactured materials are limited to AC-DC cables, structures, switch gear panels, transformers, switchyard components, earthing and LPS which contribute to approximately 30 per cent of the entire BOM of a solar project; balance 70 per cent materials are being imported since there are no high efficiency modules, high precision and robust string combiner boxes and monitoring solution manufacturers/ suppliers in India.

"I would recommend to encourage high efficiency module technology manufacturing in India for not only meeting our country's solar target but also for aiding it to develop stable and healthy grid conditions with quality power generation, ultimately serving the community by meeting the power demand. Additionally, we can contribute to the country's socio-economic development through latest technology."

Sancheti also believes that community model solar has a large scope; "Very low penetration of SWH (less than 5 per cent), trend of townships in realty segment, increased pollution, and heavy dependency on fuel imports are the socio-economic factors which will drive the growth in community design (large scale projects)."

Kumar concurs, "This model is good provided it is implemented through government regulations in a systematic way to acceptable international standards and with best practices. The community design models appear to be more challenging, especially due to the unorganised infrastructure in place."

He adds, "the highest level of design and standards are to be forced strictly on community design models with net metering from policy to the implementation stage. The power density in urban areas and poor connectivity in semi-urban and rural areas can be addressed with a high degree of safety and technology standards substantiated by healthy grid conditions driven by centralised data management, control and operations."

The community design model can substantially contribute adding to meeting at least 10 per cent of India's solar target, Kumar believes.

Technology & Trends

Sancheti spoke about their end-to-end solution from concept to commissioning, which comprises in-depth understanding of customer requirement from the envelope stage, system configuration and design, layout planning, 3D modeling, shadow analysis, structural consideration, etc. Emphasis is given on simplified solutions which will deliver the highest value proposition for users with minimum maintenance post installation.

"Racold's expertise and experience of handling projects in different segments like realty, hospitality, healthcare, industrial application complements to this. A major differentiator is the holistic approach: doing right things at every stage. The process is as under: Product (range and quality) » Smart Designing » Erection and Commissioning » Customer Education » After sales service."

Kumar adds about Panasonic, "Our HIT solar module is known for lowest negative temp-coefficient and high power density in the global market. At given Indian climatic conditions, Panasonic HIT modules perform from low light conditions to higher temperature providing consistent generation."

"In our project design we do consider the advantage of LID and PID free, high efficiency at high temp and relative humidity, and zero quality loss with highest energy yield. We generate 30-35 per cent more energy per sq meter area offering a distinct differentiation than our competition," he adds.

Since projects are different, **ET Solar**, another player in the field designs solar projects to maximise electricity yield and minimise LCOE by considering all factors, such as local irradiance, weather, soil, wind, topography, layout, technology selection, and system configuration. Having engineered several global utility-scale power plants following industry best practices and designed hundreds of solar systems, ET Solar smart energy solutions is able to provide global customers with complete system design and engineering services.

Meanwhile, **First Solar** is focused on maximising energy output and project value, wherein their expert engineers have in a process called "design optimisation," regularly optimise the right combination of DC:AC ratio with a project's unique financing and site constraints to deliver the best combination of LCOE vs. NPV, thus achieving the customers' most important objectives by delivering the project specific economics that are most important to them.

Commenting on the trends, specific to the solar water heating segment, Sancheti feels that hybrid solutions integrated with energy efficient heat pump water heaters is catching up, for new projects as well as retro-fit projects. "This type of solutions assures hot water in all seasons (particularly in rainy season), installation space is minimum, 75 per cent saving in auxiliary heating and so on," he points out.

Additionally, smart features like auto time and temperature setting reduces manual intervention; monitoring of different data points like quantity of water used (flow), pressure, temperature, consumption of different fuels in hybrid solutions (electricity, diesel, gas etc), saving simulations etc is also expected in some of the application. Recirculation system to avoid stagnant water wastage (overnight temperature loss in pipeline) and automated fixed time hot water supply are the other trends he lists.

"Apart from adopting international standard practices for project design until the completion of projects, we have adopted realistic field data management techniques, wherein we do the design improvement from assumptions to realistic performance. In order to execute this process, we make use of the most modern testing equipments and latest software. Our data established is proven on real time basis," says Kumar about his company.

Research and Development

Addressing an important aspect of research and development (R&D), Sancheti states, "R&D has a vital role to play in giving new direction and dimension to industry as a whole, keeping in mind interest of all the stakeholders. This will call for leverage from incremental and radical innovation."

Smaller steps to improve product efficiency, cost reduction by value engineering, alternate usage of material and processes for existing products or technologies; at the same time, introducing completely new super-efficient technologies is the crux for rapid penetration.

While Kumar believes that solar manufacturing is an untapped resource having a huge potential for industrial development. "There is a large scope to use educated technical expertise for R&D for improvement of not only cost effectiveness, but also for bringing value for highest performance in Indian environmental conditions," he opines.

Panasonic invests nearly seven to eight per cent of sales revenue for development of eco-solutions and high efficiency PV module technology in R&D as a part of corporate social responsibility to support carbon neutral globally. Thr company has developed highest efficient cell manufactured in-house, the cell efficiency is recorded as 25.6 per cent which is the highest in global standards.


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"The Japanese are known for best cost reduction techniques and quality control processes. Therefore a combination of Indian technical skills and Japanese process and control techniques can bring new synergy in the PV module area suitable to Indian conditions. R&D is a continuous process for project design and creating a data for assumption vs reality of solar plant performance, can pave the way significantly towards cost reduction," he ends.

- JOCELYN FERNANDES