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Everyone is connected in this world and sustainability relates to the welfare of mankind. All discussions and debates based on "green revolution" aim to construct and build the future lifestyle.

As one of the world-leading industries in China, photovoltaic industry has become an important template for high-quality green development in China. After the State Council of China released the Guiding Opinions about Facilitating the Building and Improvement of the Green, Low-carbon and Circular Economic System, the photovoltaic+ industry has been growing rapidly, which focuses on diverse applications, actively and extensively pushes forward the formation of green production and lifestyle.

Nowadays, manufacturing, construction, big data, management, transportation, agriculture, etc. are integrating with the photovoltaic industry, thus providing unlimited possibilities for the diversity of photovoltaic application scenarios. All these opportunities and realities aim at the same goal that "new energies provide power for future life and modern civilization".

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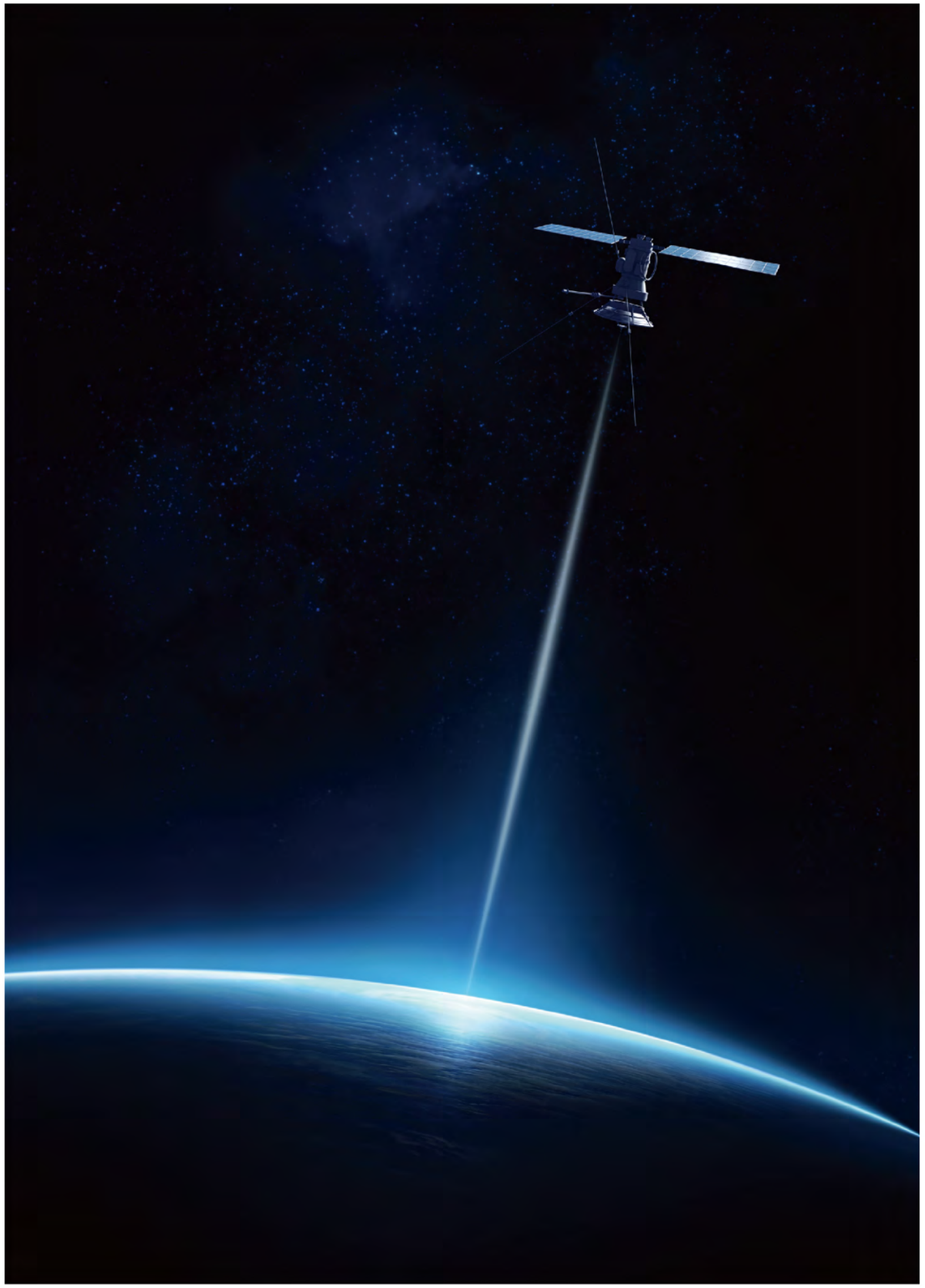

Estimating PV module value and how & when TOPCon technology to dominate the market

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Main Body: Before marketing any new photovoltaic technology, it is necessary to consider the value law of industrial chain, analyze the characteristics of products in detail, and then carry out the quantitative management of product value according to the above-mentioned law. Reasonable product analysis and value competitiveness analysis can greatly reduce the decision risks of laboratory products to mass production promotion. Customers' choice of products is ultimately value-oriented, so in the link between R&D and market, special attention needs to be paid to combing the logical chain of product value. Occupying the market with new products too early or too late, or with inappropriate new products may put the enterprise in greater risks. Making appropriate product decision and management at the right time is a way to take advantage of the market and effectively control risks. Besides, guiding customers to make value choices may effectively expand market share and take the preemptive opportunities.

From its inception in 2001 to date, the crystalline silicon photovoltaic product has gone through the monocrystalline silicon, polycrystalline silicon, mono-facial and bifacial types in the market. Especially in recent years, from the introduction of P-type PERC module, N-type bifacial module (PERT, HJT, TOPCon) to the evolution of large-size wafer module, PV module products have been surging like a rising storm. The competition of changeable technical routes leads to a new round of upgrading of technology and production line, and quietly transforms the ecology of photovoltaic industry. Well, what is the logic behind these technological changes?

In fact, the alternation of technical routes of photovoltaic products follows the logic of market value of products. Sorting out the previous changes in the market of crystalline silicon photovoltaic products at key nodes, it is found: from 2007 to 2008, the market switch from the monocrystalline silicon to polycrystalline silicon products was dominated by the price factors of polycrystalline products; from 2013 to 2015, the market trend was switched from the polycrystalline to the monocrystalline, which was dominated by the BOS cost of the system; in 2017, bifacial module gradually cut in the mainstream photovoltaic market, which was dominated by the levelized cost of energy; from 2018 to now, the main logic of market switching into large-size wafer module is based on the cost of industrial chain and BOS cost. In general, the product switching logic depends on the innovation of application value on the PV system based on product reliability.

I. Value innovation centered on cost per watt

The cost per watt has always been the keypoint of cost control in photovoltaic manufacturing industry. In the case of homogeneous products, more attention is paid to the cost control and internal control and management of enterprises, including the supply chain, production, financial cost and asset structure management, market and sales management, internal quality assurance of product, increase of unit capacity output, improvement of automation, reduction of labor costs, balance of production, supply and marketing, and reasonable decisions on inventory management in different market environments. Effective internal management of enterprises is an important supporting force to reduce the cost per watt, and it is also the core of product competition under the condition of homogenization. Under the homogenization, the conversion efficiency can be improved, and the levelized cost of energy will be effectively reduced. However, since the improvement of homogeneous photovoltaic conversion efficiency often depends on the improvement of equipment and auxiliary materials, it is difficult to form a strong technical barrier. Because of the rapid diffusion of industrial technological progress caused by the change of suppliers, the replacement and improvement of mainstream technologies can be realized by just following these strategies. After decades of development in the photovoltaic industry, the cost per watt at the manufacturing end has gradually become the core advantage of some long-established photovoltaic enterprises. The core advantage of large-size wafer module centered on expanding unit output, and its focus is still on the cost per watt at the manufacturing end.

II. Value innovation centered on BOS cost per watton cost per watt

Another value core of large-size wafer module is to reduce the cost of BOS, focusing on the cost per watt of PV system construction. On the one hand, due to the increased size of cell and the fine adjustment of solar cells spacing in module, its conversion efficiency is slightly improved. At the same time, due to the change of the length and width of the module, the amount of bracket and land requirement reduced in a specific installation mode (vertical), which reduces BOS cost to a certain extent. The large-diameter silicon wafer is used, consequently, the current is increased, and the margin of cables and inverters is utilized, which also reduces the BOS cost of the system. From 158.75 to 166, and then to 182-wafer-sized module, the marginal utility of efficiency improvement caused by the large size is obvious, but the conversion efficiency of module is just slightly improved when the size of 182 is changed into 210. The change of BOS cost caused by bracket and land cost per watt, caused by the change of wafer size, is smaller than that of 166 to 182. However, large-sized module have some disadvantages, such as the reduction of redundancy of mechanical load, the change of DC cable, and the significant reduction of the effect of utilizing margin. However, due to the increasing short-circuit current of large-size module, it poses serious challenges to the junction box providing hot spot protection for PV module. Generally speaking, for the 158.75-wafer-sized module, the short-circuit current is 10-11A, 11-12A for the 166-wafer-sized module, 13-14A for the 182-wafer-sized module, and 18A-19A for the 210-wafer-sized module. The rise of short-circuit current will inevitably lead to the

rise of junction temperature. On the one hand, the rising temperature results in the increase of the failure probability of diode in long-term operation at high temperature, and on the other hand, it also causes the increase of probability of thermal runaway theoretically (the reverse leakage current double when junction temperature rise 10 degrees centigrade). Therefore, in terms of the junction box, the larger the wafer size, the higher the protentional risks in its reliability.

III. Value innovation centered on levelized cost of energy (LCOE)BOS cost per watton cost per watt

The LCOE is the actual production cost per kilowatt-hour of electricity generated by the photovoltaic system within its life cycle, and its calculation formula is as follows:

$$LCOE=\frac{\text{Life cycle cost}}{\text{Life - cycle gross generation}}=\sum_{t=1}^{N}\frac{\left(\frac{C_t}{(1+d)^t}\right)}{\left(\frac{E_t}{(1+d)^t}\right)}$$

t: The measuring time of power station; N: The lifetime of power station; : The annual energy production in Year t; d: The actual discount rate, equal to WACC (weighted return on capital); Ct: The cash flow in Year t

Compared with the value innovation of the above two central systems, the LCOE is the most comprehensive index, which is also the fittest for the rules of the electricity market, and can be used for the price competition of electricity. It not only reflects the proportion of product cost (including BOS cost) in the construction of system power station, but also reflects the contribution of power generation to product value, making the evaluation of products more objective and rational. Especially, after the emerging of bifacial module products, for large-scale PV plant, the power generation may increase by about 5%-18% due to the back side in general application scenarios (fixed bracket & ground), in particular, when the cost of PERC bifacial module is only increased by about 0.03 yuan (the total cost increased by below 1%, and the power generation increased by more than 5%), the levelized cost of energy of photovoltaic power station can be significantly reduced.

After the introduction of the value-oriented concept of levelized cost of energy, it is found through sensitivity analysis that under a certain weighted return on capital, the power gain has a significant impact on the levelized cost of energy. Therefore, different technical plans are adjusted to improve the power generation capacity of the PV system, and the relationship between investment growth and income acquisition is weighed to minimize the levelized cost of energy.

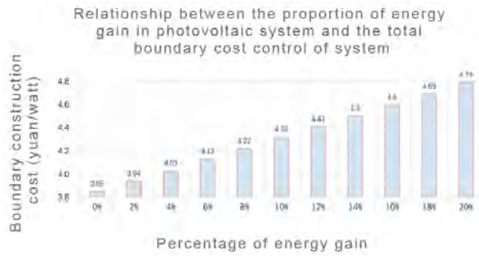


Fig 1 - The Relationship between energy gain of Photovoltaic System and EPC Boundary Control Cost at IRR of 8%

IV. Characteristics of bifacial module and energy gain under different application conditions

With the same power of front side, the biggest difference of bifacial module of different technical types lies in the bifaciality of the PV module, that is, the different conversion efficiency of the back side.

The gain of back side depends not only on the backside power rating, but also on the energy that reached back side. The power output of the module per unit area can be improved by increasing the light reception on the back side, so as to effectively reduce the levelized cost of energy. However, the gain on the back side of the bifacial module strongly depends on the environment and engineering conditions. The influencing factors include albedo of the ground, GCR (ground coverage ratio), ground clearance, installation angle and proportion of direct and scattered light. In the fixed installation mode, the designed GCR at different latitudes is different. The smaller the GCR is, the lower the land utilization rate is, resulting in the increase of the intensity of the reflected light on the back side. The bifacial module prefers high albedo, high clearance and high latitude in fixed installation mode; the light intensity of back side can also be significantly improved in some areas with high scattering ratio. Usually the energy gain of fixed installation mode in bifacial application technology, is not constant. it changes with weather and seasons. In addition, snowfall could significantly affect the effect of power generation on the back side.

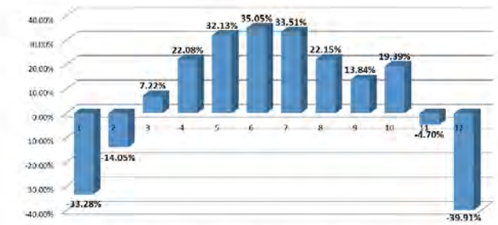


Fig 3 - Gain Curve of Single-axis horizontal tracker+ bifacial module VS Fixed bifacial module

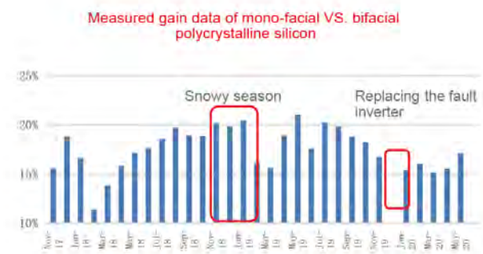


Figure 2 - Power Generation Gain of Bifacial module by month(2017-2020)

As the process fliow of PERC and TOPCon is different, the bifaciality of PERC is usually lower than that of TOPCon, which leading to power gain is lower. However, the cost of TOPCon is higher than that of PERC due to the complexity of its process. So how to weigh the cost performance of two products under the framework of levelized cost of energy becomes more urgent.

Actually, in the installation scenario with fixed inclination angle, such as PV plant above water (low reflectivity), there is no significant difference in power generation gain between PERC bifacial module and TOPCon bifacial module due to the low reflectivity (10%-20%) in the deeper water. However, in areas with high latitude, since the fixed GCR is small, it is more conducive to increasing the light intensity, and the relative gain of TOPCon bifacial is greater than that of PERC bifacial.

One thing that worth mentioning here is the application of bifacial technology with single-axis horizontal tracker. When bifacial module was applied on the early stage, it was widely believed that the effect of 1+1>2 would be achieved by single-axis horizontal tacker+ bifacial module, that is to mean, if the bifacial module power gain is 10% and the single axis horizontal gain is 8%,the combination gain of bifacial module and single axis horizontal will exceed 18%. After more than three years of practical application, it was proved that was not true. The front surface module of single-axis honzizontal tracker absorbs more light, while the light that can reach the ground decreases; the ground will reflect less light quantity to the backside of the bifacial module. What is the cause of this illusion? The seasonal characteristics of single-axis horizontal tracker+ bifacial module power generation are the main reasons. Fig. 3 shows the comparison of simulated power generation capacity per watt between bifacial module in fixed installation mode and in single-axis horizontal tracker+ bifacial module mode in Zhangjiakou, Hebei Province. By comparison, it can be seen that the power gain in single-axis horizontal tracker +bifacial module mode relative to fixed bifacial mode decreases significantly in winter, but increases greatly in summer. If the power gain is observed in summer, it is easy to draw the conclusion that 1+1 is greater than 2, On the contrary, if the power gain per watt is observed in winter, the conclusion is no longer valid. Therefore, the power gain of single-axis horizontal tracker +bifacial module technology should be evaluated annually. As the effect of 1+1 being greater than or equal to 2 cannot be achieved by single-axis horizontal tracker +bifacial module mode, under some specific conditions (especial for high-latitude areas), due to the gain of the single-axis horizontal tracker is lower, the competitiveness of single-axis track +bifacial module will decrease. Maybe seasonal adjustment technology is more feasible for the lowest LCOE.

In order to get more energy gain, the single-axis tracker with tilted angle +bifacial module (10-20 degree) is applied to further improve the power gain. the single-axis tracker with tilted angle +bifacial module mode usually need more space to avoid the shading effect, the GCR is relatively lower. The lower GCR will be benefit to bifacial module which will get more reflected light on the backside of the module. In specific occasions such as desert with low land cost and high albedo, the power gain will be more obviously, and the LCOE will decrease. the single-axis tracker with tilted angle +bifacial module will need more the brackets, thus the module with high efficiency and high bifaciality is conductive to decrease the cost of BOS cost per watt for the PV system.

V. How to choose a cost effective module

Application of mono-facial module. For roof projects, considering the requirements of mechanical loading (including wind & snow loading) , the modules are usually installed with a small tiled angle or flat. In this case, we need pay more attention to the safety of the structure of the building, the principle of get more electricity is not the priority. In this case, the GCR is rather high, more module could be installed in a specific roof area. The efficiency of polycrystalline module is too low, its BOS cost no longer comparable with PERC(monocrystalline) technology in most cases. Bifacial module have no advantage in this scenario.Considering the cost of N type bifacial module is higher than PERC monocrystalline module, mostly PERC monofacial module will dominate the roof scenario related market.

Application of bifacial module. PERC bifacial module with glass/glass encapsulation is ~0.03 yuan more expensive than PERC mono-facial module in the market, but it achieves more than 5% energy gain, greatly improving the captical internal rate of return. Therefore, the general trend of large-scale terrestrial solar power station will be dominated by bifacial module. Howerver, due to the limit efficiency (23.5%) and low bifaciality (65%-75% on average) of PERC, PERC bifacial module technology would be challenged by other technology. Taking TOPCon technology as an example, of whose bifaciality is 75%-85% on average, while the cost of TOPCon solar cells will be much higher than bifacial PERC. If we take IRR or LCOE as a basic principle to balance the cost and energy gain (the efficiency of the TOPCon and PERC is the same), about 3%-4% more energy gain will be needed compared to bifacial PERC module. 3%-4% more power gain from TOPCon technology cannot be realized in all application scenarios (requiring high ground reflection, low GCR& high clearance). Meanwhile, for most of the customer, the psychological barrier effect brought by the increase of investment play a negative effect. Meanwhile some manufacturers boast the TOPCon power gain compared to bifacial perc module regardless of application scenarios would also mislead the market. When the power gain compared to bifacial module is falsified by the market in some specific scenarios(low ground albedo,low latitude &high GCR), the coustomers will think they have been cheated, thus affecting the brand effect of market products. Therefore, with the same conversion efficiency, there is only a regional advantage area for TOPCon technology to participate in market competition. In order to obtain more market share, a breakthrough shall be made in the conversion efficiency of TOPCon technology, the cost of TOPCOn per watt shall be reduced through technological innovation, reducing the manufacturing cost per watt and BOS cost of TOPCon, thereby completely replacing PERC bifacial module technology.

In addition, in terms of reliability, TOPCon has advantages in LeTID and light degradation, but this long-term reliability advantage is only shown in laboratory tests, its long-term quantifiable value can only be calculated in theory. Customers need more time to evaluate the advantage of the reliability of TOPCon, and its value will be finally understood only after being proved by time.

VI. The watershed between PERC bifacial technology and TOPCon bifacial technology in 182 size wafer in large-scale PV plant market

Whether or not a new technology become dominant in the market is not absolutely depend on the marketing, it depends on the customer. For a PV module, It's reliability is very important, meanwhile the market value should be dig out, and then try to let the customer known it. When most of the customer say yes, the product is OK, the product will be dominated in the market. Mostly the price of module(yuan/watt) is acceptable very easily, the cheaper, the better; the value of BOS cost per watt and the value of reduced levelized cost of energy seems difficult for most of the customers. So the market penetration of the product can be classified into three categories by the complexity. The value of levelized cost of energy is the survival threshold point (Level 1) of new module products, the value of system BOS cost is the watershed of market (Level 2), while the value of cost per watt is the subversion point of alternative technology (Level 3).

TOPCon bifacial technology and PERC bifacial technology should be between the Levels 1 and 2 according to the current competition status. With the innovation of large-size module, TOPCon technology manufacturer is unable to adjust their production line fast, resulting in TOPCon technology market staying in a disadvantaged position. But wafer size is not the technical threshold, and the advantage of BOS cost reduction caused by wafer size innovation is expected to be absorbed by TOPCon technology soon. Under the current conditions, it is difficult for TOPCon technology to completely replace PERC technology(166 TOPCon VS 182 PERC).

As mentioned above, Energy gain of bifacial module is limited by geographical conditions and application environment, in the specific area, the TOPCon technology have no advantage in the levelized cost of energy compared to PERC bifacial, making it impossible to gain the competitiveness of completely occupying the global market. Thus, it must be compensated by improving the efficiency to reduce and the manufacturing cost per watt and the BOS cost per watt of PV system, and become more competitive in the regional market. Due to different markets and technical solutions, the composition of cost system of the photovoltaic system is different. In areas with high labor costs, TOPCon bifacial with high conversion efficiency can be used to effectively reduce the BOS cost per watt of the system; single-axis horizontal tracker+ bifacial module can also decrease the BOS cost per watt of the system. For some project which the land cost is very high, improving conversion efficiency and reducing system BOS cost is also effective. It depend on the specific project.

It is calculated that, the the conversion efficiency of TOPCon bifacial solar cells remain about 1% efficiency higher relatively than that of PERC bifacial , and the BOS cost per watt of single-axis horizontal tracker+bifacial module technology remain low, combined with the advantage of low degradation rate of TOPCon will be more competitive regardless of the energy gain advantage . If efficiency of TOPCon technology remain 1.5% relative higher than PERC, The BOS of TOPCon bifacial technology will be lower than PERC bifacial technology in all application forms (including fixed bracket). Therefore, the conversion efficiency of TOPCon, 1% relative higher than that of PERC, is close to enabling the market to initiate the technology substitution. If the conversion efficiency difference between TOPCon and PERC technologies exceeds 1.5%, the whole market will be reversed compeletely. Besides improving the efficiency of TOPCon solar cells , there are some other factor such as reducing the cost of N-type silicon wafer and cost of production line of TOPCon will be benefit for TOPCon to dominate photovoltaic the PV market.

VII. Conclusion

Any alternation of photovoltaic technology is inseparable with its inherent value logic. The PV module market has experienced the shifts of oriented mechanisms - from the modue-cost-oriented mechanism, gradually developing into the BOS cost-oriented mechanism, and transitioning to the LCOE-oriented mechanism, which are all based on the value cognition of photovoltaic system. Integrating the whole industry chain (including system application technology) and making overall judgement of the value of product can clarify the selection of different technology competition routes. In addition, the speed of new technology promotion and the pace of technological innovation depend on the complexity of industrial chain value cognition and the value of innovation. The more complex it is, the slower the customer's cognition is, and the longer it takes to wait for the application client to be mature.

COLUMN

Step into Standards and Standardization

Tingting Yan

Master's degree in Optical Engineering, Senior Engineer, Patent Attorney, and Off-Campus Academic Advisor for Postgraduates of Jiangnan University.

Joined Wuxi Suntech in 2009 and engaged in the research and development of high-efficiency crystalline silicon solar cells. During this period, participated in 4 national, provincial and ministerial projects, and won the Wuxi Patent Award and the Jiangsu Science and Technology Award and other honors; currently engaged in intellectual property management, industry standardization, and industry-university-research project cooperation in Suntech Institute.

How to define human activities and standardize food has been an issue since people began to engage in production by understanding and shaping nature, and learning how to use tools in order to achieve the consistency of individual behaviors and social activity needs, and improve the effectiveness and efficiency of human activities. In the production practices, raising requirements on the similar and unified performances and shapes of tools and implements to facilitate processing, manufacturing and operation promoted the standardization of products and processes on the basis of manual labor;

the science and technology and successful experience developed in production were confirmed and promoted, and transformed into greater productivity; in order to meet the needs of social development, achieve systematization, standardization and simplification of gradually complicated management, make management and control more effective, a normal and optimal order for various social, economic and technical activities was established so as to get maximum outputs with minimum resources inputs for the continuous improvement of the quality of people's life. Standardization, as a basic discipline, inevitably came into being with the continuous development of human productivity.

Let's get to know about standards and standardization from the following questions.

I. What are "Standardization" and "Standards"? What are the difference and connection between the two?

"Standardization" is defined in GB/T 20000.1-2014 "Guide for Standardization - Part 1: Standardization and Related Activities - General Vocabulary" as: "the activities of determining common use and repeated use clauses and compiling, publishing and applying documents for actual or potential problems in order to obtain the best order within the established scope and promote common benefits." Standards are the products of standardization activities. Standards are "documents that provide rules, guidelines or characteristics for various activities or their results through standardization activities and are formulated by consensus in accordance with prescribed procedures for common use or repeated use."

Standardization is not something in isolation, rather an activity process, mainly the process of formulating standards, implementing standards and modifying standards, and this process is a continuously cyclical and spiraling escalation process. As a work, standardization is to continuously promote the progress and development of this cyclical process according to the changes in objective circumstances. Its purposes and functions are to be achieved through the formulation and implementation of specific standards.

II. What are the categories of standards?

Based on the main subjects of formulation, standards can be categorized as international standards, regional standards, national standards, industry standards, local standards, and corporate standards.

By the binding force of standards, China's standards can be categorized as mandatory standards and recommended standards. According to the Reform Plan on Deepening Standardization Work issued by the State Council (G.F. [2015] No. 13), the reform measures point out that the government-led standards are be reduced from 6 categories to 4 categories, and the current mandatory national standards, industry standards and local standards shall be gradually integrated into mandatory national standards. The 4 standards after simplification shall be mandatory national standards, recommended national standards, recommended industry standards, and recommended local standards; standards independently formulated by the market will be categorized as group standards and enterprise standards. The government-led standards shall focus on ensuring basics, and the standards independently formulated by the market shall focus on improving competitiveness.

Table 1 Categories and Characteristics of Standards

Dominant subject	Categories	Characteristics
Government	Mandatory national standards	Standards with legal attributes and safeguarding human health and personal and property safety, which are mandatory as stipulated by laws and administrative laws, such as drug standards and food hygiene standards.
	Recommended national standards	Recommended standards refer to the various standards that are voluntarily adopted through economic means or market regulation in terms of production, exchange, and use, which have strong and flexible universality. Industry standards can be formulated where there are no national standards but nation-wide unified technical requirements across the industry are required; local standards can be formulated where there are neither national standards nor industry standards, and province-wide unified industrial product and hygiene requirements are required.
	Recommended industry standards	
	Recommended local standards	
Market	Group standard	The standards jointly formulated by market players coordinated by the societies, associations, chambers of commerce, federations and other social organizations and industrial technology alliances with corresponding capabilities that meet the needs of the market and innovation, which can be chosen by the market voluntarily to increase the effective supply of standards. Group standards may be upgraded to industry standards or national standards.
	Corporate standards	Standards established by enterprises without violating the above-mentioned standards. By formulating and implementing standards, enterprises can establish systematic, controllable behavior and scientific operation order in line with objective laws, perform scientific management of the enterprises, improve the work efficiency, ensure the quality of work and products, and improve the economic benefits of the enterprises. Enterprises are encouraged to establish competitive corporate standards higher than national standards, industry standards, and local standards; high-demand corporate standards are the embodiment of enterprise competitiveness.

By the basic attributes of standardization objects, standards can be categorized as technical standards and management standards. Technical standards can be in the form of standards, technical specifications, procedures and other documents, as well as physical standard samples. Management standards can be management system standards, management procedure standards, quota standards, etc.

III. What are the elements of standards?

Technical standards are the subjects of the standard system, which are large in quantity, broad in scope, and diverse in variety, dominated by product standards. The following is the introduction of the arrangement of structural elements in standards by taking product standards as an example. Normative elements are the elements that declare the clauses that should be followed to comply with the standards; informative elements are the elements that introduce the standards and provide additional information to the standards.

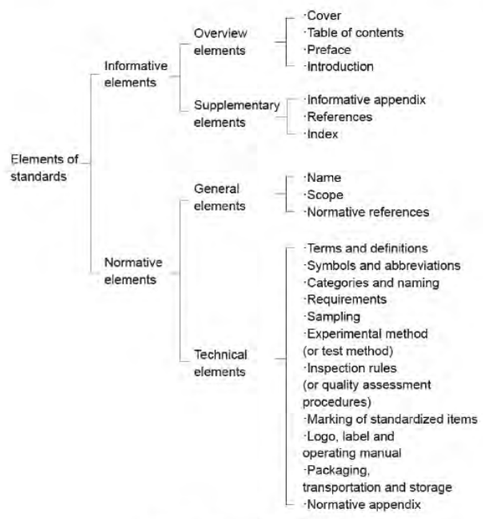


Figure 1 Elements of standards

IV. What should be taken into consideration in formulating standards?

The pertinence, practicability and operability of the standards must be taken into full consideration in formulating standards to ensure the authority of the standards. In addition to the basic requirements for writing standards described in GB/T 20000-2014 Guidelines for Standardization Work, it must also comply with scientific advancement, economic rationality, and safety and reliability.

1) Scientific advancement

The technical indicators and various requirements stipulated in the product standards can reflect the advanced achievements of science and technology and the advanced experience of production and construction, and should be conducive to promoting technological progress and improving product quality. In formulating product standards, it is necessary to take into account the latest level of technological development as much as possible, adhere to high standards and strict requirements, especially actively adopt international standards and advanced overseas standards, so that the content of the standards can truly promote production and guide production. Moreover, in formulating standards, it is recommended to provide a framework and room for future technological development.

2) Economic rationality

The formulation of scientific and advanced product standards does not mean a blind pursuit of high standards. "Advanced" is often at the cost of "cost effective", and is usually restricted by economic conditions. In order to obtain the optimal economic benefits, enterprises need to weigh between "advanced" and "cost effective" when producing products, so as to maintain the advancement of technologies and keep economically reasonable. Under the premise of meeting the operating requirements, the level of technical indicators and the increase of production costs should be fully weighed and considered to make reasonable judgments.

3) Safety and reliability

Product safety refers to the capacity of a product to ensure human health, personal safety and product safety during the manufacturing, use and maintenance processes. In defining the performances of the product, factors such as hygiene, health, and safety must be taken into account.

In addition, the formulation and implementation of standards are based on the comprehensive results of science, technology, and practical experience, and are limited by the level of scientific and technological development in the field during a certain period. However, in the economic era, most owners of new technologies seek to use intellectual property rights to protect their own new technologies. With the development of standards, their technical contents may be integrated with intellectual property rights (especially patents). Therefore, the establishment of standards needs the investigation and disclosure of intellectual property; the "unification" of standards and the "exclusiveness" of intellectual property shall be taken into consideration; and response plan shall be formulated to prevent the promotion of standards restricted by intellectual property.

V. What do the common letters indicate in standards?

1) How to tell the standard type from the standard number?

The domestic standard numbers are generally composed of "code, serial number, and year of the standard". The difference between various standards is mainly embodied in the standard codes. For example, the code of mandatory national standards is GB, and the code of recommended national standards is GB/T; the codes of the standards vary in different industries. The standard code of the electronics industry is SJ, and the local standard code is DB + local code, such as DB32 for Jiangsu; the group standard code is T/social group code, such as T/CPIA for the standard code of group standards of China Photovoltaic Industry Association; the numbers of corporate standards are composed of Q/local code + company code, for example, the code of Suntech's corporate standard is Q/320217DAY.

2) We often see IDT, MOD or NEQ on the title of national standards. What do they mean?

The state encourages the active adoption of international standards, and it is encouraged to analyze the technical content of international standards and advanced foreign standards and incorporate them into China's national standards to varying degrees, which can ensure their international acceptance and promote the development of China's foreign trade. If a national standard is compiled on the basis of corresponding international standard, it will be necessary to specify and mark the degree of consistency between the two documents. Usually, IDT, MOD and NEQ are used to indicate the degree of difference.

IDT (identical to other standards) means that the technical content of international standard is not changed, but there may be a small amount of editorial changes to facilitate understanding and implementation. Therefore, IDT means that the national standard is identical to the international standard. MOD (modified in relation to other standards) allows technical differences between Chinese standards and international standards, but these differences have been clearly marked and explained in term of reasons.

In addition to IDT and MOD, the correspondence between Chinese standards and international standards also includes

NEQ. NEQ (not equivalent to other standards) means that the technical contents or text structures of a national standard and the corresponding international standard are different, and the differences between them are not clearly indicated, or only the degree of consistency of few or insignificant terms are retained.

If the degree of consistency between a national standard and an international standard is NEQ, the international standard shall not be deemed adopted. The method of compiling international standards is divided into translation method and redrafting method. When IDT method is adopted, the translation method will be adopted; when MOD method is adopted, the redrafting method will be adopted.

3) What do the suffixes TS and TR of international standards ISO/IEC mean?

ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) are world-wide specialized organizations for standardization. ISO and IEC stipulated many years ago that the main task of technical commission is to formulate international standards (IS), but in exceptional circumstances, technical commission can submit one of the following types of technical reports;

- Type 1: After repeated efforts, it is still unable to obtain the support needed to publish an international standard;

- Type 2: The project in question is still in the technological development stage, or it is possible to reach an agreement on an international standard in the future rather than imminent for reasons other than this;

- Type 3: When the data collected by technical commission is not derived from officially published international standards (for example, the Current Technological Level).

Type 1 and Type 2 technical reports shall be submitted for review within 3 years after publication to determine whether to change them to international standards. Type 3 technical reports do not have to be reviewed unless the data they provide is no longer valid. At present, Type 1 and Type 2 technical reports have been renamed as Technical Specifications (TS), and only Type 3 is still called Technical Report (TR).

VI. What is the current standard system of the photovoltaic industry?

By the production process and products, the photovoltaic industry chain can be divided into photovoltaic materials, photovoltaic cells, photovoltaic modules, photovoltaic components, photovoltaic power generation systems, photovoltaic applications, and photovoltaic equipment. The photovoltaic industry chain is long, and there are many standardization technical organizations and standard authorities involved in China. The main standardization technical organizations include the National Standardization Technical Committee for Semiconductor Equipment and Materials (SAC/TC203, responsible for the standards in the field of photovoltaic materials and equipment), and the National Standardization Technical Committee for Solar Photovoltaic Energy System (SAC/TC90, responsible for the standards in the fields of battery, module, component, and system), etc.; competent authorities for standards in photovoltaic manufacturing and system mainly include the Ministry of Industry and Information Technology, the National Energy Administration, etc.

Figure 2 Photovoltaic industry chain and various links

Figure 3 China's standardization administration system

Focusing on the construction of the photovoltaic industry chain, taking the improvement of product quality and technology level and meeting application demands as the starting point, the current comprehensive standardization technical system framework of the photovoltaic industry is mainly composed of basic general, photovoltaic manufacturing equipment, photovoltaic materials, photovoltaic cells and modules, photovoltaic components, photovoltaic power generation systems and photovoltaic applications, totally 7 major directions and 35 sub-categories, which are as follows.

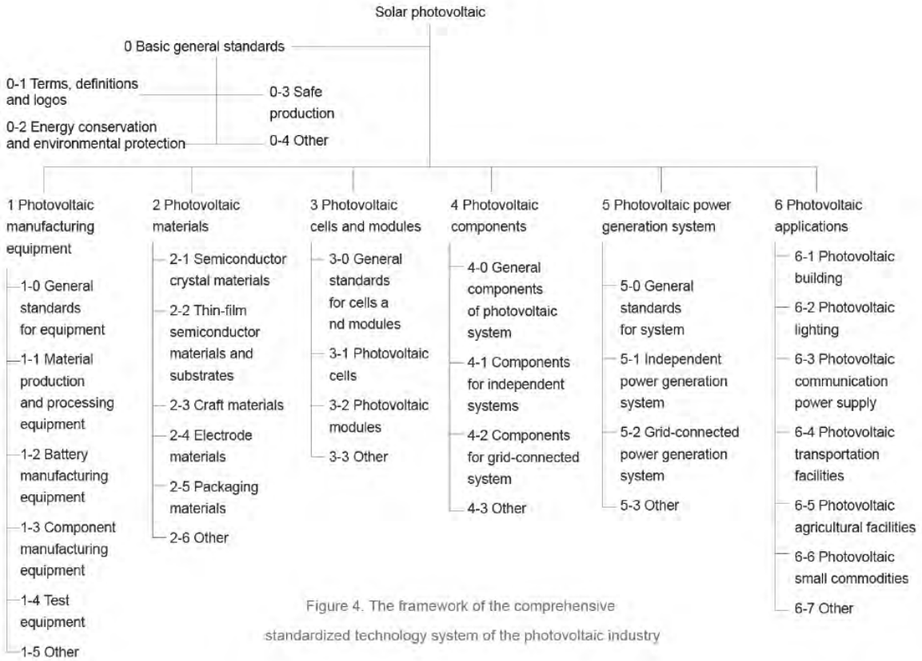


Figure 4. The framework of the comprehensive standardized technology system of the photovoltaic industry

VII. What process does a standard go through from formulation to release?

The processes from developing to releasing standards at all levels are similar. Taking national standards as an example, the following processes are required: pre-research, project approval, drafting, opinion solicitation, review, approval, and release.

Pre-research and project approval stage: On the basis of research and argumentation, make proposals for the development of project, carry out necessary feasibility analysis and other sufficient demonstration of the project proposal, and, after review and opinion solicitation, deliberate the approved project, formulate a plan and issue it to relevant units.

Drafting stage: Establish a standard Working Group (WG), reach an agreement within the group, and prepare standard draft and prepare instructions.

Opinion solicitation stage: The technical commission (TC) organizes extensive solicitation of opinions, and the standard working group revises the standard draft based on the opinions, and forms the opinion processing record and the revised draft for review.

Review stage: The technical commission conducts joint review or letter review of the draft submitted for review, and the standard working group revises the draft submitted for review based on the comments to form a draft submitted for approval.

Approval stage: review standard and serial number. The administrative authority of standardization under the State Council reviews and coordinates the procedures over the draft for approval and related working documents.

Publishing and release stage: release, printing and publishing, and filing. The national standards publishing agency makes editorial revisions to the draft for approval and publishes the final draft in accordance with the provisions of GB/T 1.1 Directives for Standardization.

It should be noted that the standard does not end when it is released. Later, the technical commission shall evaluate the applicability of the standard, form a review conclusion, and timely revise it. The standard determined to be unnecessary after the review shall be abolished in time.

VIII. What standards did Suntech participate in the formulation of?

Up to now, Suntech has presided over or participated in the formulation of more than 40 standards, including 3 advanced overseas standards, 2 national standards, 4 industry standards, and 1 local standard. 29 of which have been released. The list of standards that Suntech presided over the formulation is as follows:

Serial number	Standard category	Standard name	Release time
1	International advanced standard	Specification for Silver Paste, Used to Contact with N+ Diffusion Layer of Crystalline Silicon Solar Cells	April 2021
2	International advanced standard	Specification for Anti-Reflective-Coated Glass, Used in Crystalline Silicon Photovoltaic Modules	October 2018
3	International advanced standard	Specification for Aluminum Paste, Used in Back Surface Field of Crystalline Silicon Solar Cells	January 2015
4	National standard	Photovoltaic Devices - Part 11:Test Method of Initial Light-induced Degradation of Crystalline Silicon Solar Cell	April 2016
5	National standard	General Specification of Crystalline Silicon Terrestrial Solar Cells	December 2012
6	Industry standard	Test Method for Mechanical Vibration of Crystalline Silicon Photovoltaic (PV) Modules in Shipping Environment	January 2016
7	Industry standard	No-clean Flux Used for Crystalline Silicon Photovoltaic (PV) Modules	October 2015
8	Industry standard	Tin-based Solder Dipping Ribbon Used for Crystalline Silicon Photovoltaic (PV) Modules	October 2015
9	Industry standard	Code for Operation and Maintenance of Building Mounted Photovoltaic System	December 2011
10	Local standard	The Technology Code in Integration of Building and Photovoltaic	November 2009

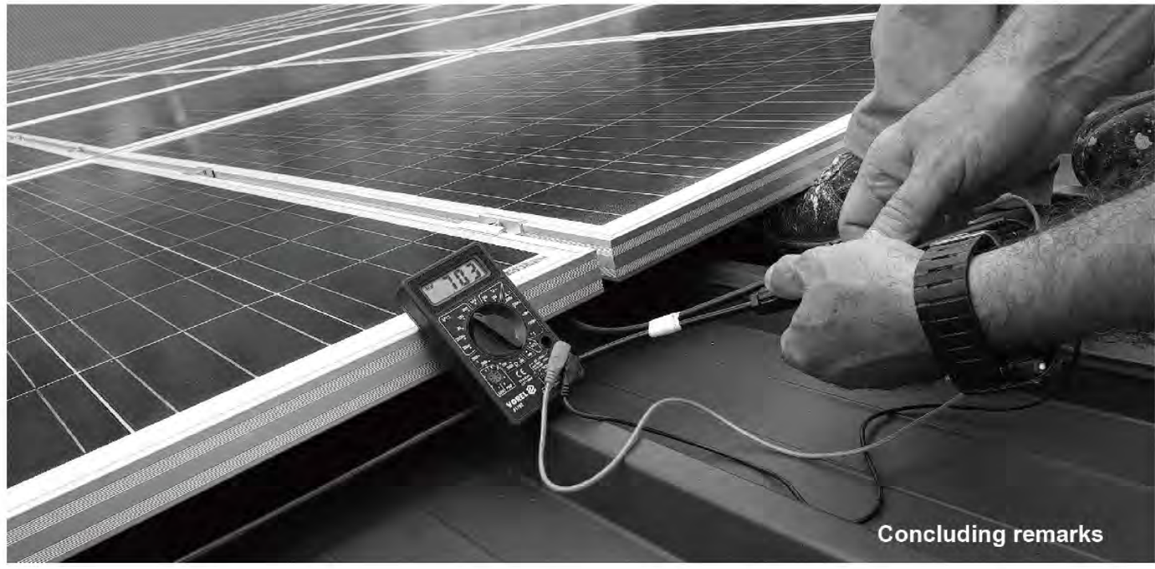
Table 2 List of standards that Suntech presided over the formulation

IX. Commonly used standard search websitesparticipate in the formulation of?

According to the standard type, the commonly used standard search websites are as follows:

Standard type	URL	Related Information
International standard	ISO Online Browsing Platform https://www.iso.org/obp/ui#home	Full texts of some standards can be browsed
National standard	National Public Service Platform for Standard Information http://std.samr.gov.cn/	National Standard Catalog Free accessing of full texts of mandatory standards and some recommended standards
	China Government Network http://www.gov.cn/fuwu/bzxxcx/bzh.htm	Latest filing information of national, industry, and local standards
	China National Institute of Standardization https://www.cnis.ac.cn	Latest standard research trends
	China Standard Service Network http://www.cssn.net.cn	Texts of domestic and overseas standards
	Websites managed by local administrations of market regulation and local standardization institutes E.g., Wuxi Standard Service Network http://www.stdwx.org/	Texts and compilations of domestic and overseas standards
Industry standard	National Public Service Platform for Standard Information http://std.samr.gov.cn/	Texts of industry standards
Local standard	National Public Service Platform for Standard Information http://std.samr.gov.cn/	Texts of local standards
Group standard	Websites managed by local administrations of market regulation and local standardization institutes National Group Standard Information Platform http://www.ttbz.org.cn/	Texts of group standards
Enterprise standard	Public Service Platform for Corporate Standard Information http://www.qybz.org.cn/	Texts of corporate standards

Table 3 Commonly used standard search websites



Concluding remarks

It is far from enough to solely rely on the efforts of standardization personnel to participate in industry standardization work. It requires the high attention of business managers and the participation and cooperation of enterprise employees (especially technical personnel). The formulation of standards can guide the direction of industry development and promote its healthy development; establish industrial access threshold, eliminate low-quality enterprises, and standardize the market management of the industry. For enterprises, it can improve their right of discourse, embody their technological advantages, avoid being controlled by others, and help strive for the best interests according to the enterprises' own conditions; increase industrial exchanges, establish corporate image, and enhance brand value; strengthen the construction and management of corporate standardization, and improve product quality. In addition, participation in standard formulation can also help obtain government funding and create economic value.

INTERPRETATION

TOPCon High-Efficiency Cell in Development

Chen Liping

Master of Optical Engineering, MBA of Tongji University, Senior Engineer, Vice Principal of Jiangsu (Suntech) Institute for Photovoltaic Technology, and off-campus cooperative advisor of graduate students with masters' degrees in School of Science, Jiangnan University. She joined Suntech (Wuxi) in August 2005 and has been engaged in research and development and technical management of high-efficiency cells. During her work, she participated in eight national-level, provincial-level, and international cooperative scientific research projects as the core technical backbone, published more than 20 papers, applied for 24 patents, and applied for 11 patents as the first inventor, which had four invention patents and two utility model patents authorized by the China National Intellectual Property Administration. She was awarded the title of "Young and Middle-aged Experts with Outstanding Contributions in Wuxi City" in 2020, and won the first prize of Jiangsu Photovoltaic Science and Technology Award in 2020 and the second prize in the Science and Technology Progress Award of Chinese Renewable Energy Society in 2020.

2021 is the first year of the 14th Five-Year Plan, and it is also a key year for China's photovoltaic power generation to enter the stage of grid parity. Cost reduction and an efficiency increase in photovoltaic products are the basis of realizing the grid parity of photovoltaic power generation in China. Therefore, developing solar cells with new structures and high conversion efficiency has always been an important part of cell manufacturing. According to the statistics of China Photovoltaic Industry Association, with the continuous unlocking of new production capacity of PERC, the market share of PERC cell will increase to 86.4% in 2020, while the market share of the traditional Al-BSF cell will decline to 8.8%. The expansion of PERC production capacity will intensify homogenization competition, urging the cell manufacturer to make a breakthrough with the differentiation for development. In this situation, the N-type silicon wafer has attracted researchers' attention because of its high minority carrier lifetime, no light-induced attenuation and resistance to metal contamination.

In the past two years, the production capacity of cells in China is still dominated by PERC. The photoelectric conversion efficiency of industrialized PERC cells has reached 23%, with the theoretical limit efficiency of 24.5%. At present, the bottleneck of industrialized efficiency of PERC cell has appeared. The loss, caused by carrier recombination at the interface between metal electrode and silicon, is the key factor that restricts the further improvement of the efficiency of traditional crystalline silicon (c-Si) solar cells. Given that, the traditional method is to use local contact, such as passivated emitter and rear cell (PERC) and passivated emitter and rear locally-diffused (PERL) cell; the conversion efficiency of PERL cell, manufactured by the University of New South Wales (UNSW) in Australia, reached 24.7% [1], breaking the world record at that time. This method is not suitable for industrial application due to its high temperature and complicated process. The local contact structure increases the complexity of manufacturing technology, and makes transverse transmission a key factor in the design of solar cells. At present, the most typical example of the solution is a tunnel oxide passivated contact (TOPCon) solar cell using ultra-thin silicon oxide (SiOx)/polycrystalline silicon (poly-Si) [2], as well as the heterojunction with intrinsic thin-layer (HIT) solar cells using silicon-based materials for passivation contact, with the highest conversion efficiencies of 25.8% and 26.6%, respectively [2-3], which proves the great potential of passivation contact in the application of crystalline silicon solar cells.

1. Structure and Principle of the TOPCon Cell

In 2013, Dr. Frank Feldmann of Fraunhofer Institute for Solar Energy Systems in Germany first proposed the concept of TOPCon cell at the 28th European Photovoltaic Solar Energy Conference and Exhibition. TOPCon is a passivation structure for crystalline silicon solar cells. As shown in Figure 1, it is composed of a layer of ultra-thin silicon oxide and a layer of heavily-doped polysilicon. The ultra-thin silicon oxide is in direct contact with the silicon substrate, neutralizing the dangling bonds on the silicon surface and performing excellent chemical passivation; due to the Fermi-level difference between the heavily doped polysilicon layer and the silicon substrate, the energy band is bent on the surface of the silicon substrate, blocking the passage of minority carriers more effectively without affecting the transmission of majority carriers, thus realizing the selective collection of carriers. Compared with the traditional PERC, the TOPCon cell structure has the following advantages: passivated back surface in the whole area, and no direct contact between metal and silicon, avoiding contact recombination caused by direct contact with silicon substrate, significantly reducing interface recombination while achieving good contact performance, collecting carriers in the whole area, reducing life sensitivity, and being conducive to improving the open circuit voltage and short-circuit current of the cell. Solar Energy Research Hamelin (ISFH) analyzed the theoretical efficiency limits of solar cells with different structures at the report meeting of Silicon PV in 2019, and concluded that the efficiency limits of passivated contact cells can reach 28.2-28.7%[4], which is slightly higher than the limit efficiency of HJT cells (27.5%), much higher than the limit efficiency of PERC cells (24.5%), and closest to the theoretical limit efficiency of crystalline silicon solar cells (29.43%).

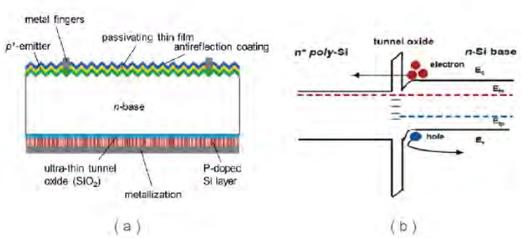


Fig. 1 Schematic Diagram of Topcon Cell Structure (a) and Tunneling Band Structure (b)

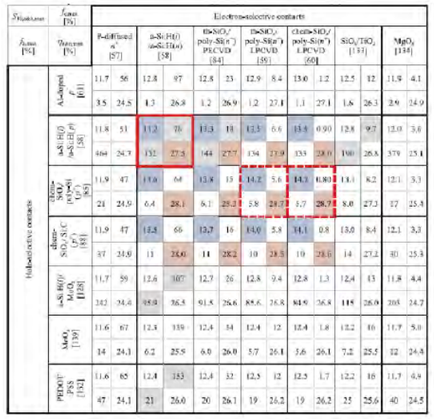


Fig. 2 The Efficiency of Double-side Passivated TOPCon Reaching 28.7%

Source: Surface passivation of crystalline silicon solar cells: Present and future

2. Research Progress of TOPConof

In 2013, the Fraunhofer Institute for Solar Energy Systems in Germany first proposed the TOPCon cell structure technology, and the open circuit voltage of the N-type substrate cell released was 703mV, with the efficiency of 23.7%; in 2014, the efficiency was increased to 24.4% by optimizing the metal contact area; in 2015, by applying the TOPCon structure to the rear of the cell, the efficiency reached 25.1%; in 2017, Feldmann achieved an efficiency of 25.8% on Fz silicon wafer with an area of 4cm², a resistivity of 1 ω cm and a thickness of 200μm by optimizing the thickness and resistivity of the silicon wafer, keeping the world record of TOPCon cell all the time. Meanwhile, the efficiency of the cell manufactured by the Fraunhofer Institute on a large-area P-type silicon wafer of 100 cm2 was up to 24.5%. In addition, the Energy Research Centre of the Netherlands (ECN), Solar Energy Research Hamelin (ISFH) in Germany, the Australian National University (ANU) and National University of Singapore (NUS) all carry out relevant research and development work in this technology field.

The crystalline silicon photovoltaic enterprises in China have made a series of outstanding achievements in TOPCon cell technology, continuously refreshing the record of TOPCon efficiency. In 2020, Yingli Group developed a large-size N-type TOPCon monocrystalline silicon double-sided cell based on a mass production process, with the photoelectric conversion efficiency of 23.96%; JinkoSolar developed a TOPCon monocrystalline silicon cell, with the conversion efficiency of 24.87%. In May 2021, LONGi Group developed the monocrystalline-silicon double-sided N-type TOPCon cell, with a conversion efficiency of 25.21%, and the commercial-size monocrystalline-silicon double-sided P-type TOPCon cell, with a conversion efficiency of 25.02%, which is the highest efficiency of commercial-size P-type cell up to now.

Table 1 Record of Conversion Efficiency of N-type TOPCon Cell

Institutions	Voc (mV)	Jsc (mA/cm2)	FF (%)	Conversion efficiency (%)	Area (cm²)	Time (year)
Fraunhofer	724	42.9	83.1	25.8	4	2017
Fraunhofer	713	41.4	83.1	24.5	100	2017
Trina Solar	716.8	40.57	84.52	24.58	244.62	2019
JinkoSolar	714.9	41.54	83.78	24.87	267.8	2020
Yingli Group	701	40.85	83.62	23.96	251.99	2020
Jolywood	702	41.43	81.99	23.85	251.99	2020
Fraunhofer	732	42.1	84.3	26.0	4	2020
Longji	721.6	41.64	83.90	25.21	242.97	2021

3. Process Flow of TOPCon

TOPCon has a higher theoretical efficiency limit. Compared with PERC, only boron diffusion, tunnel oxide deposition and other steps are added for TOPCon. Its process can be upgraded on the basis of the PERC production line. To that end, existing traditional P-type cell equipment can be retained and utilized to the greatest extent, thus making Topcon the first choice for the subsequent transformation of existing PERC production capacity.

The current technological process of TOPCon cell includes four types:

Source: CPIA

1) Polycrystalline silicon film prepared through LPCVD combined with a traditional full diffusion process;

2) Polycrystalline silicon film prepared through LPCVD combined with boron diffusion and an ion implantation process of phosphorus;

3) Polycrystalline silicon film prepared through PECVD and an in-situ doping process;

4) Polycrystalline silicon film prepared through PVD and an in-situ doping process.

Among them, LPCVD technology is mature and its mass production has been realized, with the sophisticated localization of equipment, but rolling coating and slow film forming speed are still the main problems of the current process; in the last two years, the new technology direction is to prepare the polysilicon layer of TOPCon cell through PECVD, greatly reducing the cost due to less process flow; the PECVD deposition speed is fast, but the resulting film-bursting phenomenon will reduce the overall yield, and its long-term stability remains to be seen; the current PVD technology is still immature, with large equipment investment, large floor space and a long way to go before mass production.

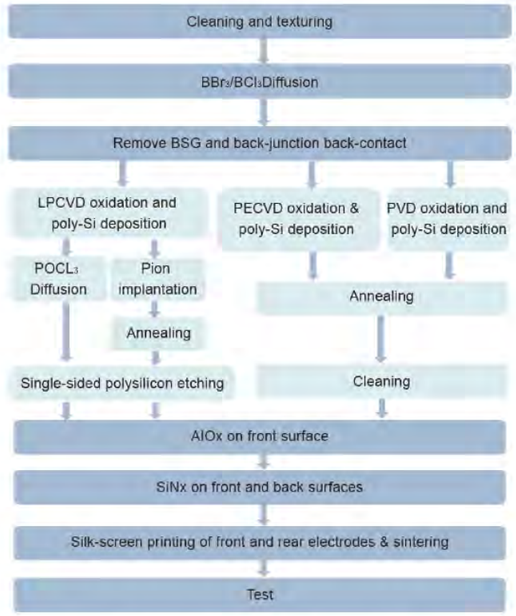


Fig. 2 Four Different TOPCon Process Flows

Table 2 Comparison of Different Technical Routes of LPCVD, PECVD and PVD

	LPCVD	PECVD (tubular)	PVD
Equipment investment CAPEX	Low	Medium	High
Web coating	Serious	Small	No
Compatibility of different sizes	Low	Low	High
Capacity	High	Low	High
In-situ doping	Difficult, SiH_4+PH_3	SiH_4+PH_3/B_2H_6	Silicon target +PH_3
Film quality	Better	General, prone to film bursting	General
Gas consumption	Low	High	Low
Special gas	SiH_4, PH_3	SiH_4, PH_3/B_2H_6 ,H_2	PH_3
Cost of consumables	High (quartz boat, quartz tube)	General (graphite boat cleaning)	Low (carrier cleaning)
Floor area	Small	Small	Large
Energy consumption	High	Low	Low
Advantages	High process maturity and many years of experience in mass production; Low gas consumption; Good film forming quality; Smaller equipment investment; Small floor area	Short process time; Prone to in-situ doping (P-type and N-type, with the deposition rate basically unaffected by doping); Small floor area	No web coating; Short process time; Prone to in-situ doping; Different sizes of silicon wafers are compatible; conducive to flaking
Disadvantages	Web coating; Difficult in-situ doping; High energy consumption; High cost of quartz consumables; Poor compatibility of silicon wafers with different sizes	Web coating; Poor film uniformity; Prone to film bursting; High gas consumption; Poor compatibility of silicon wafers with different sizes	Large equipment investment; Large floor area

References:

[1] Zhao J, Wang A, Green M A. 24.5% Efficiency silicon PERT cells on MCZ substrates and 24.7% efficiency PERL cells on FZ substrates[J]. Progress in Photovoltaics Research and Applications, 1999, 7(6):471-474.

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[4] Schmidt J, Peibst R, et al. Surface passivation of crystalline silicon solar cells: Present and future[J]. Solar Energy Materials and Solar Cells, 2018,187:39-54.

4. Key Process of TOPCon

4.1 Process of tunneling oxide growth

The TOPCon structure of rear passivated contact based on N-type substrate is composed of an ultra-thin tunneling oxide layer and a phosphorus-doped Poly-Si layer. The tunneling oxide layer is used to isolate the silicon substrate from the heavily-doped Poly-Si layer and achieve chemical passivation. To reach the passivated contact performance of the TOPCon structure, the thickness of oxide layer is greatly required. If the oxide layer is too thin, the local oxide layer will be discontinuous, affecting the surface passivation quality. In the process of annealing at high temperature, a large number of "pinhole" structures will appear in the extremely-thin SiOx, and the silicon substrate will directly contact with n+ Poly-Si, resulting in the increased surface recombination. Secondly, due to the perforation of the tunneling oxide layer, the blocking effect to phosphorus atoms becomes weak, as a result, a large number of phosphorus atoms will diffuse into the silicon substrate, causing larger auger recombination and increasing body recombination. If the oxide layer is too thick, however, it will affect the tunneling transport of most carriers. Therefore, the tunneling oxide layer needs to have the following characteristics: thin gauge, with stability and controllability; good chemical passivation effect, and fewer defects of oxide layer and high quality.

4.2 Process of phosphorus-doped poly-Si layer

The doping concentration of n^+ Poly-Si not only affects the field passivation, but also the contact performance and optical performance. To ensure high conversion efficiency of solar cells, the metal-semiconductor contact needs to be "ohmic contact", that is, the doping concentration in the metal-semiconductor contact area should be as high as possible. Heavily-doped n^+ Poly-Si features the strong free carrier absorption, which belongs to the parasitic absorption, and has no contribution to light current. The doping concentration of n^+ Poly-Si will affect both optical and electrical properties. Therefore, it is necessary to achieve a balance between the passivation performance and contact performance, form a better ohmic contact between the doped layer and the metal grid line, and ensure a lower recombination in the metal contact area, so as to reach the optimal open-circuit voltage value.

5. Outlook

The core driving force for the development of the photovoltaic industry is the continuously-reduced leveled cost of energy, and cost reduction and efficiency increase are the constant pursuit of industrial development. With the PERC conversion efficiency and cost reduction space approaching the limit, the new cell technology with higher conversion efficiency ushers in a development window phase. The mechanism of N-type TOPCon passivation contact is relatively clear. With the rapid progress achieved in academia and industry, TOPCon cell technology has become one of the most concerned future development directions, and it is expected to become a high-efficiency cell put into production on a large scale in the post-PERC era. The efficiency of TOPCon cell from industrial production in the future will have the potential to exceed 25%.

INSIDE

Workshop on Sustainable Factory Held in Suntech

On June 10, the Workshop on Sustainable Factory was held in the Ecology Building in Suntech Headquarters in Wuxi. Jointly hosted by AHK Greater China (Shanghai) and Wuxi International Chamber of Commerce, the workshop was organized by Suntech and attended by more than 80 corporate representatives. The participants, focusing on sustainable factory development, discussed the sustainable production and manufacturing. Many industrial leaders and senior insiders in the industry gave excellent speeches on green and sustainable development of manufacturing and on how to fulfill CSR.

On the premise that major economies including China and EU have put forward the carbon neutrality target and climate change action plan, many speakers having the background of green development, environmental protection and sustainable development discussed how enterprises make their facilities and equipment more sustainable and how to reduce impact on environment. During the event, Mr. Li Kui, Sales General Manager of Suntech Europe & US gave a speech on how new energy, in particular solar energy, can exert positive influence in the process of carbon neutrality in the world. After introducing the development of new energy in the world and Suntech global business, Mr. Li said, "Realizing carbon neutrality is the extensive, profound and systematic reform of economy and society, in which solar energy will play a crucial role. In the background of carbon neutrality, the solar energy will, by means of high conversion efficiency, low power-generation cost and flexible ways of installation, integrate into other industries and application scenarios while jointly helping boost sustainable development in the world".

Recent years has witnessed the release of the United Nations Framework Convention on Climate Change and the Paris Agreement, revealing that sustainability has become the global consensus. In the process of carbon neutrality, Suntech, as a famous photovoltaic manufacturer in the world, devoted to the production of solar cells and modules for 20 years, will continue to respond to the higher requirements raised by solar market for the corporate strategy, production and management of supply chain. At the same time, Suntech will provide better products and service to serve the global carbon neutrality process and make contributions to fulfilling CSR for green life and to sustainable development.

Highlights of SNEC 2021

From 3rd to 5th June, 2021, the 15th International Photovoltaic Power Generation and Smart Energy Exhibition & Conference (SNEC 2021) ended in Shanghai New International Expo Centre. Let us review the highlights of Suntech.

New product launch

Ultra V Pro series launched TOPCon products: designed with 182 mm large-sized TOPCon high-efficiency battery.

There were a total of three exhibits, including: bifacial transparent Tedlar backsheet 72-cells module; double-glass 78-cells large module; 54-cells small size all-black module for BIPV roof application with special frame design.

The high-efficiency TOPCon battery production line intelligent plant jointly developed Suntech, Lead Intelligent and Jiangsu Leadmicro adopts industry-leading digital intelligent plant solution based on industrial Internet technology. TOPCon process route is: exclusive oxide layer atom deposition technology and rapid polysilicon plasma deposition technology. Its technical advantage is rapid film formation rate without winding plating. The production line uses intelligent logistics and a Flexible Manufacturing System (FMS) that runs through the entire process, compatible with 182 mm and 210 mm N-type silicon wafer battery. The conversion efficiency exceeds 24%. The total production capacity reaches 2GW.

Leaders discussion

Global Green Energy Leaders Discussion, as an important forum of SNEC 2021, was kicked off as scheduled. Mr. Tang Jun, president of Suntech, was invited to participate in Global Green Energy Leaders Discussion, and discussed with industrial higher-ups around the theme of "opportunities and challenges in the PV industry under the dual-carbon goal (peak carbon dioxide emissions before 2030 and carbon neutrality before 2060)".

When it came to the development trend of the PV market, Mr. Tang emphasized that the PV industry is ushering in new development opportunities under the background of the dual-carbon goal, and technical progress continuously brings about iteration of the products and improvement of power generation efficiency; the equipment for expanding production at each terminal of the industry chain is characterized by long physical life and short technical life; therefore, the compatibility upgrade shall be considered in investment to avoid waste and go against the low-carbon goal. Compared with high power and high efficiency, industrial development and product reliability shall be given priority. On the premise of complying with the market law, industrial judgment and its related policies need to be treated rationally.

Alliance strategy

On 3rd June, the opening day of SNEC 2021, the "Yangtze River Delta BIPV Research Institute" co-sponsored by Suntech, The IT Electronics Eleventh Design & Research Institute Scientific and Technological Engineering Corporation Limited (EDRI), CMEC-GL, Sineng Electric, Longmax Technology and UTTsolar was officially inaugurated on the "Opening Ceremony of Yangtze River Delta BIPV Research Institute & CREC 2021 Press Conference" held on the EDRI booth.

According to the agreement, Suntech, together with cooperative enterprises, will jointly integrate investors, developers and roof owners to establish in-depth cooperative relationships in development, investment and financing, design, construction, and operation and maintenance of distributed energy projects such as BIPV; and create the greater business value for all the partners by mutually supporting market expansion strategy and enhancing competitive force, on the basis of achieving the innovations of PV building integration technology, business model, and financial model.

Honors

During SNEC 2021, Suntech won Industrial Contribution Award and Talent Cultivation Award issued at the 5th Asian PV Industrial Award (APVIA 2021). The awards were judged by authoritative experts, analysts, journalists and academic representatives from the PV industry. The purpose of "Industrial Contribution Award" is to commend the photovoltaic enterprises that lead the development of the industry, promote the progress, over-perform in annual operating performance, and play a pivotal role in the industry chain. The purpose of "Talent Cultivation Award" is to commend the enterprises that are committed to cultivating talents in the PV field and importing a large number of outstanding talents.

In addition, Suntech stood out of 2,000 exhibitors due to a new generation of "monocrystalline TOPCon all-black BIPV module", winning the "Terawatt Diamond Award", the highest honor award among the "Top Ten Highlight Selection Activities" of SNEC 2021.

With Conclusion of UEFA Euro 2020, Let's Recall the Relationship between PV and Footbal

On July 12th, the final of UEFA Euro 2020 was played at the Wembley Stadium in London, the UK. Italy beat the host and won the champions after a penalty shoot-out, becoming the new European champions. We believe that people are immersed in all kinds of emotions after a month of excitement and sharing.

In fact, the relationship between PV and football has lasted for a long time. Solar energy is the richest energy in the world, while football is the most popular sport in the world. When they are combined together, they have created a civilization under the sunshine. Today, driven by the passion of the world, Suntech invites you to review these "PV and football" projects.

Estádio Nacional de Brasília Mané Garrincha

01 The installed solar capacity at the Estádio Nacional de Brasília Mané Garrincha is 2.5 MW, which is the largest in the world. In the 2014 FIFA World Cup, the third-place match was played in this stadium. In this match, Brazil lost 0-3 to the Netherlands, while the Dutch claiming the third place, the Brazilians burst into tears at their national stadium.

Maracanã Stadium

02 Maracanã Stadium is the second stadium to have held the finals of two world cups in the history, and is widely regarded as the largest football stadium in the world. In the 2014 FIFA World Cup, Maracanã Stadium introduced the solar power generation system with PV modules made in China, and the installed capacity was 400 KW.

Mineirão

03 The Mineirão is a local cultural heritage of Brazil, and also one of the stadiums for the 2014 FIFA World Cup. In 2013, the stadium installed 1.4 MW rooftop PV system, which could produce 1.4 million kWh every year.

Fritz-Walter-Stadion

04 Fritz-Walter-Stadion is the home of Bundesliga club 1. FC Kaiserslautern. Before the 2006 FIFA World Cup, this stadium was renovated and installed a PV power generation at its roof with a total installed capacity of 1 MW.

Stadion Wankdorf

05 Stadion Wankdorf is also known as Stade de Suisse and situated in Bern, the capital of Switzerland. In 2007, a solar power generation equipment with a total of 7,930 sets of PV modules was installed in this stadium. The total installed capacity was 1.3 MW, and it could produce 1 M kWh of power every year.

Arena Pernambuc

06 Arena Pernambuco is located in Recife, Brazil. It applies a solar PV power generation system with a total installed capacity of 1 MW. It can generate 1.5 million kWh per year, equivalent to the electricity consumption of 6,000 Brazilians per year, and can satisfy 30% of the power demand of the arena.

07 Lincoln Financial Field

Lincoln Financial Field is the home of the Philadelphia Eagles of the National Football League (NFL). This stadium has installed 2,500 solar panels and 80 vertical axis wind turbines, and built a power plant which uses biodiesel or natural gas. According to estimates, it has produced over 1 billion kWh of power in two decades.

08 National Stadium (Kaohsiung)

The National Stadium (Kaohsiung) is currently the largest stadium in Taiwan, China. Themed on dragon, this stadium looks like a huge twisted Chinese dragon. On its roof there are 8,844 solar panels, forming the scales of the dragon. The total installed capacity of this stadium is 1 MW, and it is the first stadium fully powered by solar power in the world.

China National Stadium "bird's nest"

From cuju in ancient China to the football culture which is popular across the globe, China has also made significant contribution to the development and popularization of this international sport. Nowadays, sports are also increasingly integrated with high-tech energy-conservation methods to provide inexhaustible power for the sustainable development of the country and cities. The Beijing Bird's Nest PV-building integration project is a good example.

In 2008, Suntech provided a 130 KW solar power system for the Bird's Nest, the National Stadium of China. The PV power generation system was installed on the 12 main aisles of the Bird's Nest with a total investment of RMB 10 million. This system integrated clean and environmentally friendly solar power generation with the National Stadium, and played a positive role in promoting the use of green energy, effectively controlling and reducing air pollution in Beijing and the surrounding areas, and advocating a green and environmentally friendly lifestyle.

The sportsmanship won't stop there, and the idea of green life is constantly being updated and developed. Under the sunshine, Suntech will firmly adhere to the corporate mission of " Solar powering a green future", and take responsibility to improve the utilization of energy, continuously explore new energy conservation and emission reduction technologies and methods, and lead the new low-carbon trend.

WE SUPPORT UN GLOBAL COMPACT

CBCA CHINA BUSINESS CLIMATE ACTION 中国企业气候行动

Suntech Officially Joins the United Nations Global Compact and China Business Climate Action

Recently, Suntech had officially joined the United Nations Global Compact (UNGC) and the China Business Climate Action (CBCA) to take positive actions for renewable energy enterprises to be socially responsible and promote global sustainability development.

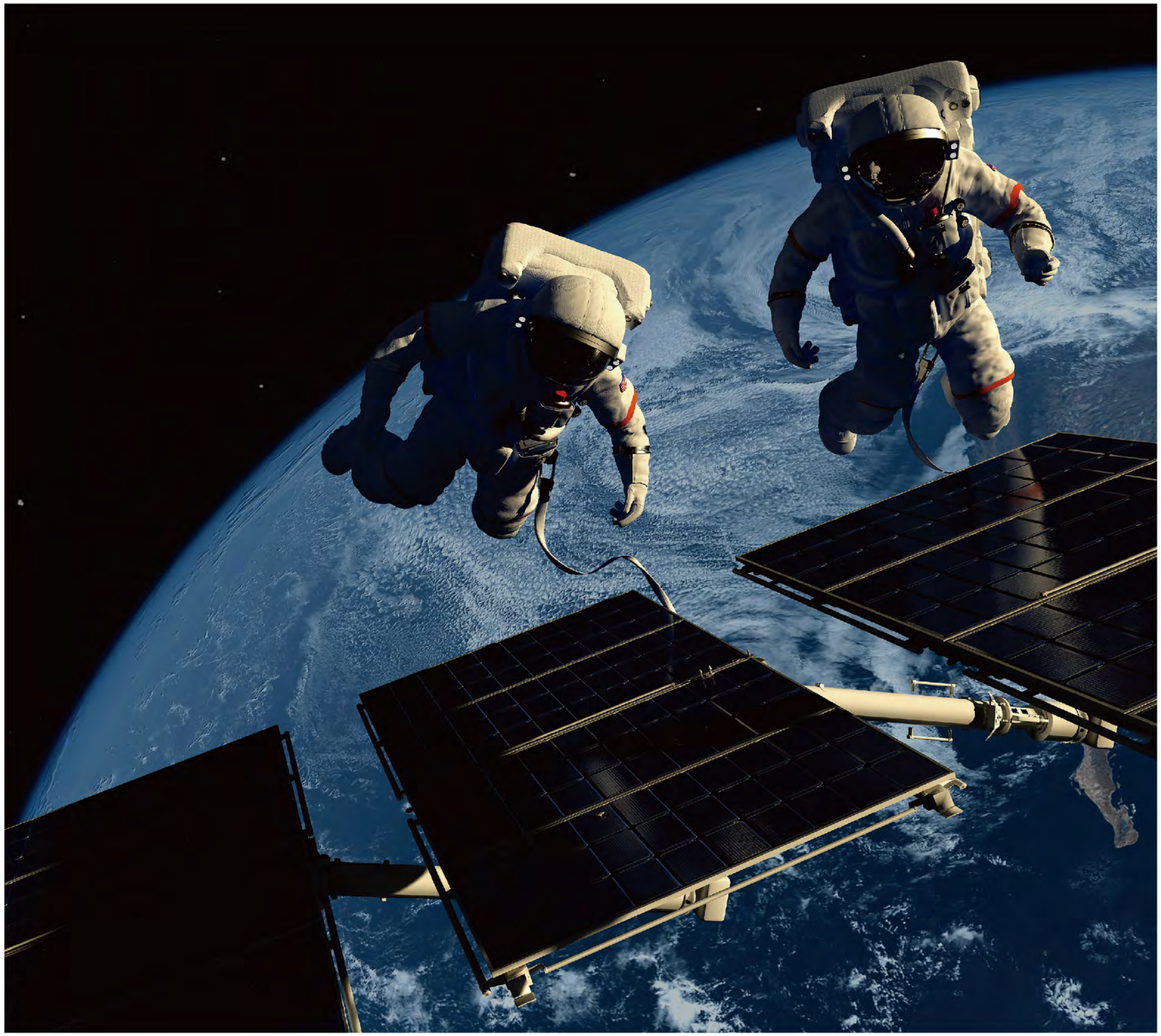
The United Nations Global Compact is part of the United Nations Secretariat and the largest international organization to promote the sustainable development of enterprises with more than 160 participating countries, 13,000 enterprise members, and 3,000 associated members. Members are committed to the Ten Principles of the United Nations Global Compact in the areas of human rights, labor standards, the environment, and anti-corruption practices. Members will report annually their progress and support the broader goals of the United Nations.

The China Business Climate Action (CBCA) was launched in September 2019 during the Global Climate Action Summit. It is a voluntary movement initiated by industry associations, non-government organizations, and research institutions. From its inception, the CBCA actively launched initiatives in all sectors of the society by calling on industry associations and chambers of commerce to lead and drive the reduction of carbon emissions, green transformation, and innovation along the entire industrial chain and cluster. CBCA also calls on industrial and commercial entities to integrate climate change into their development strategies and corporate social responsibilities. Enterprises are to actively promote sustainable business practices and provide solutions to climate problems. They should strive to become a model for climate change and help to drive and steer the industry towards common goals.

The rapid development of the economy and worsening environmental problems have increasingly gained the public's attention. The development towards a high-quality industry needs to go hand in hand with economic and ecological development. Industries must actively adopt green practices and move towards a lower carbon footprint. Enterprises need to cultivate and lead the change towards low-carbon and sustainable operations which are socially responsible. Suntech, being a leader in the renewable energy industry, has established the corporate mission of "Charging the earth for a better future". In these twenty years, Suntech had always planned for the future. Its mission continues to be to improve the efficient use of energy and continue to develop means to save energy and reduce wastages.

By officially joining the UNGC and CBCA, Suntech has taken a firm step towards using solar power generation to promote energy reforms, energy conservation, and reduction in emission in line with the United Nation's sustainability development. In the future, Suntech will actively fulfill its responsibilities as a member of the organizations, take the initiative to assume its corporate duties, and spare no effort to deliver green energy to thousands of households and illuminate every corner of the world with clean energy!

COVER STORY



Solar Energy in the Vast Space: Exploring the Mystery of China Space Power Generation

Tiangong II

Tianhe core module

2021 plays a significant role in China's space history. Specifically, "Tianwen-1" Mars Rover, symbolizing the first Chinese Mars exploration mission, landed on Mars and left a Chinese mark on the planet for the first time; China's space industry developed rapidly, and its pace of exploring the vast stars also attracted extensive international attentions.

On June 17, 2021, the Long March 2F Y12 carrier rocket carrying Shenzhou XII manned spacecraft was ignited and launched at Jiuquan Satellite Launch Center, successfully sending three astronauts, Nie Haisheng, Liu Boming and Tang Hongbo, into space. This exciting milestone marks that Chinese people have entered our own space station for the first time, started the innovation stage of space science, and also brought solar panel into the boundless universe again.

Why does space technology rely on the solar power generation? Actually, spacecraft such as space ship and satellite needs huge energy to fly in space, and the fuels they carry are limited. In order to complete the operation and exploration tasks, it is necessary to use energy locally. At this time, the stable sunlight has become the most favorable and inexhaustible energy source. The high-efficiency solar panel is accordingly the only choice to supply power and to maintain the normal operation of spacecraft. On the other hand, because of the harsh space environment, the stability and quality assurance of solar power generation help avoid some risks for aerospace industry, further proving that the application of solar power generation is irresistible.

Taking the successful launch of the Long March 5B Y2 carrier rocket carrying the space station "Tianhe Core Module" as an example, solar cell sail wing is one of the key technologies of the core module mission. It is understood that stretchable flexible solar cell wings with large area are adopted in the Tianhe Core Module for the first time, with the spread area of 134 square meters, and it is the first time that flexible solar wings are used as the energy source of spacecraft in China. Single wing provides 9 kilowatts of electric energy for the space station, not only meeting the normal operation requirements of all equipment in the module, but also ensuring the daily life of astronauts in the space station. When the flexible wings are all folded, their thickness is that of one book, which is only 1/15 of that of the rigid solar wings.

Coincidentally, the photovoltaic system of Tiangong-2 has also contributed an indispensable force to the development of China's space industry. On September 15, 2016, the Tiangong-2 Space Laboratory on the Long March-2 F carrier rocket was launched at Jiuquan Satellite Launch Center. It is reported that "Tiangong-2" is the first real space laboratory in China, with the configuration of lab module and resource module, a total length of 10.4 meters, a maximum diameter of 3.35 meters and a weight of 8.6 tons; its photovoltaic system is about 18.4 meters wide.

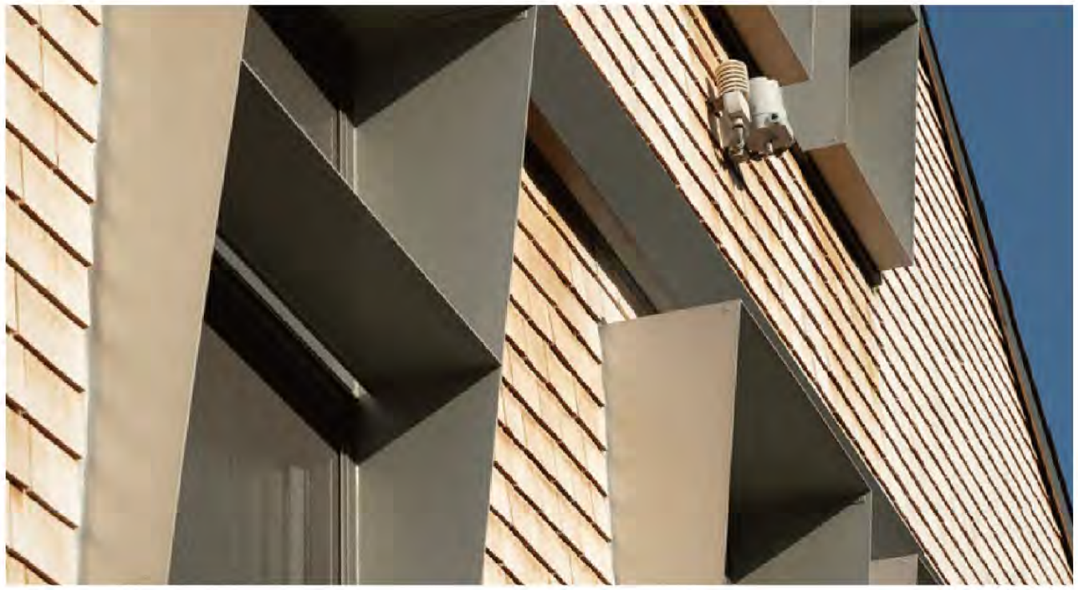
On April 20, 2017, China's Long March 7 Y2 carrier rocket was successfully ignited and launched with the Tianzhou-1 cargo spacecraft, which has a pair of solar wings, unfolded in the daytime, absorbing light energy and converting it into electric energy for storage; at the night of minus 100 degrees Celsius, the solar wings are retracted, and the stored electric energy is converted into heat energy, to prevent the equipment from being frozen. The panel on the solar wing is made of gallium arsenide through the solar power generation technology, with the conversion efficiency of more than 30%.

On December 8, 2018, the Long March 3B carrier rocket carrying Chang 'e-4 lunar probe was successfully launched in Xichang Satellite Launch Center. The "Chang 'e-4" lunar probe uses solar energy as its energy source in outer space. For this purpose, solar panels are used as its wings, bearing the expectations, yearning and pride of the Chinese people, and providing abundant power for the "Chang 'e-4". As a power source, the high-efficiency solar panel is the basis for the probe to maintain normal operation.

On May 5, 2020, the Long March 5B carrier rocket was successfully launched, sending the test ship of manned spacecraft and inflatable cargo re-entry module and lab module into space orbit, and officially kicking off the establishment of space station in China. This is a new starting point, and during the first flight of the Long March 5B carrier rocket, the "new passenger" of solar power supply system supporting power generation and lithium battery energy storage - a new-generation manned spacecraft test ship was carried. This "new bus" is equipped with a series of "black technology" products, such as the monopropellant non-toxic rocket engine, high-conversion-efficiency solar cell, TTE high-speed communication network, distributed integrated electronic system, multi-terminal integrated human-computer interaction system, etc., which comprehensively improves the overall performance of the "new bus".

On July 23, 2020, Tianwen-1 Mars Rover, symbolizing the first Chinese Mars exploration mission, was successfully launched in Wenchang, Hainan province, marking the first step in China's planetary exploration. The "Tianwen-1" consists of three parts: the orbiter, lander and rover, for which the solar panel power supply mode is adopted and the triple-junction gallium arsenide solar cell array adapting to Mars environment is used. In terms of practical solar cell array, this technology is the most advanced in China. In order to complete the 90-day patrol and exploration mission, "Tianwen-1" is equipped with four solar panels to provide sufficient energy and reserve for the Mars rover.

From manned spaceflight to lunar exploration project, many breakthroughs have been made in China's aerospace industry, which is heading for a rapid growth period of independent research and development. Exploring the vast universe has always been the common dream of all mankind. With multi-industry linkage and cooperation, the stupendous force is produced. As Zhao Lijian, the Spokesman of the Chinese Foreign Ministry, once said: We are willing to carry out international exchanges and cooperation with all countries and regions committed to the peaceful use of outer space, and to make positive contributions to mankind's exploration of the mysteries of the universe, the peaceful use of outer space and the promotion of the construction of the community with a shared future for mankind.



Imagining the Future Life from Zero-energy Buildings in Japan

In order to cope with the increasingly severe environmental situation, it is an urgent task for the construction industry to reduce building energy consumption and carbon dioxide emissions while seeking alternative conventional fossil fuels.

The residential building provides us with physical functions (keeping out wind and rain) and belonging sense to some extent. However, the environmental pollution caused by its construction and living process should not be underestimated. According to the statistics of the International Energy Agency, the construction industry is the largest energy end user in the world, generating nearly 40% of the global carbon emissions.

China has a total building stock about 65 billion square meters, and during its use, generate the carbon dioxide accounting for about 20% of China's total carbon emissions and 20% of the total global building emissions. These carbon emissions mainly come from the production and transportation of steel, cement, glass and other building materials, endangering the environment and making the "zero-energy building" imminent option for the society.

What is "zero-energy building "?

As early as 1976, Technical University of Denmark carried out theoretical and experimental study on using solar energy to heat buildings in winter, and first put forward the term "Zero Energy House" for residential buildings.

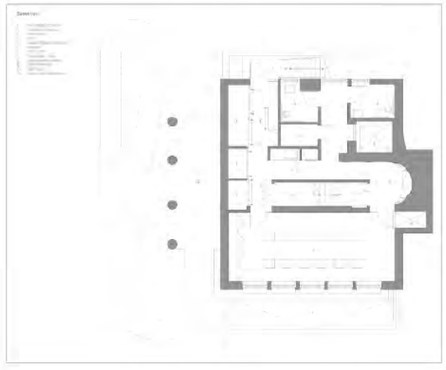
In 1992, the Fraunhofer Institute for Solar Energy Systems in Germany further defined "Zero Energy Building" as a building which is able to generate electricity by itself, and supply to the public power grid connected, or use the power from the grid, with a balance between the energy generation and consumption at a time (unit: years).

In recent years, "zero-energy building" have been widely valued in the world. The landing and implementation of various projects show a positive development trend. This can be seen from the development of ZEH (Zero Energy Home) in Japan.

"Zero energy home" in Japan

The Agency for Natural Resources and Energy has announced the schedule for popularizing zero-energy home in Japan. According to the schedule, by 2030, all newly-built houses must be built in accordance with the standard of "zero energy home".

The Japanese government has providing fund subsidies in policy. The maximum subsidy for residents who intend to build equipment such as high thermal insulation performance (building materials), high-efficiency machines or management systems is half of the total construction costs, with the upper limit of 3.5 million yen; small and medium-sized contractors also receive subsidies, with an upper limit of 1.65 million yen.



Zero energy consumption building plan

How does ZEH save energy?

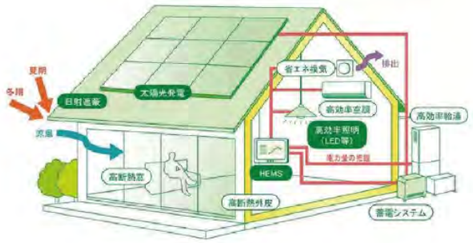
1. Solar panels are installed on the roof, and the solar power generation system is adopted for the whole house;

2. The electricity consumed by the house basically comes from its own solar power generation;

3. No gas used in a house, which prevents fire from happening to the maximum extent and curbs the carbon dioxide;

4. From the wall to the doors and windows, the thermal insulation materials are used. If the outdoor temperature is 0 ℃ in winter, the natural temperature can be kept between 10 ℃ and 15℃ indoors without air conditioning.

The "zero-energy home" in Japan, meeting the dual functions of saving energy and generating energy, has its unique advantages even in dealing with natural disasters. There are natural disasters in Japan from time to time, and inevitably, there will be unexpected situations such as large-scale power outages. In this case, ZEH's solar power generation function can be brought into full play. In addition, the electricity consumption of ZEH basically depends on solar energy, reducing the fire risk.



Operation diagram of zero energy consumption housing in Japan

Practice and ecomagination of "zero energy building" in the world

With the sustainable utilization of resources becoming a difficult problem all over the world, energy saving and emission reduction of buildings are increasingly placed in a pivotal position. In some developed countries, organic architecture, self-sustaining buildings and zero-energy buildings have emerged.

The Eulachhof Project is the first zero-energy building put into service in Switzerland. Before the air is discharged from Eulachhof house, its waste heat is recovered by a heat pump for room heating; shower sewage, for example, is recovered by another heat pump, to supply hot water for buildings; the solar photovoltaic panels are used to supply power for these two heat pumps, and can also be connected to the regional power grid for power generation; 5% of the energy comes from the nearby garbage incineration plant. An opaque glass curtain wall is installed on the outer layer of the house, allowing to adjust the heat in the building, and to keep warm in winter and cool in summer. With this design, the annual average total energy supply is equal to the total demand, realizing zero energy consumption.

In 2018, Apple Park, located in Cupertino, California, was officially put into use. The cooling and heating loads in the building can be adjusted through natural ventilation in 70% of the year, and zero energy consumption is achieved in combination with renewable energy sources, representing the highest level of zero energy building in the United States up to now.

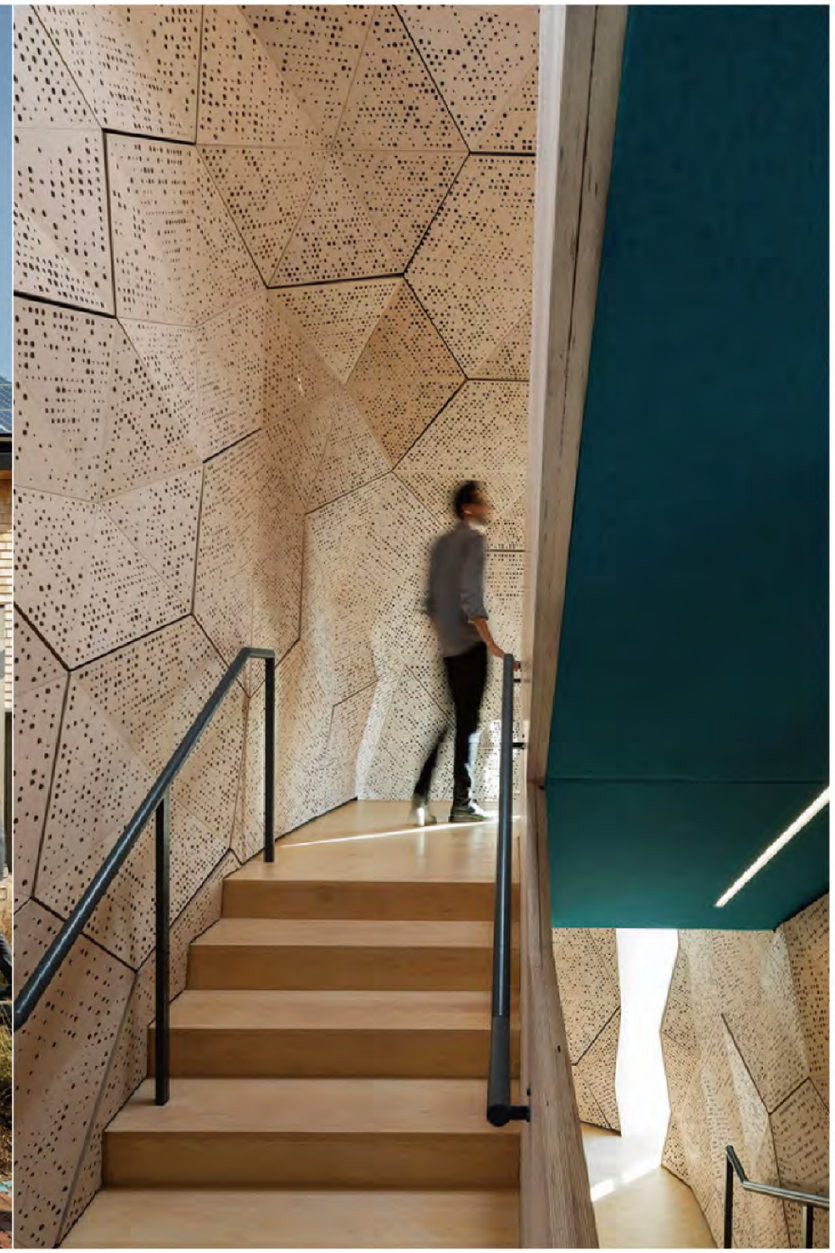
In China, as early as 2010, an attempt was made to demonstrate a zero-carbon emission building: the Expo Zero Carbon House, which is also the first public building in China to achieve zero carbon emission. In addition, water from the Huangpu River is used for the Zero Carbon House, and the water source heat pump is used as the natural air conditioner; the leftovers are also degraded into biomass energy for power generation.

Suntech has never slowed down on the road of reducing carbon and providing green and clean energy for the whole world. In 2010, during the Vancouver Winter Olympics and Paralympics, Suntech provided green electricity for the first zero-energy house in British Columbia, Canada. Designed by RDC Fine Homes, this display house is located in Whistler, and is available for Canadian athletes during the Winter Olympics. The house covers various design concepts and technical elements, reaching a super-efficient energy utilization rate and fulfilling energy consumption demands through the solar power generation system. As a famous photovoltaic manufacturer in the world, Suntech provided a 6-kW solar roof system for this 2,200-square-foot house, showing all contestants and tourists the concept of green and low-carbon life.

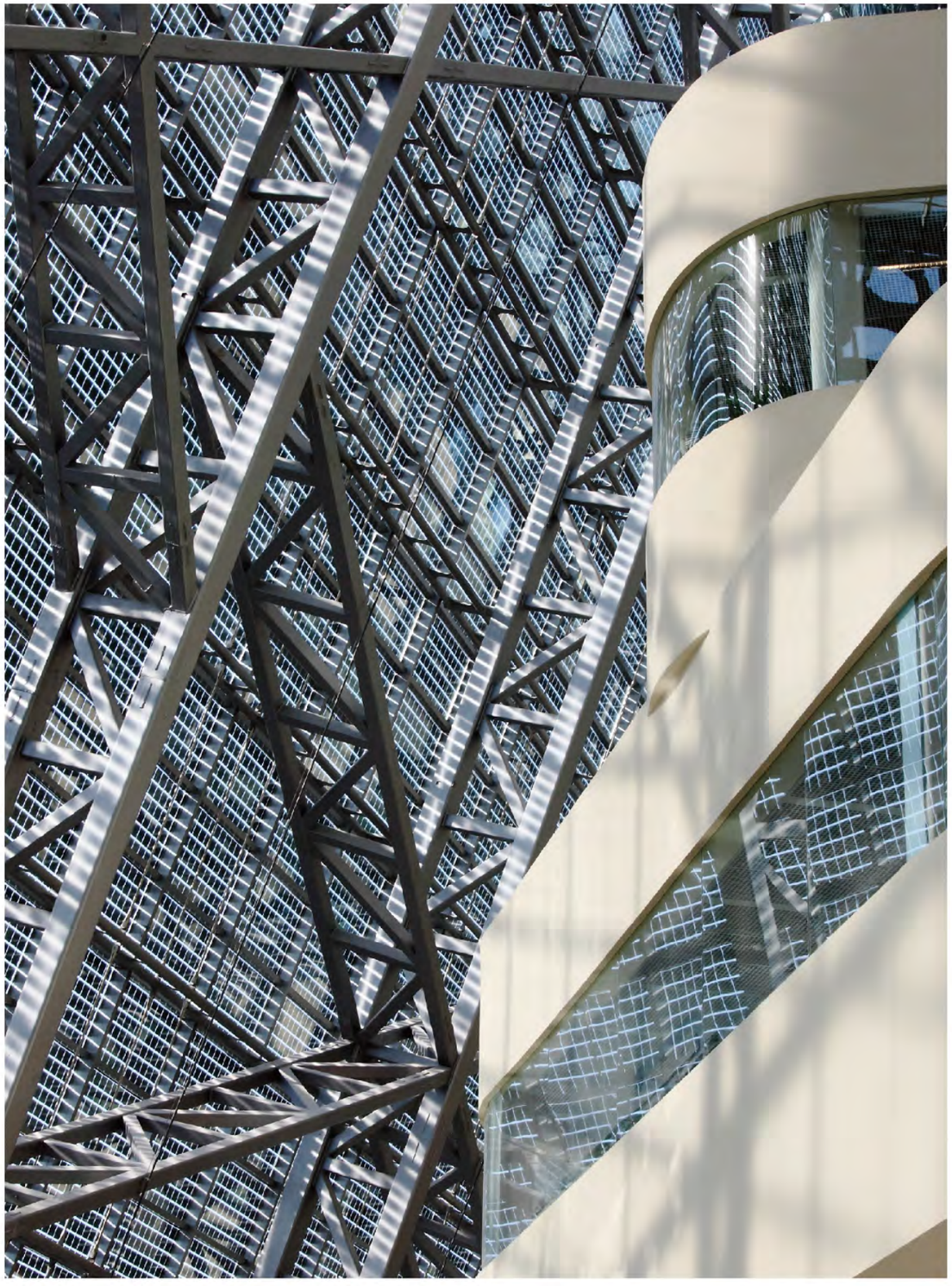
However, it must be admitted that constructing a "zero-energy building" is expensive and difficult in design, for which various factors need to be considered, and measures shall be adjusted to local conditions. As "sustainable development", "carbon neutrality" and "peak carbon dioxide emissions" become hot social topics, the advanced technology is urgently needed to be developed in the professional field from the perspective of life and production. The proportion of total energy consumption of the house even in the whole building field shall be reduced as much as possible.

In the future, the iteration and updating of technology will make a better life and a common living scenario, and the energy technology will extend the imagination of "home", helping a building transcend the functional boundary of living and residence. Let's look forward to the future life.

(Parts of information is from the network.)



EXPLORATION



Suntech eco building BIPV project

BIPV

The Next Important Application in PV Field

The concept of "nearly-zero energy building" (NZEB) is gradually accepted in China's construction industry in recent years, and it is also a physical form and trend of future life.

The PV building material, especially BIPV (Building Integrated PV), has unique advantages in energy saving, including the power generation property, beautiful appearance, low consumption of resources and energy, and little impact on ecological environment, therefore has been vigorously promoted and supported by the authorities.

BIPV belongs to a type of distributed PV power plant. With PV physical properties, the functions of the original buildings are enhanced, improved or expanded through BIPV in the process of architectural design. In addition to the architectural aesthetic concepts considered, BIPV embodies its potential to be used in urban high building density areas by various application methods, including the tile type, daylighting type and wall type.

Nippon Guanghua primary school BIPV project

Mainstream application scenarios:

◆ PV roof (integrated): BIPV used as a roof layer, supports roofing functions with other roof layers.

◆ PV sunshade: BIPV used as a building shading element, supports the corresponding functions.

◆ Outdoor PV: BIPV installed at the outer side of a building as its accessory or facility.

◆ PV stadium: The exhibition hall, science and technology museum and other buildings with roofs and curtain walls using BIPV PV materials.

◆ PV greenhouse: BIPV as the roof of agricultural greenhouse, combined with agricultural greenhouse facilities, incorporating the power generation, light transmission and heat collection properties, thus saving energy, increasing efficiency and production and income.

In 1967, MSK Company (Japan) first proposed the concept of building integrated PV product. In 2004, there were many successful attempts in the industry, such as Mars Opportunity Rover (expansion of PV application, similar buildings after project landing), Manchester Skyscraper Curtain Wall Project, etc. In recent years, BIPV industry has developed rapidly, and many Chinese enterprises have released BIPV products, showing signs of outbreak in the industry.

In China, the industrial and commercial roof market has huge capacity. According to the data of the Ministry of Housing and Urban-Rural Development and other institutions, the existing industrial and commercial buildings (including public buildings) have a total roof area of about 6 billion square meters and a facade area of about 1.6 billion square meters, available for PV installation. If BIPVs are adopted, a total of 1100 GW of capacity can be installed, which is equivalent to a potential market of 5.5 trillion yuan.

According to the Notice on Issuance of the Action Plan for Green Building, by 2022, the proportion of green building area in new urban buildings (the same year) will reach 70%, and BIPV, as an important part of green building, will be fully guaranteed in the future market.

The peak power generation of BIPV basically coincides with the peak power consumption of buildings, greatly alleviating the power shortage. It is of great significance to reduce dependence on traditional energy sources and promote building energy conservation and emission reduction.

Undoubtedly, with the development of technology and the iteration of products, BIPV will become the preferred "edge tool" for building energy conservation and emission reduction and energy allocation, leading China's PV and green building industries to achieve a new round of development and innovation.

(Disclaimer: Parts of views from the network do not represent the opinions of Suntech.)

Suntech eco building BIPV project

BIPV project in Sicily, Italy

Fresh Force in New Energy Fields: Why PV Hydrogen Production Technology Is Promising?

Hydrogen is regarded as the most promising secondary clean energy in the 21st century. It will play an important role in solving energy crisis, global warming and environmental pollution, so it has become a strategic choice for optimizing the structure of energy consumption and ensuring the security of national energy supply.

Currently, the mature technical routes of hydrogen production in China mainly include: hydrogen production by reforming fossil fuel, hydrogen production from industrial by-product gas, and hydrogen production by electrolysis of renewable energy. The latter is called an environment-friendly "green hydrogen" technology due to almost no carbon emission in the production process. PV hydrogen production is a powerful combination of two representative industries of new energy, and is regarded as one of the most potential development directions of new energy in the future.

Bright future

The main process of PV hydrogen production is to use the electricity from PV power generation, so as to produce hydrogen, and then to transport the "green hydrogen" to the destinations through pipelines or special transport vehicles and ships. The process has the advantages of no pollution, low cost, high conversion efficiency, huge energy storage utility, and stabilizing the PV power generation.

China is the largest PV market in the world. Under the strategic goal of "peak carbon dioxide emissions" and "carbon neutrality", China's PV industry is developing rapidly, and the installed capacity is rising continuously, which highlights the problem of consumption. However, with the technology of "PV + hydrogen production", the development bottleneck can be reduced, and the problems related to hydrogen production cost and green production can be effectively solved.

Dialectical thinking

In this way, is PV hydrogen production really beneficial without harm? Although the industrial integration has become increasingly mature, there is a clear plan for improving the energy structure and promoting the development of clean energy by using hydrogen energy in the current industry, how to realize the scale and commercialization of PV hydrogen production in the future remains unsolved:

Hydrogen, with low energy density at normal temperature, may penetrate metal materials, which makes it difficult to store and transport. At present, the high-pressure gaseous hydrogen storage technology in physical hydrogen storage is troubled by the problems of small reserves and high potential safety hazards, which is not ideal from the perspective of long-term planning. Other more efficient storage technologies are expensive and immature, which fail to realize the market application of PV hydrogen production, and restrict the popularization and use of hydrogen energy.

International market

In the international market, the market of PV hydrogen production by lithium-ion battery has been opened.

The PV hydrogen production is mainly used in Fukushima Hydrogen Energy Research Base, the largest hydrogen production plant in Japan. It is understood that this Plant in Fukushima covers a total area of 220,000 hectares, of which 180,000 hectares are solar power generation areas and 40,000 hectares are hydrogen production workshops, with the production capacity of 2,000 cubic meters of hydrogen per hour and the annual hydrogen energy of 900 tons, available for 10,000 hydrogen vehicles. In addition, the hydrogen energy from the PV hydrogen production in the plant can also be used for hydrogen power generation and integrated into the power grid system.

In France, PV hydrogen production is directly carried out at the application end. Last year, a new batch of hydrogen buses in France were officially put into use, and they were equipped with solar panels, to generate power through PV hydrogen production.

In addition, Germany, Netherlands, Australia, Canada and other countries have carried out research or investment in large-scale PV hydrogen production projects. With the popularity of hydrogen energy around the world, PV hydrogen production industry is rapidly ignited.

It can be seen that the PV hydrogen production not only represents the future development direction of hydrogen energy industry, but also solves the difficulties to a certain extent, and is expected to become a new outlet in the field of new energy in the next years.

Although there are unsolved problems such as the high cost, unbreakable technical difficulties, and inability to meet commercial demands, PV hydrogen production still provides a new application scenario and opens up broad market for PV power generation, and further realizes the goal of "producing clean energy with clean energy", which is of great significance to the dynamic development of renewable energy and the acceleration of decarburization process.

(Parts of information is from the network.)

NEW in SunMart
Adding New Experience to Your Life

SunMart

has introduced new products
after warm spring day.

We meet again.

What kind of summer are you hoping for?
Cool and refreshing? To relieve the dryness of hot summer;
Portable? To alleviate the burden of travel;
Full of fun? To drive away the languor with vitality;
More importantly, let your delightful life be filled with green and environmental goods.
To this end, **SunMart** pushed out some good products to enrich your wonderful life.

Retro and stylish vacuum insulated bottle

Farewell to the winter, the drinkware should be "lightweight" too.

Vacuum Insulated Bottle fades, the environmental protection linkage between Japanese drinkware brand Rivers and SunMart has started.

The fun-oriented cup design, the environmentally friendly portable experience, and 350ml capacity complement each other.

The unique cup mouth sealing design makes travel more convenient and safer.

The integrated double-layer design allows you to enjoy cold and hot drinks at any time.

Fashionable handbag for sustainable life

DuPont paper, which integrates the material characteristics of paper, woven fabric and film,

presents you with a practical and aesthetic handbag with the imagination and creative design of modern life.

Dirt-proof, rain-proof, high strength, wear resistance, considerable capacity... The bag feels smooth without losing the sense of texture owing to the attributes of the material

and reflects your personality through fashionable modeling design.

Writing down the wonderful life with the sleek pen

Nature Plus stems from the environmental protection concept series launched by Senator in 2012,

The pen body uses truly biodegradable biomaterials--Cornstalk.
It is also combined with frosted touch, anti-slip effect, and holding comfort, and is suitable for long-term writing;

The minimal designed appearance of the pen is from the BMW design team.

A smooth and soft pen is to highlight your high-grade taste.

The experience of mobile office through a light notebook

The lightweight experience of office starts with a multifunctional rechargeable notebook.

Charging, USB flash disk, card bag, business card holder, notepad... all are included.

Wireless back charging enables you to realize fast and invisible charging.

The notebook can be your mobile and portable work partner with all the basic needs of business accommodated, far more than light and thin.

SunMart is stacked with new products.

Scan the QR code and follow us, you can have a glimpse of different trend of natural creation and start the journey at your fingertips.
More highlights and secrets are coming soon.

Suntech

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