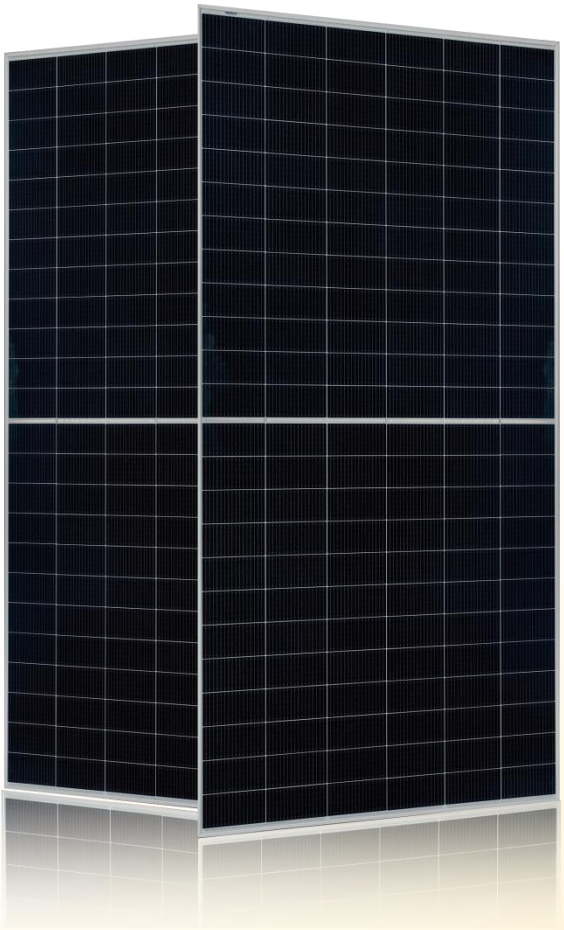
ulica solar
LEADING IN TECHNOLOGY



# Ulica High Efficiency TOPCon Photovoltaic Module

## White Paper

www.ulicasolar.com

# Contents

# 1 Background

## 1.1 PV Module Development Trends

Photovoltaic power generation has become an important part of the global energy structure, N-type cells have the advantages of high conversion efficiency, high bifaciality, low temperature coefficient, almost no initial light decline, and good performance of dim light, which is the most hopeful to replace the P-type cells and become the next generation of main technology.

Among them, TOPCon cell technology is a new type of passivated contact solar cell proposed by the Fraunhofer Solar Energy Institute in Germany, and its structure is shown in Fig.1. TOPCon cell technology stands out among the N-type routes due to its high conversion efficiency, relatively mature equipment and process, and high cost- effectiveness in mass production.

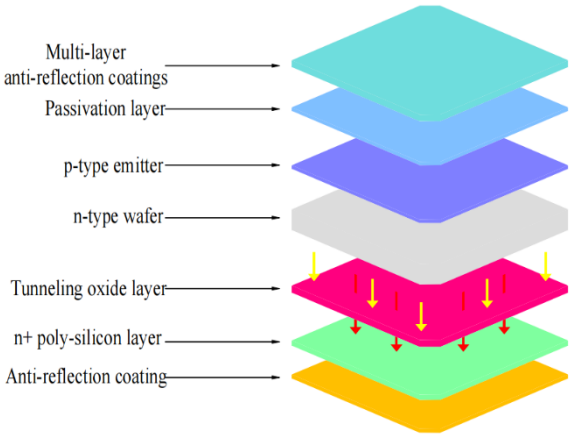



Fig.1 Schematic diagram of TOPCon cell structure

## 1.2 Introduction of Ulica PV Modules

### Ulica-N Series Products

In 2023, Ulica makes a strong entry into the N-type technology with the Ulica-N Series products. In 2024, with more innovative technology and better features, the Ulica-N Series are more competitive.

Ulica-N Series has a wide range of products, covering 182 and 210 cells, including double-glass and single-glass modules, which have the advantages of high power and high photoelectric conversion efficiency, and are suitable for large-scale ground power stations, distributed power stations, residential rooftops, etc. Moreover, Ulica-N series

products have passed the China CQC Leader Certification, European TüV, Japan JET, UK MCS, Australia CEC, Brazil Inmetro and other international certifications.


Fig.2 Ulica-N series modules

| Module | Type | Size (mm) |
|---|---|---|
| **UL-***M-108BDGN(***=440-460W)** | 54 | 1762*1134*30 |
| **UL-***M -120BDGN(***=490-510W)** | 60 | 1952*1134*30 |
| **UL-***M -144ADGN(***=565-590W)** | 72 | 2278*1134*30 |
| **UL-***M -156ADGN(***=590-625W)** | 78 | 2382*1134*30 |
| **UL-***M -132DGN(***=690-715W)** | 66 | 2384*1303*33 |

Table 1 Product information of double-glass modules

| Module | Type | Size (mm) |
|---|---|---|
| **UL-***M -108BHVN(***=420-465W)** | 54 | 1762*1134*30 |
| **UL-***M -108CHVN(***=450-475W)** | 54 | 1800*1134*30 |
| **UL-***M -120BHVN(***=480-515W)** | 60 | 1952*1134*30 |
| **UL-***M -144CHVN(***=590-620W)** | 72 | 2382*1134*35 |

Table 2 Product information of single glass modules

# 2 Core Technology

Ulica adheres to the direction of high power and high efficiency, and achieves the simultaneous improvement of module power and efficiency by superimposing technologies such as large-size silicon wafers, square single crystals, multiple busbars, non-cutting technologies, high-density encapsulation, overlapping welding, stacked grids, and white EVA.

## 2.1 High Efficiency Cell Technology

### 2.1.1 Non-cutting technology

Ulica's innovative use of non-cutting technology eliminates the need for laser cutting and significantly reduces the area of micro-cracks compared to whole cells.

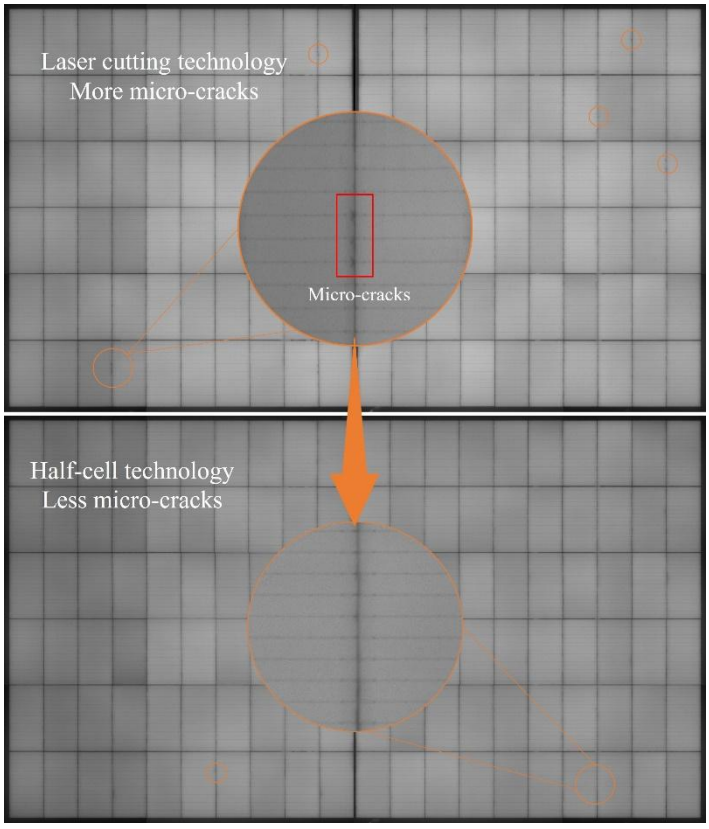



Fig.3 Comparison between laser cutting module and non-cutting module

| Cell technology | Laser cutting | Non-cutting |
|---|---|---|
| **Crack area** | 15% | 2% |

Table 3 Crack rate of laser cutting module and non-cutting module

At the same time, the module using Non-cutting technology can reduce the internal dissipation caused by the mismatch of the cells in the module, reduce the probability of hot spots, and increase the power generation by about 1% compared with the laser cutting cell module (using the rooftop project in Quzhou as a reference), due to the smaller leakage current at the edges of the module cells, the efficiency of the cells in the module is more uniform, and the consistency of voltage and current of the module is better It can also effectively reduce the production cost of module enterprises.

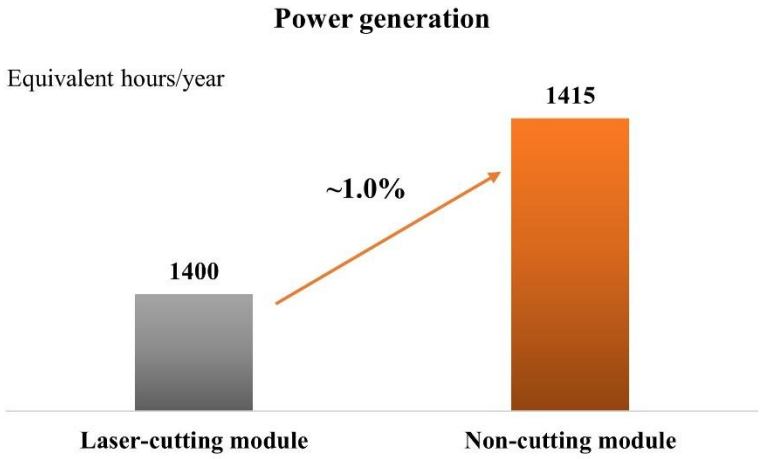



Fig.4 Power generation of laser cutting module and non-cutting module

(Quzhou rooftop project)

Fig.5 Quzhou Shanshan new material cement rooftop project

## 2.1.2 Rectangular Cells

In order to maximize module power, efficiency and container space, while keeping

two module stacks on top of each other, Ulica uses an innovative 182*(182+X) mm size rectangular silicon wafer technology solution.

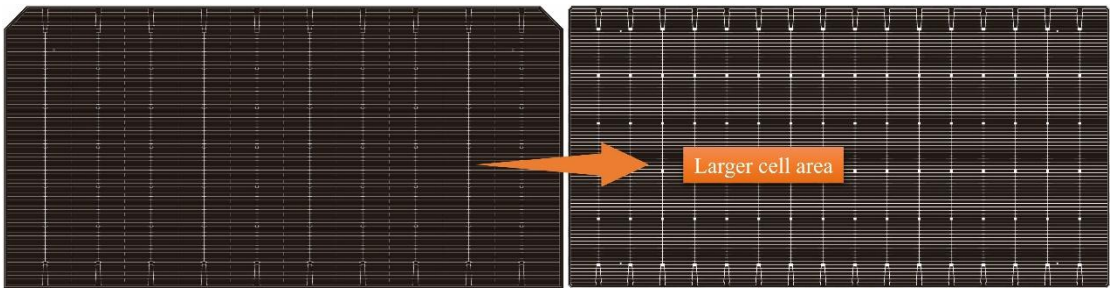



Fig.6. Schematic diagram of chamfered cells and rectangular cells

Compared with chamfered cells, the maximum area of rectangular cells can be increased by 6%, which makes better use of module space and reduces the cost of PV module integration. Combined with non-cutting technology and high-density encapsulation technology, it can improve the module power and photoelectric conversion efficiency. On the system side of the power station, it can further reduce the BOS cost and LCOE, thus enhancing customer value.

| Cell type | 182.2*182.2 Chamfered cells | 182.2*188 Rectangular cells | 182.2*191.6 Rectangular cells |
|---|---|---|---|
| **Area ($mm^2$)** | 33016 | 34254 | 34910 |
| **Area ratio (%)** | 100% | 104% | 106% |

Table 4 Cell area of rectangular cell and chamfered cell

### 2.1.3 Cell Laser Enhanced Contact Optimization Technology (LECO)

The LECO technology can increase the conversion efficiency of TOPCon cells by 1.6%, which is expected to reduce the cost of the cell by 2 cents/W, and greatly improve the reliability of single-glass modules. This is due to the laser can accurately heat the silver paste, locally destroy the passivation layer, so that the silver can directly in contact with the silicon, without damaging the silicon wafer, prompting the silver paste partially melted and diffused into the surface of the silicon wafer to form a tiny silver-silicon alloy junctions, which has a very low contact resistance and a very high transport efficiency for electrons. As a result, LECO has the advantages of improving cell efficiency, precise control, reducing cell loss, increasing productivity and reliability,

and reducing module costs.

| Cell technology | Non-LECO | LECO | growth rate |
|---|---|---|---|
| **Cell Conversion Efficiency (Average)** | 25.6% | 26.0% | +1.6% |
| **Module Cost (RMB/W)** | 0.75 | 0.73 | -2.7% |
| **Single-glass reliability (DH1000h degradation rate)** | 10.0% | 2.0% | -80% |

Table 5 Performance of non-LECO technology and LEOC technology

## 2.2 Super Multiple Busbar (SMBB) Design

SMBB (Super Muti-busbar) technology is an upgrade of MBB technology, with more and thinner busbars, giving full play to the technical advantages of multiple busbars, effectively shortening the current transmission path, reducing series resistance, and improving cell efficiency. In addition, the increased number of welding strip and the welding joints of busbar line, results in a more uniform stress distribution, which can improve the tolerance of the cell to grid fracture and micro-cracks, thus improving reliability.

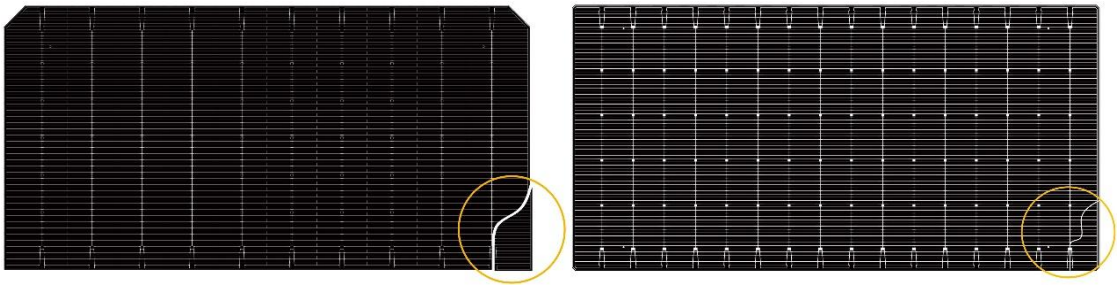


Fig.7 Micro-crack of MBB and SMBB technology cells

## 2.3 High-density Encapsulation Technology

Using small-spacing encapsulation approach, the photoelectric conversion efficiency of the module is improved under the same area of modules, ensuring the perfect balance between efficiency and reliability.


High-density encapsulation technology effectively improves the screen-to-body ratio

(take **UL-2382-156ADGN module** as an example).

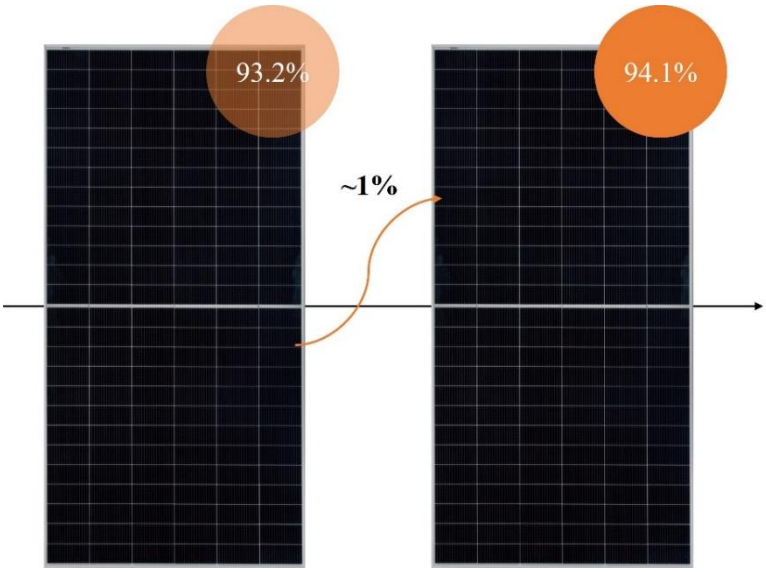



Fig.8 Small-spacing encapsulation technology and comparison of the screen-to-body ratio

## 2.4 Gap Reflective Film Technology

The gap reflective film achieves total reflection by optimizing the bottom angle of the microstructure, improves the reflectivity of sunlight at different incident angles, and increases the power generation of modules. In addition, the backside shielding area of the gap reflective film is smaller, the bifaciality rate is slightly increased, and the power generation on the back side becomes more, which can increase the power generation per watt.

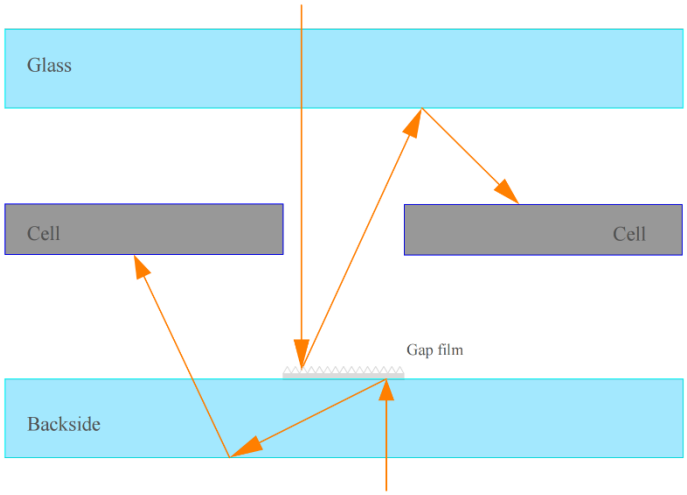



Fig.9. Working path of gap reflective film

# 3 Performance Advantages

Ulica's TOPCon modules have significant advantages over traditional PERC modules in terms of power degradation, warranty, bifaciality, low-light performance, module power, and photoelectric conversion efficiency.

## 3.1 Higher Reliability

The Ulica-N series modules have passed the standard aging test and the stricter aging test, meeting IEC standards, and they have undergone rigorous testing and certifications from leading industry authorities, ensuring their performance, safety, and reliability across various applications. In addition, the single-glass module adopts enhanced encapsulation film with better reliability, such as POE, to better isolate the adverse effects of water vapor and acetic acid on the cell, and reduce the degradation caused by long-term outdoor operation.

| Tests | IEC61730/61215 standard | Ulica Standard |
|---|---|---|
| **Damp heat (DH)** | 1000 h | 2000 h |
| **Ultraviolet (UV)** | 15kwh | 225kwh |
| **PID** | 96 h | 192 h |
| **PCT** | 48 h | 96 h |
| **Thermal Cycling (TC)** | 200 times | 400 times |
| **Wet Freeze (HF)** | 50 times | 100 times |

Table 6 Comparison of IEC standards and Ulica standards

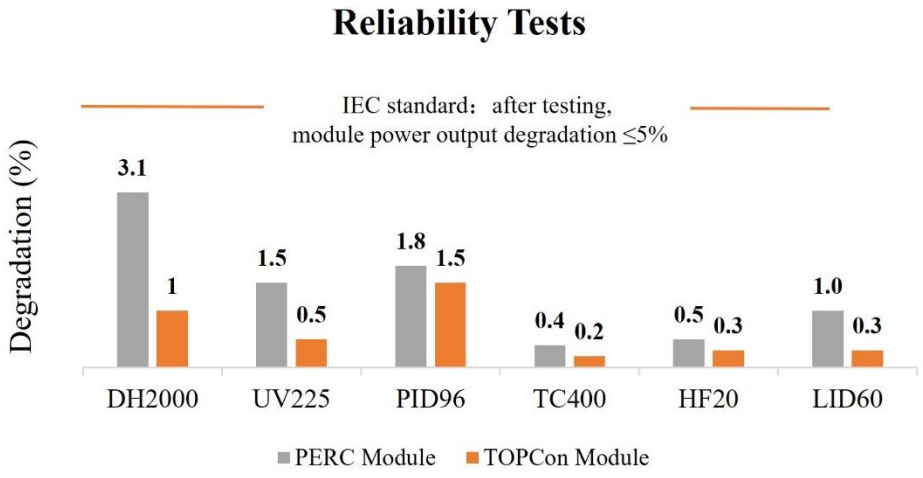



Fig.10 Reliability test results of PERC and TOPCon modules

## 3.2 Better Low-light Performance

The low-light performance refers to the ratio of the conversion efficiency of the module under 200W/m$^2$ light intensity and under STC conditions, generally expressed as %. TOPCon modules have higher series resistance and smaller saturation current than PERC modules, resulting in better low-light performance of about 0.5%.

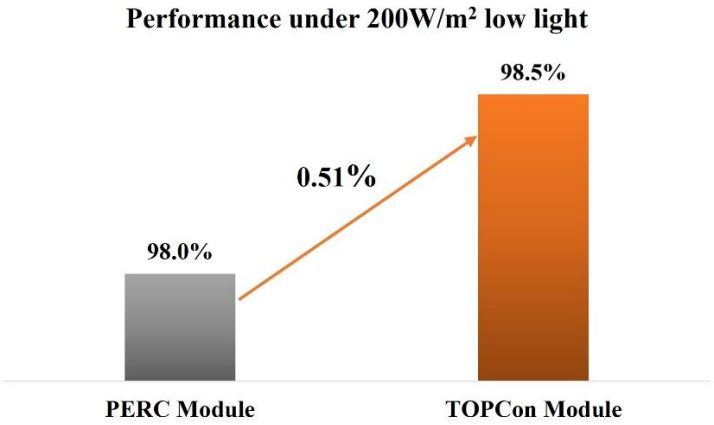



Fig.11 Comparison of low-light performance between PERC and TOPCon modules

## 3.3 Higher Bifaciality Benefits

For bifacial generation of N-type module is about 80%, and P-type module is about 60%. If the irradiance intensity of the backside is 100-150W/m$^2$, this 20% difference can translate to a 1%-1.5% power generation. Taking into varied conditions (20%-30% reflectivity), array heights and spaces, and shadowing, Ulica modules can achieve power generation ranging from 0.8% to 1.2%, as simulated by PVsyst.

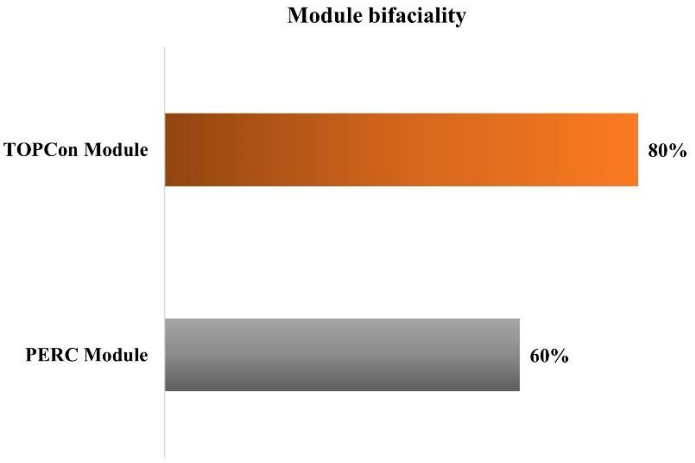



Fig.12 Bifaciality of PERC and TOPCon modules

## 3.4 Longer Warranty, Lower Power Degradation

N-type TOPCon double-glass modules: the power degradation less than 1% in the first year and less than 0.4% per year thereafter. Compared with P-type modules, N-type modules have a 2.45% lower power degradation after 30 years of use. This lower power degradation is one of the key reasons why N-Type modules achieve 3% more power generation gain over the 30-year power warranty period.

| Bifacial Module | TOPCon | PERC |
|---|---|---|
| Power Warranty | 30yr | 30yr |
| Peoduct and Workmanship Warranty | 15yr | 12yr |
| 1st yaer degradation | 1% | 2% |
| Annual degradation | 0.4% | 0.45% |

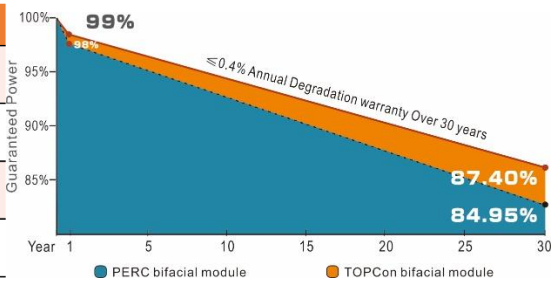



Fig.13 Power warranty of PERC and TOPCon bifacial modules

| Monofacial Module | TOPCon | PERC |
|---|---|---|
| Power Warranty | 30yr | 25yr |
| Peoduct and Workmanship Warranty | 15yr | 12yr |
| 1st yaer degradation | 1% | 2% |
| Annual degradation | 0.4% | 0.55% |

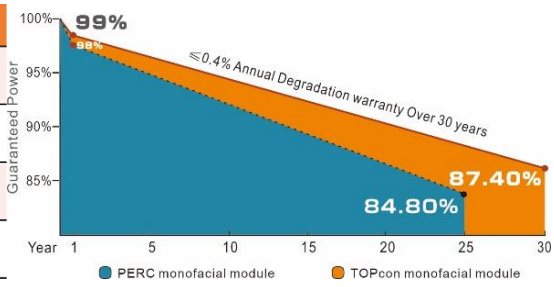



Fig.14 Power warranty of PERC and TOPCon monofacial modules

# 4 Customer Value

PV modules with high photoelectric conversion rate can install more wattage modules on the same land or roof area, generating more power and more profits. LCOE is a core measure of customer value. Modules with high power, high efficiency, high energy generation capacity, and high reliability can bring customers more value and improve overall revenue

## 4.1 Higher Power Generation

The lower power degradation results in higher power generation of the power station with the same installed capacity, and coupled with the high bifaciality of modules, TOPCon modules generate about 3.0% more average annual power per kilowatt than PERC modules.

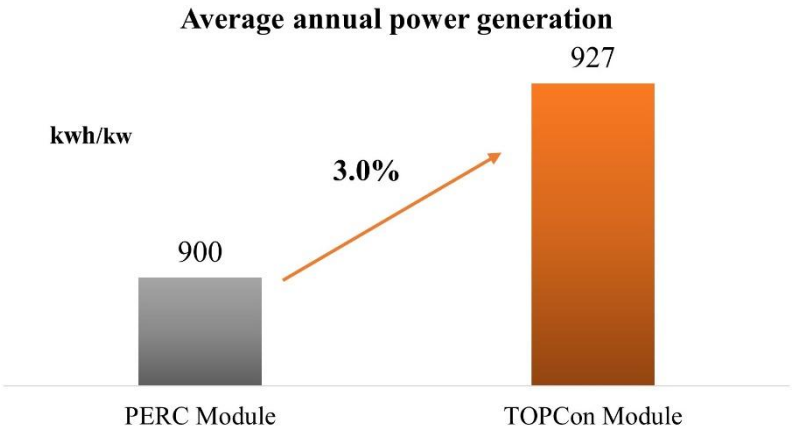



Fig.15 Average annual power generation of PERC and TOPCon modules in Europe (excluding backside benefits)

## 4.2 Lower BOS Cost and LCOE

The decline of cost drives the market demand for high-power and high-efficiency modules, and TOPCon modules have obvious effects on project cost reduction.

### Lower BOS Cost

TOPCon modules can effectively reduce the BOS cost, taking distributed rooftops

as an example, the BOS cost can be reduced by 4 cents/W.compared with PERC modules. The higher the power price of distributed rooftops make the benefits of high-efficiency modules even more obvious.

| Cost | PERC bifacial - 550W | TOPCon bifacial -615W |
|---|---|---|
| **Component installation costs** | 100% | 98.97% |
| **Bracket material cost** | 100% | 98.89% |
| **Cable and combiner box materials and installation costs** | 100% | 98.99% |
| **The cost of land** | 100% | 98.89% |
| **Total BOS cost** | 100% | 98.92% |

Table 7 Comparison of BOS cost between PERC and TOPCon module

## Lower LCOE

According to the calculation, the LCOE of the power station system using PERC (UL-2384-132DG) bifacial module is about 0.103 RMB/kWh; the LCOE of the power station system using TOPCon bifacial module is about 0.101 RMB/kWh, the TOPCon modules can reduce the LCOE of the power station by about 1.94%.

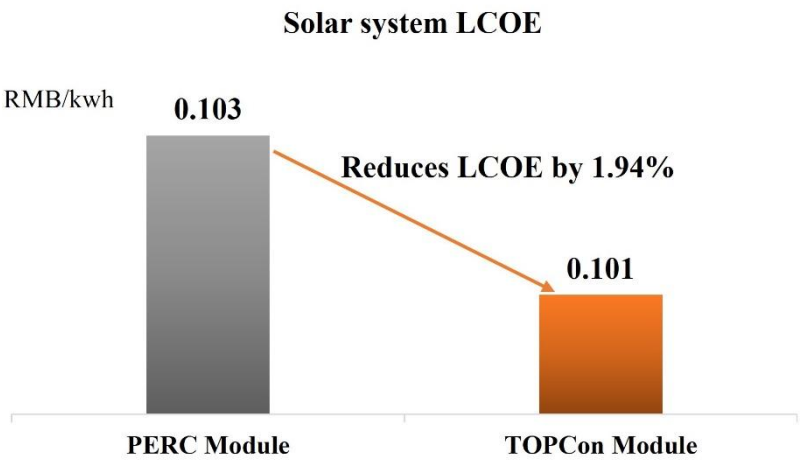
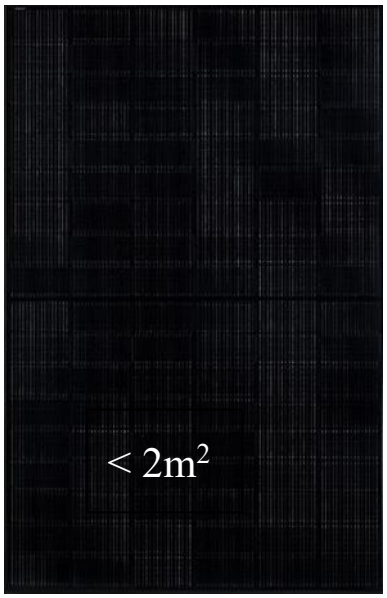


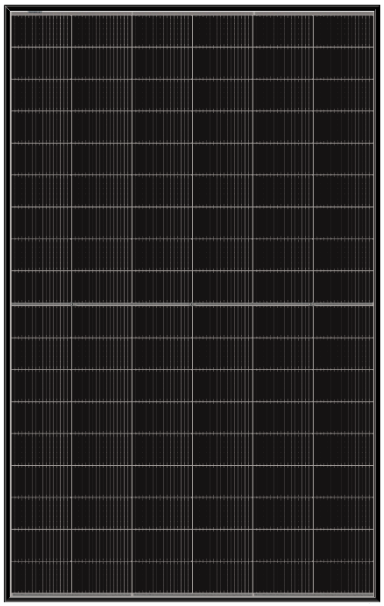

Fig.16 Comparison of LCOE between PERC and TOPCon module systems

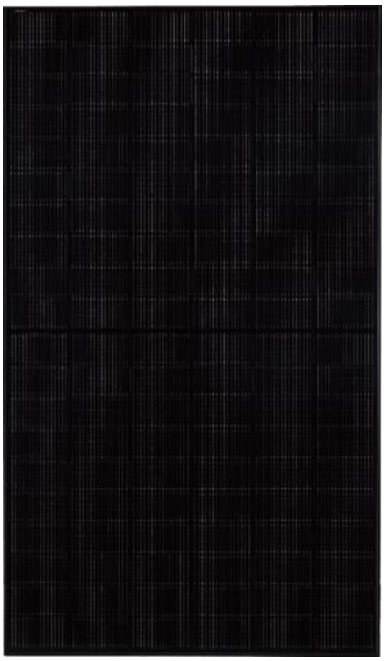
# 5 Application Scenarios

## 5.1 Residential roofs

| | |
|---|---|
| **Primary Recommendations:** | **UL-1762-108BDGN Double-glass Module, UL-1800-108CHVN Single-glass Module, UL-1952-120BDGN Double-glass Module** |
| **Market influencing factors:** | national policies, roof installation, small installed capacity, high appearance requirements |
| **Characteristics:** | small components, high appearance, high power |



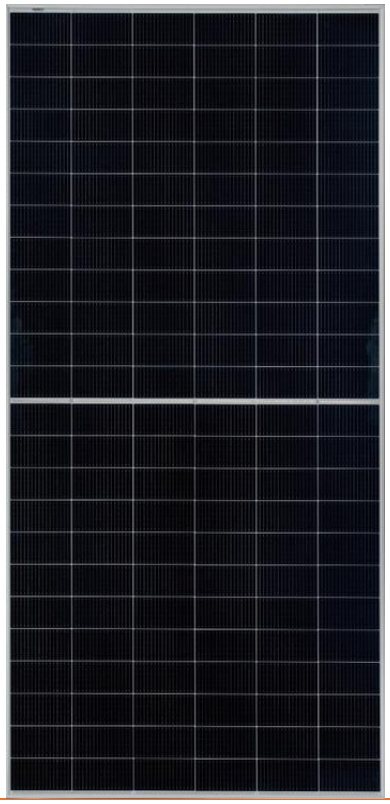


| UL-1762-108BDGN | UL-1800-108CHVN | UL-1952-120BDGN |
|---|---|---|
| 1762*1134*30mm | 1800*1134*30mm | 1952*1134*30mm |
| 24kg | 21.5kg | 26.5kg |
| 450W | 470W | 500W |

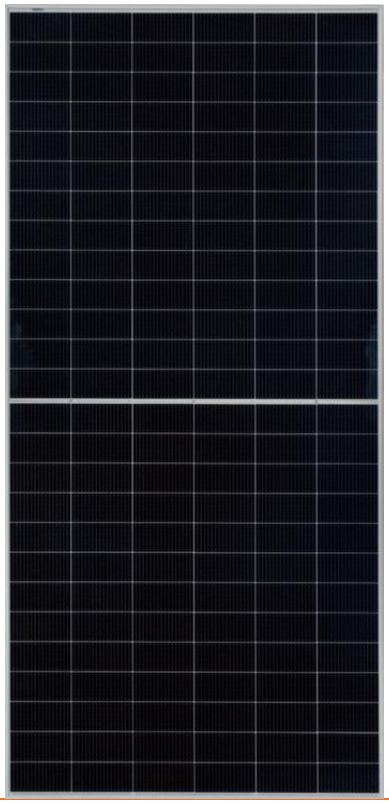
Fig.17 Residential rooftop project in Netherlands

## 5.2 Industrial and commercial distribution

| | |
|---|---|
| **Color Steel Tile Roof:** | **UL-2382-144CHVN Single-Glass Module** |
| **Cement roof:** | **UL-2382-156ADGN Double-glass Module** |
| **Influencing factors:** | (1) Due to the size limitations, industrial and commercial roofs have high requirements for module width, installation size and power.<br>(2) Roof type: color steel tile and cement roof. |
| **Characteristics:** | light weight (color steel tile), high power. |



**UL-2382-144CHVN**
2382*1134*35mm
27.8kg
620W



**UL-2382-156ADGN**
2382*1134*30mm
32kg
615W

**Cement roof:** strong load-bearing, fixed bracket installation, obvious advantages of power generation on the back of double-sided double-glass modules, combined with roof size

Fig.18 Aobo Automobile rooftop distributed project in Hangzhou Bay New Area, Ningbo

**Color steel tile roof:** weak load-bearing, tile-based, double-sided double-glass modules can not reflect the advantages of power generation on the back under this application condition, it is recommended to use lightweight single-glass

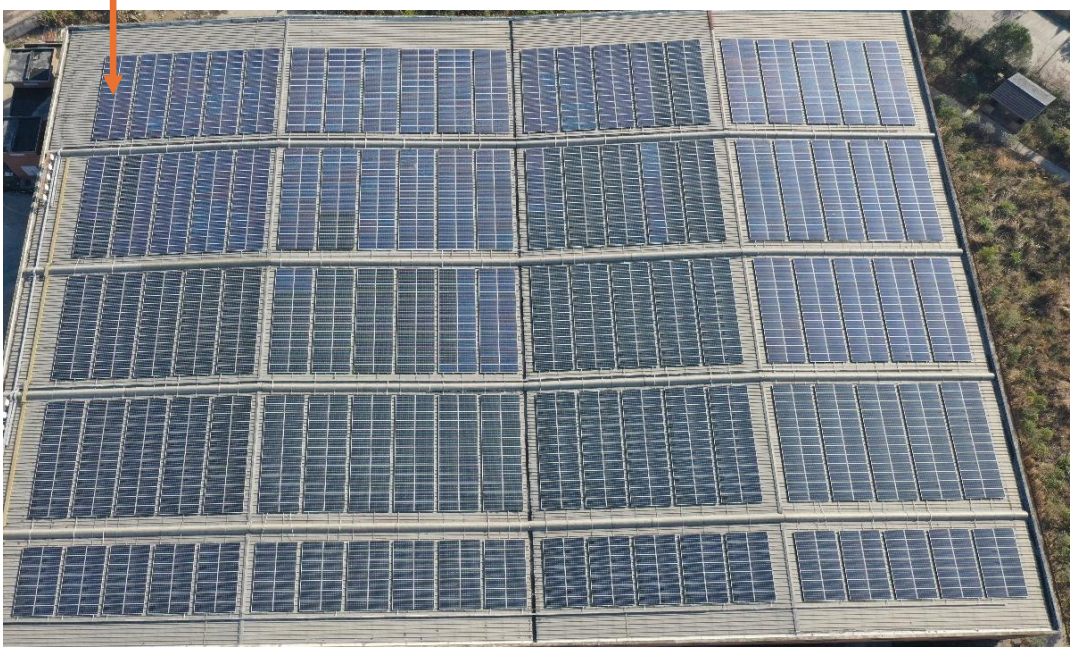
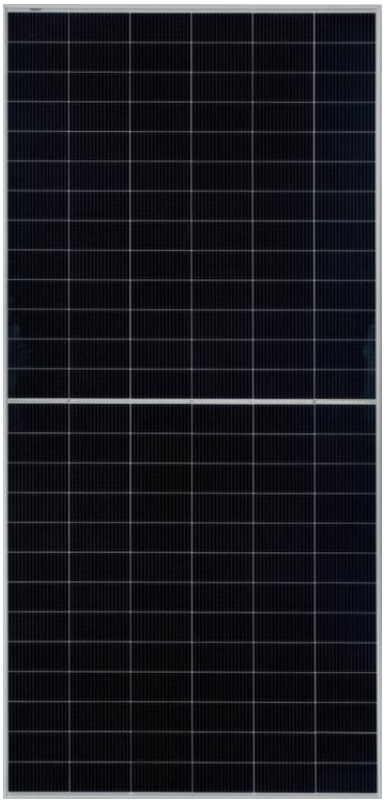


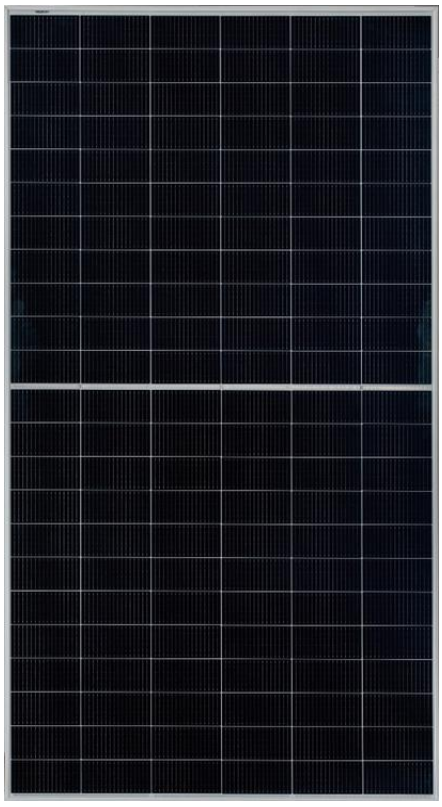
Fig.19 Hangzhou Zhongbao Steel Ball Color Steel Tile Roof Project

## 5.3 Ground power stations

| | |
|---|---|
| **Primary Recommendations:** | **UL-2382-156ADGN Double-glass Module,**<br>**UL-2384-132DGN Double-glass Module** |
| **Characteristics:** | low LCOE, high system revenues |

UL-2382-156ADGN and UL-2384-132DGN double-glass modules are the first choice for ground power station due to their better size design, low temperature coefficient, low degradation, high bifaciality and other advantages, resulting in lower BOS cost and LCOE. Other products are also available according to customer requirements.





| **UL-2382-156ADGN** | **UL-2384-132DGN** |
|---|---|
| 2382*1134*30mm | 2384*1303*33mm |
| 32kg | 37.4kg |
| 615W | 700W |

Fig.20 Trier ground power station project in Germany

Fig.21 Jingning Mountain Power Station Project in Zhejiang

# 6 Future Prospect

Ulica is deeply committed to the overseas markets of Italy, France, Spain, Belgium, Portugal, Netherlands, Japan, the Czech Republic, Australia and the United States, and our products are exported to Germany, Lia and other countries, and have been widely praised by customers.

Adhering to the spirit of "integrity, responsibility, innovation and dedication", Ulica is committed to becoming an industry-leading PV manufacturer. Adhering to the concept of sustainable development, adopting green production technology to reduce energy consumption and carbon emissions; Ulica is not only committed to providing high-quality PV products, but also actively assumes a sense of responsibility for the environment, and the company encourages employees to actively participate in environmental protection actions to create a better environment.

In the future development, Ulica Solar will continue to increase investment in environmental protection, promote the sustainable development of the PV industry, and contribute to the global energy conservation and environmental protection cause.

# Disclaimer

The contents of this "Ulica High Efficiency N-type TOPCon Photovoltaic Module Product White Paper" (hereinafter referred to as the "White Paper") are only for the purpose of product consultation and reference of Ulica Solar (hereinafter referred to as "Ulica" or "the Company") customers, and shall not be regarded as an integral part of any product sales contract of the Company. Ulica reserves the right to modify or change the contents of this White Paper at any time without prior notice. Any intellectual property rights, ownership rights and the right to interpret any White Paper belong to Ulica. Without the prior written consent of Ulica, no party may modify, reproduce, distribute, reproduce, publish, or license to use this White Paper in any form.

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