



HD Hyundai N-TOPCon Solar Panel

(Residential / Commercial / Utility)

Since

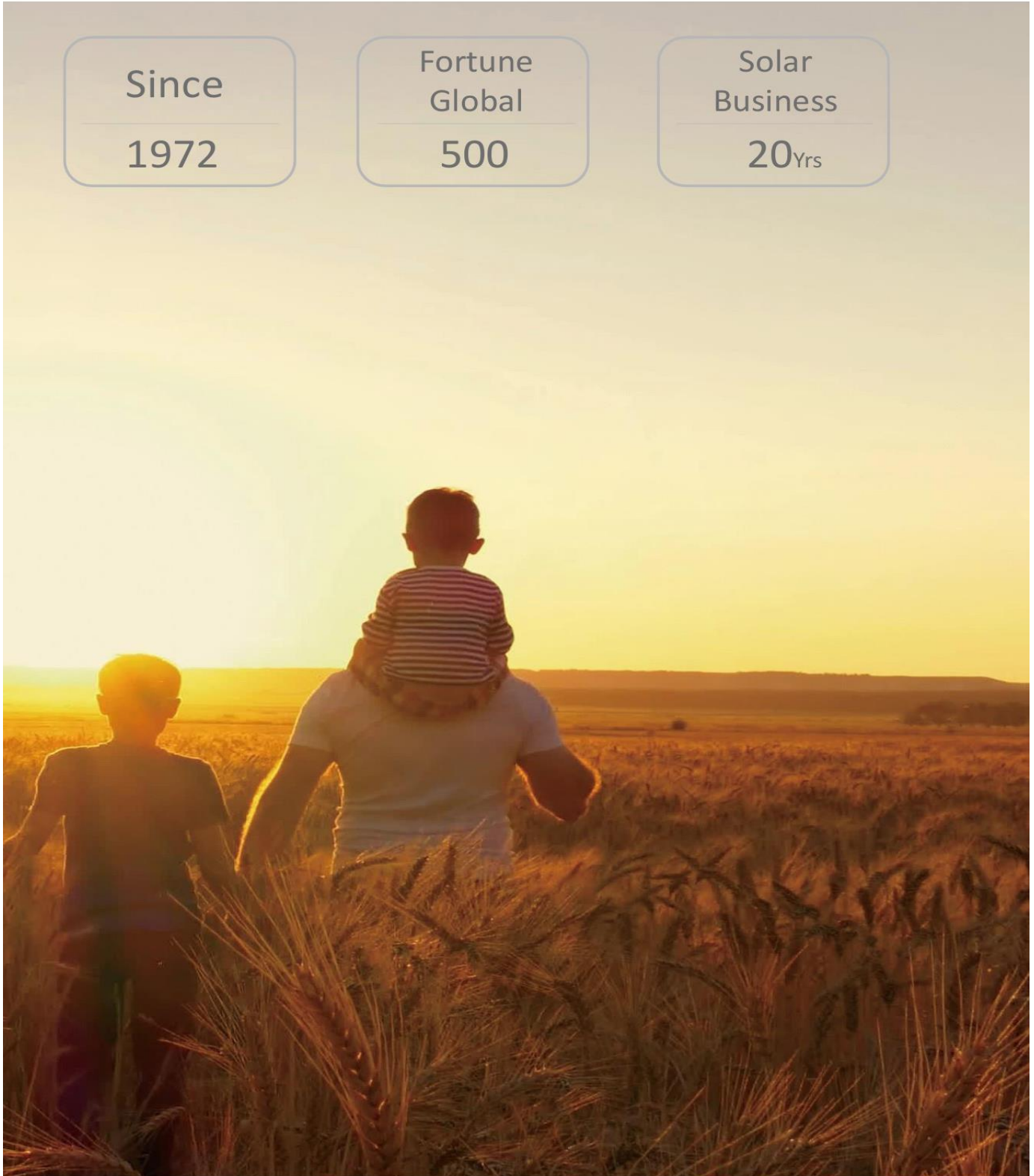
1972

Fortune
Global

500

Solar
Business

20Yrs



Brand Mission

For a sustainable energy future,
we move forward with our customers
through next-generation clean energy technologies.

Since **1972**
HD HYUNDAI
Brand
Heritage

20 years
Solar
Power
Expertise

Cutting-
Edge
Research
Institute
(5,000 researchers)

Times Square 2024
Ball Drop

CES
HD HYUNDAI
Future Builder

Participating in the
**FIFA Club World Cup
USA 2025**

LEAD FREE
RoHS Compliant

**Tandem Solar Cells
(Perovskite / HJT)**

Perovskite cell
Silicon Cell (HJT)


short-wavelength light absorption
long-wavelength light absorption

Certificate of Qualification
HYUNDAI ENERGY SOLUTIONS CO.LTD
has been assessed and found to be eligible to participate in UL
Witness Test Data Program(WTDP)

23%

UL

Summary of the main features

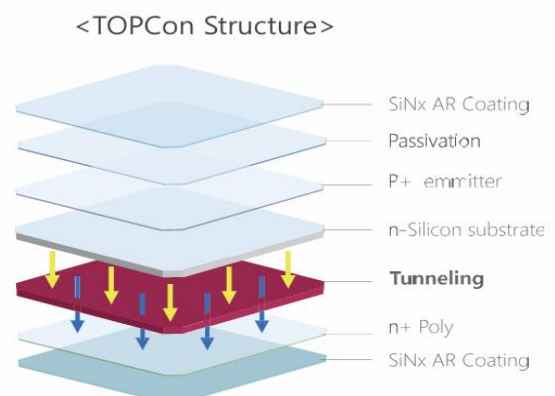
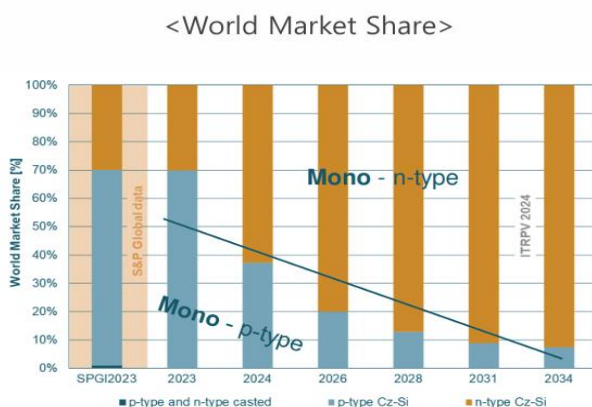


- 30 Years**
Long warranty for power production
- 22.26%-23.07%**
Highest efficiency
- 0.4%**
Low yearly degradation
- 80±10%**
Best bifaciality
- 0.30%/°C**
Lowest temperature coefficient

TOPCon Cell efficiencies

Cell	2024년	2026년	2034년
N TOPCon	25.0%	25.4%	26.1%
P PERC	23.6%	23.8%	24.2%

n-TOPCon refers to the tunnel oxide passivation contact technology of n-type silicon wafers. The cell structure is shown below. The front side is essentially the same as a conventional PERT cell, the main difference being An ultra-thin tunneling silicon oxide (SiO₂) layer and a highly doped polysilicon layer are deposited on the back side.



* Source: International Photovoltaic Technology Roadmap (ITRPV) 15th version, March 2024

■ Excellent temperature coefficient **-0.30 %/°C**

The operating temperature of PV modules is higher than the typical STC (25°C) temperature. Therefore, some output loss occurs at high operating temperatures. N-type modules have lower temperature coefficients, resulting in higher power generation returns.

Temperature		N Type 156cells (-0.3%/ °C)	P Type 156cells (-0.345%/ °C)
	85°C	525W	475W
	75°C	544W	496W
	65°C	563W	517W
	55°C	582W	538W
	45°C	602W	558W
	35°C	621W	579W
	25°C	640W	600W

Power loss at 55°C: N Type (-115W), P Type (-125W)

■ Bifaciality 80%

Higher Bifaciality means higher power production by absorbing light reflected from the ground. N-type modules are 10%p higher than P-type modules.

Condition		N Type 156cells, 640W (Bifaciality 80%)	P Type 156cells, 600W (Bifaciality 70%)
Surface	Light Reflectance		
Asphalt	10%	691W(+51W)	642W(+42W)
Grass	20%	743W(+103W)	684W(+84W)
Sand	30%	794W(+154W)	726W(+126W)
Snow	80%	1,050W(+410W)	936W(+336W)

■ Double-glass structure

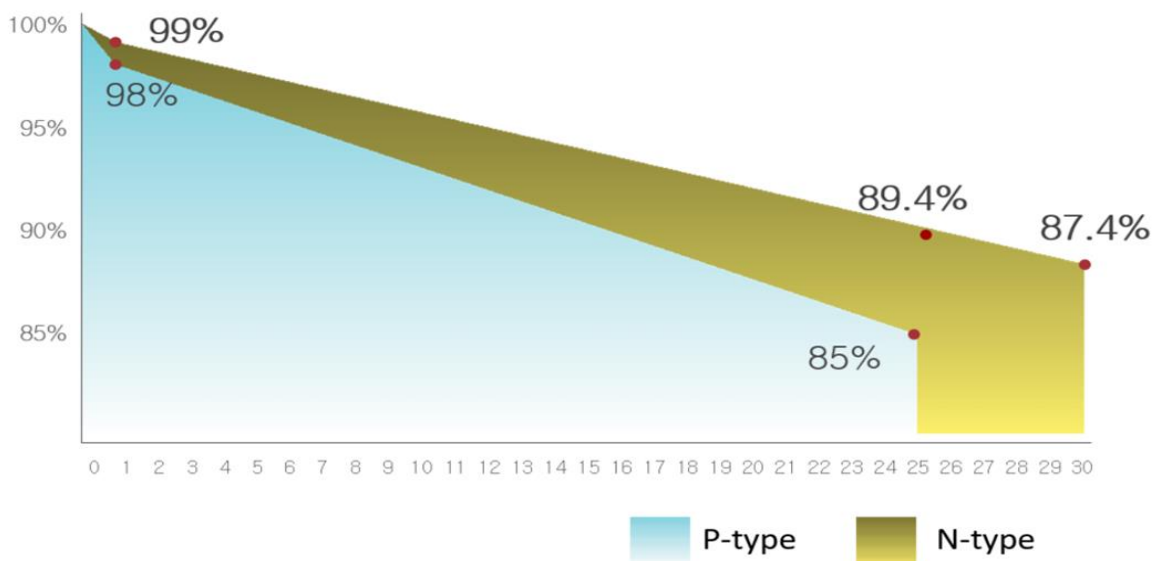
To secure the durability of cells that are relatively vulnerable to moisture, front and rear glass is applied. Provides long-term reliability in environments such as high temperature and humidity.



■ Low Degradation

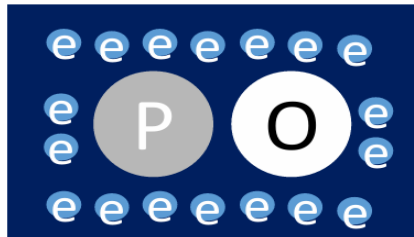

N-type modules have less performance degradation than P-type modules, are more stable, and generate longer lasting power. N-type provides the best quality assurance to maximize customer value.

Category	N Type	P Type
Performance Warranty	30yrs	25yrs
First Year Degradation	1%	2%
Linear Warranty	0.4%	0.54%



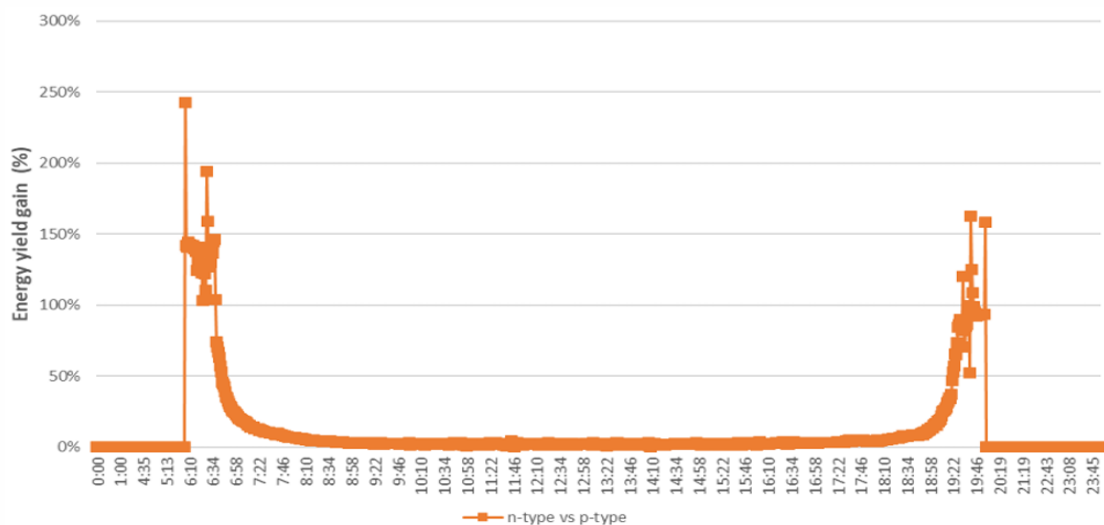
■ No LID(Light induced Degradation)

N Type does not have oxides that impede the flow of current when light is generated, so there is no decrease in output.

Category	N Type	P Type
Silicon additives(a)	Phosphorus	Boron
Silicon impurities(b)	Oxygen	Oxygen
Bonding upon Light generation(a+b)	Absence	Presence (Oxid Generation)
Output degradation Upon light	minimal	0.5~1.5%
Structure		

■ Low-irradiance performance

At sunrise and sunset, the relative energy yield between TOPCon and PERC modules shows that TOPCon performs better in low-light conditions.



TUVNORD

Product Line UP

No Antidumping or Countervailing Duty (AD/CVD)

N-TOPCon type

NF(BK) Series (Bifacial M10 108Cells)



(Black Frame & Full Black)

- 430~440Wp**
- Module Efficiency 22.02~22.53%
 - **25/30 years** product & Linear Power Warranty
 - Glass to Glass – THK 2.0mm
 - 5,400Pa(Snow & Wind)
- *See Installation Manual

1,722mm (L) x 1,134mm (W) x 30mm (H)
(67.8in x 44.6in x 1.2in)

24.5 kg (50.01lbs)

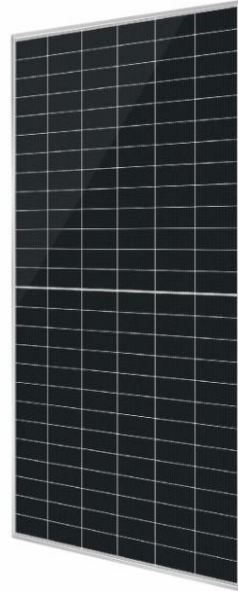


For Residential
(Full Black Design)



Carport Applications

NJ Series (Bifacial M10 156Cells)



(Silver Frame)

- 625~645Wp**
- Module Efficiency 22.26~23.07%
 - **12/30 years** product & Linear Power Warranty
 - Glass to Glass – THK 2.0mm
 - 5,400Pa(Snow) / 2,400Pa(Wind)

2,465mm (L) x 1,134mm (W) x 35mm (H)
(97.1in x 44.6in x 1.4in)

34.5 kg (76.1bs)



For Commercial &
Utility Applications

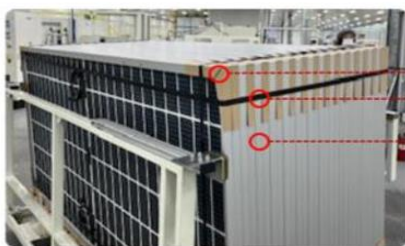


Carport Applications

Shipping Configurations

Category		Residential (108cells)	Commercial & Utility (156cells)
Loading method		Vertical	Vertical
Number of modules per container (a*b)		936	496
Capacity per container (a*b*c)		412kW	317kW
Criteria	Modules per pallet(a)	36	31
	Pallets per container (b)	26	16
	Module Power(c)	440W	640W

HD HES packages our PV modules using proven components to ensure safe transport and ease of unpacking for installers. HD HES packages each pallet as follows:

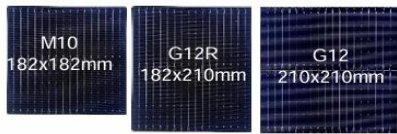


- ① Module Corner Protector(Paper)
- ② Internal Strpping(PET band)
- ③ PV Module
- ④ Cardborad Sleeve
- ⑤ TOP Cap for Sleeve
- ⑥ External Strapping(PET Band)
- ⑦ Shipping label
- ⑧ Wrapping
- ⑨ PET Band
- ⑩ Wood Pallet

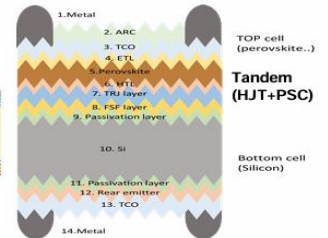
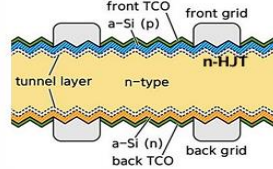
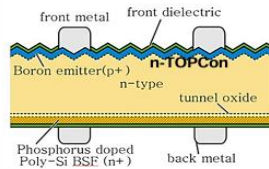
Product RoadMap

ITEM		2024	2025	2026	2027
Cell	Key Technology	p-PERC n-TOPCon	n-TOPCon n-HJT	n-TOPCon n-HJT	n-HJT HJT-Tandem*
	Busbar #, Wafer	10BB / 16BB M10 / G10	16BB ~ 20BB G10, G12R	16 ~ 24BB G12R, G12	9 ~ 24BB G12R, G12
	Efficiency	~23.3% ~25.2%	~25.5% ~26.0%	~25.7% 26.0%~	26.3%~ *30.0%~
Module	Key Technology	Glass-Glass (for n-type) Half-Cut, MBB (#10/#16)	Zero-BusBar (>#20) G/G, Half-Cut, MBB (#16)	G/G, G/B, Half-Cut, Zero-BusBar (>#20) HJT-Tandem 모듈 기술	

※ Wafers



※ Cells



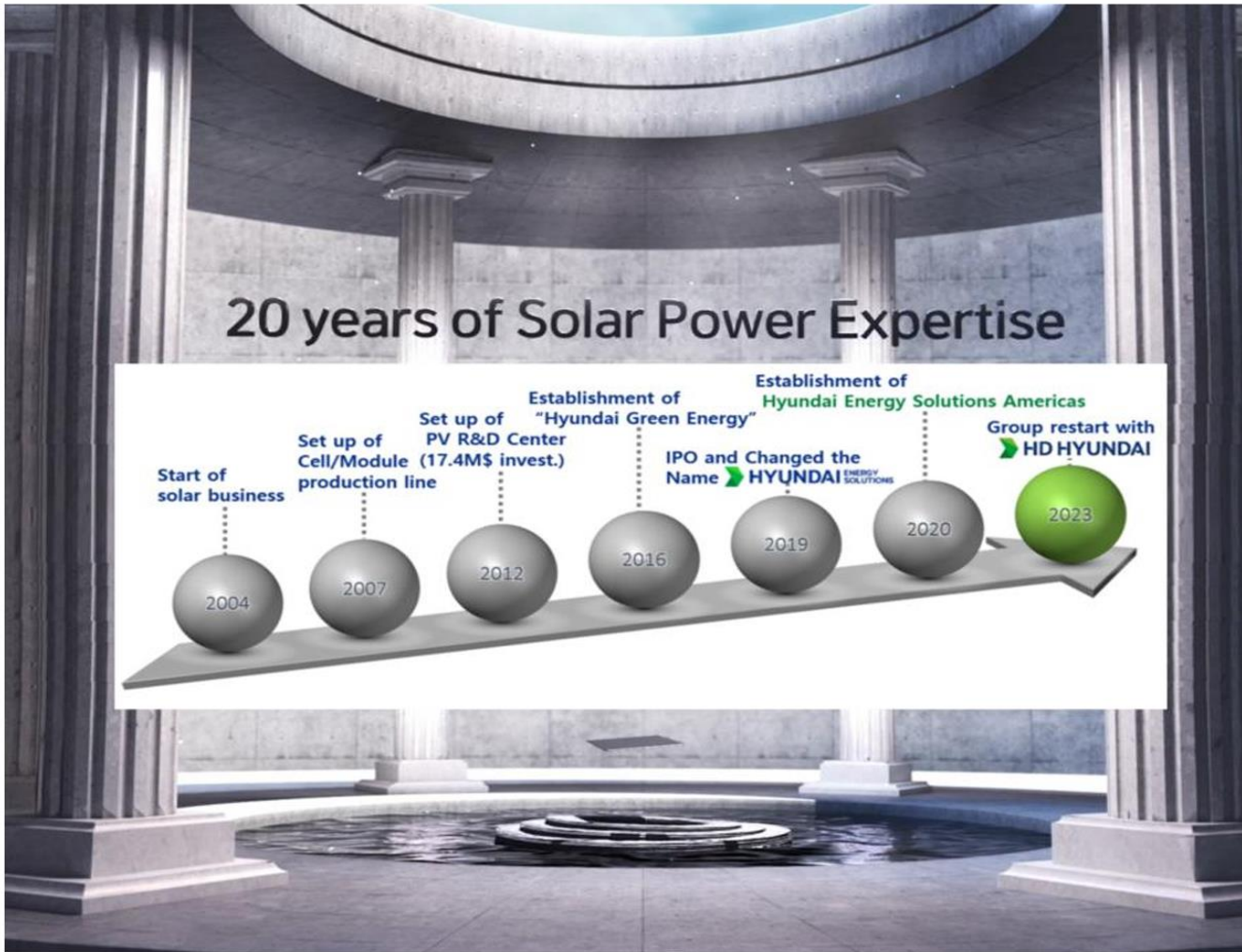
Quality Assurance

Item	IEC Standard	Internal Standard
Damp Heat	85°C, 85%RH 1,000hr	85°C, 85%RH 3,000hr(x3)
Thermal Cycling	-40°C ~ +85°C 200cycle	-40°C ~ +85°C 600cycle
UV Exposure	15kWh/m ²	30kWh/m ² (x2)
PID	85°C, 85%RH 96hr, -1000V	85°C, 85%RH 192hr(x2), -1000V



[HD Hyundai`s test laboratory @ Eumseong Factory in South Korea]

■ Company History



HD HYUNDAI

- Established in 1972
- World No.1 Shipbuilder (Based on output)
World No.1 Marine Engine Maker
- Sales : 44 billion USD (2023Y)
- Fortune Global 500 Company
- Business Scope :
Shipbuilding, Offshore & Industrial Plant,
Motors, Engine & Machinery, Industrial Robot,
Construction Equipment, Electro Electric Systems,
Refining & Petrochemical,
Renewable Energy
(HD Hyundai Energy Solutions)

