SANY

Hydrogen Energy Equipment Solution Provider

A Leading Provider

of Complete Hydrogen Energy Equipment Solutions Worldwide

CONTENTS

01 ABOUT US

SANY GROUP

Founded in 1989, SANY Group's vision to build a first-class enterprise, to foster first-class employees, and to make first-class contributions to society has never wavered, building up this established brand of "SANY" in the industry. As one of the first batch of intelligent manufacturing pilot demonstration enterprises in China, SANY is the largest construction machinery manufacturer in China and the second largest in the world.

SANY Group has played a part in pillar projects located in 158 countries and regions across the globe, including the United States, Germany, India, Brazil, etc.

Based on the principal business in the equipment manufacturing, SANY Group strives for the "international, intelligent and low-carbon" transformation to comprehensively reach out to the new energy equipment sector, and to proactively explore large-scale hydrogen use in integrated wind, solar and hydrogen energy storage and green chemical industry projects and hydrogen-powered transportation solutions.

SANY HYDROGEN ENERGY

Vision
To become one of the leading providers of hydrogen energy equipment solutions worldwide.

Strategy
To stay committed to the R&D, manufacturing, sales and operation of hydrogen producing and refueling equipment and core components to realize a closed-loop ecological industry chain involving green power, hydrogen energy and end-use, facilitate the third energy revolution and build a zero-carbon future.

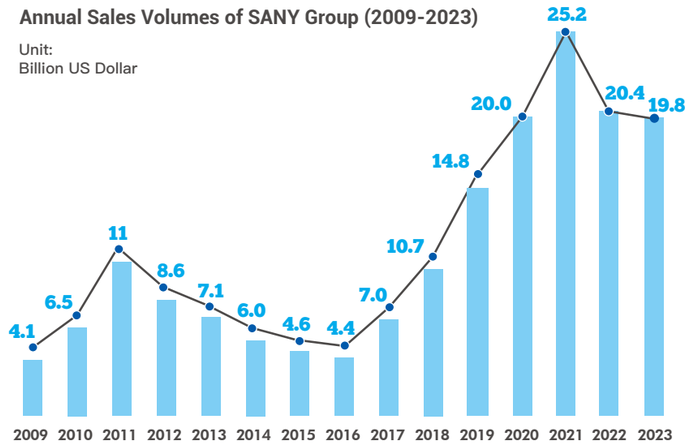
Mission
To promote the construction of a hydrogen energy society for sustainable development.

Value
Be innovative and forward-looking, good and better, active and fast, always grateful.

In 2021, SANY Group's sales hit a record high to

25.2 billion USD

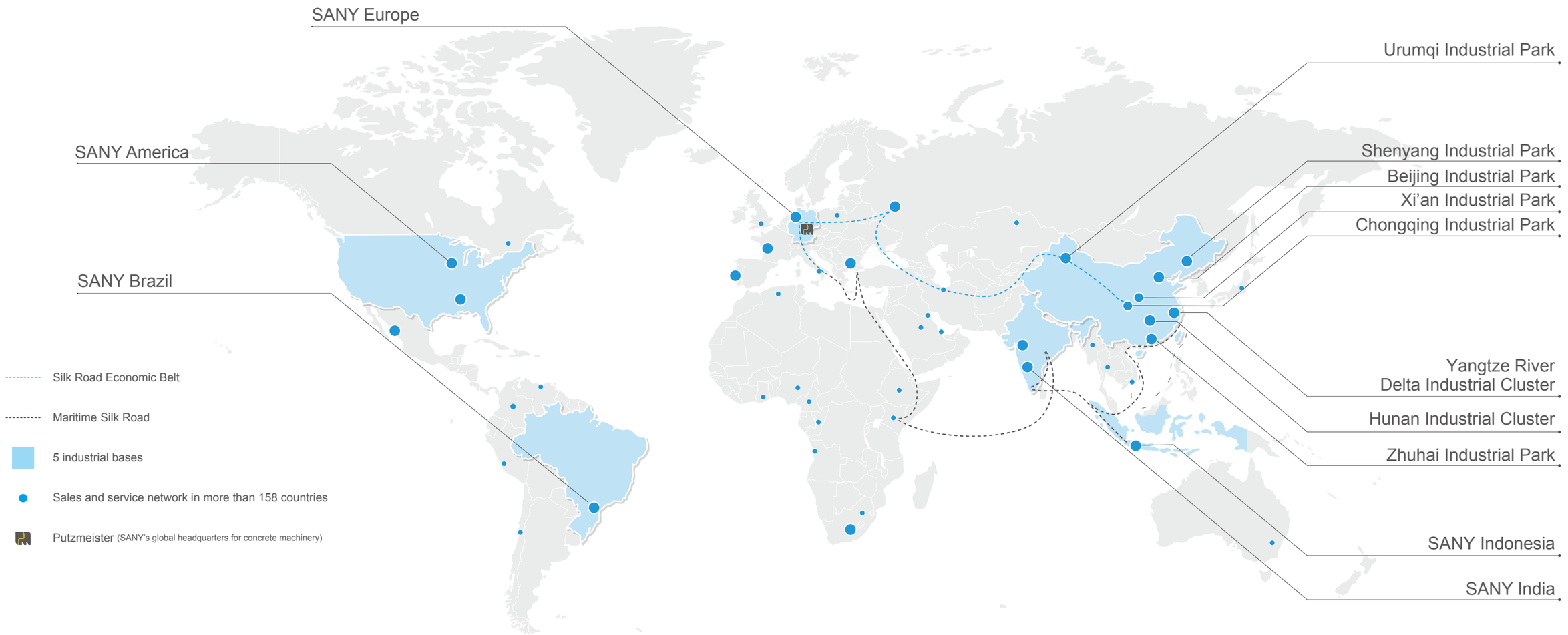
SANY ACHIEVEMENT



TOP 3 BRAND IN THE FIELD OF CONSTRUCTION MACHINERY

- Top 1 Brand of Concrete Machinery in the Globe
- Top 1 Company of Excavator in Terms of Production Capacity and Sales Volume in the Globe
- Top 1 Company of Heavy Duty Crane in China
- Top 1 Company of Crawler Crane in China
- Top 1 Company of Complete One-step Solution with Road Building and Construction Machinery in China
- Top 1 Company of Mobile Port Machinery in China
- Top 1 Company of New Energy Heavy Truck in Terms of Sales Volume in China
- Top 1 Company of Piling Machinery in China
- Standardization of Architectural Design SPCS3.0
- Top 1 Company of Coal-mining Machinery in China
- Global comprehensive solution provider in new energy industry
- High Class R&D Manufacturer of Petroleum Equipment

GLOBALIZATION



60,000
60,000 employees worldwide

10,000+
Including more than 10,000 R&D employees

75%+
Over 75% of the sales revenue have been generated from the countries and regions along the 'Belt and Road'

50+
No.1 brand in more than 50 countries

15
15 overseas manufacturing plants

158
Export to 158 countries and regions

39%
Annual compound growth rate of exports reached 39% in the past 6 years

02 CORE ADVANTAGES

Advantage in large-scale hydrogen production from wind, solar and green power

01

To meet the demand for new scenario of large-scale hydrogen production from wind, solar and green power, SANY Hydrogen Energy has developed the hydrogen production equipment with a capacity of 1,000 Nm^3/h and the multi-in-one hydrogen production system made up of four 1,000 Nm^3/h units by selecting core materials such as high-activity and high-stability electrodes, membranes with high airtightness and low surface resistance, PTFE-modified sealing gaskets, and using CAE emulation for the analysis and optimization of the flow field structure of the electrolyzer, with the key indicators reaching the advanced level in China. In 2023, SANY Hydrogen Energy won the bid for Da' an Wind and Solar Green Hydrogen Synthesis Ammonia Integration Demonstration Project of Jilin Electric Power Co., Ltd., and we will provide 2 sets of multi-in-one hydrogen production systems made up of four 1,000 Nm^3/h units each, as a important support for the operation of the project.

Advantage in the self-developed and self-manufactured BOP system

02

The R&D and design of BOP system are conducted on the basis of chemical engineering calculation data, which aims for installation convenience, reliable and safety operation, to make a shorter time of installation, ensuring that the BOP system is highly adaptable to fluctuating operating power of hydrogen production. SANY Hydrogen had completed the development and experimental verification of the 100-6,000 Nm^3/h separation and purification system, which are used in a number of projects. Customized BOP system services are available to meet the specific needs of customers.

Advantage in the equipment testing platform

03

The 20MW-class multi-in-one electrolyzer testing platform has been built and put into operation, which integrates performance testing, control optimization, reliability verification and other functions, passed HAZOP, SIL and QRA safety assessments and lightning protection tests. The platform fully meets the need of comprehensive testing for alkaline electrolyzers and BOP systems, which platform has operated for thousands of hours in total, providing important data support for the rapid verification and iterative upgrading of electrolyzers, BOP systems and auxiliary equipment products.

Advantage in intelligent manufacturing of large-scale equipment

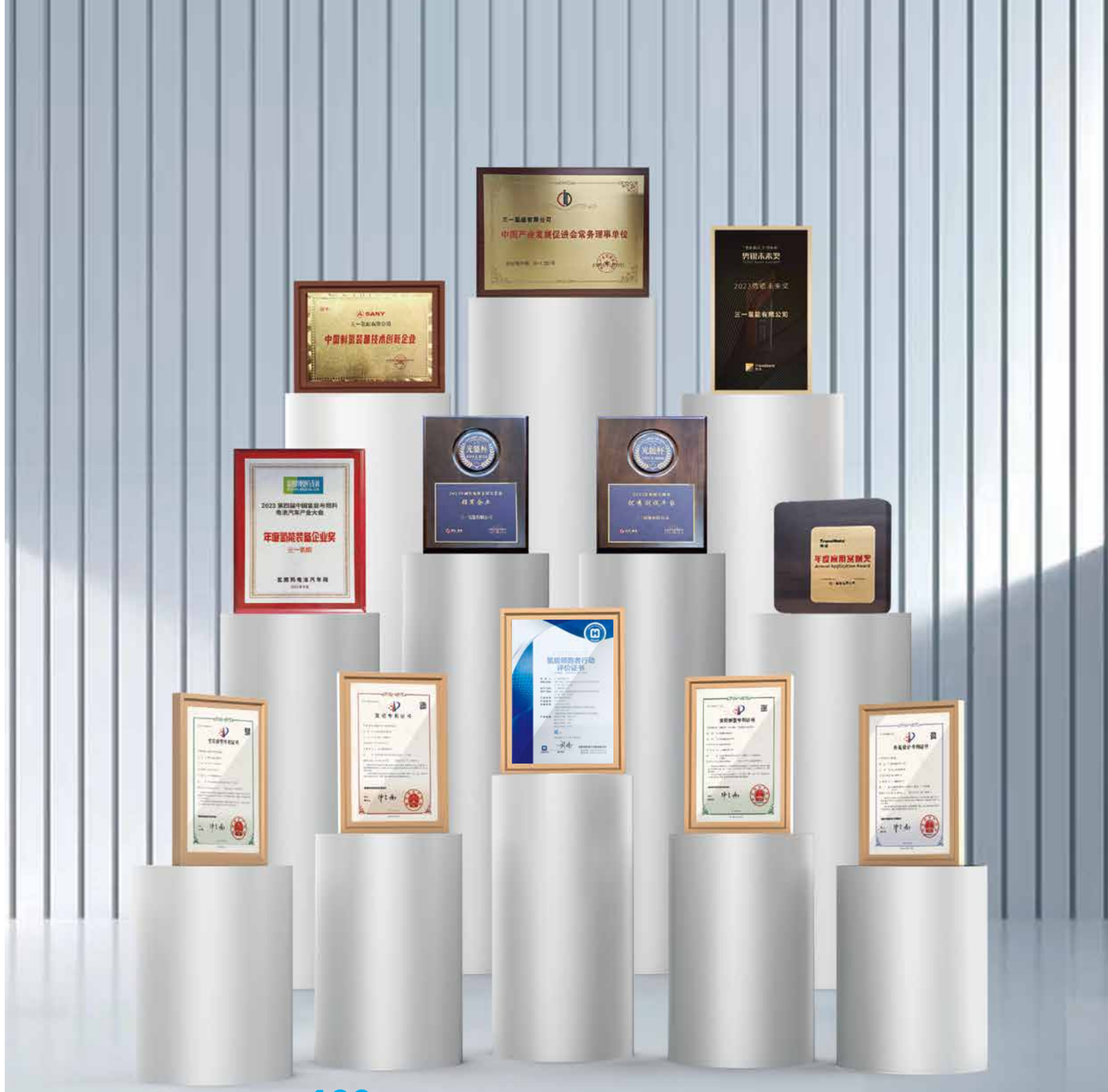
04

Relying on the advantages of SANY Group in intelligent manufacturing and quality assurance systems, we have built automatic production lines for 2GW electrolyzers, and has taken the lead breakthrough in the core processes of automatic feeding, automatic argon arc welding, automatic resistance welding, pipe prefabrication and high-precision stacking, which has significantly improved the manufacturing quality of hydrogen equipment. We have established a comprehensive manufacturing process standard guidance system covering the entire process of hydrogen equipment manufacturing to ensure that the process meets the regulatory requirements.

Advantage in synergy of wind power, solar power, hydrogen, stations and vehicles

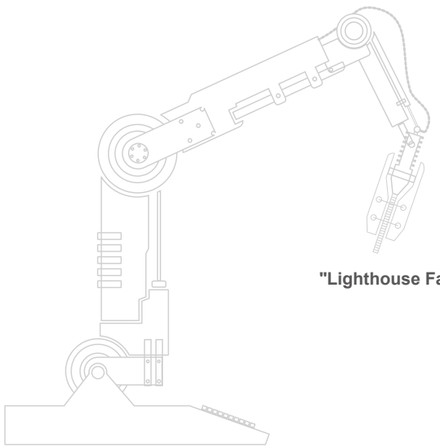
05

As guided by the low-carbon strategy of SANY Group, SANY Hydrogen Energy (hydrogen production equipment and hydrogen refueling equipment) works closely with SANY Renewable Energy (wind power and large-scale hydrogen production from green power), SANY Silicon Energy (photovoltaics) and SANY Heavy Truck (electric vehicles and hydrogen fuel cell electric vehicles) to form a closed loop of the low-carbon industry. SANY Hydrogen Energy not only are capable of R&D and manufacturing of hydrogen energy equipment, but also has access to big data of wind power and photovoltaic power, laying the foundation for the development of the hydrogen production system from green power, and continuous upgrading of cluster control strategy, which facilitates providing customers with more sophisticated and economic solutions for integrated green hydrogen production and utilization, and promotes the high-quality development of the entire industry.



- More than **100** patents
- Over **20** core inventions
- A standing member of China Association for the Promotion of Industrial Development
- TrendBank Award: The Future
- Hydrogen Energy Equipment Enterprise of the Year
- Leadership Award
- Excellent Testing Platform Award

INTELLIGENT MANUFACTURING FACTORY



"Lighthouse Factory" for Intelligent Manufacturing

2GW Electrolyzer Production Line

INNOVATIVE PROCESSING STEPS

01 Bipolar plate processing

- **Machining:** Made with full-length electromagnetic chucks to control the thermal deformation and residual stress during the machining process to ensure the minimal deformation of bipolar plates.
- **Welding:** Automatic double-sided laser welding of the bumpy plate and the frame, pressing, fitting, shaping, and 100% detection of kerosene leakage.
- **Electroplating:** Acid etching activation process for the firmer bonding of bipolar plates, and constant current nickel plating process for even and stable coating.

Machining production line

Plate welding equipment

02 Manufacturing and automated assembly of electrodes

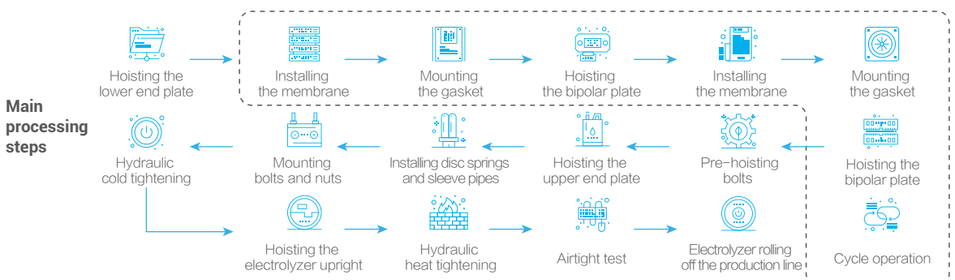
- Drawing, netting, spraying, activation, and laser cutting for products with the large specific surface area, stable size, high current density.
- The independently developed and implemented robotic work island flexibly covers 200-2000 Nm^3/h products, which realizes the entire process of bipolar plates from automatic rolling on and off the line, conveyance and rotation.

Linear spraying by a manipulator

Robotic working island

03 Electrolyzer stacking

- Hydraulic screw jacking structure makes it possible to pass through the screw hole on the upper end plate of the electrolyzer from bottom to top for better assembly efficiency.
- 4-point cylinder-type hydraulic automatic lifting enables adjustable speed and stable lifting for the assembly of 3000 Nm^3/h and below products.
- European imported single beam motor with double speed modes and double control options for frequency conversion between large and small volumes enables safe and stable stacking of bipolar plates and end plates.
- Bipolar plates are assembled under three-hole positioning and tested with five-line laser leveler+lead hammer line drop to ensure proper vertical deviation.

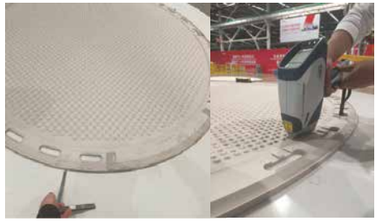


PROFESSIONAL INSPECTION AND TESTING

01 Product testing

- Upon the welding of the frame and the bumpy plate, the leak testing is conducted on the weld seam in accordance with the kerosene leakage testing method as mentioned in NB/T 47003.1-2022.
- The flatness of the bipolar plate is controlled with a dedicated detection platform, and the thickness of the bipolar plate coating is detected with the X-ray fluorescence spectrometer.
- The weld seam of the separation and purification system is detected for flaws in strict accordance with the requirements of the Pressure Piping Code (GB/T 20801).

Leakage Testing



Flatness and Coating Testing

02 Experimental verification

- To focus on the development, incubation and application of the core technology for hydrogen production from electrolytic water, including electrode, membrane, new structures, and PEM electrolytic water hydrogen production technology.
- To provide experimental basis for the selection and innovative research and development of electrodes. Functions: Fast inspection platform for electrode performance, fast inspection platform for electrode parameters, comprehensive testing platform.
- To provide experimental basis for the selection and technical demonstration of membrane materials. Functions: Membrane material parameter characterization platform, membrane material performance testing platform, development incubation platform
- To provide low-cost and fast response parameters of "emulation→optimization" for core components such as electrodes. Functions: Core component parameter acquisition platform, operation parameter acquisition platform, component optimization verification platform.

PEM Electrolytic Water Testing Platform

Electrode Experiment

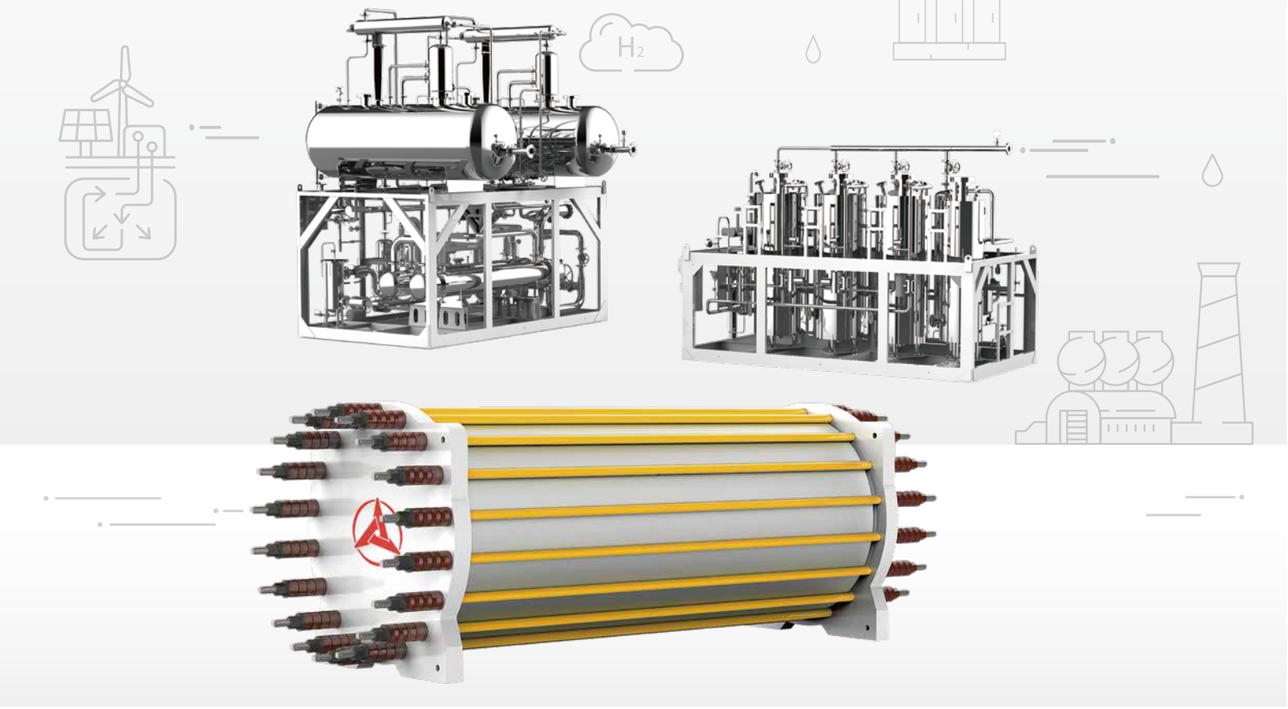
03 Testing platform

- To build a systematic and standardized experiment-test-research and development system including electrochemical testing laboratory, material research development and production center and hydrogen production system machine testing site.

200-2000 Nm^3/h Electrolyzer Testing Platform

Multi-in-one Equipment Testing Platform

03 PIVOT PRODUCTS



Advantage

Low power consumption

- New flow-field design with simulation testing features for flow uniformity in fuel cells
- New-generation electrodes with industry-leading resistance overpotentials
- Comprehensive power consumption ≤4.9kWh/Nm³

Short cold start time

- Self-developed lye heating circulation system, cold start time reduced by 50%

Wide power fluctuation range

- Power fluctuation range of 30-120%, better suiting wind and solar based hydrogen production

High stability

- Double security with internal and external sealing
- Upgraded fastening system reducing the leakage of electrolyzer under alternating working conditions
- Large diameter double pole plate technology, effectively reducing the length of the electrolyzer
- Bipolar plate coating thickness of more than 50μm at the lowest point

ALKALINE ELECTROLYZER HYDROGEN PRODUCING EQUIPMENT

Specifications of E-series AWE Equipment

Name	E-200	E-500	E-1000	E-1200	E-1500	E-2000
Hydrogen production capacity (Nm³/h)	200	500	1000	1200	1500	2000
DC power consumption (kWh/Nm³)	4.2~4.4	4.3~4.5	4.3~4.5	4.3~4.5	4.4~4.6	4.4~4.6
Hydrogen purity (Before purification)	≥99.8%	≥99.8%	≥99.8%	≥99.8%	≥99.8%	≥99.8%
Hydrogen purity (After purification)	≥99.999%	≥99.999%	≥99.999%	≥99.999%	≥99.999%	≥99.999%
Operating pressure (MPa)	1.8	1.8	1.8	1.8	1.8	1.8
Operating temperature (℃)	90 ± 5	90 ± 5	90 ± 5	90 ± 5	90 ± 5	90 ± 5
Power fluctuation range	30~120%	30~120%	30~120%	30~120%	30~120%	30~120%
Cold start time (Minute)	≤30	≤30	≤30	≤30	≤30	≤30
Hot start time (Minute)	≤5	≤5	≤5	≤5	≤5	≤5

- Definition of a cold start: The period from starting at the environment temperature to when the hydrogen and oxygen purity is qualified.
- Definition of a hot start: The period from starting at the alkaline temperature of 45 ℃ to when the hydrogen and oxygen purity is qualified.

PEM ELECTROLYZER HYDROGEN PRODUCING EQUIPMENT

Advantage

Small volume

- High operating current density (1.5~3A/cm²)
- Thickness of the core area of the tank less than 1m
- Skid-mounted integrated auxiliary control system

High efficiency

- DC power consumption below 4.3 kWh/Nm³
- Thermal efficiency higher than 75%
- Preferred PEM membrane electrodes of international leading level

Strong expandability

- Compatible assembly program
- Designed to meet the needs of different tank parameters
- Skid-mounted platform integration

Fast response

- Less than 30 seconds for hot start, less than 300 seconds for cold start
- Adaptable to load variations of 5-110%
- Verified cyclic start/stop performance and life time

Ultra-safe

- Self-developed dual-wire sealing design program
- Multi-gas sensor monitoring and alarm interlock
- Pressure, temperature parameters and hydrogen production circuit logic control

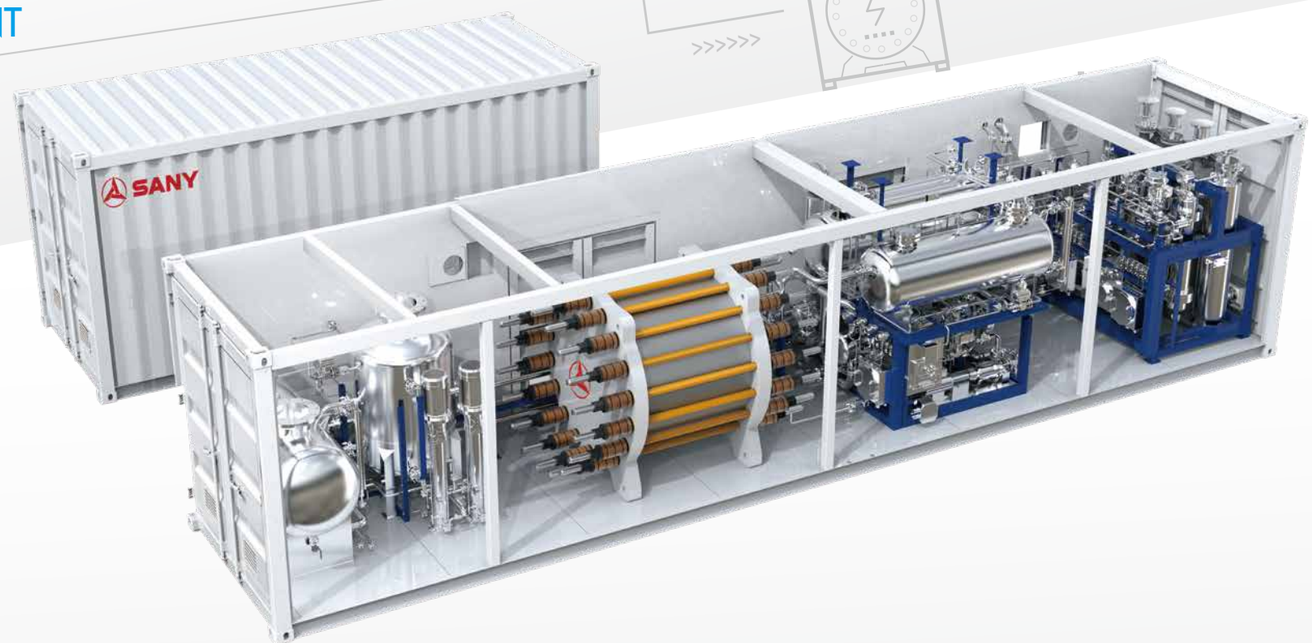
Specifications of P-series PEM Equipment

No.	Name	P-200
1	Hydrogen production capacity (Nm³/h)	200
2	DC power consumption (kWh/Nm³)	4.3
3	Hydrogen purity (Before purification)	⩾99.9%
4	Hydrogen purity (After purification)	⩾99.999%
5	Operating pressure (MPa)	3.0
6	Operating temperature (℃)	70±5
7	Power fluctuation range	5~110%
8	Cold start time (Minute)	⩽5
9	Hot start time (Minute)	⩽0.5

Definition of a cold start: The period from starting at the environment temperature to when the hydrogen and oxygen purity is qualified.

Definition of a hot start: The period from starting at the alkaline temperature of 45 ℃ to when the hydrogen and oxygen purity is qualified.

SKID-MOUNTED ALKALINE ELECTROLYZER HYDROGEN PRODUCTION EQUIPMENT



Advantage

Highly integrated and Modularized design

- Highly integrated equipment of the electrolyzer with separation, purification, and auxiliary systems
- Skid-mounted modular design with module-based installation and transportation of hydrogen production skids and power supply skids

Low power consumption

- New flow field design with the uniformity of flow field in the cell ensured by emulation and testing, DC power consumption ⩽4.5kWh/Nm³

Wide power fluctuation range

- Adaptable to the power fluctuation range from 30~ 120%, and applicable to the hydrogen production from renewable energy sources such as wind and solar energy

High reliability

- Made of sophisticated technology and core components verified by mass production
- Monitoring and early warning of important parameters and indicators over the whole process

CE certification

- CE certification granted on the entire skid-mounted equipment, pressure-bearing components, and electrical components, qualified for foreign exports

Flexible application scenarios

- Adaptable to application scenarios such as integrated hydrogen producing stations, small and medium-sized refining, hydrogen compressed natural gas, etc., due to flexible transportation, easy installation, compact layout, and small footprint

Specifications of V-series Skid-mounted AWE Hydrogen Production Equipment

No.	Name	V-200	V-500
1	Hydrogen production capacity (Nm³/h)	200	500
2	DC power consumption (kWh/Nm³)	4.2~4.4	4.3~4.5
3	Hydrogen purity (Before purification)	⩾99.8%	⩾99.8%
4	Hydrogen purity (After purification)	⩾99.999%	⩾99.999%
5	Operating pressure (MPa)	1.8	1.8
6	Operating temperature (℃)	90 ± 5	90 ± 5
7	Power fluctuation range	30~120%	30~120%
8	Cold start time (Minute)	⩽30	⩽30
9	Hot start time (Minute)	⩽5	⩽5

Definition of a cold start: The period from starting at the environment temperature to when the hydrogen and oxygen purity is qualified.

Definition of a hot start: The period from starting at the alkaline temperature of 45 ℃ to when the hydrogen and oxygen purity is qualified.

SQUARE AWE EQUIPMENT

ALKALINE ELECTROLYZER HYDROGEN PRODUCING EQUIPMENT

Advantage

Easy to operate and maintain

- Sealed by hydraulic extrusion, short time for on-site dismantling and maintenance

Modular design

- Independent single-chamber unit, expandable single cells, and connectable multiple cells

Low power consumption

- Zero-gap design, pure nickel electrodes, and high conductivity

High reliability

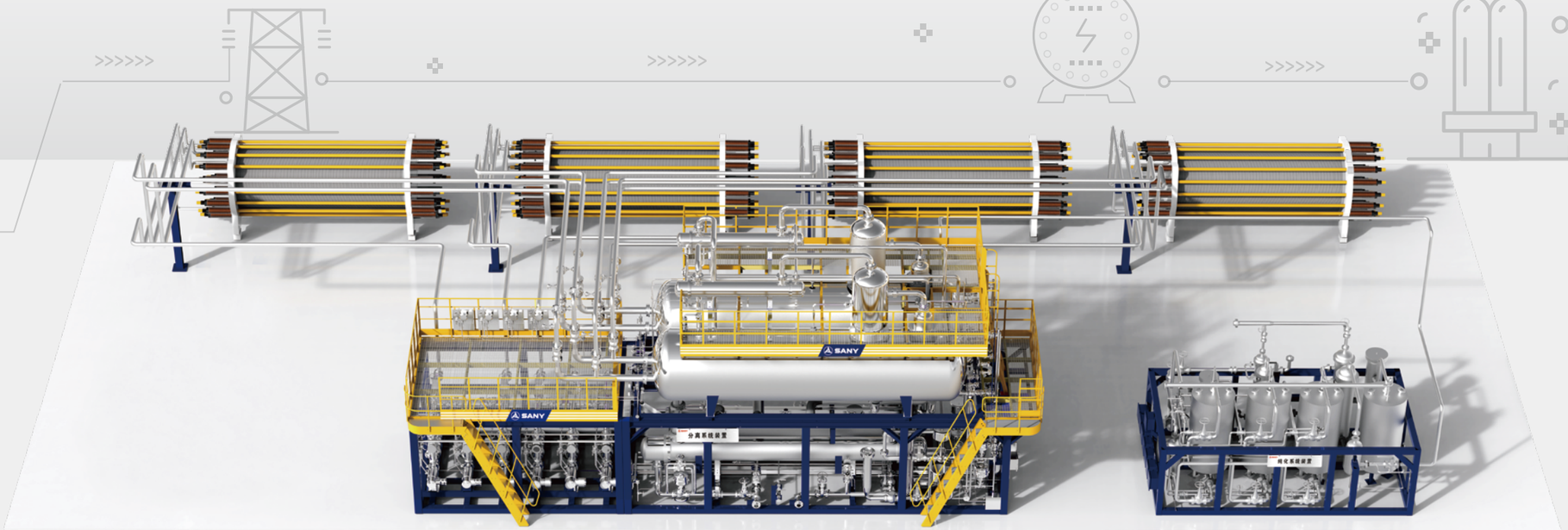
- Double safety insurance with hydraulic automatic control and multi-point mechanical locking, high-strength mechanical support frame, and independent liquid inlet and outlet of the single chamber to ensure uniform temperature field

Specifications of S-series Square AWE Equipment

No.	Name	S-1000	S-2000	S-3000
1	Hydrogen production capacity (Nm^3/h)	1000	2000	3000
2	DC power consumption (kWh/Nm^3)	4.0~4.2	4.1~4.3	4.1~4.3
3	Hydrogen purity (Before purification)	≥99.8%	≥99.8%	≥99.8%
4	Hydrogen purity (After purification)	≥99.999%	≥99.999%	≥99.999%
5	Operating pressure (MPa)	0.5	0.5	0.5
6	Operating temperature (℃)	85±5	85±5	85±5
7	Power fluctuation range	10~120%	10~120%	10~120%
8	Cold start time (Minute)	≤35	≤35	≤35
9	Hot start time (Minute)	≤5	≤5	≤5
10	Annual working hours (h)	8000	8000	8000

- Definition of a cold start: The period from starting at the environment temperature to when the hydrogen and oxygen purity is qualified.
- Definition of a hot start: The period from starting at the alkaline temperature of 45 ℃ to when the hydrogen and oxygen purity is qualified.

MULTI-IN-ONE ELECTROLYZER HYDROGEN PRODUCING EQUIPMENT



Advantage

Safety and Stability

- This multi-in-one system uses an independent alkaline recirculation process, and has features such as automatic interlocking shutdown, five-level safety protection. The whole system is equipped with control means to control the over-temperature of the stack, ensure the liquid level balance, stabilize the pressure adjustment, enhance the purity initiative, and inspect the voltage of the small cell (optional).

Module-oriented Design

- Platform-based products, standardized PID process and interfaces, and user-friendly assembly-oriented operating platform and skid-mounted separation system design based on ergonomic concepts.

Standardized Manufacturing

- The manufacturing process includes mass production of prefabricated pipeline, independent components of pipeline systems, standardized operating processes, and real-time production quality assurance.

Intelligent Control

- Automatic sampling and analysis, automatic water replenishment, intelligent drainage, and intelligent nitrogen replacement.

Energy Efficiency

- The operating unit and current density of the electrolyzer are intelligently adaptable to the fluctuation of renewable energy;
- The heat transfer of the standby electrolyzer is optimized to ensure the best temperature of the electrolyzer and reduce the consumption of cooling water. Efficient electric heating and automatic algorithms for purification can lower heat loss.

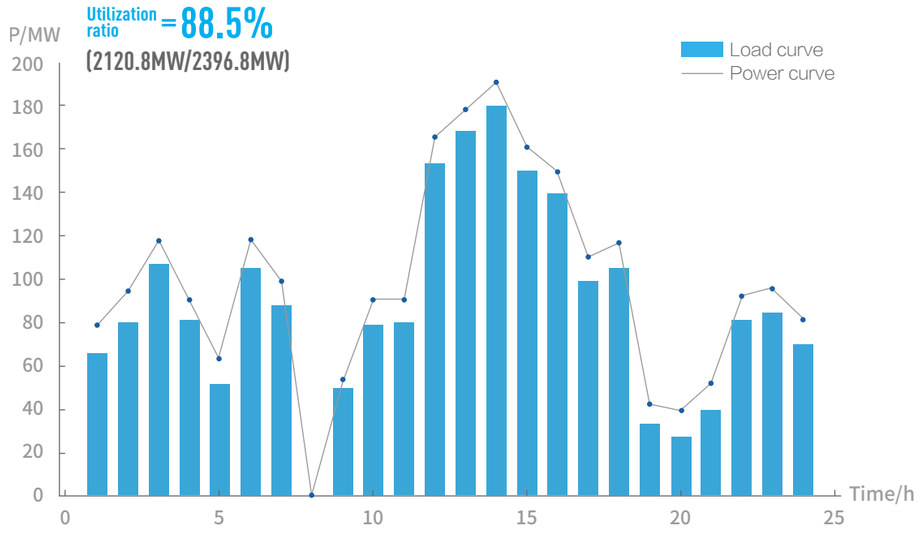
Technical specifications of Multi-in-one Electrolyzer Hydrogen Producing Equipment

No.	Name	Parameter
1	Processing capacity of the separation system （Nm³/h）	4000-6000
2	Processing capacity of the purification system （Nm³/h）	8000-12000
3	Hydrogen purity (Before purification)	≥99.8%
4	Hydrogen purity (After purification)	≥99.999%
5	Operating pressure (MPa)	1.8
6	Output pressure (MPa)	1.6
7	Dew point (℃)	-70
8	Power fluctuation range	15~120%
9	Operating temperature (℃)	90±5

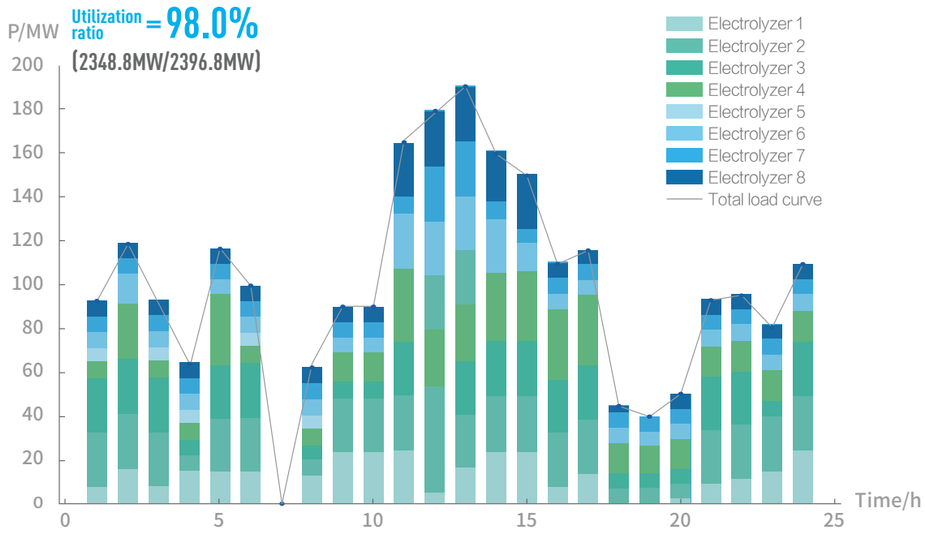
HYDROGEN PRODUCING CLUSTER CONTROL SCHEME

Based on a deep understanding of the wind and solar power generation system and hydrogen producing system, we can provide control schemes for a 4-in-1 electrolyzer unit and even a cluster of multiple 4-in-1 electrolyzer units on the basis of the self-developed intelligent scheduling algorithm, which is superior to conventional flexible hydrogen producing schemes from wind and solar energy in the market in terms of the utilization ratio of the coupled wind/solar energy and safety and stability of the system.

Conventional flexible hydrogen producing scheme from wind and solar energy



Hydrogen producing cluster control scheme



HYDROGEN REFUELING EQUIPMENT

Compressor

01

The hydrogen compressor is a core device of the hydrogen refueling station, for which we use the industry-leading multi-stage frequency conversion compression technology to self-adapt the displacement, power and pressure ratio to the working conditions and requirements.

Name	Displacement	Exhaust pressure	Inlet pressure	Exhaust temperature (After cooling)	Service life of seals	Main motor power	Noise
Parameter	≥1000 Nm³/h@12.5MPa	45 MPa	2~20 MPa	≤40 ℃	≥2000h	110 kW	≤80 dB(A)

Hydrogen refueling equipment

02

The hydrogen refueling equipment is a specialized device for refilling hydrogen fuel cell vehicles with pressurized hydrogen gas and presenting accurate measurement and pricing.

Name	Flow range	Measurement error	Measurement repeatability	Operating pressure	Explosion-proof grade
Parameter	0~5.0Kg /min	±1.5%	0.5%	35MPa	ExdemibIICT4Gb

Sequence control panel

03

The sequence control panel is a specialized sequence control device that connects the compression system, hydrogen storage system and refueling system for automatic multi-division refueling/storage.

Name	Applicable medium	Operating pressure	Design pressure	Environment temperature	Rating
Parameter	H_2	45MPa	50MPa	-40°C~50°C	III

Hydrogen discharge column

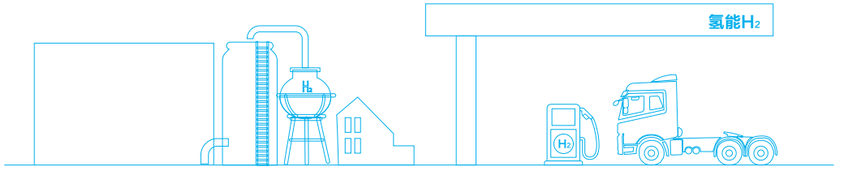
04

The hydrogen discharge column is a specialized gas discharge device that connects hydrogen tube trailers, compressors or hydrogen storage facilities, consisting of mass flow meters, pneumatic valves, pressure transmitters, safety relief, electric control and other parts, for active measurement (or pricing) of hydrogen.

Name	Applicable medium	Operating pressure	Design pressure	Measurement repeatability	Filtration accuracy
Parameter	H_2	0~20MPa	25MPa	0.5%	5μm

INTEGRATED HYDROGEN PRODUCING AND REFUELING STATION

Full sets of equipment for stationary and skid-mounted hydrogen refueling stations



04 DEMONSTRATION PROJECTS

1

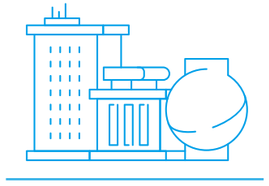
- The largest integrated electrolysis hydrogen producing and refueling station in China.
- Hydrogen producing: 2000 Nm^3/h, hydrogen refueling: 2000 kg/day.
- A demonstration case of the comprehensive application of hydrogen energy integrating "producing, refueling and use".

2000kg

INTEGRATED HYDROGEN PRODUCING AND REFUELING STATION DEMONSTRATION PROJECT

2

DA'AN WIND AND SOLAR GREEN HYDROGEN SYNTHESIS AMMONIA INTEGRATION DEMONSTRATION PROJECT



No.	Name	Scale	Remark
1	Air separation unit (Including air compression station, oxygen liquefaction unit)	20000Nm³/h Nitrogen	
2	Electrolysis hydrogen producing unit	46000Nm³/h Hydrogen	36 sets of 1000 Nm³/h alkaline electrolyzers, and 50 sets of 200 Nm³/h PEM electrolyzers
3	Synthesis ammonia unit	$30*10^4$ t/a	
4	Solid hydrogen storage unit	60000Nm³/h Hydrogen	

3

1 million kW Wind Power Hydrogen and Ammonia Production Project in Balikun County, Xinjiang

Wind and Solar Hydrogen Storage and Ammonia Digitalization Demonstration Project in Changling, Jilin

500,000kW Wind and Solar Hydrogen and Ammonia Storage Integration Demonstration Project in Urad Middle Banner, Inner Mongolia

Wind and Solar Hydrogen and Ammonia Storage Integration Demonstration Project in Delingha City, Qinghai

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SANY Hydrogen Energy always conducts product and technology R&D based on the core mission to provide GW-class ultra-large-scale wind/solar off-grid hydrogen production solutions for global customers.

SANY Hydrogen Energy helps to promote green chemical industry, hydrogen energy transportation, hydrogen energy storage, blending hydrogen in natural gas pipelines, and other application scenarios, creating a large-scale, reproducible operation model.

TOGETHER WITH SANY HYDROGEN ENERGY FOR A SHARED FUTURE

SANY

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