

CCUS Technology and Product Application Manual

2026



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01

Corporate Overview



Tonexus listed on the Shenzhen Stock Exchange Main Board (003027), upholds the corporate philosophy of “Toward Net-Zero, Beyond Industry”. The company is committed to becoming a globally recognized strategic partner in pollution, carbon reduction and industrial net-zero, contributing Tonexus’s expertise to the world’s green transition.

Core Business Areas

Flue Gas Treatment (EPC & Catalysts), CCUS, R&D and Production of New Energy Materials and Equipment, etc.

Key Service Sectors

Steel, Power Generation, Coking, Construction Materials, Chemical Industry, Non-Ferrous Metals, Waste Incineration, Pulp & Paper, Renewable Energy, etc.





CORPORATE VISION

Lower Emissions for the Planet,
Achieve Net-Zero for the Industry.



CORPORATE MISSION

By 2035, Become the Recognized Global Leader in
Pollution Control and Carbon Reduction.



CORPORATE VALUE PROPOSITION

Customer First Integrity & Responsibility
Learning & Innovation Collaboration & Sharing
Pursuit of Excellence

02 Industry Cases

Multiple 10,000-tonne Scale Marine Carbon Capture System Solvent Projects

Application scenario: Low-concentration CO₂ (<4%) in marine steam turbine exhaust gas with high O₂ content.

Core Highlights: Stable supply of absorbent. The absorbent is suitable for high-oxygen and high-chlorine operating conditions. It features low volatility loss and stable capture efficiency when applied to 2 sets of marine carbon capture units with a gas intake flow rate of >25,000 m³/h.



Carbon capture project for flue gas from a cement kiln in Vietnam

Application scenario: Supply of TX-1c solvent, suitable for lime kiln flue gas (20~22% CO₂), high oxygen content and low partial pressure gas source; annual carbon capture capacity of this project is 25,000 tons.

Core Highlights: Adopting TX-1c solvent to meet design specifications. Its service life is more than 3 times longer than that of MEA.



CO₂ capture unit for converter gas of a steel plant in Rizhao

Application scenario: Converter gas from steel plant (18% CO₂), high moisture content, containing S, Cl, etc.

Core Highlights: 150,000 tpy CO₂ capture unit for converter gas. Its pretreatment process adopts TX^{io} patented technology, which can reduce annual operating cost by up to 3.5 million RMB and recover 80,000 tons of water compared with traditional design.



Carbon capture project for a cement plant in Tangshan

Application scenario: Cement kiln gas, high oxygen content, low partial pressure CO₂ gas source.

Core Highlights: Manufacturing and supply of core equipment, including pretreatment tower, absorption-desorption tower, rectification tower, etc.



Carbon capture project for gas boiler flue gas from a steel plant in Shanxi

Application scenario: Boiler flue gas (20~24% CO₂), high oxygen content, low partial pressure CO₂ gas source; annual carbon capture capacity of this project is 50,000 tons.

Core Highlights: Supply of TX-1a solvent with strong resistance to degradation. Using only traditional processes, CO₂ capture rate is over 85%, and regeneration energy consumption is 1.15 t steam/t CO₂.



Carbon-Nitrogen Cogeneration Project at Haoji Power Plant, Liaocheng Xinfu Group

Application scenario: Typical flue gas from coal-fired power plants (11~14% CO₂)

Core Highlights: Supply of pressure vessels



Carbon capture project for a large building materials enterprise

Application scenario: Side-stream test of lime kiln gas (18~20% CO₂), gas source with oxygen content of 6-40% and low partial pressure.

Core Highlights: Adopting TX-1b solvent, under the classic process, the average capture rate exceeds 97%. The solvent shows almost no color change after one month of operation.



03

Advantages and Applications of Tonexus TX-1 Absorption Solvent

3.1 Pain Points in Carbon Capture

Readily Biodegradable



Conventional absorbents are prone to rapid degradation and failure when treating complex gas streams such as coal-fired flue gas or lime kiln gas with high oxygen content, resulting in single-event generation of large waste liquid volumes and significantly increasing both solvent operational costs and waste disposal expenses.

High Cost



Conventional processes exhibit inadequate heat utilization and, when combined with traditional absorption solvents, lead to high steam energy consumption of 3.5-4.0 GJ/tCO₂, accounting for over 70% of operational costs.

High Degradation



The regeneration gas exhibits amine escape and high operational loss of conventional absorption solvents, leading to a significant increase in solvent costs.

3.2 Core Performance of TX-1: Redefining Carbon Capture Economics

Parameter Content	MEA Absorption Solvent	Tonexus TX-1 Absorption Solvent	Customer Value
Regeneration Energy Consumption	3.9-4.1 GJ/t CO ₂	2.1 GJ/t CO₂	Steam costs reduced by over 35%
Service Life	3-10 months	12-30 months	Absorption solvent service life extended by 2-3 times, with operating costs lowered by over 30%
Acid Gas Net Loading Capacity	18-20 L/L	30-36 L/L	Size reduction of up to 20% for selected pipelines and equipment models
Oxygen Tolerance	Poor, requires frequent activation of amine purification and recovery systems	Excellent, capable of long-term stable operation	Compatible with high-oxygen tail gases from cement kilns and steel plants



3.3 Interpretation of TX-1 Laboratory Data

Relying on its own CNAS-certified laboratory, Tongxing Technology has invited industry expert teams to observe the anti-degradation performance and absorption-desorption performance tests of the TX-1 series solvent for six times. The relevant achievements have been highly recognized by experts and scholars.



No.	Types of Absorption Solvents	Initial Degradation Time (min)	Remarks
1	4M MEA	11	1. Using MEA as the reference, PZ and DGA demonstrate relatively better stability, offering approximately 3 times and 2 times the lifespan, respectively. 2. By comparison, the polyamine AEEA exhibits inferior resistance to degradation.
2	4M DEA	10	
3	4M DGA	23	
4	4M MDEA	18	
5	4M PZ	36	
6	4M AEEA	8	
7	4M AEEA	160	By adopting Tongxing's stability technology, the stability of AEEA is increased by 20 times.
8	2M AEEA+2MPZ	16	
9	4M TX-1a	373	33 times higher than MEA
10	4M TX-1b	597	54 times higher than MEA
11	4M TX-1c	1200	109 times higher than MEA
12	4M TX-1c (+100 mg/LFe3+, 100 mg/L Cl)	1140	103 times higher than MEA

1.Test Conditions:

- 1.0Mpa O₂
- 120 C
- 600rad
- 22-25L/LCO₂

2.Concept Explanation:

Initial Degradation Time — The absorption-enhanced oxidation process typically exhibits an initial "resistance" phase followed by an accelerated degradation phase. The duration of this resistance period is defined as the initial degradation time. In this context, a 10% pressure drop is used as the reaction endpoint.

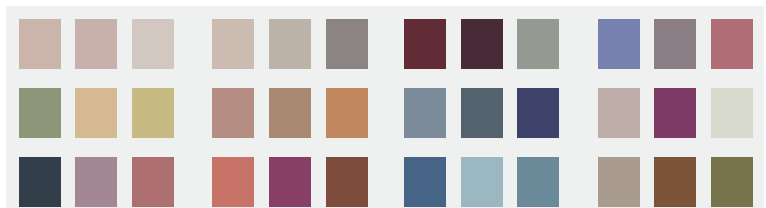
Comparative Table of Laboratory Degradation Data

3.4 Fully Customized TX-1 Absorption Solvent



Traditional products

TX-1 series products



TX Series Customization Capabilities

The TX-1 series expands from linear → planar (TX-2) configurations

- **Demand Mining** — Develop absorption solvents with distinct characteristics tailored to varying steam prices (ranging from 30 to 250 RMB/ton).
- **Customized Products** — Product evolution extends from point to line (three major categories of absorption solvents), with further customization of the TX-1 series to create TX-2 based on plant design and user-specific requirements.

3.5 Comparative Analysis of Tonexus Absorption Solvent Performance: Before vs. After Operation

Figure 1 Comparative Diagram of TX-1a Absorption Solvent Performance: Before vs. After Operation



3.6 Customer Benefit Model: Economic Leap Under Policy Incentives

Taking a cement plant lime kiln with an annual CO₂ capture capacity of 300,000 tons as the simulation calculation (specific benefits shall be accurately calculated based on actual solutions and local policies; consultation is welcome).

Annual Net Benefit	=	\$150,000 (Absorption Solvent Savings)	+	\$5,670,000 (Steam Cost Savings)	=	\$5,820,000
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Cost Items	Traditional solution (MEA)	Tonexus Systemized Solution (TX-1)	Annual Savings
Absorption Solvent Consumption and Waste Liquid Treatment Costs	\$5.5 per ton (CO ₂) requires a total of \$1.65 million	\$5.0 per ton (CO ₂) totals \$1.5 million	\$150 thousand
Steam Energy Consumption Costs	Approximately 2 tons of steam are needed for each ton of CO ₂ . At a cost of \$21 per ton of steam, the total cost for 300,000 tons of CO ₂ is: 2 * 21 * 300,000 = \$12.6 million	Approximately 1.1 tons of steam are required for each ton of CO ₂ . At a cost of \$21 per ton of steam, the total cost for 300,000 tons of CO ₂ is: 1.1 * 21 * 300,000 = \$6.93 million	\$5.67 million

- Steam Savings: (2 - 1.1) tons steam/ton CO₂ × 300,000 tons = 270,000 tons of steam saved
- Generating 1 ton of steam consumes approximately 0.11 tons of standard coal equivalent, equivalent to saving 32,625 tons of standard coal
- This amount of coal can generate approximately 259 million kWh of electricity, sufficient to meet the total annual electricity demand of 730,000 German households (based on an average German household consumption of 3,500 kWh/year)

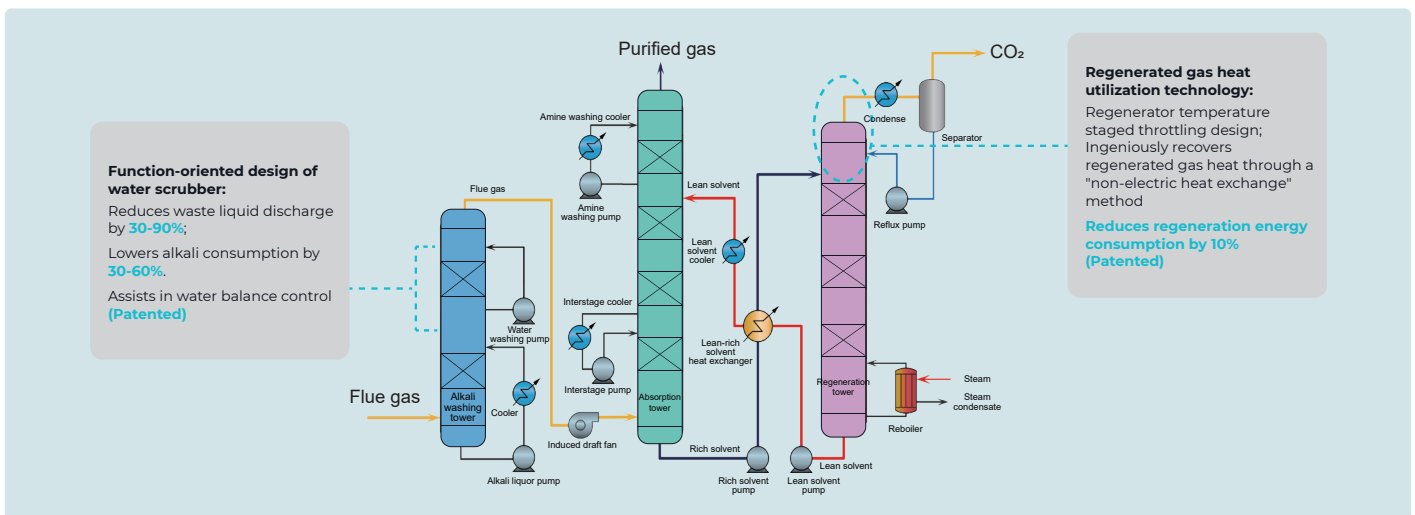


04

Technical Advantages of the Tonexus TX^{io} Wet Capture Process

4.1 Introduction to Tonexus TX^{io} Wet Capture Process

Figure 2 Process Flow Diagram of Tonexus TX^{io} Wet Capture



4.1.1 CO₂ Capture Wet Process: Energy Saving Optimization + Water Balance Optimization

The TX^{io} process developed by our company is optimized based on the classic process, including:

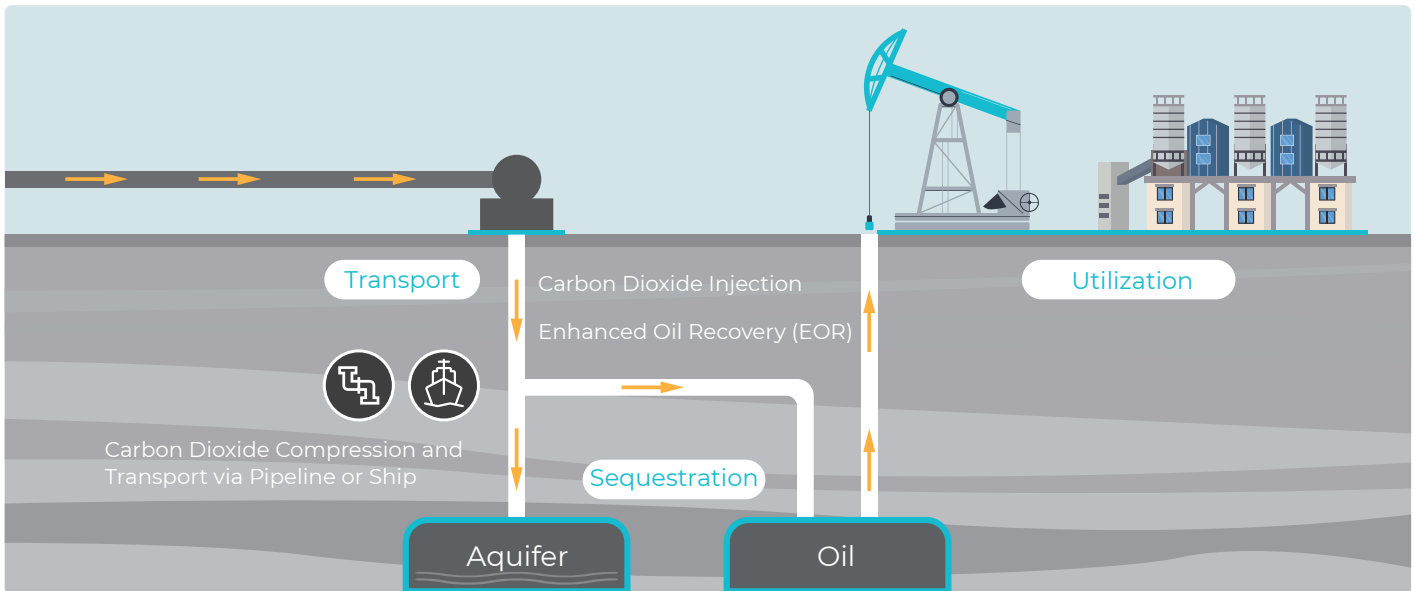
- The multi-functional design of the alkaline washing tower (also known as the pretreatment tower) can greatly reduce the usage of desulfurization solution and the generation of waste liquid after alkaline washing, lowering treatment costs.
- The discontinuous temperature distribution design in the regeneration tower reduces the proportion of water vapor in the regeneration gas to recover latent heat, significantly decreasing the load of the regeneration gas cooler. This process does not adopt "electricity-for-heat exchange" and can reduce regeneration energy consumption by 10%, while also significantly lowering the organic amine content in the regeneration gas.

In addition, according to different requirements, the TX^{io} process can be combined with non-system heat sources such as MVR and heat pumps to further reduce regeneration energy consumption.

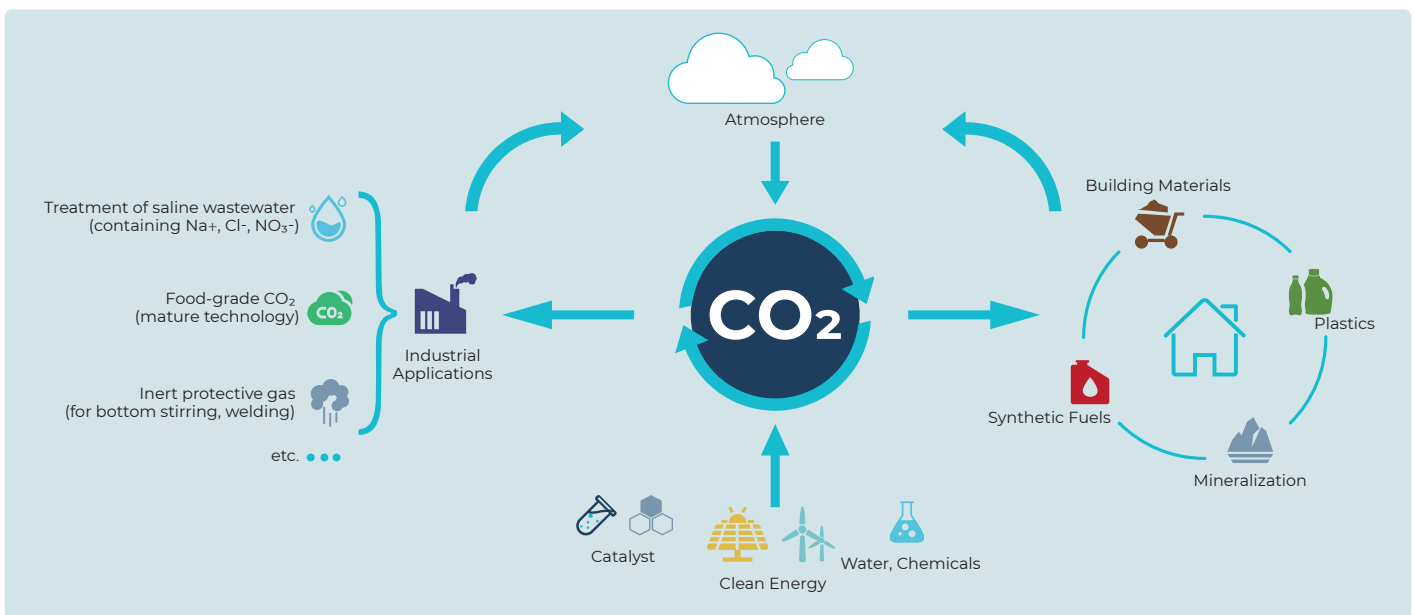
4.1.2 Highlights of the Process Flow

- Multifunctional Pretreatment Tower Design. This design significantly reduces waste liquid discharge by 30%–90% and alkali consumption by 30%–60%, while also assisting in water balance control.
- The purified gas from the absorption tower undergoes an enhanced gas-liquid separation stage, which reduces amine escape loss from the absorption solvent.
- The latent heat utilization process for the regeneration gas at the top of the regeneration tower enhances system water balance control, recovers waste heat, and optimizes the temperature distribution within the tower.
- MVR Design for Heat Transfer Medium in Non-Capture Systems

4.2 CO₂ Storage (consulting service available)



4.3 CO₂ Utilization (consulting service available)

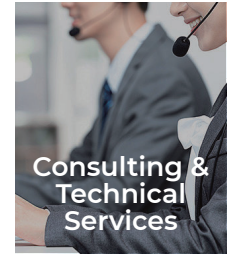


The captured CO₂ product gas, after purification, achieves a purity of 99.99% and can be applied in the following areas:

- **Storage Compatibility:** Specifications meet the requirements for geological storage injection.
- **Energy Sector:** Designed for CO₂ mineralization applications such as enhanced oil recovery (EOR) and fracturing.
- **Chemical Synthesis:** Methanol / acetic acid / olefins / methane / carbonate esters.
- **Industrial Applications:** Treatment of saline wastewater (containing Na⁺, Cl⁻, NO₃⁻); Food-grade CO₂ (mature technology); Inert protective gas (for bottom stirring, welding) etc.

4.4 Tonexus CCUS Production and Service Capabilities

4.4.1 One-stop Solution



Core Adaptable Industries & Gas Types (Low partial pressure complex gas sources containing O₂, H₂S, Cl₂, etc.)

Iron & Steel and Coking: Self-provided power plants, blast furnace / converter gas, etc.
(Oxygen-containing, sulfur-containing and other complex gas sources)

Power Industry: Coal-fired units, gas-fired units
(Adaptable to high-sulfur, high-humidity, large-flow flue gas characteristics)

Petrochemical Industry: Self-provided power plants, oilfield produced gas / vent gas
(Adaptable to complex gas sources with high CO₂, sulfur and hydrocarbon impurities)

Cement Industry: Cement kiln, lime kiln gas
(Adaptable to high-oxygen, high-dust, low CO₂ partial pressure working conditions)

Shipping & Maritime: Offshore marine exhaust gas treatment systems
(Adaptable to space-limited and dynamically fluctuating operating conditions)

In addition to the above industries, also applicable to complex gas sources and working conditions in non-ferrous metals, waste incineration, papermaking and other sectors.

Core Adaptability Capabilities

Accurate Working Condition Analysis: Customized process solutions based on the owner's flue gas composition (O₂, sulfur, dust content), pressure and temperature parameters.

Seamless Equipment Integration: Modular design adapts to existing plant layout without affecting the normal operation of main facilities.

Collaborative Operation Optimization: Process parameters are adjusted in line with the owner's plant load to ensure stable and coordinated operation between the capture system and main equipment.

4.4.2 Equipment Manufacturing

- Non-standard atmospheric vessels: Absorption towers, storage tanks, separators, etc.
- Non-standard medium/low-pressure vessels: Desorption towers, drying beds, distillation columns, heat exchangers, etc.

Figure 3 Equipment Manufacturing Workshop



Figure 5 On-site Equipment Installation & Assembly at Customer's Project Site



Figure 7 Automated Welding

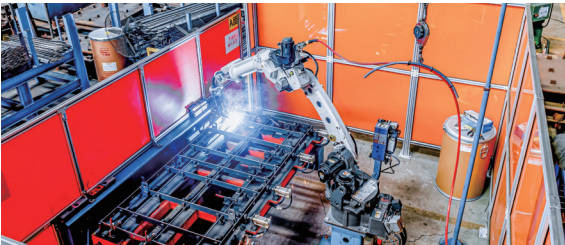


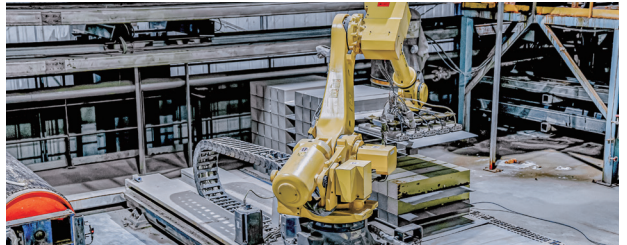
Figure 4 Laser cutting machines



Figure 6 Physical and Chemical Testing & Metering Room



Figure 8 Automated Production



05

Tonexus CCUS Cooperation and Business Models

5.1 EPC (EP, BOT) Turnkey Services

- **Service Process:** Covers design-construction-commissioning, including preliminary assessment & feasibility study, process design & optimization, equipment supply & construction commissioning.
- **Standard Control:** Meets requirements for design, equipment manufacturing, construction safety, and performance indicators.
- **Policy Incentive Application Service:** Identifies the optimal policy portfolio based on project scale and technical route, and handles the application process.

5.2 Channel Cooperation

- **Solvent Agency:** Partners act as agents for Tongxing CCUS carbon capture solvent products, responsible for marketing and customer development. The company provides product, technical and brand support.
- **Engineering Cooperation:** Both parties leverage complementary advantages to jointly develop, design, construct and operate CCUS projects, achieving risk sharing and benefit sharing.

5.3 Ecosystem Partnership Expansion

- **Storage End:** Connects with renowned enterprises to provide integrated capture-to-storage solutions.
- **Utilization End:** Collaborates with chemical / food companies to customize purity levels and achieve direct supply.
- **Service End:** Integrates authoritative institutions to offer carbon footprint accounting and CSRD compliance services.



06

Appendix

6.1 Qualifications

We possess **36** certifications and qualifications, including **5** design and engineering qualifications (among which is the ASME certification for design and supply).

- Class-A Design Qualification for Atmospheric Pollution Prevention & Control Engineering in Environmental Engineering
- Class-I Professional Contracting Qualification for Environmental Protection Engineering
- Class-B Design Qualification for Chemical Engineering within the Chemical, Petrochemical & Pharmaceutical Industries
- Class-II Professional Contracting Qualification for Building Mechanical & Electrical Installation Engineering
- Pressure Vessel Design & Manufacturing, and Pressure Piping Design Qualifications



6.2 Core Technologies



Tonexus Leads Consortium with Zhejiang University and Chinese Research Academy of Environmental Sciences in National Key R&D Program (China-ROK Intergovernmental Cooperation) (2023–2026)

In July 2023, Tonexus's TX-1 carbon capture absorption solvent successfully passed the technical achievement appraisal at Zhejiang University. Under conventional process conditions (**without energy-saving measures**), the TX-1 solvent demonstrated oxygen resistance that was **21 times** higher than that of MEA, with a regeneration energy consumption of **2.56 GJ/t CO₂**, reaching internationally leading standards.

6.3 Patents

No.	name
1	A Flue Gas CO ₂ Capture Method with Low Partial Pressure and Low Energy Consumption
2	A Flue Gas CO ₂ Capture System with Low Partial Pressure and Low Energy Consumption
3	A Decarbonization Absorption Solvent
4	An Organic Amine-Based Composite Carbon Dioxide Absorption Solvent and Its Preparation Method
5	A Water-based Biphasic Decarbonization Absorption Solvent
6	Modular Carbon Dioxide Absorption Tank
7	A System for Integrated Utilization of Blast Furnace Gas and Its Application Method
8	Carbon Dioxide Capture Unit
9	An Oxygen-enriched Combustion Carbon Enrichment Process System for Coke Oven Gas
10	A Wet Carbon Capture Process Integrating Water Balance Control and Internal Heat Utilization Coupling
11	Wet carbon capture process coupling water balance control with utilization of internal heat of system
12	A Regeneration Gas Heat Recovery Process System for Wet Decarbonization Technology

6.4 Abbreviations

No.	Abbreviations	Chinese Name	English Name
1	CCUS	碳捕集、利用与封存	Carbon Capture, Utilization and Storage
2	MVR	蒸汽机械再压缩技术	Mechanical Vapor Recompression
3	EPC	工程总承包	Engineering、Procurement、Construction
4	EP	设计、采购	Engineering、Procurement
5	BOT	建设-经营-转让	Build-Operate-Transfer

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