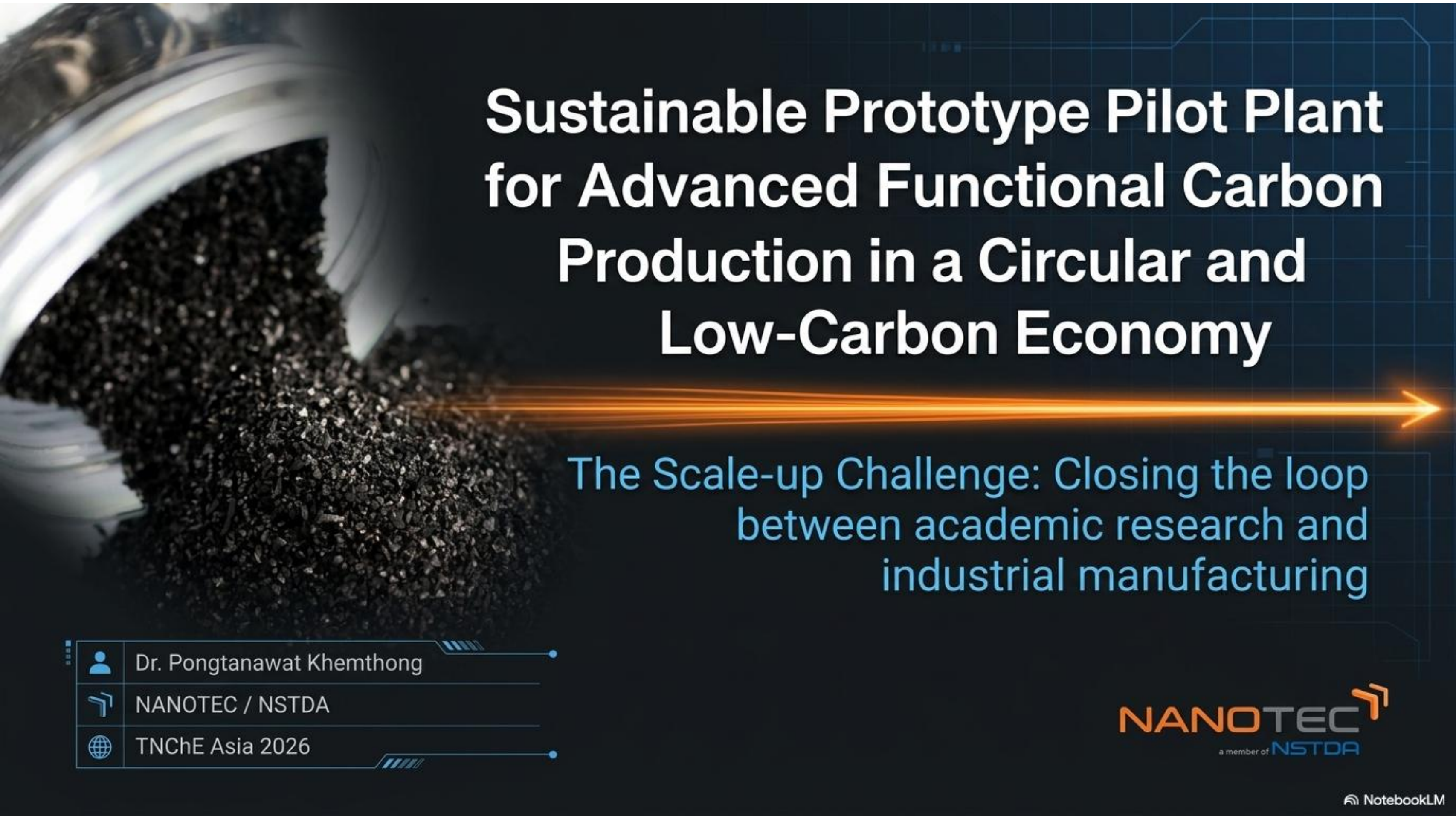




Sustainable Prototype Pilot Plant for Advanced Functional Carbon Production in a Circular and Low-Carbon Economy

The Scale-up Challenge: Closing the loop
between academic research and
industrial manufacturing



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NANOTEC / NSTDA



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Activated Carbon in Thailand TH



HS4 38.02 (Harmonized System 2017 for 4-digits)

\$60.1M

EXPORTS
\$43.6M
Ranking 476 / 1
(2024)

TOP DESTINATION
Indonesia

FASTEST GROWING MARKET
Indonesia
+\$1.59M
(2023 - 2024)

SHARE OF TH EXPORTS
1.25%
Ranking 18 / 136
(2024)

TOP ORIGIN
China
\$21.1M
(2024)

FASTEST GROWING ORIGIN
India
+\$1.32M
(2023 - 2024)

THE RESOURCE
Abundant Domestic Biomass
Open Burning Risk

IMPORTS
1.73%
Ranking 20 / 198
(2024)



THE PARADOX
Import Dependency Value
HS4 38.02 Activated Carbon

PRODUCT COMPLEXITY
-0.48

Thailand possesses the raw materials for a circular economy, yet functional carbon production remains trapped at the laboratory scale, forcing a massive reliance on foreign imports.

The Scale-Up Diagnostic Matrix



**The Valley of Death
(TRL 4 to TRL 8)**

Materials science frequently dies in the gap between the gram-scale precision of academia and the ton-scale brute force of industry.

Technology Readiness Level (TRL) 6-7

Continuous Kilogram-Level Production

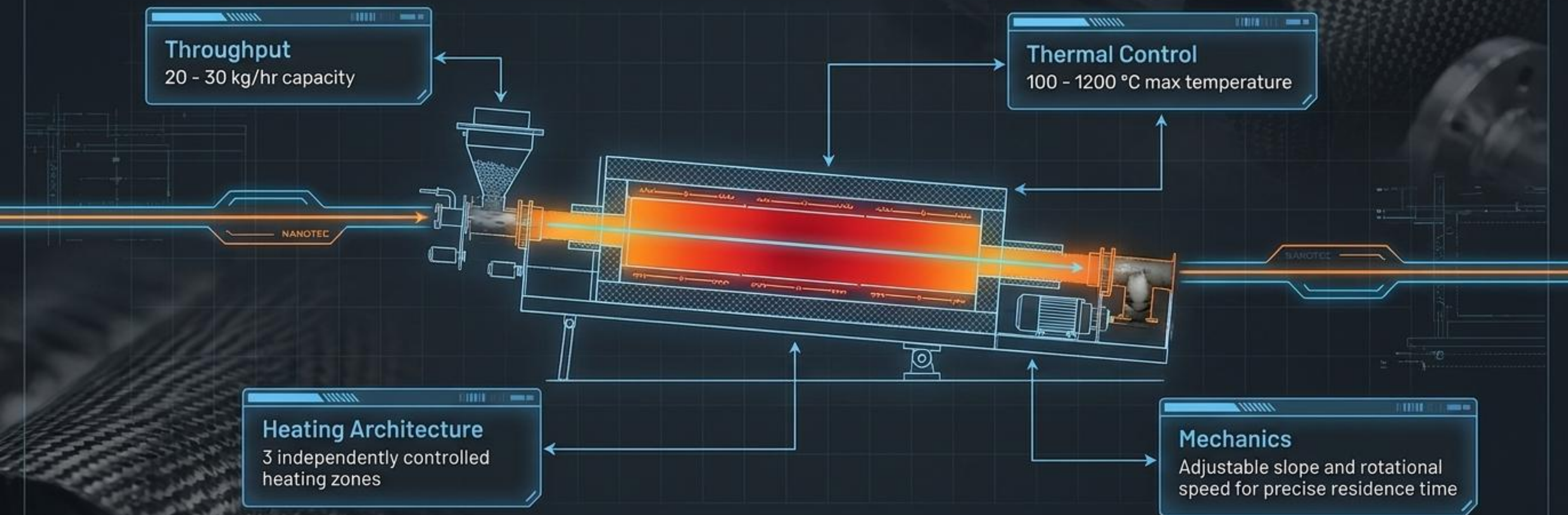
Stage 1:
Advanced Carbon
Synthesis

Stage 2:
Continuous
Functionalization

**The Valley of Death
(TRL 4 to TRL 8)**

The CARBANO semi-industrial pilot plant is a two-stage integrated processing system designed to maintain lab-grade functional performance at industrially relevant scales.

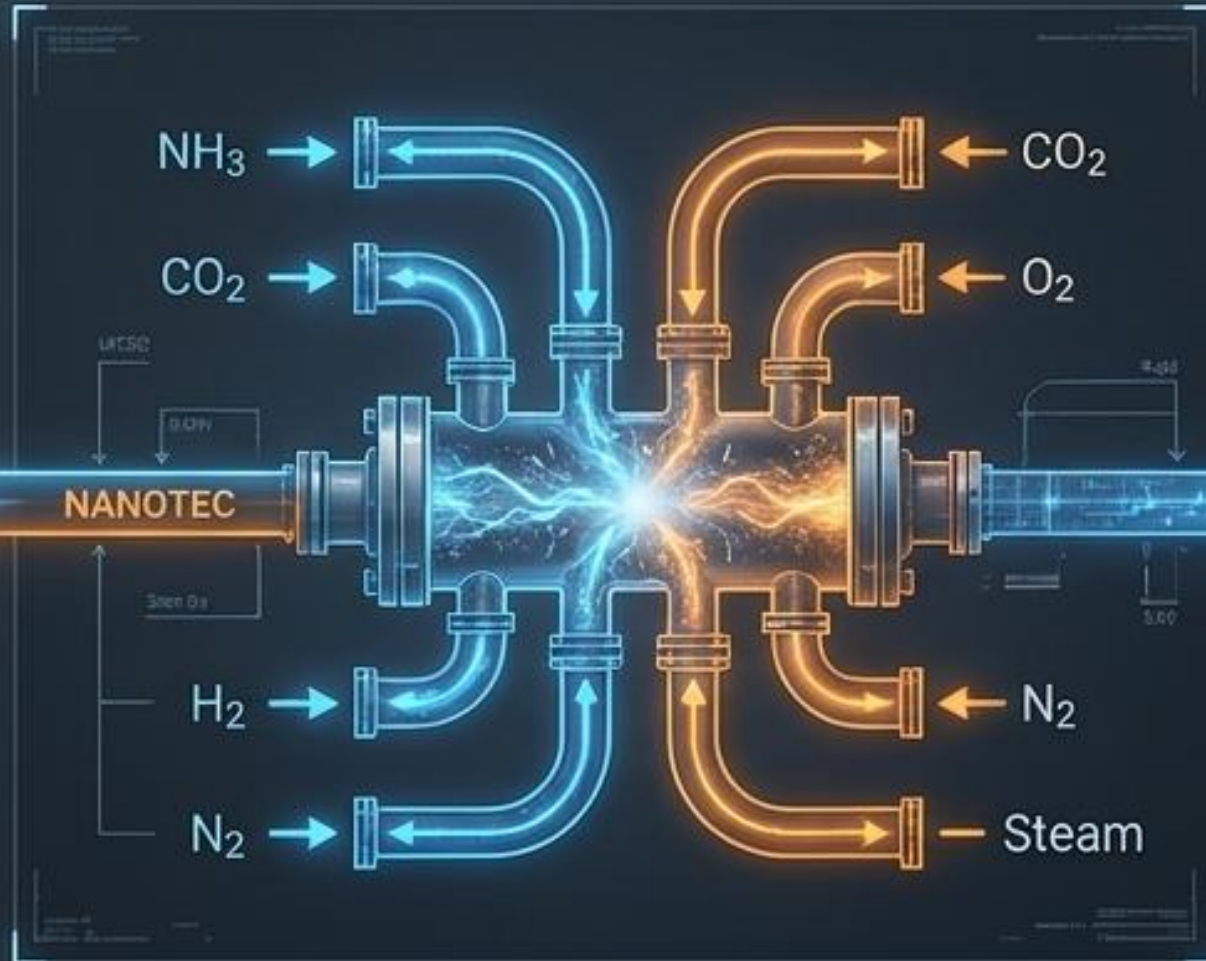
Stage 1: Advanced Carbon Synthesis



Rotary Kiln V2 overcomes batch limitations through cascading and rolling movement characteristics, ensuring uniform thermal activation at an industrial pre-pilot scale.

Engineering Versatility: Adapting to Industrial Variance

Atmospheric Control



Tailors carbon structure and surface chemistry dynamically during continuous operation.

Interchangeable Tube Materials



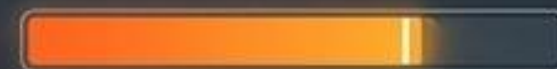
Allows operation in standard, highly acidic, or highly basic environments up to 1200 °C.

Industrial feedstocks are unpredictable. By customizing atmospheres and tube materials, the system handles everything from palm shells to chemical waste seamlessly.

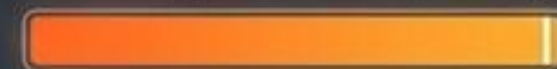
Stage 1 Output: Uncompromised Material Performance



Surface Area



Adsorption Capacity



Pore Structure

Tailored microporous to
macroporous hierarchies

Stage 1 successfully delivers Carbano™ N-doped Activated Carbon, maintaining the rigorous specific surface area required for advanced catalytic and environmental applications.

Stage 2: The Functionalization Bottleneck

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The Impregnation Bottleneck

- ⚠ Produces chemical wastewater
- 🌀 Zero heating system integrated
- 🔴 Strict limits on carbon particle size (45x60 only)
- ⬆ Impossible to upscale effectively



The Industrial Requirement

Must accept all AC sizes (45x60, 8x30, 4x8)



Ensure completely uniform surface coating

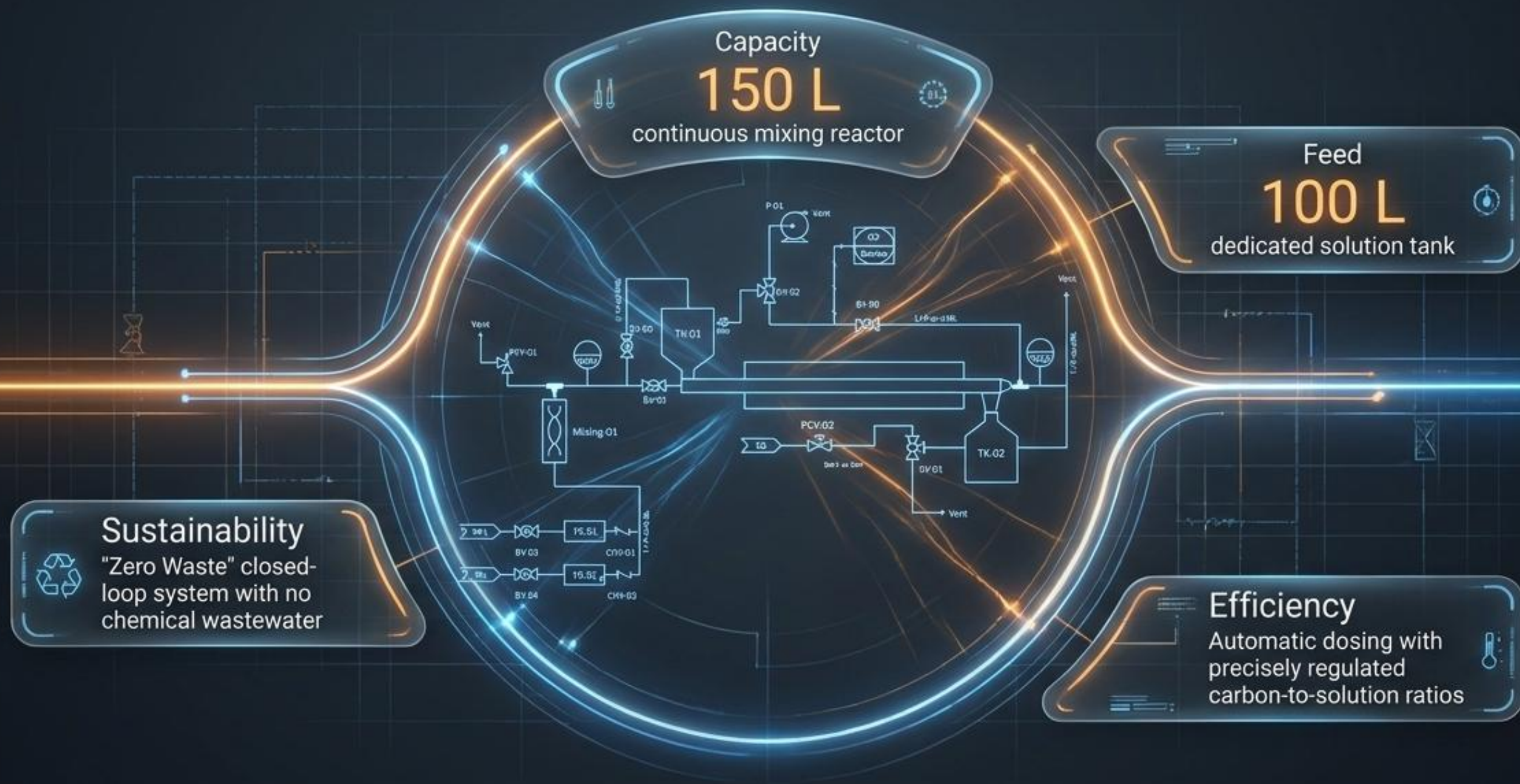


Eliminate solvent waste entirely



Synthesizing the carbon is only half the battle. Impregnating it with active metals or functional groups at scale requires abandoning traditional batch reactors.

The Solution: Continuous Green Functionalization



Stage 2 bridges the gap in impregnation (TRL 5-6), delivering uniform metallic and organic surface modifications while operating entirely as a green process.

Stage 2 Output: Commercial Superiority of Ag/AC

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— NSTOR



Comparison Matrix

PARAMETER		COMMERCIAL AC	CARBANO-AG
1	Microorganism Removal	N/A	>95%
2	Metal Removal	<50%	>90%
3	Chloroform/TCM Removal	N/A	99.95%

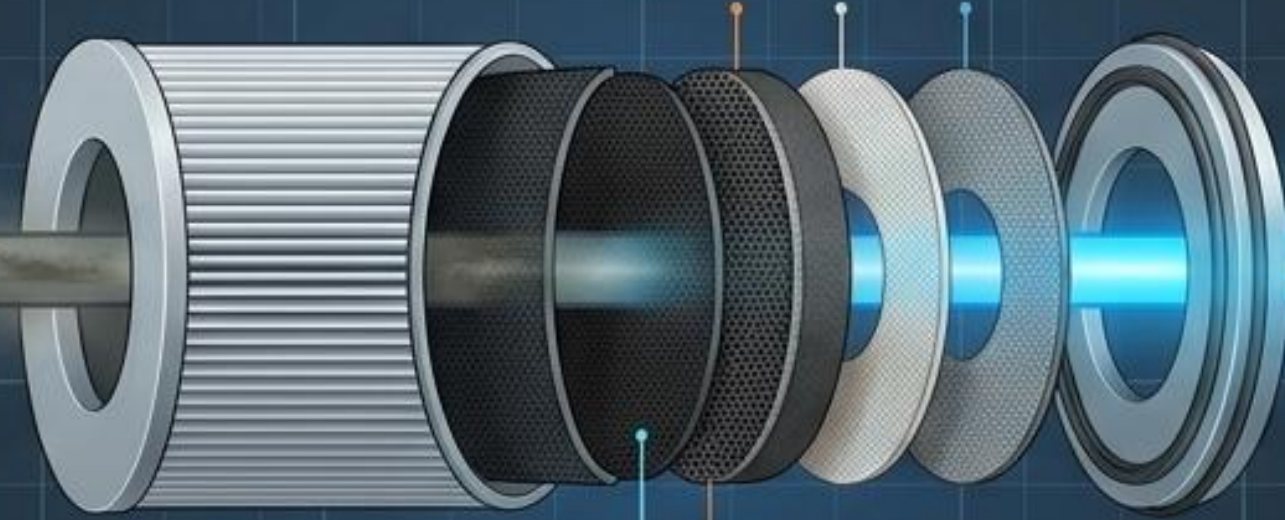
The continuous impregnation unit successfully bonds active nanometals to the carbon matrix, yielding a high-performance Ag/AC product drastically superior to standard commercial filtration media.

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Application Case Study: High-Value Air Filtration

Target Applications:

-  PM2.5 Mitigation
-  Airborne Pathogen Disinfection
-  Volatile Organic Compounds (VOCs)



Mechanism of Action:

Ag-AC (Silver-doped) provides dual-action filtration: a physical micro-porous trap combined with a highly active biological disinfection layer.



By domesticating this technology, Thailand can replace imported air filter sheets with locally produced, high-value functional filters specifically engineered for the low-carbon economy.

Real-World Economics: Commercial Viability

~102 THB / kg

Unit Economics at TRL 7 Scale



85%
Conversion
Efficiency



Scale Output:
1-50 kg per production cycle

Scaling up achieves **economies of process**. The CARBANO pilot plant demonstrates that high-grade functional carbon can be produced **domestically** at highly competitive **unit costs**.

Industrial Validation & Partner Ecosystem



SCG Chemicals

Application: Catalytic support materials for advanced chemical processes.



PTT-EP

Application: Mercury (Hg) and Arsenic (As) removal in energy production.



Healthcare Sector / Hospitals

Application: I-131 (Radioactive Iodine) removal and medical environmental remediation.



The technology is already validated by Thailand's largest industrial players, proving that the gap between academia and industry has been successfully bridged.

Synthesis: Closing the Loop

Technical Mastery

- TRL 7 continuous operations.
- 2 Patents secured.
- T1/Q1 publications in "Catalysis Today" and "ACS Sustainable Chem & Eng".



Economic Viability

- ~102 THB/kg unit cost.
- Directly reduces Thailand's \$60.1M dependency on imported commercial carbon.



Environmental Sustainability

- BCG Model compliance.
- Waste-to-Wealth execution by diverting agricultural residues from open burning (mitigating PM2.5 at the source).



The CARBANO pilot plant is a scalable platform that perfectly aligns chemical engineering with national economic and sustainable realities.

Partner with NANOTEC to scale the future of functional carbon.

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The technology is de-risked, validated, and ready for commercial deployment.