The Super Turbine: A Modular Supercritical CO_2 Architecture for Power, Cooling, and Energy Recovery

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https://www.infinityturbine.com/super-turbine-architecture-by-infinity-turbine.html

The Super Turbine is a modular supercritical CO_2 power system that integrates natural gas heating, compression, power generation, and optional hydraulic or ejector cooling modules to deliver efficient, quiet, and scalable energy for modern infrastructure.

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The Infinity Super Turbine rethinks how energy systems are built—breaking power generation and cooling into modular, interchangeable blocks that convert natural gas heat into electricity, hydraulic power, and cooling with unmatched flexibility and efficiency.

Introducing the Super Turbine Architecture

The Super Turbine is a next-generation energy platform built around a high-temperature supercritical CO_2 (sCO_2) cycle, designed from the ground up as a modular, block-based system. Unlike conventional gas turbines that rely on air-breathing combustion and fixed architectures, the Super Turbine separates energy conversion into discrete functional modules that can be configured, expanded, or rebalanced based on site needs.

This approach enables a single system to deliver electric power, cooling, and mechanical or hydraulic energy—all from a compact, sealed-loop design optimized for modern data centers, industrial facilities, and distributed power applications.

Core Modules of the Super Turbine

1. High-Temperature Heat Exchanger Module
The first block is a natural gas burner integrated with a high-efficiency heat exchanger, transferring combustion heat directly into supercritical CO_2. This indirect heating approach isolates combustion products from the working fluid, enabling cleaner operation, higher material longevity, and precise temperature control. Turbine inlet temperatures of 700–750°C are achievable without exposing rotating machinery to flame or contaminants.

2. CO_2 Compressor Module
The compressed CO_2 loop is driven by a dedicated compressor block optimized for supercritical operation. Near-critical compression significantly reduces parasitic power consumption, improving cycle efficiency and enabling compact machinery compared to traditional gas turbines.

3. High-Temperature sCO_2 Turbine Generator Module
At the heart of the system is the Super Turbine generator, where high-temperature supercritical CO_2 expands through a turbine to produce electricity. Because the system is sealed and non-air-breathing, it operates silently, avoids ambient derating, and is immune to dirty air, dust, smoke, or altitude effects.

Optional Bottoming and Energy Recovery Modules

After the topping cycle produces electricity, the Super Turbine architecture allows operators to select from interchangeable downstream modules to capture remaining energy.

4A. Hydraulic Power Bottoming Module
One option uses residual CO_2 energy to drive a bottoming turbine coupled to a hydraulic pump. This module converts thermal and pressure energy into hydraulic power, which can be used for energy storage, mechanical loads, or secondary generation. Hydraulic output offers robust load-following and provides an alternative to purely electrical recovery.

4B. Ejector Cooling Module

Technical Appendix: High-Temperature Supercritical CO_2 Topping Cycle with Cooling-Focused Bottoming Architecture

1. System Architecture Overview

The proposed system replaces a conventional air-breathing natural gas turbine with a closed-loop, high-temperature supercritical CO_2 (sCO_2) Brayton cycle operating as the topping cycle. Natural gas combustion heat is transferred to CO_2 via a high-effectiveness gas-to-CO_2 heat exchanger. The sCO_2 turbine generates electricity, while residual thermal energy is recovered downstream to power cooling-only bottoming functions rather than secondary power generation.

Key architectural distinction:
Electricity production is maximized in the topping cycle; all remaining recoverable heat is intentionally allocated to cooling.

2. Topping Cycle Technical Parameters (Representative)

Working fluid: CO_2 (closed loop)
Turbine inlet temperature (TIT): 700–750 °C
Turbine pressure ratio: ~2.5
Cycle type: Recuperated sCO_2 Brayton
Fuel source: Natural gas (direct-fired heater, indirect CO_2 heating)
Cooling sink: Dry cooler (air-cooled, water-free)

Expected performance (per 1 MWe output):

Fuel-to-electric efficiency: ~45–50% (LHV-equivalent)
Fuel input: ~2.0–2.2 MW thermal
Electric output: 1.0 MW
Remaining thermal energy: ~1.0–1.2 MW thermal

Because the system is sealed and non-air-breathing, performance is independent of ambient temperature, altitude, and air quality, unlike conventional gas turbines.

3. Waste Heat Characteristics and Recoverability

Unlike gas turbines that exhaust large volumes of diluted hot air, the sCO_2 system concentrates thermal recovery into controlled heat-exchanger stages:

High-grade heat recovered through recuperation
Medium-grade heat available from flue gas and turbine exhaust exchangers
Stack temperature typically designed to 150–180 °C for non-condensing operation

Recoverable heat fraction:

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A Better Way to Power and Cool AI Data Centers with Supercritical CO_2

As AI data centers rapidly scale, power availability and cooling—not compute—are becoming the limiting factors. Conventional natural gas turbines solve short-term grid constraints, but they waste roughly half of their fuel energy as heat, generate significant noise, and suffer performance losses in hot, dusty, or high-altitude environments.

A high-temperature supercritical CO_2 (sCO_2) turbine generator offers a fundamentally better alternative. Instead of using an air-breathing turbine, natural gas heat is transferred into a sealed CO_2 Brayton cycle operating at 700–750°C. This produces electricity at equal or higher efficiency than conventional gas turbines, while eliminating air intake, exhaust dilution, ambient derating, and noise.

The key advantage is what happens next: the remaining thermal energy is intentionally used for cooling, not wasted. Per megawatt of electricity produced, an sCO_2 system can deliver up to an additional megawatt of data-center-grade cooling using low-cost ejector or absorption systems—directly offsetting electric chillers and reducing grid load. Cooling is no longer an add-on; it is built into the power plant.

From a financial standpoint, this architecture shifts value away from expensive bottoming power cycles and toward low-cost cooling recovery, delivering more usable energy per dollar invested. The result is lower total cost of ownership, quieter operation, siting flexibility in any climate, and a system that aligns naturally with modern liquid-cooled AI infrastructure.

In short, supercritical CO_2 power systems don't just generate electricity—they deliver power and cooling as a single, optimized energy platform for the next generation of AI data centers.

Combined Cycle

AI data centers are increasingly constrained by power and cooling, not compute. A high-temperature supercritical CO_2 turbine generator offers a better alternative to conventional natural gas turbines by converting fuel heat into electricity in a sealed, quiet system that does not derate in hot climates or suffer from dirty air. More importantly, the remaining thermal energy is intentionally used to produce data-center-grade cooling, delivering up to an additional megawatt of cooling per megawatt of power generated using low-cost heat-driven systems. The result is a single platform that provides power and cooling together, lowers total cost of ownership, and reduces grid and chiller dependence—purpose-built for modern liquid-cooled AI infrastructure.

Thermodynamic Comparison Table

Below is a side-by-side thermodynamic comparison table for a 1.0 MWe module, contrasting a conventional natural gas simple-cycle turbine versus a high-temperature sCO_2 closed-loop topping cycle (natural-gas-heated), with the bottoming function focused on cooling.

Key basis and assumptions (so the table is internally consistent)

Net electric output basis: 1.0 MWe
Fuel basis: Natural gas LHV
Ambient for cooling: 70°F (21°C) dry cooler
Gas turbine net electrical efficiency (simple cycle, data-center prime power class): 42%
sCO_2 net electrical efficiency (high-temp recuperated, 700–750°C TIT class): 47%
Recoverable "drive heat" fraction of rejected heat for cooling: 85% (non-condensing stack design)
Cooling COP (thermal):

Absorption (double-effect class): 1.1
Ejector: 0.5
Conversion: 1 kW = 3,412 BTU/hr, 1 MW = 3.412 MMBTU/hr

Thermodynamic comparison (per 1.0 MWe net)

| Parameter | Natural Gas Turbine (Simple Cycle) | High-Temp sCO_2 Closed-Loop Topping (NG-Heated) |

Parameter	Natural Gas Turbine (Simple Cycle)	High-Temp sCO_2 Closed-Loop Topping
Net electric output (MWe)	1.0	1.0
Net electric efficiency (LHV)	0.42	0.47
Fuel thermal input (MWth)	2.38	2.13
Fuel thermal input (MMBTU/hr)	8.12	7.27
Total rejected heat (MWth)	1.38	1.13

Total rejected heat (MMBTU/hr)	4.71	3.86
Recoverable drive heat (MWth)	1.17	0.96
Recoverable drive heat (MMBTU/hr)	3.99	3.28
Absorption cooling output (MW_{cool})	1.28	1.06
Absorption cooling output (MMBTU/hr)	4.37	3.61
Ejector cooling output (MW_{cool})	0.59	0.48
Ejector cooling output (MMBTU/hr)	2.00	1.64

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