



Optimal Sequencing of Compression, Heating, Recuperation, and Turbine Stages for Maximum sCO₂ Turbine Work

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<https://infinityturbine.com/sequence-compression-heat-recuperation-and-expansion-by-infinity-turbine.html>

A practical design guide to configure supercritical CO₂ power cycles for maximum turbine work. Covers the preferred number of compressor and turbine stages, where to add heat, how to size recuperators, and the target pressure ratio window.



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Introduction

To maximize generator output in a supercritical CO₂ (sCO₂) power system, the sequencing and sizing of compression, heating, recuperation, and turbine stages must be tuned as a whole. The biggest levers are minimizing compressor work in the dense region, maximizing turbine enthalpy drop with high turbine inlet temperature, and recovering as much internal heat as possible with highly effective recuperation. The configuration that consistently delivers strong performance across practical turbine inlet temperatures and materials limits is a recuperated cycle with recompression, often augmented with reheat on the turbine side and intercooling on the compressor side.

Core Principles

1. Compress when CO₂ is dense

Operate the main compressor close to and above the critical point to keep specific work low. Intercool between compressor stages when overall pressure ratio is high.

2. Add heat after compression

Heat at nearly constant pressure to raise turbine inlet temperature. Use internal heat recovery first and top up with the external heater only as needed.

3. Recover heat aggressively

High effectiveness recuperators raise cycle efficiency and increase turbine work for a given external heat input by preheating the compressed working fluid with turbine exhaust.

4. Match pressure ratio to turbine inlet temperature

In sCO₂, the preferred pressure ratio depends strongly on turbine inlet temperature and recuperator performance. Moderate pressure ratios often yield the best net work because the compressor penalty grows quickly at higher ratios.

Recommended Architecture

A) Recompression Recuperated Brayton Cycle

This is a split-flow variant of the simple recuperated cycle that boosts internal heat recovery and maintains favorable temperature profiles.

Configuration

1. Two or three compressor stages

Main compressor inlet slightly above the critical point.

Intercooling between stages if the total pressure ratio exceeds about three.

Recompressor to route a fraction of flow around the low temperature recuperator, improving recuperation and lowering the external heat requirement.

2. Two recuperators

Low temperature recuperator followed by a high temperature recuperator with high effectiveness.

Design for tight pinch points and low pressure losses; these heat exchangers often dominate both cost and performance.

3. External heater


