



Comparing Carnot Efficiency in Organic Rankine Cycle and Supercritical CO2 Turbomachinery

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<https://infinityturbine.com/infinity-turbine-comparing-carnot-efficiency-in-orc-and-sco2-cycles.html>

Learn how Carnot efficiency defines performance limits for Organic Rankine Cycle and supercritical CO2 turbomachinery. Explore practical efficiencies, temperature ranges, and key differences between the two working fluids.



This webpage QR code

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Introduction

All heat engines are bound by the same thermodynamic law: the Carnot efficiency. Whether the working fluid is an organic compound in an Organic Rankine Cycle (ORC) or supercritical carbon dioxide (sCO2) in a Brayton cycle, the maximum efficiency achievable depends only on the hot side and cold side temperatures. This article examines how Carnot efficiency applies to both systems and what real world performance looks like.

The Carnot Efficiency Formula

Carnot efficiency is expressed as:

$$\eta = 1 - \frac{T_c}{T_h}$$

Where:

T_h = hot side temperature in Kelvin
 T_c = cold side temperature in Kelvin

This formula represents the upper theoretical limit for any cycle, regardless of working fluid.

Organic Rankine Cycle (ORC)

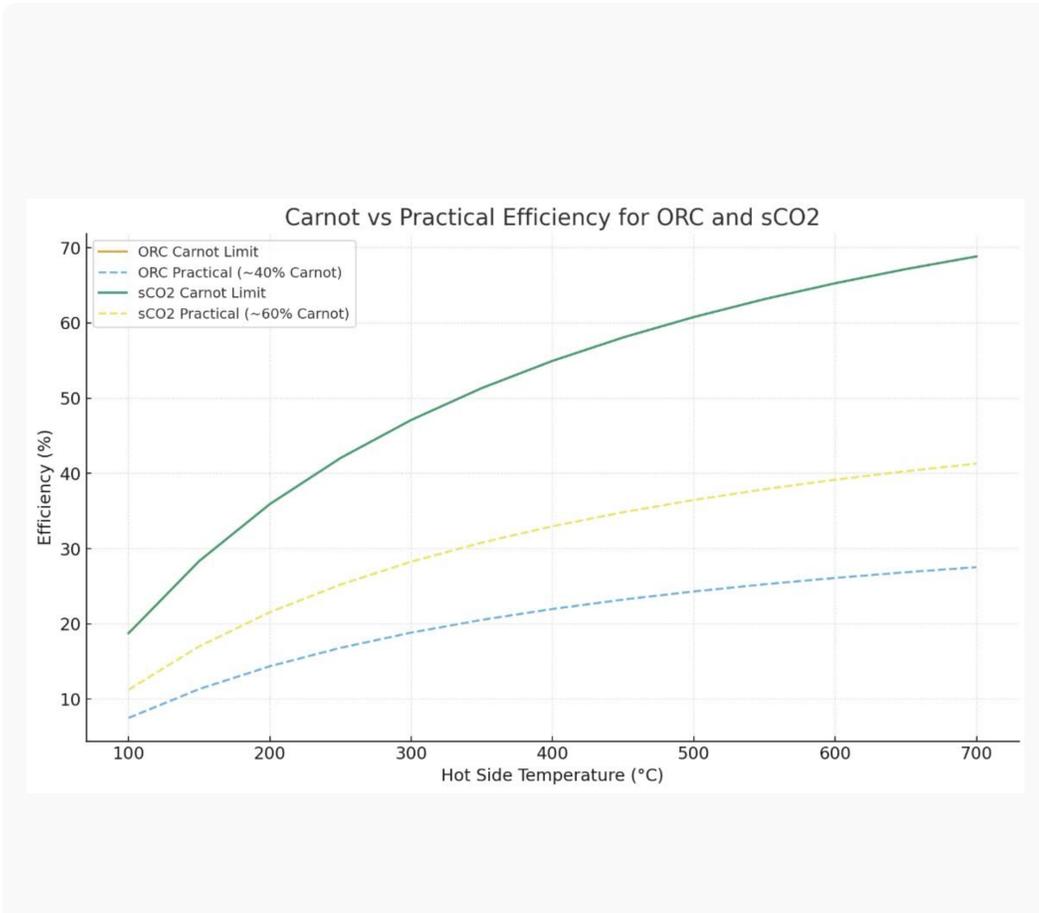
ORC systems are often used for low to medium temperature heat sources such as geothermal, biomass, and industrial waste heat.

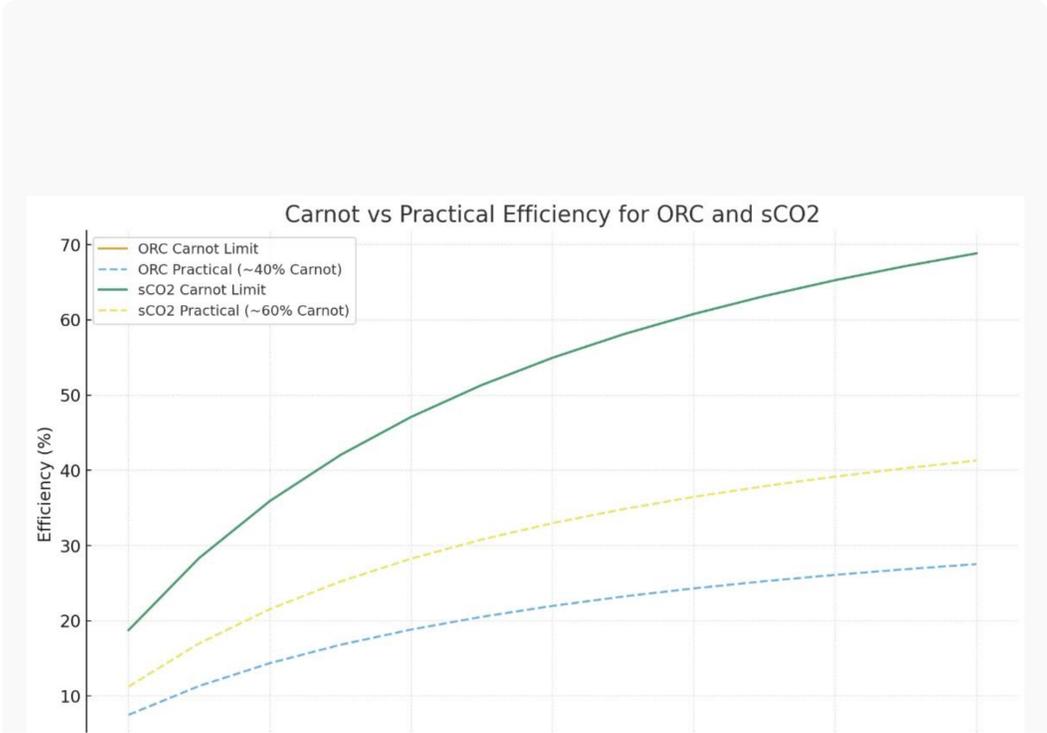
Typical hot side: 100 to 350 °C
Typical cold side: 20 to 40 °C
Example: With $T_h = 200$ °C (473 K) and $T_c = 30$ °C (303 K), Carnot efficiency is 36 percent.

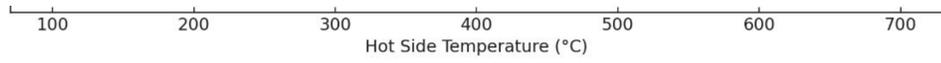
Practical efficiency: ORC systems typically achieve 8 to 20 percent. This corresponds to about 30 to 50 percent of Carnot, limited by pump losses, turbine design, and heat exchanger effectiveness.

Supercritical CO2 Turbomachinery

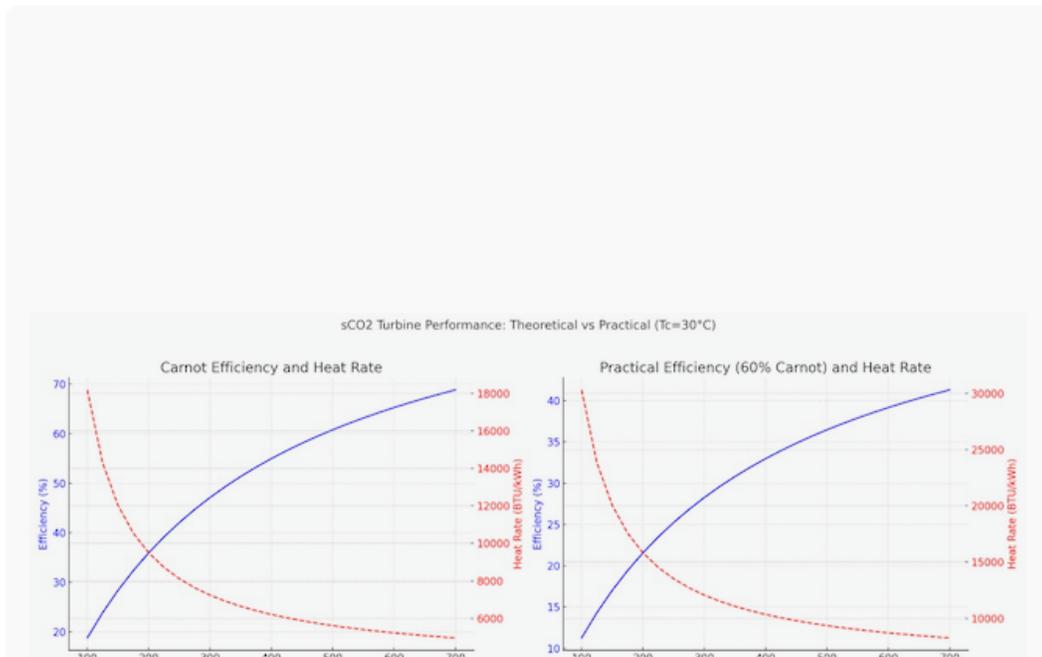
sCO2 cycles are well suited for high temperature heat sources, including concentrated solar power, nuclear reactors, and high grade industrial waste heat.







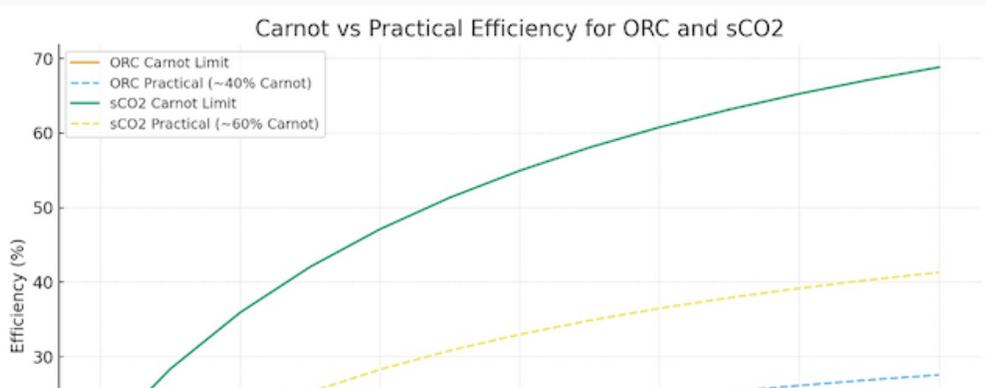
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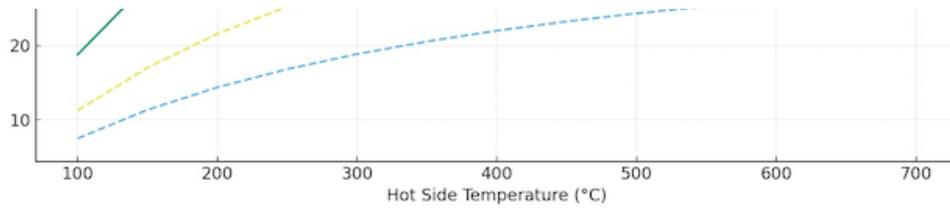


Turbine Inlet Temperature (°C)

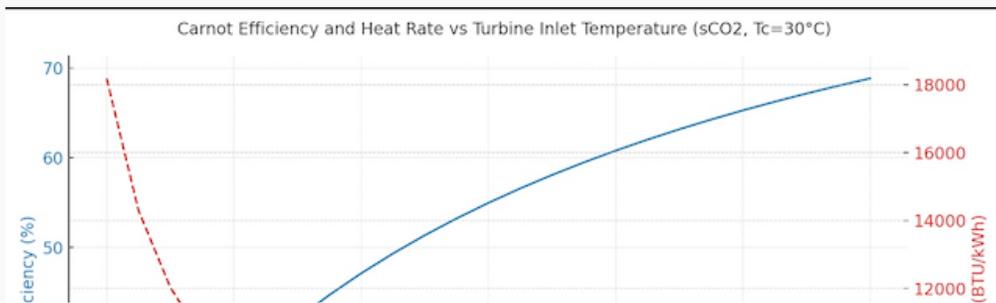
Turbine Inlet Temperature (°C)

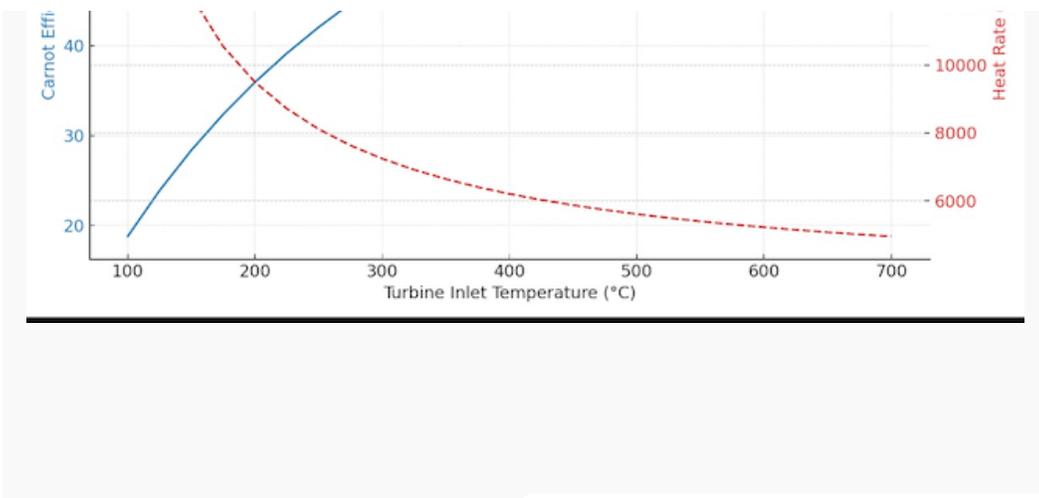
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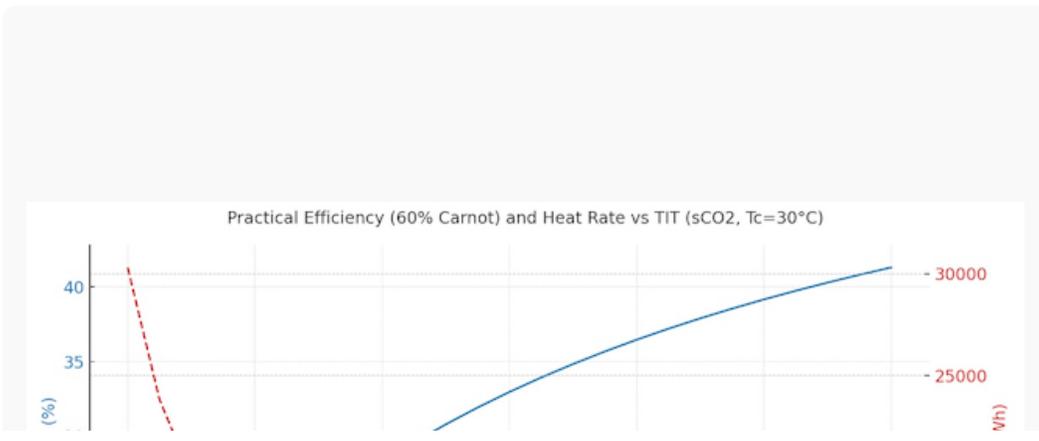


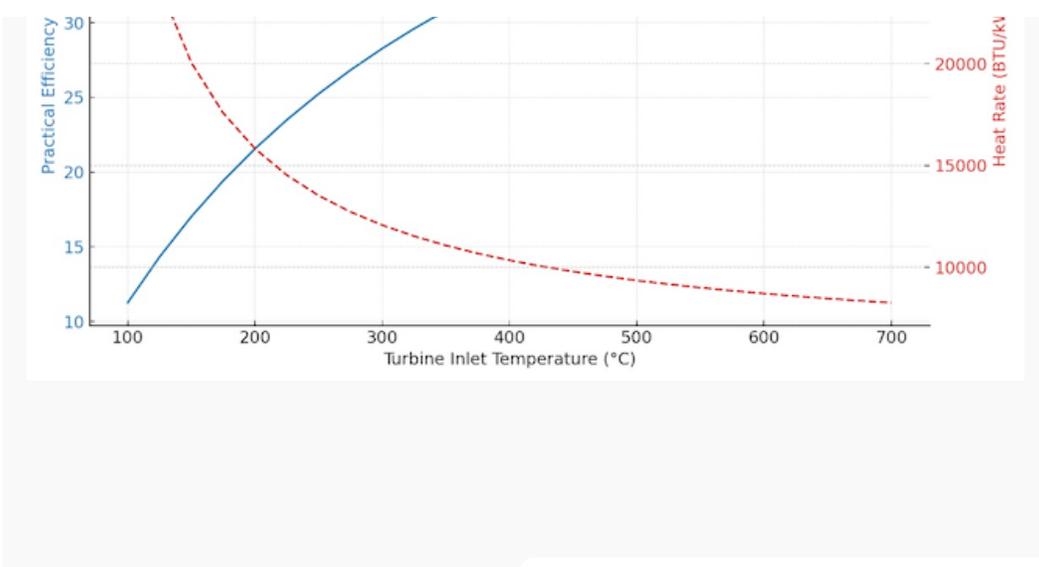
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