Free Cooling from a 10 MW Supercritical CO2 Turbine: How Much and What Is It Worth

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https://infinityturbine.com/infinity-turbine-sco2-power-block-power-and-cooling-savings.html

Engineering estimate of the free cooling available from the pressure drop at the outlet of a 10 MW supercritical CO2 turbine operating at a 500 C turbine inlet temperature (TIT). Includes cooling power in BTU/hr, effective COP discussion, and dollar value compared to running a chiller at $0.10/kWh, plus avoided-cost savings from 10 MW of generated power.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

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Executive summary (assumptions up front)
- Plant size: 10 MW_e supercritical CO2 power block
- Turbine inlet temperature (TIT): ~500 C
- Cycle efficiency used for heat-rate estimate: ~45% (representative for well-designed sCO2 RCBC at 500 C)
- Heat rate: ~7,582 BTU/kWh
- Turbine mass flow (engineering estimate): ~66.7 kg/s (consistent with ~150 kJ/kg turbine specific work)
- Post-turbine pressure letdown for cooling: from ~8 MPa to ~1 MPa via throttling (Joule–Thomson)
- Joule–Thomson cooling for CO2 near ambient: ~0.8 K/bar → ~56 K drop for ~70 bar letdown
- Specific heat (near ambient): cp ≈ 0.9 kJ/kg-K

These are standard, conservative design-basis values to yield order-of-magnitude results. Actual numbers depend on your exact pressures, recuperation, setpoints, and available Δp.

Cooling power available from the pressure drop
Using isenthalpic throttling (Joule–Thomson) across a suitable valve on (a) the low-temperature, high-pressure side or (b) a dedicated sidestream post-turbine:
Temperature drop (ΔT): ~56 K
Mass flow ($\dot{m}$): ~66.7 kg/s
Cooling capacity:
$Q \approx mcp\,\Delta T \approx 66.7 \times 0.9 \times 56$ kW ≈ 3,360 kW

In BTU/hr: 3,360 kW × 3,412 ≈ 11,470,000 BTU/hr

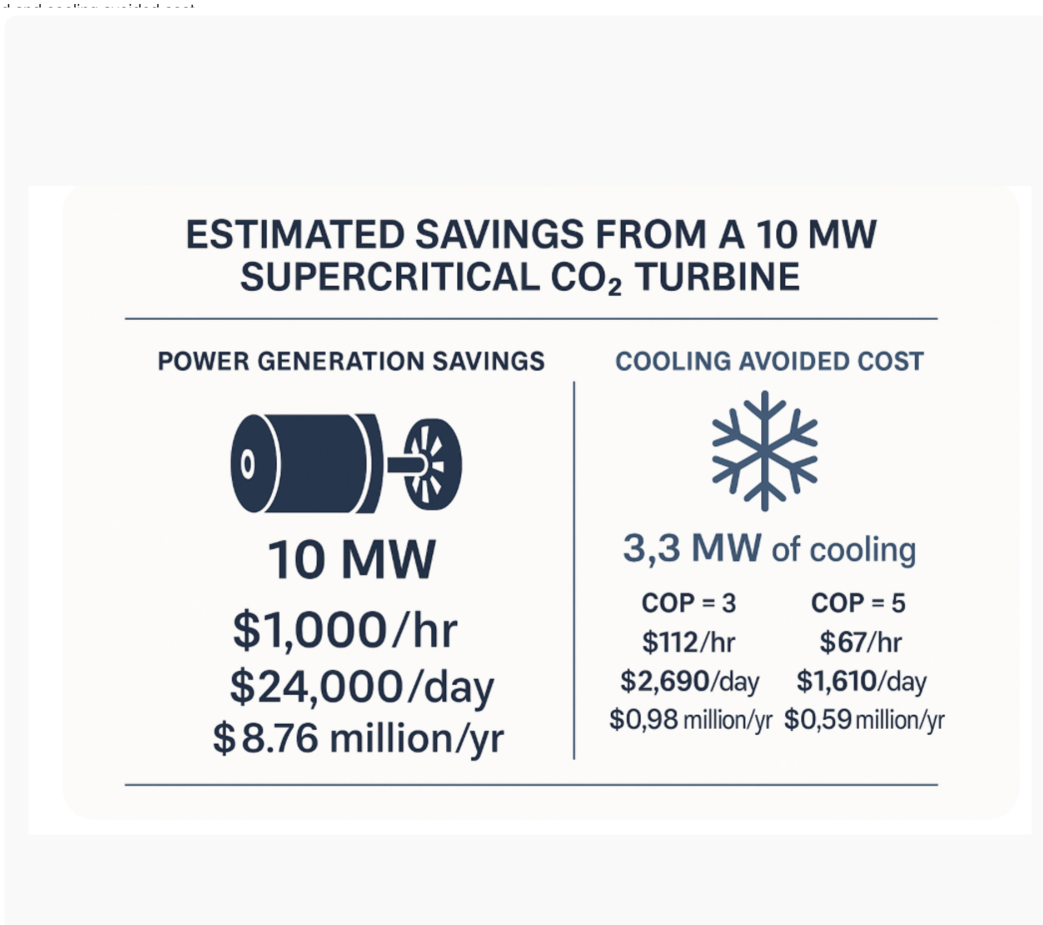
In refrigeration tons:
3,360 kW / 3.517 ≈ 956 tons

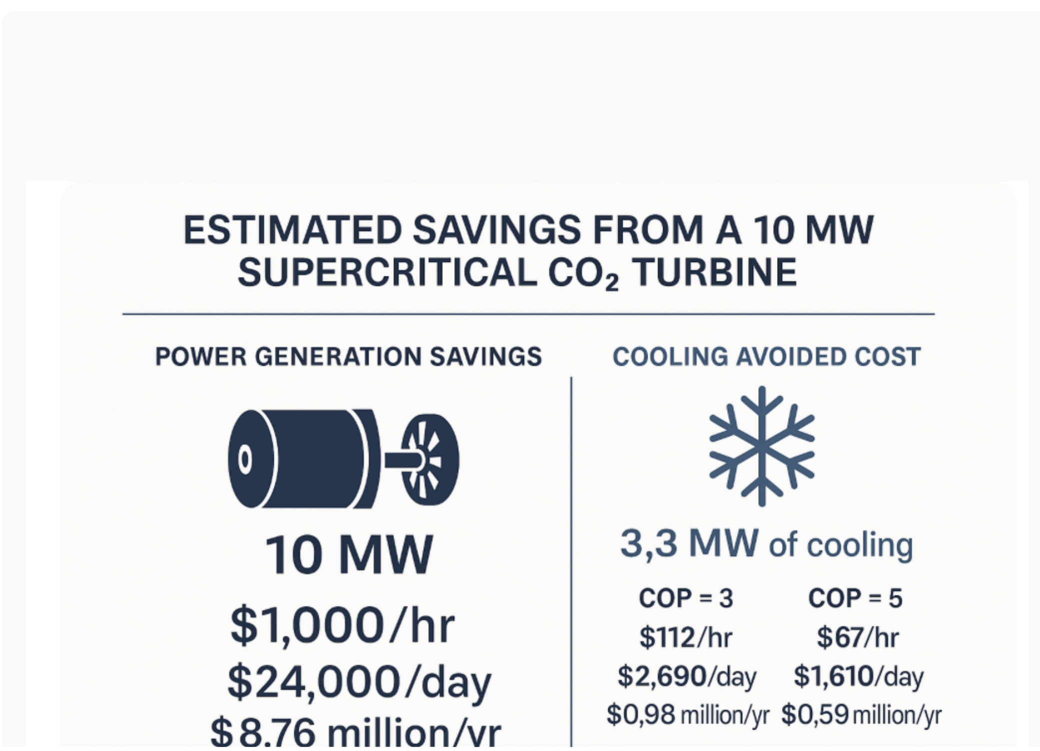
Range note: If your actual Δp is lower or state point differs (e.g., slightly different temperature or pressure), expect roughly 2.5–4.0 MW of free cooling as a realistic band.

What is the COP?
Key point: This cooling comes from a pressure letdown that the cycle already needs; there is no additional electric compressor as in a chiller. In that sense, the effective COP is extremely high (cooling as a byproduct of a power cycle).

Two useful COP views:
Lower-bound COP (very conservative): Attribute all main-cycle compression work to this cooling function (even though you would incur that anyway to run the power cycle).
Representative sCO2 compression work ≈ 40 kJ/kg
For 66.7 kg/s → ~2.67 MW compressor power
COP LB ≈ Qcool/Wcomp ≈ 3.36/2.67 ≈ 1.26 COP

This is an intentionally conservative, worst-case accounting.
Effective COP (process viewpoint): Since the letdown is inherent to the power process, additional electric input for the cooling is near zero, so the effective COP is very large (practically free cooling). Many operators simply treat it as cooling available at negligible marginal electrical cost.




ESTIMATED SAVINGS FROM A 10 MW SUPERCRITICAL CO₂ TURBINE
POWER GENERATION SAVINGS
10 MW
$1,000/hr
$24,000/day
$8.76 million/yr
COOLING AVOIDED COST
3,3 MW of cooling
COP = 3
$112/hr
$2,690/day
$0,98 million/yr
COP = 5
$67/hr
$1,610/day
$0,59 million/yr