

Termodinamica marine inverter HVAC

Direct refrigerant expansion system vs a traditional chilled-water HVAC system (BAU) on a 500 GT superyacht

1 INTRODUCTION

Termodinamica's yacht air conditioning uses direct refrigerant expansion: refrigerant carries heat straight to each room, with no chilled-water circuit. Its reversible cycle lets it run as a heat pump in winter. The sea-water heat exchanger is titanium, against corrosion.

2 METHODOLOGY

Functional unit. 1 year of use of the whole HVAC system on a 500 GT yacht: 1 compressor unit (230,000 BTU), 16 air handling units, 1 heat recovery ventilation unit. Same set-up in both scenarios.

System boundaries. Cradle to grave, same for both scenarios. *Upstream*: raw materials. *Core*: material transport, manufacturing, packaging. *Downstream*: distribution, installation, use, compressor replacement, disassembly, end of life.

Standards. ISO 14040; ISO 14044 (incl. Amd 2, 2020); PCR Yachts and small crafts (2015, v1.01); stage definitions from the International EPD System GPI v4.0.

Impact methods. CML 2001 (GWP100, AP, POCP, EP, ODP, NOx, SOx, PM10); AWARE (water); ReCiPe 2016 (H) endpoint single score, Ecopoint (Pt).

It compares a 500 GT yacht using this system (Scenario 2) with one using a traditional HVAC system (Scenario 1, BAU): a chiller cooling a water circuit, with electric heaters for winter. Goal: verify if it is the more sustainable choice (WRF solution verification).

Data sources. Mainly primary data from Termodinamica (bills of materials, invoices, measurements, counters). Ecoinvent v3.9 for raw materials, fuels and electricity. SimaPro 9.5. No allocation.

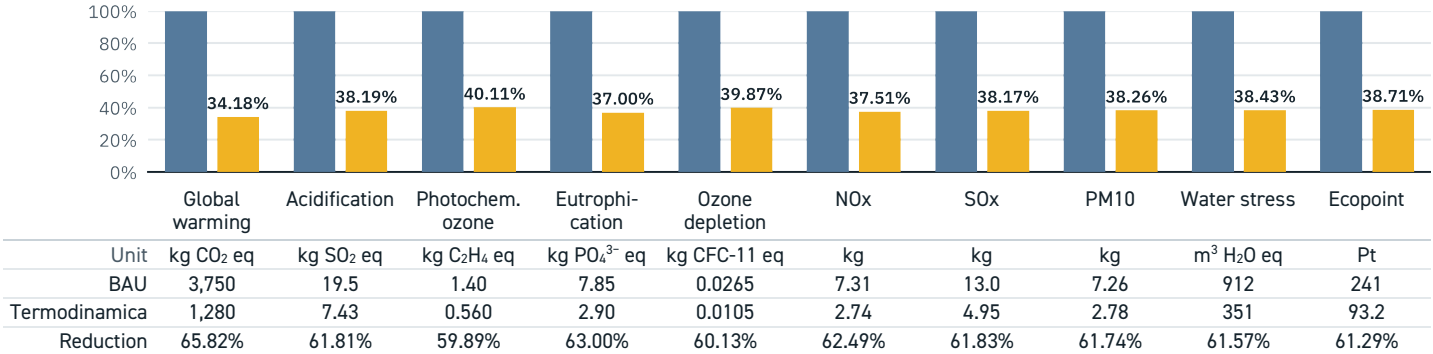
Use phase. Termodinamica's estimates of average power (Mediterranean), summer / winter / mid-season: BAU 10 / 18 / 4 kW; Termodinamica 3 / 3 / 1 kW. 3,854 h/yr at sea on a diesel generator (PCR); rest of the year EU grid mix.

Lifetimes. Yacht and air handling units: 20 years. Compressor unit: 2 years (BAU), 5 years (Termodinamica; company states 5–10).

BAU reference. Chilled-water HVAC with electric heaters and a copper condenser. Few BAU data: weights, factory energy, waste and packaging set equal to Termodinamica's; 100 km truck transport (weights, transport and energy called conservative). Refrigerant charge from literature: 20 kg (BAU), 45 kg (Termodinamica).

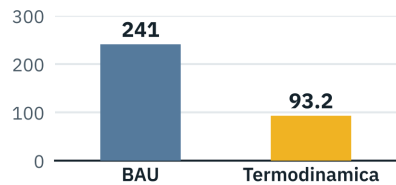
3 RESULTS per functional unit (1 y+ear of use)

Scenario 2 as % of BAU (BAU = 100%), with reported values



Bars reproduce report Figure 4 (§4 Interpretation). Values from the §3 LCIA results tables, written out in full (e.g. 3.75E+03 = 3,750).

Single score, Ecopoint (Pt)



Damage (Pt)	BAU	Termodinamica	Red.
Human health	233	90.5	61.15%
Ecosystem quality	5.28	1.89	64.22%
Resources	2.45	0.785	68.01%

Chart: report Figure 1. Damage categories: §3.

Sensitivity analysis (report §4.3, Figures 7–8): reduction from BAU to Termodinamica

Case	Range, all 10	GWP	Ecopoint
Base case	59.89–65.82%	65.82%	61.29%
BAU raw material impacts –30%	50.56–61.37%	61.37%	52.36%
BAU also runs as heat pump (winter 18 → 10 kW)	57.56–60.04%	57.56%	58.69%

Life-cycle stages: covers full life cycle stages. Per the report, downstream (energy use, compressor replacement) dominates every category in both systems; refrigerant gas at installation causes almost all ODP.

4 KEY FINDINGS

Lower in all 10 indicators. Termodinamica scores 59.89% to 65.82% lower than BAU. The largest cut is global warming: 3,750 → 1,280 kg CO₂ eq per year. Ecopoint: 241 → 93.2 Pt.

Use phase drives the result. Per year, BAU uses 7,435 kg diesel and 44,145 kWh grid power; Termodinamica 1,652 kg and 9,810 kWh (heat pump instead of electric heaters). Compressor life: 5 vs 2 years.

Keep in mind: use-phase power and compressor lifetimes for both systems are Termodinamica estimates; most BAU inventory data were set equal to Termodinamica's. Only the BAU heat pump case tests the power inputs; no test covers lifetimes.

Holds in both sensitivity tests. Reductions stay at 50.56–61.37% when BAU raw material impacts drop 30%, and at 57.56–60.04% when BAU also runs as a heat pump.

Trade-offs. No indicator is worse for Termodinamica. It needs more refrigerant (45 vs 20 kg per charge) and a titanium condenser; some parts ship 16,000–17,000 km by sea, which the report finds is not a major contributor.