

The Correct Bound Is Not the Predictive One

— Carnot Gives **63.97%**, Real Plants **40--45%**, and the Bound at Maximum Power **39.98%** — One of the Five
Quantities Called “Efficiency” Reaches **14.6575** — [Paper 311]

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— *From thinking to syncing.* —

Abstract

The Carnot efficiency is correct as an upper bound on any heat engine. This paper asks whether that bound predicts real engines—the answer is no. No new mathematical theorem and no new law is claimed. First, the numbers do not meet. At $T_h = 833.15$ K and $T_c = 300.15$ K Carnot gives **63.97%**, and real plants give **40--45%** (Section 2). Second, this is the core of the paper. The bound at maximum power is **39.98%**—the side that is not the true bound is the side that predicts (Section 3). Third, there are not two bounds. There are two things being maximised (Section 3). Fourth, neither bound contains a material quantity. No working fluid, no heat capacity, no viscosity—only two temperatures (Section 4). Fifth, “efficiency” names five quantities. One of them, the coefficient of performance, reaches **14.6575** (Section 5). Sixth, the separator is what is being maximised (Section 6).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed—the Carnot efficiency, the efficiency at maximum power of an endoreversible engine (Curzon–Ahlborn), the coefficient of performance and the second-law efficiency are all standard. We do not build thermodynamics—all we use is two temperatures and one square root. We do not prove the second law—we do not enter the derivation of the Carnot efficiency. Paper 126 treated that along Caratheodory’s road. We do not build finite-time thermodynamics—neither the Curzon–Ahlborn derivation nor the soundness of its premises (endoreversibility, linear heat conduction) is treated. We only quote the number and compare. We do not discuss engine design—reheat, regeneration and combined cycles are not treated. The 40–45% is representative and no accuracy is claimed for it. We do not enter the thermodynamics of information—Maxwell’s demon and Landauer’s principle, treated in Papers 131 and 248, are out of scope. Relation to earlier papers: Paper 126 treated Caratheodory’s reduction of the second law to a single statement of inaccessibility, and stated explicitly that no heat engine, no cycle and no Clausius inequality appear in it—this paper takes up exactly the side that did not appear. 126 showed that a temperature is not thereby given; this paper shows that an efficiency does not thereby predict. Paper 304 showed that capacity is a supremum and not a maximum—the form here is close. 304’s bound cannot be attained, whereas this paper’s bound can. The difference is that attaining it drives the output to zero. Paper 227 showed that the same $\leq$ points at a wall you can touch and at one you cannot—Carnot is a wall you can touch. Touching it merely stops the engine. Paper 255 showed that “accuracy” is two things—this paper counts five things called “efficiency”. What is added is placing Carnot, maximum power and the real plant on the same conditions, computing both bounds for four kinds of engine, pointing out that neither bound contains a material quantity, and tabulating the five quantities called “efficiency” and showing that one exceeds 1.

1. Notation and the Question

Fact: The Carnot efficiency is

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

and no heat engine can exceed it. This is a theorem.

Question: Does that bound predict real engines?

Observation 1.1

This paper’s answer is no. The correct bound and the predictive bound are different things—and both of them are bounds.

2. The Numbers Do Not Meet

Setting: Take a modern coal plant at representative values: steam at 560 °C, condenser at 27 °C.

Check 2.1:

Quantity	Value
T_h	833.15 K
T_c	300.15 K
T_c/T_h	0.360259
$\eta_C = 1 - T_c/T_h$	0.639741 (63.97%)
Real thermal efficiency (representative)	40--45%

Observation 2.2

A gap of more than 20 points.Carnot is not wrong——no real plant exceeds it, so it works as a bound.

Observation 2.3

But working as a bound and predicting are different.“At most 63.97%” is correct and does not hit 40%——0% is also at most 63.97%.

Observation 2.4

The gap is usually explained by friction, heat leaks and incomplete combustion.This paper does not take that explanation——a simpler reason makes the gap inevitable (Section 3).

3. The Core: The Bound at Maximum Power Is 39.98%

Setting: A Carnot engine is reversible, and to be reversible it must run infinitely slowly.An engine running infinitely slowly delivers zero power.

Observation 3.1

This is the core of the paper. An engine that attains the Carnot efficiency does no work at all—it is not that the bound cannot be attained; it is that attaining it is useless.

Check 3.2: So maximise power rather than efficiency. For an endoreversible engine

$$\eta_{\max P} = 1 - \sqrt{\frac{T_c}{T_h}}$$

Quantity	Value
$\sqrt{T_c/T_h}$	0.600216
$\eta_{\max P}$	0.399784 (39.98%)
Real plants	40--45%
$\eta_{\max P}/\eta_C$	0.624914

Observation 3.3

39.98% against 40--45%—it lands. Carnot misses by 20 points; this one very nearly agrees.

Check 3.4: The same for other engines.

Engine	T_h [K]	Carnot	At maximum power
Car engine	2500	85.08%	61.37%
Geothermal (200 °C)	473	36.58%	20.36%
Ocean thermal (25 °C / 5 °C)	298	6.71%	3.41%
Body heat (37 °C / 20 °C)	310	5.48%	2.78%

Observation 3.5

There are not two bounds. There are two things being maximised——maximise efficiency and you get Carnot, maximise power and you get this.

Observation 3.6

Paper 227 wrote that the same $\leq$ points at a wall you can touch and at one you cannot. Carnot is a wall you can touch——reachable, and the moment you reach it the engine stops.

Observation 3.7

This is where it differs from Paper 304's capacity. Capacity is unattainable at every finite length, whereas the Carnot efficiency is attainable——attaining it merely drives the output to zero.

	Attainable?	On attaining it
Capacity (Paper 304)	no	—
Carnot efficiency (this paper)	yes	the output becomes zero

Observation 3.8

A point to write honestly—— $\eta_{\max} P$ does not land because it was built to land. It is a result under premises (endoreversibility, linear heat conduction), and nothing guarantees real plants meet them——the agreement is suggestive, not a proof.

4. Neither Bound Contains a Material Quantity

Check 4.1: Counting what appears in the two formulas.

Formula	What appears	What does not
$1 - T_c/T_h$	two temperatures	working fluid, heat capacity, viscosity, pressure, volume
$1 - \sqrt{T_c/T_h}$	two temperatures	the same

Observation 4.2

Not one material quantity enters either. Water, air or ammonia give the same bound——this is what “thermodynamic” means.

Observation 4.3

And both are dimensionless. T_c/T_h is a ratio, and it is neither kelvin nor celsius——only one thing acts: the ratio is meaningless unless the temperature is absolute.

Observation 4.4

Paper 126 treated the second law along Caratheodory’s road and stated that no heat engine, no cycle and no Clausius inequality appear. This paper stands on the side that did not appear——126 showed that a temperature is not thereby made unique; this paper shows that an efficiency does not thereby predict. Both are about what does not follow from the second law.

5. “Efficiency” Names Five Quantities

Check 5.1: The quantities that go by the word “efficiency.” Values for the plant above, and for $T_h = 293.15$ K, $T_c = 273.15$ K (heating).

Name	Formula	Value	Bound
Carnot efficiency	$1 - T_c/T_h$	0.639741	≤ 1
Efficiency at maximum power	$1 - \sqrt{T_c/T_h}$	0.399784	$\leq \eta_C$
First-law efficiency	W/Q_{in}	0.400000	≤ 1
Second-law efficiency	η/η_C	0.625253	≤ 1
Coefficient of performance (heating)	$T_h/(T_h - T_c)$	14.657500	can exceed 1

Observation 5.2

Only the fifth row exceeds 1. It is 14.6575—and it violates neither the first law nor the second.

Observation 5.3

The reason it may exceed 1 is simple. The denominator is different—an efficiency asks what fraction of the heat put in becomes work; a coefficient of performance asks how many times the work put in is moved as heat. Moving is cheaper than making.

Check 5.4: Moving the conditions.

Condition	Coefficient of performance
20 °C from 0 °C (heating)	14.6575
20 °C from −10 °C (heating)	9.7717
5 °C into 25 °C (cooling)	13.9075
A real domestic heat pump	3–4

Observation 5.5

A real unit reaches 3--4, that is 23.88% of the bound—here too the Carnot-type bound misses by about a factor of 4.

Observation 5.6

Paper 255 showed that “accuracy” is two things. “Efficiency” is five—and that exactly one of the five may exceed 1 is the evidence that they are not one quantity.

6. Separator: What Is Being Maximised

Observation 6.1

Separator—what is being maximised.

What is maximised	The bound obtained	The output there
Efficiency	$1 - T_c/T_h = 63.97\%$	zero
Power	$1 - \sqrt{T_c/T_h} = 39.98\%$	maximal

Observation 6.2

Choosing the first row stops the engine. So no real plant is aiming at the first row—the gap is not a failure but a choice.

Observation 6.3

These are distinct roots in the sense of Paper 300. Applying the criteria—

Criterion	Result
Does the agreement persist under motion?	no. Move T_c/T_h and the ratio leaves 0.624914
Do they come from the same limit?	no. One is quasi-static, the other finite-time
Does one follow from the other?	no. The $\sqrt{\cdot}$ does not come out of η_C

Observation 6.4

All three say **no**——the two bounds are distinct roots.

Observation 6.5

To state it generally——for bounds, “correct” and “useful” are different properties. A correct bound guarantees that it is not broken; a useful bound guarantees that it is close——no single inequality is required to do both.

7. Roll Call and Closing

1. Carnot gives **63.97%** (Check 2.1): **Real plants give 40–45%.**
2. A miss of **20 points** (Observation 2.2): **Correct as a bound.**
3. Maximum power gives **39.98%** (Check 3.2): **It lands.**
4. The ratio is **0.624914** (Check 3.2): **Six-tenths of Carnot.**
5. Attaining it gives **zero output** (Observation 3.1): **A wall you can touch.**
6. No material quantity (Check 4.1): **Only two temperatures.**
7. “Efficiency” is **five** (Check 5.1): **One exceeds 1.**
8. The COP is **14.6575** (Check 5.1): **A different denominator.**
9. Real units reach **23.88%** (Observation 5.5): **Heat pumps too.**
10. Three criteria say **no** (Observation 6.3): **The bounds are distinct roots.**

Closing: The Carnot efficiency is correct as a bound on any heat engine, and at $T_h = 833.15$ K and $T_c = 300.15$ K it is **63.97%**——while real plants give 40–45%, a gap of more than 20 points. Carnot is not wrong——nothing exceeds it, so it works as a bound. But working and predicting are different——0% is also at most 63.97%. What lands is a

different bound—the efficiency at maximum power, $1 - \sqrt{T_c/T_h} = \mathbf{39.98\%}$. There are not two bounds; there are two things being maximised—maximising efficiency drives the output to zero, and no real plant is aiming there. The gap is not a failure but a choice. Neither bound contains a single material quantity—no working fluid, no heat capacity, no viscosity, only two temperatures. And the word “efficiency” names five quantities—the Carnot efficiency, the efficiency at maximum power, the first-law efficiency, the second-law efficiency and the coefficient of performance, of which only the coefficient of performance exceeds 1, at **14.6575**. Its denominator is different, and it violates nothing. One thing separates them—what is being maximised. Paper 300’s criteria return no three times over: the two bounds are distinct roots. For bounds, “correct” and “useful” are different properties—a correct bound guarantees that it is not broken, a useful one that it is close. No single inequality is required to do both.

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