EXECUTIVE BRIEF · OPERATIONAL THERMODYNAMICS INTELLIGENCE

HEAT RATE IS AN OUTCOME

Not A Primary Control Variable

YBGGlobal.com · ControlAlign™

EXECUTIVE SUMMARY

A KPI that is observed, not directly controlled

Heat rate is one of the most closely monitored KPIs in thermal power generation because it directly reflects fuel efficiency.

Lower heat rate generally means:

- lower fuel consumption,
- lower operating cost,
- lower emissions intensity,
- and improved operating margin.

For this reason, thermal-performance discussions often focus heavily on the heat-rate number itself.

> **However, heat rate is not a directly controlled process variable. It is an operational outcome produced by the combined thermodynamic state of the unit over time.**

This distinction is important because thermal plants can maintain apparently stable operation while heat-rate performance progressively deteriorates.

In many cases:

- combustion remains stable,
- generation remains stable,
- steam conditions remain acceptable,
- and dispatch obligations continue to be met,

while progressively more fuel becomes required to sustain the same electrical output.

This raises an important operational question:

“What underlying thermal-state conditions are influencing the heat-rate outcome?”

HEAT RATE COMPRESSES COMPLEXITY

Heat rate is typically defined as: “The amount of fuel energy required to produce one unit of electrical output.”

While operationally useful, this KPI compresses a highly complex thermodynamic environment into a single numerical result.

Between fuel entering the furnace and electrical output leaving the generator exists an entire thermal transfer environment involving:

- combustion kinetics
- flame behaviour
- radiative heat transfer
- thermal coupling effectiveness
- heat absorption behaviour
- furnace-state stability
- working-fluid enthalpy rise
- load-transition behaviour
- operational drift
- and dynamic process interaction

> **Historically, much of this complexity becomes operationally compressed into the final KPI: Heat Rate.**

The KPI indicates the result. But not necessarily:

- why performance changed,
- how thermal-state conditions evolved,
- or which operational conditions correlate with superior historical performance.

STABLE OPERATION DOES NOT ALWAYS MEAN STABLE THERMAL PERFORMANCE

One of the operational challenges in thermal power generation is that units can remain operationally “normal” while thermal efficiency gradually deteriorates.

Operators may continue successfully maintaining:

- dispatch targets,
- steam pressure,
- combustion stability,
- emissions compliance,
- and generation output,

while the underlying thermodynamic transfer environment evolves over time.

This can occur due to interacting operational variables such as:

- excess O_2 variation
- air–fuel imbalance
- burner-condition drift

- pulverizer variation
- slagging and fouling
- air ingress
- fuel variability
- sootblower influence
- thermal absorption imbalance
- load-transition instability
- radiative coupling changes

These conditions influence:

- heat-transfer effectiveness,
- thermal-state stability,
- and the efficiency with which thermal energy reaches the working fluid.

> **Two operating periods may produce identical electrical output, appear operationally stable, and remain within acceptable operating ranges — while exhibiting materially different heat-rate performance.**

THE VISIBILITY CHALLENGE

Historically, thermal plants monitor very large numbers of operational signals.

Viewed independently, these signals can become operationally overwhelming.

The challenge is therefore not simply: collecting operational data.

The challenge is: interpreting the thermodynamic meaning of continuously evolving operating states.

This is particularly important because thermal-performance deterioration often develops gradually rather than through sudden operational failure.

> **The unit continues operating. The process appears stable. Yet fuel intensity progressively increases.**

AN EMERGING OPERATIONAL PERSPECTIVE

As industrial historian environments become increasingly data-rich, an emerging operational perspective is beginning to develop:

> *“Heat rate may be better understood not as an isolated KPI — but as a thermodynamic outcome produced by continuously changing operational-state conditions.”*

This creates growing interest in:

- thermal-state interpretation,
- operational drift reconstruction,
- radiative coupling behaviour,
- and historian-derived thermodynamic intelligence.

HISTORIAN-DERIVED OPERATIONAL INTELLIGENCE

At YBGGlobal.com, part of the current focus involves reconstructing thermal-state behaviour from existing plant historian environments to improve visibility into:

- operational drift,
- fuel-to-steam conversion effectiveness,
- thermal coupling stability,
- and the operating conditions associated with superior historical heat-rate performance.

The objective is not replacing:

- plant operators,
- DCS environments,
- APC systems,
- or combustion controls.

> **The objective is improving visibility into the thermodynamic operating environment influencing the heat-rate outcome itself.**

CLOSING OBSERVATION

Thermal plants do not directly control heat rate.

They control operating conditions that influence the thermodynamic transfer environment producing the heat-rate outcome.

As a result, the next evolution in thermal-performance management may increasingly involve understanding:

- how thermal-state conditions evolve,
- how operational drift develops,
- and how effectively thermal energy is transferred, absorbed, and sustained throughout the operating environment.

YBGGlobal.com · Operational Thermodynamics Intelligence