

EXECUTIVE BRIEF · OPERATIONAL THERMODYNAMICS INTELLIGENCE

THERMAL PLANTS DO NOT LOSE PERFORMANCE ALL AT ONCE

They Drift — Shift By Shift

YBGGlobal.com · ControlAlign™

EXECUTIVE SUMMARY

Performance deteriorates beneath apparently stable operation

Thermal-performance deterioration in power generation environments is often imagined as:

- a major equipment event,
- a sudden operational failure,
- or an immediately visible process abnormality.

In reality, many thermal plants lose performance gradually.

The unit continues operating. Generation remains stable. Dispatch obligations are met. Combustion appears acceptable.

Yet over time:

- heat rate deteriorates,
- fuel intensity rises,
- emissions intensity increases,
- and operating margin progressively declines.

This process is often incremental. Shift by shift. Day by day. Load cycle by load cycle.

This phenomenon is operational thermal drift. Thermal drift frequently develops beneath apparently stable operation.

THE NATURE OF THERMAL DRIFT

Thermal plants operate within continuously evolving thermodynamic environments.

The operating state of the furnace is influenced by interacting variables such as:

- excess O₂ variation,
- burner-condition drift,
- pulverizer variation,
- fuel-quality variability,
- slagging and fouling accumulation,
- flame-shape instability,
- air ingress,
- thermal absorption imbalance,

- sootblower influence,
- load-transition instability,
- and radiative transfer behaviour.

These conditions evolve continuously over time. As they evolve, they influence:

- thermal-state stability,
- heat-transfer effectiveness,
- fuel-to-steam conversion behaviour,
- and overall thermal efficiency.

Importantly, the unit may remain operationally stable while these thermodynamic conditions progressively drift.

STABLE OPERATION CAN CONCEAL DETERIORATING PERFORMANCE

This distinction is operationally important. A unit may continue:

- meeting dispatch targets,
- maintaining steam conditions,
- operating within acceptable combustion ranges,
- and satisfying emissions requirements,

while progressively requiring more fuel to sustain equivalent electrical output.

The challenge is that traditional operational indicators often reveal the outcome of drift — without fully revealing how the thermodynamic operating environment evolved to produce that outcome.

HEAT RATE REVEALS THE CONSEQUENCE

Heat rate is typically defined as the amount of fuel energy required to produce one unit of electrical output.

Heat rate remains one of the most important thermal-performance KPIs because it directly influences:

- fuel cost,
- emissions intensity,
- and operating margin.

However, heat rate itself is not directly controlled. It is an operational outcome produced by continuously evolving thermodynamic operating conditions.

As a result, heat-rate deterioration often develops progressively rather than suddenly.

THE COMPRESSION OF THERMODYNAMIC COMPLEXITY

Between fuel entering the furnace and electrical output leaving the generator exists a highly dynamic thermodynamic transfer environment involving:

- combustion kinetics,
- flame behaviour,
- radiative heat transfer,
- thermal absorption,
- thermal coupling effectiveness,
- furnace-state stability,
- and working-fluid enthalpy rise.

Historically, much of this complexity becomes operationally compressed into:

- heat rate,
- fuel flow,
- output,
- and emissions KPIs.

These KPIs remain operationally essential. But they may not fully explain:

- how drift developed,
- which operating conditions evolved,
- or how thermal-state stability changed over time.

THE VISIBILITY CHALLENGE

Modern thermal plants already possess large operational historian environments. Thousands of operational signals are continuously recorded.

The challenge is no longer data acquisition. The challenge is thermodynamic interpretation.

This includes improving visibility into:

- operational drift development,
- thermal-state evolution,
- radiative coupling behaviour,
- and fuel-to-steam conversion stability.

HISTORIAN-DERIVED OPERATIONAL INTELLIGENCE

At YBGGlobal.com, part of the current focus involves historian-derived reconstruction of thermal-state behaviour from existing plant operational data.

The objective is improving visibility into:

- operational drift,
- thermal transfer effectiveness,
- thermal-state stability,
- and the operating conditions associated with superior historical thermal performance.

The framework is intended to help transform large operational historical environments into more interpretable thermodynamic operational intelligence.

DRIFT OFTEN DEVELOPS GRADUALLY

One of the important operational observations in thermal environments is that performance deterioration frequently develops gradually rather than catastrophically.

The unit remains online. The process appears stable. Generation continues.

Yet progressively:

- fuel intensity increases,
- thermal transfer effectiveness changes,
- and operating efficiency drifts away from historically superior states.

This creates an emerging operational need: improving visibility into how thermal-state conditions evolve over time.

AN EMERGING OPERATIONAL PERSPECTIVE

Historically, thermal-performance management has focused heavily on:

- combustion stability,
- generation reliability,
- emissions compliance,
- and equipment availability.

An emerging operational perspective suggests that thermal-performance management may increasingly involve understanding:

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

CLOSING OBSERVATION

Thermal plants often do not lose performance through sudden failure. In many cases, performance deteriorates gradually through operational drift.

Shift by shift. Load cycle by load cycle.

The operational challenge may therefore increasingly involve not only controlling combustion — but improving visibility into the evolving thermodynamic transfer environment influencing thermal performance itself.