

METHODOLOGY DECK

THERMAL-STATE RECONSTRUCTION FRAMEWORK

Historian-Derived Operational Thermodynamics Intelligence
for Thermal Infrastructure

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Thermal Performance Drift Develops Beneath Apparently Stable Operation

In many thermal environments:

- generation remains stable,
- dispatch targets are met,
- steam conditions remain acceptable,
- and combustion appears operationally normal,

while:

- heat rate deteriorates,
- fuel intensity rises,
- and thermal efficiency progressively declines.

This creates an operational visibility challenge.

Heat Rate Reflects The Result — Not Necessarily The Cause

Heat rate is generally defined as:

“Fuel energy required to produce one unit of electrical output.”

Operationally important:

Yes.

Directly controlled:

No.

Heat rate is an outcome produced by the thermodynamic operating state of the unit over time.

Thermal Plants Compress Complex Thermodynamic Behaviour Into A Few KPIs

Typical monitored KPIs

- Heat Rate
- Fuel Flow
- Output
- Steam Conditions
- Emissions

Yet between fuel input and electrical output:

- combustion kinetics
- flame behaviour
- radiative heat transfer
- thermal coupling
- heat absorption
- load-transition dynamics
- operational drift

Thermal-State Drift Develops Through Interacting Operational Variables

Examples include

- excess O₂ variation
- air–fuel imbalance
- pulverizer variation
- burner-condition drift
- fuel variability
- slagging and fouling
- air ingress
- sootblower effects
- thermal absorption imbalance
- load-transition instability
- radiative transfer changes

These continuously influence

- thermal-state stability
- heat-transfer effectiveness
- fuel-to-steam conversion behaviour

Operational Data Exists — Thermodynamic Interpretation Is Often Limited

Thermal plants already possess:

- DCS environments
- historian infrastructure
- APC systems
- process instrumentation

The challenge is not data collection. The challenge is interpreting evolving thermodynamic operating conditions from large operational historian environments.

Historian-Derived Thermal-State Reconstruction

ControlAlign™ reconstructs operational thermal-state behaviour Objective: improve visibility into using:

- existing historian environments
- operational process data
- thermodynamic correlation logic
- load-normalized interpretation
- deterministic analysis frameworks
- operational drift
- thermal-state behaviour
- radiative coupling effectiveness
- fuel-intensity variation
- thermal performance stability

Operational Thermodynamics Intelligence Architecture



Engineering Visibility Requires Deterministic Operational Interpretation

The framework emphasizes

- historian-derived analysis
- traceable interpretation
- operational contextualization
- load-band normalization
- engineering-reviewable logic
- audit-grade outputs

Maintain interpretability across continuously evolving operational

Emerging Operational Focus: Thermal Coupling Effectiveness (TCE)

TCE refers to:

“The effectiveness with which released thermal energy is transferred and absorbed throughout the operating environment.”

Potentially influenced by:

- radiative coupling behaviour
- furnace-state stability
- flame geometry
- thermal absorption conditions
- operational drift

Small Thermal-State Variations Become Material At Fleet Scale

Progressive thermal drift may influence:

- fuel consumption
- operating margin
- emissions intensity
- unit consistency
- fleet performance stability

Historically, these conditions may develop gradually while units continue appearing operationally stable.

The Objective Is Not Replacing Existing Control Systems

ControlAlign™ is designed as

- a read-only operational intelligence layer
- historian-derived
- non-intrusive
- operationally contextualized
- integration-safe

The objective is improving visibility into the thermodynamic operation to achieve optimal thermal-performance outcomes.

Thermal Performance May Increasingly Depend On Understanding The Thermal-State Environment Itself

As industrial environments become increasingly data-rich, operational intelligence 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.

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Operational Thermodynamics Intelligence

Historian-Derived Thermal-State Interpretation for Thermal Infrastructure