SteamVision: From Field Insight to Digital Clarity

Indorama Ventures Xylenes & PTA LLC, Decatur AL (CPET Segment)

By Hunter McBrayer

conneqt

Who we are!

INDORAMA VENTURES

IVXP – Decatur, AL

IVXP's

Steam Focus

Digital

Front-Tier

Summary

& Next Steps

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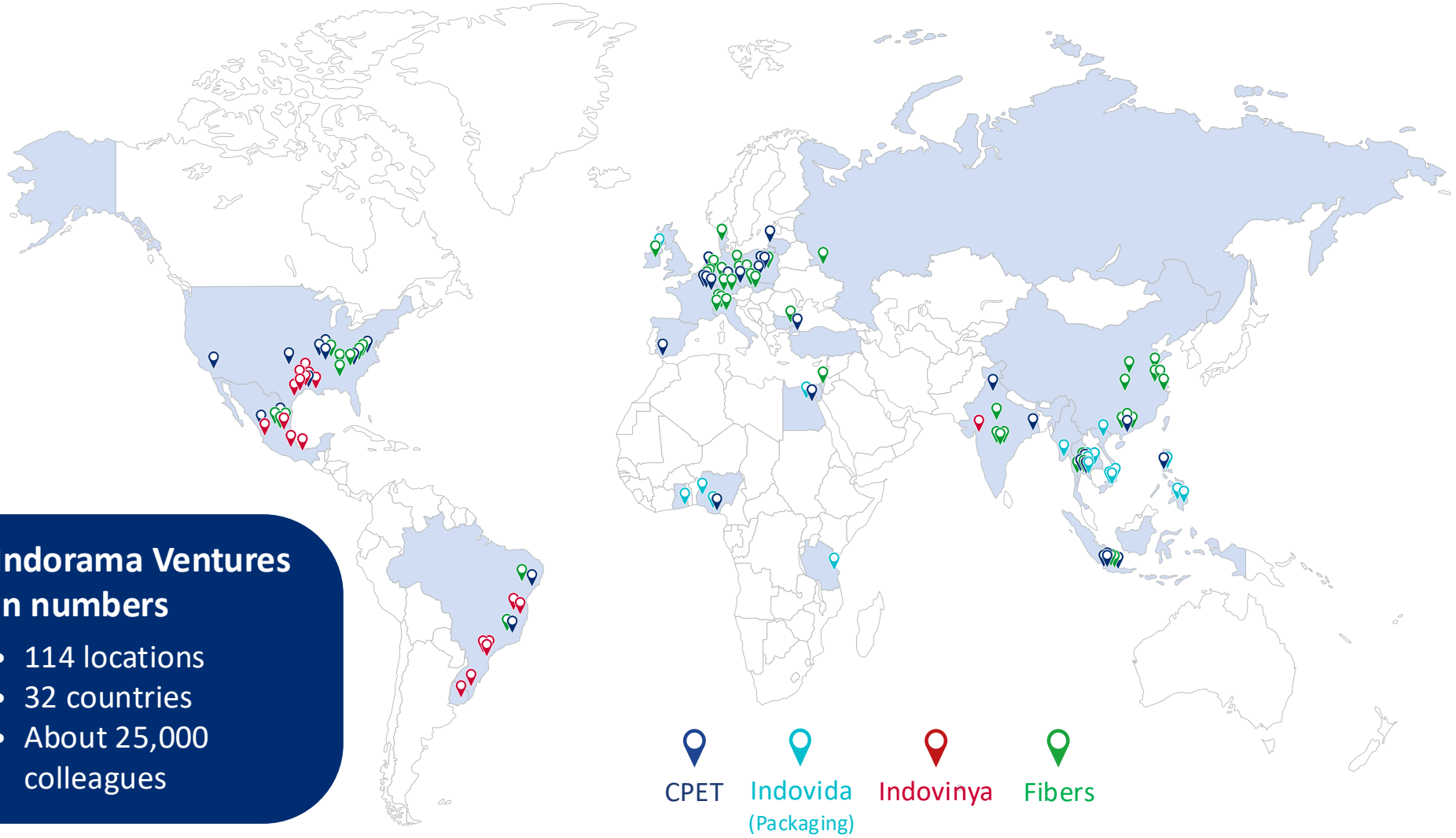
Our Global Manufacturing Footprint



Indorama Ventures in numbers

- 114 locations
- 32 countries
- About 25,000 colleagues

*update as of Apr 2025

Americas

Brazil
Mexico
Uruguay
USA

EMEA

Bulgaria
Czech Republic
Denmark
Egypt
France
Germany
Ghana
Ireland
Italy
Isarael
Lithuania
Luxembourg
Netherlands
Nigeria
Poland
Russia
Slovakia
Spain
Tanzania
Turkey
UK

APAC

China
India
Indonesia
Myanmar
Philippines
Thailand
Vietnam

Company Snapshot

Presence in **32** countries
*update as of Apr 2025

114 manufacturing locations
*update as of Apr 2025

about **25,000** employees

Consolidated revenues of **$15.4B** (FY2024)

Our customers help us grow as a market leader

CPET

- #1 PET producer globally
- #1 Recycled PET producer globally
- The only shale-integrated player in the West

Indovida

- #1 Market position in ASEAN
- #2 Market position in Africa
- Packaging leadership in emerging markets

Indovinya

- #1 Non-ionic surfactants Producer in Americas
- #1 Americas' home care ingredients provider
- #1 Crop solutions provider in Americas

Fibers

Lifestyle	Hygiene	Mobility	Mobility
#1 in PET staple fiber ASEAN	#2 in BiCo fiber	#2 in airbag yarn	#2 in tire cord fabric

Digital x IVEX x Sustainability

ADVANCED INDUSTRIAL ANALYTICS COMPETITION 2025

CPET Segment

3rd Place Winner for Sustainability for CPET

From Indorama Ventures' Internal AIA (Seeq) Showcase – Dec. 2025

SteamVision: From Field Insight to Digital Clarity

Sustainability Project

Hunter McBrayer

Process Engineer

IVXP (CPET Segment)

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INDORAMA VENTURES – CPET

Decatur, AL, USA

Located in **Decatur, Alabama**, this site produces key feedstocks including paraxylene (PX), purified terephthalic acid (PTA), and purified isophthalic acid (PIA). It also manufactures specialty chemicals such as 2,6-naphthalene dicarboxylate (NDC) and 2,6-naphthalenedicarboxylic acid. As the **world's largest producer of PNDA**, the site supplies both co-located Indorama Ventures operations and external customers globally.

Steam: The Backbone… and the Blind Spot

Understanding the hidden operational, energy, and sustainability impacts within steam systems

Indorama Ventures Xylenes & PTA, LLC (IVXP),
a subsidiary of global chemical producer Indorama Ventures Public Company Limited (IVL)

"True progress lies where **business performance** and **sustainability** reinforce one another—driven by purpose, collaborative partnerships, and unwavering commitment."
- **YASH LOHIA,** Chairman of the ESG Council

At **IVXP,** steam powers a complex, interconnected operation at scale—making it one of the site's most critical systems.

Inefficiencies at this level translate into hundreds of thousands of dollars in **hidden cost.**

Common Steam Inefficiencies Across Chemical Plants *(Industry-Wide)*

Trap Failures → Energy loss + reliability risk
Insulation Gaps → 5–15% energy loss
Condensate Recovery Gaps → 18–30% recoverable energy lost
Design Constraints → Reduced steam quality + equipment risk

The Steam Team: *A Cross-Functional Engine for Efficiency*

Transforming Steam from Utility → Strategic Advantage

The Team — Clear Ownership

Management (Lead): Driving accountability & results
Process Engineer: Owns use cases & economics, Sustainability Impact
Utilities/Boiler SME: Ensures system integrity & optimization
Maintenance: Executes on traps, leaks & reliability gaps
Operations (Frontline Rep): Shift-level ownership & action
Digital/Analytics (Seeq): Enables visibility, speed, and scale

Success Metric:
Deliver measurable steam loss reduction aligned to site & corporate energy goals

Mandate — What We Deliver

Identify & quantify losses across the steam system
Prioritize highest $ impact opportunities
Drive measurable reductions in:

- Fuel usage
- Water consumption
- CO_2 emissions

Loss Identification (High-Value Targets)**:**

- Trap failures (live steam loss)
- Venting / bypass losses
- Blowdown optimization
- Insulation gaps
- Condensate recovery gaps

***Objective**: Deliver measurable **sustainability** impact by significantly **reducing** steam **losses** & maximizing **energy efficiency** across operations*

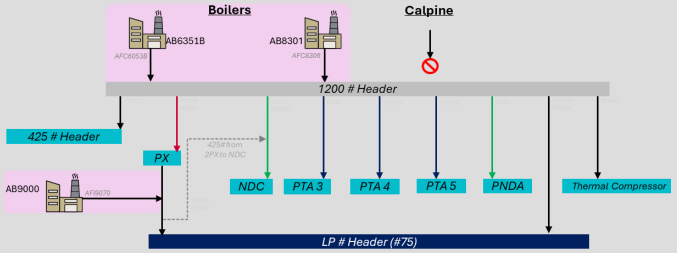
Steam System Optimization Framework

Engineering Execution that drives Value

Visibility

System Visibility & Control

- **Steam Balance**
- **APC & Controls**
- **Benchmark Consumptions**
- **Real-Time Visibility**



Establishes trusted system-wide visibility

Trap Program

Targets highest energy waste

- **Trap Health Monitoring**
- **Failure Identification** (Blow / Block)
- **Steam trap surveys**
- **Maintenance Prioritization**

TrapMan®

Identifies hidden losses in real time

Prioritization

Drives $-based decision making

- **Rank Losses by $ Impact**
- **Unit-Level Accountability**
- **Opportunity Pipeline**
- **Savings Tracking & Validation**

Converts insights into measurable savings

Not a **study group**—it's an **execution engine** tied to **measurable value.**

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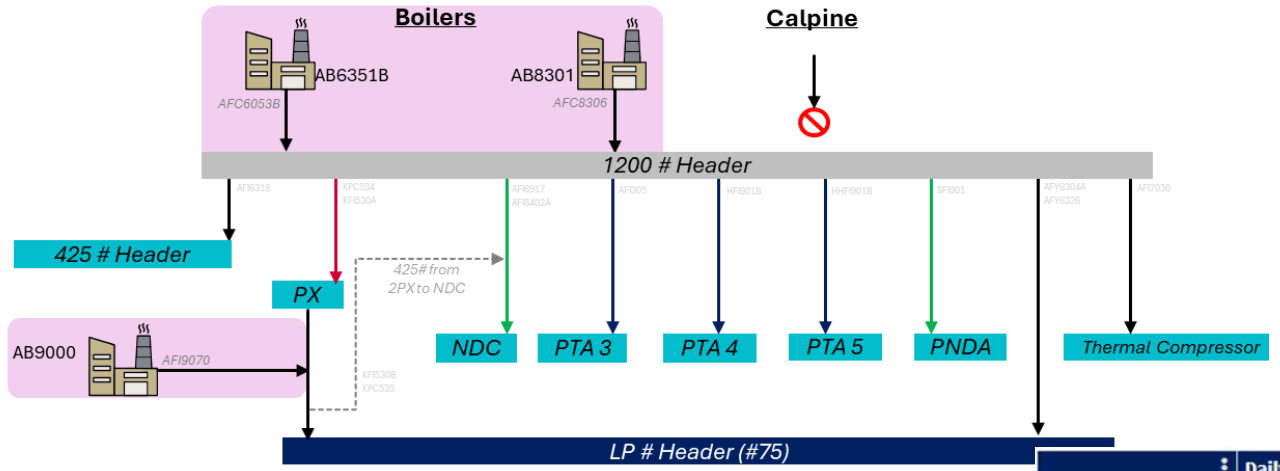
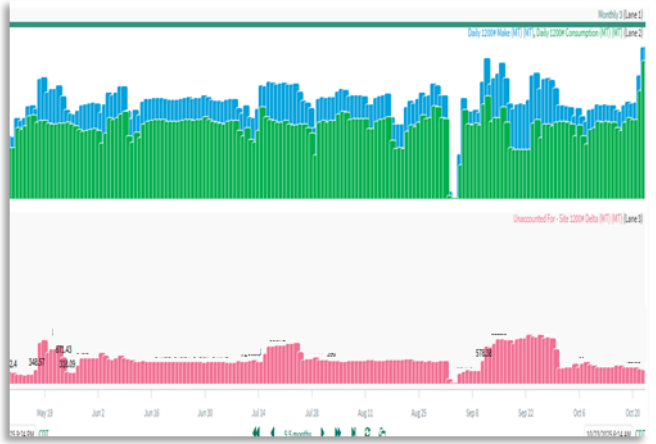
The Digital Front-Tier | *Where Data Becomes Action*

Site Steam Balance & Optimization

Value: ***Accurate live steam accounting*** *that will aid in* ***identifying usage gaps.*** *There is an average of ~15% of steam produced that is unaccounted.*
Conservatively if we could just recover a fraction of that steam we could save over ~$300,000 a year.

Measure: **Steam in** (generation + imports) **= Steam out** (exports + users + vents + leaks)





SUSTAINABILITY

Opt

	Daily 1200# Make (MT) Avg	Daily 1200# Consumption (MT) Avg	Unaccounted For - Site 1200# Delta (MT) Avg
5/1/2025 - 6/1/2025	MT	MT	MT
6/1/2025 - 7/1/2025	MT	MT	MT
7/1/2025 - 8/1/2025	MT	MT	MT
8/1/2025 - 9/1/2025	MT	MT	MT
9/1/2025 - 10/1/2025	MT	MT	MT
10/1/2025 - 11/1/2025	MT	MT	MT

Daily Unaccounted for Steam

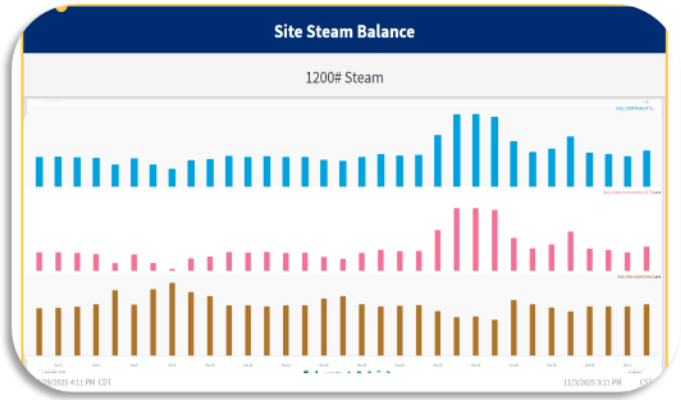
Site Wide Overall Balance

Finding the Loss | *3* Steps to Breakdown Site Steam (Digital) Focus

Define ***The loss is visible… The source is not.*** ***(DMAIC)***

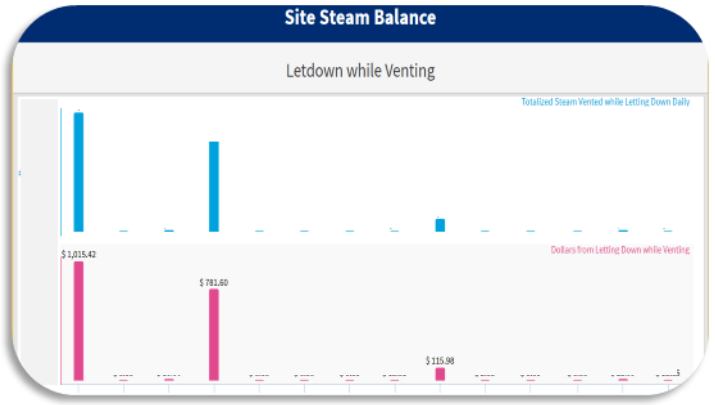
Measure: **Steam in (generation + exports) = Steam out (uses + vents + leaks)**

1 Overall Steam Generators / Consumers (High Level)



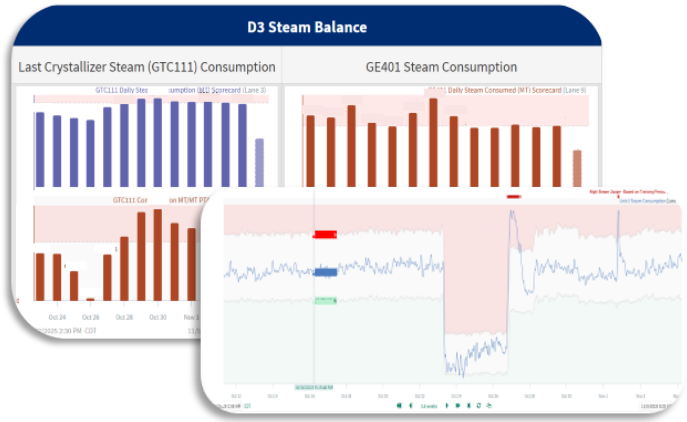
On Going: Monitor & Detect Unexplained Discrepancies Between Produced & Confirmed Usage

2 Venting / Let Down Verification



Complete: Check Main Venting and Letdown scenarios and address any issues.

3 Unit Efficiency Calculations (Med – Low, level drill downs)



On Going: Create Unit Drill down with Score Cards & Predictive Usage based on Historical Benchmark

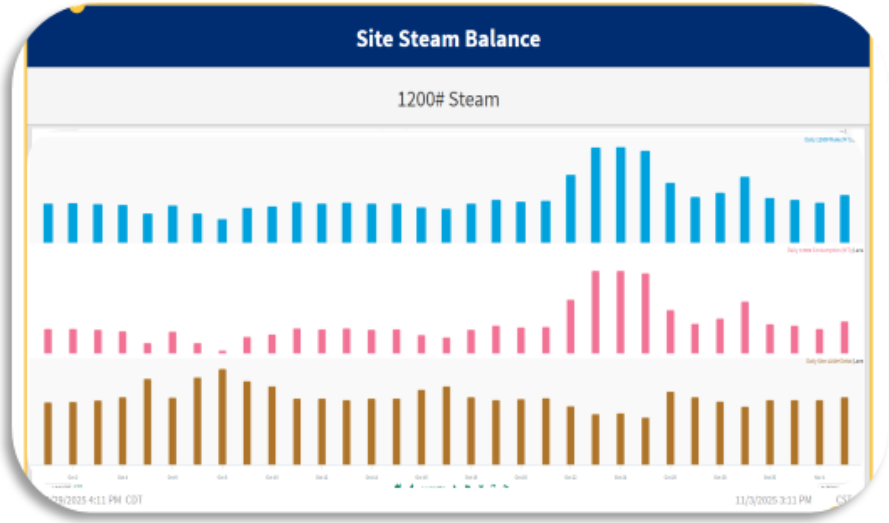
Steam Balance Visibility | Identifying Unaccounted Steam Across IVXP

Define ***Steam accounting at IVXP is highly inaccurate and manual.*** ***(Unaccounted for Steam)***

Part 1. *Overall Steam Generators / Consumers (High Level)*

Value: Establishing a **live steam accounting framework** to expose **usage gaps**, improve **operational accuracy**, and **reduce hidden energy losses**.

Measure: **Steam in (generation + imports)** = Steam out (exports + **uses** + vents + leaks)



#1200 Delta – Accounted for Steam

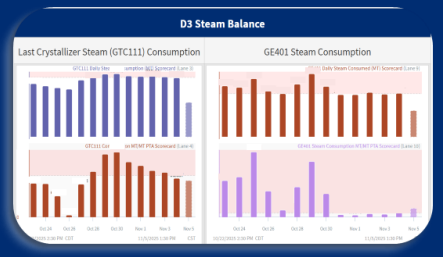
Next Step: Establish overall unit mass balance, then identify mass distribution and usage at the equipment level to pinpoint inefficiencies and variances.

1200 # Header

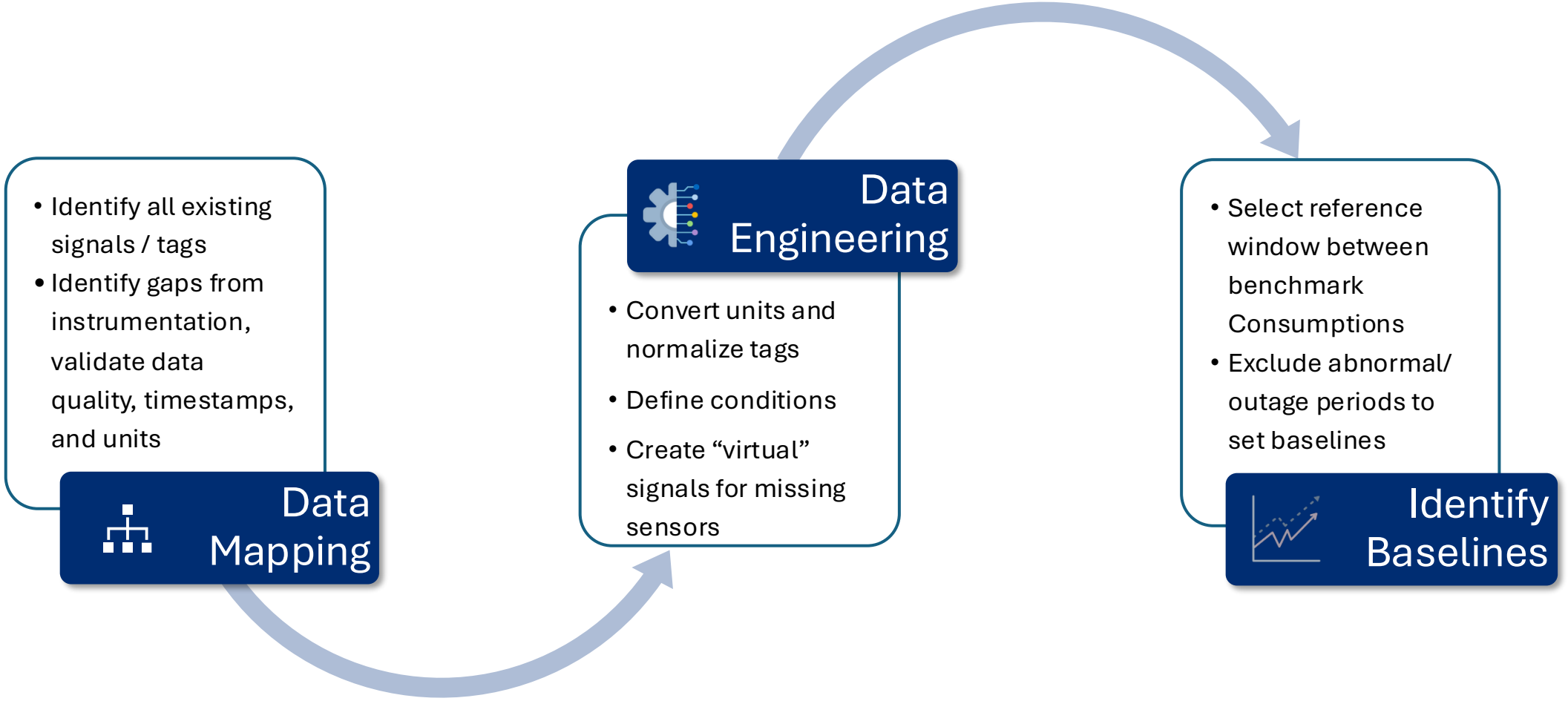
AFI6305

*A sustained effort over the next **several months as we refine accuracy**, close gaps, and reduce losses.*

PTA 3



Engineering Visibility: Closing the Gap on Unaccounted for Steam



*If You **Can’t** **See It,** You **Can’t** **Fix It**!*

Shift the Mindset | From “we don’t have time or Instrumentation”

Back to **engineering fundamentals that drives action**

Mass Balances

Account for **Every Unit** In / Out

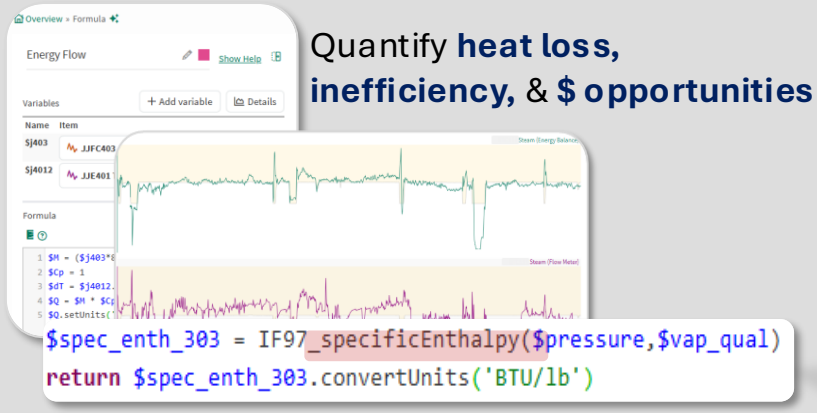
Identify **losses, leaks,** & **inefficiencies** in **real-time**

1200# Header** = **Make** - **Consumers** - **Losses
425# Header** = **Make** - **Consumers** - **Losses
75# Header** = **Make** - **Consumers** - **Losses

Move from **estimated losses to quantified cost ($/t impact)**

Energy Balances

Translate **Steam Properties** into Actionable Energy Insights



Quantify **heat loss, inefficiency,** & **$ opportunities**

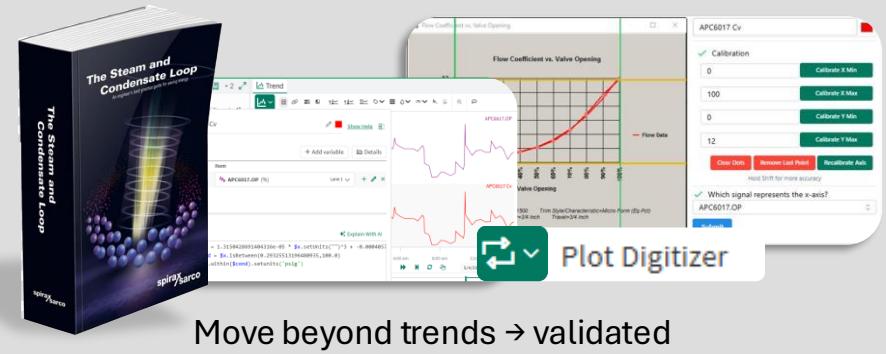
No instrumentation? **Engineer the signal** using Press., temp. & process context.

Engineering Know-How

Apply **first principles** (CV equations, thermodynamics, hydraulics)

3.21.2 Sizing a Control Valve for Saturated Steam

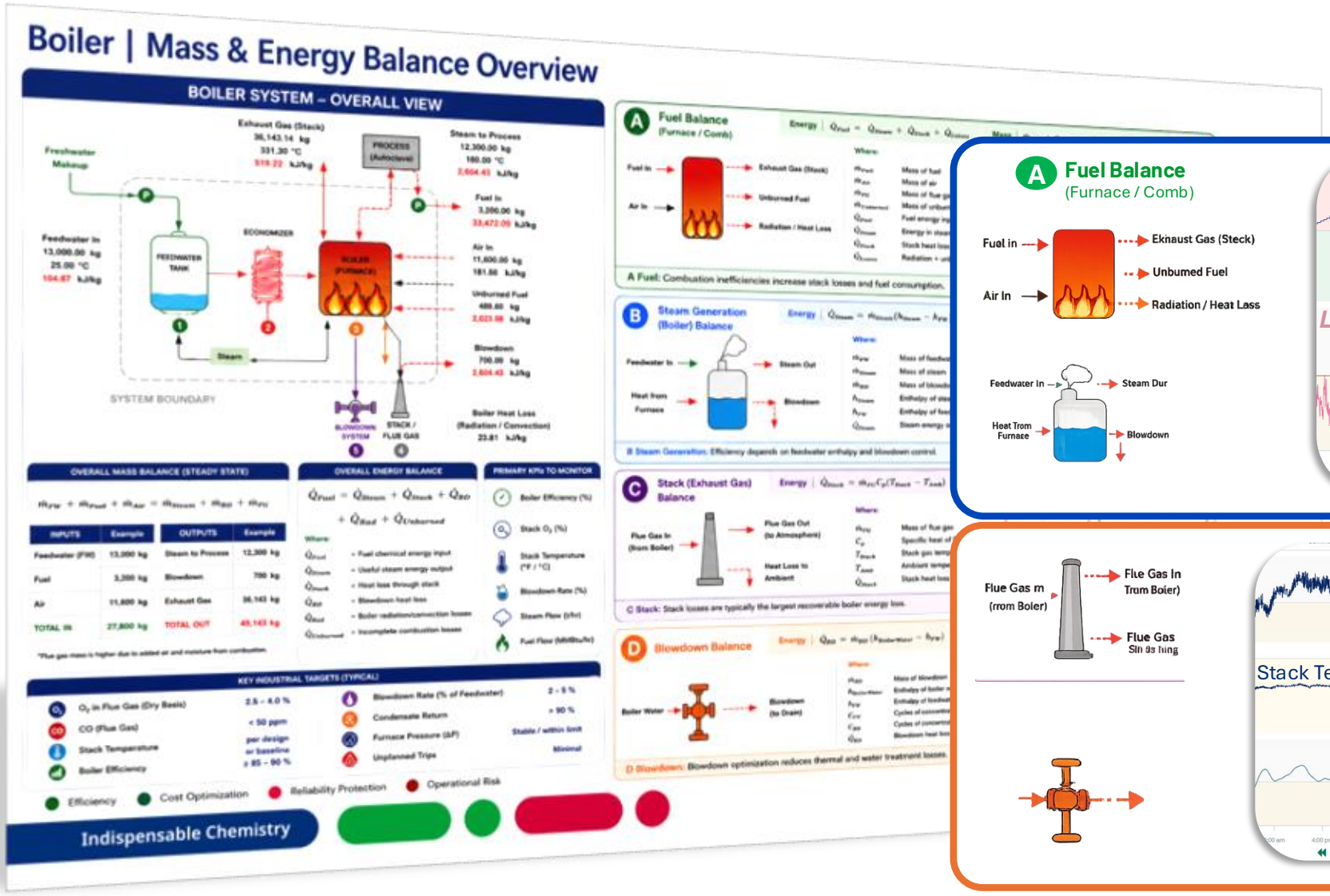
$$\dot{m}_s = 12K_v P_1\sqrt{1 - 5.67(0.42 - x)^2}$$

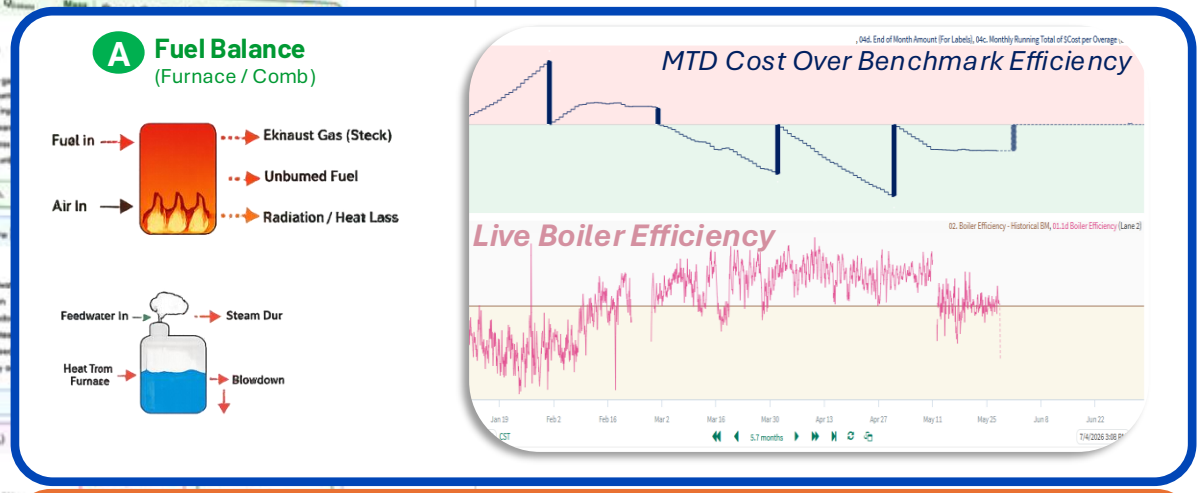


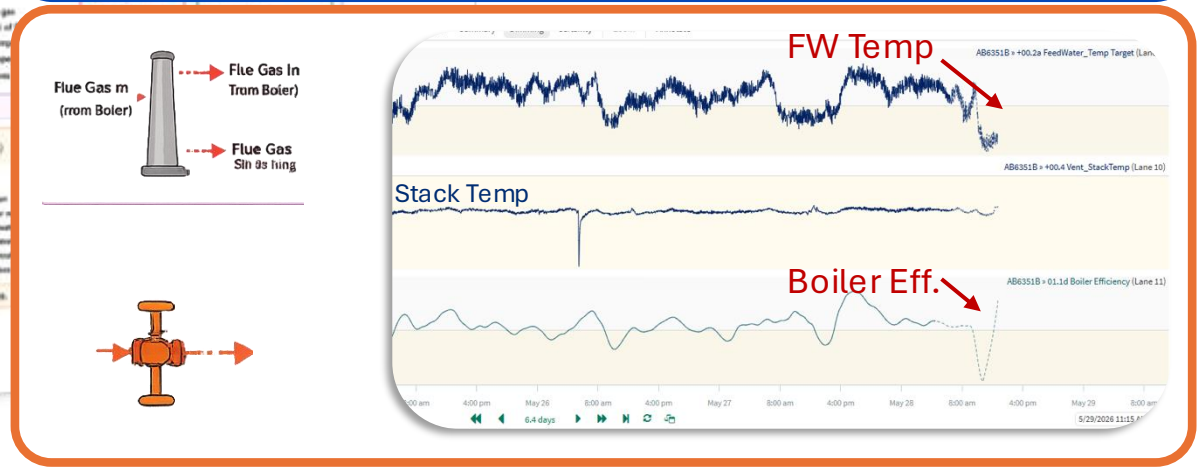
Move beyond trends → validated **engineering calculations**

Not just trends → **Engineering Calculations**
Not dashboards → **Decisions**
Not IT → **Operational capability**

Energy Balance Across Boilers | Identifying Efficiency Gaps







Steam System Improvements | Venting / Let Down Verification

Controls Improvement: Rate Curve Development + NOx Controls + Recirc Strategy

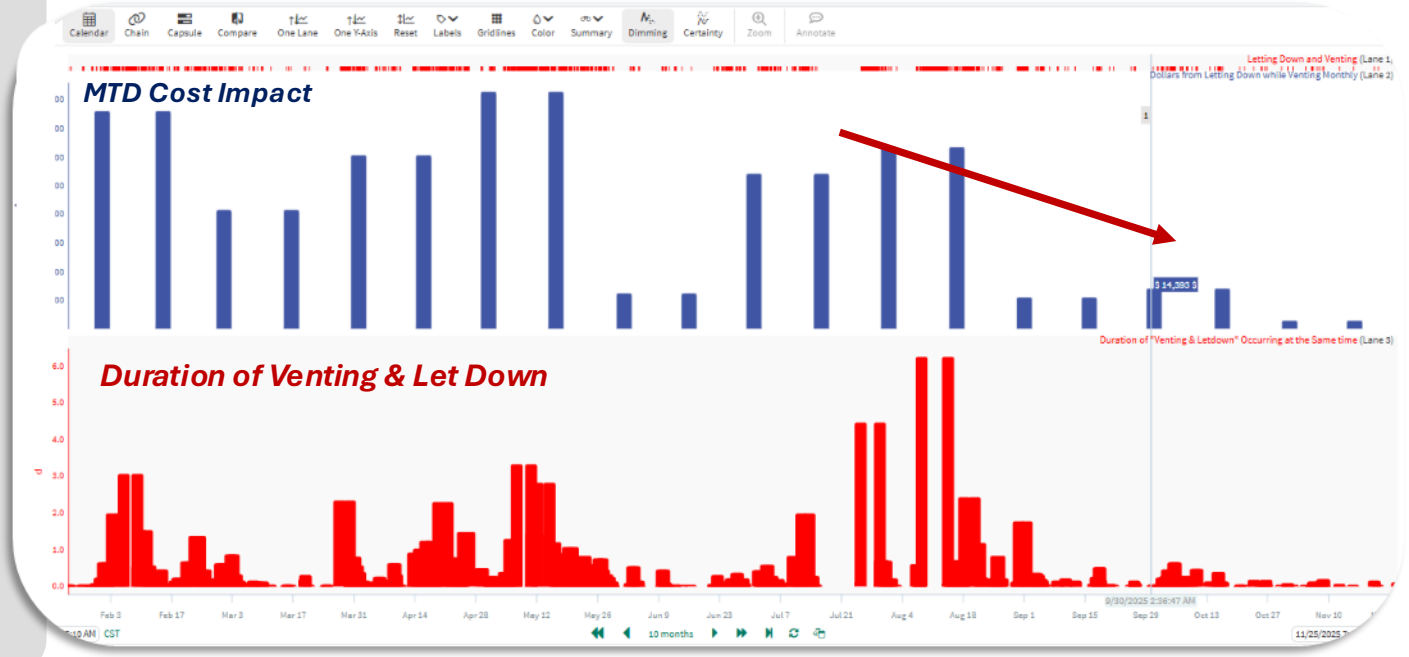
Venting | Venting & Recirc Controls Improvement

Improvement 1:

Letdown while venting was identified as an issue facing the site.

The leading cause of this issue was an increase in NOx being generated at lower fire rates requiring a fire rate higher than needed to comply with environmental limits.

Many of the instruments were skewing the data making typical DCS style data steer you away from the actual issue.



Steam Visibility | Unit Level Focus

Define ***Steam accounting at IVXP is highly inaccurate and manual.***

Part 3. *Unit Efficiency Calculations (Med – Low, level drill downs)*

(Efficiency Drill throughs)

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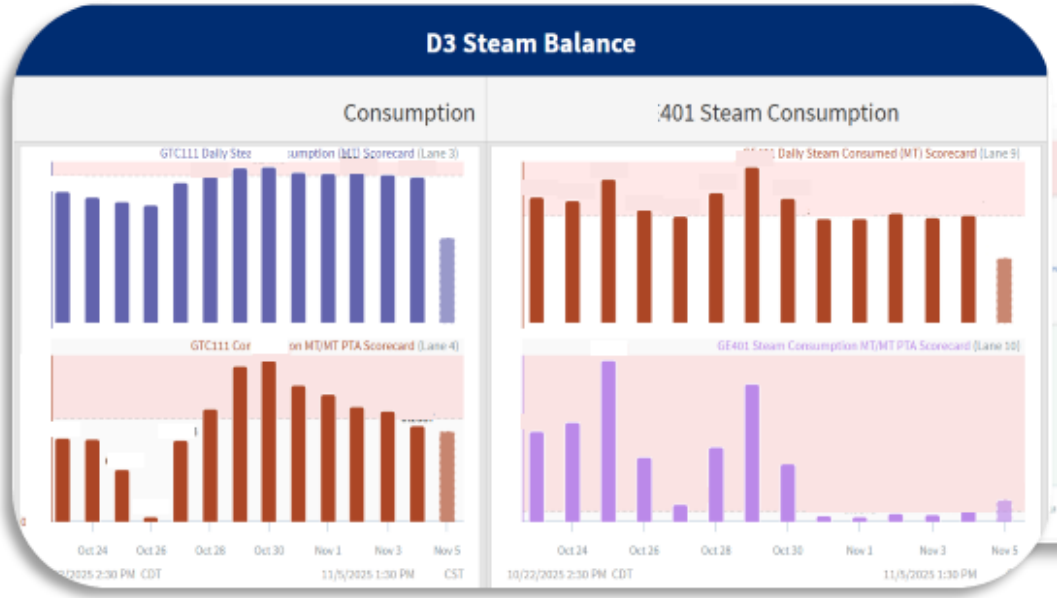
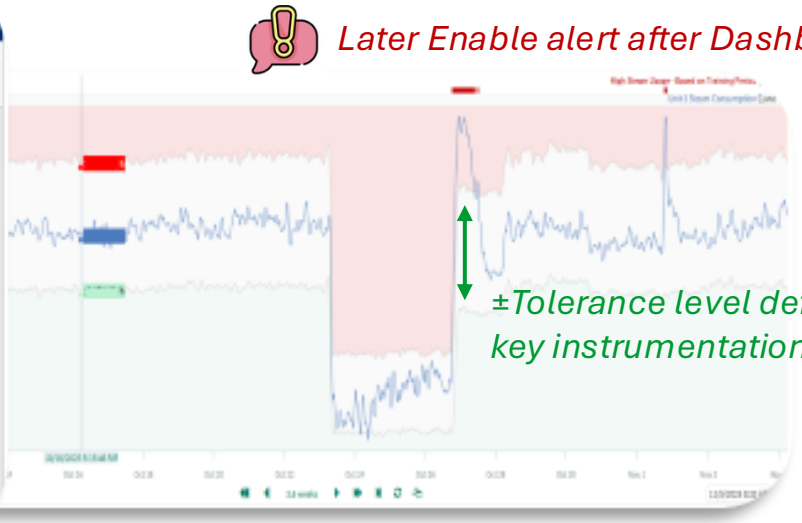




Later Enable alert after Dashboard is finalized

±Tolerance level defined for the key instrumentation

*We have started creating the **Steam dashboard** and **developed Predictive D3 Steam Consumption** based on production rates, using the appropriate time frame for the training period to **highlight tolerance levels.***

Steam Visibility | Turning Steam Visibility into Actionable Findings

IVXP

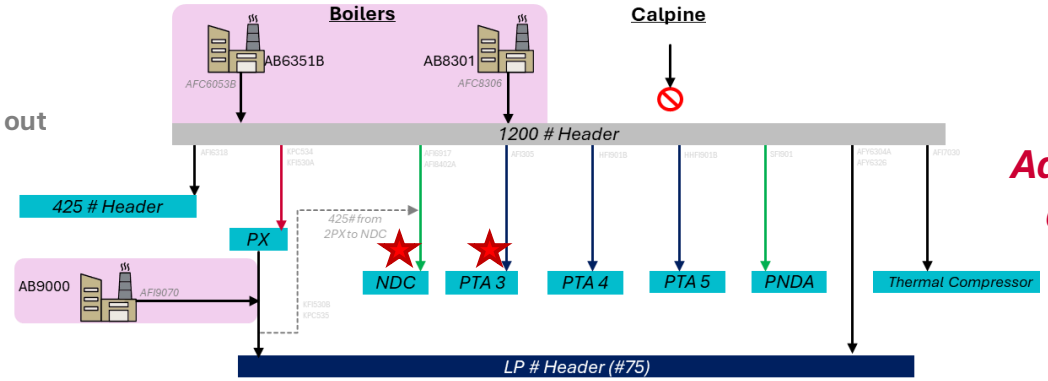
3 Unit Efficiency Calculations
(Med – Low, level drill downs)

Define *Unit Efficiency Calculations (Med – Low, level drill downs)* ***(Unaccounted for Steam)***

Analyze:

(DMAIC)

Steam in (generation + exports) = Steam out (**uses** + vents + leaks)

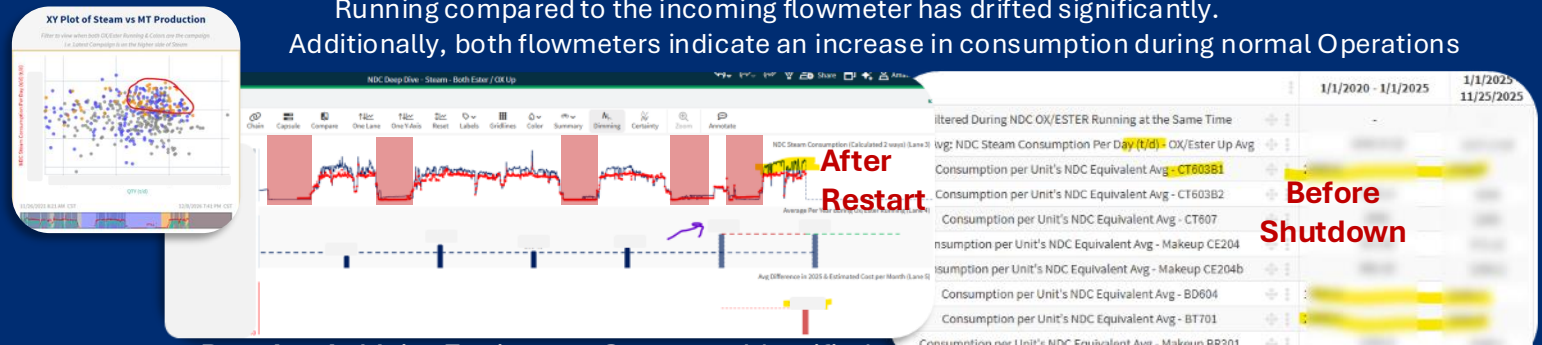


Additional Early Findings *as we drill through Unit Deep Dives*

D3 Shutdown – Observed that "Unaccounted Steam" decreased by nearly 50%.

Investigation Underway

NDC Steam Consumption - Higher than expected Consumption. "Internal Calculation during NDC Ester/NDC OX Running compared to the incoming flowmeter has drifted significantly. Additionally, both flowmeters indicate an increase in consumption during normal Operations



Resolved: *Major Equipment Concerns Identified*

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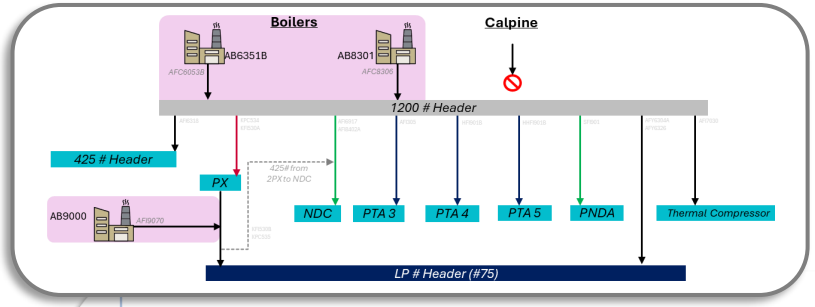
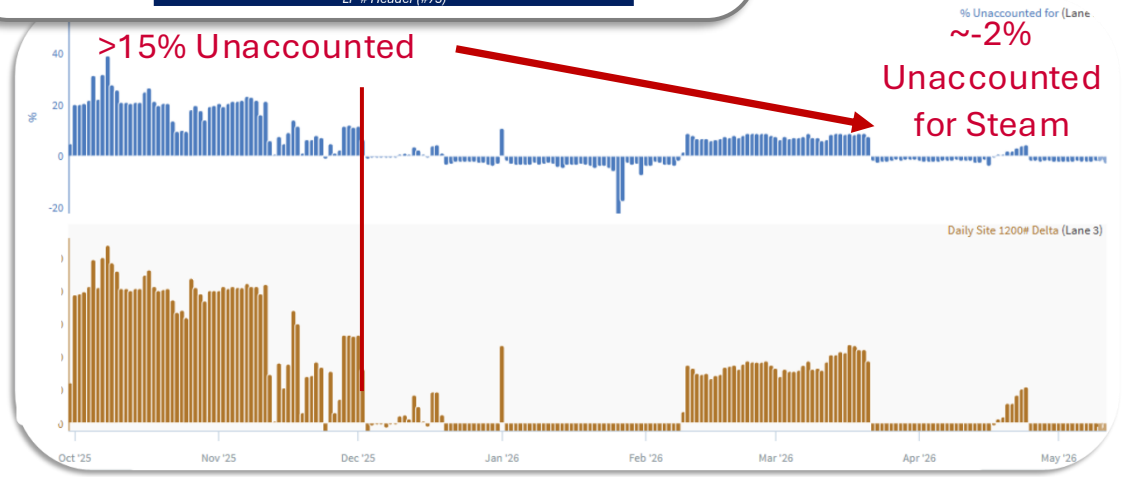
The Results | Site Steam Balance Main Header

Reducing the Gap of Unaccounted for Steam





Building **Trust** in the Data to Drive the Next Level of **Operational Excellence**

Summary for Overall Balance

- Established a site-level steam balance to improve visibility of **generation** vs. **consumption**.
- **Reduced** major sources of **unaccounted steam** through analytics-driven investigations.
- Reduced **unaccounted steam** gap from ~**15% to ~2%.**
- Improved **visibility** of **abnormal losses**, **venting** & **steam inefficiencies**.

Typical Steam Accountability / Balance Closure Expectations*[1]

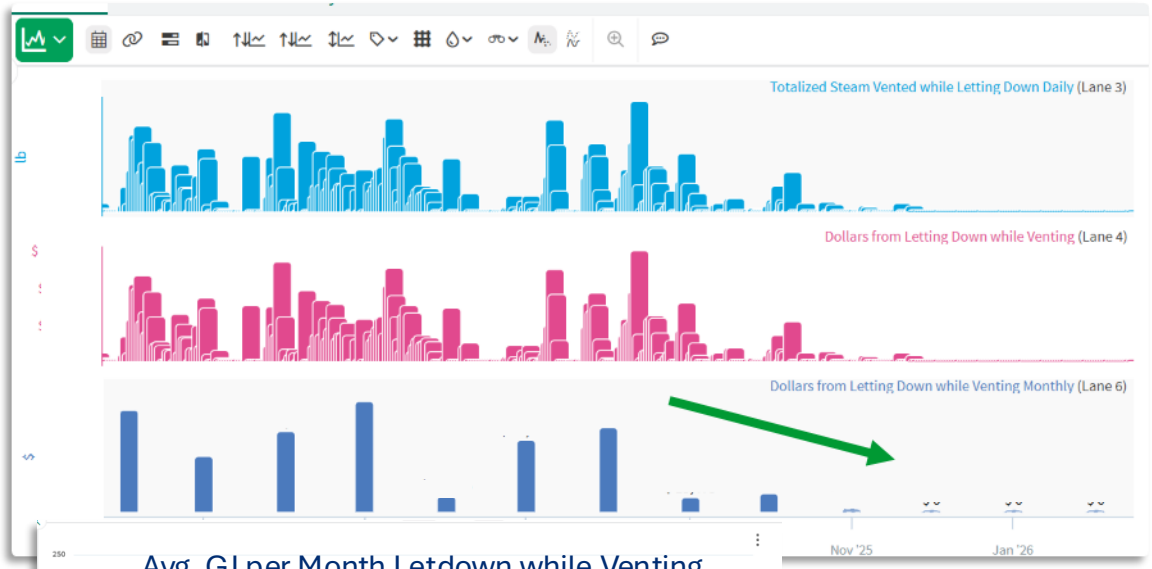
Steam Balance Quality	Typical % Error (Unaccounted Steam)	General Interpretation
World-Class / Best Practice	**< 2%**	Excellent instrumentation, validated condensate return, strong utility analytics
Strong Utility Program	**2–5%**	Typical target for mature sites w/ good metering discipline
Acceptable Manufacturing Range	**5–10%**	Common industrial performance; usually indicates some instrumentation or modeling gaps
Concerning / Investigation Needed	**>10%**	Likely meter drift, missing users, venting, leaks, condensate issues, or bad assumptions
Severe Reliability / Measurement Issue	**>15%**	Significant imbalance; often indicates major instrumentation or operational problems

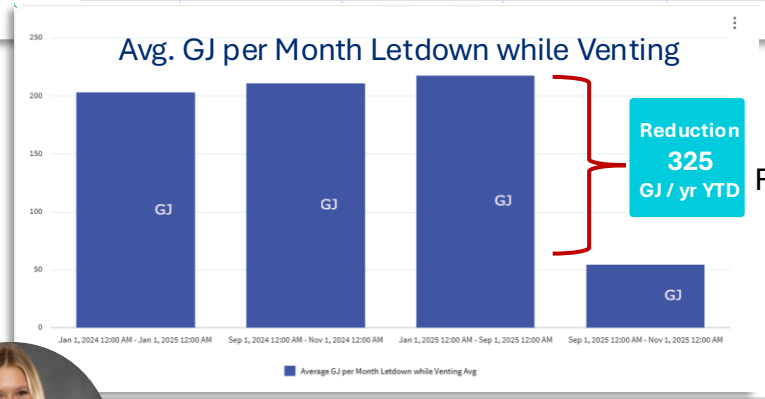
1* **Important Note:** There is no single universal ISO standard that defines acceptable steam balance closure percentage across manufacturing sites. However, guidance is commonly derived from: 1. ISO standards related to flow measurement uncertainty 2. ASME PTC guidance 3. Utility engineering best practices 4. Instrument uncertainty propagation methodologies , etc...

The Results| Waste Energy Opportunities (*Venting & Let Down)*

IVXP – Steam Optimization

Improve: **Part 2 Only**: Venting / Let Down Improvement





From Sept - Dec

DMAIC *(Vented / Letdown Verification)*

Improvement 1:

Letdown while venting was identified as an issue facing the site. The leading cause of this issue was an increase in NOx being generated at lower fire rates requiring a fire rate higher than needed to comply with environmental limits.

In 2024 we had the following averages per month:

1. *142 MT of Steam*
2. *18.5 MT of CO2*
3. *203 GJ of Energy Cost*

The following actions were taken to reduce the time this was required:

1. *Wind box O2 setpoint curves for fire rate.*
2. *Flue Gas Recycle setpoint curves based on fire rate*
3. *Flue Gas Recycle was placed in control as opposed to manual*

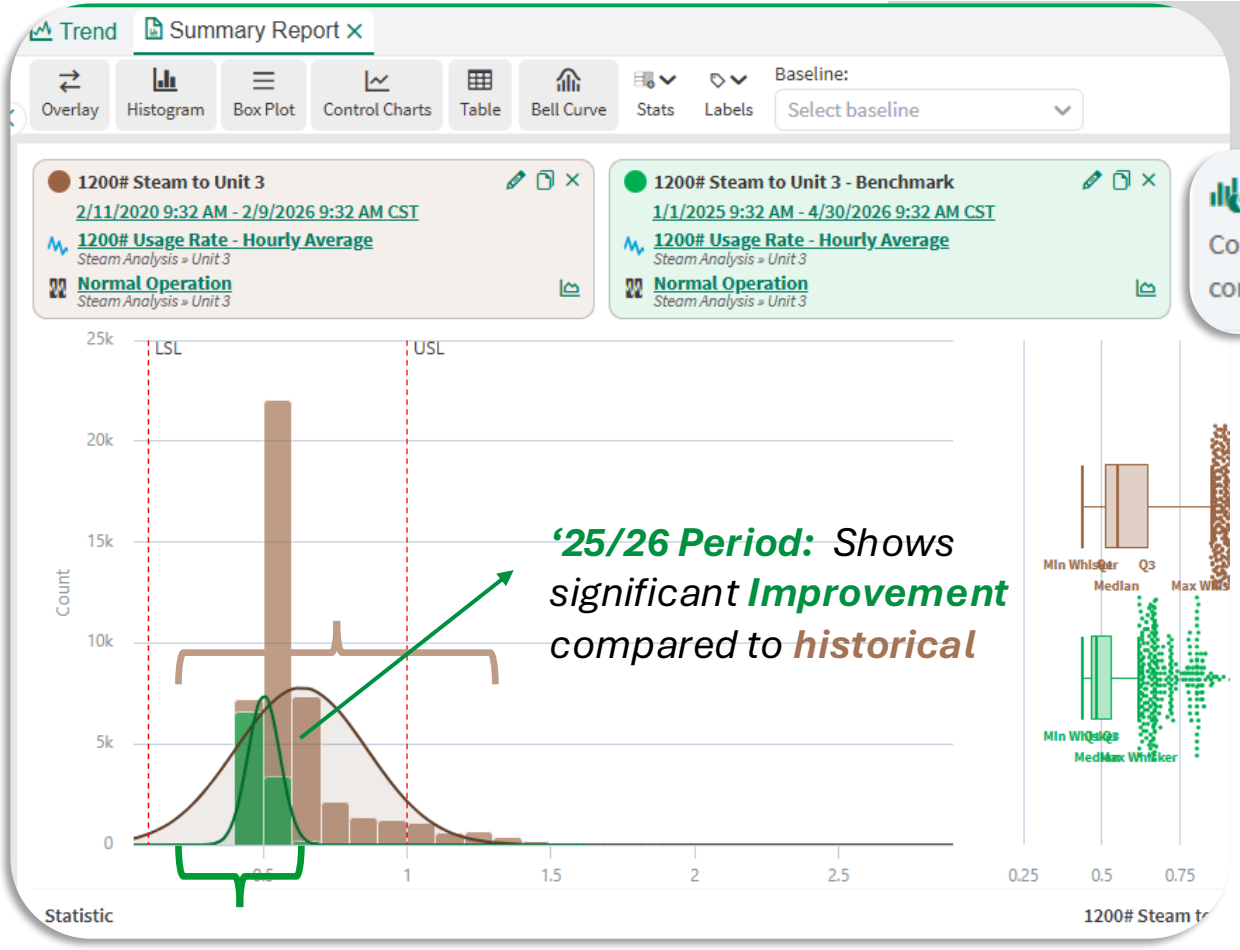
These changes in September 2025 to November 2025 has given these results:

1. *Saving **13.5 MT of CO2 production** a month on average*
2. *Saving **148.5 GJ of wasted energy** a month on average*

Special thanks to the Utilities **Process Engineer**, **Area Manager**, **Operations**, **Controls Engineer**, and entire **Utilities Team** for successfully driving this fantastic improvement to completion.

The Results | *Unit 3 Drill Down (1200# Performance)*

Reducing Steam Variability Through Benchmark-Based Operational Control



‘25/26 Period: *Shows significant* ***Improvement*** *compared to* ***historical***

Significantly Stabilizing Unit 3 Steam Usage

Statistical analysis **tool** enable **Faster** Operational **Insights**

Quickly identify shifts, variability, and abnormal performance

Score Card Visibility & Tolerance Levels

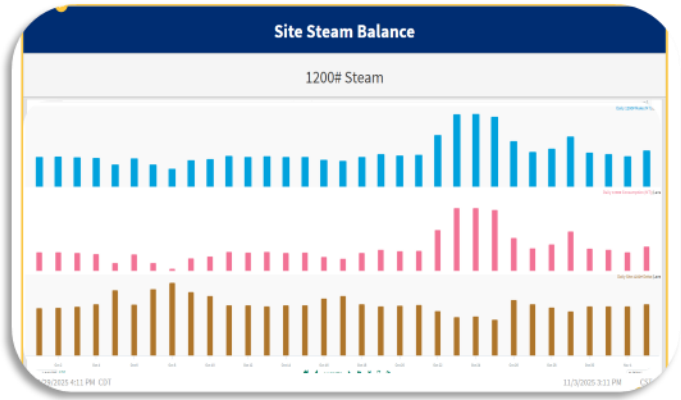
The baseline is now readily established through statistical analysis.

Summary: SteamVision

Define ***The loss is visible… The source is not too, now!*** ***(DMAIC)***

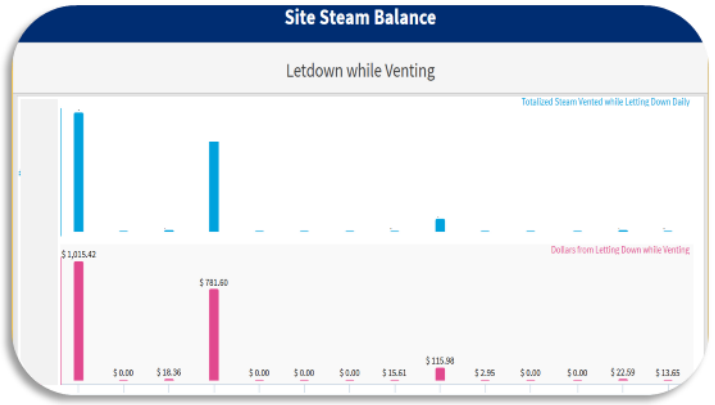
Measure: **Steam in (generation + exports) = Steam out (uses + vents + leaks)**

1 Overall Steam Generators / Consumers (High Level)



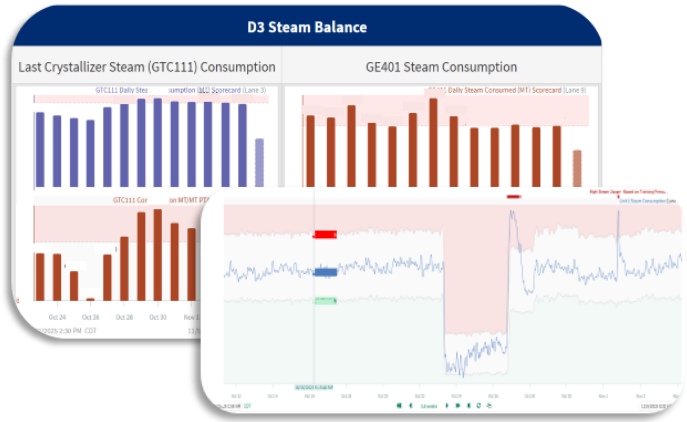
Evergreen: Monitor & Detect Unexplained Discrepancies Between Produced & Confirmed Usage

2 Venting / Let Down Verification



Complete: Check Main Venting and Letdown scenarios and address any issues.

3 Unit Efficiency Calculations (Med – Low, level drill downs)



On Going: Create Unit Drill down with Score Cards & Predictive Usage based on Historical Benchmark

Digital Front-Tier | *What's Next?*

Amplifying Engineering Impact: When Engineering KPI's are embedded into Operations Daily KPI Workflows

Empower Frontline Teams
Enable operators and supervisors with intuitive dashboards and clear insights.

Identify in Terms of Cost
Translate issues into cost impact to make opportunities tangible and actionable.

Drive Priority
Focus on the biggest cost and performance opportunities to maximize impact.

Create Daily Habit
Make data-driven decision making part of everyday operations.

Deliver Sustainable Results
Continuous improvement through engaged teams and measurable outcomes.

When frontline teams have the right analytics — and understand the operational and cost impact — they can make smarter decisions every day and drive measurable results.

Analytics in Every Hand. Impact at Every Level.

Digital x IVEX x Sustainability

ADVANCED INDUSTRIAL ANALYTICS

#All_IN Analytics in Every Hand. Impact at Every Level. 2026

AN INDISPENSABLE MEMBER OF INDORAMA VENTURES