

Unlocking Furnace Energy Savings Potential: A local Consortium Approach to Deploying Machine Learning

The Northwest Ohio Innovation Consortium
GMIC Glass Problems Conference, 2026



**NORTHWEST OHIO
INNOVATION CONSORTIUM**

POWERING INNOVATION TOGETHER

Unlocking Glass Furnace Energy Savings: A Hybrid Physics –AI Digital Twin Approach

The Comprehensive Innovation Consortium Model

PRESENTERS

Dr. Donghui Zhao

Associate Professor, University of Toledo
(UToledo) & Director of Glass Research, NOIC
Glass and Solar Innovation Hub

Matthew Kirian

NOIC Process AI Technical Program Manager,
NOIC Glass and Solar Innovation Hub

KEY COLLABORATION

Academic & Regional Hub

University of Toledo, Northwest Ohio Glass
and Solar Innovation Hub (NOIC)

Industry Partners

O-I Glass, Owens Corning, Libbey, NSG
Pilkington

Agenda

01

The Challenge & Strategic Consortium Vision

~5 mins

- **Consortium Approach:** Overview of NOIC and its position as a global glass innovation hub, backed by the state of Ohio
- **The Strategic Consortium Roadmap:** Aligning 4 technical pillars to target 4–5% furnace energy reduction, leveraging the consortium model

02

The Dual Data Engines

~9 mins

- **Dual-Platform Approach:** Bridging high-variability pilot data at TAGG with production scale furnaces
- **Data Engine 1:** Diagnostic capabilities and optical/thermal profiling at TAGG gas-fired research furnace
- **Data Engine 2:** Solves transport phenomena and builds synthetic CFD datasets

03

AI Predictive Core & Twin

~6 mins

- **Surrogate Architecture:** Encoder–Decoder & CNN framework delivering 10x–100x CFD speedup
- **Real-Time Estimation:** Inferring 3D temperature fields and batch conversion lines in under 1 minute

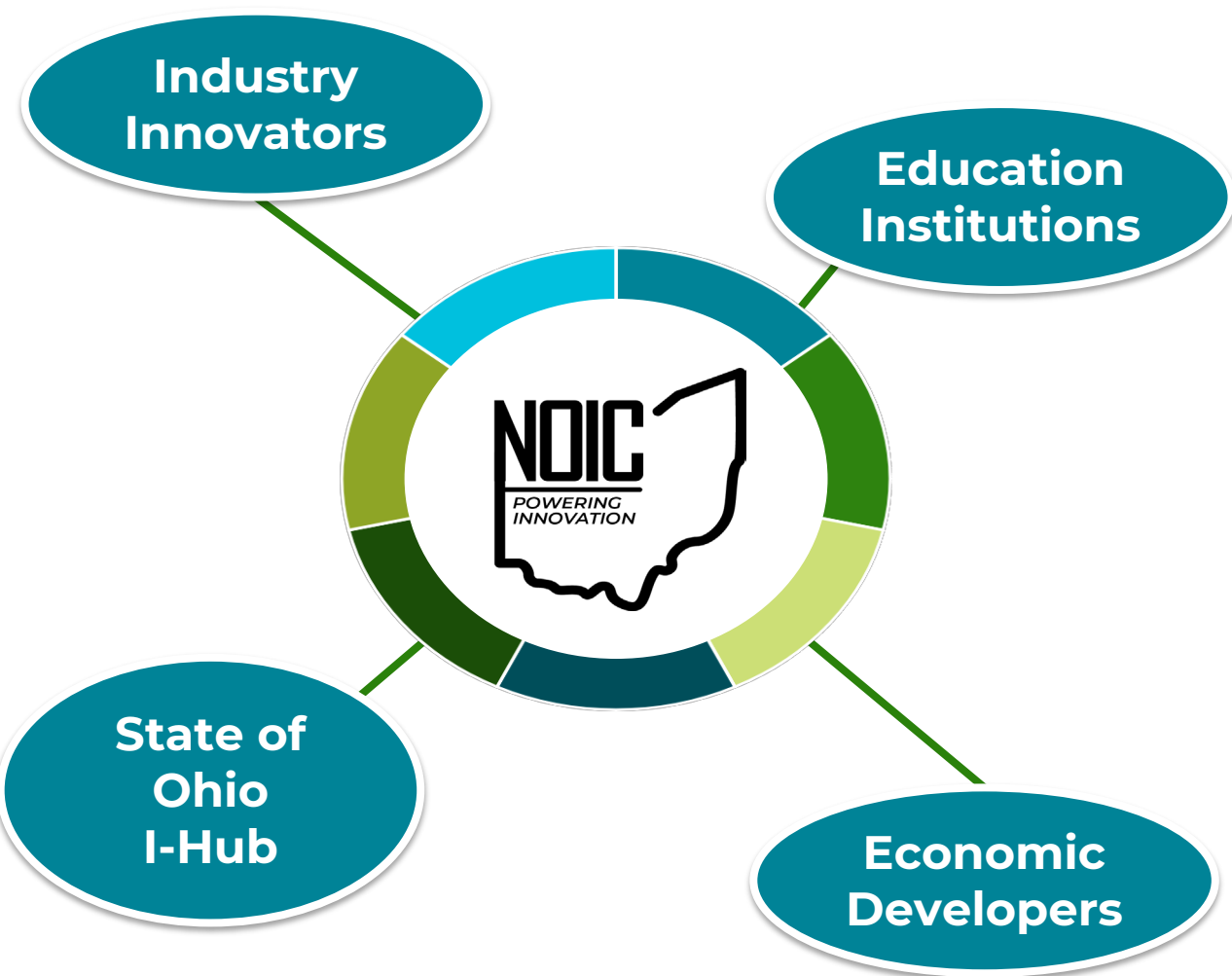
04

Supervisory Control & Roadmap

~10 mins

- **Closed-Loop Control:** Human-in-the-Loop setpoint optimization and IRIS glass expert system
- **Performance Gate Metrics:** Target accuracies (10–15% error) and deployment timeline through 2028

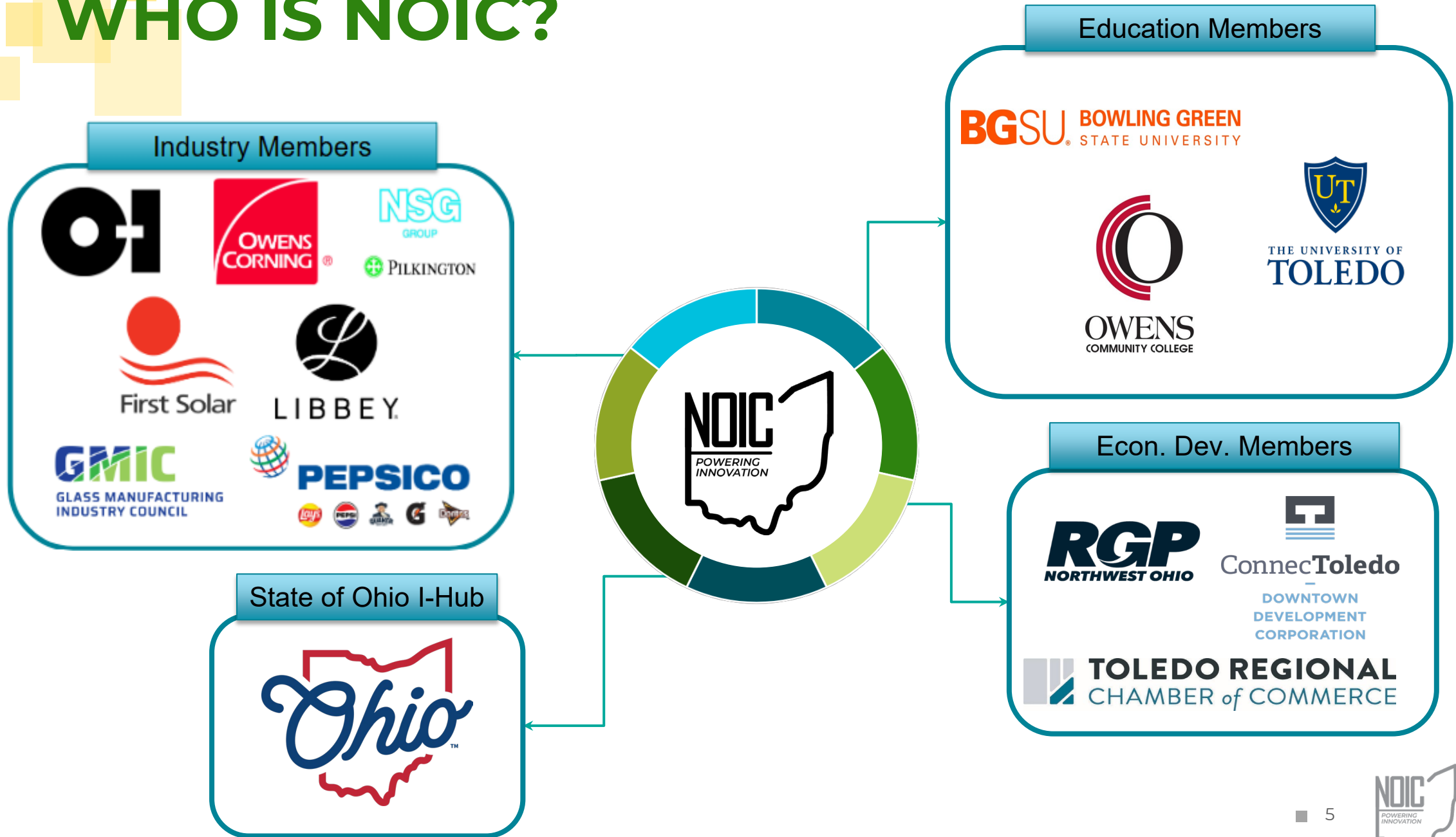
WHAT IS NOIC?



MISSION:

Act as a platform for collaboration between local industries, education partners and workforce development organizations serving to catalyze technology commercialization, talent development pipelines and sustainable manufacturing for all regional stakeholders.

WHO IS NOIC?



GLASS & SOLAR HUB FOCUS & RESULTS:

Industry Talent Development

Engaging students from high school to PhD with STEM programs, paid internships, and career pathways

Melting Technology

Enhancing furnace efficiency, longevity, and performance

AI Process Control

Advancing energy optimization, process control, and consistency, and quality/safety process improvements

Recycling System Optimization

Maximizing efficiency and utilization of the recycling stream

Glass Surface Treatments

Improving strength, durability, and lightweighting

Glass Melting Fuels

Commercializing alternative fuels & supporting infrastructure

Electrification of Fining & Conditioning

Converting key stages of the melting process to electric power, including annealing and post processing

July 25, 2025

IMPACT METRICS



NEW FTE JOB
CREATION
1,600



NEW STATE TAX
REVENUE
\$25M



TOTAL ECONOMIC
IMPACT
\$248M



NEW
STEM GRADS
230

New Catalyzed Investment,
New Research Dollars, Outside
Capital

Completion within 5 years –
Associates,
Baccalaureate, and Graduate

NORTHWEST OHIO INNOVATION HUB PROGRESS

Milestones Achieved

Glass Center of Excellence



UT Glass Science: Dr. Zhao joins UToledo to lead glass science technologies program

Labs: NOIC Cullet Lab, UT Glass Science Lab, BGSU Materials Science Lab Active

AI Process Control



IRIS Expert: Phase 1 validation 90% complete, Phase 2 active

Furnace Control AI: Optimization modeling 95% complete

Talent Development



STEM Interns: 198 sponsored positions, exceeding the target

Camps: 30 summer camps supported over 2 years, for both students & educators

Recycling Optimization



Research: System development for solar & industrial cullet streams

Collection: GRIT system expanded to bars & events, collected > 260 tons in 1st year

Furnace Improvements



3 Projects Active: Energy management insulation, New formulations of refractory, Refractory monitoring system

Electrification



Core Team: Active determination of highest value projects

Approach: Finalizing forehearth & lehr electrification business cases

Alternative Fuels



Testing: Validating burner performance during fuel transitions

Dr. Zhao's UToledo Glass Research Programs

1. HF-Free Chemical Analysis Methods

Role: Dr. Zhao (Testing & Methods Director / Adviser)

Objective: Eliminate corrosive and toxic hydrofluoric acid (HF) in glass analytical procedures, developing alternative methods for iron speciation.

Partners: Sponsored by NOIC; collaborating with Owens Corning, O-I Glass, Libbey, and NSG Group.

2. Pilot-Scale Research Furnace (TAGG Platform)

Role: Lead Investigator (Construction, Instrumentation, & Data)

Scope: Developing a highly instrumented pilot-scale research furnace housed at Toledo Area Glass Guild.

Capabilities: Acts as an experimental "data engine" utilizing thermocouple arrays and high-speed flame imaging to train AI models.

3. Enhancing Radiative Heat Transfer via Fuel Additives

Role: Project Lead

Scope: NOIC-funded initiative to enhance flame radiative heat transfer in gas-fired furnaces through fuel chemistry and natural gas additives.

Integration: Directly supports the physical construction of the TAGG furnace and feeds empirical combustion datasets into AI models.

4. Glass Science & Workforce Programs

Role: Program Creator & Regional Industry Liaison

Scope: Building an interdisciplinary glass research and education curriculum at UToledo, bridging academia with manufacturing.

Collaboration: Partnering with regional leaders, including Owens-Illinois, Owens Corning, NSG Pilkington, and First Solar.

The Energy Challenge & Process Blindness

Energy Baseline

Operating Temp: Continuous operation exceeding **1,400°C**.

Consumption: Highly intensive, consuming **4–8 GJ per ton** of glass.

Scale: Production often exceeds **100-500 tons/day** per furnace.

PHYSICAL PROCESS

Extreme Temps (>1,400°C) limit physical sensors, leaving operators blind.

Process Blindness

The Core Problem: Batch melting is the main operational bottleneck and most energy-intensive stage.

In Situ Limits: Extreme internal environments prevent direct in-furnace sensing.

Unobservable States: Cannot directly trace batch conversion or reaction progression.

THE REAL-TIME CONTROL GAP

Physics simulations are too slow, and operators must act reactively.

Current Limitations

Reactive Control: Traditional operator experience and external sensors lead to narrow operating windows.

CFD Simulations: Highly accurate physics models, but far too computationally slow for real-time adjustments.

NUMERICAL SIMULATION

CFD models are highly accurate but too computationally heavy for live control.

The Strategic Consortium Framework

Strategic Roadmap

Path to Closed-Loop Energy Optimized AI Control (2026–2028 Horizon). Powering automated, intelligent control systems from input to final product.

CORE TARGET

4–5% furnace energy reduction and **10%** reduction in raw material upsets through AI-driven supervisory control.

Pillar 1: Energy Control

Focus: Multi-Objective AI setpoint logic

Goal: Closed-loop supervisory control

Pillar 2: Quality Sensing

Focus: In-line optical & gas monitoring

Goal: Real-time quality feedback loop

Pillar 3: Digital Twins

Focus: Physics-informed surrogates

Goal: Predictive engine (<1 min latency)

Pillar 4: Raw Material

Focus: Batch/cullet characterization

Goal: Feed-forward upset prevention

Enabler A: Data & IP Anonymization

Focus: Secure anonymization engine preserving >95% model utility while protecting member IP.

Timeline: Q3 2026 – Q2 2027 prototype and validation.

Enabler B: IRIS Decision Support

Focus: Deploying "IRIS" glass melting chatbot using RAG to surface cross-pillar insights.

Timeline: Phase 1 deployment in 2026 H2; Phase 2 proprietary integration Q4 2026.

Dual-Platform Strategy: TAGG vs. Production

THE INDUSTRIAL DATA BOTTLENECK

Problem: Industrial furnaces run under strict, static conditions to protect assets and product quality.

Impact: This produces narrow datasets that lack the high variability required to train AI and ROM models.

TAGG Mini Furnace (Pilot Scale)

Location: UToledo / TAGG

Core Subsystem Focus:

- Focused specifically on the **batch-to-melt conversion** subsystem.

High-Variability Design:

- Built for continuous, highly flexible experimentation.
- Rapid testing of diverse burners, raw additives, new sensor technology, and variable feed rates.

Production Twins (Industrial Scale)

Partners: O-I, Owens Corning, Libbey, Pilkington NA

Full Furnace Integration:

- Plan to scale to commercial glass furnace operations (combustion, melt tank, and fining stages).

Direct Value Transfer:

- AI methodologies and learnings validated at TAGG are transferred seamlessly to commercial production assets.

The TAGG Pilot Gas-Fired Research Furnace

Experimental Platform Infrastructure

(Commissioning 2026)

- **Toledo Area Glass Guild (TAGG):** Gas-fired research furnace location.
- **Process Simulation:** Dedicated to simulating flame–batch–melt interactions under tightly controlled conditions.

Furnace Integration Flow

Flame Imaging & Radiative Spectra

In Situ Optical Diagnostic Input

TAGG Pilot Batch-Melting Furnace

- Batch Loading Mechanism
- Molten Glass Bed (Constant Temp)
- Exhaust Gas & PM Profiling

Batch & Melt Depth Thermocouple Arrays

Traditional Thermal Profiling Feedback
New Experimental Temperature Sensing

Key Instrumentation & Diagnostic Capabilities

In Situ Optical Diagnostics

High-speed flame imaging, spectral radiation, and real-time batch surface evolution mapping.

Multi-Point Thermal Profiling

Thermocouple arrays strategically embedded across batch depth, roof structure, and side walls.

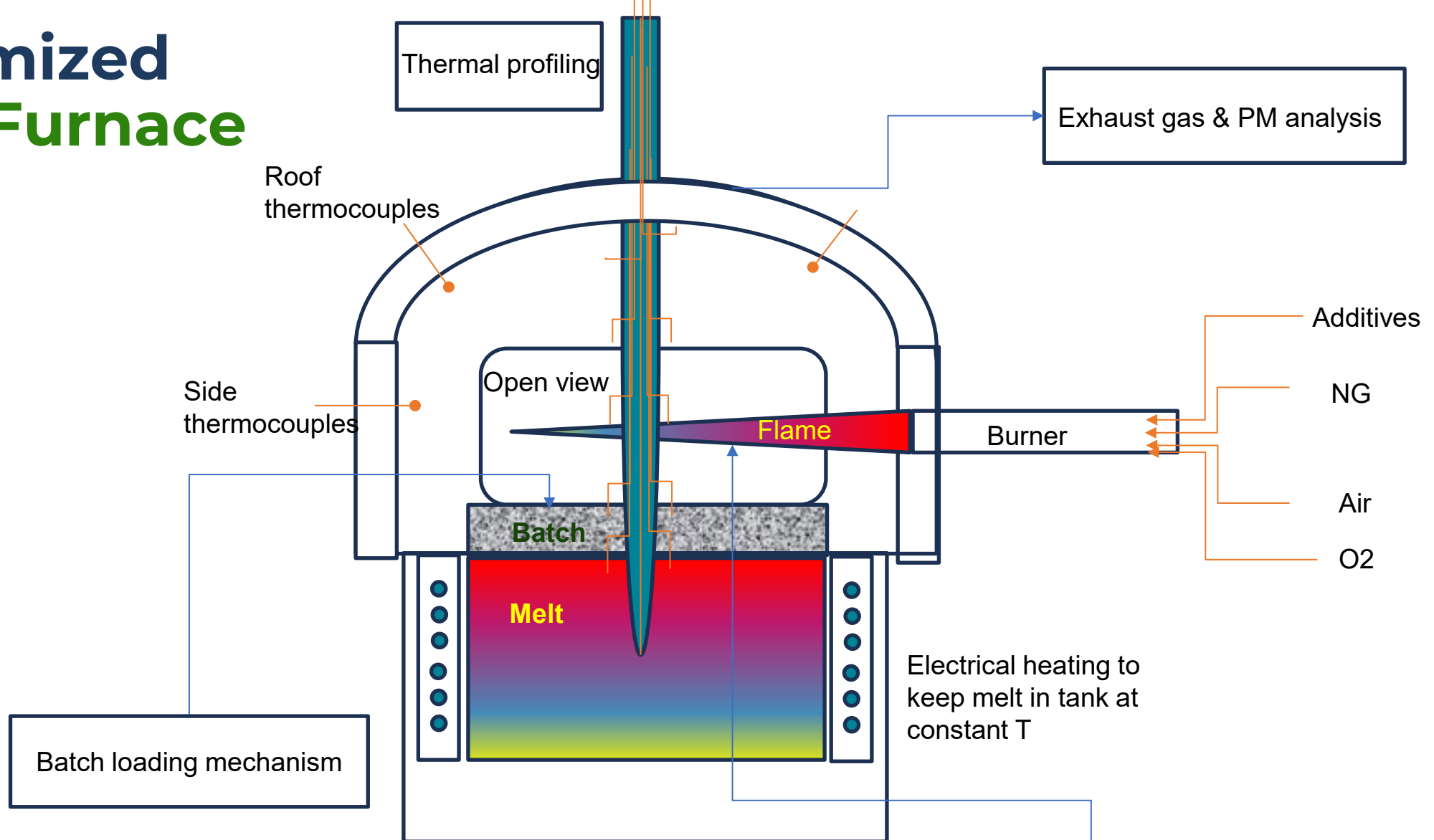
Exhaust Analysis

Continuous, real-time gas composition monitoring and particulate matter (PM) emission tracking.

Modular Testing

Highly flexible plug-and-play burner designs, direct support for natural gas additives, and adjustable pull rates.

Customized TAGG Furnace



TAGG Advantages

- Pre-pilot size, flexible, In person access as demand
- Molten glass bed for flame-melt coupling study
- Thermal profiling for direct study of melting rate
- Plug-play burner suits for other NOIC projects

Flame characterization
module

Data Engine: Physics-Based CFD & Synthetic Datasets

Role of CFD in the Digital Twin Pipeline

- **Solves high-fidelity transport phenomena:** combustion chemistry, radiative heat transfer, and melt thermal-fluid dynamics.
- **Generates synthetic datasets** across conditions entirely beyond physical testing capabilities.

The Transition to AI

CFD serves as the essential **physics foundation**, providing the ground truth data required for modeling rather than acting as the real-time execution engine itself.

Supports validation of Reduced Order Modeling.

CFD Workflow & Expansion

Stage 1: Baseline CFD

Baseline CFD geometry and initial simulation mapping to at least 3 operating states (≥ 3).

Stage 2: Parametric Expansion

Expansion of parameters to cover a broader space of more than 10 operating variables (> 10).

Stage 3: Full Dataset Generation

Full synthetic dataset generation encompassing more than 20 comprehensive operational states (> 20) to power AI training.

Predictive Core: Physics-Informed AI Surrogate Models

Stage 1 (CFD-Trained)

Encoder–Decoder compresses high-dimensional CFD thermal/flow fields into a low-dimensional latent space. A Multilayer Perceptron (MLP) maps furnace operating parameters directly to this latent space.

Stage 2 (Hybrid Refinement)

Integrates Convolutional Neural Networks (CNNs) to ingest real-time spatial flame imagery and thermal sensor feeds from the pilot furnace.

10x–100x

Faster

Computation Speed

Dramatic acceleration in execution time incorporating traditional CFD

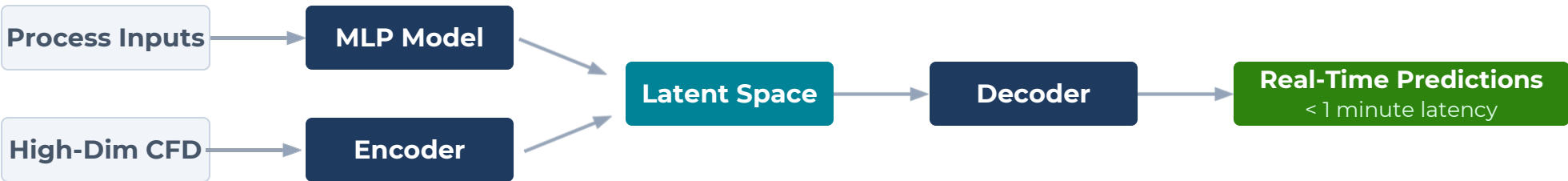
< 1 min

Latency

Real-Time Latency

Generates complete, highly accurate temperature and batch-state predictions almost instantly.

Surrogate Model Pipeline Flow



Closed-Loop Supervisory Control & Energy Optimization

Human-in-the-Loop Supervisory Control

- **AI Supervisory Optimizer:** Calculates optimal setpoints for fuel-air ratios, burner staging, and batch feed rates.
- **Operator Guidance:** Receives clear setpoint recommendations equipped with automated override limits.

Cross-Pillar Support: IRIS Chatbot

Integrated with **IRIS Glass Expert (Chatbot)** to explain complex AI recommendations to furnace operators and engineers in intuitive, plain language.

Multi-Objective Optimization Balance

- **Maximize Thermal Efficiency**
Action: Minimize GJ/ton to reduce fuel usage and environmental footprint.
- **Maintain Glass Quality**
Action: Minimize seed/blister counts and maximize R values dynamically via integration with Pillar 2 feedback.
- **Stabilize Production Throughput**
Action: Ensure consistent, predictable flow rates to avoid downstream manufacturing delays.

Control Loop & Recommendation Pipeline



Milestones, Performance Gate Metrics & Future Outlook

Key Performance Gate Metrics

10–15%

Predictive Accuracy Error

Or lower error against physical pilot furnace validation data.

10x–100x

Speed Advantage

Speedup with under 1 minute prediction latency.

≥30%

Data Scaling

Error reduction when moving from CFD-only to hybrid training.

≤20%

Generalization

Maximum error on completely unseen operating regimes.

Path to 2028 Horizon

2026

Pilot Furnace Commissioning

Commissioning of TAGG furnace and all process AI Pillar Scopes

2027

Prototype Deployment

Deployment of production twin prototypes at member sites

2028

Closed-Loop Control Active

Full closed-loop supervisory control active across partner industrial facilities.

Thank You!

Powering Innovation Together



**NORTHWEST OHIO
INNOVATION CONSORTIUM**

POWERING INNOVATION TOGETHER