WHITE PAPER

Envia revisited: From demonstration to deployment

Performance highlights and key learnings from operating Velocys microchannel Fischer-Tropsch technology at commercial scale

VELOCYS

FT SYSTEM

operated on a commercial scale

6,000 HOURS

of cumulative operation were achieved

1.6 MILLION

liters of low-carbon liquids produced

EXPERIENCE

critical to reducing future deployment risks

Executive summary

The Envia facility in Oklahoma City represents one of the most significant commercial demonstrations of modular Fischer-Tropsch (FT) technology using landfill gas as a feedstock. Developed as a first-of-a-kind (FOAK) project, Envia provided a real-world operating environment to validate microchannel FT performance at commercial scale.

Key conclusions from Envia operations are clear:

- The FT system operated on a commercial scale, not laboratory or pilot conditions
- System performance met or exceeded modeled expectations, as independently evaluated
- Over 6,000 hours of cumulative operation were achieved across two commercial-scale reactors
- Approximately 1.6 million liters of low-carbon liquids were produced
- A single reactor was compromised due to an external coolant system transient, not a flaw in reactor core design
- Independent investigation confirmed the event originated in the ancillary coolant system, not a flaw in FT reactor core design
- Corrective actions were implemented, validated in operation and incorporated into all subsequent designs

Beyond validating performance, Envia generated critical operating experience that strengthened system design, improved reliability and reduced risk for future commercial deployments.

Prepared by Velocys Technology and Operations, September 2026

Commercial context: Why operating history matters

For first-of-a-kind energy systems, credibility is established through sustained operation under real-world conditions, not theoretical design or pilot-scale demonstrations.

Operating history provides three forms of validation that cannot be replicated through modeling alone:

- Confirmation that observed performance aligns with design expectations
- Demonstration of operational resilience across start-up, shutdown and transient conditions
- Identification and elimination of edge-case failure modes revealed only through extended integrated operation

In this context, Envia represents a significant benchmark for modular Fischer-Tropsch deployment:

- 6,000+ hours of cumulative operation across commercial-scale reactors
- Production of approximately 1.6 million liters of low-carbon fuel

This operating history provides a substantial commercial dataset and enables a clear distinction between:

- Core technology performance, and
- External system interactions within an integrated plant

The reactor event described in this paper occurred within an extended period of successful commercial operation that validated both the performance and durability of the FT system.

Operating history

The Envia project in context

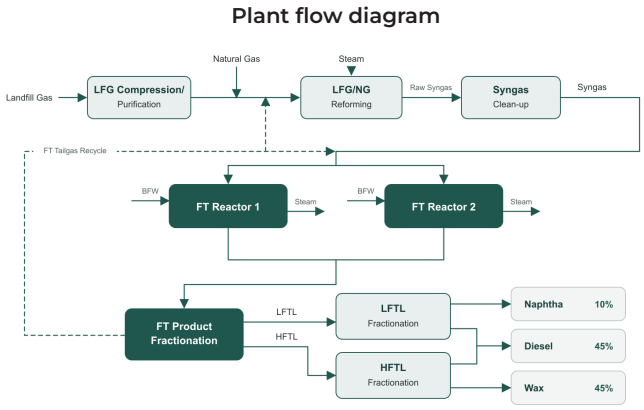
Envia was developed as a joint venture between established industry participants to demonstrate the conversion of landfill gas into liquid fuels using a modular FT configuration.

Key characteristics of the project include:

- **Feedstock:** Landfill gas, supplemented with natural gas as necessary
- **Configuration:** Modular FT system with two parallel trains
- **Capacity:** 200 barrels per day of low-carbon FT fluids
- **Objective:** Commercial validation of compact, distributed FT technology

Unlike pilot systems, Envia operated as a commercial-scale facility, producing renewable diesel and other FT products that were certified and sold into the market.

As a FOAK deployment, the project was designed not only to validate performance, but also to generate operating experience under commercial conditions. This is an essential step in advancing industrial technology toward repeatable deployment.



Simple block-flow diagram of the Envia plant

Performance highlights

The ENVIA GTL Plant achieved “ready for startup” status in February 2017. Initial startup operations ran through June 2017, at which time a turnaround was conducted to modify various units in the plant to enable continuous stable operation.

The turnaround addressed a range of plant-wide issues identified during commissioning and initial startup, including design and implementation deficiencies that hindered stable operation. Key corrective actions included:

- Feed gas conditioning (Unit 100): Replacement of sulfur removal catalyst due to higher than anticipated H_2S levels, and addition of correct molecular sieve dryer media.
- Instrumentation and controls: Extensive updates to temperature control system programming to resolve operational instability and improve reliability.
- Utilities and infrastructure: Upgrades to water treatment system, insulation and heat tracing
- Systems integration: Improvements to plant control architecture, including better integration of local package controls into the basic process control system (BPCS).

These improvements were systemic and involved multiple equipment packages that were outside the boundary limits of the Velocys FT unit, including the feed conditioner, reformer and overall control systems. After the comprehensive turnaround was complete, the plant was brought back online and operations continued.

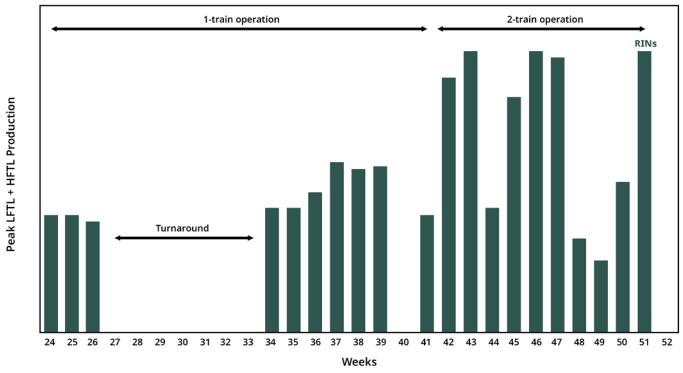
From August to October 2017, the ENVIA GTL Plant operated one of the two reactors (“Reactor 1”), increasing throughput during that window.

The second reactor (“Reactor 2”) was brought online in October 2017. From October 2017 to March 2018, both reactors were in operation in the single-pass mode (no internal tail gas recycle). Later in 2018, the targeted design point was achieved with internal recycle.

Overall, Reactor 1 operated for approximately 2,550 hours and Reactor 2 operated for approximately 3,530 hours, reaching a peak production rate of 200 BPD (9 KTA) of total FT liquid.

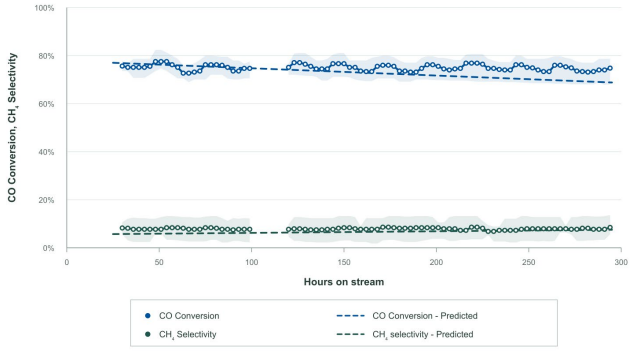
During this period, ENVIA operating records and certificates of analysis (COA) for naphtha, diesel and wax show that the final products being produced met all requirements.

Timeline of operations



Envia plant timeline showing initial single-train and double-train operation.

Plant stability demonstration



The operating data matched predicted data

Note: The CO conversion is per pass and without tail-gas recycle

Performance of the FT system at Envia was independently evaluated, including review by Leidos.
Key outcomes include:

- Strong alignment between observed operating data and process model predictions
- Successful production ramp-up across both reactor trains
- Sustained operation under commercial conditions

The FT unit demonstrated high operational resilience, with only a limited number of shutdown events directly attributable to the FT unit itself.

These results confirm that Velocys' two commercial-scale AlphaCore™ microchannel FT reactors performed as designed.

"A third-party inspector found that an ancillary coolant system was the root cause of the leak and determined the leak was not a result of any flaw in the core FT technology"

- Erin Krueger, Biomass Magazine
"Velocys Announces Close-Out of Envia Joint Venture" 1 May 2019

Key learnings

Reactor event: Incident summary and root cause

Event description

A reactor incident occurred during a transition in the coolant system from superheated steam to liquid coolant following prolonged delay in reaching the transition step.

During this transition, a slug of relatively cold liquid entered the hot reactor system.

Physical effect

The coolant transient caused a rapid temperature change of approximately 128°C (~230°F) resulting in a breach of the reactor's design ΔT limits and a severe thermal shock.

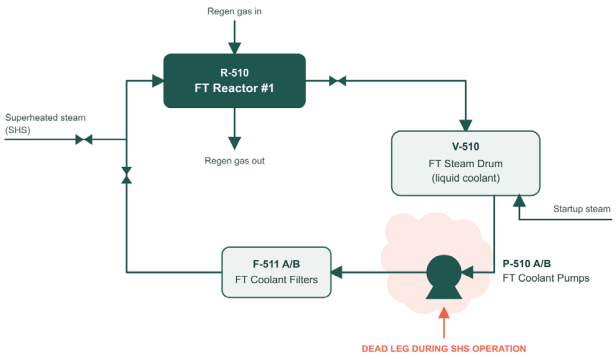
The thermal shock resulted in a cross-leak that occurred in one of the four reactor cores, near the coolant entry point.

Root cause

Investigation determined the root cause to be:

- A dead-leg condition within the ancillary coolant system
- An abnormal restart transient that allowed stagnant coolant to enter the hot reactor

Cooling system with dead leg



Prolonged downtime enabled steam to cool in a dead leg, which introduced a slug of cold water upon restart to the reactor, exceeding ΔT limits.

This was a balance-of-plant issue associated with coolant system behavior during transition operations.

What the event was not

The investigation also established that the event was:

- Not a reactor core design flaw
- Not related to catalyst performance
- Not indicative of a systemic limitation of FT technology

Independent third-party review concluded that the issue originated in the ancillary coolant system and not within the FT reactor core itself.

Engineering analysis: Thermal transients in reactor systems

The incident highlights the importance of managing thermal transients in high-temperature process systems.

While steady-state operation is typically well understood and controlled, transient conditions (including start-up, shutdown and coolant phase transitions) introduce additional engineering challenges.

Critical considerations include:

- Maintaining temperature differentials within defined ΔT limits
- Eliminating stagnant coolant volumes that can generate off-design conditions
- Integrating coolant system behavior with reactor protection requirements

This type of failure mode is not unique to microchannel FT systems. It is a known risk in improperly managed thermal systems across multiple industrial applications.

Velocys reactors are designed to accommodate controlled temperature transitions during operations such as catalyst regeneration. In this case, those limits were exceeded due to an external coolant system transient.

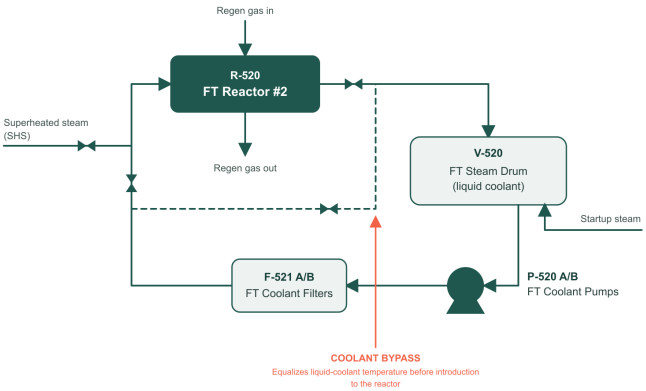
Corrective actions and validation

Following identification of the root cause, Velocys implemented a series of design and operational improvements.

Design and operational changes

- Installation of a coolant bypass loop to eliminate dead-leg conditions
- Removal of stagnant coolant volumes
- Controlled temperature equalization before introducing coolant to the reactor
- Enhanced operating procedures and automated safeguards

Coolant system with a bypass to eliminate the dead leg



Coolant bypass was added and tested on Reactor #2, validating its ability to prevent dead legging in the system and future reactor damage.

Validation

These corrective measures were:

- Implemented on Reactor #2 at Envia
- Successfully validated during catalyst regeneration without recurrence of the event
- Further demonstrated during subsequent SAF production in the Toyo/NEDO project

The identified failure mode was eliminated, validated in operation and incorporated into all subsequent designs.

System-wide learnings embedded in current designs

Lessons from Envia have been integrated across all subsequent Velocys projects.

These include:

- Updated HAZOP analyses explicitly addressing unplanned downtime and this event
- Increased rigor in transient operation procedures and safeguards
- Enhanced coolant system design standards
- Expanded use of independent engineering review and hazard analysis

These changes reflect institutional learning derived from commercial operating experience and have strengthened both system reliability and project bankability.

What Envia demonstrated

The Envia project provided extensive validation of modular FT technology utilizing Velocys' commercial-scale, standard-sized AlphaCore reactors.

Demonstrated capabilities include:

- Commercial-scale operation of microchannel FT systems, confirming predictable performance across capacity by numbering up instead of sizing up
- High operational resilience and availability
- Reactor restart and ramp-up to pre-trip conditions capability within approximately 12 hours
- Catalyst regeneration readiness under real operating conditions (with subsequent effective catalyst regeneration in the Toyo/NEDO project)
- Practical deployment of modular FT systems using distributed feedstocks

Collectively, these results establish a strong foundation for future commercial deployment, where additional AlphaCore reactors can be added to achieve the desired commercial capacity.

By way of example, the Altalto municipal solid waste-to-SAF project in the UK is designed to utilize five AlphaCore 200 reactors to produce a planned 750 BPD (30 KTA) of FT liquid.

Project conclusion: Commercial context

As a FOAK project, Envia operated within a commercial and regulatory environment that evolved significantly over time.

Factors contributing to the conclusion of the joint venture include:

- Changes in renewable fuel credit dynamics and market incentives
- Strategic priorities among project stakeholders
- Commercial readiness associated with early-generation deployments

The conclusion of the Envia joint venture reflected commercial and strategic considerations typical of FOAK energy projects, not limitations of the underlying FT technology.

NovaSAF 1 – Biogas to SAF Pioneering the first electrified biogas-to-SAF plant

From Envia to today: Continued deployment and validation

Operating experience gained at Envia has directly informed subsequent deployments and ongoing commercial projects.

These developments include:

- Successful SAF production in the Toyo/NEDO project
- Advancement of commercial projects including NovaSAF™ 1*, ClearSkies** and others
- Standardization of design and operating practices
- Continued reductions in system cost and complexity

These advancements build directly on the operating experience and engineering learnings established at Envia.

Velocys and SuMo Commission Fischer–Tropsch System at Wednesbury Facility, Advancing UK Waste-to-SAF Pathway

** NovaSAF™ is a trademark of Syzygy Plasmonics LLC ** ClearSkies is a project name belonging to Sustainable Molecules Ltd (SuMo)*

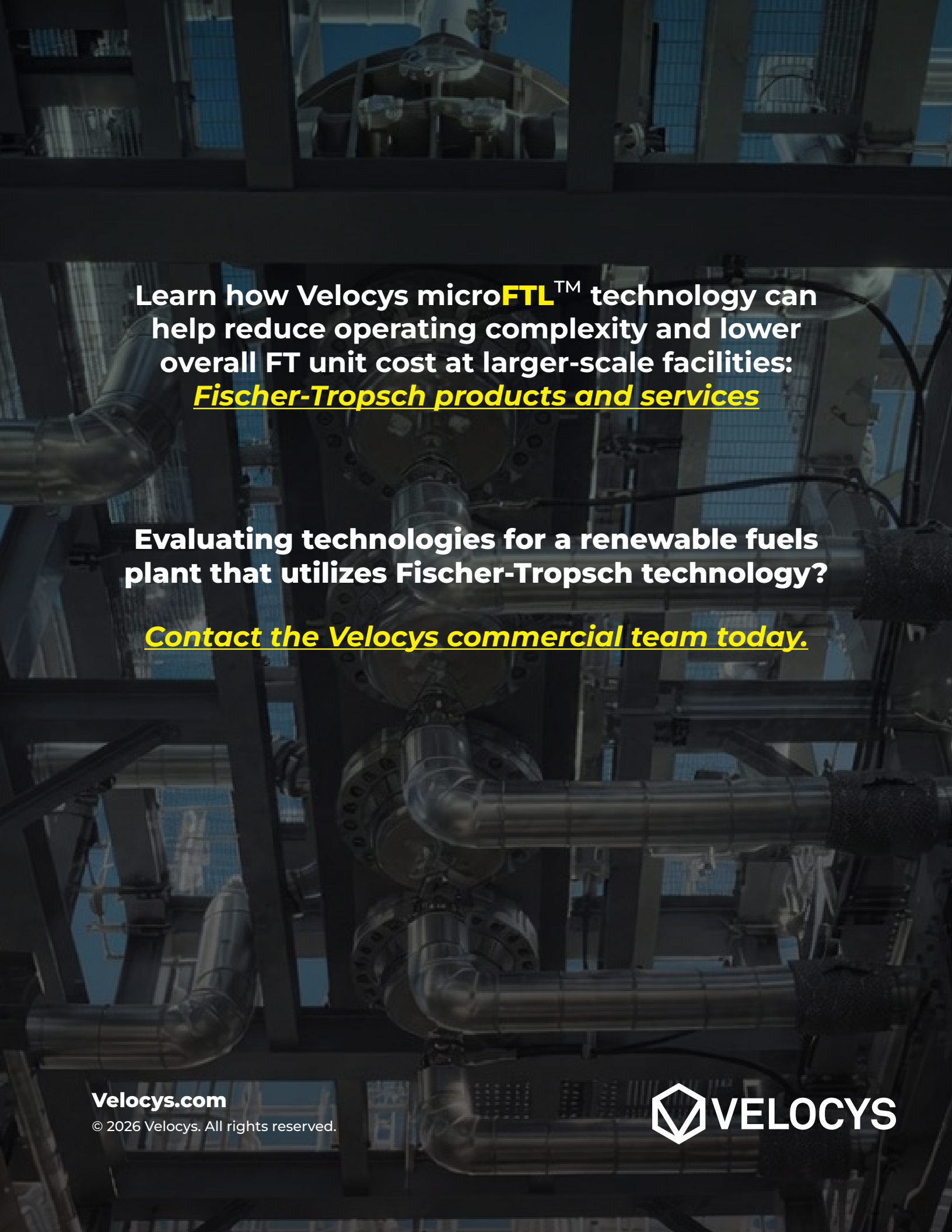
Conclusion

The Envia facility represented a critical step in the commercial validation of modular Fischer-Tropsch technology.

The operating record demonstrates that:

- The FT system performed as designed under commercial conditions
- The reactor incident resulted from an external coolant system transient that has been fully understood and addressed
- Corrective actions were validated in operation and standardized across future designs
- Real-world operating experience strengthened the technology and reduced deployment risk for future projects

Engineering progress is defined not by the absence of events, but by how those events are understood, resolved and incorporated into future systems.



Learn how Velocys microFTL™ technology can help reduce operating complexity and lower overall FT unit cost at larger-scale facilities: *Fischer-Tropsch products and services*

Evaluating technologies for a renewable fuels plant that utilizes Fischer-Tropsch technology?

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