

# White Paper: The Hy.REC Hydrogen Recovery System for Glass Manufacturing

## Introduction

The global glass manufacturing industry is undergoing a major transformation, driven by the demand for enhanced energy efficiency and reduced carbon emissions. HyGear's Hy.REC system, a cutting-edge hydrogen and nitrogen recovery technology, addresses these challenges head-on. Specifically designed for the energy-intensive glass production process, Hy.REC reduces dependency on fossil fuels while improving overall operational efficiency. By capturing and recycling hydrogen and nitrogen, Hy.REC helps manufacturers reduce costs and minimize environmental impact. With a proven track record, Hy.REC is poised to be a critical driver in reshaping the future of glass manufacturing.

## Benefits of the Hy.REC Technology

Hy.REC delivers numerous advantages, making it a game-changer for the glass manufacturing sector. Key benefits include:

1. **Cost Efficiency:** By recycling hydrogen and nitrogen, substantial cost savings are realized. The system offers savings by significantly reducing raw material expenses.
2. **Emission Reduction:** Through hydrogen and nitrogen recycling, Hy.REC helps glass manufacturers reduce their carbon footprint, supporting global sustainability initiatives and environmentally conscious production practices.
3. **Dust Management:** The system collects dust typically emitted into the air, helping mitigate local air pollution in and around manufacturing plants.
4. **Enhanced Glass Quality:** By optimizing gas refreshment, Hy.REC contributes to improved glass quality.

## The Business Case for Hy.REC

Hy.REC offers a compelling business case for glass manufacturers:

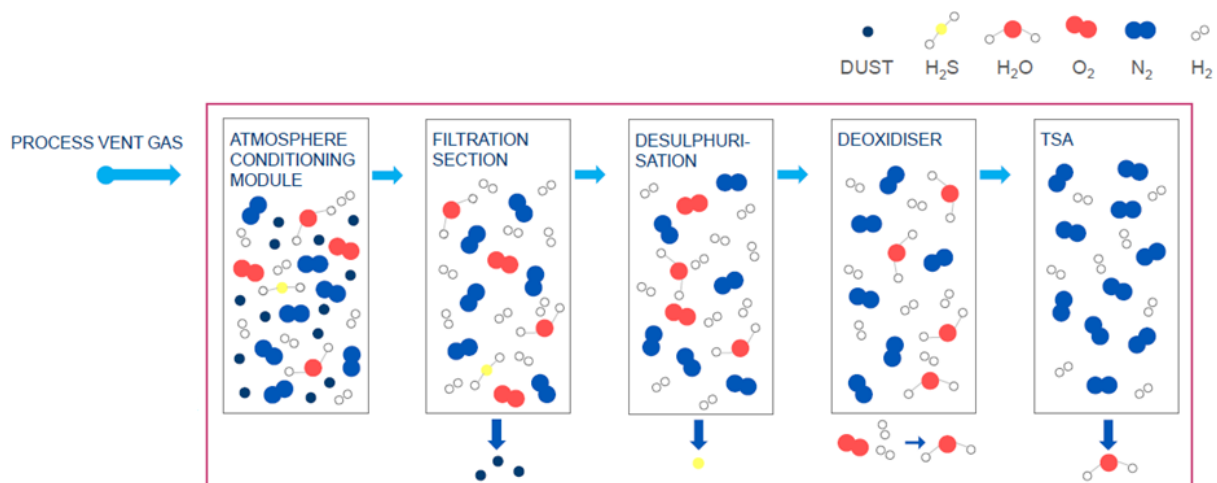
1. **Reduced Operational Costs & Strong ROI:** Reusing hydrogen and nitrogen instead of purchasing new supplies results in significant cost reductions. These savings enable a quick return on investment, often within 2-3 years, making Hy.REC a highly cost-effective solution that aligns both economic and environmental objectives.
2. **Increased Gas Supply Independence:** By recovering hydrogen and nitrogen on-site, manufacturers reduce their reliance on external gas suppliers, protecting themselves from market fluctuations and enabling more cost-effective gas management solutions.
3. **Regulatory Compliance and Sustainability:** As environmental regulations become stricter, Hy.REC helps manufacturers meet demanding standards. Additionally, adopting Hy.REC may unlock government incentives promoting green technologies.

*For a detailed business case, refer to Annex 1.*

## System Modules within Hy.REC

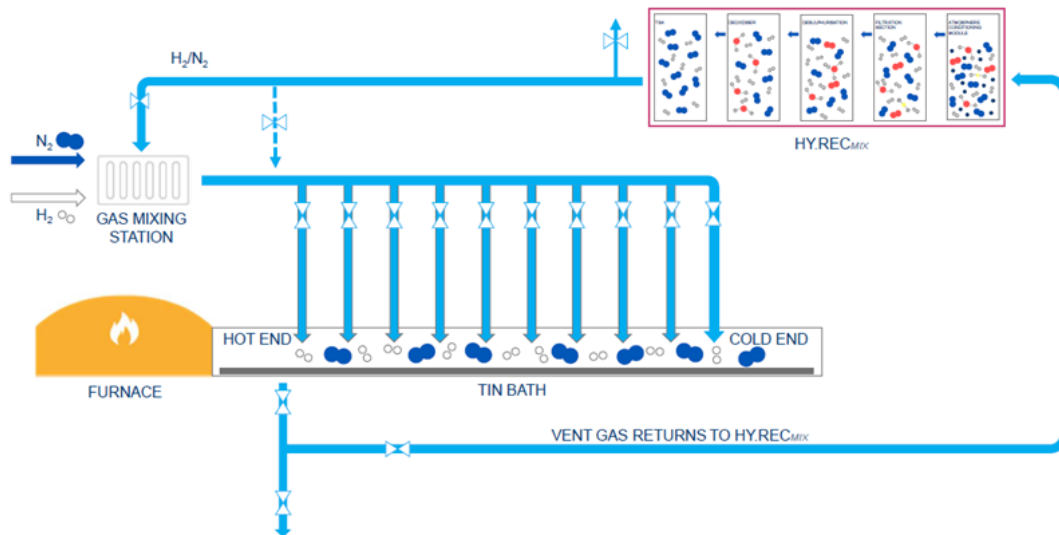
Hy.REC consists of several key modules that all fit in one 40ft container:

1. **Atmosphere Conditioning Module & Filtration Section:** A blower pulls the gas through a self-cleaning heat exchanger, cooling the gas from the float line. The filtration section then removes dust, collecting it in a bin for easy disposal.
2. **Desulfurization Module:** Adsorbent vessels remove hydrogen sulphides from the process gas.
3. **Deoxidation Module:** After desulfurization, the gas enters the deoxidation reactor (DeOxo), where any remaining oxygen reacts with hydrogen to form water, effectively removing oxygen from the gas stream to  $\leq 5$  ppmv.
4. **Temperature Swing Adsorption Module:** The vent gas then enters the Temperature Swing Adsorber (TSA), where it is dried to a dew point of  $\leq -58^{\circ}\text{C}$ . Removing water is crucial, as any moisture in the gas could react with tin, creating defects in the glass production process.
5. **Control and Monitoring System:** A smart control system controls the entire process, enabling real-time monitoring and automation of the Hy.REC system.



## Integration of Hy.REC into Glass Manufacturing Plants

Hy.REC's modular design allows seamless integration into glass production lines. Typically, it connects with the hot end of the float line, where the gas is most polluted. In most cases, the system can also be connected during operation of the float line. Depending on the operating pressure, the system can connect directly to the gas mixing station or to the gas supply line of the tin bath. The advanced control system, which incorporates data from sensors and analyzers, integrates easily into existing plant operations, enabling smooth operation and monitoring. In the picture on the next page integration possibilities are presented.



### What Sets Hy.REC Apart from the Competition

The Hy.REC system differentiates itself from competitors through several unique features that make it the leader in hydrogen and nitrogen recovery technology for the glass industry:

1. **Proven Track Record with References:** HyGear's Hy.REC system is operational at leading glass manufacturing plants worldwide, consistently delivering reliable results. Its current references demonstrate Hy.REC's ability to meet its performance promises.
2. **Advanced Technology and High Efficiency:** While other systems may offer hydrogen recovery, Hy.REC stands out in terms of energy efficiency and recovery rates. Its state-of-the-art, self-cleaning heat exchanger, along with advanced separation and purification technologies, ensures lower energy consumption and higher hydrogen and nitrogen recovery compared to solutions that rely on scrubbers or compressors. This translates into greater cost savings and operational efficiency.
3. **Tailored Solutions for Glass Manufacturing:** Unlike generic solutions, Hy.REC is specifically designed for the glass industry. Its focus on aligning with the specific demands of glass production ensures optimal energy recovery performance. Additionally, HyGear provides integrated hydrogen production units and gas mixing stations, offering a complete, one-stop solution for all gas management needs.

### Conclusion

HyGear's Hy.REC system is a game-changer for glass manufacturing, offering significant cost savings, improved energy efficiency, and reduced environmental impact. By capturing and recycling hydrogen and nitrogen, it lowers operational costs and enhances glass quality while helping manufacturers meet sustainability goals and regulatory standards. With its proven performance, tailored design, and seamless integration into existing processes, Hy.REC provides a clear competitive advantage for manufacturers looking to future-proof their operations.

# Annex 1 Business case example Hy.REC

GAS	MIX RATE	FLOW	PRICE PER NM <sup>3</sup>	TOTAL COSTS PER YEAR
Hydrogen	5%	100 Nm <sup>3</sup> /h	€ 0.60	€ 525,600
Nitrogen	95%	1,900 Nm <sup>3</sup> /h	€ 0.08	€ 1,331,520
<b>TOTAL</b>		<b>2,000 Nm<sup>3</sup>/h</b>	<b>€ 0.106</b>	<b>€ 1,857,120</b>

OPERATIONAL COSTS HY.REC INDEPENDENT FROM RECOVERY RATE			
UTILITIES	CONSUMPTION	PRICE	COSTS PER YEAR
Electricity	36 kW	€ 0.10 /kWh	€ 31,000
Cooling water	14 m <sup>3</sup> /h	€ 0.10 /m <sup>3</sup>	€ 12,000
Compressed air	1 Nm <sup>3</sup> /h	€ 0.02 /Nm <sup>3</sup>	€ 172
Maintenance			€ 40,000
<b>TOTAL</b>			<b>€ 83,172</b>

RECOVERY OF 700 NM <sup>3</sup> /H MIXED GAS (5% H <sub>2</sub> AND 95% N <sub>2</sub> )			
Gas	Flow	Price	Costs per year
Hydrogen (5%)	35 Nm <sup>3</sup> /h	€ 0.60 /Nm <sup>3</sup> (typical price)	€ 184,000
Nitrogen (95%)	665 Nm <sup>3</sup> /h	€ 0.08 /Nm <sup>3</sup> (typical price)	€ 466,000
<b>Value of recovered gas</b>	<b>700 Nm<sup>3</sup>/h</b>		<b>€ 650,000</b>
Operational costs Hy.REC			€ 83,000
			<b>Savings per year</b>
<b>TOTAL SAVINGS</b>			<b>€ 567,000</b>
Rough estimate pay-back time			Between 2 and 3 years

