Industrial Processes Emissions Reduction (IPER) Technology Workshop

DECARBONIZATION IN CONTAINER GLASS MANUFACTURING

CARL FAYERWEATHER, O-I GLASS, INC.

JANUARY 30 – 31, 2024

AGENDA

- Background on O-I glass
- Our Sustainability Goals
- Our decarbonization strategy
- Waste heat recovery technology
- Electric boosting/hybrid approach
- Challenges associated with some of the technologies
- End notes

AT A GLANCE

FOUNDED IN 1903
as Owens Bottle Company

$6.9 BILLION
in net sales in 2022

APPROX. 41 BILLION
containers sold in 2021

6,000+
direct customers

~24,000+
employees worldwide

3,500+
patents

PRODUCT PORTFOLIO
33% beer, 21% wine, 14% spirits, 14% NAB, 18% food

SUSTAINABILITY AT O-I

Our Sustainability Goals

It is our vision to become the most sustainable producer of the most sustainable rigid packaging.

50% TARGET

Increase recycled content to 50% average by 2030. O-I is taking a tailored approach to increase recycled content rates across its enterprise network as rates vary significantly by geography.

40% RENEWABLE

Renewable energy is a pillar in our strategy to lower carbon emissions. Our goal is to reach 40% renewable electricity use by 2030 and to reduce total energy consumption by 9%.

ZERO INJURIES

As part of our journey toward zero injuries, we are committed to a 50% improvement of our Total Recordable Incident Rate (TRIR) by 2030.

SOCIAL IMPACT

We see tremendous opportunity to positively impact the planet and communities where we operate. We will collaborate with customers, NGOs, suppliers and local leaders with an aim to make glass recycling available in 100% of our locations.

25% GHG REDUCTION

Approved SBTi target to reduce GHG emissions 25% by 2030 (interim target of 10% by 2025).

SUPPLY CHAIN SUSTAINABILITY

Achieve sustainability balance, together, by aligning our supply chain with our 2030 sustainability vision and goals.

DIVERSITY, EQUITY & INCLUSION

At O-I, we are better when we reflect the diverse world we serve, feel welcome, and have equal access to opportunities. We are focused on increasing all aspects of diversity, equity and inclusion across our team.

R&D TRANSFORMATION

Reinvent and reimagine glass-making so the circularity of glass meets the potential of our MAGMA melting technology, low-carbon alternative fuels, and light-weighted glass packaging.

ZERO WASTE

Reduce the amount of natural resources used, reduce the generation of waste by reuse, and recycling as we drive towards a "Zero Waste" organization.

25% WATER REDUCTION

We are committed to reducing our global water usage 25% by 2030, prioritizing operations in higher risk areas.

GOAL: 25% GHG EMISSIONS REDUCTION (SBTI)

CLIMATE CHANGE STRATEGY

following the SBTi Reduction Pathways- the first container glass company to commit!

In glass manufacturing, primary emissions stem from the combustion of fossil fuels and the degradation of raw materials in the furnace (process emissions). Additionally, there are indirect emissions associated with the use of electricity from the grid.

Manufacturing a Lower-Carbon Future

Our journey to a lower-carbon future begins with working to achieve our 2030 target to **reduce GHG emissions by 25%**. Between now and 2030, our strategy to attain that goal involves **four key major levers**.

2017 – 2029

2030

Increasing Recycled Content	Sourcing Renewable Energy	Energy Reduction & Efficiency	G.O.A.T. Gas-Oxy Advancement Technology	25% GHG Emissions Reduction

OUR JOURNEY TO NET ZERO

Net Zero Path Incorporating Low Carbon Fuels:

- Reducing the use of natural gas and integrating low-carbon fuels as they become commercially available.
- Strategic exploration of options like green hydrogen or biomethane for reduced carbon footprint.

Complete Electrification as a Decarbonization Avenue:

- We recognize the challenges in achieving complete electrification for glass manufacturing.
- Making of reduced glass, use of high cullet ratio, grid stability, enough green electricity, etc. pose a challenge.

Hybrid Approach is seen as the Most Viable Solution:

- Strategic use of electricity with a gradual increase in boosting.
- Balancing the benefits of electricity and alternative fuels in decarbonization.
- Exploration of low-carbon fuel options such as green hydrogen or biomethane simultaneously.

Exploration of Heat Recovery Technologies:

- Utilization of waste heat to efficiently heat both batch and cullet materials in an oxygen-fired furnace.
- Investigation into Thermal Chemical Regeneration and preheating of oxygen and fuel for effective heating.

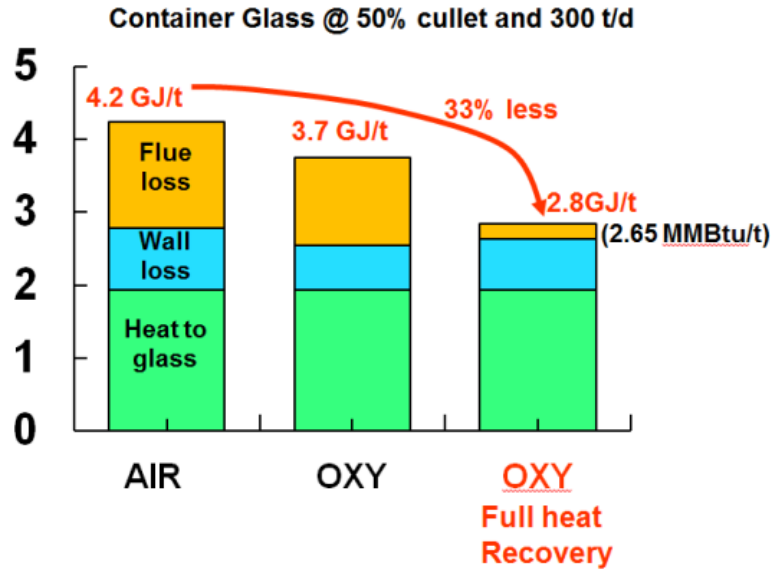
Other avenues:

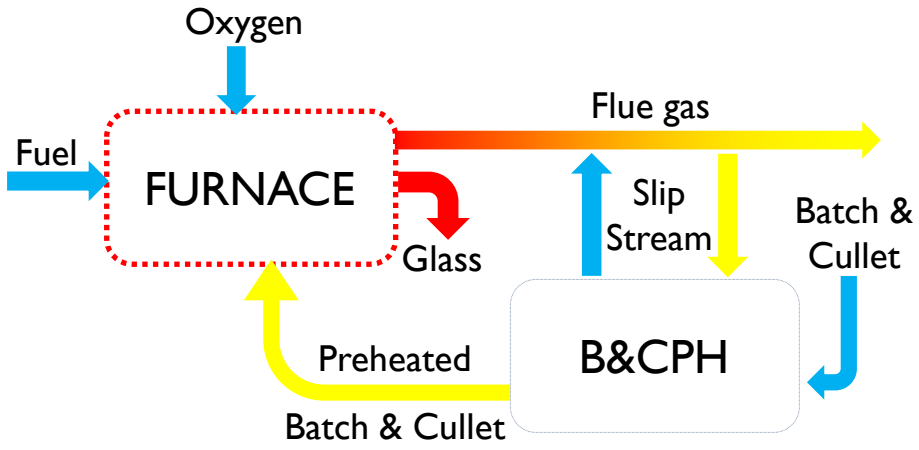
- Extreme light weighting
- Use of 100% renewable electricity to minimize Scope 2 emissions.

WASTE HEAT RECOVERY

Batch and Cullet Preheating

- Hot flue gases preheat batch and cullet
  - Dries batch
  - Reduces heat demand on furnace
- Rotary design promotes uniform heating of batch
- Achieves temperatures of up to 400°C
  - Potentially reducing fuel by 20% from baseline
- Uses a slip stream to temper flue gas to desired temperature
- Drawbacks
  - Capital intensive
  - Additional maintenance
  - Reduced flue flow and temperature can affect downstream abatement





ELECTRIFICATION – BOOSTING

Purpose of Electric Boosting:

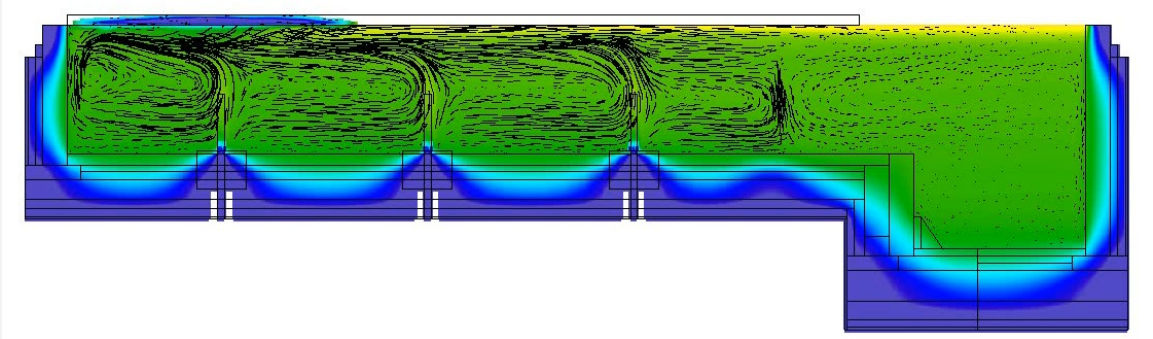
- Generate recirculation flows
- Provides additional heat source

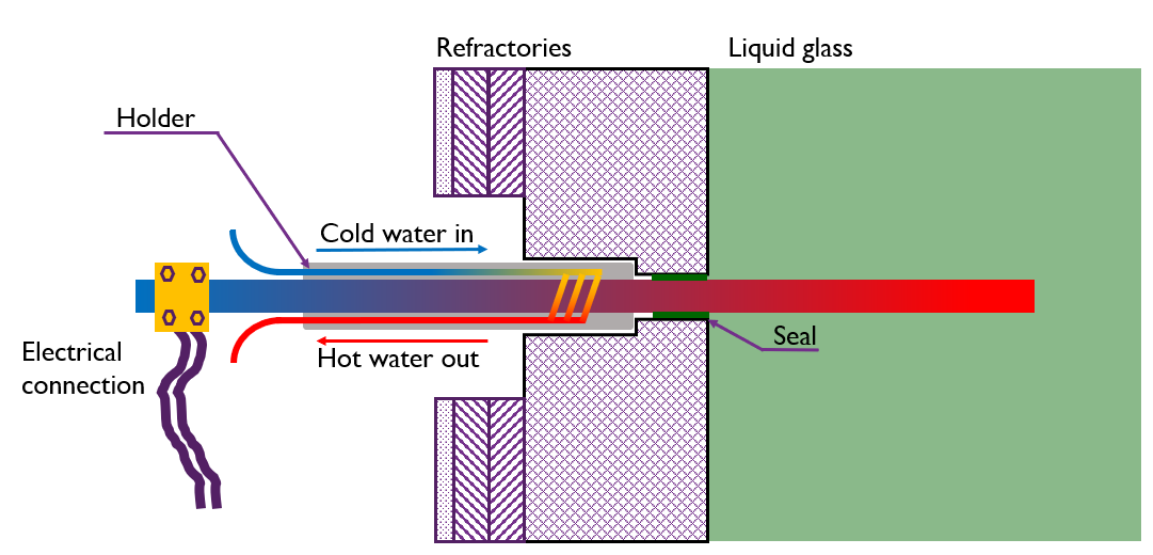
Benefits of Increased Electric Boost:

- Lower carbon emissions
- Improved sustainability
- Consistent melting
- Enhanced glass quality

Mechanism:

- Electrodes inserted through sidewalls or bottom of the melter
- Potential difference applied between electrodes
- Molten glass is electrically conductive
- Most heat is generated at electrode ends, heating glass locally
- Localized heating influences glass flow
- Correct positioning improves glass quality and melting efficiency





HYBRID MELTING

Energy Contribution and Environmental Impact:

- ~5-10% of total energy input currently from electric boost
- OI is modeling/engineering a furnace with 70% boost
- Targeting regions with green(er) grids

Application in Darker Glasses:

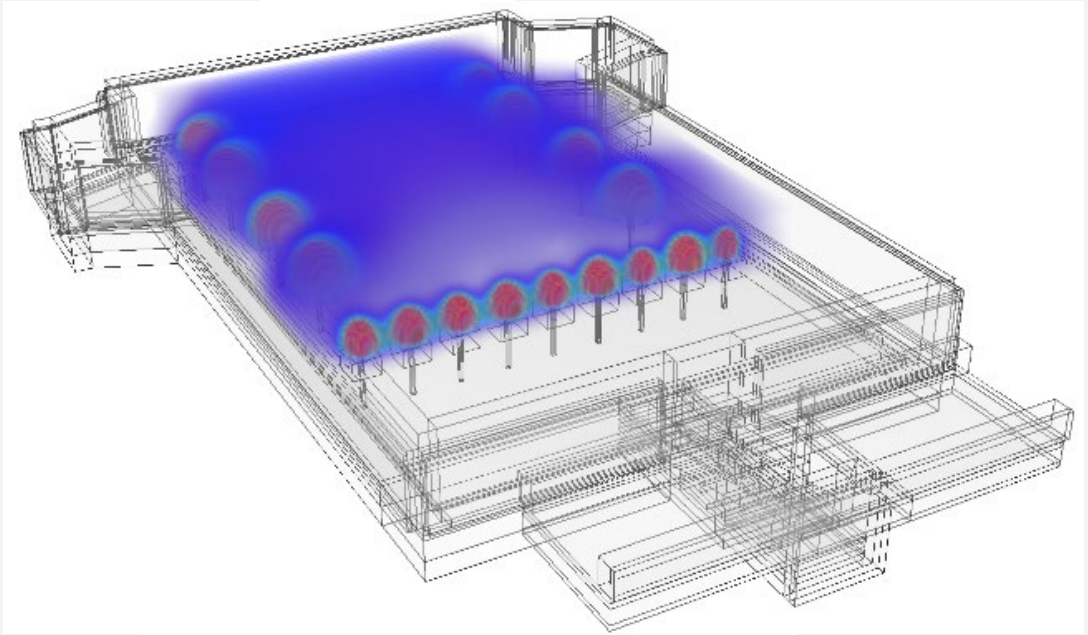
- Dark glass absorbs most/all radiation at glass surface
- Boost required to heat glass on bottom

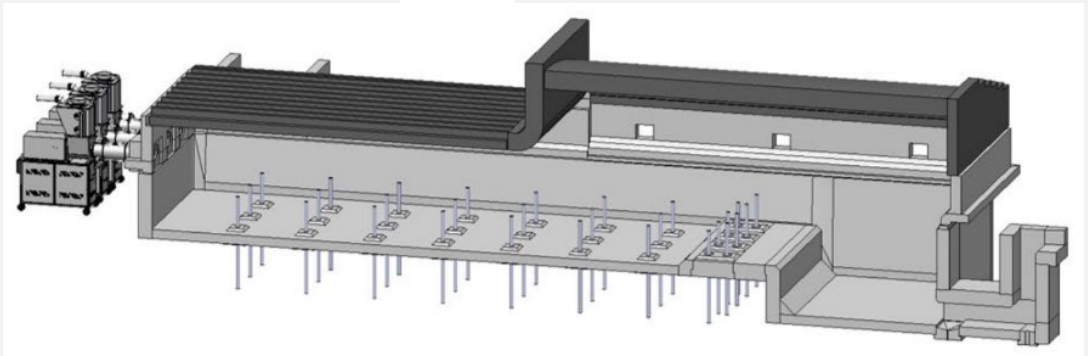
Challenges and Considerations:

- Balancing electric boost with operational efficiency and cost
- Optimizing electrode positioning
- Availability of electricity
- Some glass chemistries/recipes are very sensitive to boost

Future Prospects:

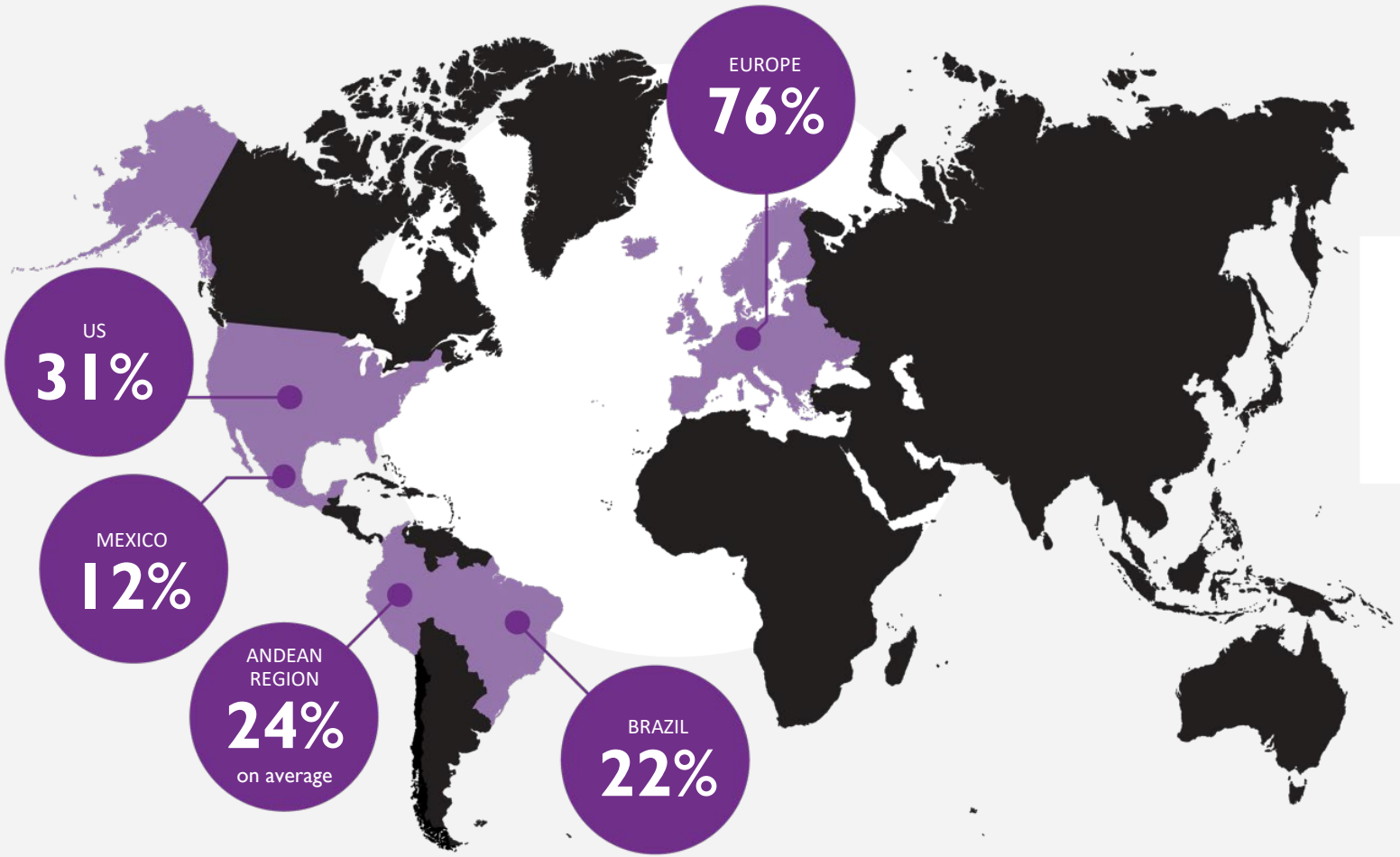
- Improved hybrid designs with high pull (>2.6 MT/day/m²)
- All electric designs without current pull restraints (>200 TPD)
- The above two without limits on cullet % or glass color





FIVES – Hybrid Melter EcoFlex

CHALLENGES WITH RECYCLED CONTENT



- Cullet availability drives recycled content in our products
- O-I is working to improve glass recycling in under-performing regions
- 91% of the communities where we operate have access to recycling
- However, we cannot solve this problem alone

Sources: Glass Packaging Institute, Close the Glass Loop, El Financiero, Abivdro, Cempre, Reciveci, Reciclame

CHALLENGES WITH GREEN FUELS

Green hydrogen

- Cost tied to price of electricity plus the efficiency of H_2 process
- Availability is scarce; DOE hubs will help some
- New burners will need to be retrofitted
- Additional skids required to meter or mix hydrogen
- Additional training/certification for operators
- Refractory corrosion likely to accelerate; furnace life reduced
- Some glass colors very sensitive to water vapor partial pressure
- Storage of a combustible gas on site

Biofuel

- Cost is ~4x that of NG
- Consistent heating values required
- Consistent means of delivery required
- Biomethane production in the EU has ramped up greatly
  - Still not able to supply the needs of even one glass sector in the EU

* https://glassforeurope.com/wp-content/uploads/2020 /01/flat-glass-climate-neutral-europe.pdf.

END NOTES

- There is not a single solution to achieving decarbonization in glass manufacturing
  - Demands a holistic and tailored approach
- The absence of sufficient economic incentives is a critical hurdle to decarbonization
  - Success relies heavily on government support
- Demonstrated large-scale low-carbon process options are lacking
- Resolving these complex issues requires active engagement across the entire value chain
  - Gas suppliers, electricity providers, raw materials suppliers, etc.
- Consumer-level barriers are primarily rooted in norms and behaviors related to glass use
  - Recycling, reusing, and responsible disposal
- Carbon emissions in glass manufacturing is predominantly confined within the factory premises
  - As scalable technologies emerge, glass decarbonization can occur primarily within the factory gates

THANK YOU!

FOR MORE INFORMATION CONTACT
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EXTRA SLIDE

Engaging the Value Chain to Build Recycling Ecosystems

O-I is engaging stakeholders throughout the glass value chain to build ecosystems that drive glass recycling, which enables increased recycled content in our products.

CONSUMERS

Rebalancing the dialogue on glass and educating consumers on the sustainability advantages of glass

CUSTOMERS

In 2021, more than 100,000 tons of glass collected through 49 closed-loop programs

COMMUNITY

Nine community collection sites and two Glass4Good™ programs implemented in 2021

PROCESSORS

O-I is involved in glass recycling processing plants, such as Glass to Glass in Oregon, U.S., O-I PROMAPI in Mexico, and Julia Vitrum in Italy

SUPPLIERS

Collaborating with suppliers to improve cullet quality and increase its usability in furnaces

GLASS INDUSTRY

Engaging with partners to grow recycling

OTHER INDUSTRIES

Exploring opportunities to create end markets