



Decarbonization pathway of the glass Industry, challenges, opportunities for different segments and possible solutions regarding different energy inputs.

Survival & Sustainability with ICG

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Business Development Director Glass Service Group & SEFPRO
President International Commission on Glass (ICG)

ICG Annual meeting & EDG April Lyon France



AGENDA of my talk



Introduction to International Commission on Glass
and how it can help decarbonization transition

Glass Service & SEFPRO
(Saint Gobain Ceramics)

Decarbonisation options

Example projects

Conclusions

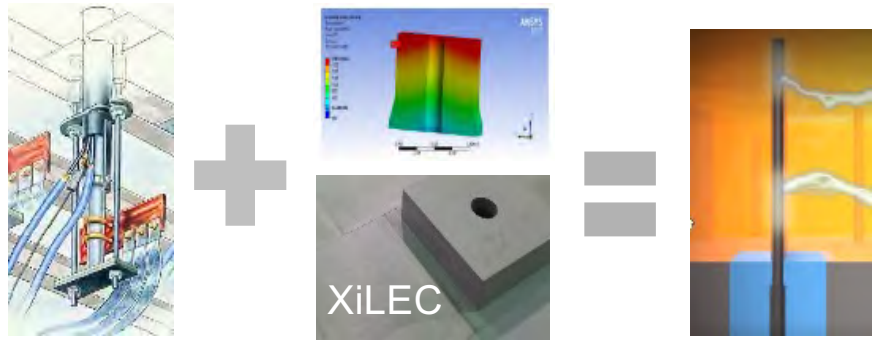
Solutions to support customers' operations



- GS Group & SEFPRO supply
- GS technologies enables GHG reduction and cost savings.
- ES III ensures all these technologies works together.

REFRACTORY SOLUTIONS

Electrode Holder + Block = Electric heating solution



CORROSION FEATURES IN MODELLING



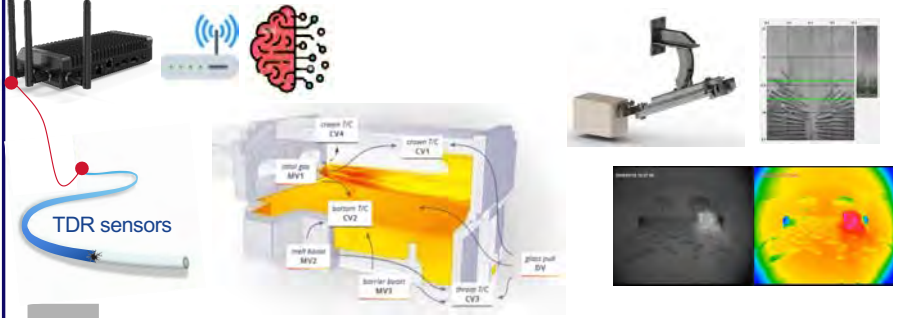
- Unique software solution to handle all the constraints of new furnace design

SEFPRO GUARD & EXPERT SYSTEM



- Process control solution with real-time corrosion assessment

DIGITAL FACTORY / A.I. / SENSORS



- New digital solutions for Smart furnace

Beyond Carbon Reduction: Securing a Reliable Energy Future



Source DNV energy insights report 2026, tankers waiting

**Renewable (Offshore) Electricity from Wind Turbines
(Turbine blades can be made of Glass Fiber)
And Solar**

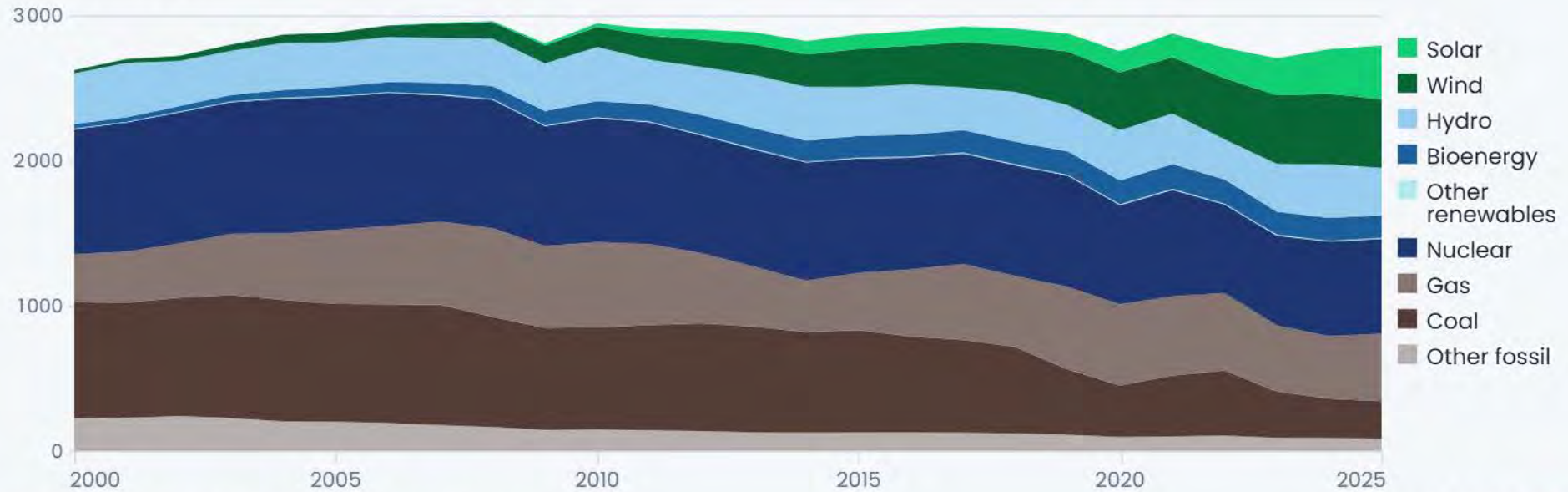


[https://cdn.britannica.com/37/213337-050-70AA9F96/
offshore-wind-farm-in-north-sea.jpg](https://cdn.britannica.com/37/213337-050-70AA9F96/offshore-wind-farm-in-north-sea.jpg)

Electricity generation in EU

Electricity generation in EU

Terawatt hours



Data: Ember Electricity Data Explorer, ember-energy.org
<https://ember-energy.org/data/electricity-data-explorer/?entity=EU>

EMBER

30%

Wind and solar generated a record 30% of EU electricity, higher than fossil power for the first time on record.

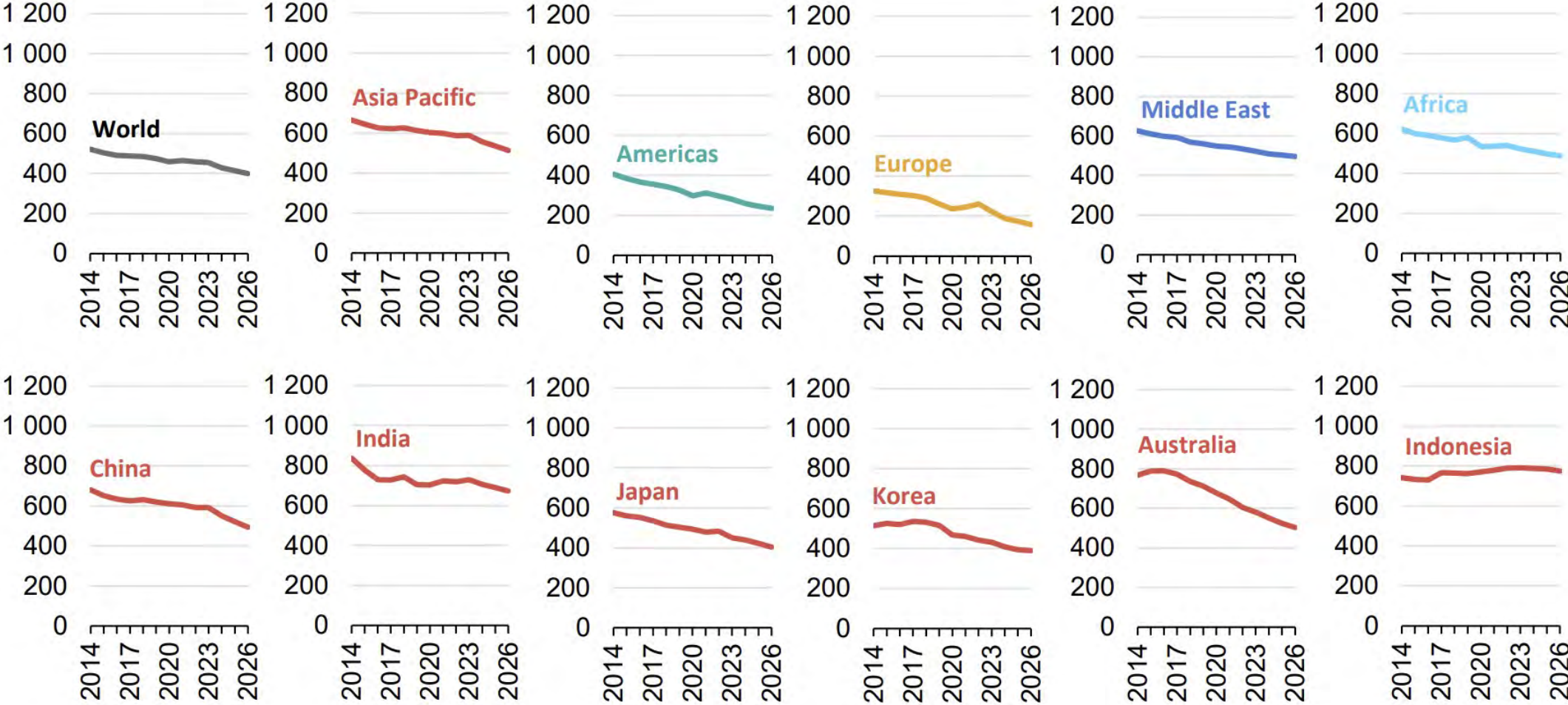
369 TWh

EU solar generation reached a record 369 TWh in 2025, 20% higher than last year.

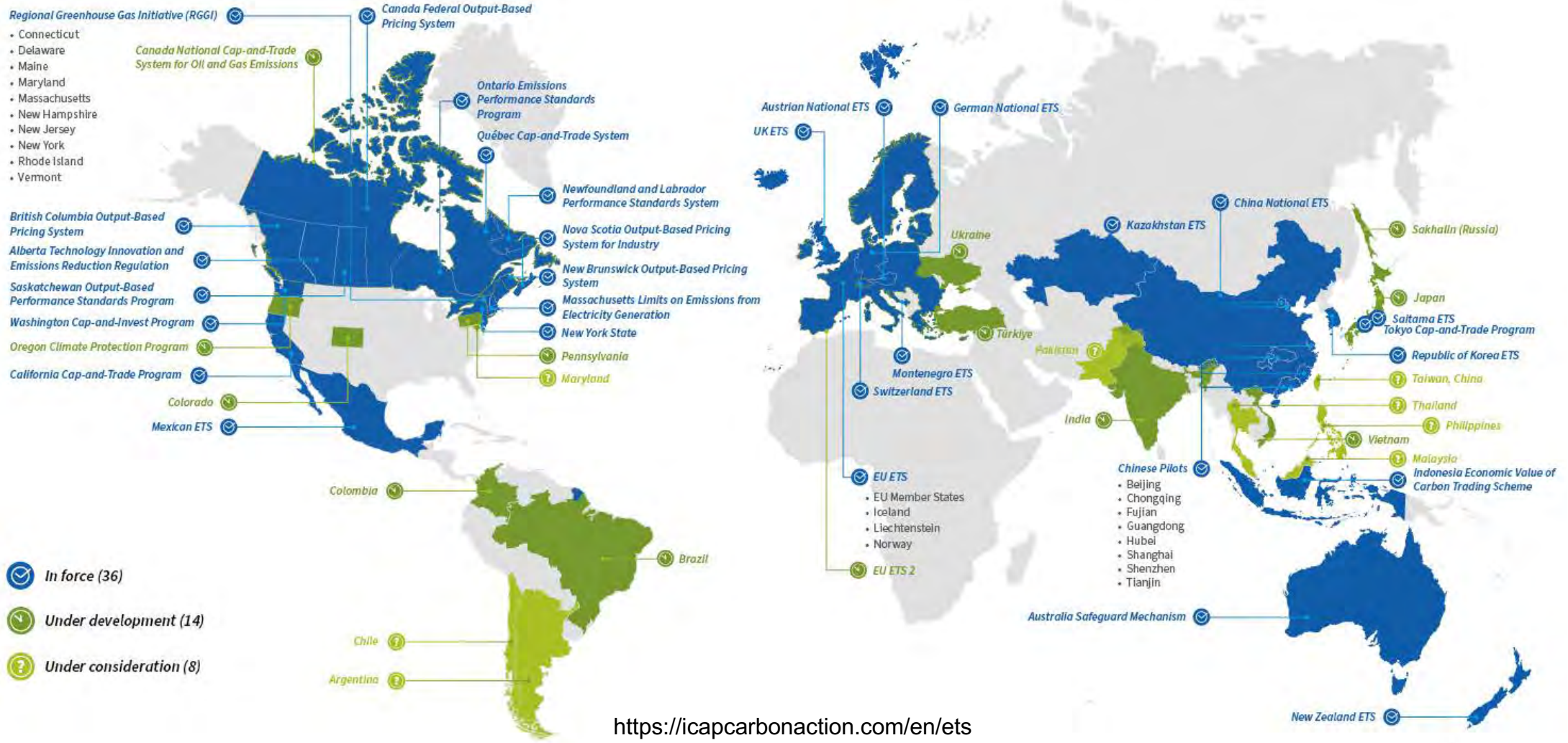
14

In 2025 wind and solar generated more electricity than fossil fuels in 14 of the 27 EU countries.

CO₂ intensity of electricity generation in the world, by selected countries and regions (g CO₂/kWh), 2014-2026



The ETS Map shows ETSs that are in force or development Emission Trading System



<https://icapcarbonaction.com/en/ets>

Glass has so many different useful and life enriching applications



1. Packaging

Food and Beverages: Glass bottles and jars for water, wine, beer, sauces, pickles, and jams.
Pharmaceuticals: Vials, ampoules, and containers for medicines and vaccines.

2. Construction and Architecture

Windows and Doors: Transparent, energy-efficient glass for homes, offices, and buildings.
Facades and Skylights: Modern architectural designs using tempered or laminated glass.
Glass Tiles and Partitions: Used for interiors and decorative purposes.

3. Automotive and Transportation

Windshields: Laminated safety glass for durability and shatter-resistance.
Windows and Mirrors: Heat-treated glass for better strength.
Headlights and Taillights: Special optical glass.

4. Technology and Electronics

Screens: Smartphone, TV, and computer display panels.
Optical Fibers: For telecommunications and internet connections.
Photonic Applications: Glass used in lasers, sensors, and photonics.

5. Renewable Energy

Solar Panels: Glass as a protective and functional layer in photovoltaic cells.
Wind Turbines: Fiberglass composites used in turbine blades.

6. Household and Kitchenware

Cookware: Heat-resistant glass for baking dishes, cookware, and utensils.
Tableware: Drinking glasses, plates, and decorative items.

7. Medical and Scientific Equipment

Laboratory Glassware: Beakers, test tubes, and flasks made of borosilicate glass.
Optics: Glass for lenses, microscopes, and telescopes..

8. Data Storage and Computing

Data Storage: Glass substrates for hard drives and optical discs.
CPUs: Photonic glass used in advanced computing.

9. Aerospace and Defense

Aerospace Applications: Lightweight glass composites in aircraft windows and components
Ballistic Glass: Bulletproof and shatterproof glass for vehicles and buildings.

10. Arts and Crafts

Decorative Items: Stained glass, glass sculptures, and handmade glass art.
Jewelry: Glass beads and ornaments.

11. Lighting Fiberglass

Lighting: Glass for lightbulbs, LED covers, and chandeliers.
Insulation: Fiberglass used in thermal and acoustic insulation.

12. Recycling

Recycling: Glass cullet is repurposed for new glass products or other industries.

The Glass Age



On 18th May 2021 the UN General Council approved a joint application by the International Commission on Glass (ICG), the Community of Glass Associations (CGA) and ICOM-Glass that 2022 be declared a **United Nations International Year of Glass**. The Year celebrated the essential role Glass has in Society.



<https://www.iyog2022.org/>
<https://icglass.org/>

The Glass Age

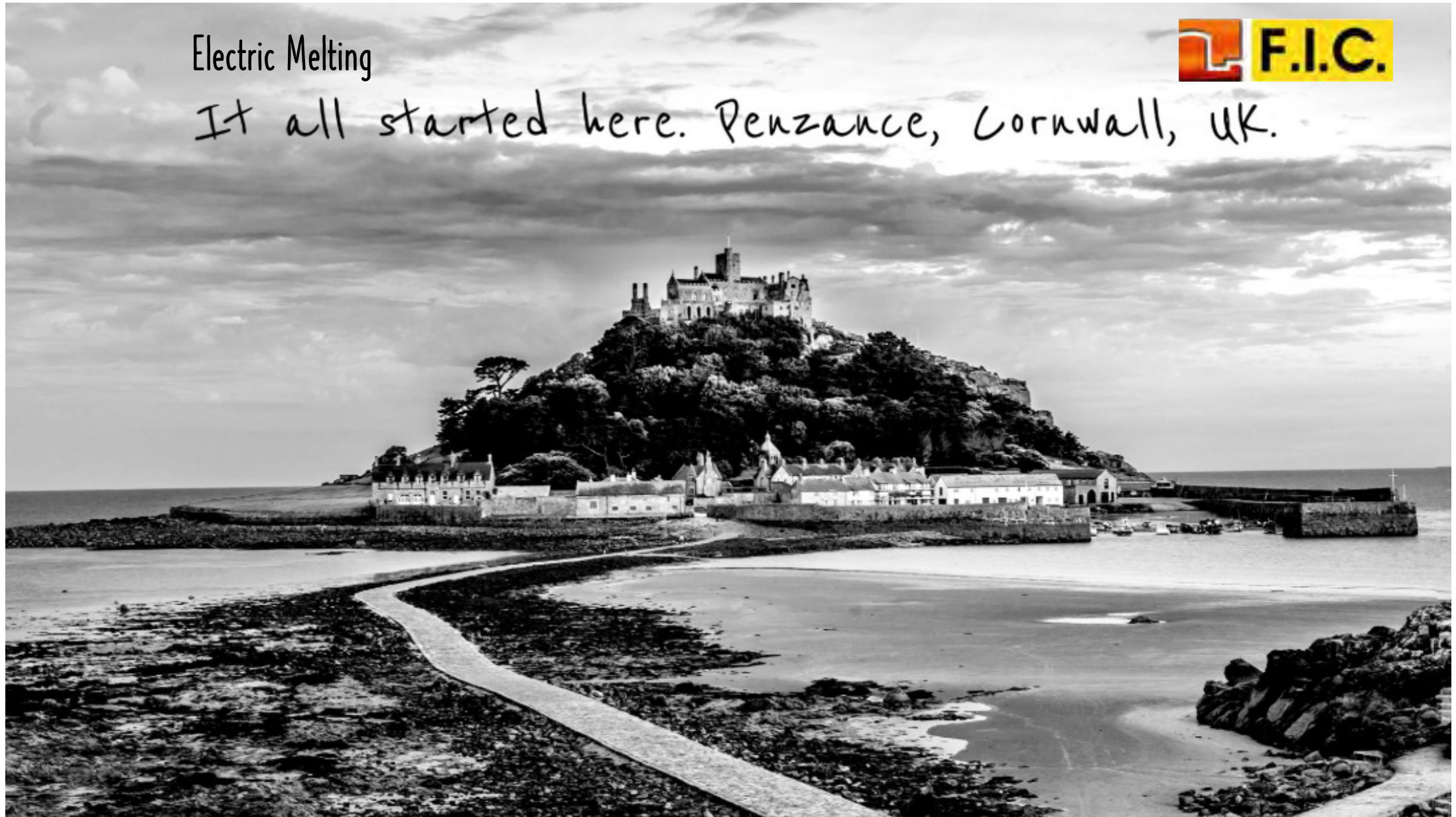


<https://www.iyog2022.org/>
<https://icglass.org/>

Electric Melting



It all started here. Penzance, Cornwall, UK.



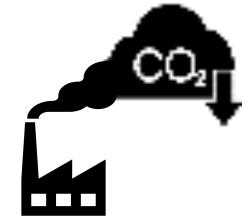
Electrical melting : the path toward fossil energy substitution



End-fire
700 kg CO₂/t

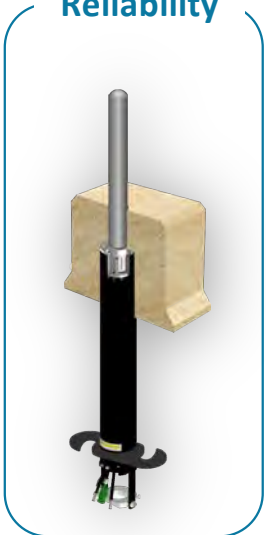
Hybrid
300 kg CO₂/t

All-electric
150 kg CO₂/t

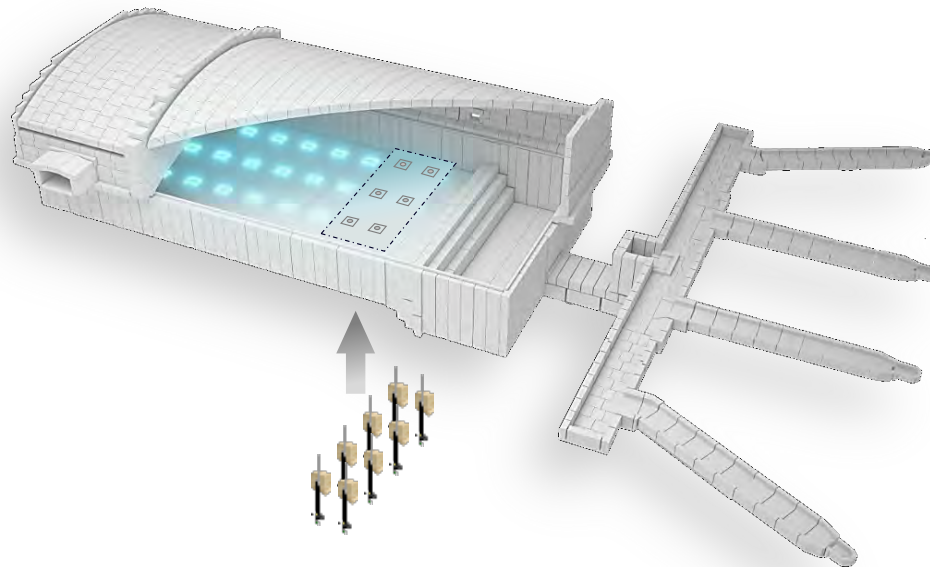


Increasing electrification rates, a need for reliability & safety

Reliability



Electrode holder and electrode block solution



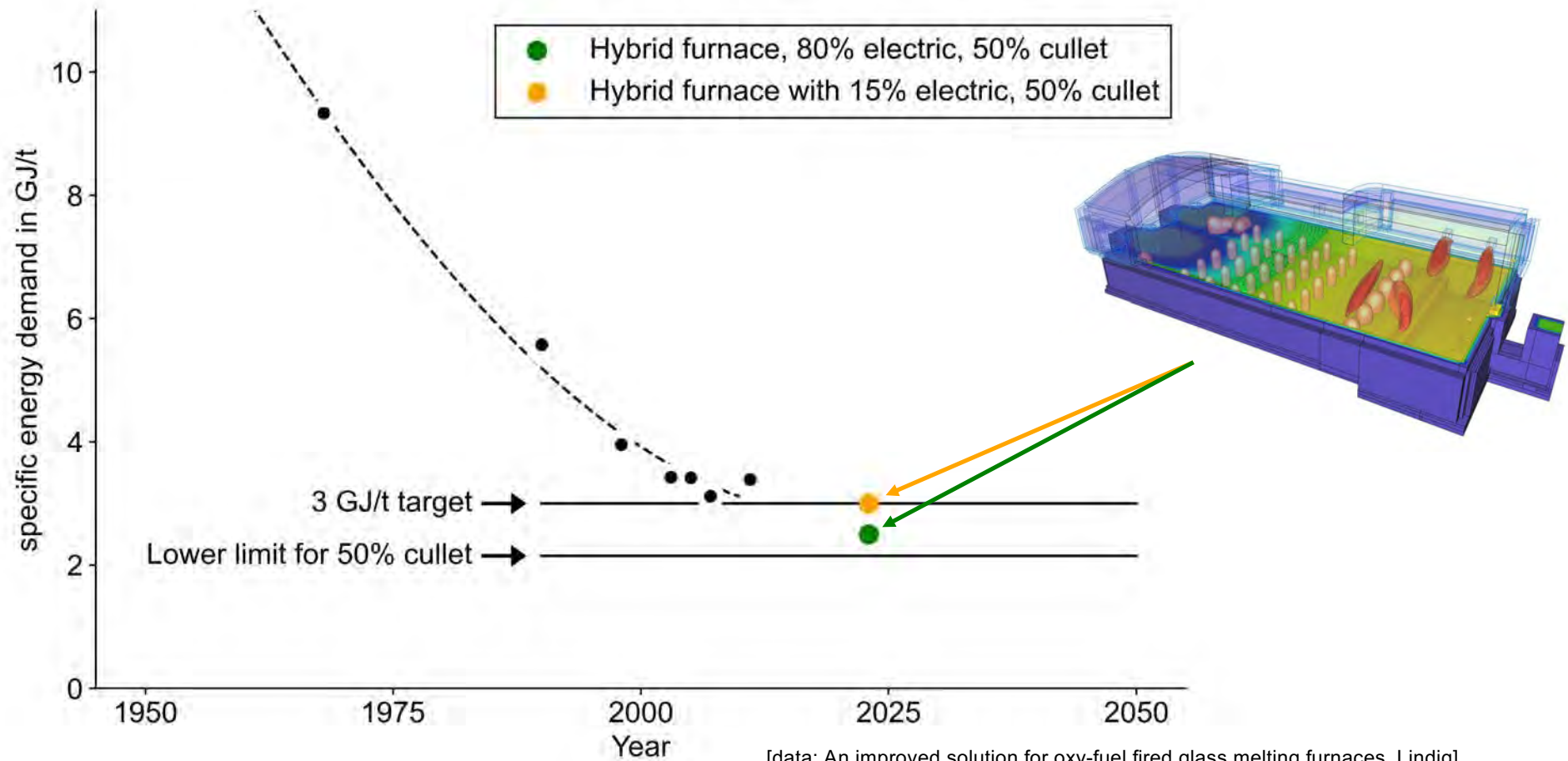
Safety



Down time, maintenance, risk of leakage

Specific energy demand improves with share of Electricity

1930 SED at 20 GJ/t

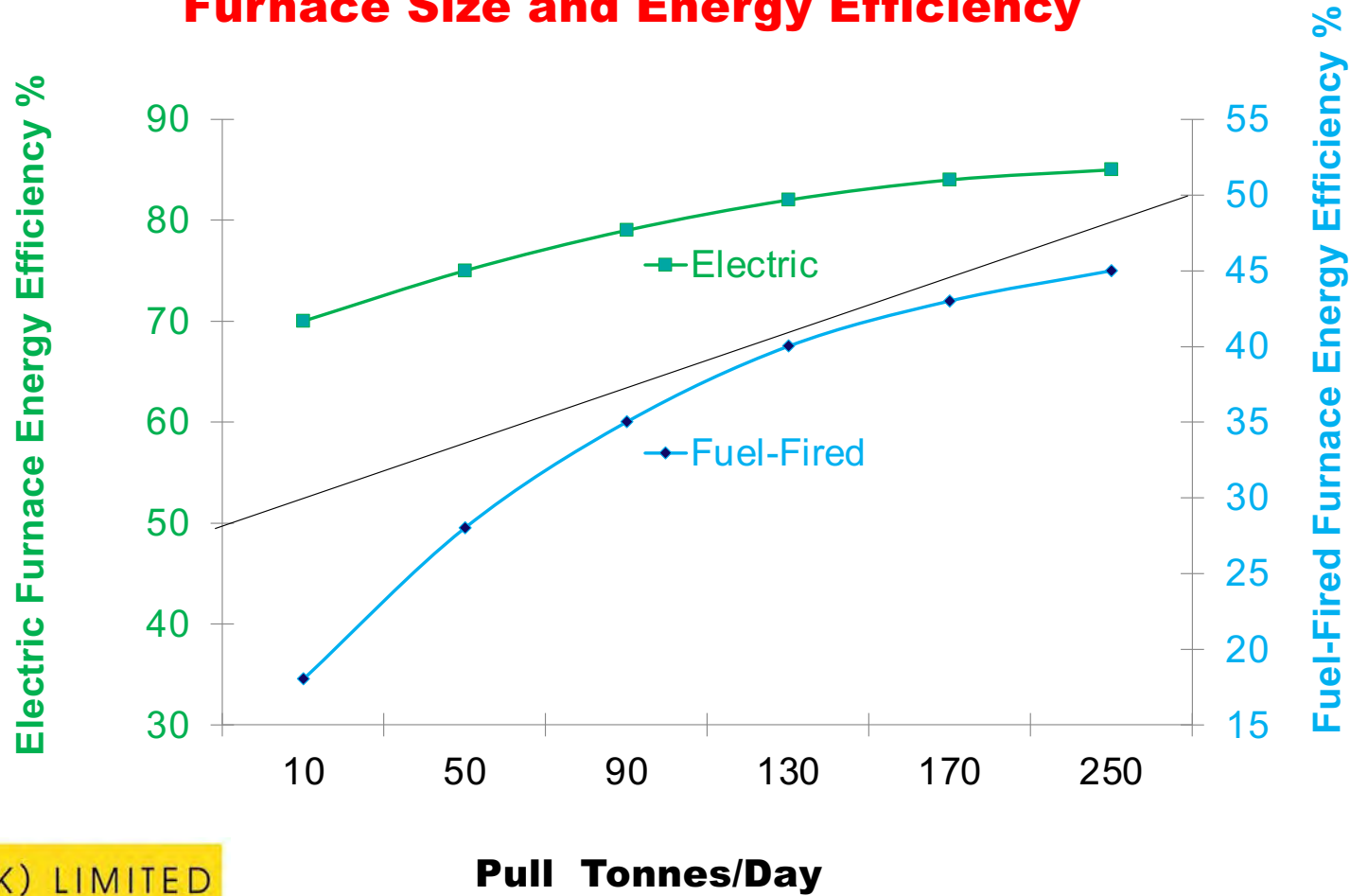


[data: An improved solution for oxy-fuel fired glass melting furnaces, Lindig]
[data: Prospects and physical limits of processes and technologies in glass melting, Conradt]

Specific energy demand Gas vs Electric



Furnace Size and Energy Efficiency



How your furnace of the future looks like?

Choice for Future Furnace Technology	Gas Fired	Hybrid	All Electric
Glass Colour	Reduced & Oxidized	Reduced & Oxidized	Oxidized
Pull (tons per day)	High >400	200–400	Lower <200
Flexibility	Flexible	Flexible	Stable
Cullet Ratio	Till 99%	0–80%	<60%
Electric Infrastructure	<5 MW	5–10 MW	>10 MW
Hydrogen Costs & Availability	Oxy	Oxy	Backup Fuel Cell

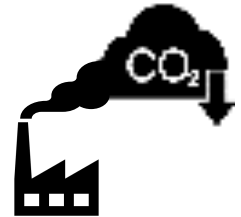
Gas fired can be also Bio gas and some H₂ addition till 20/30%

Electrical Conditioning : toward fossil energy substitution



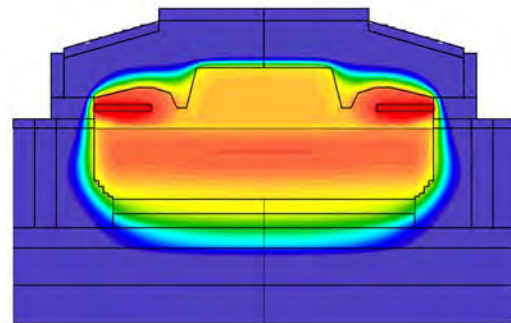
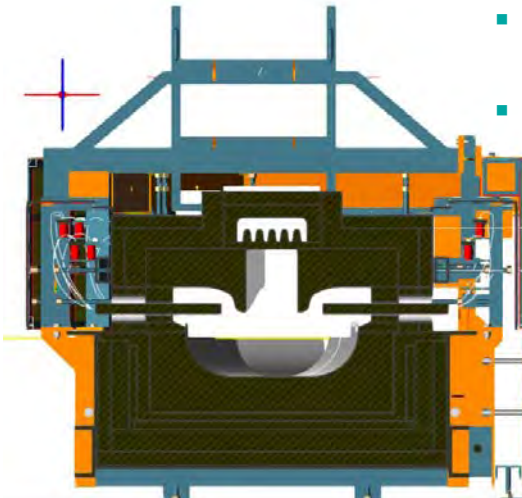
F.I.C. AE-FH: Design Results – Energy Savings

Design Example I (Container Glass): Layout Line A1

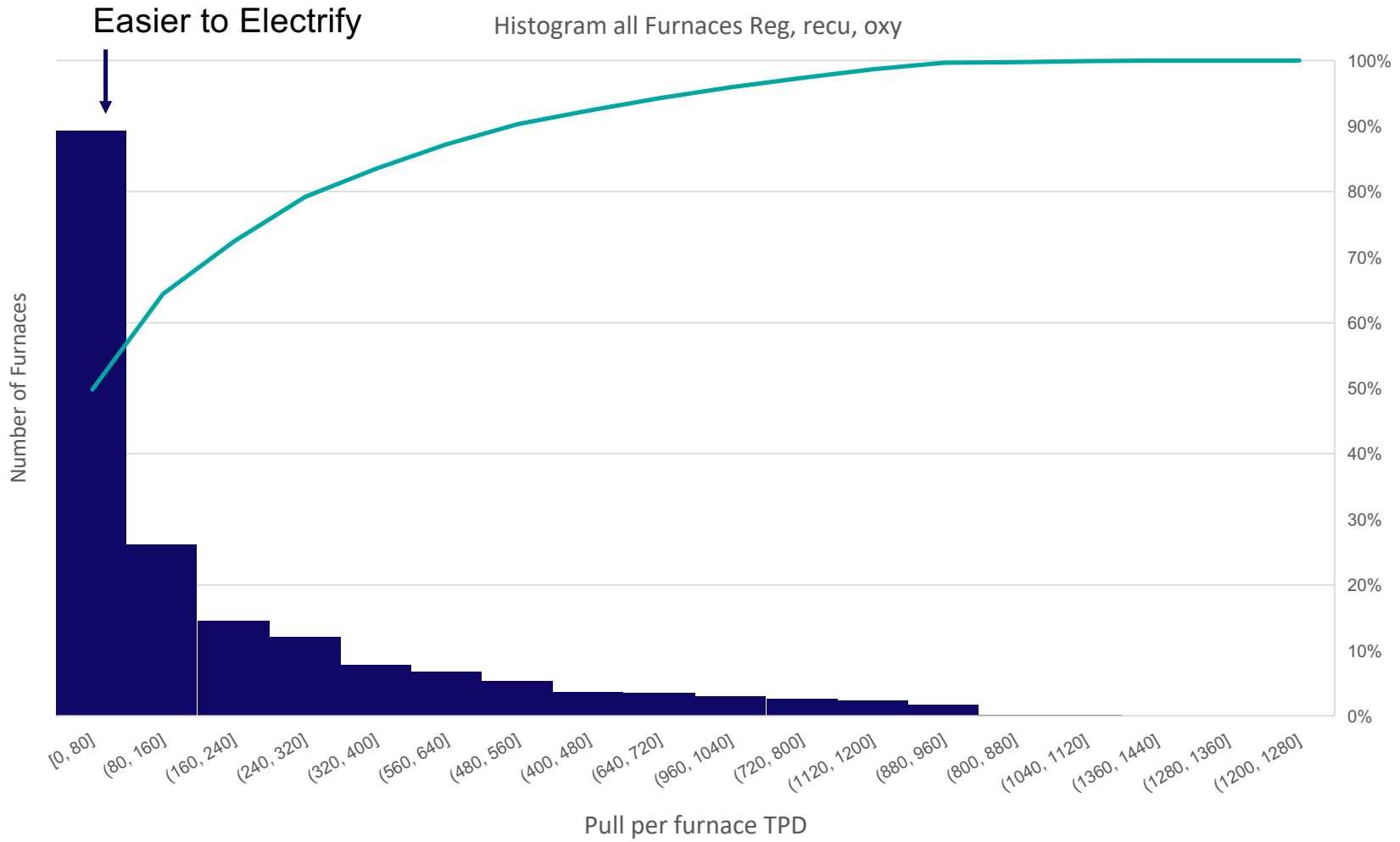


Metric	Length	Width	Pull range	Max ΔT	Min ΔT	Installed Power	Operating Power @ 125 tpd	Operating Power @ 105 tpd
Unit	[ft]	[inch]	[tpd]	[K]	[K]	[kW]	[kW]	[kW]
Line A1	29	36/48	105-125	100 (1260°C-1160°C)	48 (1243°C-1195°C)	200	44 (8.4 kWh/t and day)	58 (13.3 kWh/t and day)

- Energy Savings for **Higher Pulls**: Between **90%** and **95%**
- Energy Savings for **Lower Pulls**: Between **87%** and **92%**



Total amount of furnaces, gas and electric as function of pull



About 4000 furnaces
 In total in the world
 Already 400 All Electric

Cold top, hot top, semi-hot top



Geometry

Square
Rectangular
Hexagonal
Duodecagonal
Round
Shelf



Transformers

Three Phase
Delta-Open/Closed/Partial
Star
Two Phase
Scott Squares (balanced)
Single Phase

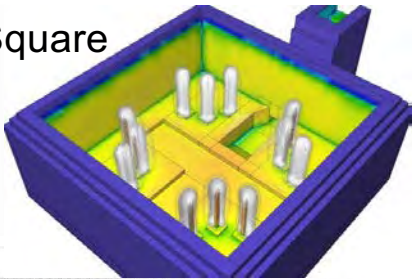


Electrode positions

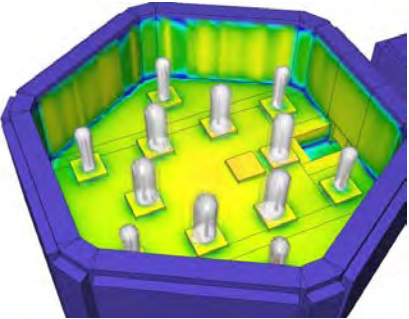
Top Electrodes
Sidewall Electrodes
Shelf Electrodes
Bottom Electrodes
Plate Electrodes

Different Electric Melting furnaces

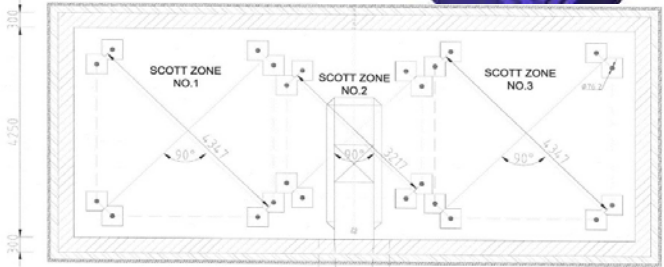
Square



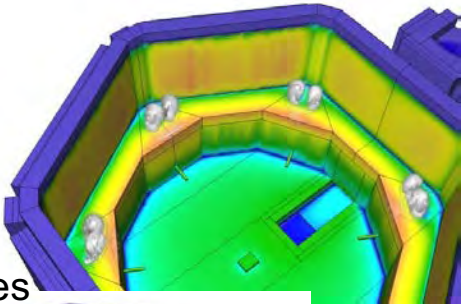
**Hexagonal cold top
Bottom electrodes**



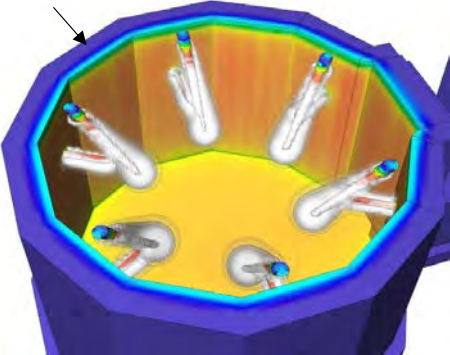
Rectangular




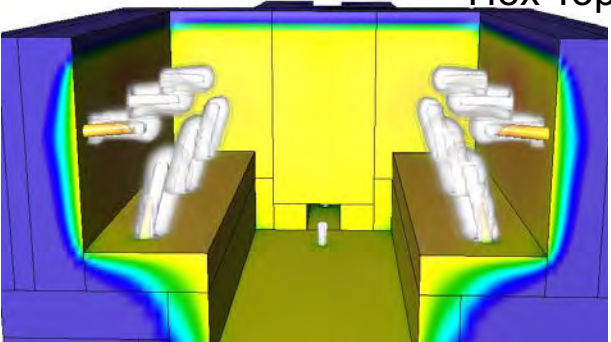
Shelf/bottom



Hex Top electrodes



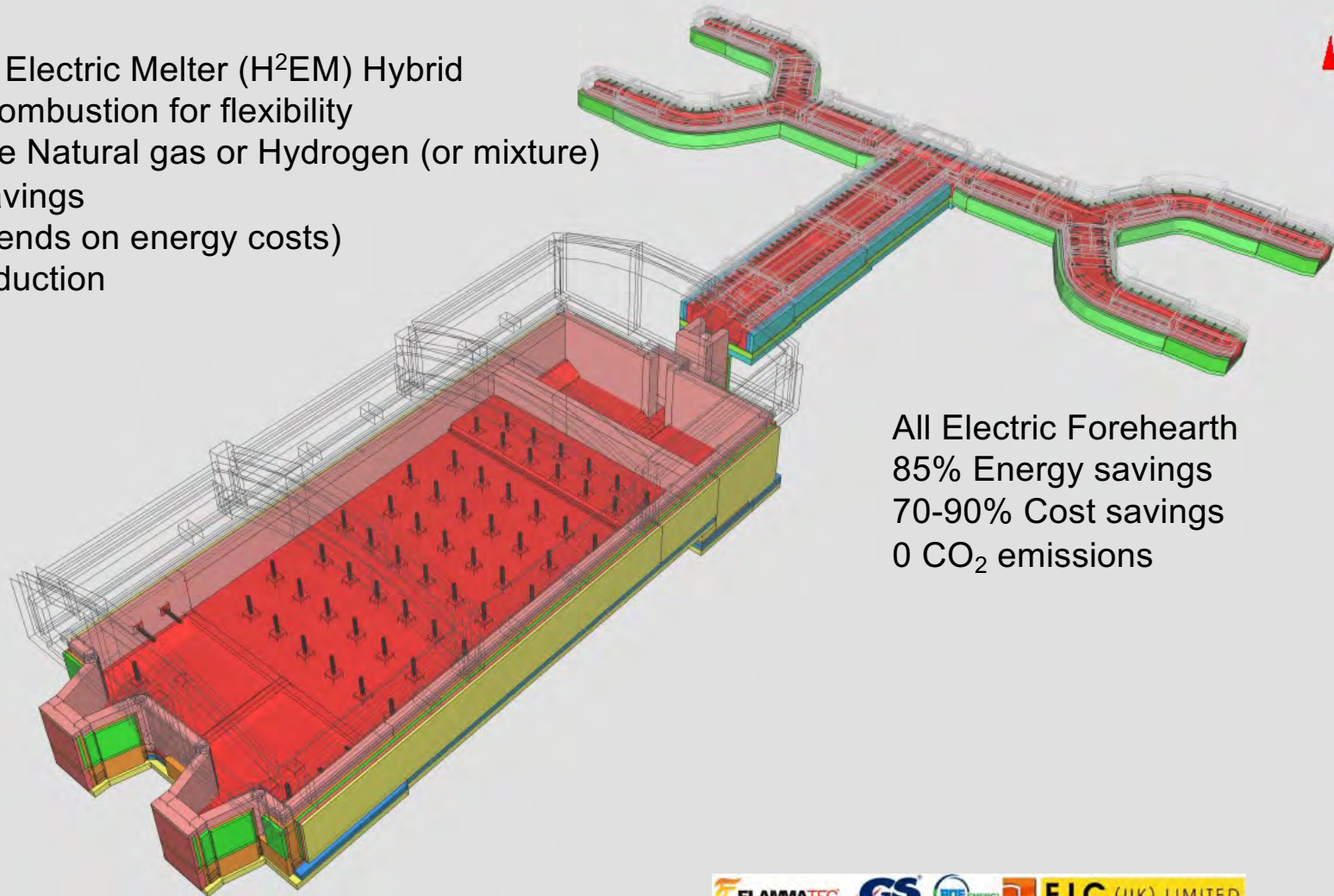
Side wall plate electrodes



Horizontal Hot Top (Oxy-Gas) Electric Melter (H²EM Concept)



Horizontal Hot top Electric Melter (H²EM) Hybrid
Remaining 20% Combustion for flexibility
Combustion can be Natural gas or Hydrogen (or mixture)
25-40% Energy savings
Cost savings (depends on energy costs)
50 till 80% CO₂ reduction

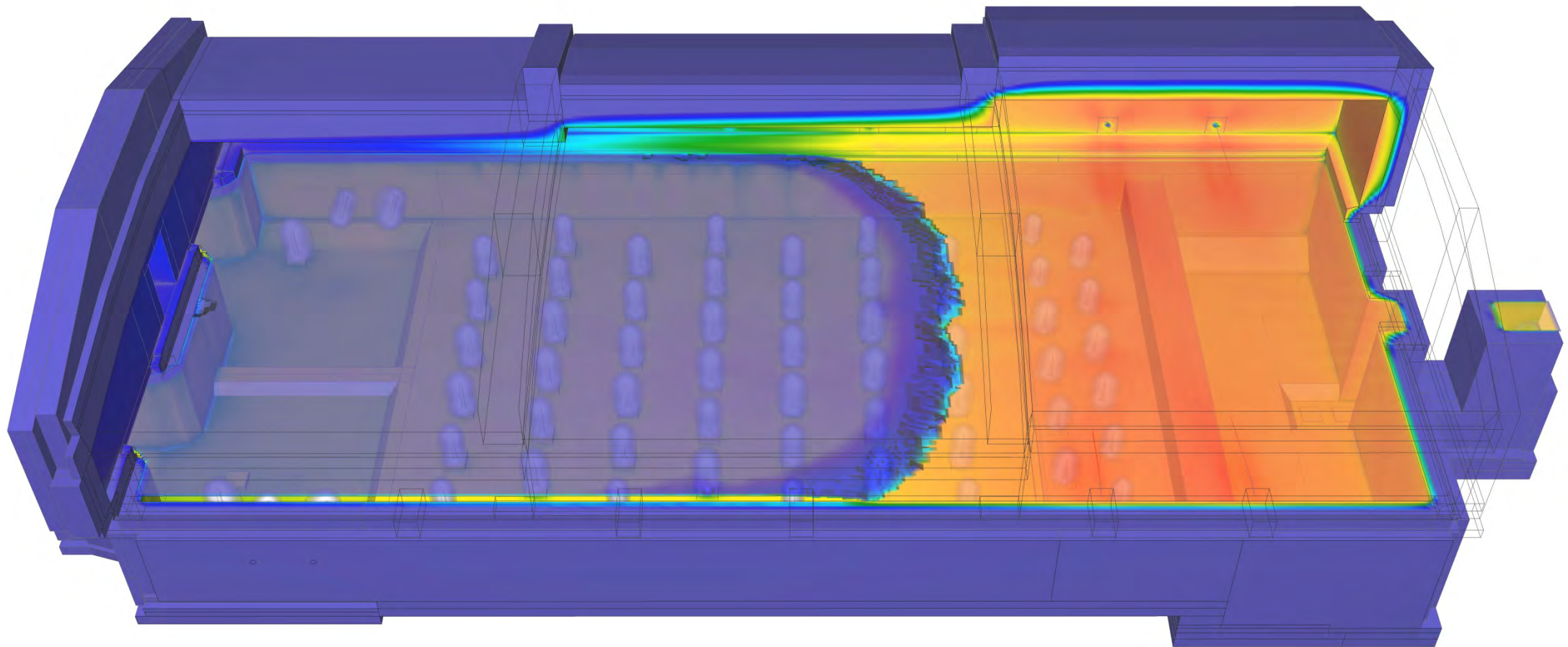


All Electric Forehearth
85% Energy savings
70-90% Cost savings
0 CO₂ emissions

Ideal to make cost optimization of gas versus FIC super boost



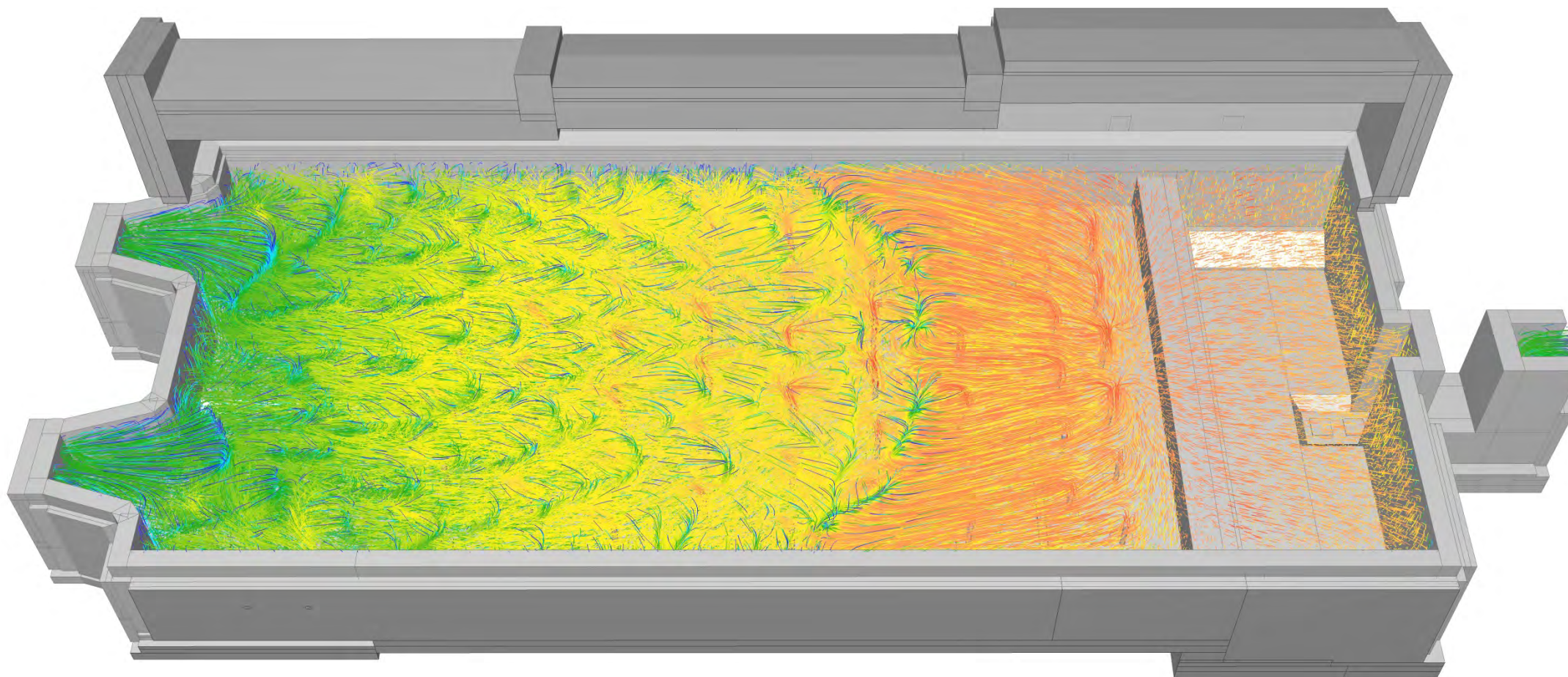
Example on a Hybrid melter



Ideal to make cost optimization of gas versus FIC super boost



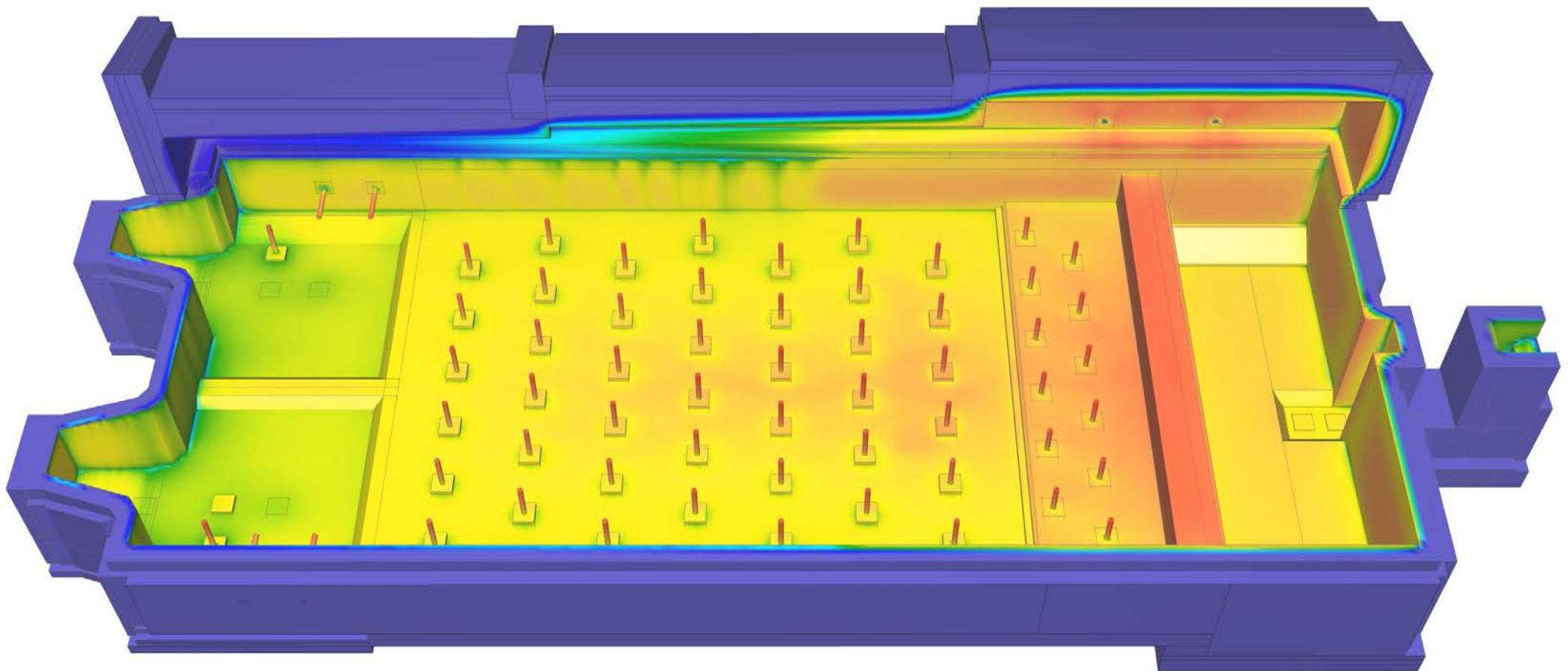
Example on a Hybrid melter



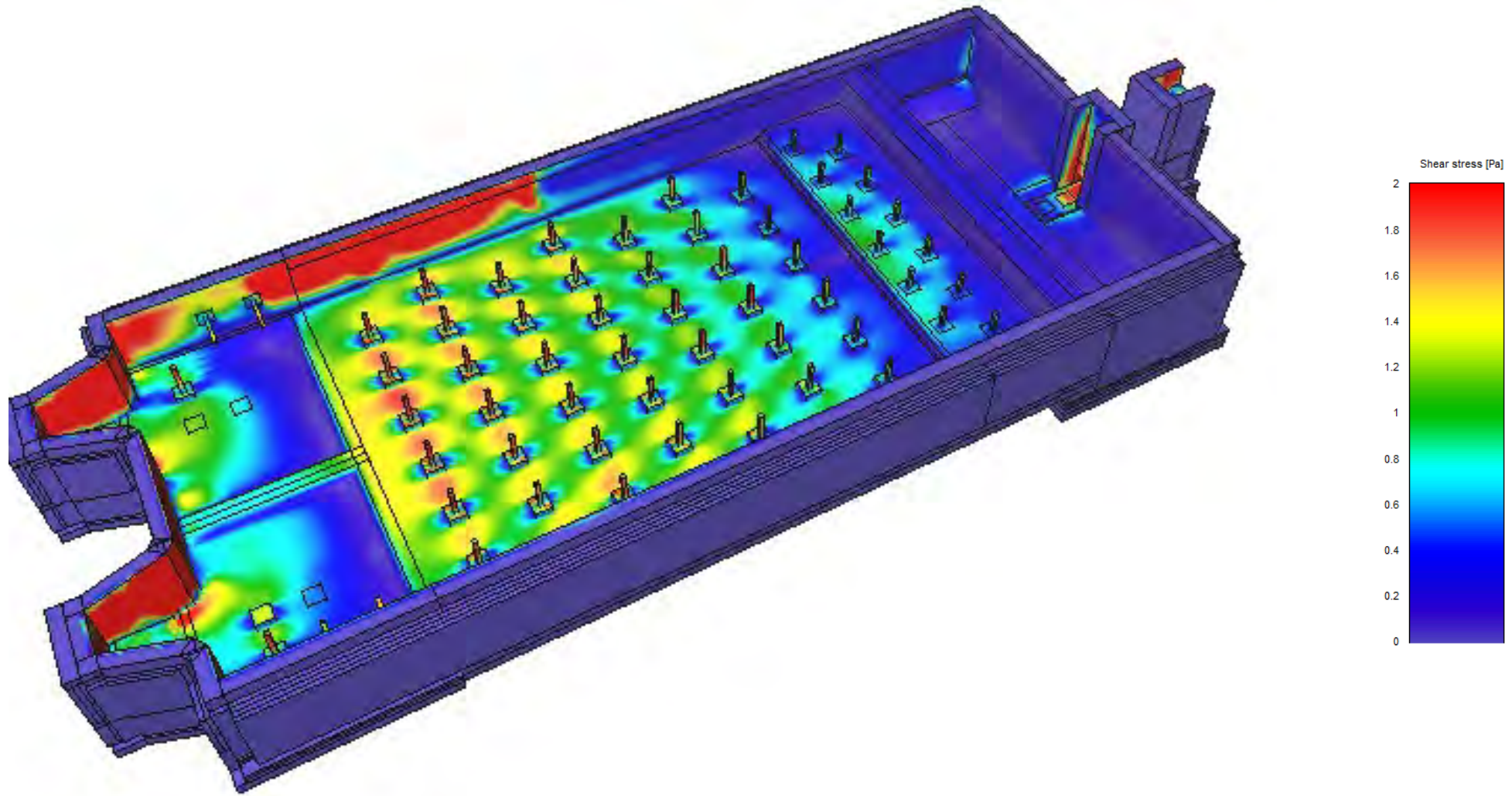
Ideal to make cost optimization of gas versus FIC super boost



Example on a Hybrid melter



SEFPRO / GFM Corrosion calculation



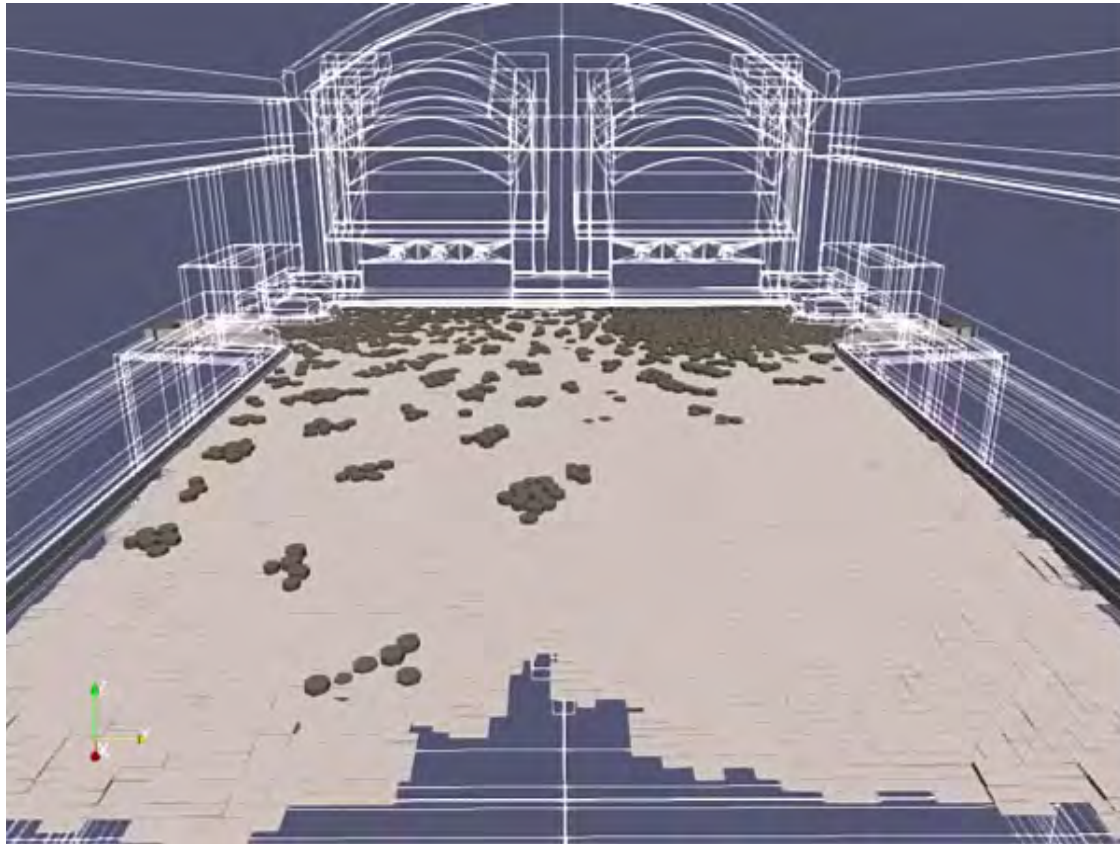
GFM Development – Recent New Features – DEB



Time-averaged data are provided to combustion model and glass model

Interaction between batch elements and flow of combustion gases and glass melt is considered

Calibration is required to for parameters having the strongest influence on batch coverage, motion and heat transfer



So what about H₂?



<https://www.wa.gov.au/government/document-collections/renewable-hydrogen-target-western-australia>

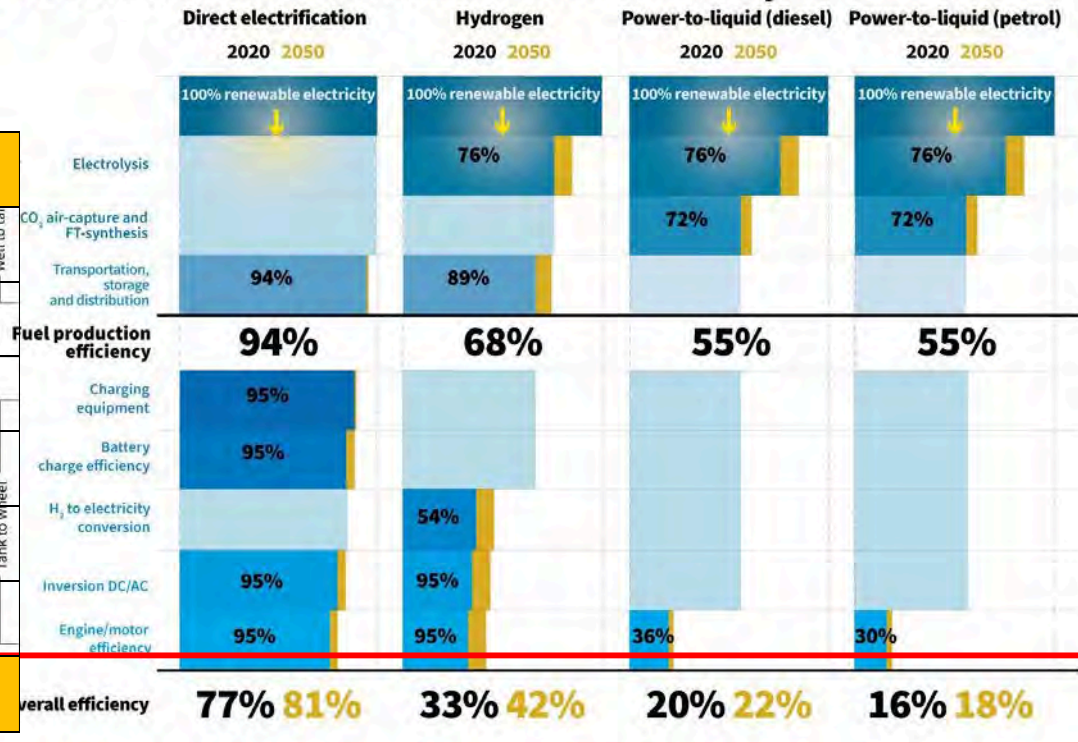
Electric heat transfer efficiency is about 3 X higher vs combustion from energy source to glass 79% vs 28%!



Comparison of electricity versus Hydrogen efficiency

	Electricity	H ₂ Electric	H ₂ Combustion
Renewable source	100%	100%	100%
Electrolyzer		70%	70%
Compressor		92%	92%
Transportation	92%	98%	98%
Transformer/Fuel cell	95%	52%	
Heat losses effect (electricity)	90%	90%	45%
Total	79%	30%	28%

Cars: direct electrification most efficient by far

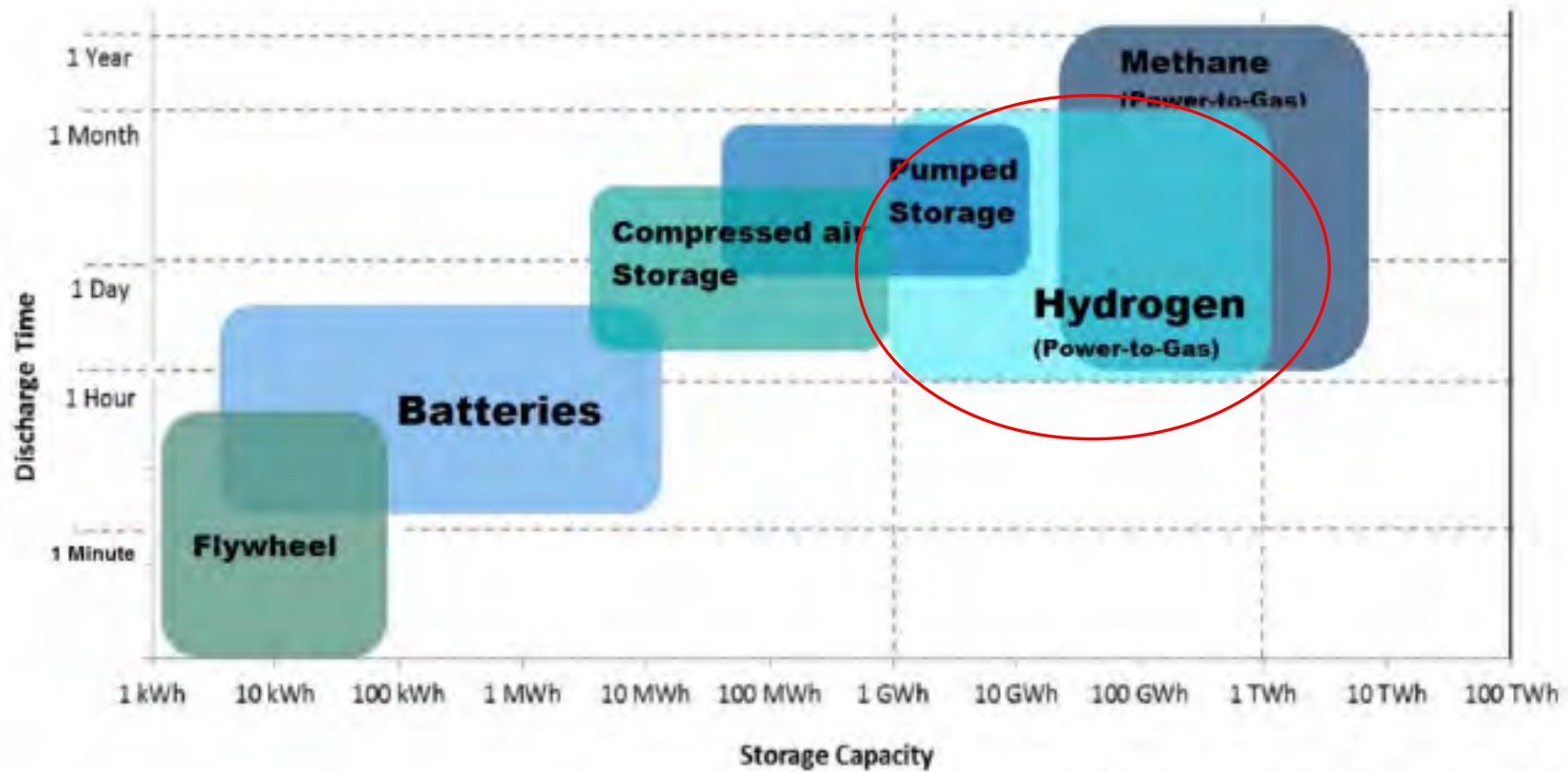


Notes: To be understood as approximate mean values taking into account different production methods. Hydrogen includes onboard fuel compression. Excluding mechanical losses.

Worldbank (2014), Apostolaki-Iosifidou et al. (2017), Peters et al. (2017), Larmanie et al. (2012), Umweltbundesamt (2019), National Research Council (2013), Ricardo Energy & Environment (2020), DOE (no date), ACEA (2016).

**Hydrogen has 3 advantages, Transport, Storage and Transformation (TST)
Electricity advantage is also 3, 3 times more efficient if it can be used directly**

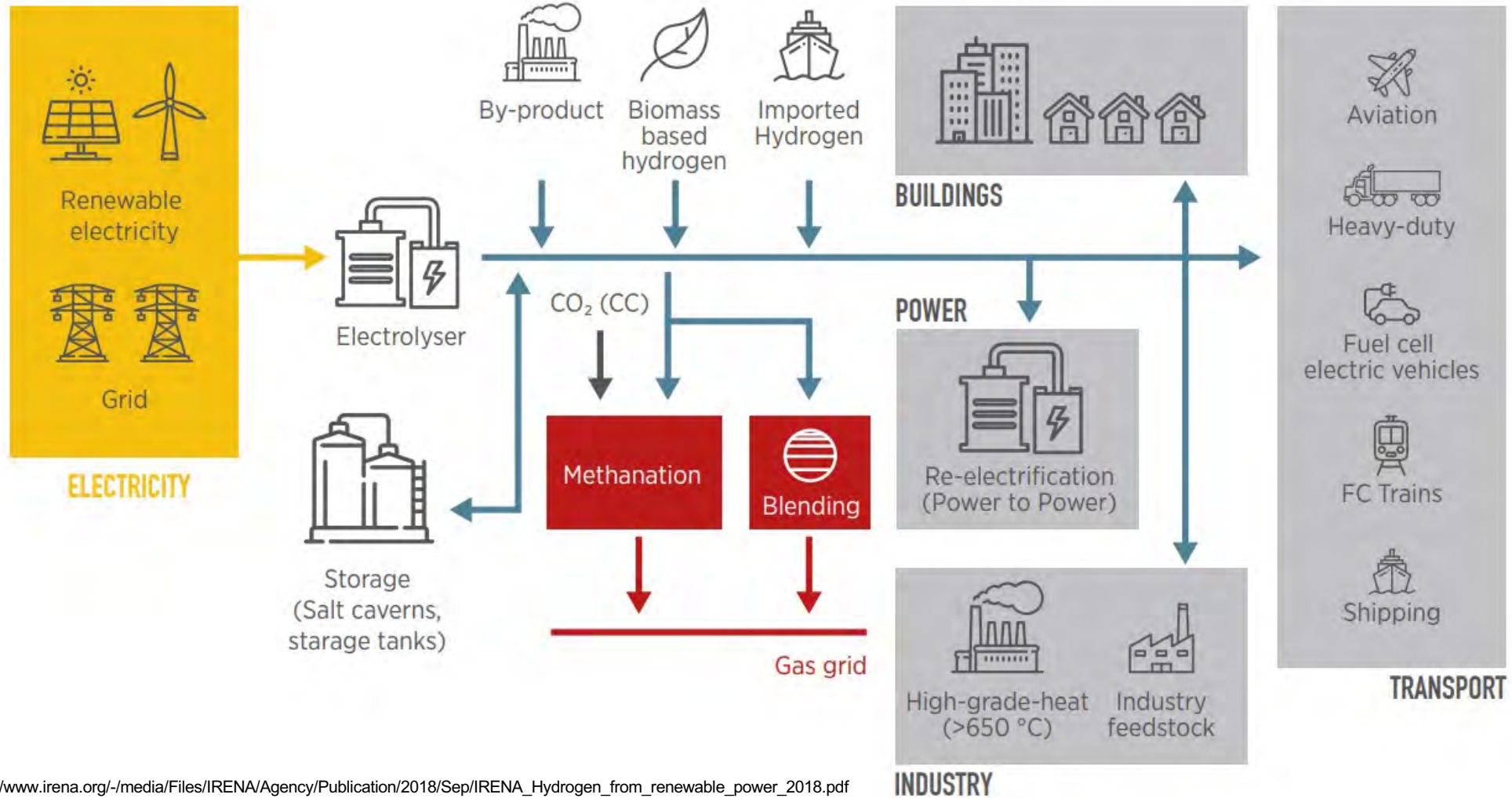
Energy Storage vs amount and time



Source: School of Engineering, RMIT University (2015)

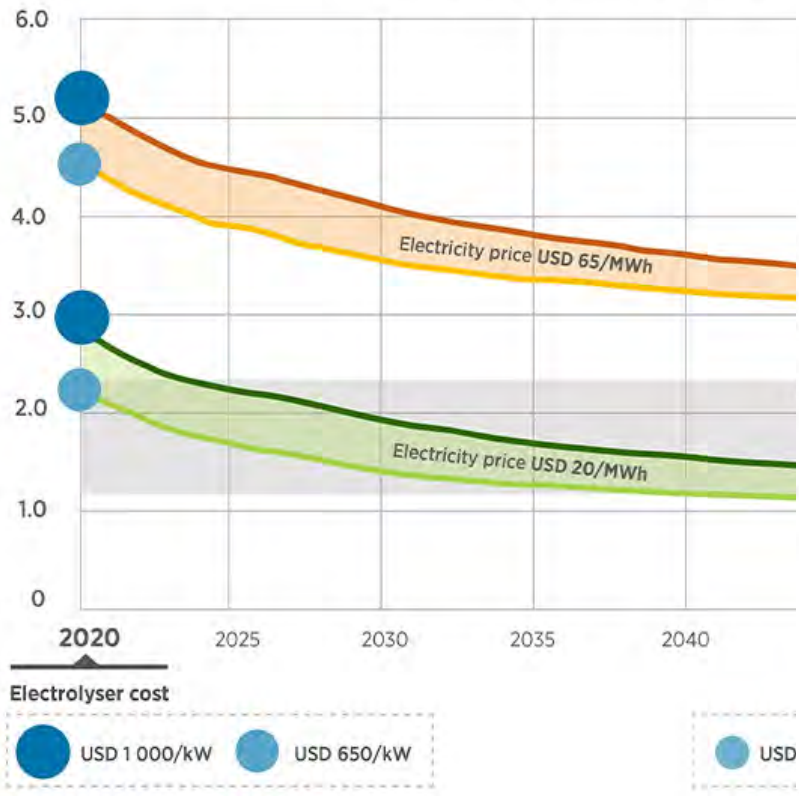
Figure 3. Available storage technologies, their capacity and discharge time.

Transport of Hydrogen as Methane or Ammonia

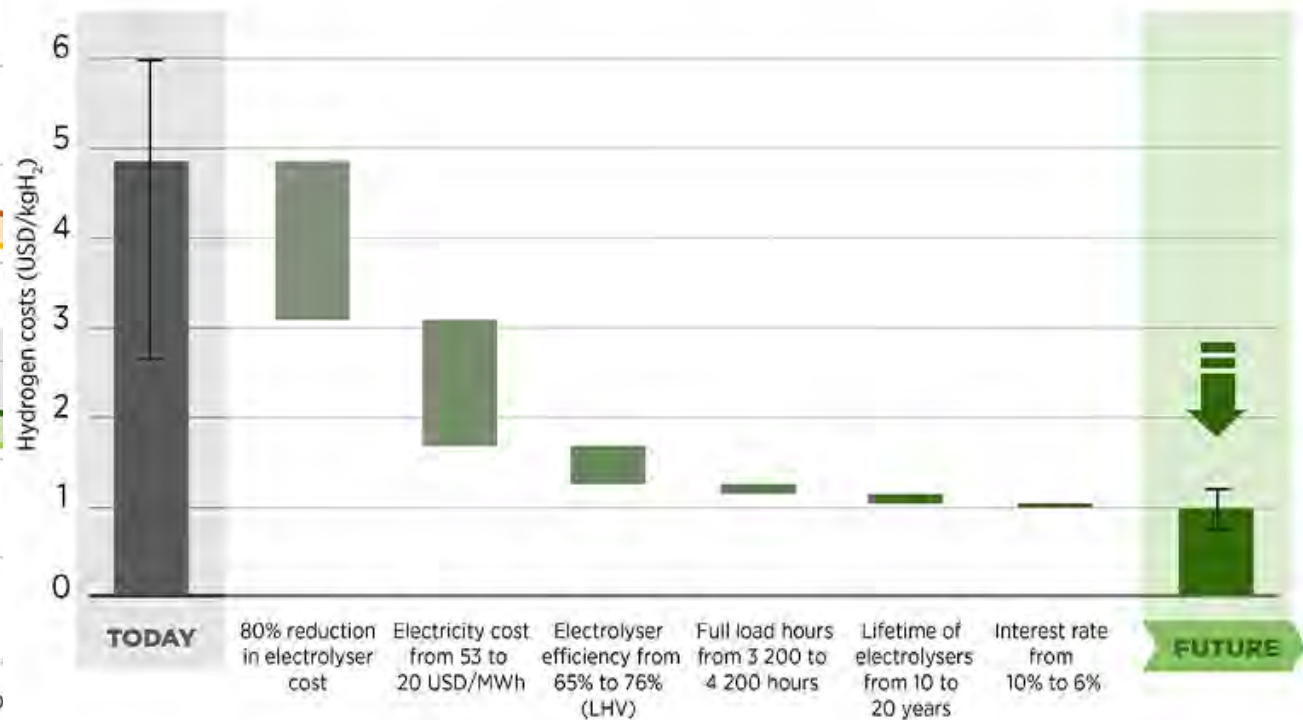


Hydrogen price to become competitive 2035+

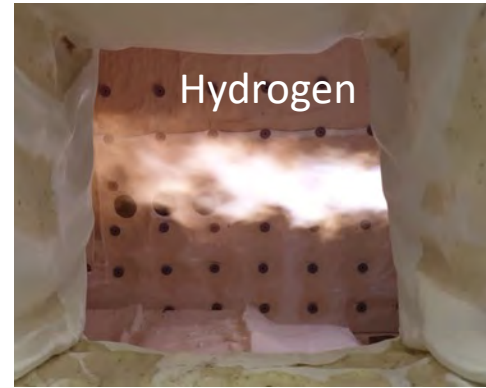
Hydrogen cost (USD/kg H₂)



The journey to a competitive green hydrogen

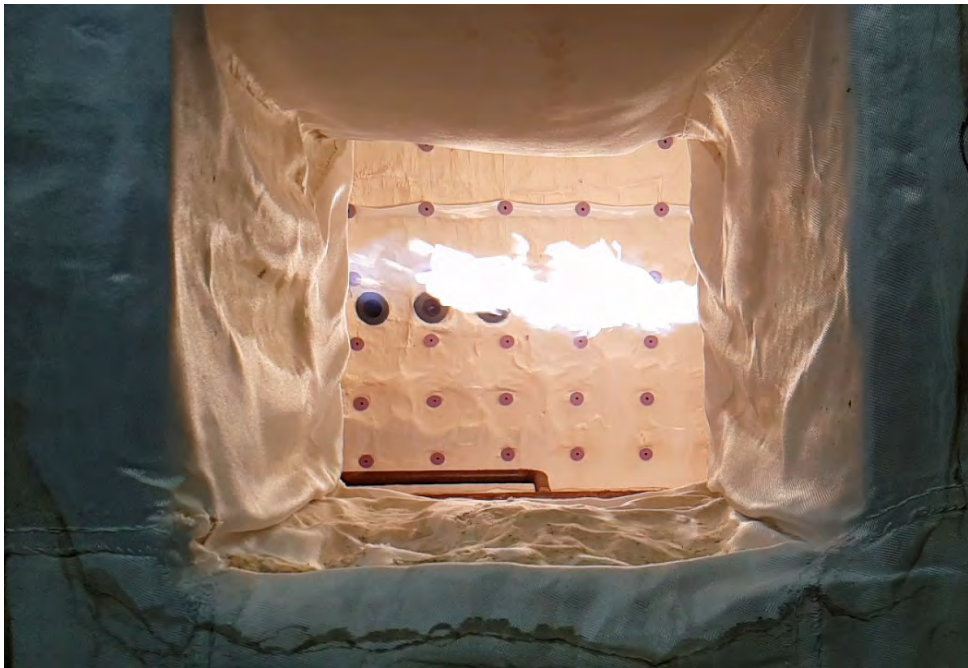


CH₄ vs H₂



Observation at 200KW CF burner in NG-Mode

Observation at 200KW CF burner in HYDROGEN-Mode



Decarbonisation projects 2024-2025



Company	Location	Technology	Capacity TPD	Timeline	% Electric	Engineering
Bormioli Luigi	Parma, Italy	All Electric Cold Top	6-80	Long time	100	Fives, GS model
SG Isover	Several	All Electric CT	<350	Long time	100	Internal, FIC
LMFV Pyrex	Chateauroux F	Hybrid	180	>2018	65	Internal, GS, FIC
Verallia	Cognac, Fr	All Electric Cold Top	180	2024	100	Fives
Verallia	Zaragoza, ES	Hybrid Oxy-Gas	350	2025	<80	SORG
Verallia	Saint Romain L P, Fr	Hybrid Oxy-Gas	350		<80	Internal
Verallia	Pescia, It	Heat-Oxy	350	2026	Large	Internal & AL
Verallia	Compo, Br	Heat-Oxy	350	2026	Large	Internal & AL
Ardagh	Obernkirchen,	Hybrid Oxy-Gas	350	2024	<80	SORG (FFVES)

	R, FI					
Verallia	Pescia, It	Heat-Oxy	350	2026	Large	Internal & AL
Verallia	Compo, Br	Heat-Oxy	350	2026	Large	Internal & AL
Ardagh	Obernkirchen, D	Hybrid Oxy-Gas	350	2024	<80	SORG (FEVES)
AGC & SGG VOLTA	Barevka, Czechia	Hybrid Oxy-Gas Melter	200(?)	2025	50	Internal & Linde
AGC	CZ & FR	Heat-Oxy	600	2012	0	Internal & AL
Pilkington (NSG)	UK (Various Sites)	Hydrogen Glass Furnace	800	Trials	>0	Internal & FIC
Guardian Glass	Global (Various Sites)	Electric Boost	600	Ongoing	>0	Suppliers & FIC
O-I Glass	Toledo, OH, USA	MAGMA Furnace	Modular	Ongoing	0	Internal
O-I Glass	Europe (Various Sites)	OptiMelt	200	2025	>20	Internal & Linde
Pochet du Courval	France	All Electric	66	2025	100	FIVES
Heinz Glas	Germany	All Electric	60-100	2020>	100	FIVES & Others



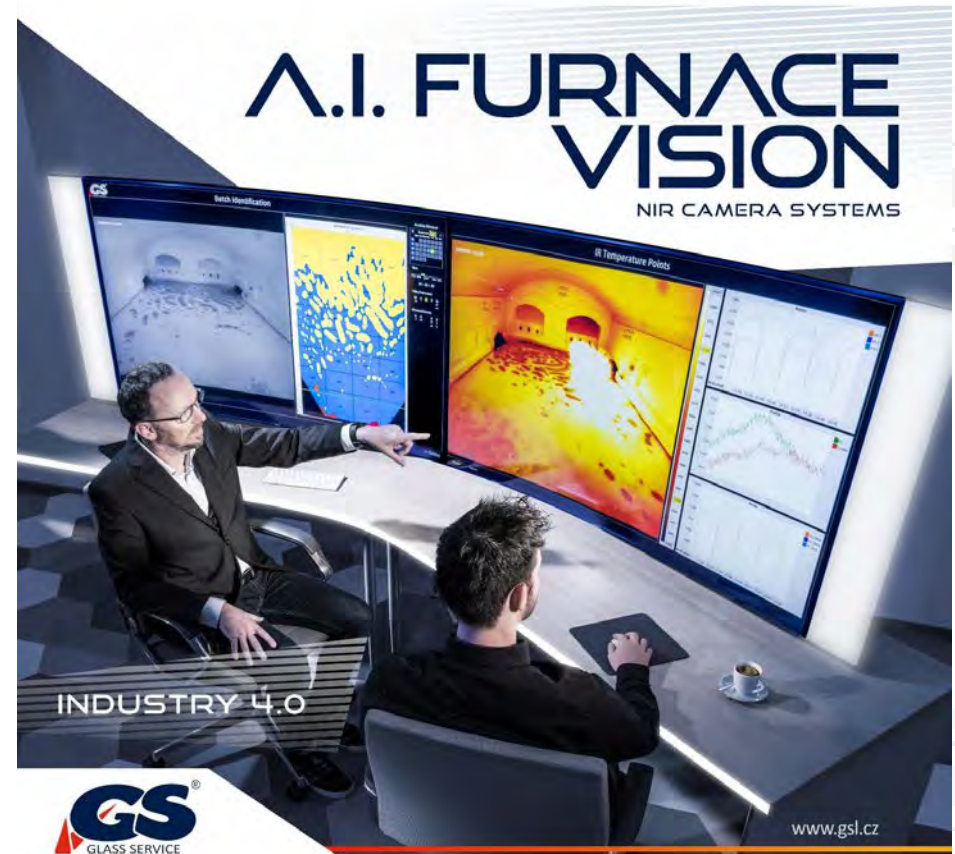
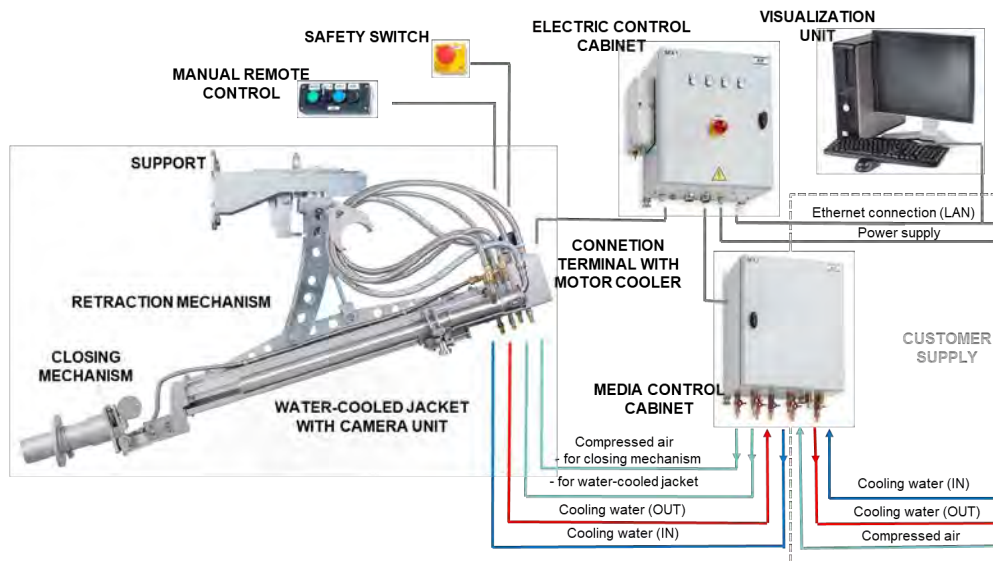
Guardian Glass	Global (Various Sites)	Electric Boost	600	Ongoing	>0	Suppliers & FIC
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O-I Glass	Europe (Various Sites)	OptiMelt	200	2025	>20	Internal & Linde
Pochet du Courval	France	All Electric	66	2025	100	FIVES
Heinz Glas	Germany	All Electric	60-100	2020>	100	FIVES & Others
IPGR	Aachen, D	Hybrid Oxy-Gas	6 <1tpd/m2	2025	Range test	Horn
Glass Futures	St. Helens, UK	Hybrid Oxy-Gas	30 <1tpd/m2	2025	Range test	Stara, FIC, FlammaTec



Near infrared camera (NIR)

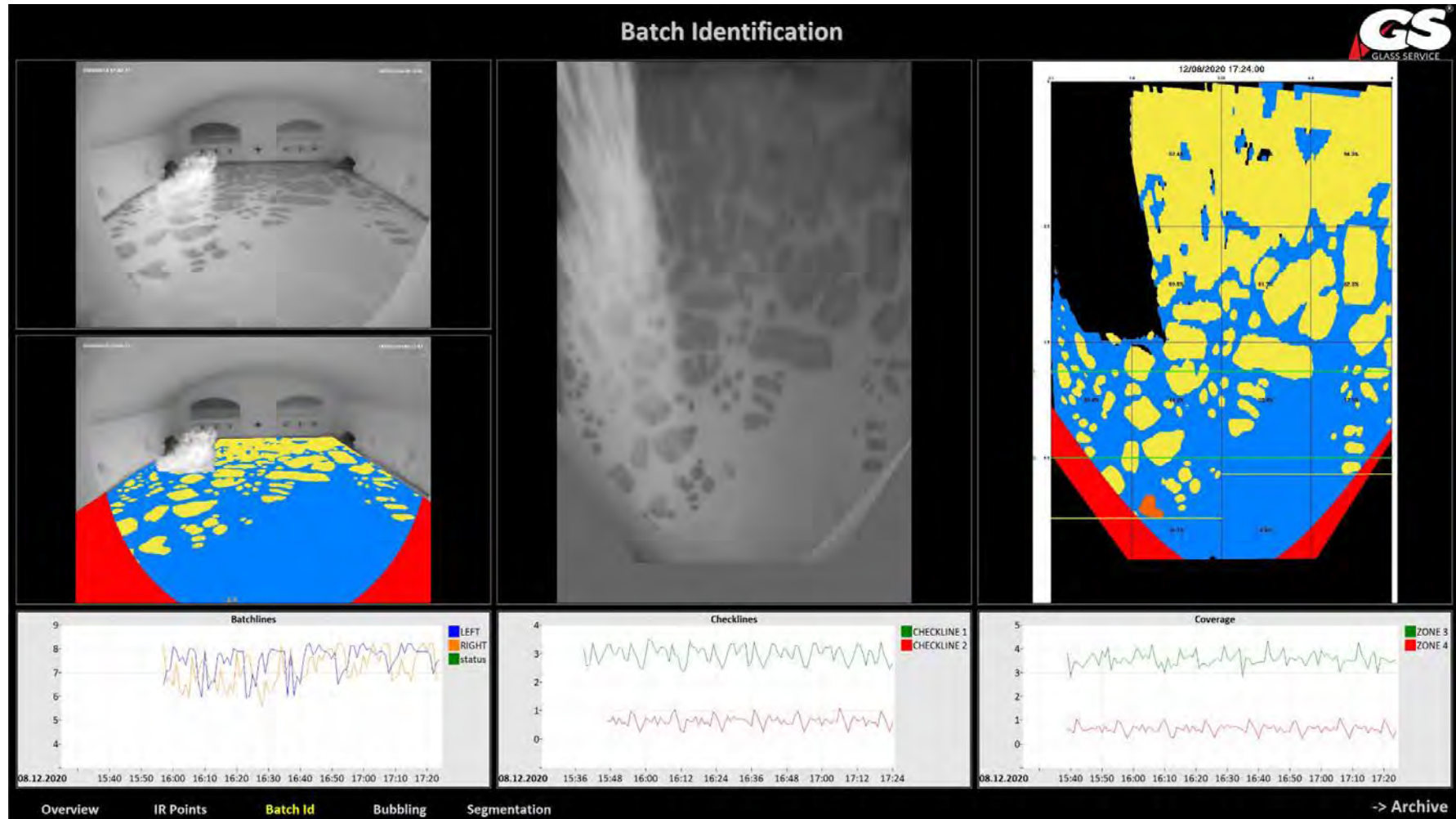
Introduction

- Highest resolution (5 mega pixel) camera for batch monitoring
- Possible to connect to furnace control (PLC / SCADA, *ESIII*)
- High-quality stainless steel jacket construction (1600°C max)
- Lens cleaning by air nozzles at the front of the jacket
- AI (Neural network) Image Software



AI Batch Monitoring Module container glass

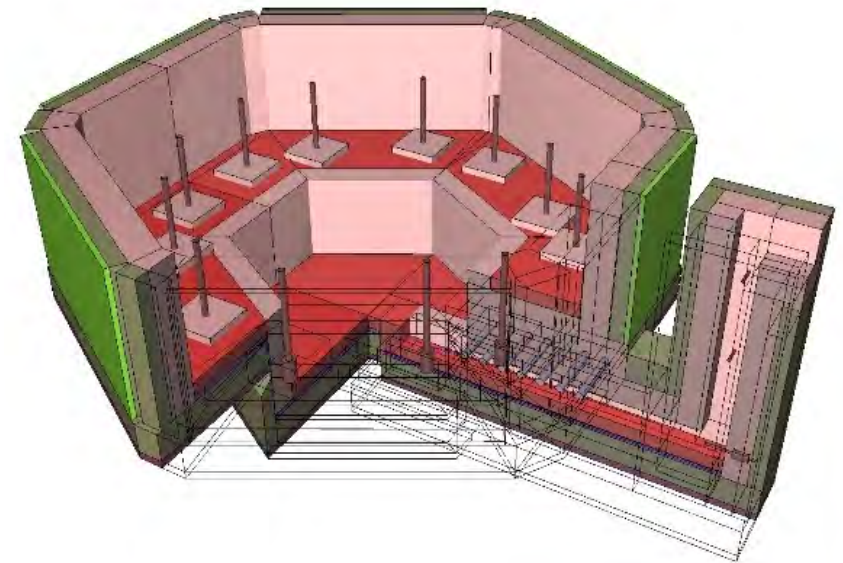
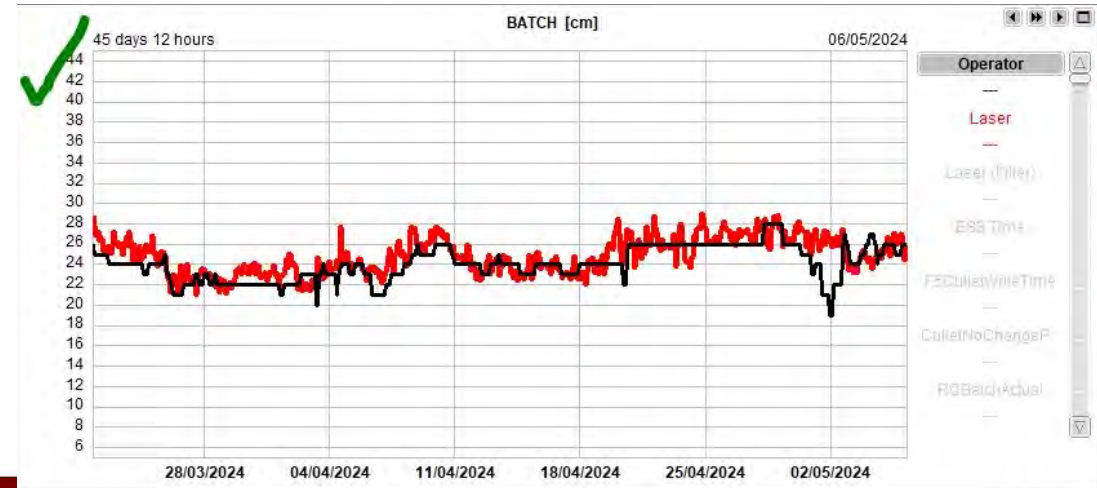
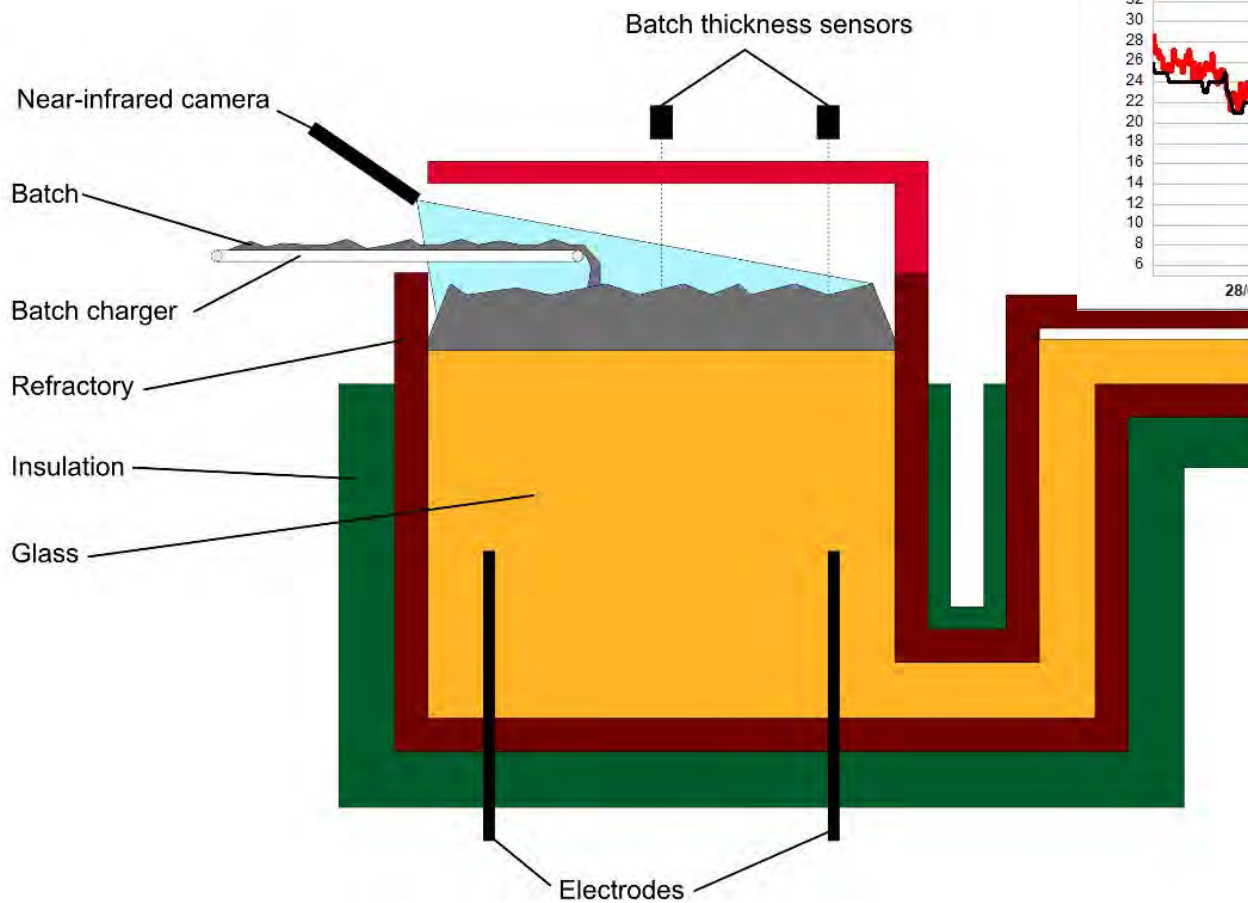
Glass/Batch Coverage with Historical Trends



Laser & camera batch crust thickness measurement system



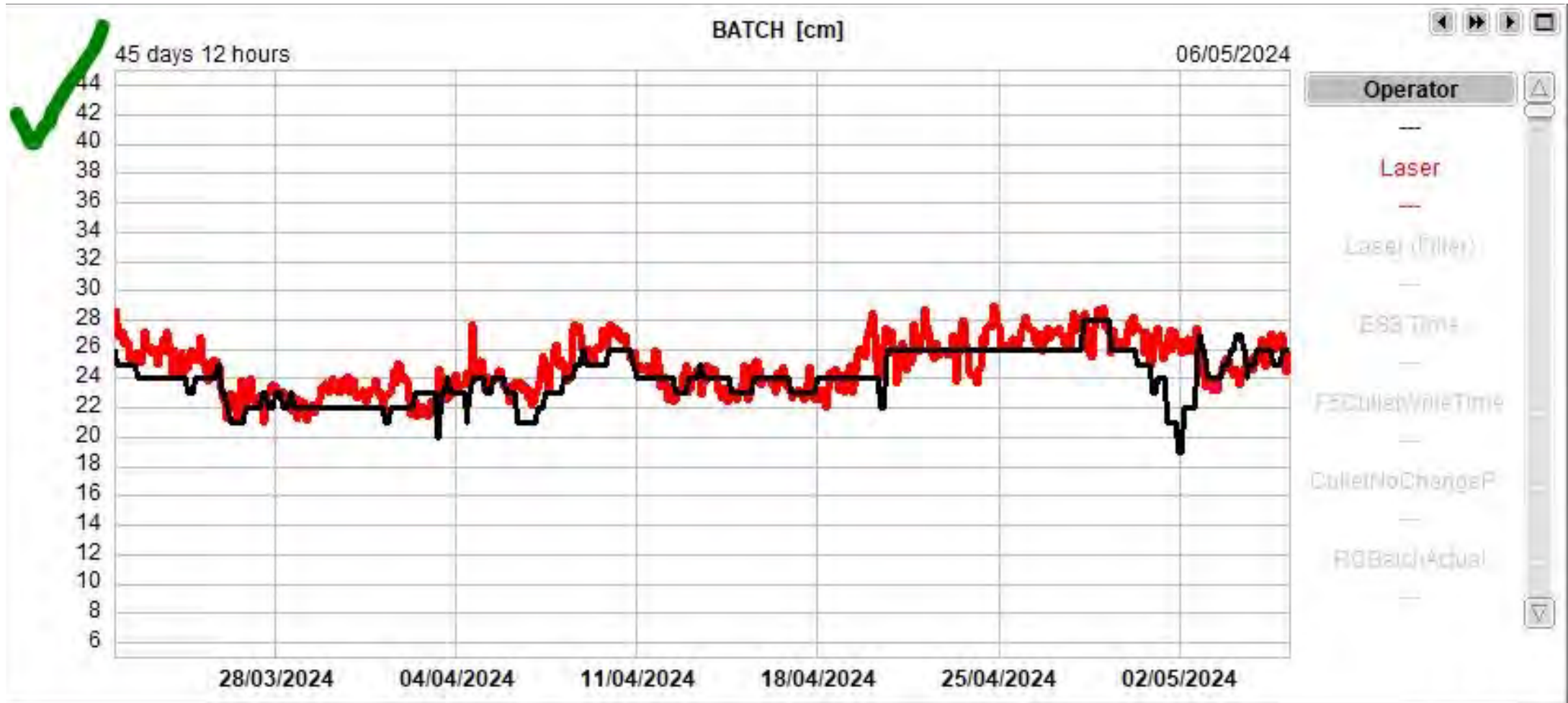
For all electric cold top melters



Laser & camera batch crust thickness measurement system



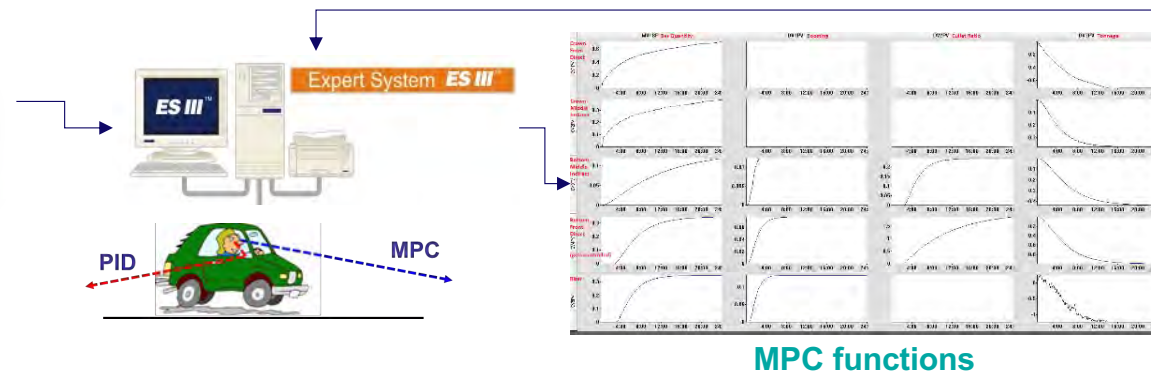
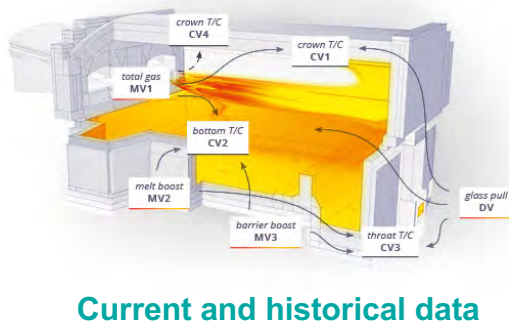
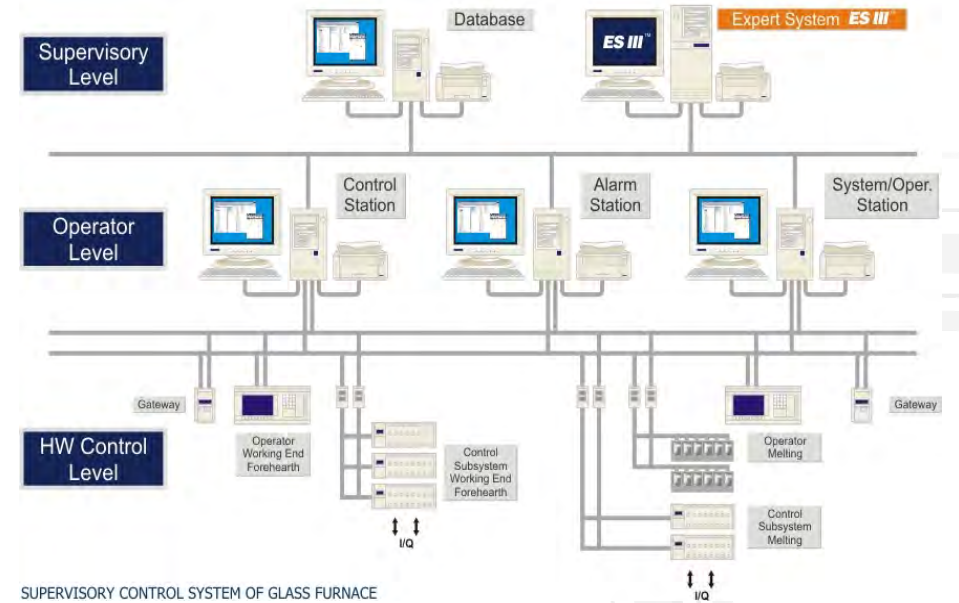
For all electric cold top melters



Expert System *ES III*



- *ES III*: state-of-the-art furnace control software introduced at supervisory level
- Model-based predictive control (MPC): correlations between input parameters and resulting process control / target variables
- Can be installed in different zones of the furnace
 - Melting area → combustion parameters, boosting level, batch feeding
 - Forehearth & feeders → heating / cooling intensity and distribution
- Specific energy cost calculation & carbon reduction in real-time and online
- Reduced risk of human mistakes (>95% control time)



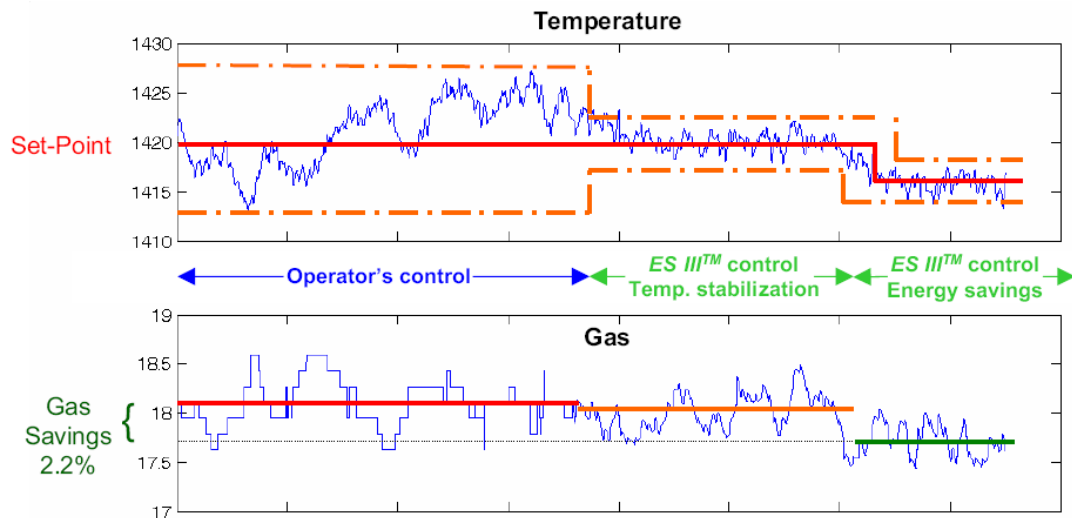
Glass quality (AI)

Expert System *ESIII*

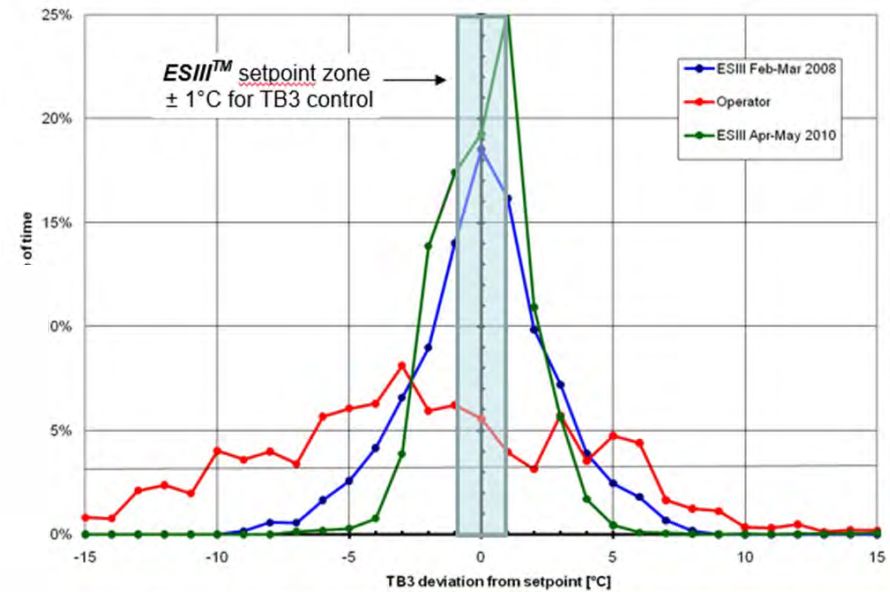


Glass melting

- Preserves energy and temperature profiles
- Better process stability
- Rapid and optimal adjustment to change in glass pull
- Gas / E-boost cost minimize controller
- Energy savings: 2-4% (150-400 k€ annual)

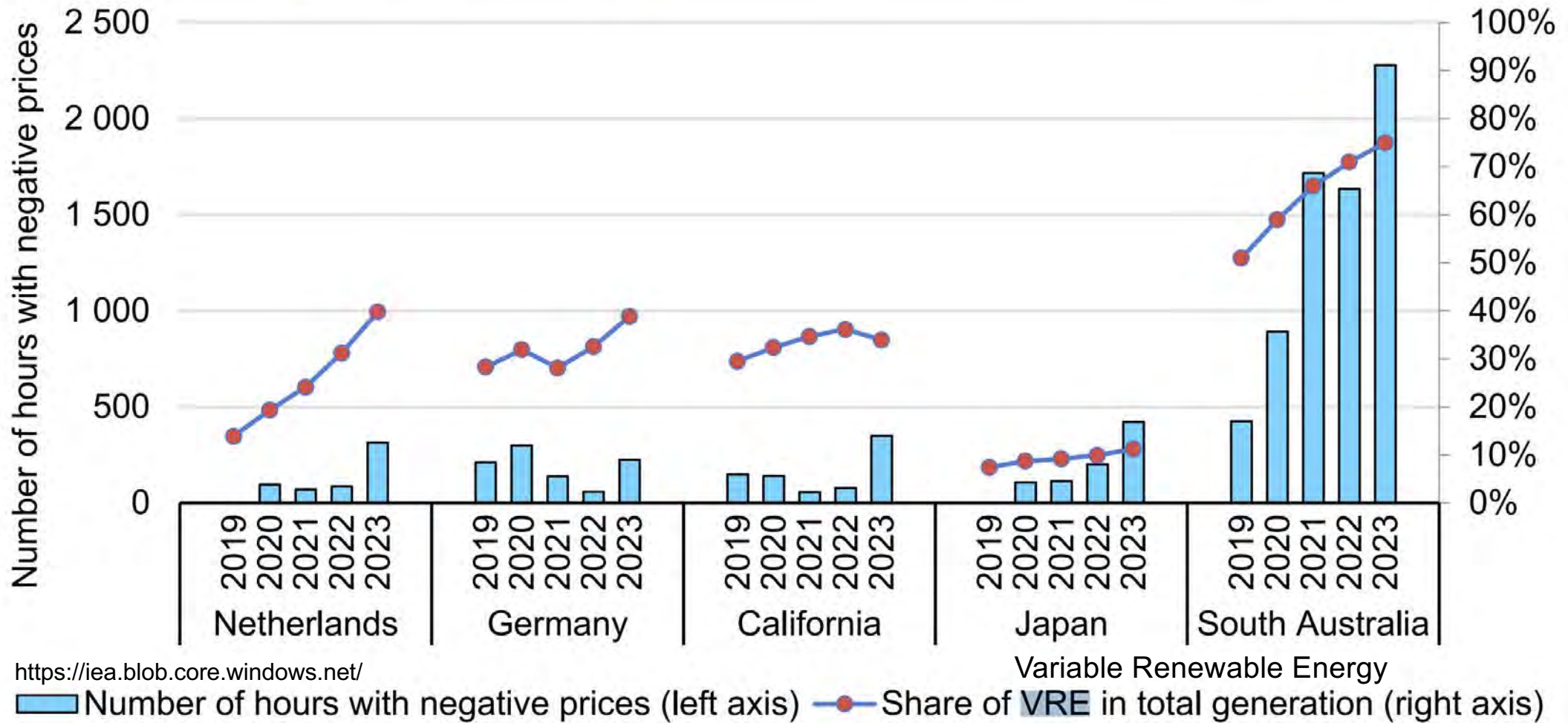


- Over 450 installation World Wide

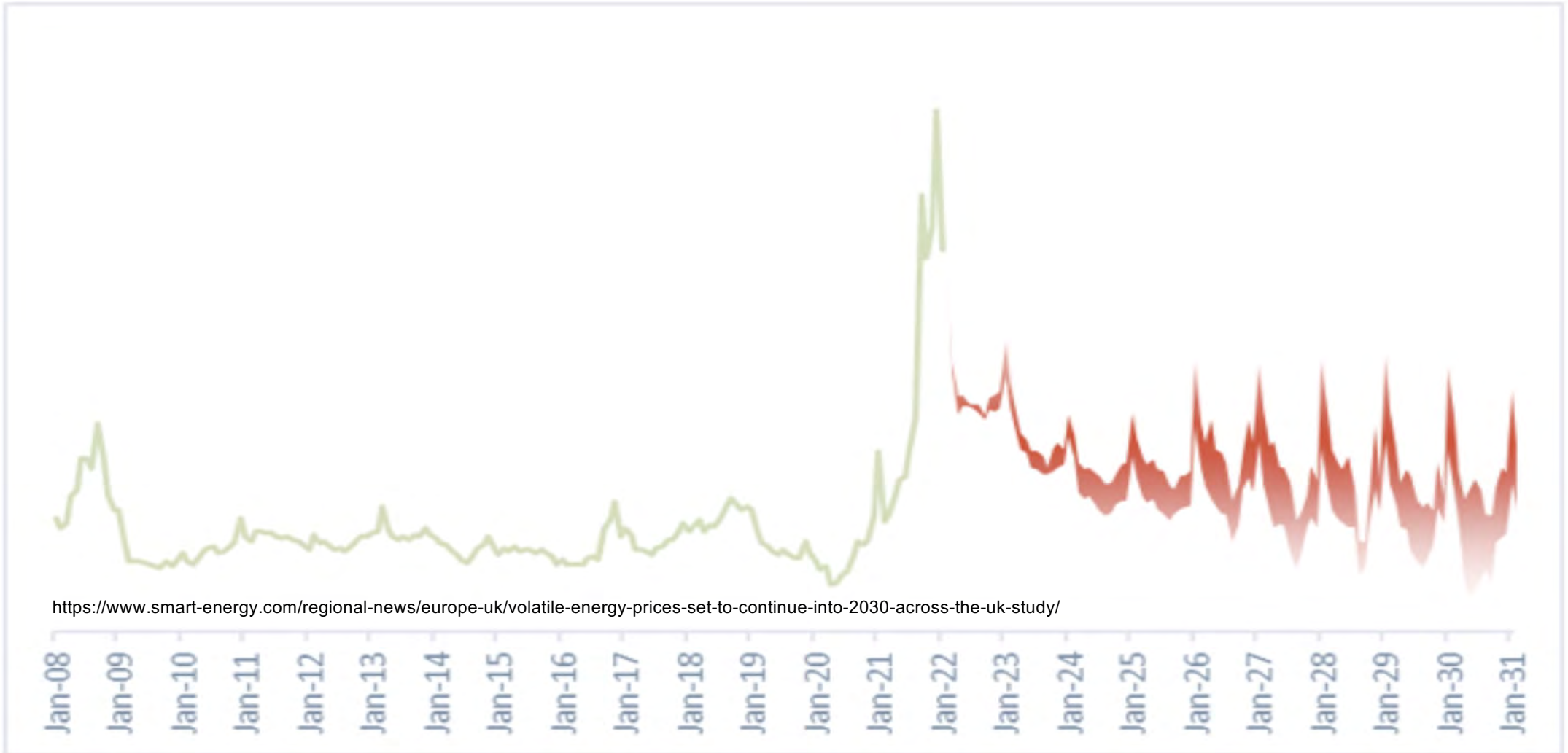


TB3 tolerance	Operator	<i>ES III™</i> (old furnace)	<i>ES III™</i> (new furnace)
$\pm 2^\circ\text{C}$	19.6%	64.8%	74.4%
$\pm 4^\circ\text{C}$	44.5%	91.6%	97.4%

Number of hours with negative wholesale electricity prices and share of variable renewable energy in total electricity generation in selected regions, 2019-2023



Electricity prediction lower, but highly variable !

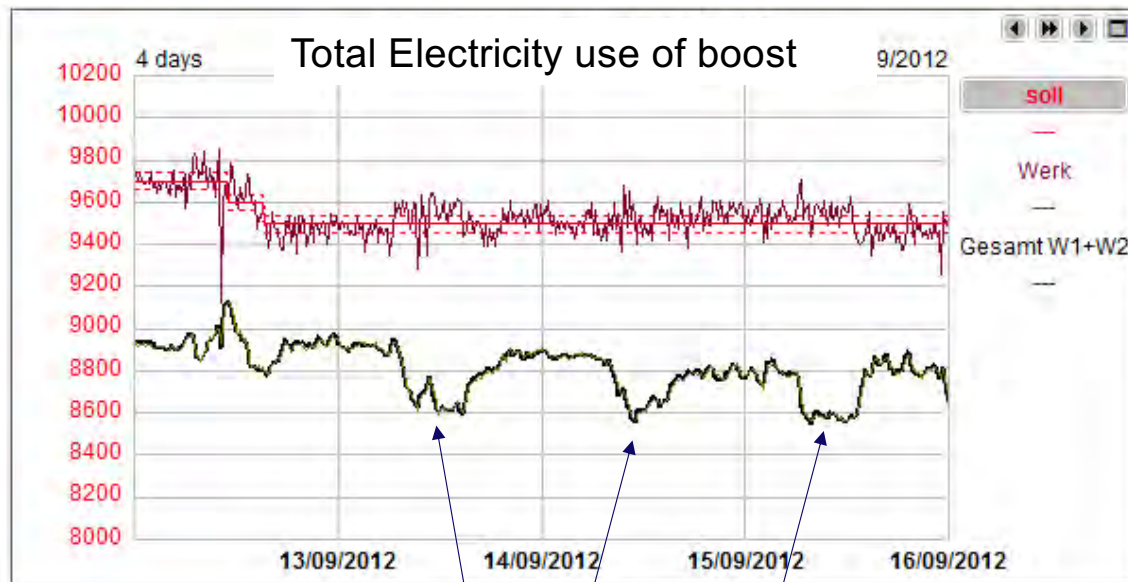


Source: Cornwall Insight, scale deliberately withheld

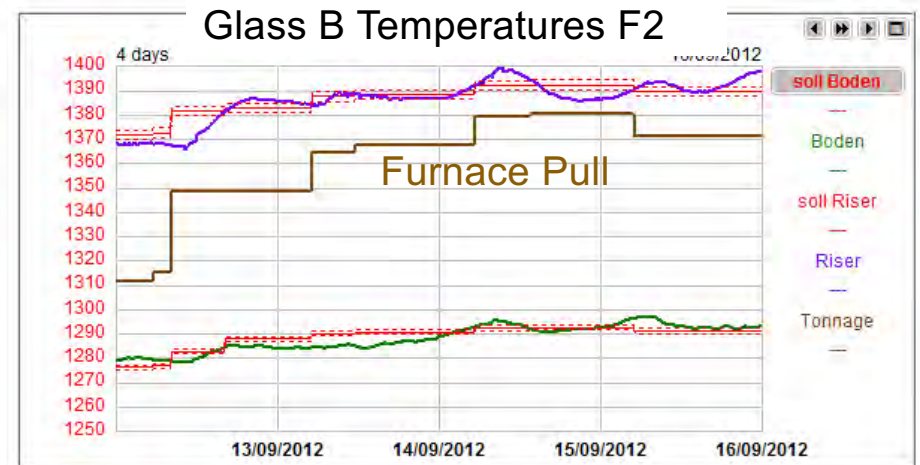
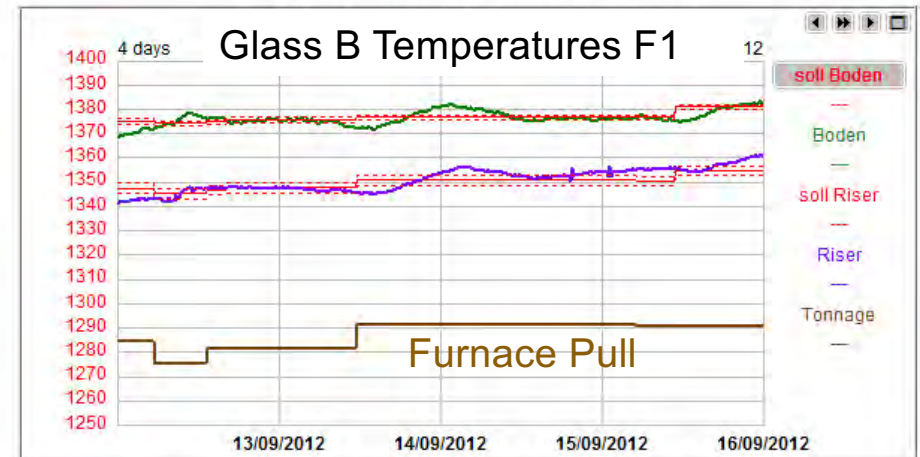
ESIII™ ENERGY MANAGEMENT SYSTEM



Use more boost when Electricity costs are low and less when costs are up



Boost by *ESIII* reduced during day time in this example from 2012



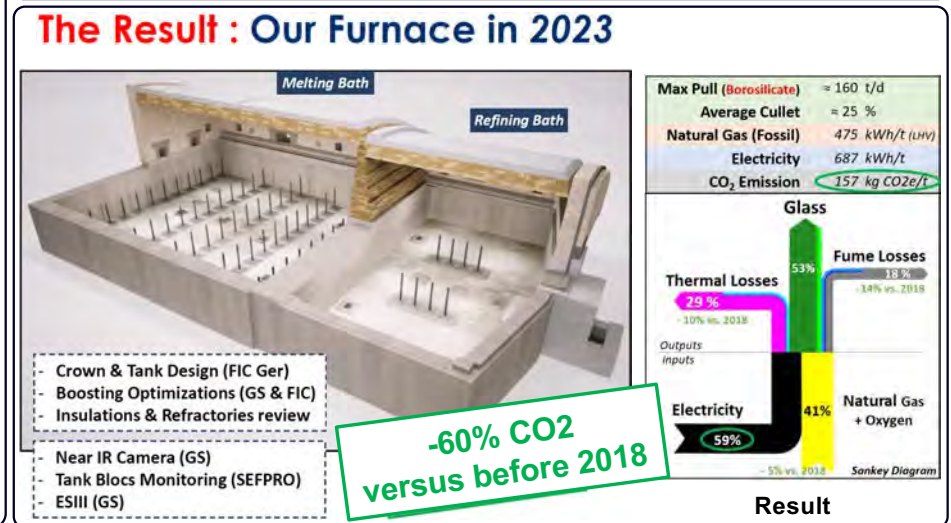
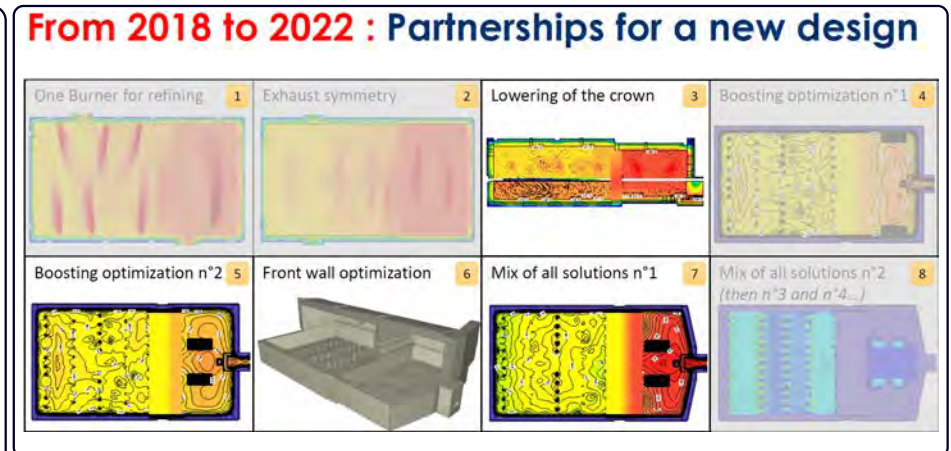
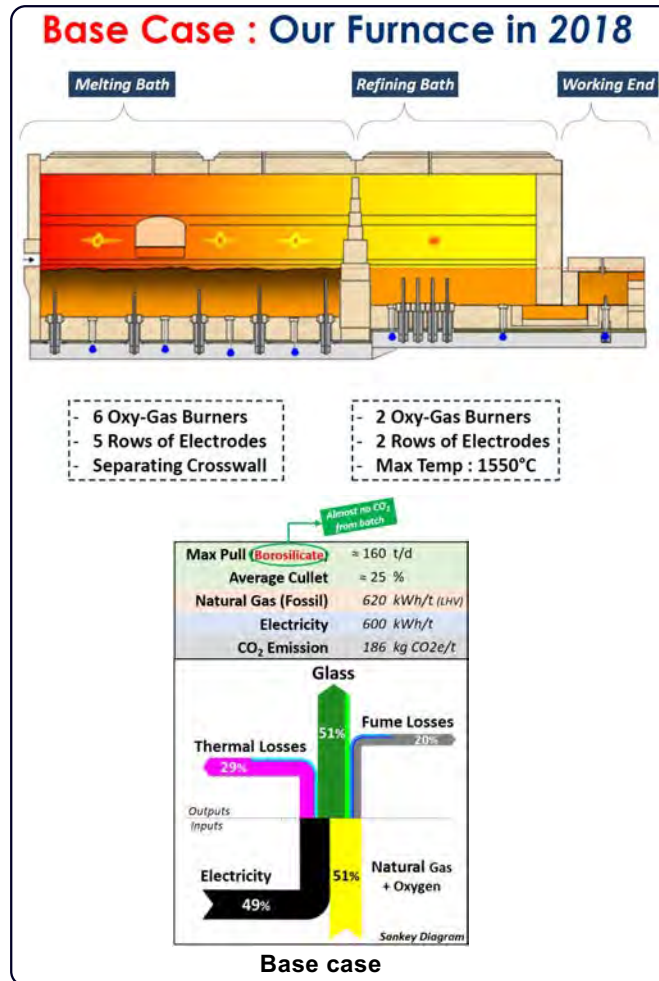
ESIII™ ENERGY MANAGEMENT & DECARBONISATION



Use more boost when Electricity costs are low and less when costs are up

Optimization of LMFV (La Maison Française du Verre)'s furnace

Presented on 16th International Seminar On Furnace Design – Operation & Process Simulation, Velké Karlovice, Czech Republic, 2023

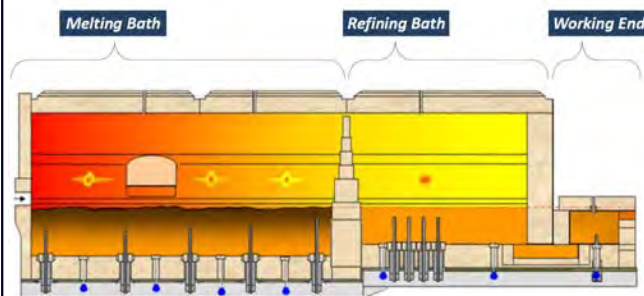


ESII™ ENERGY MANAGEMENT & DECARBONISATION

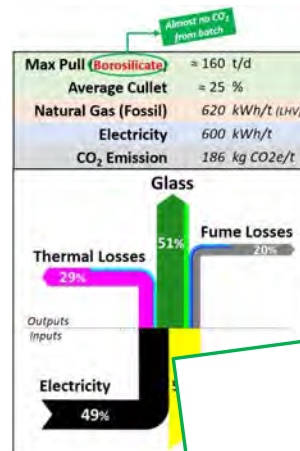


Use more boost when Electricity costs are low and less when costs are up

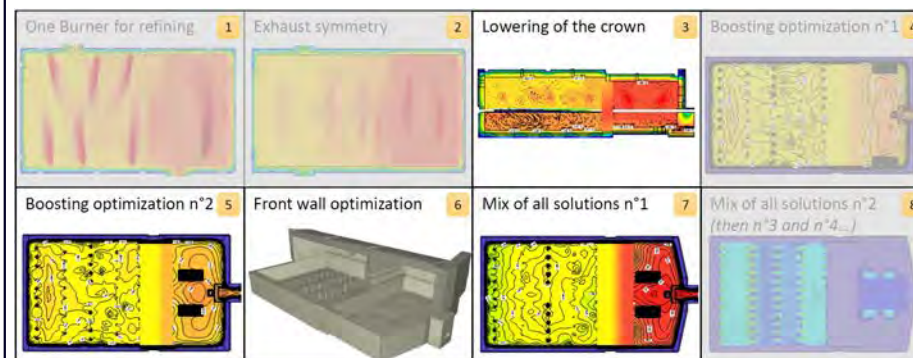
Base Case : Our Furnace in 2018



- 6 Oxy-Gas Burners
- 5 Rows of Electrodes
- Separating Crosswall
- 2 Oxy-Gas Burners
- 2 Rows of Electrodes
- Max Temp : 1550°C



From 2018 to 2022 : Partnerships for a new design



The Result : Our Furnace in 2023



Max Pull (Borosilicate)	≈ 160 t/d
Average Cullet	≈ 25 %
Natural Gas (Fossil)	475 kWh/t (LHV)
Electricity	687 kWh/t
CO ₂ Emission	157 kg CO ₂ e/t

Optimization of LMFV (La Maison Française du Verre)'s furnace

Presented on 16th International Seminar On Furnace Design – Operation & Process Simulation, Velké Karlovice, Czech Republic, 2023



-60% CO₂

Base case

Result

- **Decoupling from Fossil Fuels:** Over time, as renewables dominate, electricity prices will **become less dependent on oil and gas prices**. However, in the short to medium term, natural gas remains a critical balancing fuel, keeping fossil price fluctuations relevant.

Predictions (2025–2035 Outlook)

- **Short-Term (2025–2028):** Moderate declines in average prices, with **high volatility** due to renewable growth outpacing storage capabilities.
- **Medium-Term (2028–2032):** **Stabilization begins** as storage, smart grids, and flexible demand systems scale up.
- **Long-Term (2032–2035+):** **Sustained low average prices** with occasional volatility, especially in regions slow to adopt flexibility solutions.

Thank you for your attention



Increase the share of recycling and electric melting, supported by advanced model based supervisory control, will enable us to decarbonize and reduce our dependence on fossil fuels.

Let us combine our expertise and efforts with the support of the ICG and welcome the Glass Age:

<https://icglass.org/>



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