Schott Climate Neutral 2030
A way to decarbonization in the glass industry

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Climate Neutral 2030

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Plasma assisted heating

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Admixture with NG

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Green Hydrocarbon
Bio-Methan
Bio-Ethanol

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Outlook

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A sustainable corporate model

Carl Zeiss Foundation
Heidenheim an der Brenz and Jena
Foundation acting as shareholder

SCHOTT AG Mainz	Carl Zeiss AG Oberkochen
Subsidiaries	Subsidiaries

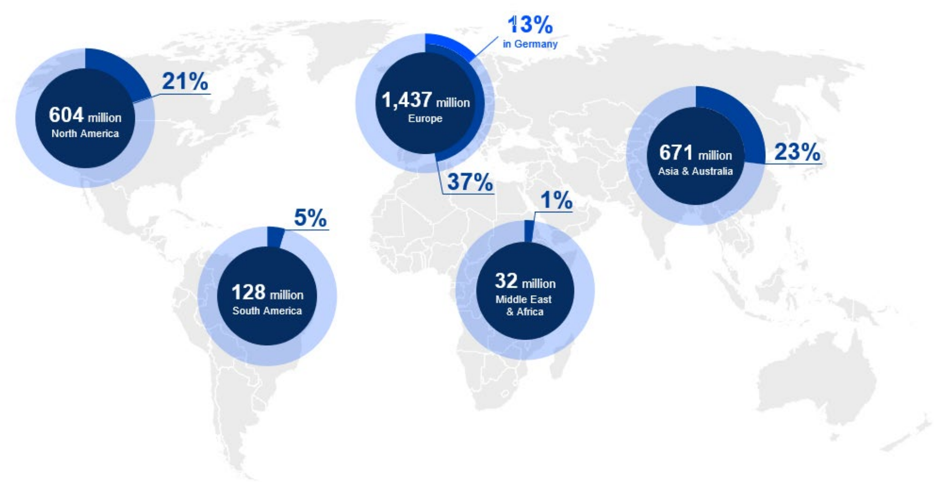
Our goal is sustainable growth

FY 2022/23

2,9 billion EUR Global sales	413 million EUR EBIT	277 million EUR Net income
451 million EUR Investments in property, plant & equipment	63% Equity ratio	17,100 Employees

Strong presence in global markets

Sales and share of sales in FY 2022/23 by sales region in EUR



Worldwide presence

40 productions sites / 24 sales offices

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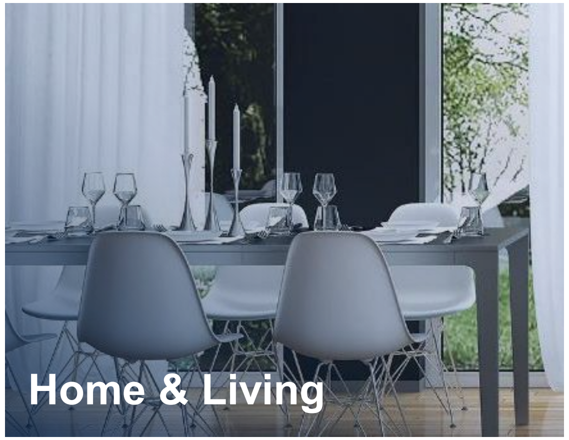
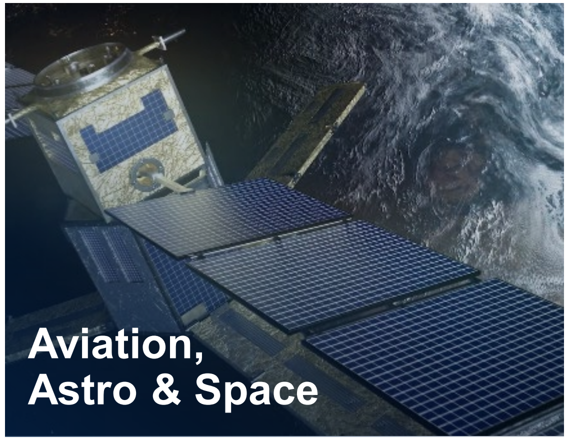
Broad product portfolio for high-tech markets





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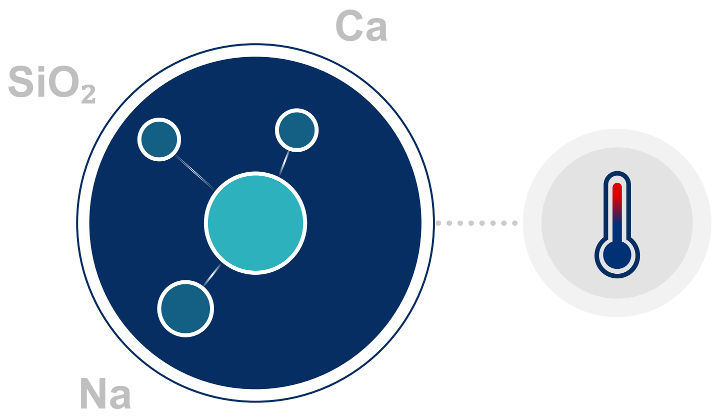
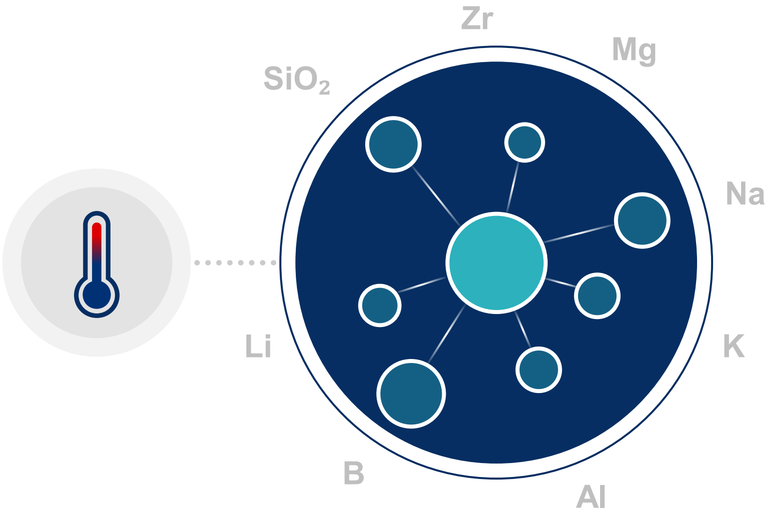
Specialty glass – a high-tech material

Glass is made by melting quartz sand and other raw materials



Sodalime glass
Melting point up to 1,400 °C

Specialty glass and glass ceramics
Application designed melting point up to 1,700 °C



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Our path towards climate neutrality

We want to avoid, reduce or offset emissions that are harmful to the climate.

Technological change

We will **avoid** emissions by using new technologies, but this change will take time.

Energy efficiency

We **reduce** emissions by continuously increasing our energy efficiency.

Green electricity

We **avoid** emissions by purchasing 100 percent green electricity.

Compensation

We **compensate** any remaining emissions with high-quality climate protection projects.

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Technology Change
Is ecology and economy possible?

Year	Price of Electricity [EUR/MWh]	Price of Natural Gas [EUR/ MWh]	Price of CO2 EUR/t	Price of NG + CO2[4] [EUR/ MWh]	Base value Bio Methan [Eur/MWh]	Price of Green H2 [EUR/MWh]	Price share % NG vs. El	Price share % (NG eff.)[3] vs El	Price share % (NG eff.+CO2)[3] vs El	Price share % H2 vs El	Price share % (H2 eff.)[3] vs El
2024[1]	**120,0**	55,0	70,0	**69,0**	69,0	**300,0**	46	92	**115**	250	**500**
2030[2]	86,0	40,0	90,0	58,0	58,0	195,0	47	93	135	227	454
2040[2]	51,0	25,0	180,0	61,0	61,0	114,9	49	98	239	225	451
2050[2]	**45,0**	25,0	180,0	**61,0**	61,0	**75,0**	56	111	**271**	167	**333**

1: SCHOTT Market Review | 2: BMWK, Carbon Contracts for Difference, Outline of funding limits in energy pricing | 3: **hot crown heating: approx. 50% of applied energy only used for glass processing, rest thermal loss in superstructure and hot flue gas** | 4: 0,201 t CO_2/MWh NG

Messages for way of Technology Change for special glass

- Develop melting to electro boosting / full electrical melting wherever it is technological feasible
- Reduce as much as possible need of crown heating by chemical burning
- Use green Hydrogene or Hydrocarbon only instead of NG for the residual crown heating which is unavoidable

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Our Way of Technology Change

We Rely on Innovative Technologies to Avoid Carbon Emissions in Glass Production.

Approach 1

Green Electricity

Electro Boosting

Plasma Burner for crown

Microwave assisted melting

Approach 2

Green Hydrogen

Admixtures with Natural Gas (NG) and Liquid Propan Gas (LPG)

Full replacement of fossil fuel

Approach 3

Green Hydrocarbon

Admixtures NG with Bio-Methan, Bio-LPG, Bio-Ethanol

Full replacement of fossil fuel

The Technology-Roadmap to Drive Technology Change

Technology

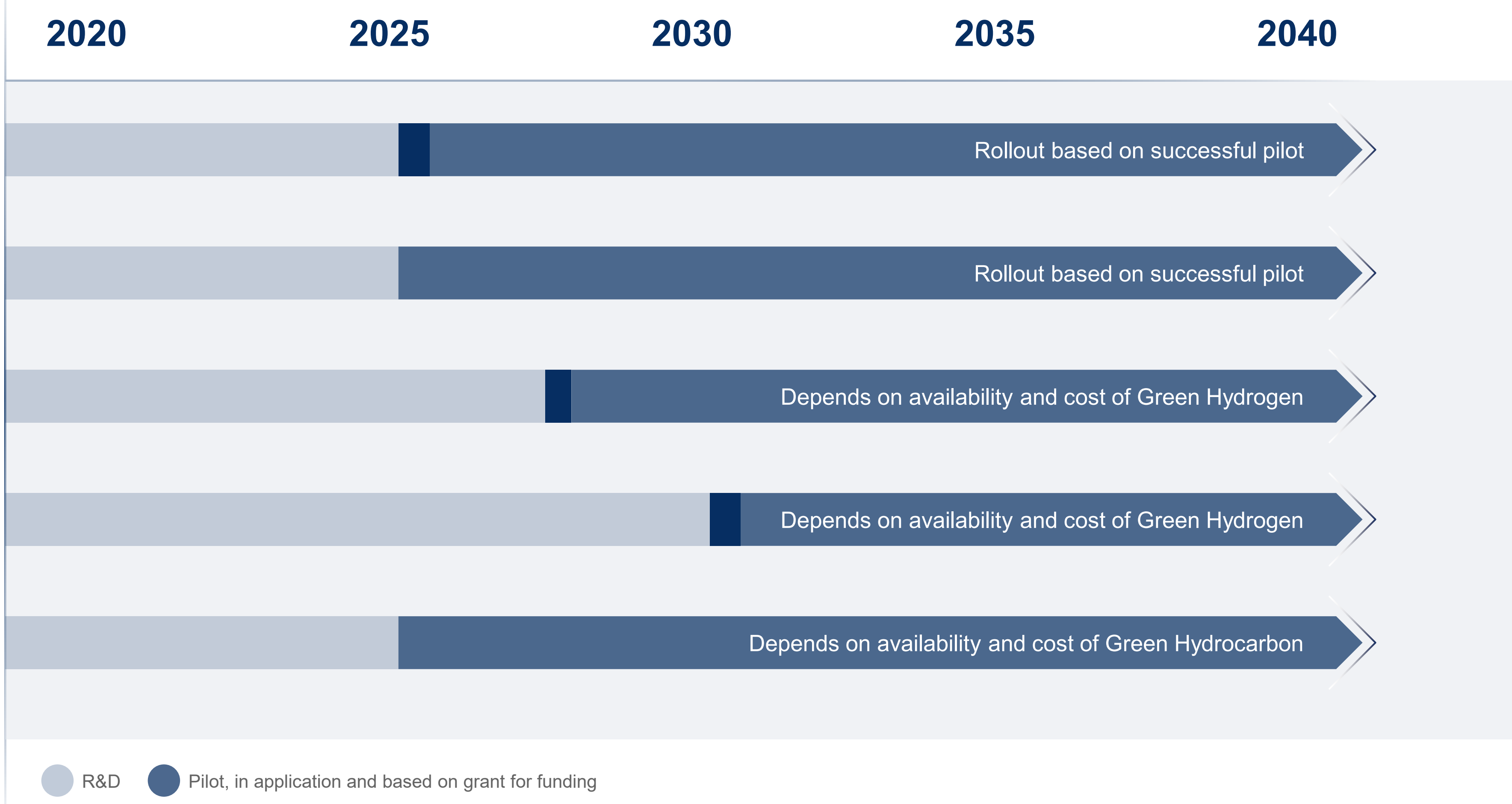
High Electric-melting pilot PLANET

Electric-melting pilot PROSPECT

Melting tank with admixture Natural Gas – Hydrogen fuel

Melting tank based on Hydrogen fuel

Melting tank with admixture Bio-Methan



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Approach 1
Overview Green Electricity Research Tasks@SCHOTT

Application oriented
Electro Boosting

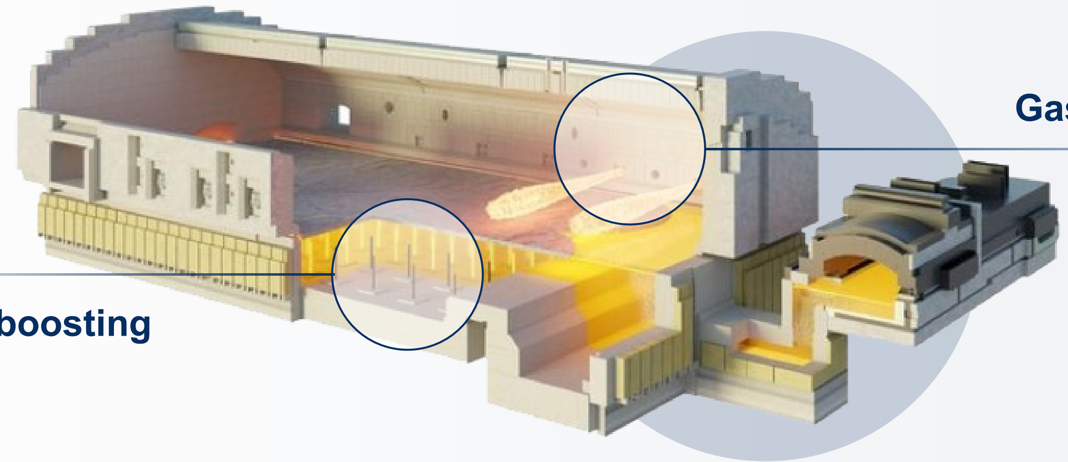
Project PLANET
high electrification (>60% of overall energy consumption in tank)

Project PROSPECT
E-Melter + RT (residual CO_2 < 20% of former melting process)

Basic Research

Project GIFFT
burner replacement by fuel-flexible plasma torch

Project MiGWa
micro-wave assisted melting



Source: Horn@Glass-Industries – Hybrid tank

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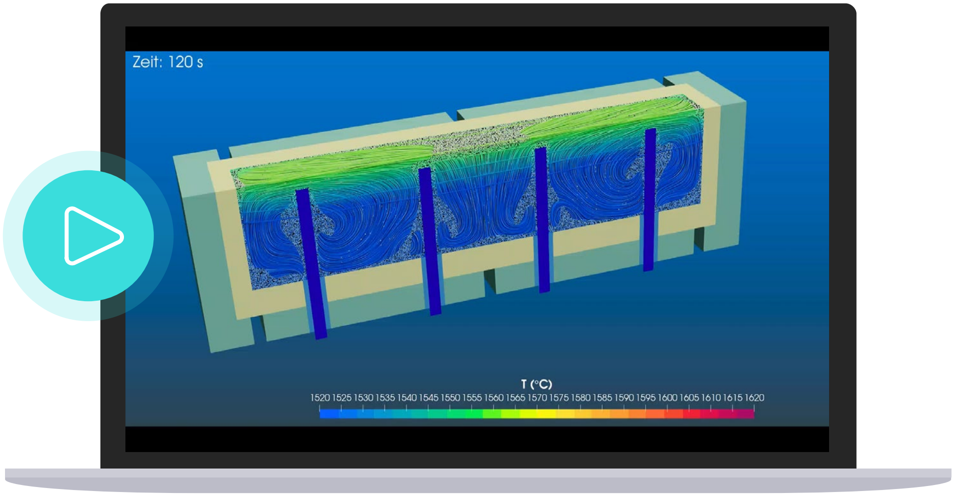
Electro Boosting

Glass Flow and Electrode Corrosion to Be Considered



Glass	°C	A/cm²	50 Hz	1 kHz	3 kHz	10 kHz
Type 1	1620	1,0	1,0		< 1	<1
Type 1	1620	2,0	1,5			
Type 2	1620	2,0		1,5		< 1
Type 3	1650	2,0	1,5			< 1
Type 4	1650	2,0	2,0			< 1

Data based on representative Lab-Test, Mo-electrode

Significant change in temperature and glass flow based on heat circuit design in standard 50Hz

Electrode corrosion in mm/a based on glass type and current density / frequency. Current density increased or corrosion reduced by use of inverter technology >1 kHz*

* Patents pending

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Flagship project PROSPECT Characteristics

Melting and Refining in one tank

Conventional technology

7.500 kW Airfuel
13.200 t CO_2/a

PROSPECT

Full Electric Melter

2.200 kW
Electricity
0 t CO_2/a

Refining Tank

1.000 kW NG+Oxy
400 kW Electricity
1.800 t CO_2/a

>80% reduction CO_2/a with electricity and use of NG only in refining tank. Potential of 100% reduction of CO_2/a out of thermal processing with use of green H_2 or Bio-fuel in refining tank. (approx. 500 t/a CO_2 will remain from carbonated raw materials)

"Implementation and operation of a 'Zero Carbon' pharmaceutical glass pilot furnace on an industrial scale"

- Start of the pilot furnace campaign with start of annealing in Q1 2026
- Solution for 5.0 Pharmaglass
- Target throughput: > 40 t/d pharmaceutical glass per day
- Technology concept Full Electric Melter + electro-boosted Refiner
- Location: Mitterteich / Germany
- New tank for trial operation in production
- If successful, roll-out existing tanks of common technology at repair with new technology

Invest: > 40 Mio€, funding 14,85 Mio€

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Funded by the European Union
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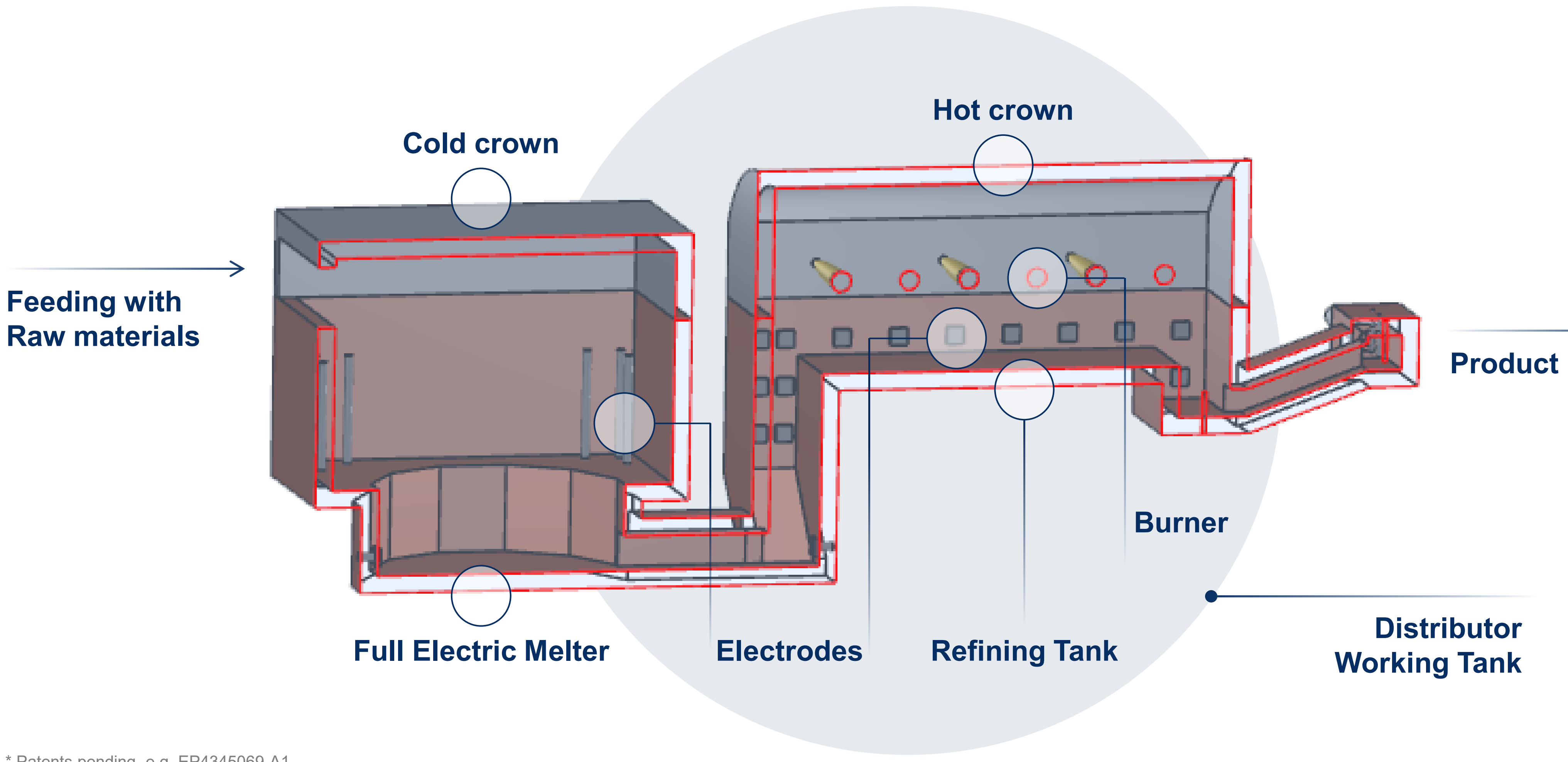
Flagship project PROSPECT
Scetch of tank design*

Approach 1: Green Electricity



* Patents pending, e.g. EP4345069 A1

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Challenges for PROSPECT

Development of technology (Prospect F&E) and start of pilot production (Prospect Pilot) within 5 years

Glass production > **40 tonnes/day**. Standard indus-trial tank size

Large surface of electrodes in interaction with glass, no impact to glass allowed

New electrical heating technology with **higher fre-quent** AC power

Keep **glass quality** without any compromise

Option for **100% free** of CO2 from thermal processing

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Plasma Burner

Approach 1: Green Electricity

Applied R&D to the special needs for Glass Industry

Source: LIETUVOS ENERGETIKOS INSTITUTAS

GIFFT Concept Assessment
Follow-On Demonstration of the Integration to Existing Glass Melting Furnace

- Techno-Economical Feasability Evaluation
- Regional Case Studies LCA Analysis
- Technical Readiness and Risk Analysis
- Dissemination, Communication and Exploitation

GIFFT Sustainable Glass Industry with Fuel-Flexible Technology

Low-Economic Value, Biogenic Residues and Wastes
- Potential
- Logistic
- Pretreatment
- Ash Management

Development and Validation of Key Enabling Technologies to TRL5
- Plasma Assisted Entrained Flow Gasification
- Plasma Assisted Fuel-Flexible Combustion
- Biomass Gasification Ash Reuse
- Technicla Heat Production Flexibility in Pilot Scale

Market Oriented Operation Modes

Source: LIETUVOS ENERGETIKOS INSTITUTAS as consortium leader

Project GIFFT

Sustainable Glass Industry with Fuel-Flexible Technology, Oct 2023 - Sep 2027

GIFFT Sustainable Glass Industry

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Plasma Burner
Plasma assisted Fuel Flexible Combustion

Initial **free flame test** in laboratory, overall energy approx **80kW**

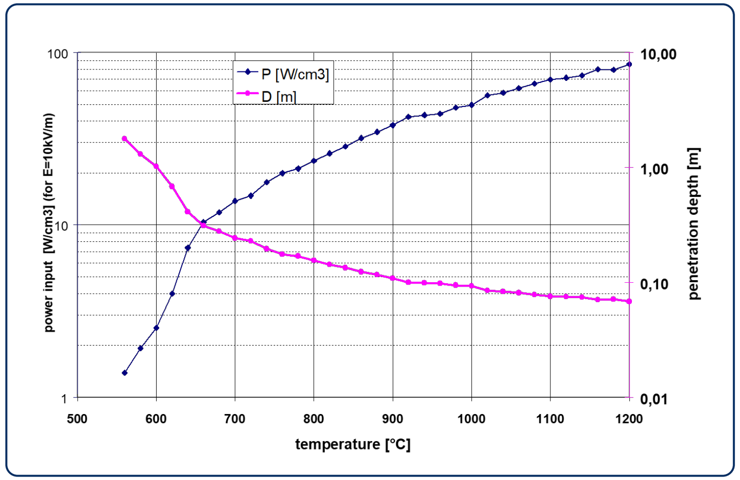
DC-Plasma + CH4 Oxyfuel

DC-Plasma + H2 Oxyfuel

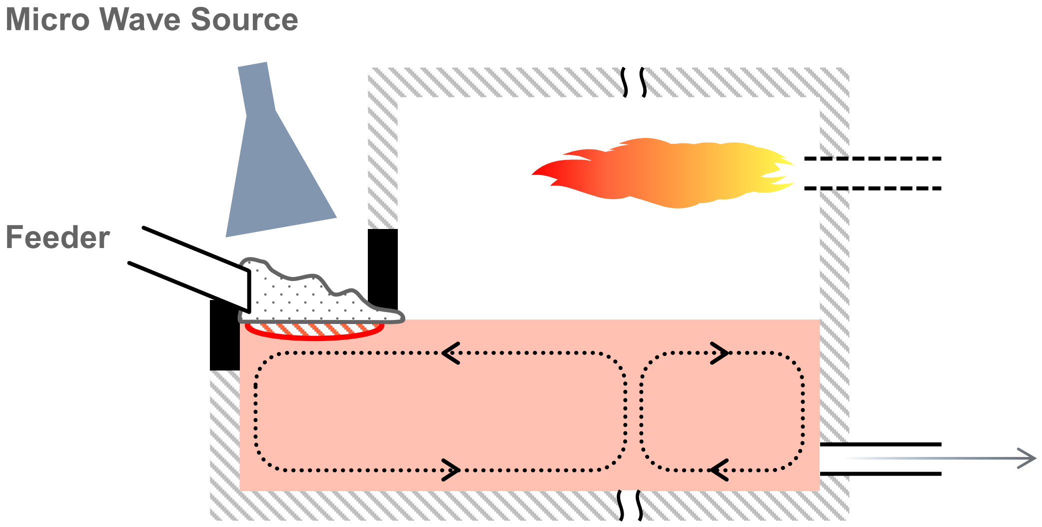
by courtesy of LEI, project GIFFT, March 2024

Microwave

Basic Research in Assisted Heating for Melting



Penetration depth and power input for soda lime glass at **2,2 GHz**



Source: Microwave heating of glass, H.Römer et al, Congress on Microwave and Radio Frequency Processing, 2000, Orlando, USA

With micro-wave assisted processing during the heat–up of glass it is possible to provide an extra portion of energy in between batch and melt to improve and speed-up the melting process*

* Patents pending

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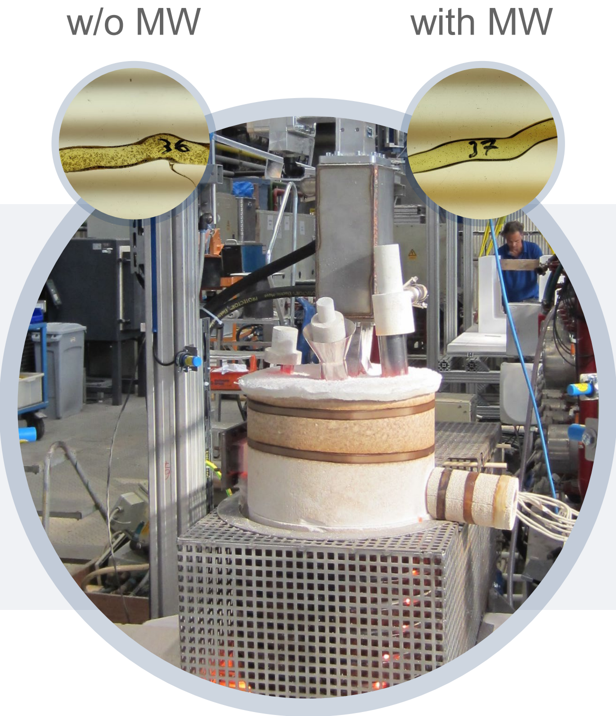
Challenge

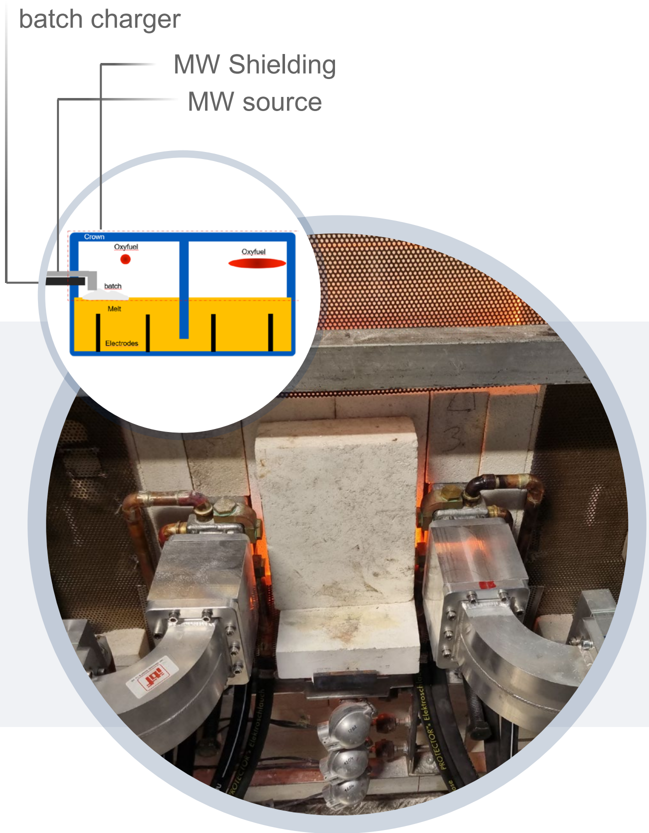
Introduce MW into melting tank

First attempts at walking with new technology

Understand application in cold trial set-up



Hot-stage test Pt-crucible with continues glass flow



Pilot application in small tank with continues glass flow

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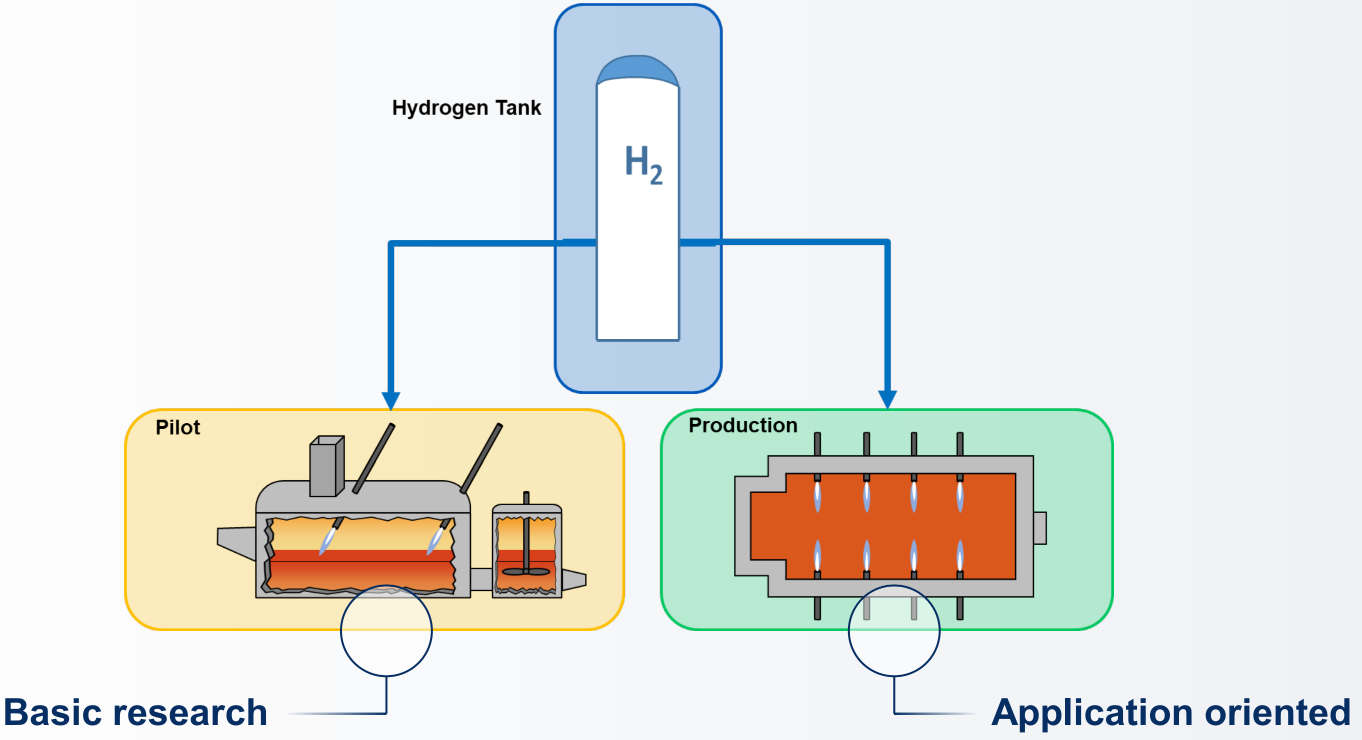
Approach 2

Overview Green Hydrogen Research Tasks@SCHOTT

SCHOTT started research in Hydrogen in **2019**



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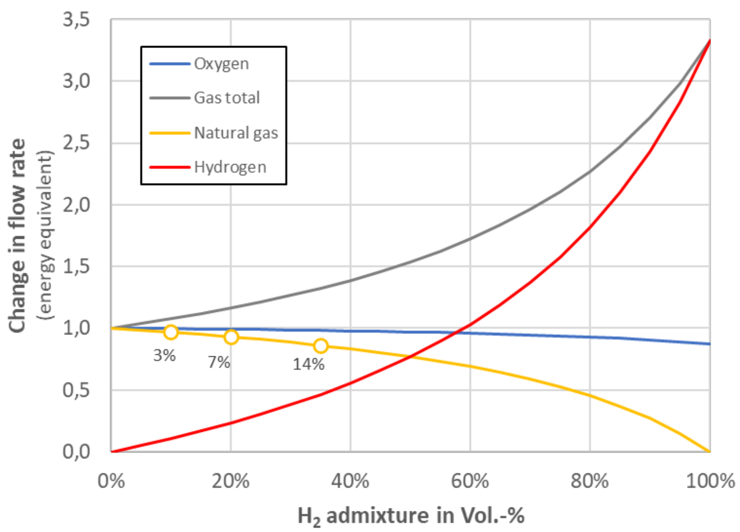
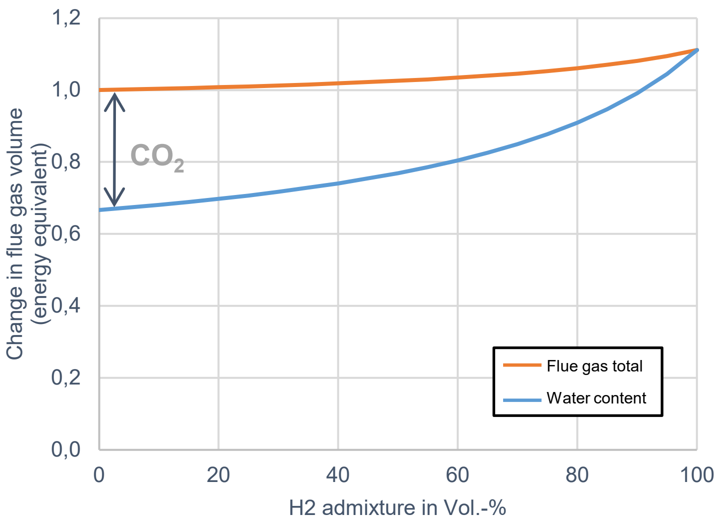
Hydrogen
Natural Gas Admixtureat Production Scale

Fuel gas and Oxygen flow rate



Flue gas



Idealised combustion calculation

$$CH_4 + 2 \cdot O_2 \rightarrow CO_2 + 2 \cdot H_2O$$

$$H_2 + 0,5 \cdot O_2 \rightarrow H_2O$$

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Gas Tank for Hydrogen Supply for Pilot and Production Test

47 t in weight

21 m in height

5.000 Nm3 H2 (approx. 450 kg)

- Constant H2 supply, up to two trailers for refill every day
- More than 1,5 years of approval process
- Buffer for <2h for one melting tank if NG fully replaced

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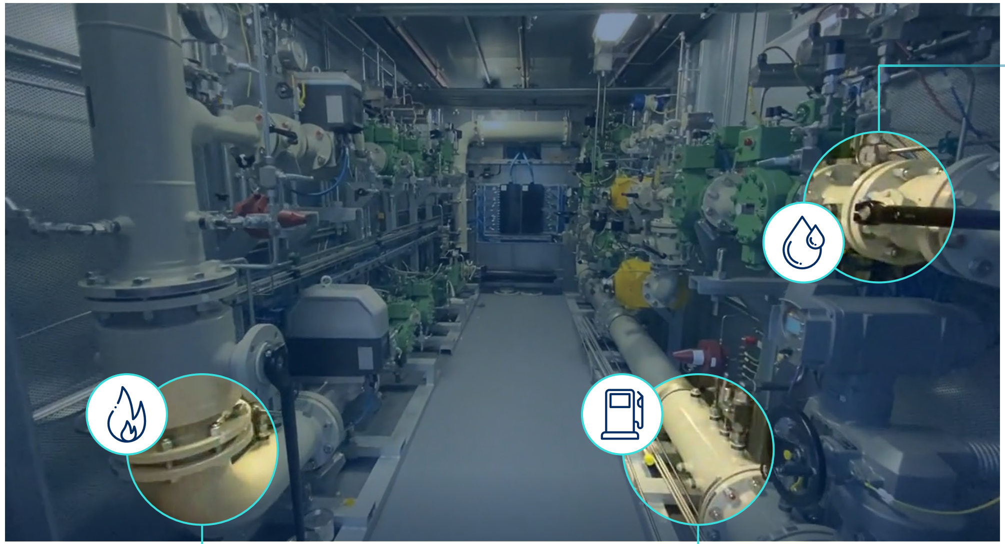
Hydrogen
Natural Gas Admixtureat Production Scale

Mixing Station provided by Mainzer Stadtwerke

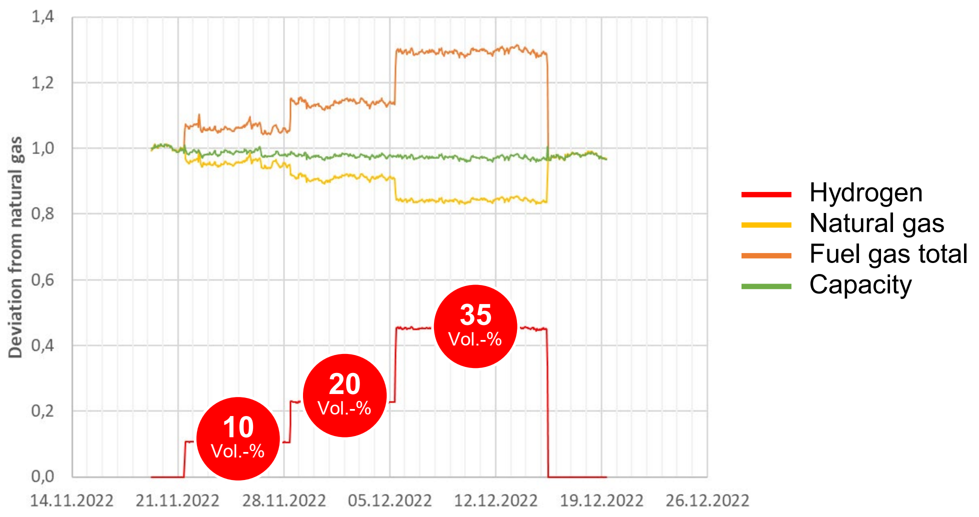


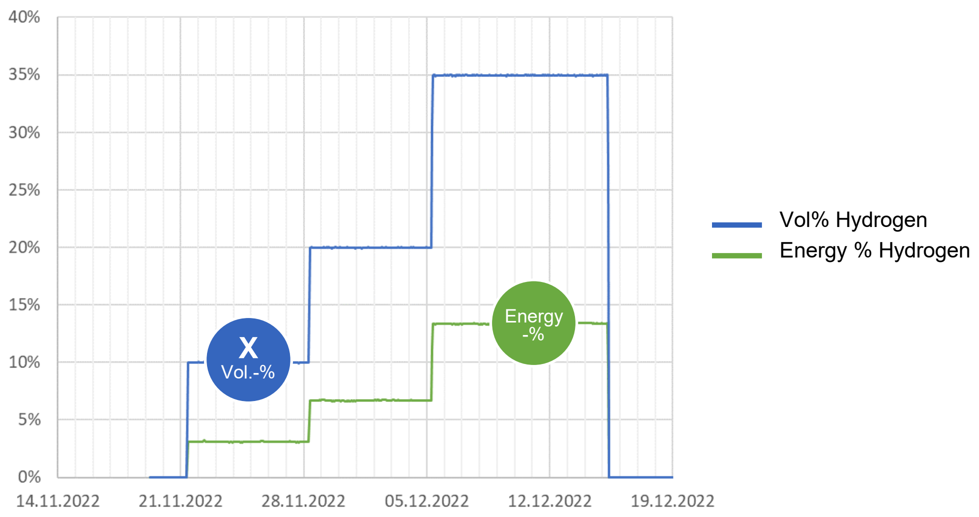
Joint project with Mainzer Stadtwerke to test hydrogen admixture on a real production melting tank.

- Starting at 10 Vol.-% H2 with incremental increase up to 35 Vol.-%, same Vol % for each burner
- Tests were running for 4 Weeks, 7 days per week, 24h per day
- Fuel gas flow rates controlled via crown temperature
- Oxygen controlled via residual O2 in flue gas

Hydrogen
Natural Gas Admixture at Production Scale

Fuel Gas Flow Rates and Capacity





- Running for 4 weeks without malfunction
- Approx 14% overall energy replaced by Hydrogen
- For constant temperatures same energy required (as calculated in advance)

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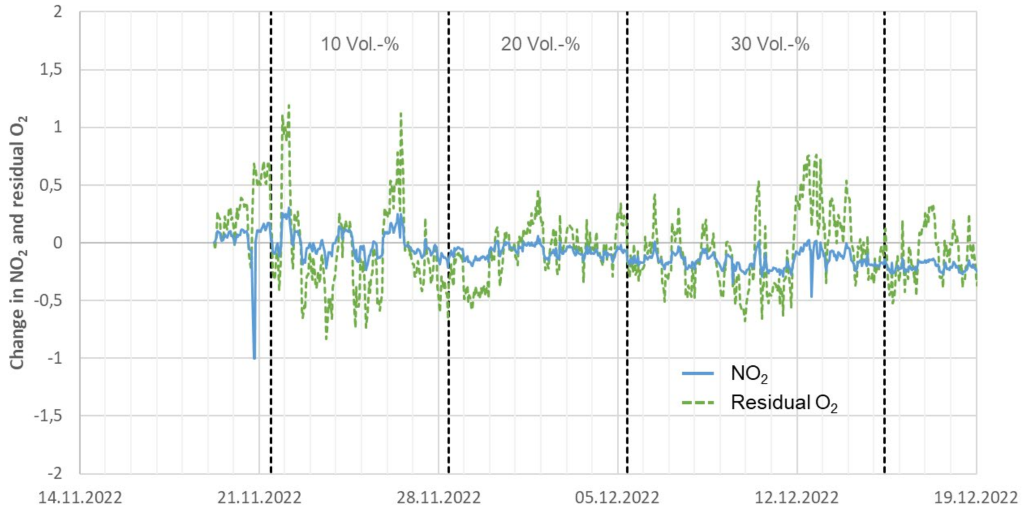
Hydrogen
Natural Gas Admixture at Production Scale

NOx measurement in flue gas



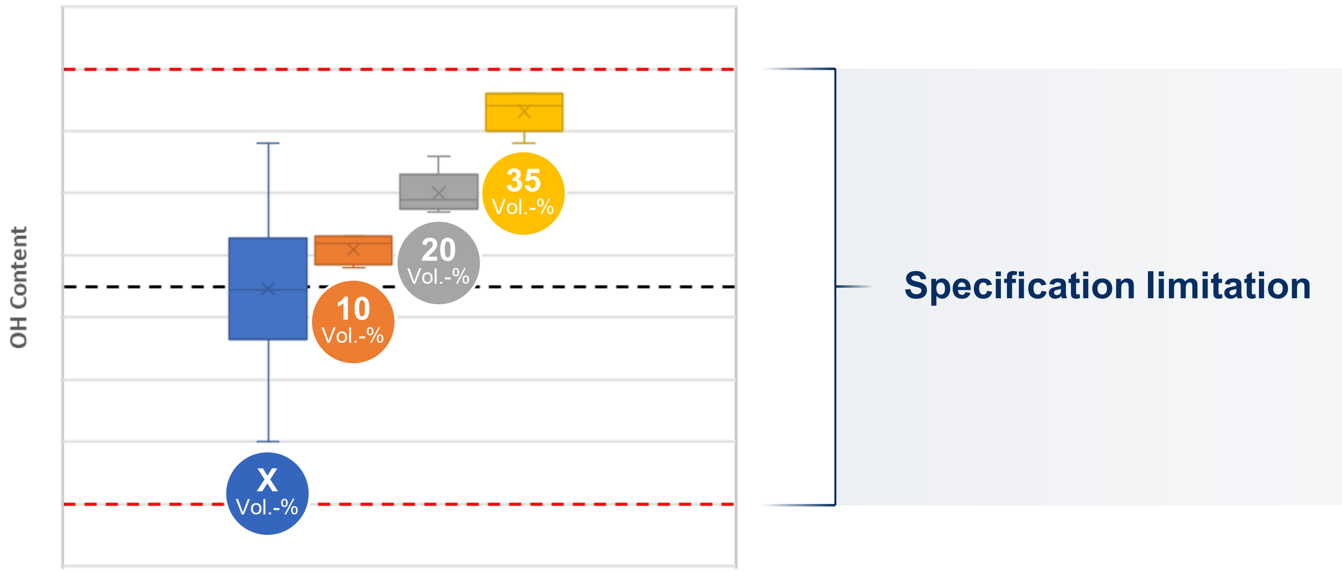
NOx measurements

NOx corelates with residual O2

No significant change in NOx noticeable

Hydrogen
Natural Gas Admixture at Production Scale

NOx measurement in flue gas



OH content measurements in glass product

- Noticeable increase in OH content with increasing H2 admixture
- For up to 35 Vol.-% H2 OH content still within specification limitation
- For full replacement OH content in glass expected to exceed limit

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Approach 3

Overview Green Hydrocarbon Tasks@SCHOTT

Biofuel for glass melting tanks

Bio-Ethanol

Fermentation and destillation

Ethanol-Oxyfuel burner

On site physical delivery

Available regular fuel oil - oxygene burner with possible conversion to NG-Oxygen

Linde / Praxair

Air Liquide

Honneywell / Maxxon

	Sulfur	Flue gas H_2O
Bio-Ethanol	< 10ppm	61,2%
Fuel oil EL	ca 50 ppm	48,0%
Natural gas	< 10 ppm	66,2%

Market (2020)*

1.000 kt/a DE   29.500 kt/a BR

Bio-Methan

Landfill Gas | **Agriculture Waste**

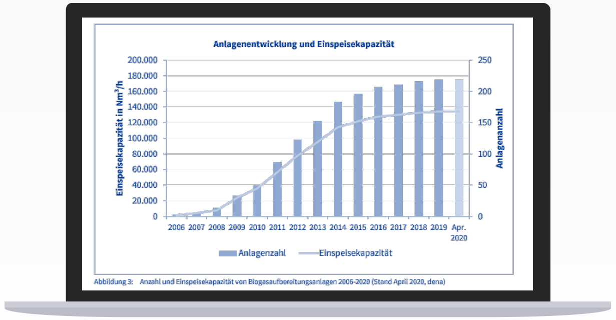
Processed to reach NG specification

Regular Gas-Oxyfuel-burner

On site physical delivery

Certificates for pipeline network use

Bio-Methan annual production in DE (Nm3/h)



Market (2020)*

10 TWh DE   30 TWh EU   NG: 950 TWh (DE)

* google research

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Conclusion

Technological change allowing for direct reduction of climate-damaging emissions **requires time. Electricity** is most promising for ecological and economical match

SCHOTT as a leading specialty glass company wants to drive the technological change in as **many platforms** as possible.

Overall, to speed up the technological change with Green Hydrogen or other Green energy substitutes **economic benefits** are the best enabler.

Hydrocarbons seem to be a feasible option as **bridging technology** or in cases were Hydrogen has techno-logical disadvantages. Today, even industrial mass supply is available.

In the end focusing on a single techno-logy does not allow to react to the future undetermined development in pricing and availability around the world to the **different green energy sources for glass melting.**

Besides the use of Green Electricity for electro boosting, **plasma burners and microwave supported melting** are additional conceivable technical solutions; basic research is in progress.

Conclusion

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GIFFT
Sustainable Glass Industry

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Thank You for Your Time!

Do You Have Any Questions?

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