SCHOTT'S Technological Transformation path of becoming climate neutral

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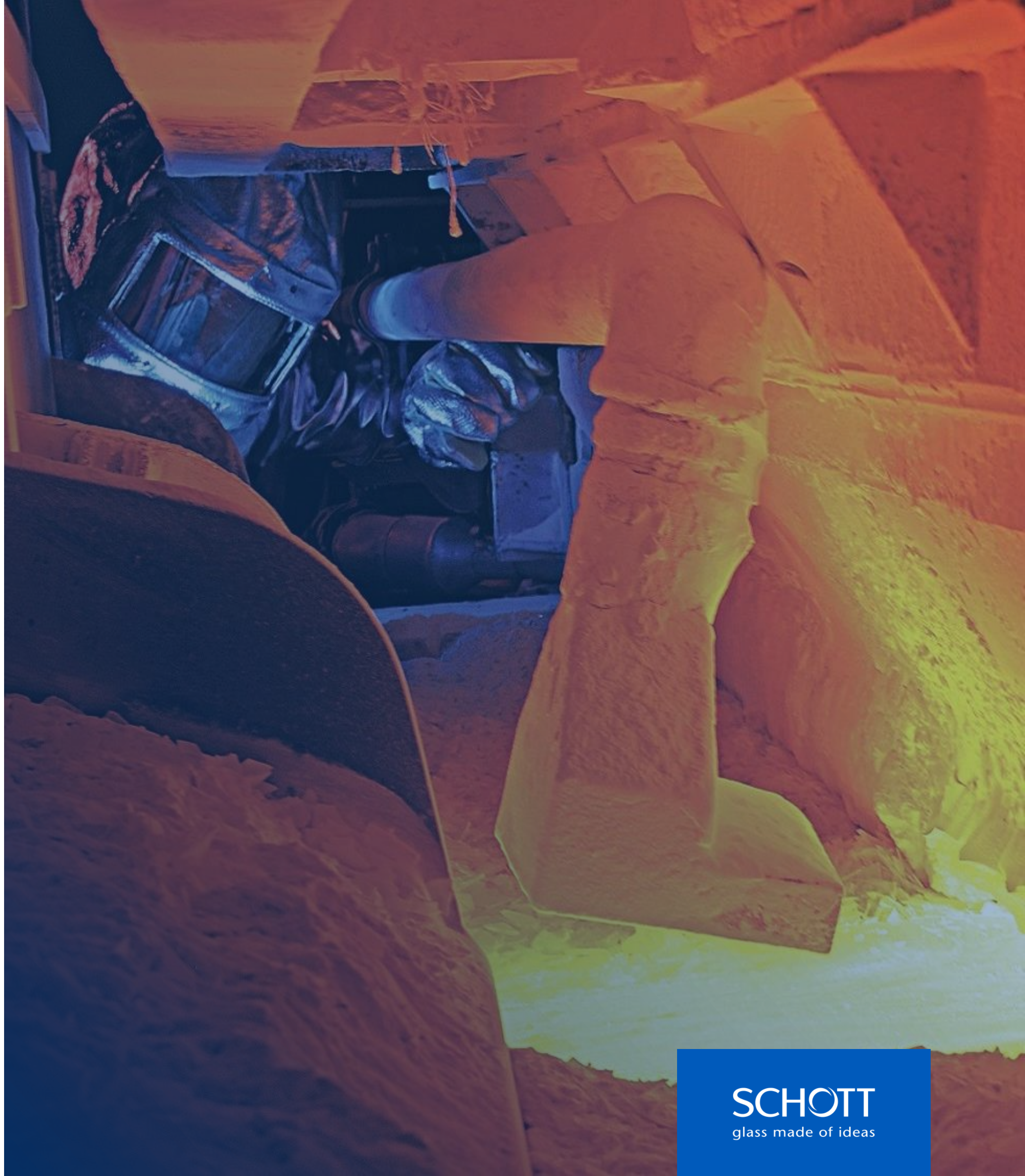
Climate Neutral 2030

Special Glass Production Is Energy Intensive

Up to 1.700 °C
Melting Temperature

Approx. 1 Mio.
tons/year of CO_2e*

*Calculation based on the market-based method of the Greenhouse Gas Protocol in 2019. We take into account emissions from our own production (Scope 1) and from purchased energy (Scope 2). From Scope 3, we also take into account business travel and employee mobility.



Our Path to Climate Neutrality

We Want to Avoid, Reduce or Compensate Climate-Damaging Emissions.

Technology Change

We will avoid through low carbon technology. But this transformation needs time.

Energy Efficiency

We reduce through an even better increase of energy efficiency.

Green Electricity

We avoid emissions by covering 100% of our electricity needs with renewable energies.

Compensation

We compensate residual emissions via high-quality climate protection projects.

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Our Way of Technology Change

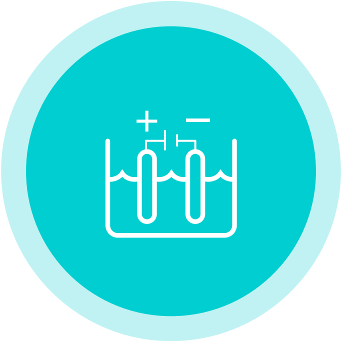
We Rely on Innovative Technologies to Avoid Carbon Emissions in Glass Production.

Approach 1

Green Electricity

- Electro Boosting
- Plasma Burner for crown
- Microwave assisted melting

Approach 2



Green Hydrogen

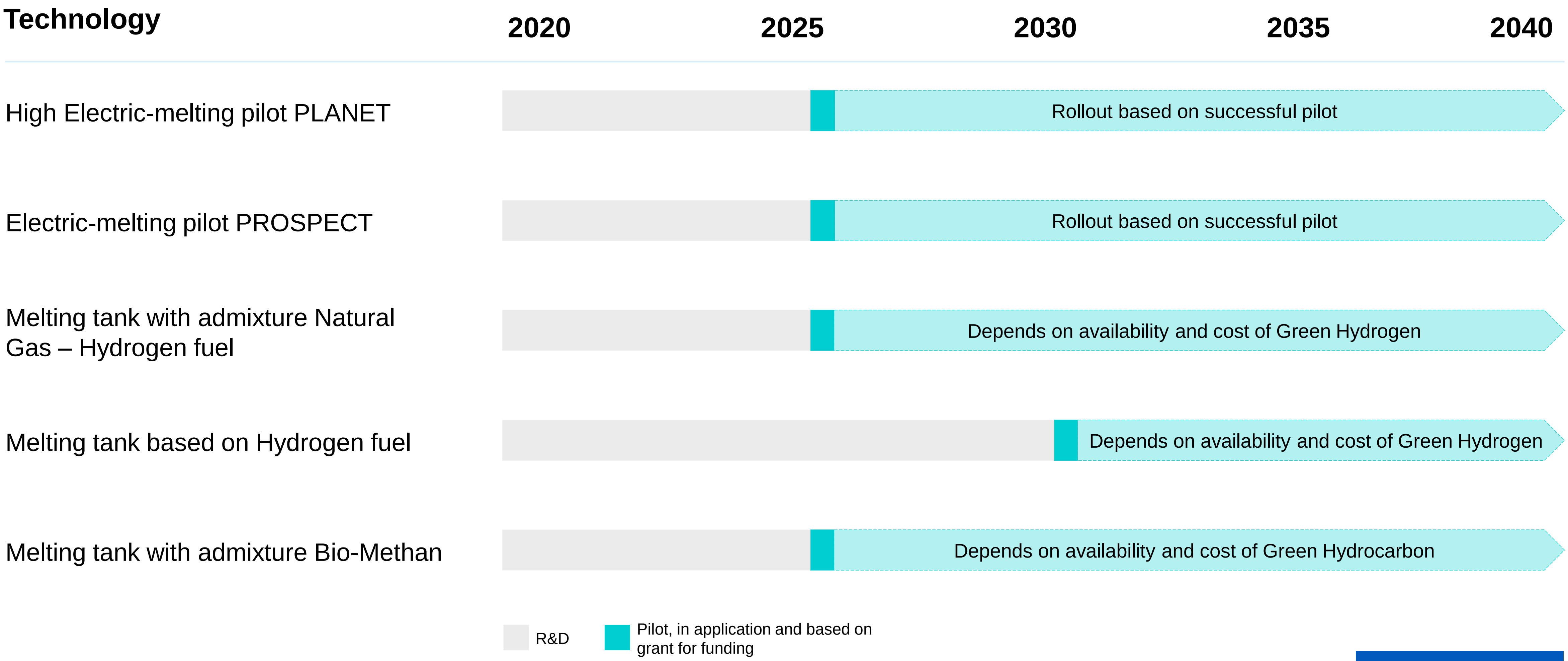
- Admixtures with Natural Gas (NG) and Liquid Propan Gas (LPG)
- Full replacement of fossil fuel

Approach 3

Green Hydrocarbon

- Bio-Methan
- Bio-Ethanol

The Technology-Roadmap to Drive Technology Change



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Our Way of Technology Change

01	02	03	04
Approach 1:	**Approach 2:**	**Approach 3:**	**Conclusion**
Green Electricity	Green Hydrogen	Green Hydrocarbon	

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Approach 1: Overview Green Electricity Research Tasks@SCHOTT

Application oriented:
Electro Boosting

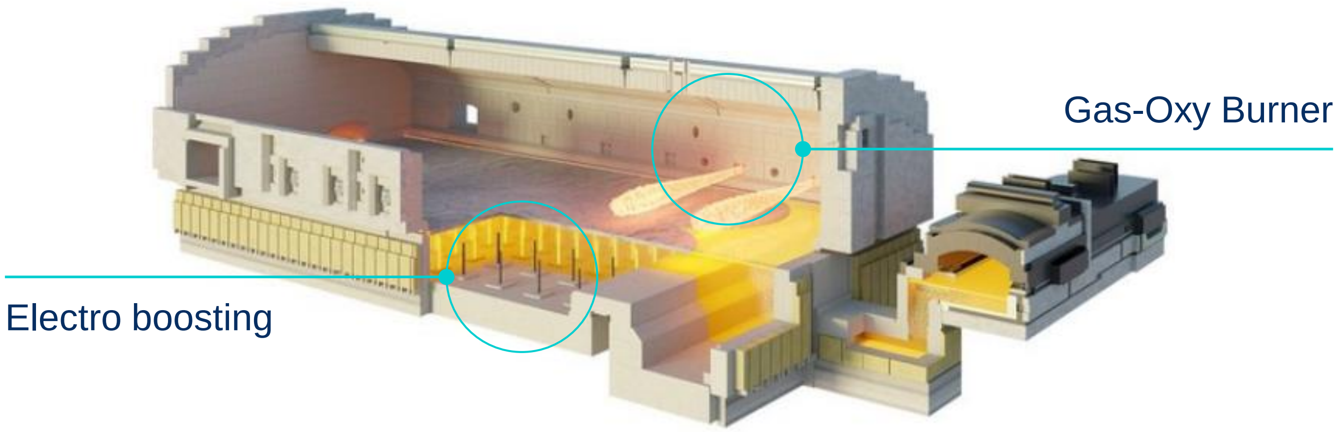
Project PLANET:
high electrification (>60% of overall energy consumption in tank)

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

Basic Research:

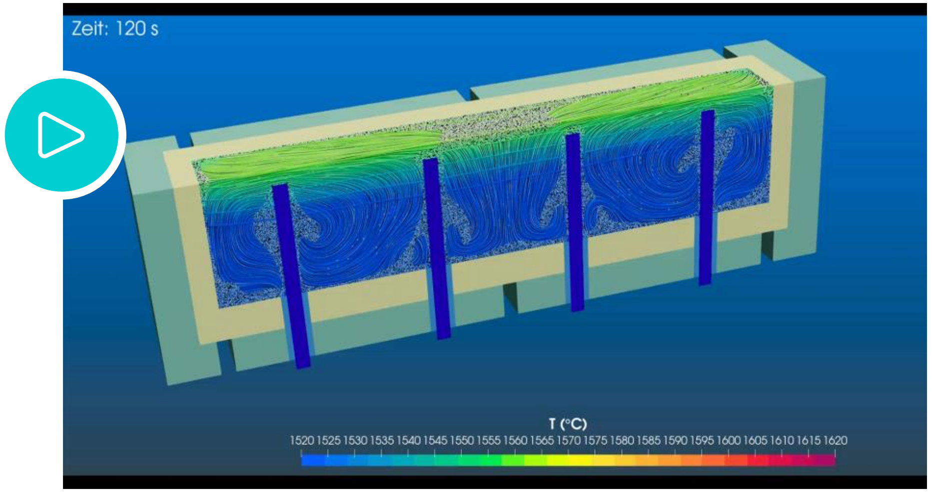
Project GIFFT:
burner replacement by fuel-flexible plasma torch

Project MiGWa:
micro-wave assisted melting



Source: Horn@Glass-Industries – Hybrid tank

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

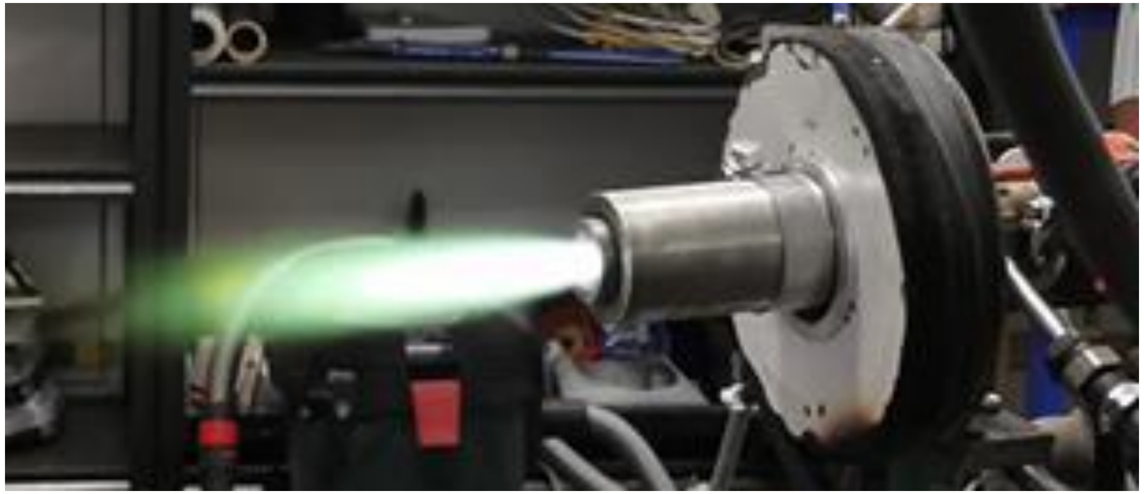
Data based on representative Lab-Test, Mo-electrode

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

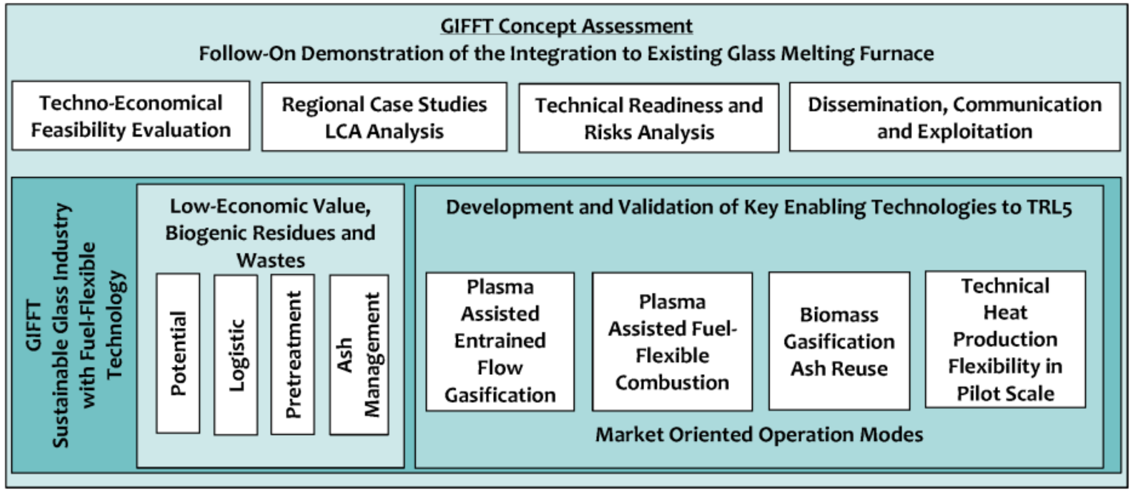
Electrode corrosion in mm/a based on glass type and current density / frequency. Corrosion reduced by use of inverter technology >1 kHz*

* Patents pending

Plasma Burner –
Research to the Special Needs for Glass Industry



Source: LIETUVOS ENERGETIKOS INSTITUTAS



Source: LIETUVOS ENERGETIKOS INSTITUTAS as consortium leader

Project GIFFT:

Sustainable Glass Industry with Fuel-Flexible Technology, start announced for Oct 2023, HORIZON-CL5-2022-D3-03-06

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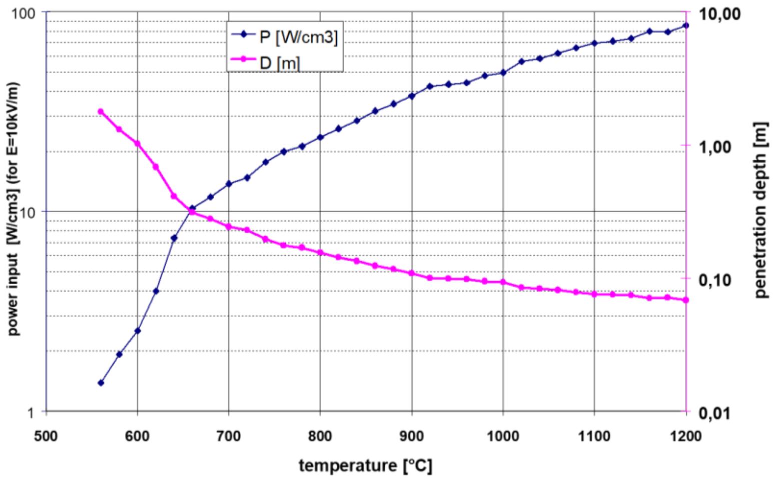
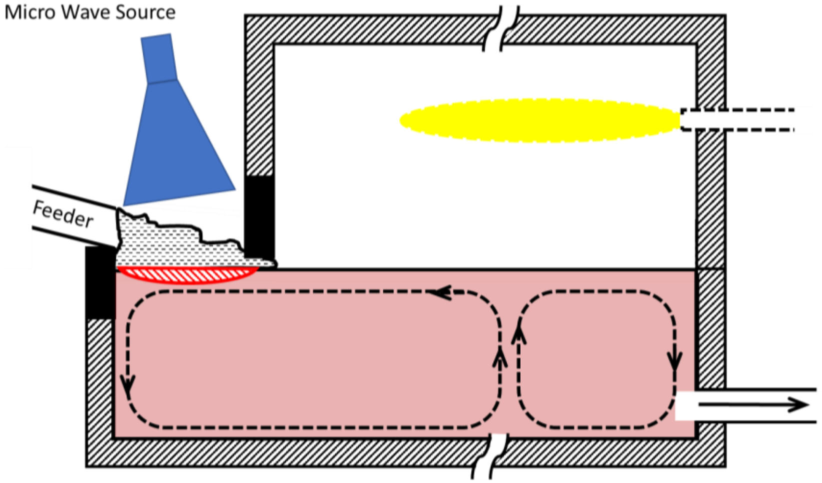
Microwave –
Basic Research in Assisted Heating for Melting



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

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



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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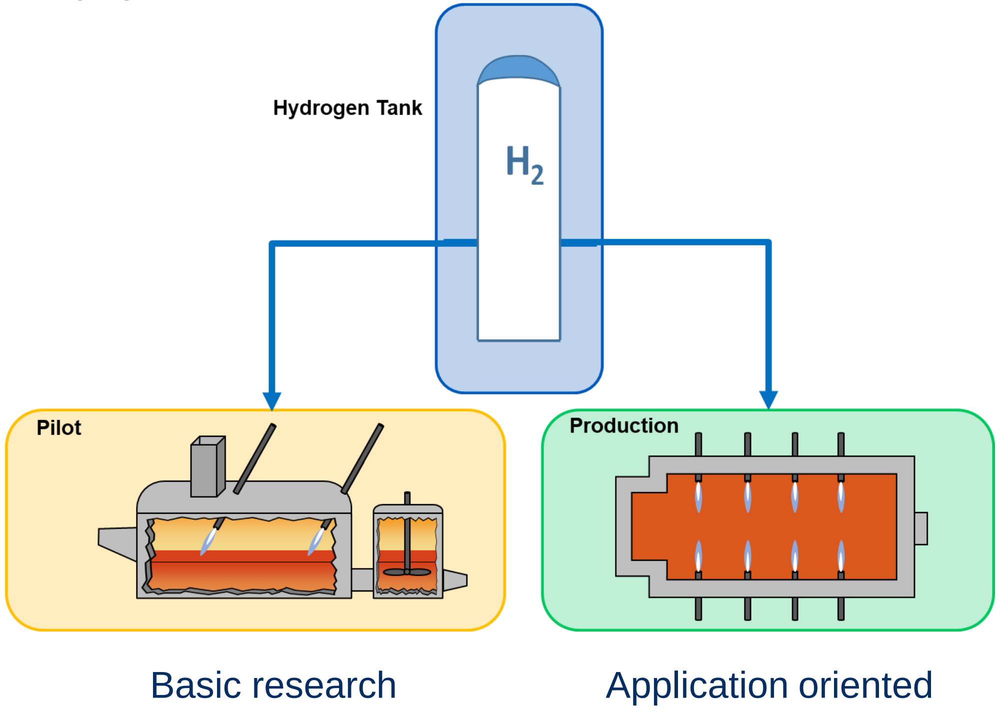
Approach 2:
Overview Green Hydrogen Research Tasks@SCHOTT

SCHOTT started research in Hydrogen in 2019.



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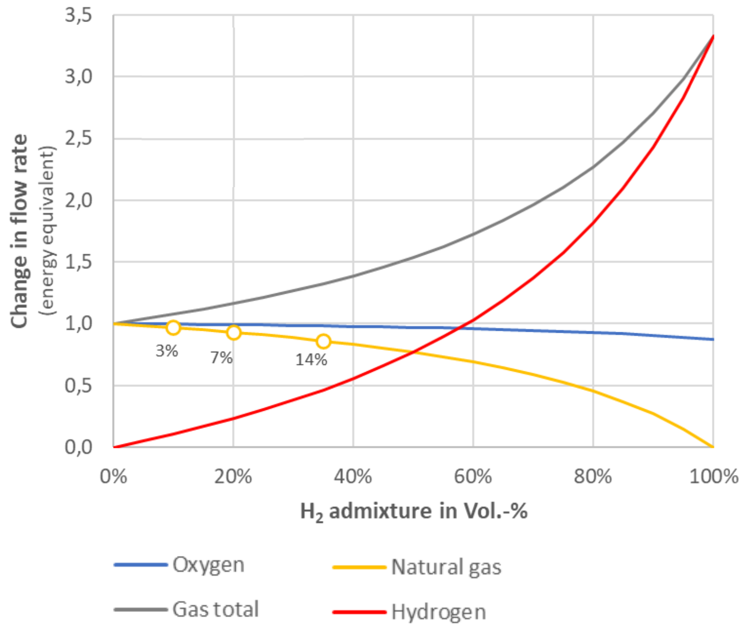
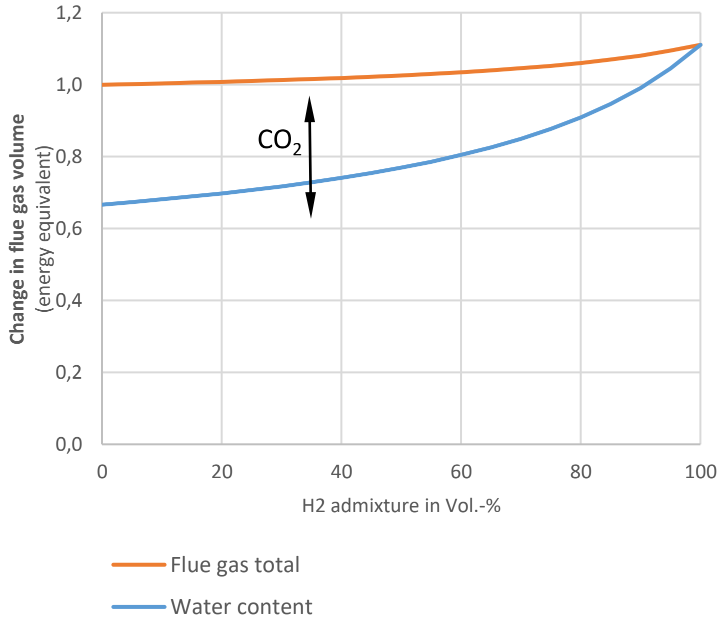
Hydrogen Combustion Basics

Changes in Fuel Gas and Oxygen Flowrates and Flue Gas Volume

Fuel gas and Oxygen flow rate



Flue gas



Idealised combustion calculation:

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

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

Gas Tank for Hydrogen Supply for Pilot and Production Test

Gas Tank Installed in September 2022

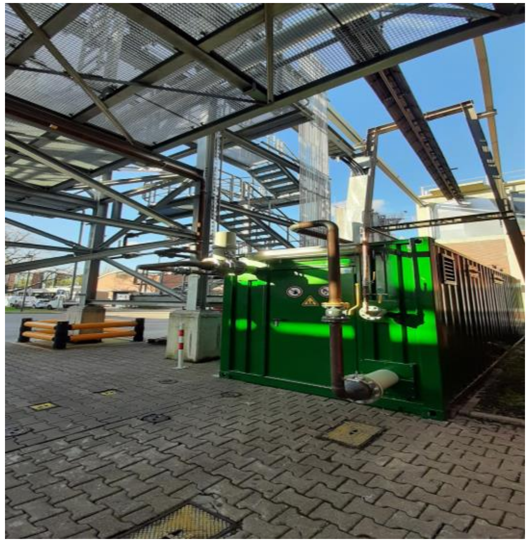
47 t in weight

21 m in height

5.000 Nm^3 H_2
(approx. 450 kg)

- Constant H_2 supply, up to two trailers for refill every day
- More than 1,5 years of approval process

Hydrogen – Natural Gas Admixture at 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.-% H_2 with incremental increase up to 35 Vol.-%, same Vol % for each burner

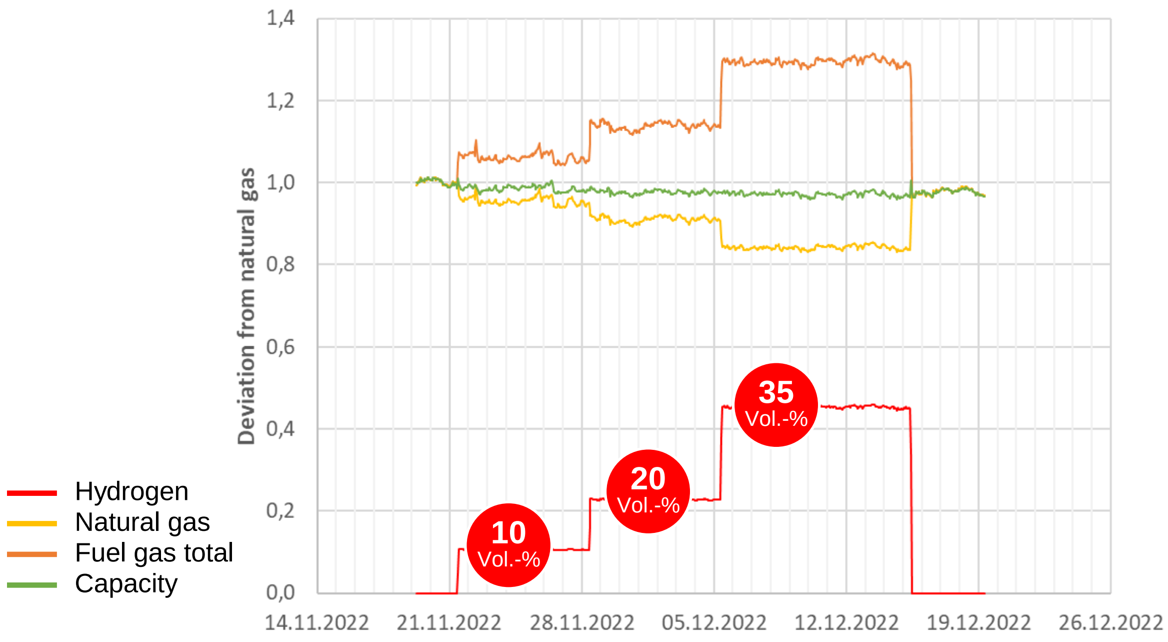
Tests were running for 4 Weeks, 7 days per week, 24h per day

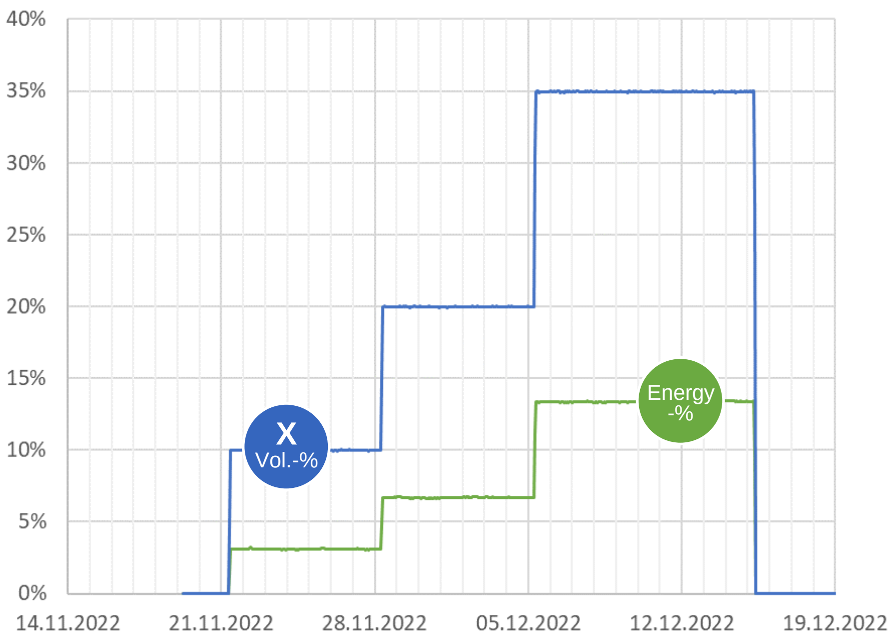
Fuel gas flow rates controlled via crown temperature

Oxygen controlled via residual O_2 in flue gas

Hydrogen – Natural Gas Admixture at Production Scale

Fuel Gas Flow Rates and Capacity





- Running for 4 weeks without malfunction
- For constant temperatures same energy required (as calculated in advance)

Hydrogen – Natural Gas Admixture at Production Scale

NO$_x$ measurement in flue gas

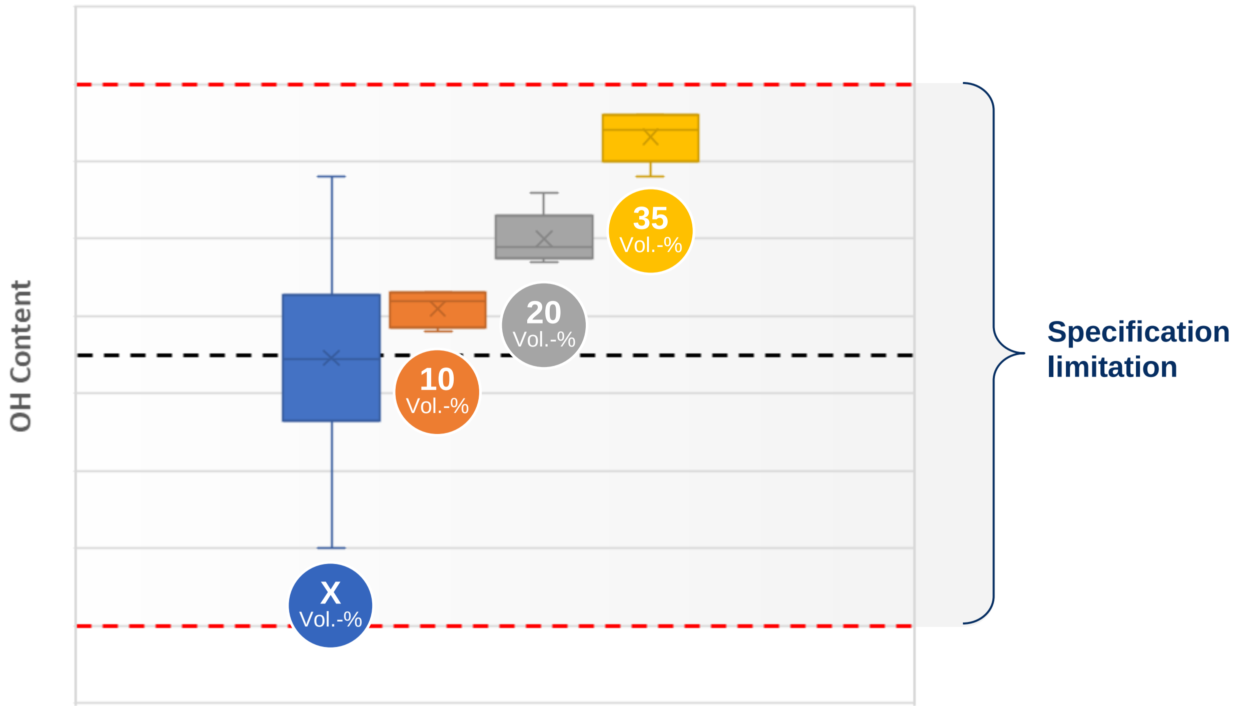
NO$_x$ measurements:

NO$_x$ corelates with residual O_2

No significant change in NO$_x$ noticeable

Hydrogen – Natural Gas Admixture at Production Scale

Water content in glass increases due to changes in flue gas – glass properties and counteractions to consider



OH content measurements in glass product:

Noticeable increase in OH content with increasing H_2 admixture

For up to 35 Vol.-% H_2 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 für 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.**

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.

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Thank You
for Your Time!

Do You Have Any Questions?