Development of new furnace technologies (H_2, electric, blend) and constraints

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ICG Spring School
Lloret de Mar

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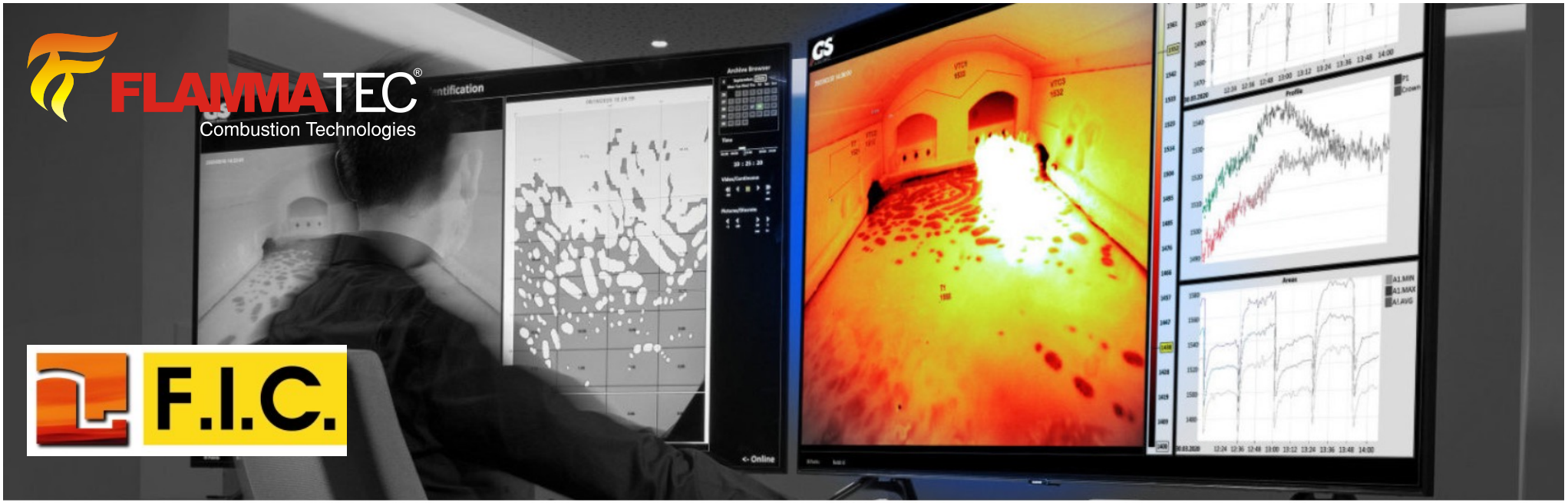
GS Group Products and Service Overview



ASSESSMENT

SIMULATIONS

3D advanced CFD simulation of the complete high temp. glass melting process for regenerator, melter, forehearth and forming.
more

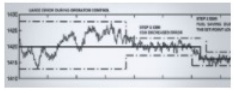
LAB SERVICES

Quick identification of glass defects and their origin to support quality improvements and operating parameter optimization.
more

AUDITS & DATA ANALYSES

Analyzing production, observing critical conditions and identifying optimization potential.
more

SMART PROCESS CONTROL



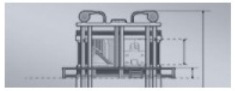
EXPERT SYSTEM *ES III™*

Full automatic process control resulting in stable operations, improved yield, reduced production costs and emissions.
more

CAMERAS & SENSORS

Smart AR sensors such as Camera systems in the Visible and NIR spectrum, simultaneously and on one chipset, compatible with Expert System.
more

PRODUCTS



ENGINEERING

Turn-key design and supply of specialized furnaces with high quality demands (for lenses, LCD or crystal).
more

RAW MATERIALS

Provide glass producers with Commodities, Specialties, Rare Earth Oxides and Polishing Compounds.
more

Together

we shape a
carbon-neutral
glass industry,
for a **brighter future**

How much energy is needed to produce glass?

Energy demand to melt glass

In a glass furnace, raw materials are transformed into glass and heated up.
The glass melt leaves the furnace at a temperature of T_{ex}.

Enthalpy of the melt at T_{ex}.

$$H_{ex} = (1 - y_{cullet}) \cdot \Delta H^0_{chem} + \Delta H\,(T_{ex})$$

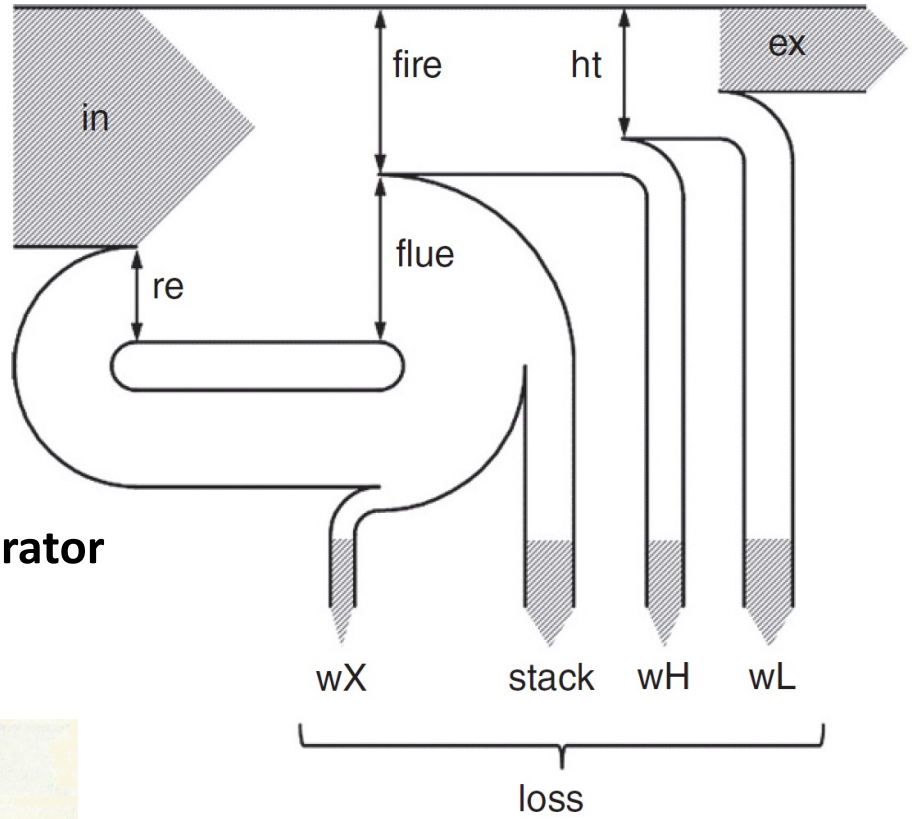
Cullet fraction in the batch.

Energy demand to transform the raw materials into glass (at 25°C)

Energy demand to heat up the glass from 25°C to T_{ex}.

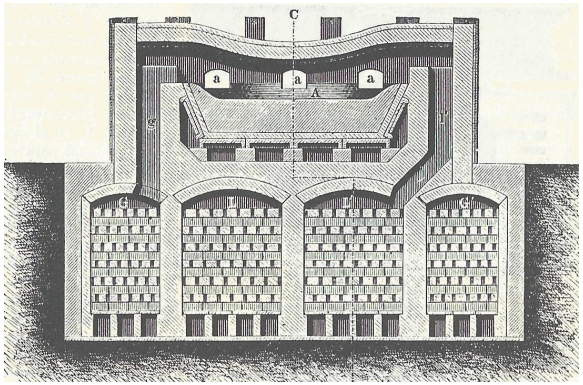
Energy demand of a regenerative fired furnace

Energy input
Combustion + electric



Exploited energy
Glass at throat
after conversion

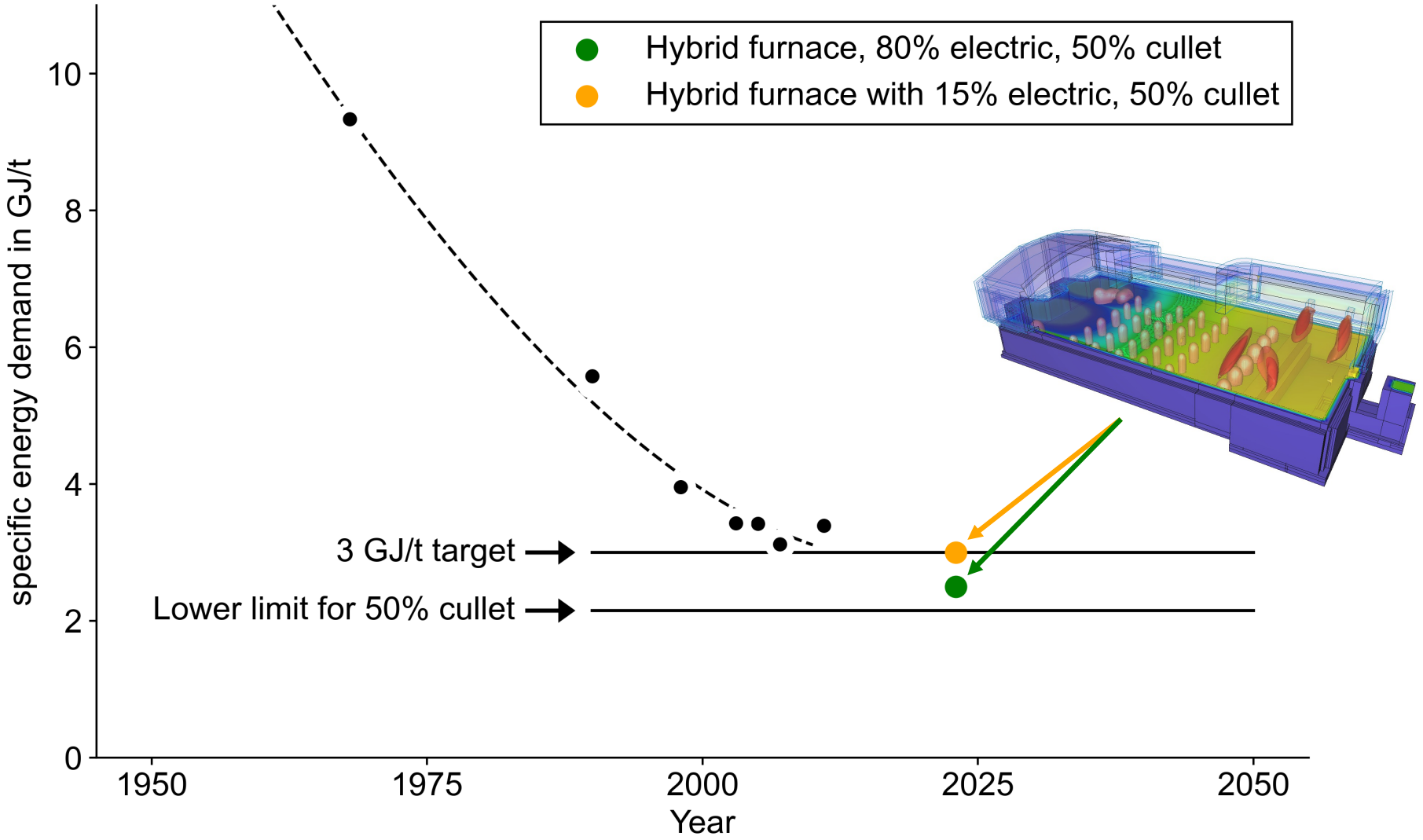
Invention of the regenerator technology in 1856 by Friedrich Siemens



[source: Physics and Modeling of Glass Furnaces; Conradt, Muijsenberg, 2021]
[https://upload.wikimedia.org/wikipedia/commons/a/ad/Siemens-Martin_converter.jpg]

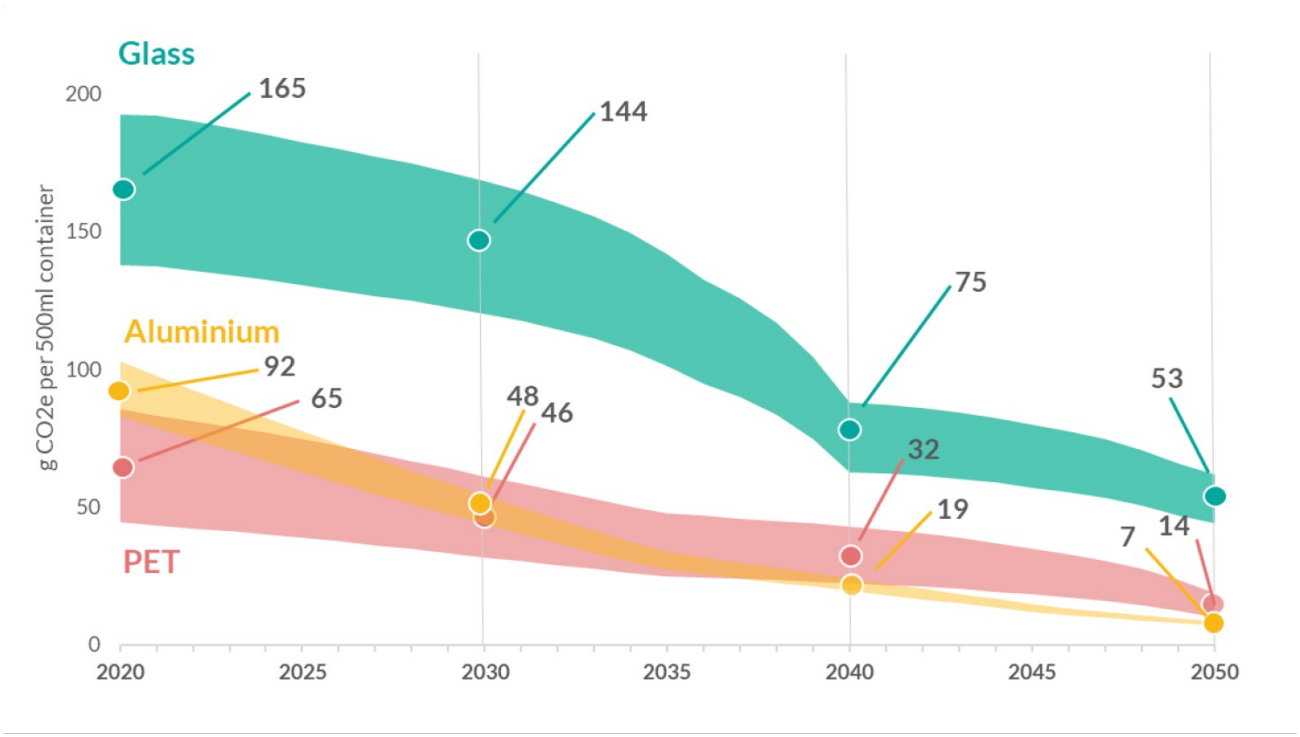
Evolutions in glass furnace designs

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]

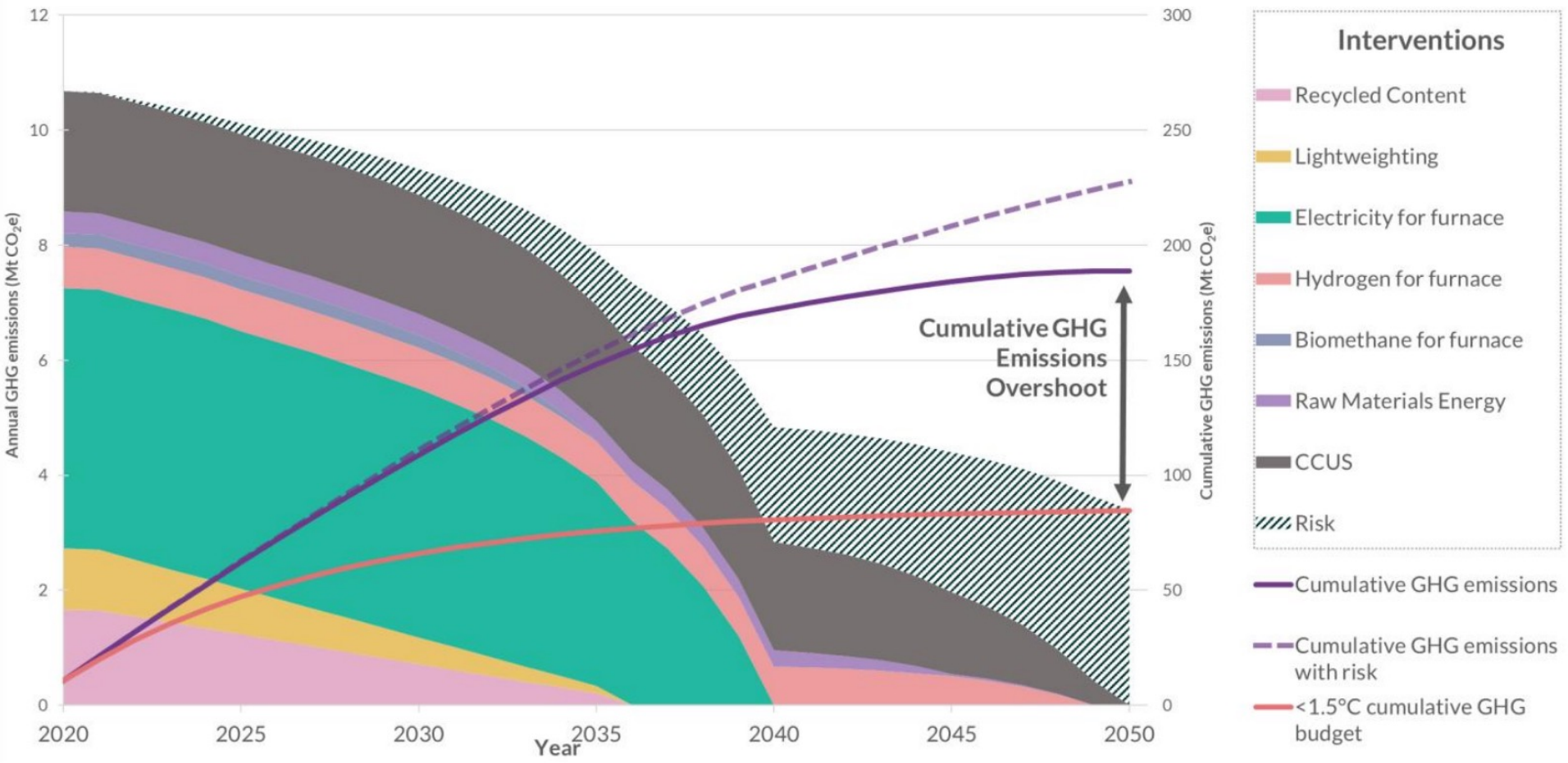
Specific CO2e emissions of a 500ml single-use container



- Still significant CO_2e in 2050.
- 2-3 times higher CO_2e emissions for glass production than PET and aluminum.

[Study: Decarbonisation of Single Use Beverage Packaging, Zero Waste Europe]

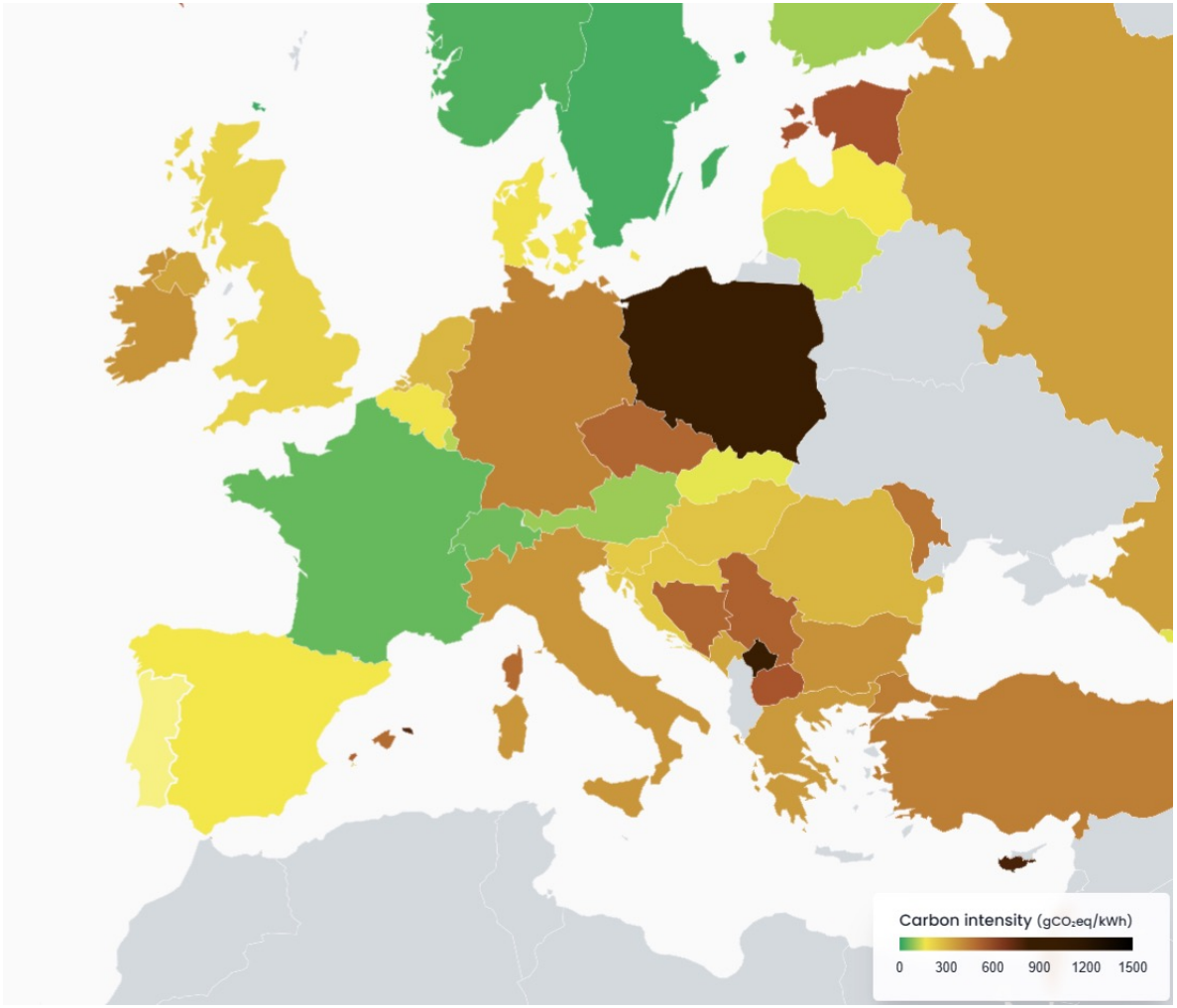
Greenhouse gas emissions of glass production



[Study: Decarbonisation of Single Use Beverage Packaging, Zero Waste Europe]

Decarbonization by electrification

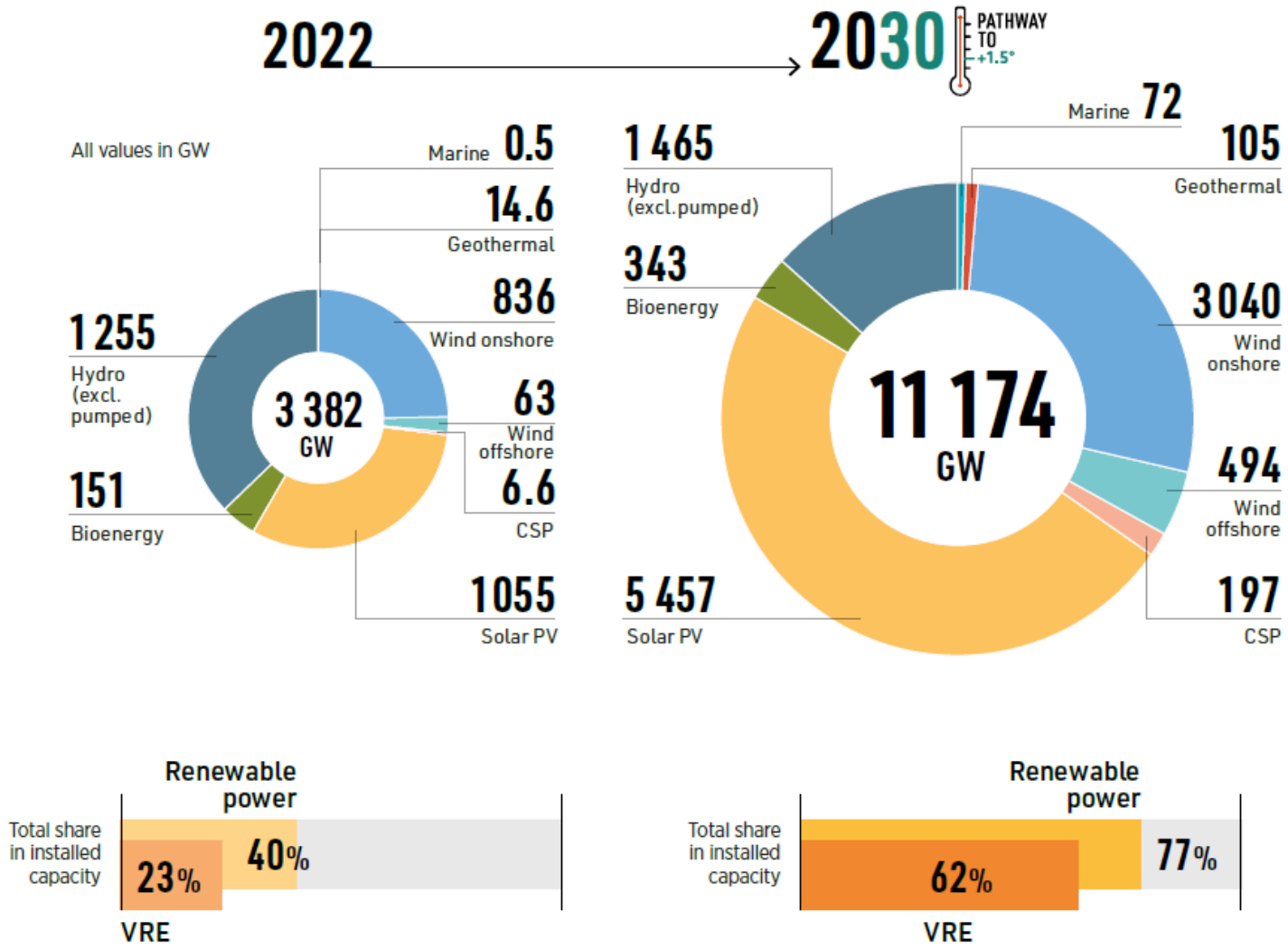
European electricity production in 2023



In many European countries coal and natural gas are used to generate electricity.

[https://app.electricitymaps.com/]

Transition to a carbon-free energy generation

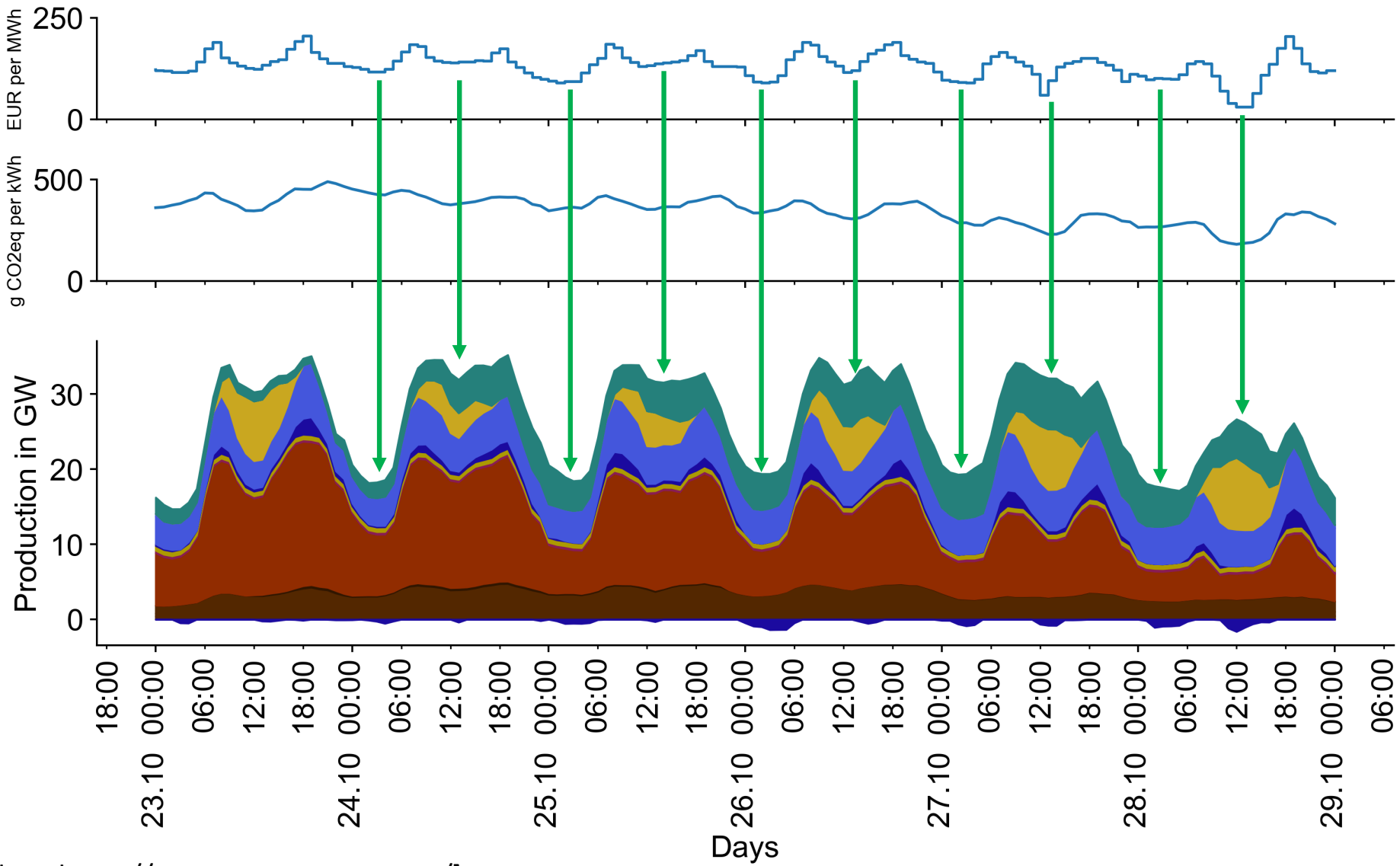


Notes: CSP = concentrated solar power; GW = gigawatt; PV = photovoltaic; VRE = variable renewable energy. Bioenergy includes biogas, biomass waste and biomass solid.

Based on: (IRENA, 2023a).

[COP28, IRENA and GRA (2023), *Tripling renewable power and doubling energy efficiency by 2030: Crucial steps towards 1.5°C*]

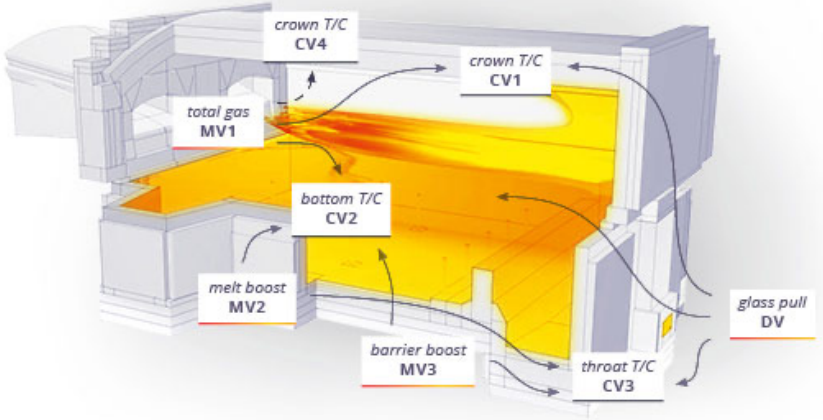
Energy mix in Italy (October 2023)



[data: https://transparency.entsoe.eu/]

Effects of variable renewable energy on glass production

- Variable energy supply requires adjustments in energy consumption to ensure a stable grid.
- The glass industry could reduce electric energy consumption during peak-demand hours.
- At high variable renewable energy supply, the glass industry could increase electric energy consumption and benefit from lower energy costs.
- Advanced furnace control is needed to stabilize glass temperatures.
- ESIII, our model predictive control software, uses multiple input parameters to calculate the best combination between fuel and electricity.
- Over ESIII 400 installations worldwide.



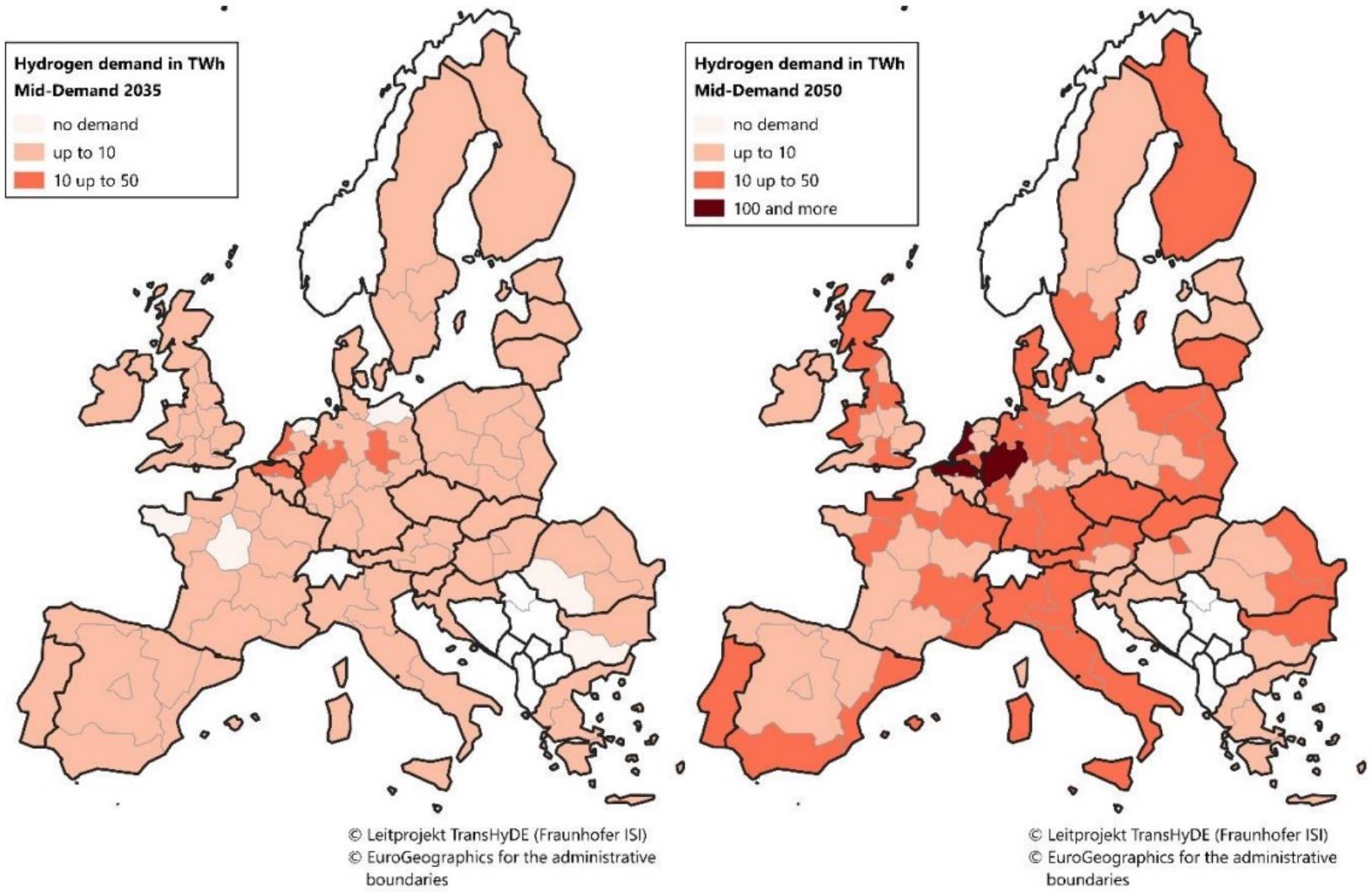
Green hydrogen as an alternative fuel

Green hydrogen

- Green hydrogen must be produced from renewable energy.
- Proton exchange membrane (PEM) electrolyzers have fast response times and can be added to the energy grid to buffer peak supply and stabilize the grid frequency.
- PEM electrolyzers are expensive. For an economic production, a high utilization rate is needed.
- In the next years only small sandbox projects will be realized. Therefore, hydrogen is not available for all industries.
- It will take decades to build a comprehensive hydrogen network.

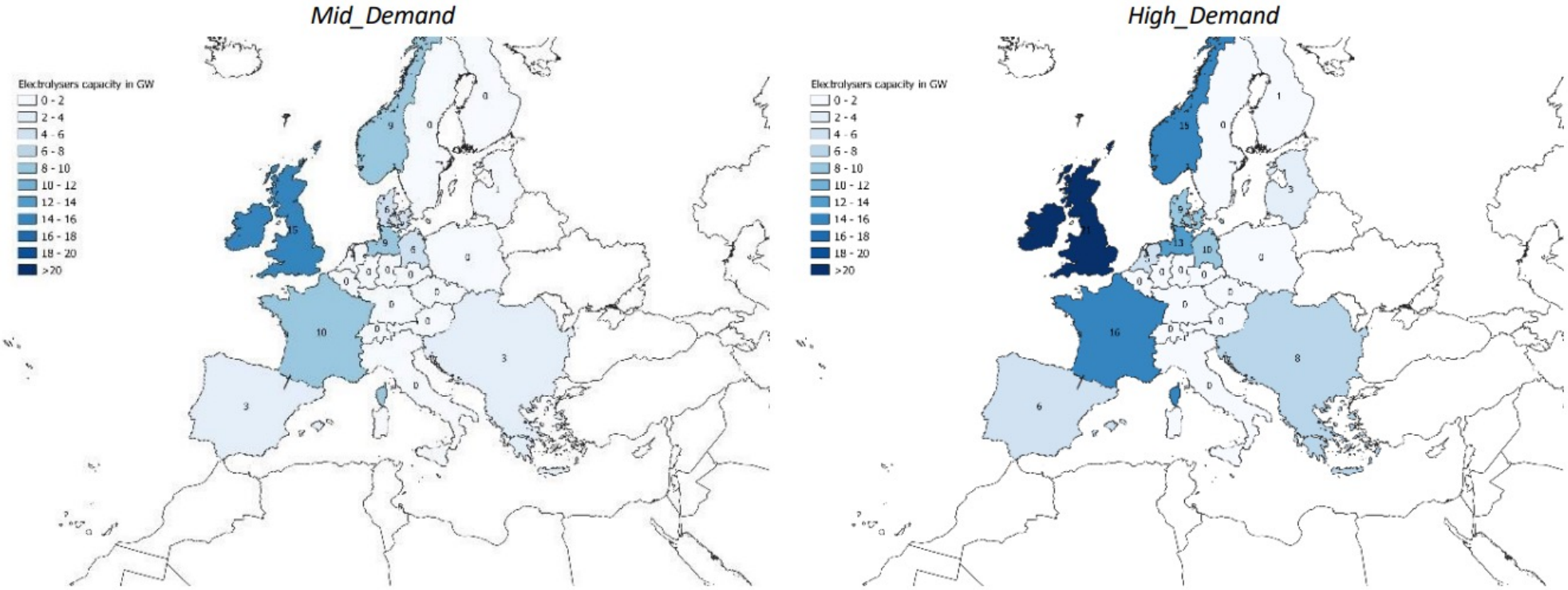
- The glass industry could use green hydrogen as energy carrier.
- Other industries need hydrogen as feedstock.
- Steel industry could can use hydrogen in the direct ore reduction as feedstock and energy carrier.

Hydrogen demand



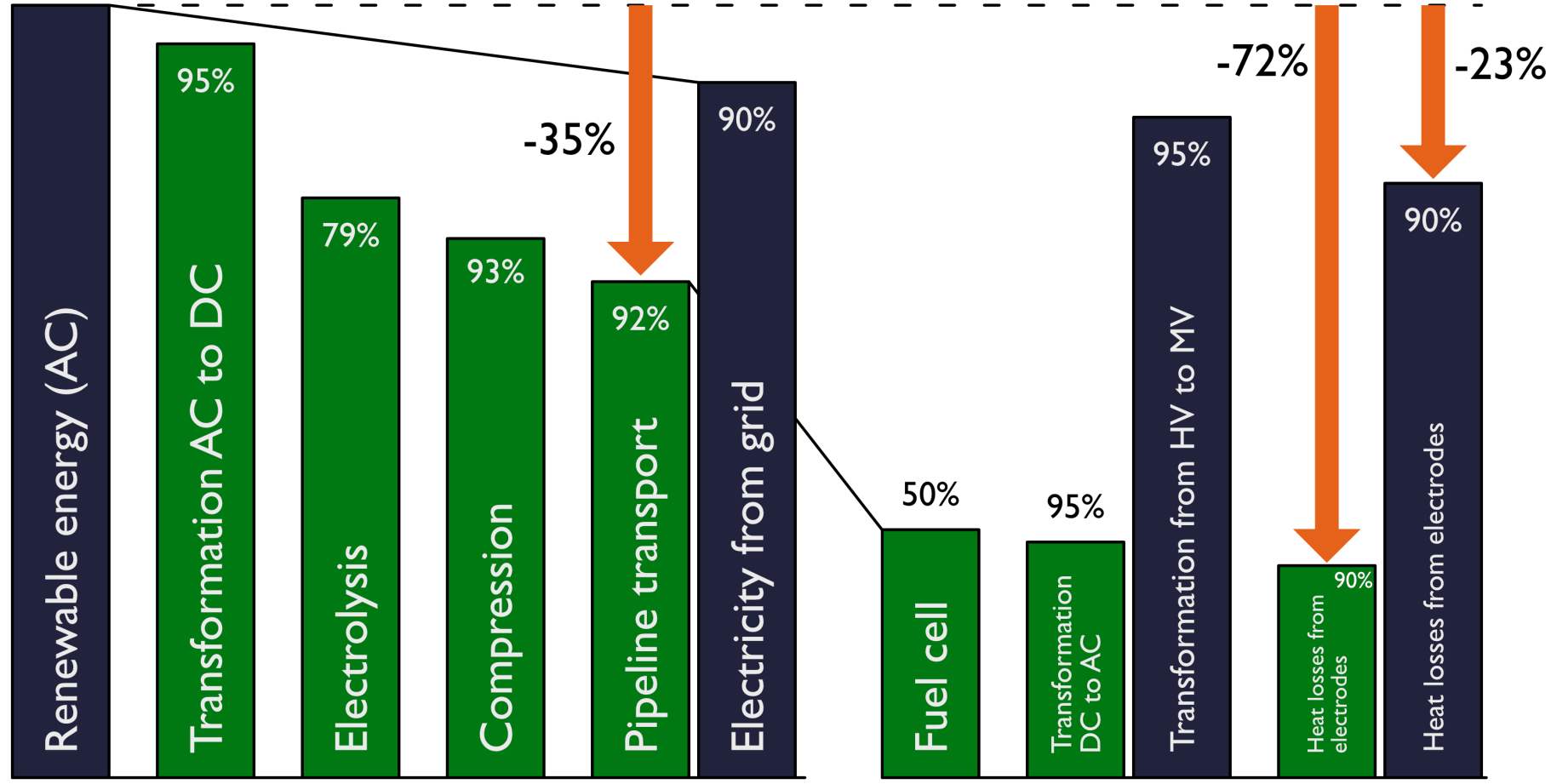
[TransHyDE, European Hydrogen Infrastructure Planning, 2024]

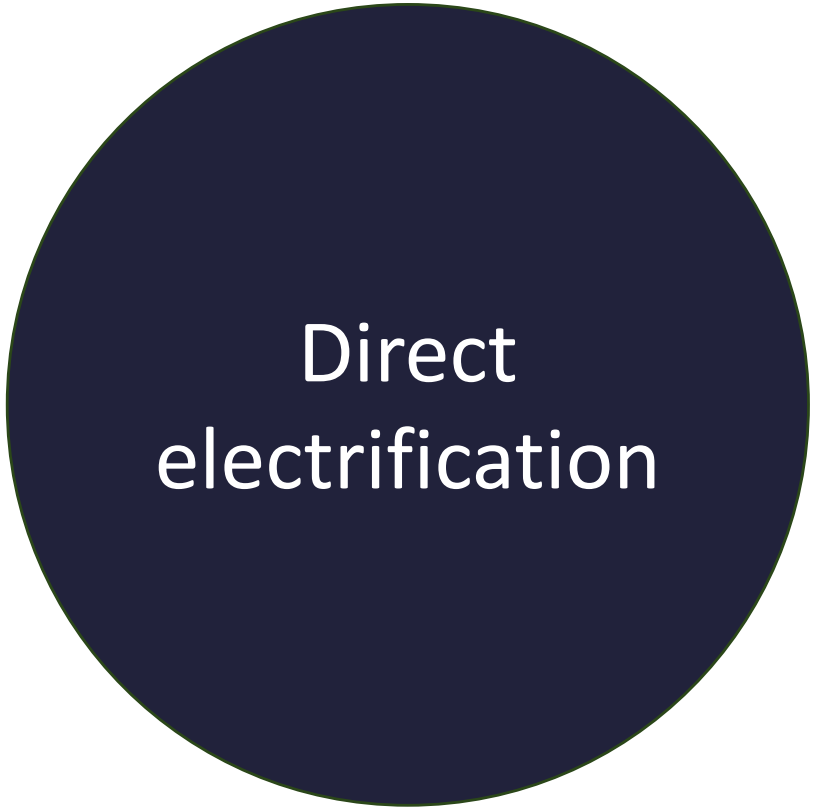
Hydrogen supply



[TransHyDE, European Hydrogen Infrastructure Planning, 2024]

Green hydrogen vs electrification





*area corresponds to available energy

Which electric heating technologies could be used?

- High-temperature **heat pumps** can be used for cullet pre-heating, e.g., during peak supply hours. Cullet preheating up to 200°C

  The cullet preheater acts as a thermal storage.

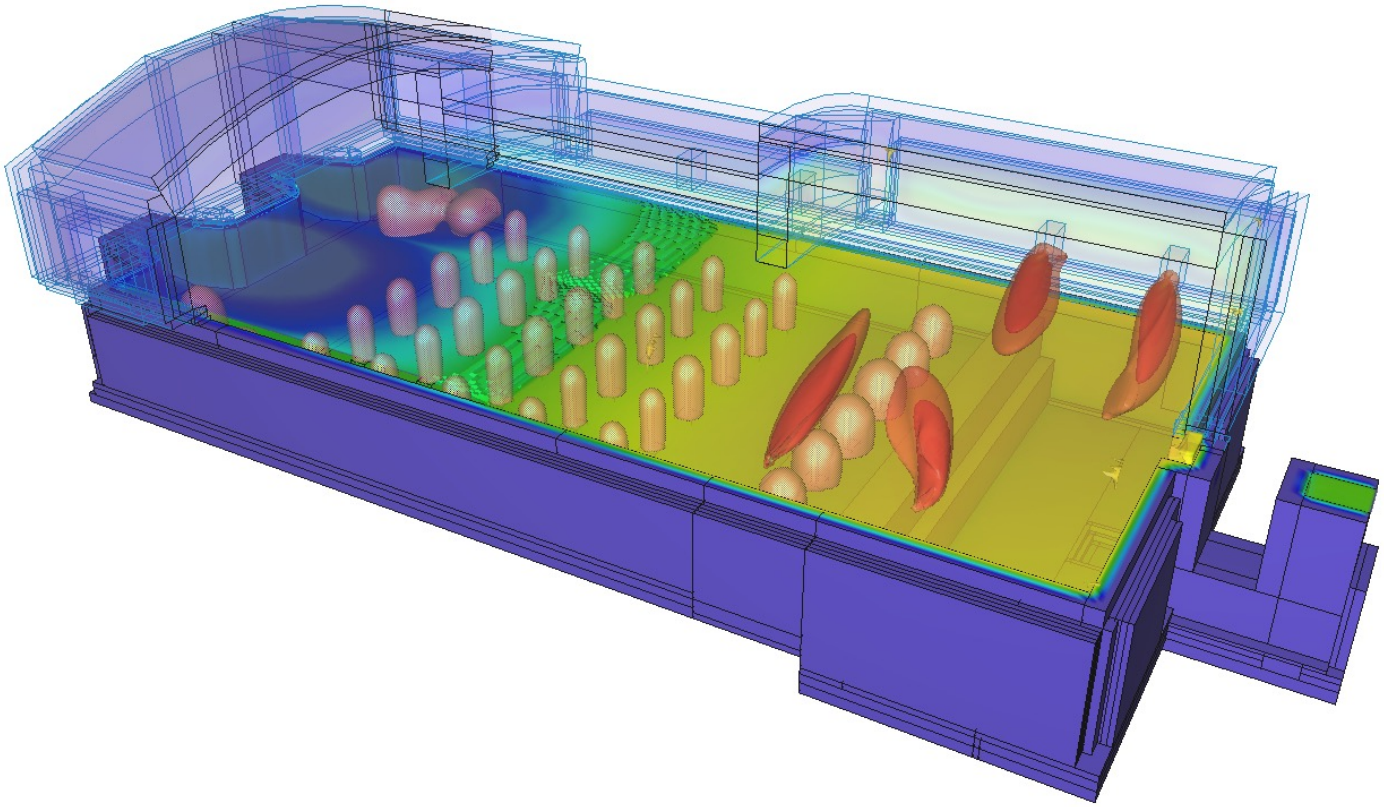
- The company *Electrified Thermal Solutions* developed **conductive refractory bricks** that can transform electric energy into thermal energy. The bricks can heat up to 1800 °C. In a regenerator-like structure, this technology could supply energy with high temperatures.

  During peak supply hours, the thermal battery can be charged.

- **Plasma burners** use electricity to generate flame temperatures of more than 10,000 °C.

- **Gyrotrons** generate high-power, high-frequency THz radiation. The radiation directly interacts with the material and can heat up rock up to 3000 °C

Simulation studies are key for new technologies



Conclusion

- The world is transforming from fossil fuels to electric power. Electricity, especially from renewable energy, will be the cheapest form of energy. Due to conversion losses, other energy carriers will be more expensive.
- Hydrogen will play only a minor role in the glass industry.
- Custom furnace designs are needed to adopt to local energy sources/carriers.
- Technologies that utilize electric energy must be investigated.
- Simulation helps to understand new technologies and to design new furnaces.

Thank you!

Questions?

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