Decarbonized Energy Roadmap Moving Away From Fossil Fuels

ŞİŞECAM Science, Technology and Design Center

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Melting Technologies and Engineering Directorship

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Our Area of Influence

14 **Countries**

45 **Production Facilities**

5.8 Million Tons **Glass Production**

4.9 Million Tons **Soda Ash Production**

4.4 Million Tons **Industrial Raw Material Production**

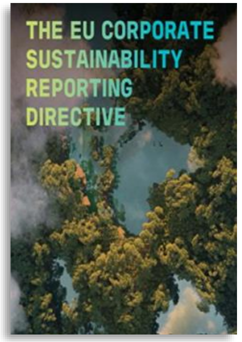
24.000+ **Employees**

WHY Decarbonization?

Global Sustainability Outlook

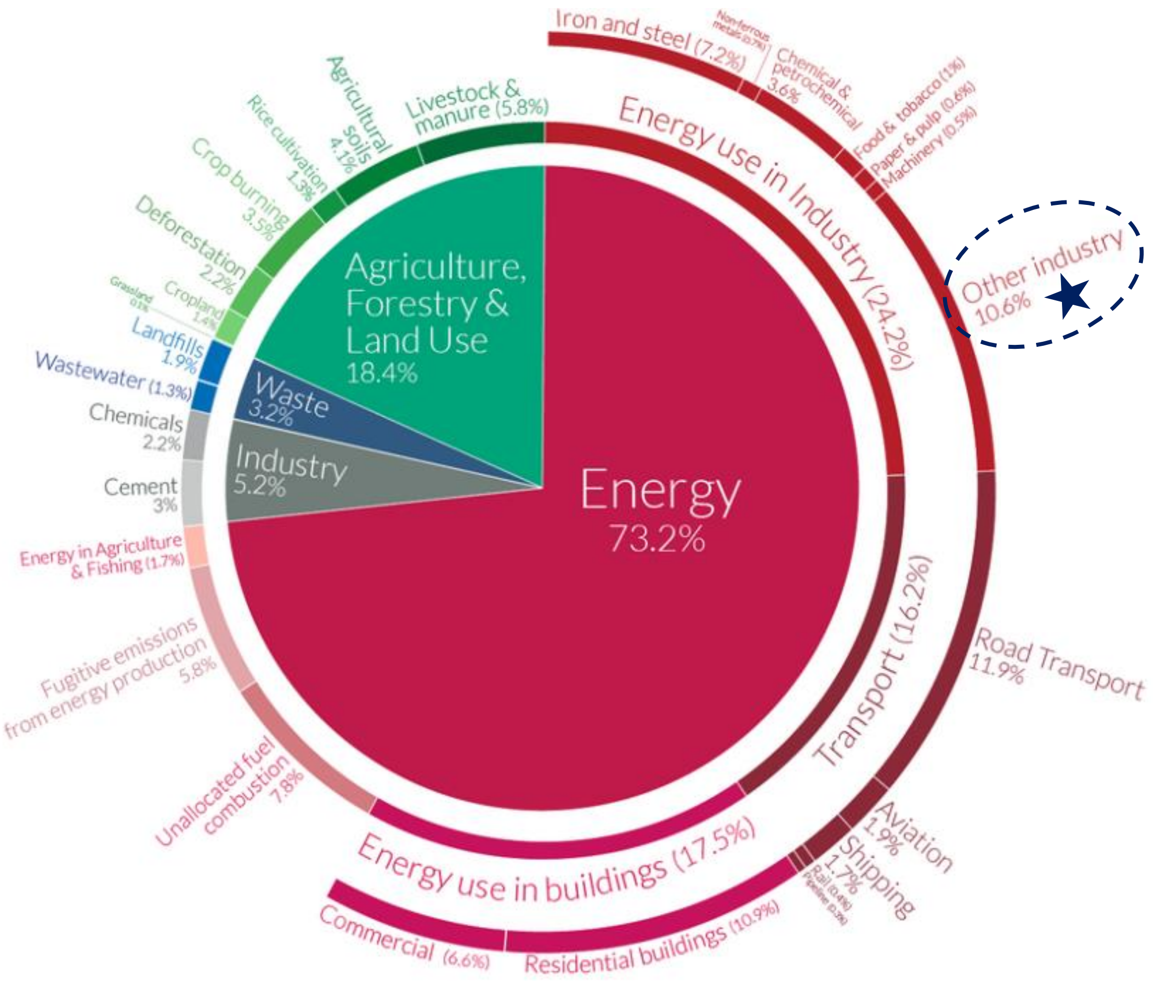
Following the decade of commitments, we have entered the decade of action !

- **1.5 Degree Pathways Is Narrowing; Faster Action Is Needed**
- **Demand for Corporate Transparency:** New **reporting** and **disclosure** requirements for 2024 and beyond
  - CSRD, IFRS S1; S2, CBAM, TR Climate Law, TR Deposit Return Scheme, SEC
- **Greenwashing In the Spotlight:** Will be supported by stronger legal definitions and consequences in 2024 and beyond
- **Scope 3 Emissions and Supply Chain Transparency**
  - Scope 3 → **70-90%** of a company's total greenhouse gas footprint
- **Investor** and **customer demands** have accelerated. **ESG ratings** at an all time high with varying priorities and methodologies
- **Geopolitical tensions**, **high interest rate** environment and **supply constraints** curb climate action

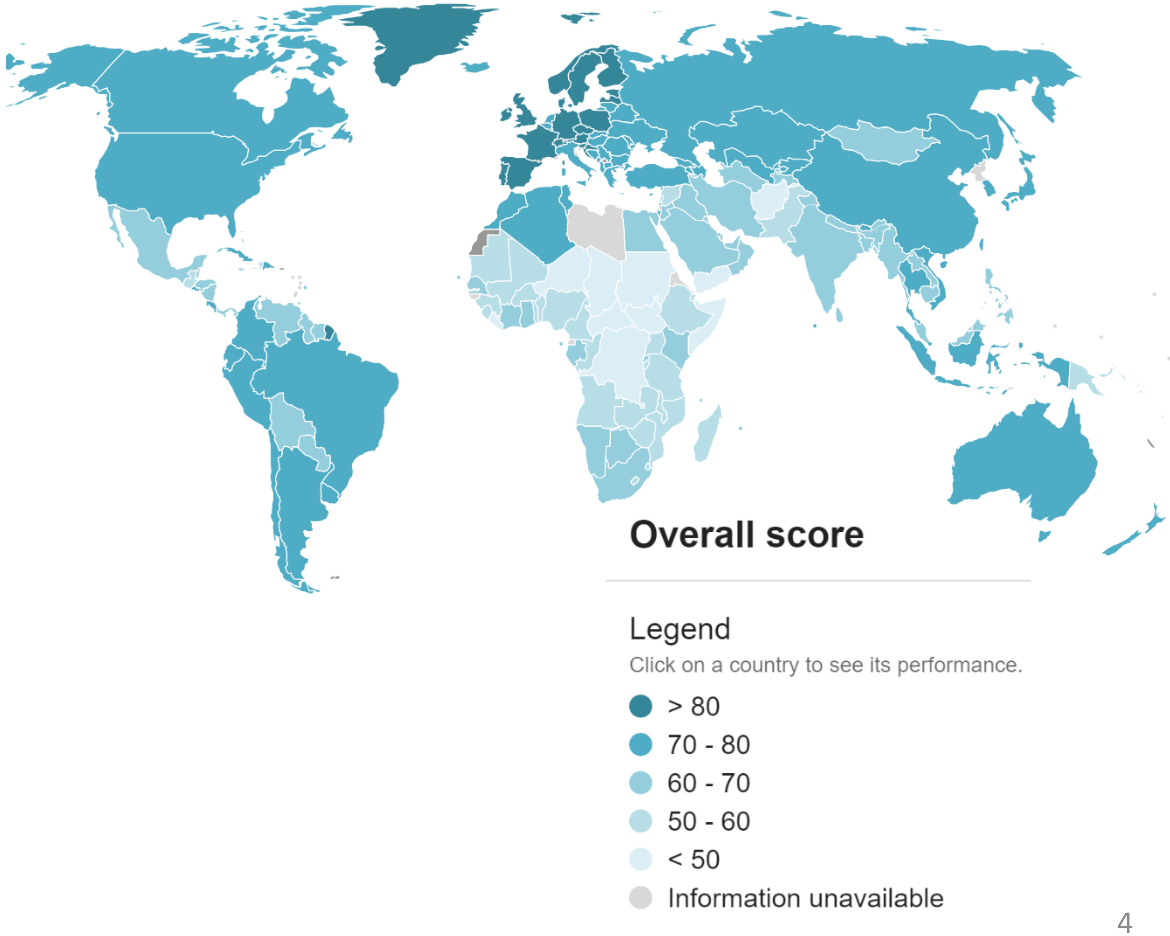


Following the decade of commitments, we have entered the decade of action

Global Greenhouse Gas Emissions by Sector;
The world emits around ***50 billion tonnes of greenhouse gases*** *each year.*



The overall score measures the total progress towards achieving **all 17 Sustainable Development Goals** (UN). *2023*

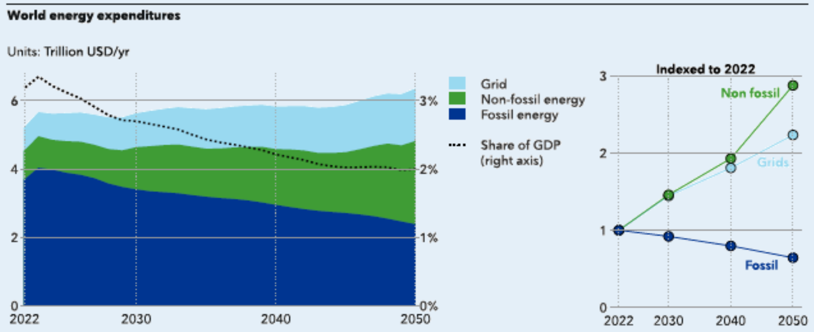


Energy Trends

An approaching peak of fossil fuel production and rising investments on low carbon fuels has the potential to change to global energy outlook.

ENERGY TRANSITION

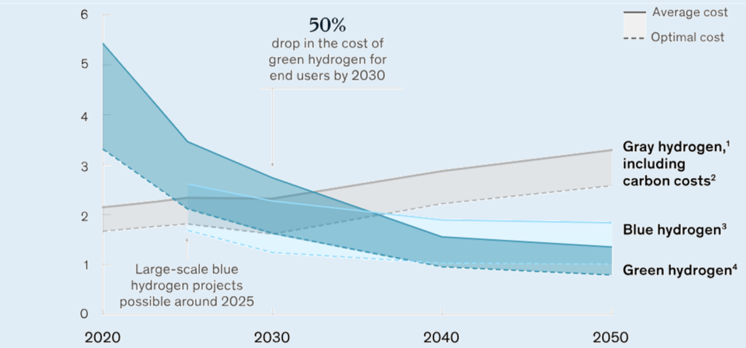
While fossil fuels will constitute 71% of total world energy expenditure in 2022, it is predicted that this share will decrease by almost half to 36% in 2050.



HYDROGEN

Green hydrogen production costs are expected to fall by approximately 50% by 2030

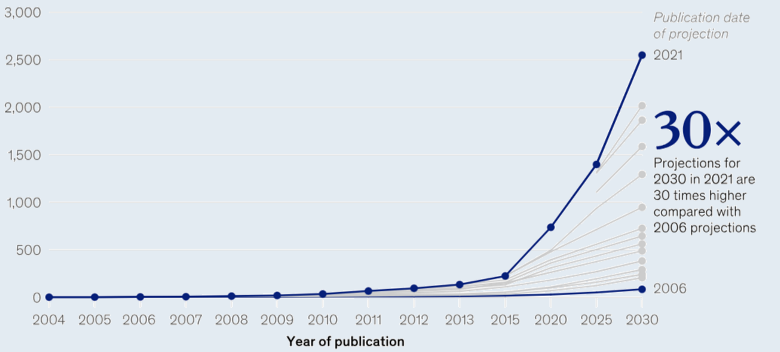
Projected global production cost of hydrogen, $/kg



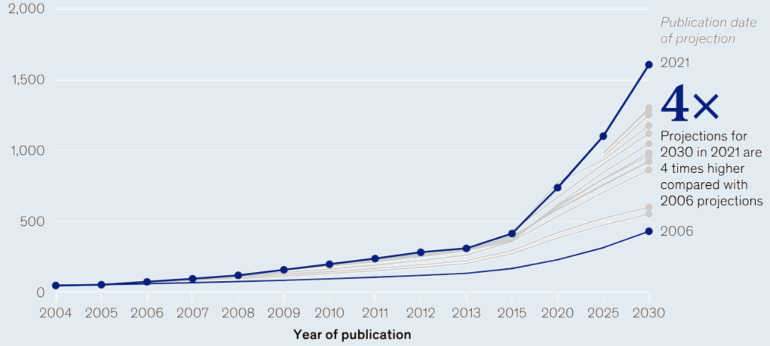
RENEWABLES: SOLAR & WIND

Over the past decade, the growth of renewable energy has consistently and dramatically outperformed nearly all expectations

Global forecast of solar PV capacity, GW



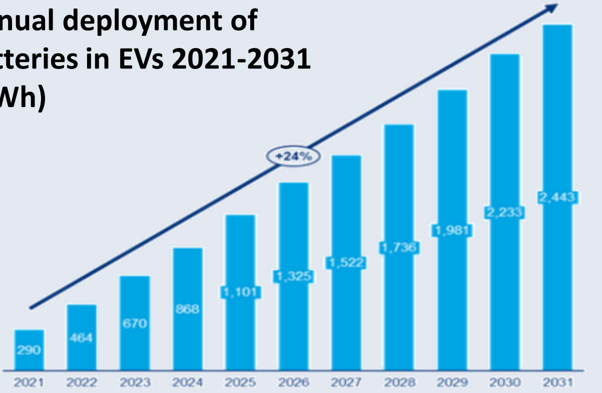
Global forecast of wind onshore and offshore capacity, GW



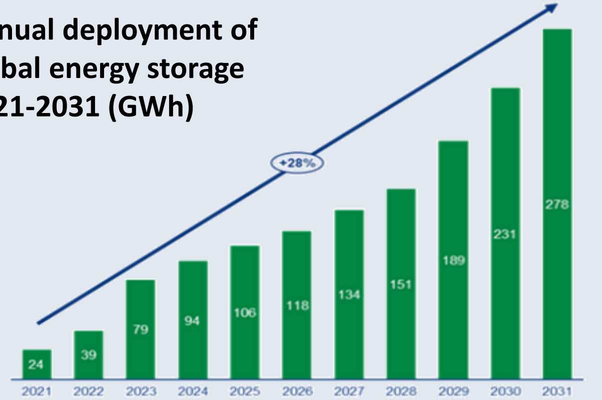
ENERGY STORAGE

Strong growth and specific requirements will drive an increasingly separate energy storage system batter market

Annual deployment of batteries in EVs 2021-2031 (GWh)



Annual deployment of global energy storage 2021-2031 (GWh)

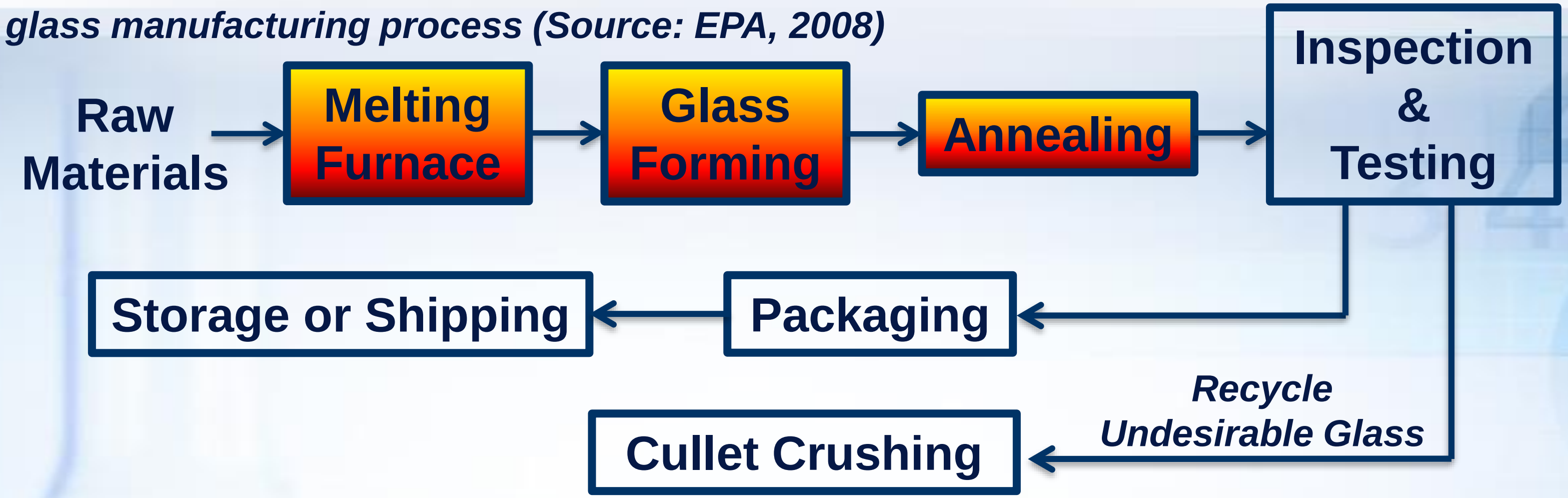


Energy Consumption in Glass Production

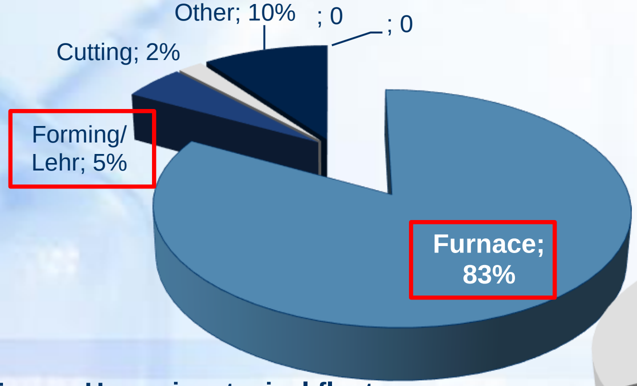
- Glass manufacture is a **high-temperature energy-intensive** process.
- The energy is used primarily to supply heat for **melting the raw materials**.
- A glass melting furnace operates at temperatures up to **1,600-1,700 °C** and **continuously** provides glass for 24 hours a day and 7 days a week.
- In general, melting step accounts around **75%** of total plant energy.
- The other **25%** consumes by glass forming, annealing, finishing and/or secondary processing steps in addition to auxiliary utilities (e.g. boilers, O_2 production, etc.).

Energy Consumption in Glass Production

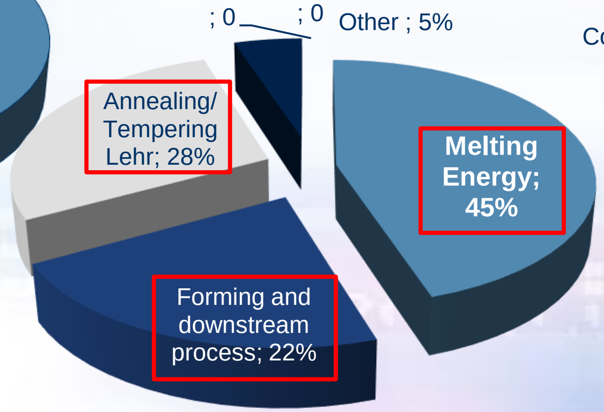
Typical glass manufacturing process (Source: EPA, 2008)



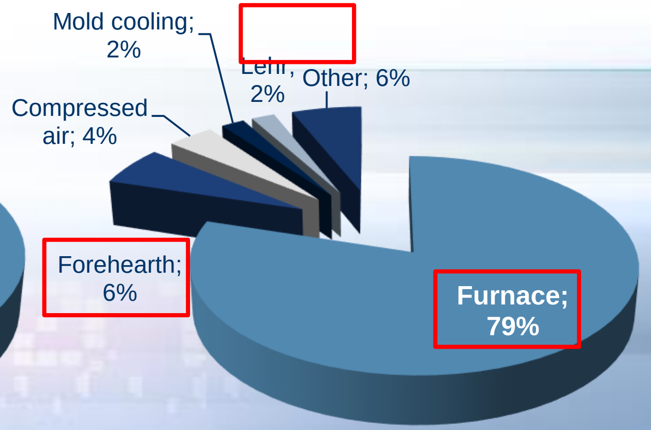
>85% of total plant energy is directly related to the <u>form of the product</u>!!!



Energy Usage in a typical float glass process



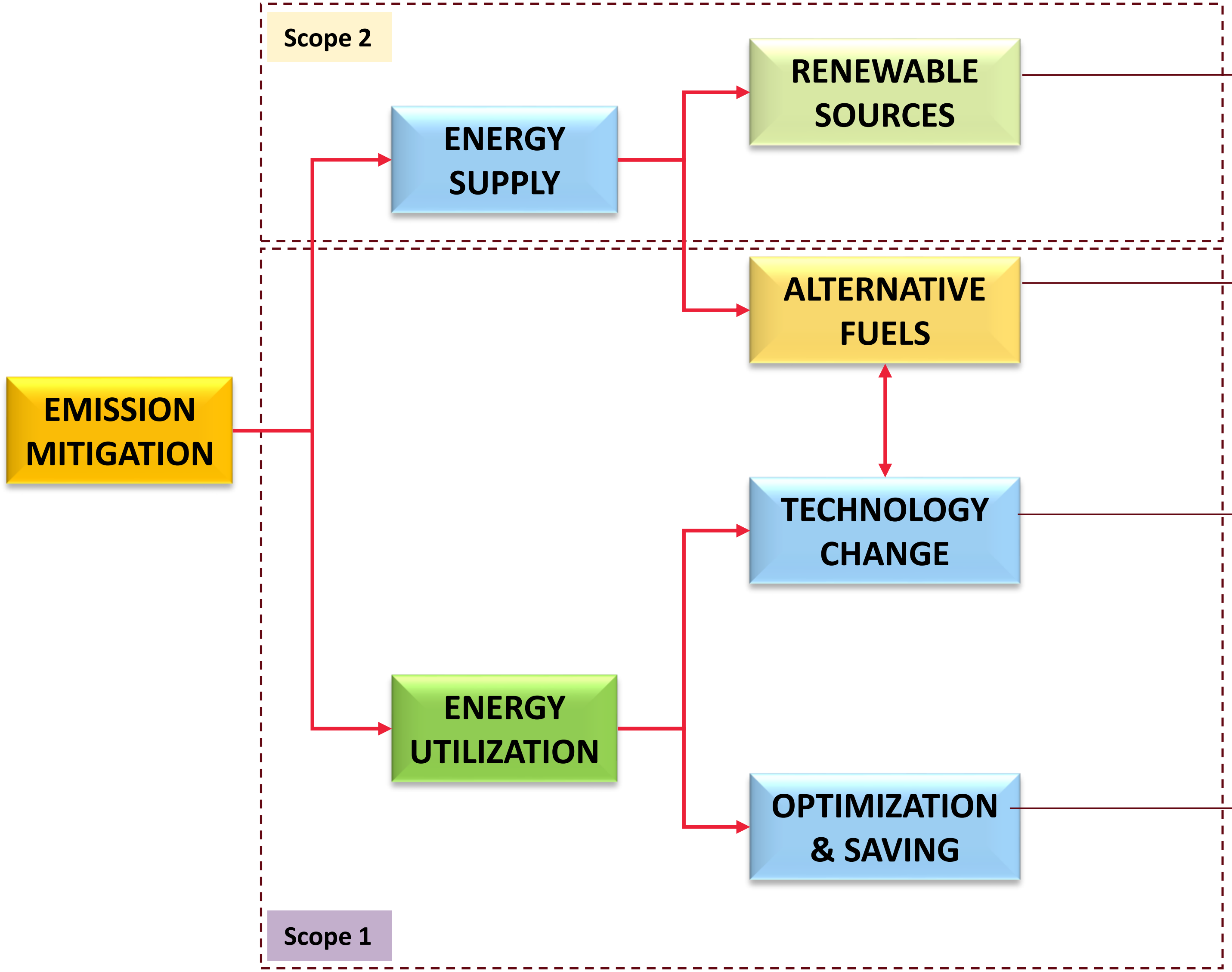
Energy Usage in a soda-lime glass tableware production



Energy Usage in a typical bottle/jar glass plant

Source: IPPC BREF

Şişecam's Decarbonization Levers Toward our 2050 Carbon Neutrality Target (2024 – 2050)



1. On-Site Renewable Investments
2. Solar Steam
3. Green Certificates
4. Power Purchase Agreements
5. High Capacity RE Acquisitions

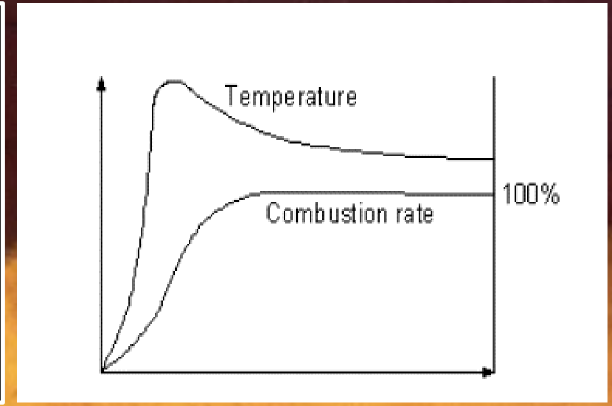
1. Coal Phase out
2. Blue and/or Green Hydrogen
3. Biofuels

1. Conventional Boosting in Flat Glass
2. Super Electric Boosting (30%)
3. 100% Electric Glass Melting
4. 100% Oxy Fuel with Green O2/H2
5. Gas Turbine Hydrogen Blending
6. Electric Heavy Soda Production
7. Carbon Capture Integrated Production
8. Alternative Material Formulations

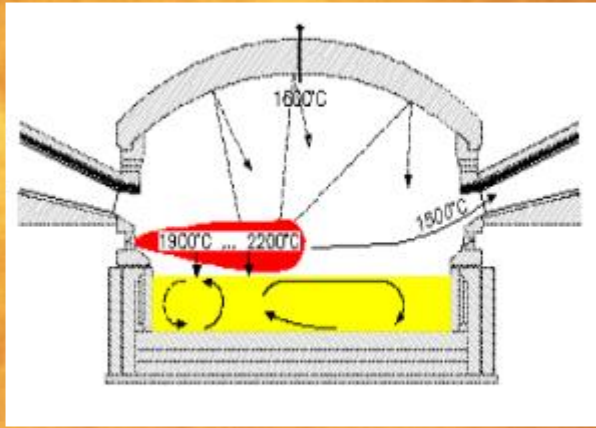
1. Improved instrumentation & control
2. Heat Recovery
3. Increased Cullet Use

Decarbonizing Glass Manufacturing

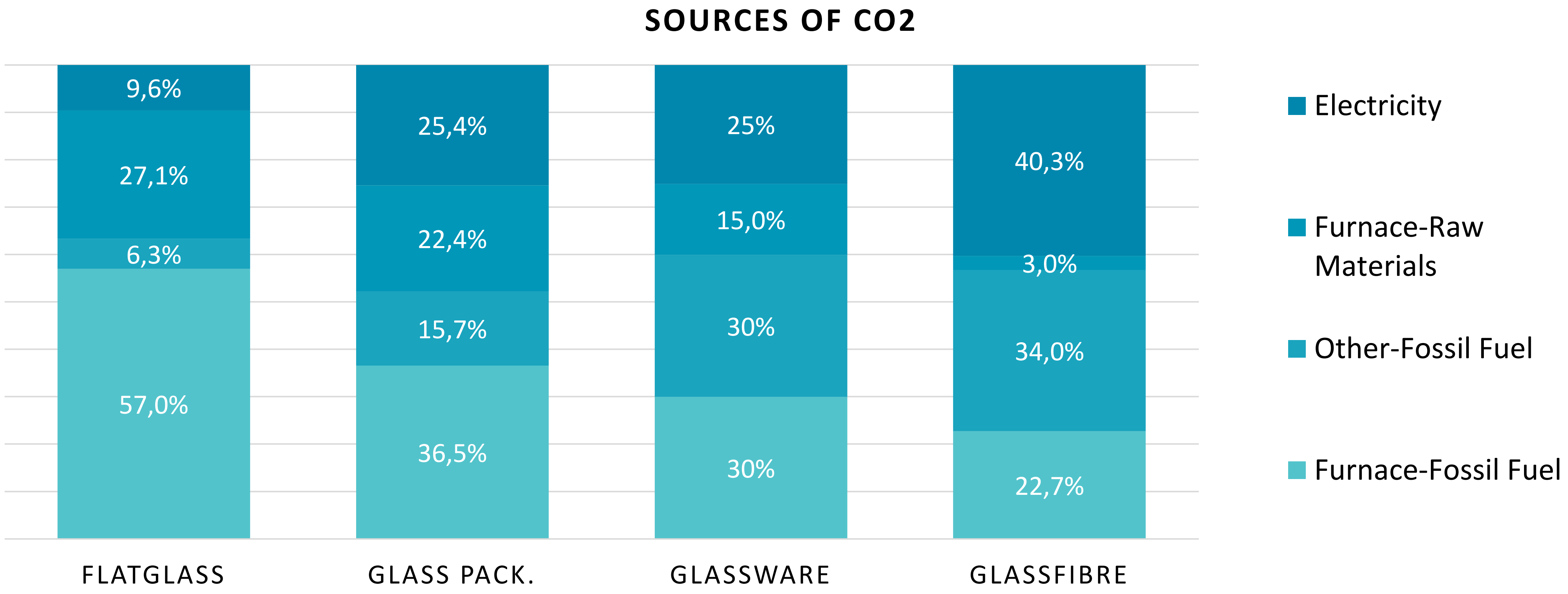
- Glass manufacturing is an energy-intensive activity, with melting furnaces consuming 85% of onsite fossil fuels.
- The specific energy consumption for continuous glass production processes is in the range of 5 - 10 MJ/kg Glass.
- Glass manufacturing is energy-intensive, with the primary energy sources being natural gas and electricity (boost)
- High-temperature melting furnaces, used in the production process, consume a substantial amount of energy.
- Energy should be provided for 7/24 throughout entire furnace life (10-15 years).
- The furnace technology is approaching the thermodynamic efficiency limits of the glass melting process.
- Energy efficiency measures such as WHR and improved furnace design are already routinely introduced.



- The glass manufacturing industry is a source of GHGE, primarily CO_2, due to the combustion of fossil fuels.
- Because of the extremely high temperatures, glass manufacturing has a high carbon footprint.
- As of 2022, the global carbon dioxide emissions from glass production amounted to 95 million metric tons(*).
- Europe, one of the world's leading glass producing regions, accounted for more than one-fifth of that amount(*).
- Efforts have been made to reduce GHG emissions through the adoption of cleaner energy sources, energy. efficiency improvements, and the use of alternative raw materials.
- Many glass manufacturers are working towards sustainability goals and initiatives to minimize their environmental impact, including carbon emissions reduction targets.



CARBON FREE GLASS – POSSIBLE or NOT?



	Fuel	Electricity	Raw Material	Application	Cost
C free Glass	Zero C fuel (green H_2)	Green Electricity	Zero –CO_3 (100% Recycled or alternative materials)	Pilot scale/ R&D	High
Low C Glass	Blended H_2 + Energy Efficiency	Supported with REs	More cullet	Possible but highly depend on the infrastructure	variable according to case and reduction rate

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Pathways for Glass Melting

As many furnaces due to be installed in the coming years will be expected to run for up to 12-15 years, new low carbon fuel technologies need to be proven technically and economically within the next 10 years if the glass sector is to fully decarbonise by 2050. Therefore, to effectively decarbonise the entire sector as fast as possible, it is recommended that the following scenarios need to be investigated and developed by the Glass Sector in order to maximise the chances of successfully decarbonising manufacturing process by 2050:

- Hydrogen
- 100% electric melting
- Alternative fuels (Biofuels)
- Hybrid-fuel scenarios
- Carbon capture

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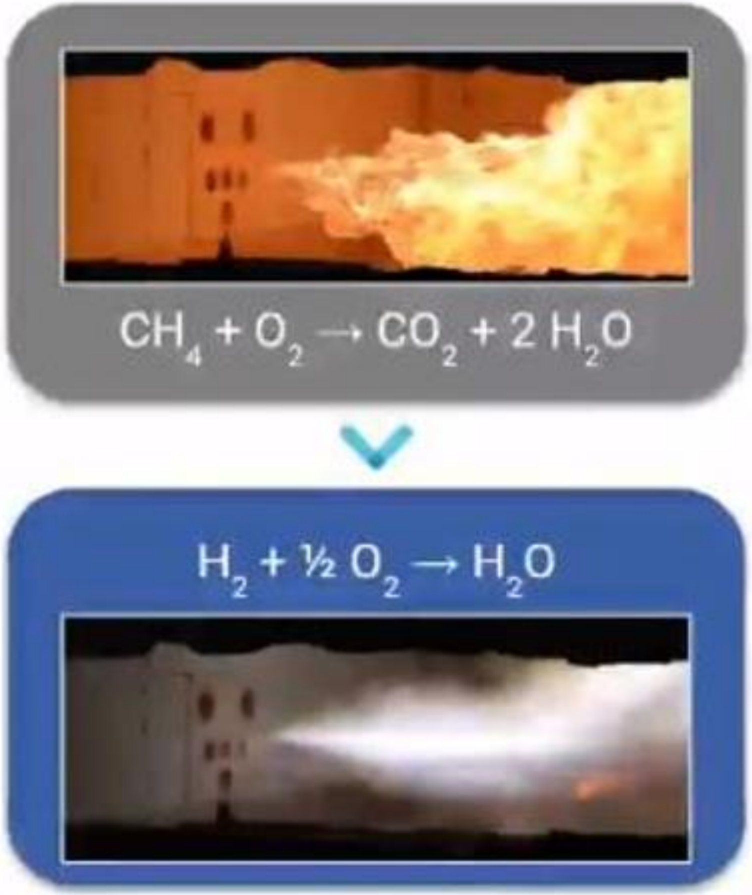
Pathways for Glass Melting

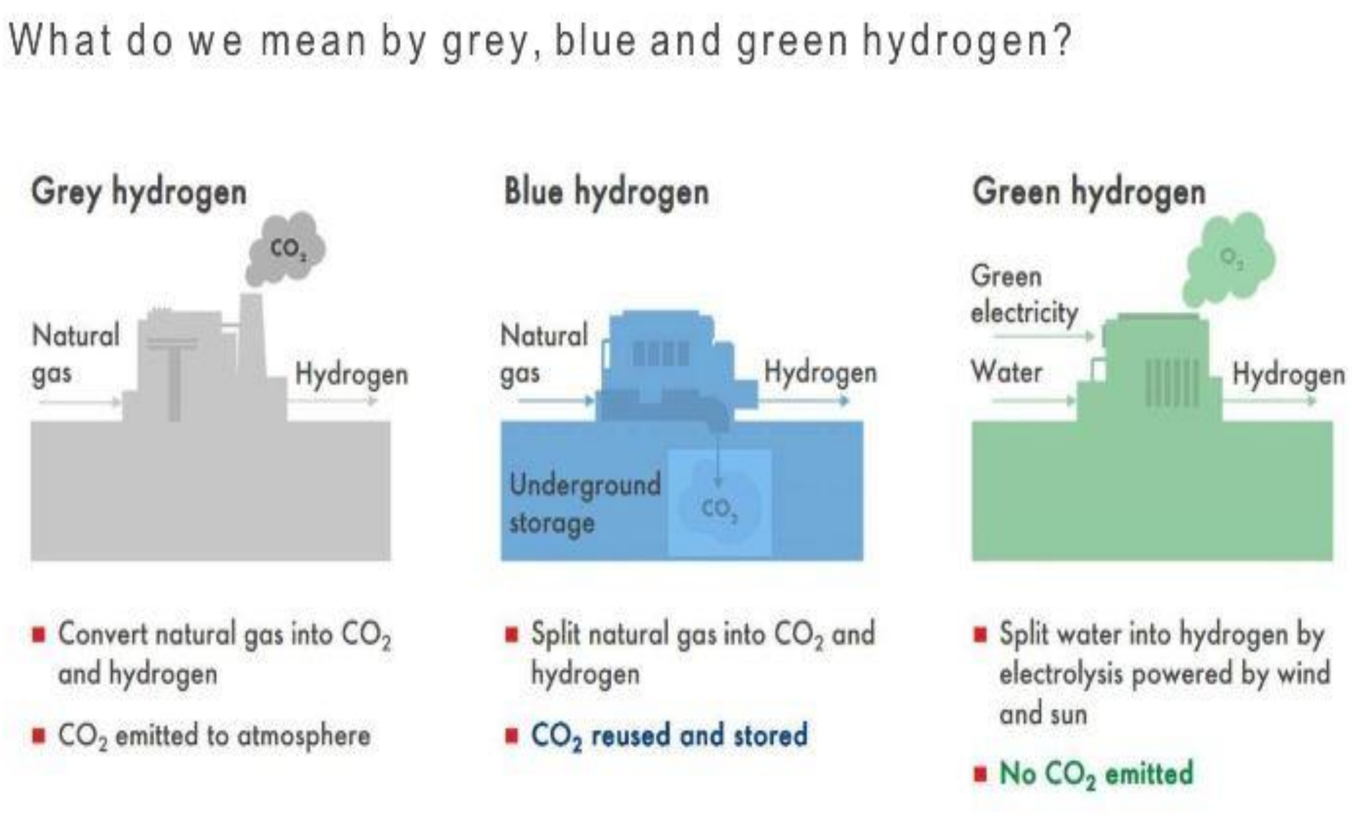
H2 Combustion



Safety	- Risk of leakage, High reactivity...
Burner design	- Control of **NOx emissions** - Control of **Flame length** - Control of **Heat transfer profile (flat flame...)**
Impacts on the process	→ *high steam content in the flue gases* - Product quality - Attack of furnace refractories - Radiation from the flame
Economics & CO2	- **Cost of hydrogen** vs expected **CO2 emissions** reduction and alternative decarbonation strategies

Pathways for Glass Melting

Source of H2



Cost

- Blue and Green Hydrogen are not currently cost competitive with the existing next best alternatives;
- As the industry grows in size, economies of scale will help reduce cost;
- To aid this we need immediate supportive policy to enable investment;
- Collaboration between energy companies, industry players, infrastructure and vehicle manufacturers is also required.

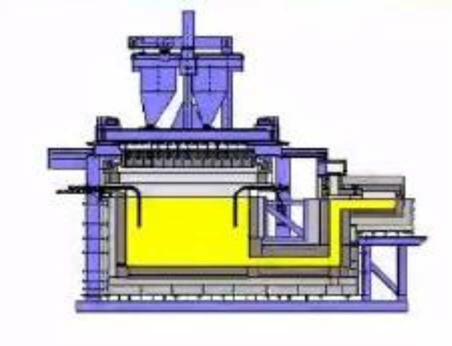
Matched supply and demand

- The hydrogen industry will only be able to succeed if new demand is established;
- New projects need to ensure that supply and demand are synchronised as well as aligning with infrastructure development;
- This will require coordination between public and private organisations at a local, national and international level.

Pathways for Glass Melting

Electric Melting:

Different designs available



Lower pull (<200 tpd)

Lower energy consumption vs. regenerative furnaces

Low furnace life time

Currently, renewable energy (including hydropower and bioenergy) makes up 54% (i.e. 56 GW) of Turkey's installed power generation capacity and has contributed to 42% (i.e. 137 TWh) of the country's annual electricity generation in 2022.

Installed renewable capacity should be increased

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Pathways for Glass Melting

Biofuels

Biofuels are fuels derived from biomass. If combined with carbon capture technologies, biofuels offer a route to net-negative CO_2 emissions from glass manufacturing processes.

- typically burn with a more radiant flame,
- have lower CV content per kg
- can contain higher moisture content than natural gas or hydrogen fuels, and therefore are expected to have a higher heat transfer from the flame into the glass melt.
- Burning at a lower flame temperature, biofuels are also likely to emit lower NO_x levels.

Sustainability is the big challange!

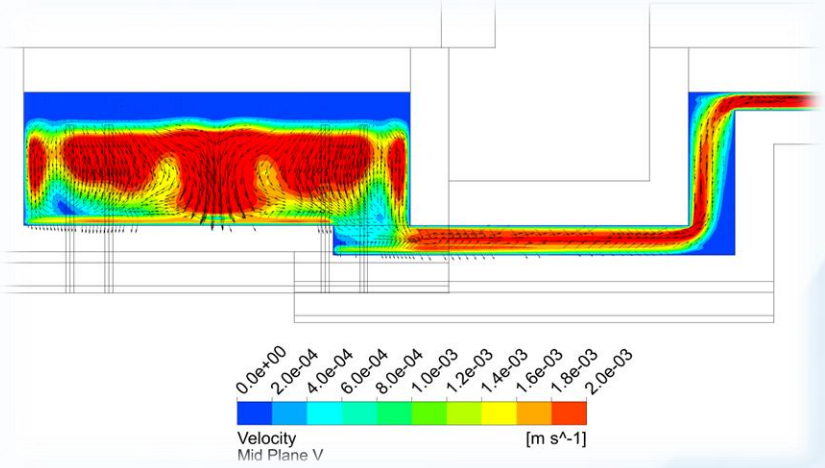
The main barrier will be cost (mainly fuel cost) and the inherent risk associated with trialling a new fuel as the first mover.
The impact of impurities within the fuel on furnace infrastructure are unknown.

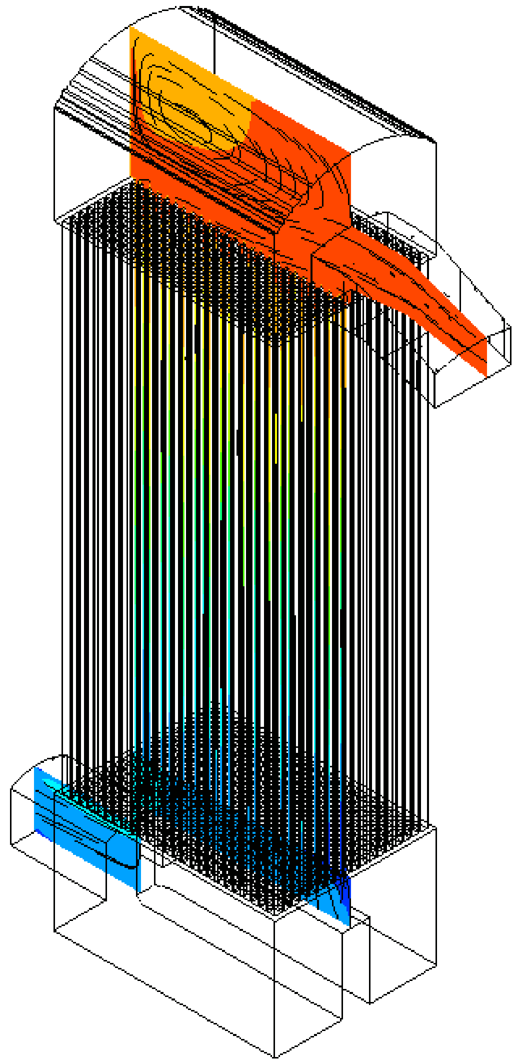
CORE COMPETENCIES IN MELTING TECHNOLOGIES AND ENGINEERING

DEVELOPING NEW MODELLING TOOLS

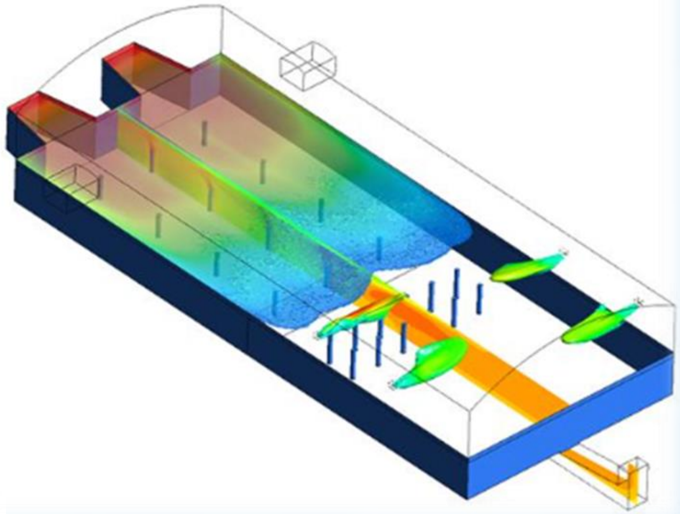
- *Reduced furnace models for fast analysis (in progress)*
- *Improvement of existing furnace modelling codes to accommodate innovative designs (oxy, high electric in melting)*
- *Data analytics with AI & Process Modelling*

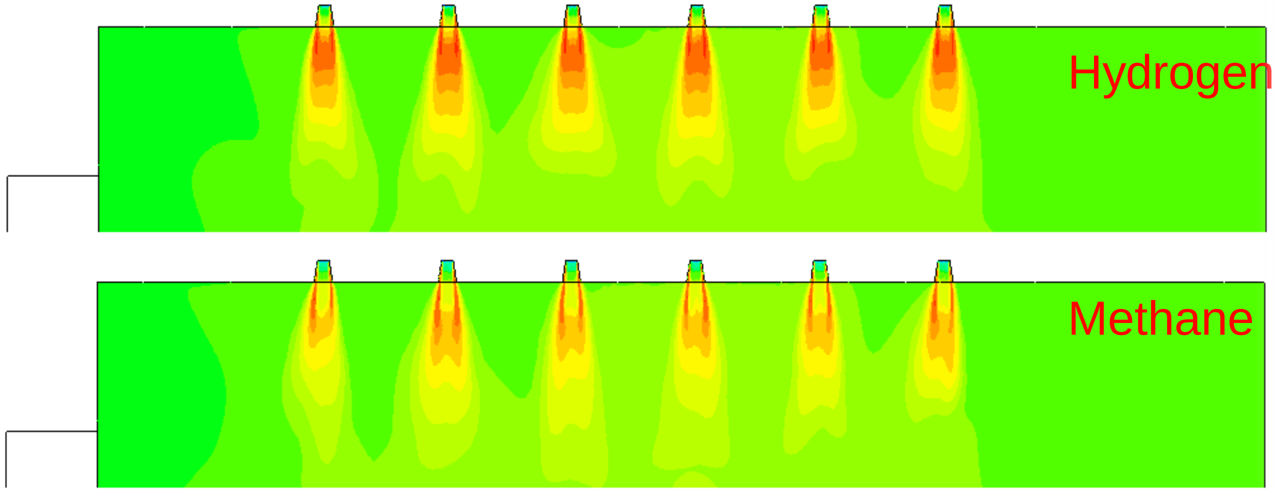
Cold-top Furnace





Hybrid Furnace (up-to %80 electric)





CORE COMPETENCIES IN MELTING TECHNOLOGIES AND ENGINEERING

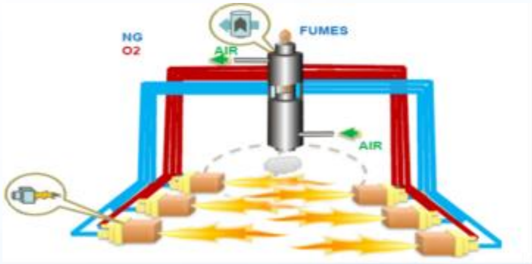
NEW MELTING/ENERGY RECOVERY TECH.

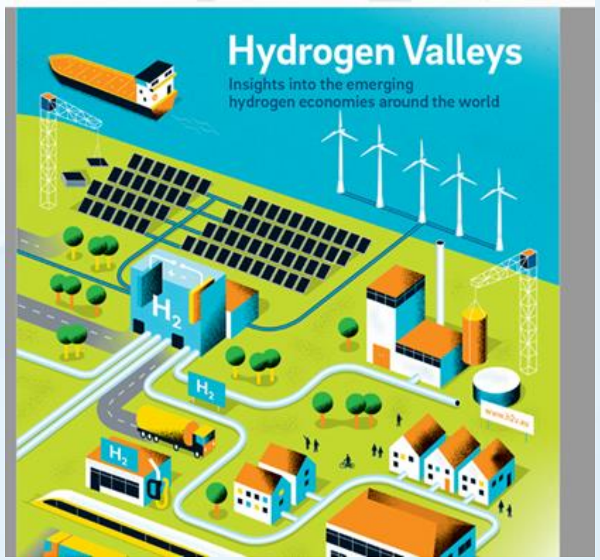
- *In-house development in parallel with technology monitoring in the market of Hybrid (>%30 electric in melting) / full electric furnaces*
- *Solar/wind renewable energy systems, electrolysis Technologies for H2 production*
- *Assessment of Hydrogen Valley Projects- GMKA*

EU FUNDED INDUSTRIAL R&D PROJECTS

- *Hysouth Marmara Hydrogen Valley Projectr*
- *EU LIFE Eco-HeatOx : pre-heating of reactants in an oxy-fuel furnace*
- *EU LIFE CleanOx: Further efficiency to Heat-Ox with innovative heat exchanger*
- *EU LIFE Smart Oxy-Boost: Capacity increase with an automated oxy-fuel burner in a float furnace*
- *EU H2020 CC-9-2020 Heat To Power : Consortium partnership in an innovative supercritical CO2 WHR system development project*

EU LIFE CleanOx





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WORK THAT MAKES A DIFFERENCE IN 2022&2023

- **10 MWp Renewable Capacity** for self-consumption
- **18.536 GJ I-REC** Certified Green Energy Supply
- **12%** reduction in specific **energy consumption** in glass production over 15 years
- **11 EPD** Certified products covering the entire flat glass product range
- A total of **6.8 million cubic meters of water saving**
- **15%** reduction in **GHG emissions** for a single bottle type with reduced-weight glass packaging solution
- **100% Recycled Aware Collection: 39%** reductions in **natural gas consumption**
- Total of **125.000 tons of glass cullet recycled,** including over 25,000 tons of external glass cullet

SODA ASH OPERATIONS CENTERED AROUND SUSTAINABILITY

US Soda Investment: Perfectly aligned with sustainability targets

50% reduction in water footprint:
Zero water use target from natural resources

50% reduction in production-related CO_2 footprint

Only producer that turns solid waste into non-hazardous form

Minimum impact on land area:
Surface area usage for only well and pipeline locations

Natural soda process has far lower environmental impact relative to synthetic

	Natural Soda	Synthetic Soda
Raw Materials	Trona	Salt, limestone, ammonia, CO_2
By-products	Deca (re-process into soda ash)	Calcium chloride (waste product)
Energy Usage	3 – 6 MMBtu/ton	9-13 MMBtu/ton
Water Usage	1.5 – 2 tons per ton of soda	10 – 15 tons per ton of soda
CO_2 Emissions Factor (ton CO_2/ton soda ash)	0,4	1,1

HOT TOPICS IN CORPORATE SUSTAINABILITY

INCREASED USE OF RENEWABLE ENERGY

- *Advanced PVs*
- *Off-shore Wind Energy*
- *Energy Storage*
- *Green Hydrogen*
- *Biofuels*

Renewable energy met approximately 29% of global energy demand in 2021. The transition from fossil fuels to clean energy stands out as a key to reduce greenhouse gas emissions.

CLIMATE ACTION MITIGATION & ADAPTATION

- *Net Zero Ambition*
- *Science Based Targets*
- *Climate Positive Products*
- *C- Neutral Certification*
- *Technology Transition*

In the last 20 years, global temperature has increased by 1.2°C. This shows how important urgent action is in tackling climate change. Globally, we emit around 50 billion tonnes of greenhouse gases each year. In this amount, industry and energy take up a large share.

RESPONSIBLE & SUSTAINABLE PRODUCTION

- *Sustainable Production*
- *Shift to Recyclable*
- *Circularity*
- *AI & Big Data*

Responsible production and consumption could generate economic benefits of $6 trillion annually worldwide by 2030. This stands out as a way to create tangible value for both business and society.

SUSTAINABLE MATERIALS & SERVICES

- *Sustainable Packaging*
- *Green Taxonomy*
- *Recycle, Reuse*
- *Green Materials*
- *Product Passport*
- *Eco-labels*
- *Sustainable Materials*

According to a report by the Ellen MacArthur Foundation in 2020, it was estimated that approximately 146 million tons of plastic packaging waste was generated annually worldwide. Sustainable packaging and materials minimize the damage to nature by reducing this waste.

RESPONSIBLE SUPPLY

- *Supply Chain Ethics*
- *C- Footprint Impact*
- *Scope 3 Emissions*
- *Logistic Optimization*
- *Clean Transportation*

Sustainable supply chain practices can reduce companies' carbon emissions by 30%. Additionally, the risk of natural resource depletion is minimized by using sustainable materials.