GBP 54 million destined for GLASS FUTURES at Saint Helens

With new financing integrated with current public and private investments, Research and Technology Organisation GLASS FUTURES continues to move ahead with its Global Centre of Excellence in glass project, which comprises R&D, innovation, training and the up-skilling of various industry players.

With Glass Futures due to release its final report from the last two years of project activity, here we look at its earlier report from 2019 to highlight the work that has been carried out in the past two years by Glass Futures into potential alternative fuel switching technologies for the glass industry. Glass Futures was founded for the precise purpose of developing a UK-based 'catapult-like' centre of excellence in glass focussed around a unique, multi-fuelled 'hot' glass pilot facility at St Helen's, Merseyside. The centre will seek to drive R&D, innovation, technology incubation and implementation, as well as training and up-skilling of industry technicians and professionals.

Bringing the global glass industry together thus with academia has Glass Futures leading some of the world's largest manufacturers and supply chain partners in the industry, as well as leading UK university research groups.

The centre is to be supported by a series of smaller research hubs across UK academic and industry research groups – all with the aim of strengthening and aligning existing industrial and academic expertise within the 'Northern Powerhouse' region. Here the ultimate ambition is to create a globally recognised UK-based glass technology and research hub that can capably drive significant improvements in productivity and sustainability within the global glass industry, thereby providing a platform that can propel the sector towards net-zero CO2 emissions by 2050.

COLLABORATION WITH GLASS FUTURES

Glass Futures operates a membership subscription model for which any organisation from the global glass supply chain can join in membership for an annual fee to participate in collaborative research and gain access to technical information from some of the projects and work that is planned to be carried out on the new pilot line in St Helens, when it opens in January 2023, and enquiries for membership should be made to info@glass-futures.org.

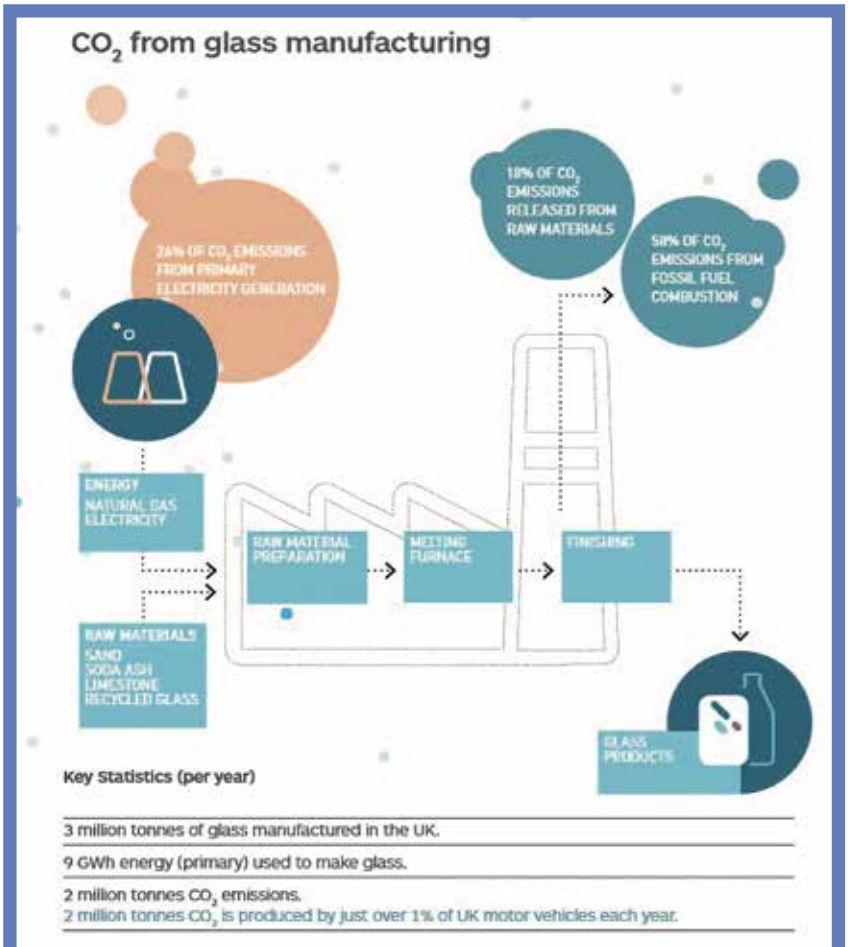
THE GLASS INDUSTRY IN THE UK

The UK glass sector currently employs 23.200 people - generating GBP 3 Billion in revenues, which contributes GBP 1.6 Billion GVA to the UK economy (Ekosgen, 2019). The sector also makes a significant contribution to many other

sectors, further addressing existing social challenges. Innovations within the glass industry can potentially benefit everyone through enhanced energy efficiency in construction, improved ways of generating green energy, as well as by demonstrating the circular economy in action with the use of recycled materials and -across many sectors- developing novel applications that benefit medicine, agriculture, transport and advanced manufacturing. At its core, the glass manufacturing industry produces around three million tonnes (Mt) of glass per annum and generates more than two million tonnes of CO2. Of these emissions, 58 percent comes directly from fuel combustion and 24 percent from primary, on-site electricity generation, with 18 percent released from the decomposition of carbonate raw materials (British Glass 2014). Whilst the sector has indeed made progress by halving emissions over the past 50 years, the need remains to urgently accelerate existing efforts to increase energy efficiency while reducing CO2 emissions – all to meet the UK's 2050 carbon commitments. Given that many furnaces due for installation over the coming years will be expected to run for up to 20 years, it follows that new low carbon fuel technologies will need to prove themselves both technically and economically feasible within the next 10 years if the glass sector is to fully decarbonise by 2050.

To address this need, Glass Futures Ltd has successfully applied for, and secured, a GBP 7.1 million grant under BEIS Industrial Fuel Switching Competition Phase 3 following on from its GBP 300 thousand grant under BEIS Industrial Fuel Switching Competition Phase 2 - all to conduct its 'Alternative Fuel Switching Technologies for the Glass Sector' industrial demonstration. This ran from January 2020 to March 2022, yielding a significant amount of data and feedback, for which a final report is due to be published in June 2022, following on from an initial report in November 2019.

With further investments, project funding now totals GBP 54M, which includes a GBP 15M UKRI grant, secured to support the installation of the globally unique, experimental furnace and state-of-the-art infrastructure capable of melting 30 tonnes of glass per day - all within a safe experimental space. St Helens Borough Council, too, committed funds for pre-planning and planning costs, and the 'Build Back Better' fund of Combined Authorities of the Liverpool City Region has provided a GBP 10M grant to support construction. Network Space has secured private sector investment and glass sector companies are contributing a further GBP 20M in resources, time and equipment to support the project.



Overview of glass process and original of CO2 emissions (British Glass, 2014)

THE OPTIONS CURRENTLY ON THE TABLE

In observing the plausibility that more than one solution is required, the report identifies significant infrastructural differences across the UK glass sector - all variously associated with furnace design, age and application typology among the factors influencing whichever route of decarbonisation proves most suitable at any given site. Here uncertainty over the availability and economics of fuels across the UK is also underscored as a variable factor, depending upon the region under examination. It follows, then, that no single fuel scenario is likely to comprehensively address the decarbonisation needs of the entire UK glass sector. Consequently, and to max-

imise the chances of swiftly and successfully decarbonizing the entire sector by 2050, the report privileges Biofuels, Hydrogen, 100 percent electric melting and Hybrid-fuel scenarios as the four fuel-scenarios it recommends for investigation and development.

TECHNICAL OPPORTUNITIES

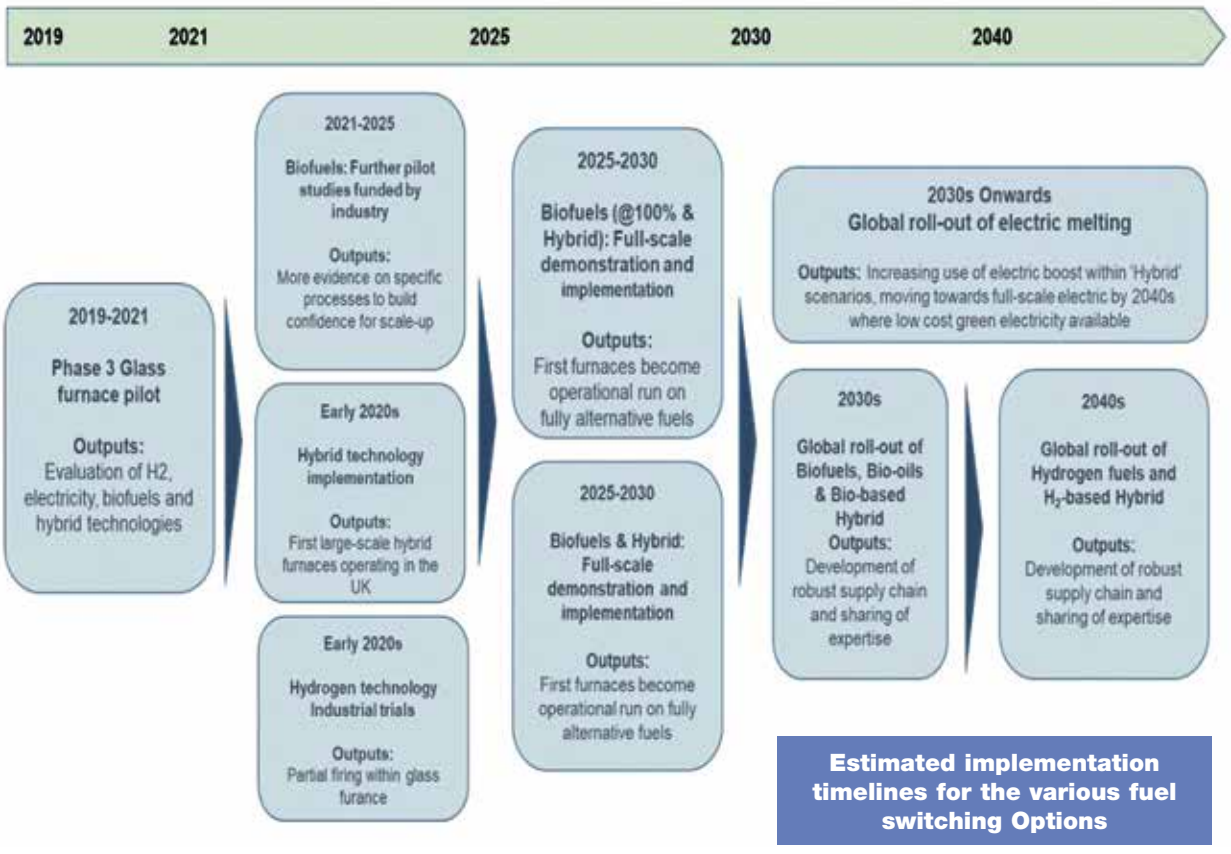
Given the glass sector's commitment to decarbonisation, the UK's industrial strategy to support this ambition and existing combustion technologies research expertise within the UK, there's a significant opportunity for the country's glass sector supply chain to bring new technical concepts to market, thus becoming a world leader in the decarbonisation of a heavy industry. These same new supply chains and processes could also provide knock-on benefits to such other sectors as Steel, Cement, Ceramics, Waste management and Energy generation.

Through industry engagement activities and literature reviews, the Phase 2 study identified much interest in fuel switching within the glass sector while also underscoring significant knowledge and technical barrier gaps that need to be addressed in order for this to be realised. The study further notes that the UK has the industrial appetite, the necessary research excellence and the government backing to address these challenges. As such, the technical developments and capabilities required to decarbonise the UK glass sector represent an important area of opportunity for UK-based businesses and research organisations to become global leaders in the field.

TIMESCALES AND FINDINGS

The study highlighted the significant impact the economics of fuel switching will have upon uptake timescales. All four of the proposed solutions investigated are reported as having the potential to enable a full decarbonisation of the heat required for glass melting across the UK glass industry before 2050. However, it's considered that to fulfil this timescale, large scale demonstrations would need to occur within a relatively short time frame (<10 years) to allow industry to make the business cases and engage new supply chains that can bring these decarbonised solutions online within 10-20 years. Here just the 15-20-year life expectancy for glass furnaces makes these timescales essential if the industry is to decarbonise by 2050.

Although an economic study was undertaken, the high level of uncertainty in fuel costs resulted in a conclusion that any of the options could represent the most economically feasible option in the future. It's stressed that this is important and is reflected in the decarbonisation roadmap for



Estimated implementation timelines for the various fuel switching Options

the glass sector, which currently shows heavy reliance upon electrification.

There is great concern across the industry that, without significant investment now, the country's ability to carry out the required research will become difficult. This is due to the capital-intensive nature of the glass sector, coupled with the requirement to run uninterrupted 24 hours a day, 365 days a year - which, as a process, hardly lends itself well to demonstrations of disruption. The glass industry has limited available R&D funding, much of which is already committed to product development rather than to process development. Moreover, the magnitude of the required research and investment warrants a united approach across all glass industry sectors, together with full government backing.

SOME BACKGROUND

The UK Government has committed to reducing net carbon dioxide emissions to zero by 2050. National efforts to meet these emissions reduction targets could potentially result in conversion to a hydrogen gas grid. Alternatively, it could see localised decommissioning of the gas grid and a move towards electrification and decentralised energy supply.

It's estimated that 90 percent of UK industry relies on energy supplied from the gas grid either directly for industrial processes or indirectly in day-to-day business. Whilst the glass sector has made progress by halving emissions in the last 50 years and its products contribute to energy savings in other sectors (including glazing and insulation, wind turbines and aerospace), the need remains to urgently accelerate efforts to increase energy efficiency whilst reducing CO2 emissions to meet the UK's 2050 carbon commitments.

The BEIS Glass Industry Decarbonisation and Energy Efficiency Roadmap to 2050 has identified 100 percent electric melting as the preferred route to decarbonisation of the industry. However, findings from subsequent industrial engagement activities have identified other technologies that can be considered now as genuine alternative routes to decarbonisation, such as biofuels and hydrogen - none of which were highlighted on the original industry roadmap. The Phase 2 study sought therefore to build upon the original findings to increase understanding of those different options while exploring how best to facilitate a wide-scale adoption of all low-carbon fuel scenarios across the glass sector.

BEIS INDUSTRIAL FUEL SWITCHING COMPETITION REMIT

BEIS has stated that the aim of the Industrial Fuel Switching Competition is to identify and demonstrate solutions which will enable industry fuel-switching from fossil fuels to those that are less carbon-intensive. These include electrification, hydrogen and biomass (while biomethane is a lower carbon fuel it's not within the scope of this competition). Here the Competition was split into three phases:

Phase 1 - a market engagement and assessment study into fuel switching in the UK;

Phase 2 - a feasibility study into fuel switching solutions;

Phase 3 – a demonstration of funding for these solutions.

In Phase 1, the market engagement and assessment study conducted by Element Energy considered the viable energy sources for industrial fuel switching, the industrial processes compatible with fuel switching and potential solutions for the achievement of such switches. As for Phases 2 and 3, BEIS' stated aim was to identify and test the requisite processes and technologies for UK industries to switch to low carbon fuels while examining funding options for the consortium to demonstrate the feasibility of their proposed technology or approach.

STUDY SCOPE

In preparation for the Phase 3 bid, Glass Futures undertook a detailed review of the original glass industry decarbonisation roadmap alongside discussions with a number of industrial and academic partners.

These highlighted that, due to differences between manufacturing requirements of subsectors (including float, container and glass fibre), capital refurbishment timetables and predicted future variations in availability and affordability of different fuels across the UK (e.g. localizable hydrogen supply; limited local grid capacity for electricity supply) no single low-carbon fuel scenario is likely to be suitable for all glass manufacturing processes. It was therefore agreed that the scope of the Phase 2 study should cover the following four low-carbon fuel scenarios:

- Biofuels (with the potential for a subsequent addition of carbon capture utilisation and storage (CCUS);
- Hydrogen;
- 100 percent large-scale electric melting;
- Hybrid fuel scenarios (i.e. combinations of the above, with or without natural gas)

Despite a strong argument to add biomethane to this list, the fuel was considered beyond scope, thus remaining uninvestigated in the study.

THE RESEARCH APPROACH

Led by Glass Futures and project managed by Glass Technology Services Ltd. (GTS), the Phase 2 study consisted of five work pack-

ages and was supported by project partners representing glass manufacturers (Encirc, NSG Pilkington), furnace designers (F.I.C, Tecoglas), control systems supplier (Siemens), research groups (Sheffield Hallam University, University of Leeds) and The Society for Glass Technology. Further support was provided by Element Energy, and the University of Sheffield.

Here the Phase 3 study aimed to determine technical and economic feasibility for each of the above four fuel scenarios, along with the potential to decarbonise the glass furnace heating process while meeting regulatory requirements.

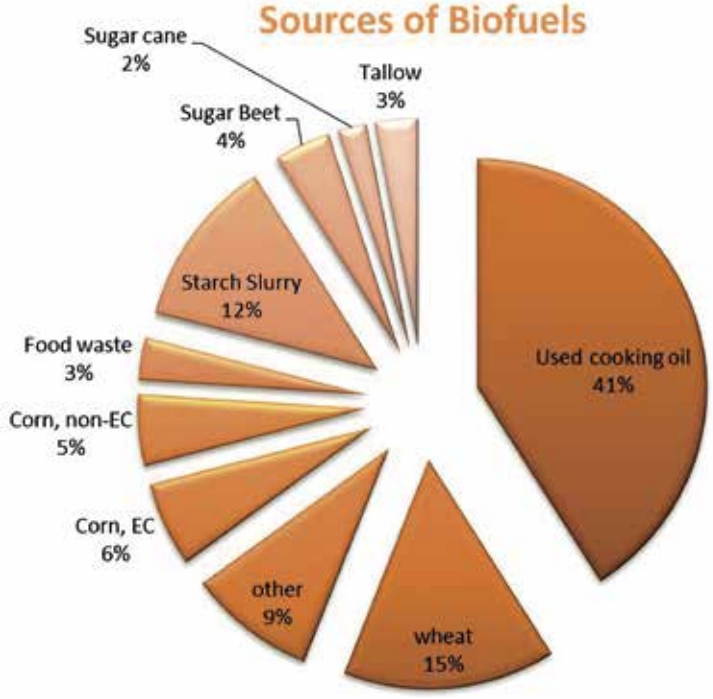
A POSSIBLE IMPLEMENTATION TIMEFRAME

The study indicates that, given suitable R&D investment, biodiesel could enable the glass industry to eliminate up to 90 percent of the CO2 emissions associated with heating glass furnaces by 2030. Not only. If combined with CCUS, this could provide a route to negative net-carbon emissions.

However, it's likely the industry would instead be after a hydrogen-electric hybrid over the long-term (when such fuel sources are available), possibly with a small amount of bio-oils (either to optimise the hydrogen flame or as a back-up when electricity is in high demand), such that fuels could be delivered to sites without any need for a road-based haulage network. This also reduces the reliance upon the biofuel network - freeing it up for other sectors.

CONCLUSIONS AND RECOMMENDATIONS

Due to uncertainties and differences between subsectors as well as predicted variations respecting future availability and the affordability of various fuels across the UK (e.g. potentially localised hydrogen supply, limited local grid capacity for electricity supply), no single low-carbon fuel scenario is likely to suit all 17 of the largest glass manufacturing sites - which jointly accounts for the greater portion of UK glass manufacturing output (as well as associated CO2 emissions from glass melting). Of the four possible fuel scenarios investigated (biofuels, hydrogen, large-scale electricity and flexible-hybrid), the study found that each can offer technical feasibility, thus affording the glass furnace heating process a possibility to fully decarbonize while meeting regulatory requirements - provided that the fuel be supplied economically.



sources of Biofuels used in the UK

BIOFUELS

Fuels directly derived from wastes or from 100 percent renewable bio-sources (blends with standard diesel being thus excluded) are known as biofuels. These are presented as a worthy fuel-switching possibility, given the similarities of certain biofuels to gas oil - a fuel the industry prefers over natural gas and considering the added potential to use lower cost bio-fuels. The UK already has biofuel upgrade capacity to supply the entire glass sector - a viable solution that could be strengthened in the event of subsequent CCUS application to mitigate process emissions and provide the sector with negative emissions. Here, however, a lack of understanding was noted as to how biofuels will perform within a glass furnace as compared to natural gas and standard diesel - especially respecting their effects upon glass melting behaviour and on emissions, since no global cases of firing a glass furnace with bio-oils have been recorded hitherto. All this necessitates further R&D in these areas.

HYDROGEN

Citing our poor understanding of how hydrogen will perform within a glass furnace, the report articulates key concerns which include heat transfer mechanism, airflow volumes through the furnace,

H&S implications like ATEX-rated equipment, effects upon glass-melting and furnace refractories as well as the suitability of furnace geometry and, finally, the effect on emissions, e.g. higher NOx due to hotter flame. Here an ambitious R&D programme that can build a competent understanding of these and other technical challenges is flagged as necessary – a requirement that's further extended both to investment in training programmes and to building an informed understanding of the site requirements for hydrogen fuel implementation. Referring to conversations with BOC the report advises that, as things stand, it would only be possible to commercially source suitable volumes of hydrogen to provide three-to-five percent fuel for a typical glass furnace. The report continues that for the present this would render any meaningful large-scale trial challenging, though suitable volumes may indeed be available in the future. Larger supplies of hydrogen would nonetheless be required to enable the glass sector to undertake meaningful large-scale trials.

LARGE-SCALE, 100 PERCENT ELECTRIC MELTING

The study identified that furnace designers are reasonably confident they can design larger-scale (>300 t/day) electric furnaces, despite such technical unknowns as how efficient a semi-hot top furnace might be. Owing to a lack of industry interest, little modelling -if any- of such designs has been undertaken – all of which should be the focus of short-term R&D efforts. Here the greatest barrier to implementation is centred upon electric melting economics (i.e. the higher cost of electricity as compared to that of natural gas). Uncertainties also remain around the scope/cost of supply upgrades to each UK site in order to facilitate full-electric melting, as well as the CAPEX investment required for new furnace designs or potential plant layout changes. Of course, for 100 percent electric melting to become viable across the UK, all suitable incentives and advance investment into national supply infrastructure will have necessitated significant prior engagement with government.

FLEXIBLE HYBRID-FUEL SCENARIOS

Beyond the natural gas-electric furnaces so widely-used, hybrid scenario possibilities have received scant attention. Dynamic fuel-switching systems too have been inadequately examined, as has the impact such systems might have upon the environment in terms of emissions or CCUS.

Within this scope, the following scenarios have been identified as having the greatest potential: (1) biofuels + natural gas + electric, (2) hydrogen + natural gas + electric, (3) biofuels + hydrogen + electric. Further R&D studies and furnace modelling are thus recommended to identify the most suitable hybrid furnace designs, which should then be worked up into pilot furnaces for larger-scale trials. The longer-term impact of a UK industry equipped with specialist knowledge in advanced furnace control could prove highly advantageous to both the economics of UK-based glass manufacture and to specialist, UK-based knowledge that can be exported globally.

BIO-METHANE

Although bio-methane was not covered within the study (owing to its being beyond the competition scope), it nonetheless represents a potential route towards decarbonising the glass manufacturing process, thus rendering it a worthy candidate for future studies.

CO2 REDUCTION POTENTIAL

The report concludes that the low-carbon fuel technologies under study have the potential to remove up to 1.2 million tonnes of CO2 emissions per year by 2030, which totals at over 20 million tonnes by 2050. However, without continued funding in this area the industry is unlikely to explore such fuel scenarios until after 2030. Besides, these new technologies are unlikely to be implemented widely until after 2040. Also, the need was identified to develop a research infrastructure as well as expertise within the UK that can support and drive rapid implementation of these low-carbon fuel technologies. Respecting the UK economy this would have a knock-on benefit in terms of creating new, high-skilled, jobs whilst leveraging significant international R&D investment.

It was further underscored that the glass industry should review the 2014 British Glass decarbonisation roadmap in order to update plans in accordance with the research findings - all to ensure that the industry is not only aware of the most promising decarbonised fuel technologies but also signed up to implement them.

NEW REPORT TIMELINE

Due to the successful funding of a GBP 7.1 million programme from 2020 to 2022, a report will be published with a major update on the above initial work carried out and this will be publicly available in summer of 2022, published by BEIS. This report will outline the success of some major industrial trials and a significant amount of laboratory work that has advance the knowledge and understanding of these low carbon fuels. ■