Circular Economy and Secondary Raw Materials in the Glass industry
Furnace Solutions
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Our origins date back to the beginning of the twentieth century when Professor W. E. S. Turner and other renowned glass experts formed a dedicated research department – the first academic institution of its kind.

Its success led to continued expansion and a worldwide reputation for excellence.

To this day we are still the leading experts in technical glass.

“Experts in glass”
Based in Sheffield in the UK.
More than 30 members of technical staff.
Over 400 years of collective experience in glass materials!

Expertise across:
- Glass manufacturing & processing;
- Development of new manufacturing process;
- Research & Development;
- Product design;
- Coatings development;
- Environmental services;

Strong links to academia and industry...
OUR UNIQUE PROPOSITION

R&D
- Grant funded R&D
- Commercially funded R&D
- Technical glass manufacture
- Supporting academic projects
- Supporting student development

Testing Services
- Analytical services
- Failure analysis
- Glass property measurements
- Performance testing
- Emissions monitoring
- Product verification
- Quality assessment

Consultancy
- Customer product development
- Specification development
- Site visits and inspections
- Training
OUR UNIQUE PROPOSITION

- Accredited Labs
- Onsite Melting Facilities
- Strong Understanding of Policy
- Cutting Edge Research in Glass
- Synergetic Expertise Across Glass
- Facilitate Collaboration
RESEARCH & DEVELOPMENT

MAINSTREAM
- Sustainability
- Process improvement
- Cost reduction

ENERGY
- Nuclear waste
- Oil & gas
- Carbon capture

PHOTONICS
- Laser gain material
- Optical components
- Laser processing

BIOMEDICAL
- Bioactive scaffold
- Antimicrobial glass
- Soluble agri-glass
Topics

- Why bother
- Background to Circular Economy and Industrial Symbiosis
- Some history
- Secondary raw materials in glass
- Practical experience in ash as a secondary raw material
- Industrial symbiosis in practice
- Where next
Why

- In 2015, The Paris Agreement set a target to reduce greenhouse gas emissions by at least 40% by 2030 and 80% by 2050 compared to 1990 levels.

- UK pledge to achieve NetZero by 2050

- For the UK’s industry emissions to fall by around 20% between 2015 and 2030.

- Commercial glass manufacture is a key sector that consumes 220TWh of energy and emits 50-60MT of CO$_2$ per year globally.

- The UK produces glass around 3.5 MT/yr. and emits 2.2MT of CO$_2$, using 4.5-7 TWh of energy at a cost of more than £70m.

- UK needs 4.1 UKs to support itself or 2.6 Earths to support itself

https://www.overshootday.org/how-many-earths-or-countries-do-we-need
The bulk materials in 2050 with Absolute Zero emissions

Most discussion of mitigation to date has focused on new energy infrastructure technologies - in particular carbon capture and storage, hydrogen as an energy vector and options for removing emissions from the atmosphere.

However, deployment rates are so slow that it is now certain that none of these ideas will be significant by 2030, and they are very unlikely to be contributing at significant scale for subsequent emissions reduction target dates.

The critical consequence for the supply-chains of the foundation industries, is that we must expect to be operating in 2050 with no cement and no blast-furnace steel, with steel and glass supplied only by recycling, and with plastics made only in electric processes.

Professor Julian Allwood explores potential growth opportunities in the Foundation Industries as a result of zero-emission sustainability
Initiatives/Efforts

- New energy infrastructure technologies: carbon capture and storage, hydrogen as energy vector and option for removing emissions from the atmosphere
- Low melting glass compositions
- Secondary raw materials
Circular Economy and Industrial Symbiosis

The circular economy vision and approach gives:

resource → waste

Take → Make → Dispose

https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy

Upcycling and Waste Hierarchy

Zero Waste Hierarchy

- Refuse/Rethink/Redesign
- Reduce and reuse
- Preparation for reuse
- Recycling/composting/anaerobic digestion
- Material and chemical recovery
- Residuals management
- Incineration

Refuse what we don’t need and change the way we produce and consume by redesigning business models, products, and packaging in order to reduce resource use and waste.

Minimise the quantity, toxicity and ecological footprint of consumption. Use products or components, that are not waste, for the same purpose for which they were conceived or repurpose them for another use that doesn’t reduce their value.

Check, clean or repair products or components of products that have become waste so that they can be re-used without any other pre-processing.

High quality material recovery from separately collected waste streams.

Technologies to recover materials from mixed waste and discard from sorting processes into new building blocks for high quality applications.

What cannot be recovered from mixed waste is biologically stabilised prior to landfilling.

Options that don’t allow for material recovery have high environmental impact and create lock-in effects that threaten the transition to Zero Waste: waste to energy incineration, co-incineration, plastic to fuel, landfilling of non-stabilised waste, gasification, pyrolysis, illegal dumping, open burning and littering.

https://zerowasteeurope.eu/2019/05/a-zero-waste-hierarchy-for-europe

British Glass
The next step - Resource Hierarchy

https://www.circulonline.co.uk/opinions/rethinking-waste-hierarchy
This is not a new concept...

Recycling:

- Glass
  - Evidence of organised glass recycling from the Roman Era

- Paper and Card
  - Japan ~1000AD paper recycling documented
  - 1600s Rittenhouse Mill Philadelphia used old rags to make paper

- Metals
  - Bronze coins and statues reused for weapons in Roman Times
  - Railings and pans to Spitfires WWII

- Textiles
  - 1800s “Shoddy Process” Rags to cloth 1860 7000T recycled wool per year

- 1897 Materials Recover Facility in New York

- 1904 Chicago First US can recycling plant

- Present day glass
  - Container glass routinely recycled to make new bottles
  - Blast furnace slag (Calumite) added to glass batches

Moving beyond cullet – the use of ash as a secondary raw material

- Saving raw materials
- Increasing recycled content
- Lowering energy use and Carbon emission

‘Secondary raw materials’ are recycled materials that can be used in manufacturing processes instead of, or alongside virgin raw materials.

“In a circular economy, wastes that can be recycled is injected back into the economy count as secondary raw materials.”
More information

RESEARCH ARTICLE | Open Access

Alternative raw material research for decarbonization of UK glass manufacture

Wei Deng, Daniel J. Backhouse, Feroz Kabir Kazi, Ronak Janani, Chris Holcroft, Marlin Magallanes, Martyn Marshall, Caroline M. Jackson, Paul A. Bingham

First published: 29 April 2023 | https://doi.org/10.1111/ijag.16637
What are the potential benefits/barriers?

Potential Benefits:
- Reduced land fill
- Reduced CO2
- Cost effective
- Good news story
- Energy reduction

Potential Barriers:
- Education and guidance
- Legislation and regulation
- Methodology and technology
- Location and infrastructure
- Economics
- Quality and standards
Historical use of Ashes as Glass Making Raw Materials

Christopher Merrett’s 1662 translation of Neri’s Art of Glassmaking contains a discussion of the raw material used, in which he states that,

‘For green-glasses in England, they buy all sorts of ashes, confused with one another [...] but the best and strongest of all English ashes, are made of the common way thistle’.

Merrett goes on to list an almost bewildering array of suitable plant ashes which includes hops, bramble, hawthorn and even tobacco.
**Enviroglass 1 (2017)**

- A general research on biomass ash, rice husk, seashell, eggshell etc. as alternative glass raw materials.
- Exploratory reformulation researches on Soda-Lime-Silica glass were delivered.

**Enviroglass 2 & BioMash projects (2018 - 2020)**

- Project focusing specifically on developing ash-based raw materials for container glass.

**EnviroAsh (2020 - 2021)**

- Expands upon an established consortium, to increase the range of wastes to be investigated and the final products that can benefit from these materials.
- Develop new Secondary Raw Materials across the foundation industries (glass, ceramic and cement).
- Working with paper, metals, chemicals and others to investigate their waste streams.
Enviroglass 2 & Biomash Projects

- Biomass-powerplant Feedstock
- Ash + Standard Batch Materials
- Lab Scale Melting
- Pilot Scale Pot Furnace Trials
- Glass produced for testing and analysis
Analysis of Ashes

- Over 23 biomass-powerplant ashes analysed:
  - Range of fuel types
  - Range of combustion configurations
- Fly Ashes:
  - Higher in Alkali (Na, K) and Calcium
  - Higher in Chlorine and Sulphates
- Bottom Ashes:
  - Still contain significant levels of Alkalis and Calcium
  - Higher in transition metals
  - Higher in carbon (often variable), some of which is unburnt fuel
- All ashes show a variability in composition over time, but not as much as expected
Pilot scale pot furnace trial (50 Kg) - Glass recipes containing ash (10wt.%), low melting point glasses (July 2020)

No Negative impact on emissions or refractory

The characterisation of the glass samples showed that the desired chemical and thermal properties could be achieved using additions of ash

Using these new raw materials will, in fact, have significant environmental benefits. It will reduce energy requirements by up to 5%, with associated energy and carbon emission savings, and reduce UK-landfill by up to 75kT/yr
Ash for Energy

Engineer new batches with lower melting temperatures

Increase the total $R_2O$ flux

Mixed Alkali Effect

Decrease the melting temperatures by 50-100°C
Initial Cost and CO₂ modelling exercise

1. £7-8 increase in raw material cost
2. 6% reduction in energy use
3. 2-3% reduction in CO₂ emission

Overall ~£7 saving per tonne of glass after accounting for increased raw material costs at +10% ash addition
True Industrial Symbiosis - EnviroAsh

New raw materials that can not only substitute existing raw materials but provide cost effective routes to reduce environmental impact within glass, ceramic and cement manufacture.

To increase the range of wastes to be investigated and the final products that can benefit from these materials.
The EnviroAsh Model

- Ceramic
- Paper Ash
- Cement
- Biomass Ash
- Glass
- Slate tailings
Conclusions

Emission results showed no noticeable differences between the batches containing ash compared to those without ash.

Characterisation of the glass samples have been done, focusing on the chemical composition, colour analysis and thermal properties.

Results show desired glass chemical and thermal properties can be achieved using additions of ash.

Breakeven or positive economics.

Chemistry
Iron
Chlorides
Organics and unburnt carbon

Particle size, not too fine

Consistency of raw material

Regulation and end of waste

Availability of sufficient material & demand from other markets
Where Next

• Technical feasibility proven at small pilot scale
• Confidential development work with industrial partners
  • Upscale of beneficiation processes
  • Standardisation and consistency
• Economic and regulatory development
• Continued cross sector work to identify high value and upcycled industrial symbiosis partnerships.
• Adding value beyond raw material substitution
• Industrial adoption in 1-2 years
Thanks to our partners

Questions?

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