“Challenges and opportunities for the UK Castings Industry – can castings be part of the solution for the transition to net zero?”

Dr P Murrell FICME
www.castmetalsfederation.com

- About the casting and foundry industry in the UK
- Key challenges
- Why energy matters to foundries
- Global competition
- Summary and recommendations

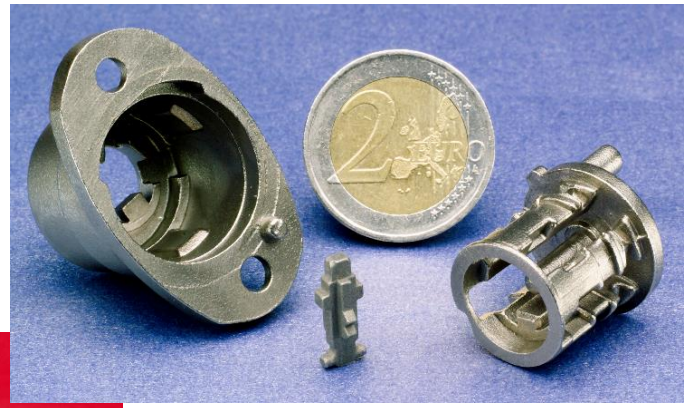
BEST OF BRITISH CASTING

Casting as a Route to Manufacture.

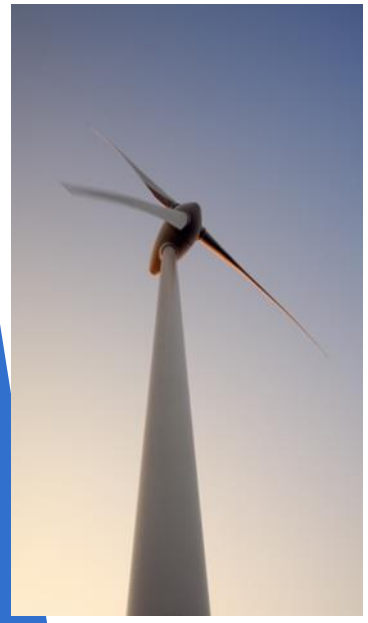
Casting still represents the most cost-effective way of producing a wide range of components in metal, and is the simplest forming method for metal parts.

Near Net-Shape Manufacturing.

Casting represents the only way to make some components with complex internal cavities and hollow channels.



Applications of castings



Casting as a Route to Manufacture

Casting Case Study - Cobalt Alloy Valve Cage

Utilising new integrated additive manufacturing and investment casting facilities, William Cook Cast Products has produced a complex valve cage casting made of cobalt-based alloy that is notoriously demanding to produce. The valve cage can withstand corrosion and erosion in an aggressive chemical environment and previously thought to be 'uncastable'.

Component – Valve cage, net weight 70kg (finished conditions, 220kg (as-cast)

Alloy – Cobalt alloy 6B

Customer Requirements – Good as-cast form and finish- with no weld repair - good surface finish

Previous part – several stacked, laminated plates, machined to profile to form individual layers.

Outcome – The conversion to a casting enables the customer to be able to take advantage of;

- Lower overall cost, Unconstrained design i.e. design for purpose not design for manufacture, reduced lead-time and freedom of alloy choice

Challenges

- Complications arising from the size and complexity of the casting with thick sections adjacent to the thin sections.
- Cobalt alloy 6B is a notoriously demanding alloy to produce
- Consideration had to be given during methoding to minimise the potential for high residual stresses during cooling.

See more examples at : www.castmetalsfederation.com/case-studies

Casting Case Study - Cast Prosthetic Multi-Part Cast Thumb for use by Children

Brand new design for multi-part thumb designed by renowned prosthetic hand designer Ted Varley, for use by children who have lost a hand due to injury, congenital conditions, or for other medical reasons, enhancing their quality of life and enabling them to regain confidence and their independence.

Investment casting by Sylatech Ltd – North Yorkshire.

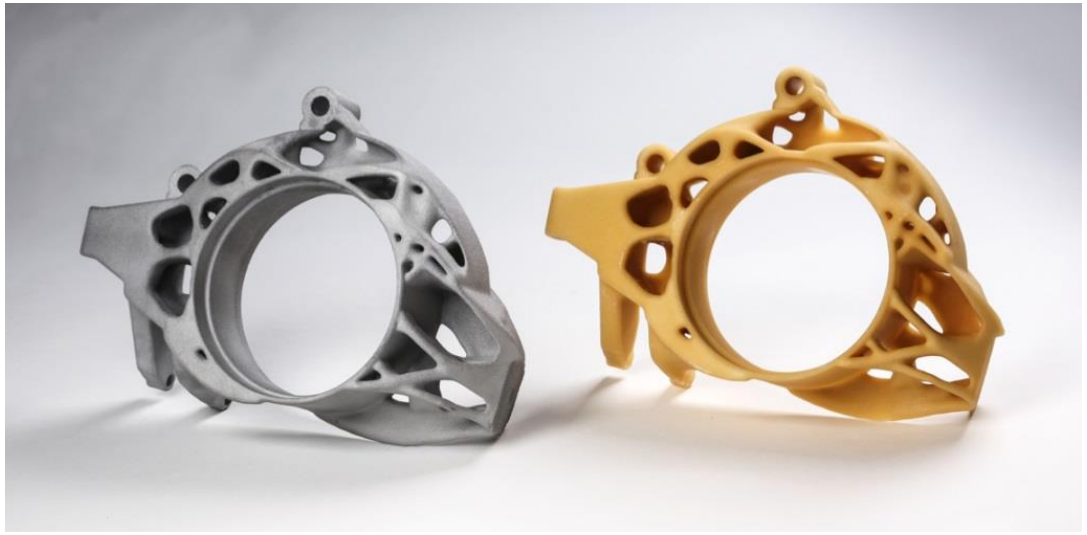
- High level of detail and as-cast surface finish required requiring no machining
- Minimisation of casting weight and maximising internal space for electronics
- Wall thickness down to 2mm for some cast elements and 1mm diameter cast-in holes.
- Design flexibility enabled through use of 3D wax printing
- Samples provided to client with a lead time of just 3 weeks including heat treatment.
- Significant cost savings achieved compared with alternative production processes.
- New design has attracted NHS funding to enable further versions aimed at children.

The company is now looking at further even smaller, lighter designs and are delighted that their castings are changing lives for the better.

Casting Case Study

Wheel upright investment casting

Working in conjunction with a 3D printing specialist, a foundry has turned an expensive to produce, complex part into an investment casting able to benefit from the economies of mass production.



Customer Requirements – Reduced weight and reduced cost - ability to withstand direct and fatigue loading

Previous Part – Costly via direct metal laser sintering (DMLS) process

Outcome – The conversion from a DMLS printed part to an investment casting means:

- The part is four times stiffer than the original design
- The part is capable of mass production
- The cost and weight is reduced
- Performance characteristics are maintained and indeed exceeded!

Challenges – Complex part, previously unable to cast

Method – Production begins with creating a 3D printed model in PMMA

By utilising the 3D process the mould could be produced in large numbers enabling the component to move to the much cheaper investment process and 3D printed patterns enable the creation of a casting that exceeds previous traditional design restrictions.

Casting as a Route to Manufacture

Range of Materials & Properties:

Aluminium

Copper Base Alloys

Zinc

Magnesium

Titanium

Steel

Irons

Casting as a Route to Manufacture

The Casting Process

- **Ancient** – *dating back to c. 6000 BC*
- **Successful** – *Still used for many thousands of products, an expanding range today*
- **Versatile** – *can create essentially any shape*
- **Fundamental** – *all other metal shaping processes begin with a cast product*
- **Ingenious** – *over 90 different casting processes have been identified*

"Castings are not a commodity – they are complex products and need experience and knowledge to produce"

Dr Wolfgang Hiller of Buderus Guss (after his move from the electronics industry, pub FTJ Dec 2014)

Casting as a Route to Manufacture

- **Range of Processes**
- Sand Casting
- Die Casting (Gravity, Low Pressure & High Pressure)
- Investment Casting (Lost Wax)

- Newer processes including thixoforming, rheocasting, and some rapid prototyping methods

Common Casting Processes - Sand

Mould made from sand and a binding agent.

A wooden, resin, or metal pattern is used – a replica of the casting to be made, with allowances for thermal contraction, taper, and stock to be removed by machining.

Pattern is withdrawn to leave a cavity in the mould

Channels are cut through the mould to allow liquid metal to enter (the running system), and to form reservoirs of liquid metal to offset shrinkage

Cores are inserted into the mould cavity to form holes in the casting

Filters, mould washes etc are applied for certain applications

Common Casting Processes – High Pressure Diecasting

- Hardened Tool Steel Die (Expensive!)
- Highly automated
- Thin wall sections, excellent surface finish

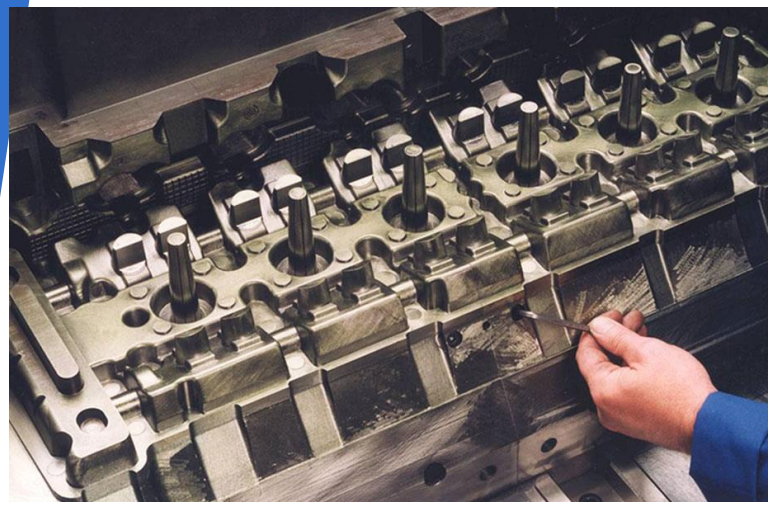
Common Casting Processes – Investment (Lost Wax) Casting

- Wax pattern / replica of the part is produced, by injection moulding. Complex shapes can be built up.
- Wax is ‘invested’ into a ceramic shell, built up of several layers
- Wax is melted out, and shell is fired
- Molten metal then cast into shell
- Shell is broken away to remove finished component.

Who works in the industry?

Job roles include:

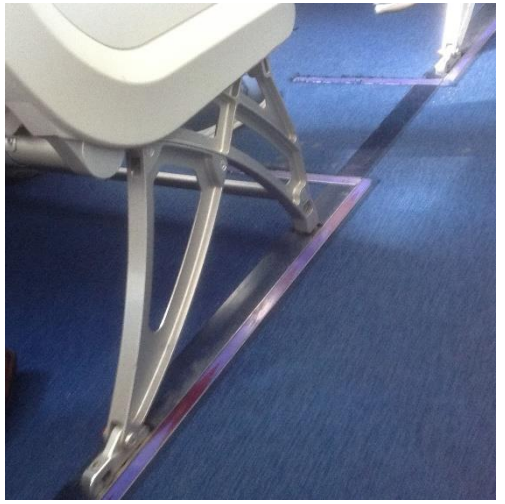
Metallurgists
Design / Simulation
Quality and Inspection
Laboratory - testing, NDT…
Moulders & coremakers
Sand technicians
Melter / caster / furnaceman
Patternmakers
Toolmakers
Machining, maintenance
Project management, sales, marketing, accounts……



Global Castings Industry

Global Production in 2021

China	54.3 Mt	
USA	?	46.3 Bn dollars in sales in 2022
India	12.5 Mt	
Japan	4.6 Mt	
Germany	3.95 Mt	
Turkey	2.96 Mt	
Mexico	2.86 Mt (2020 data)	
S Korea	2.39 Mt	
Russia	2.2 Mt (2019 data)	
Brazil	2.1 Mt	
UK	0.5 Mt	



(Source: Modern Castings, AFS, Pub Jan 2023)

Industry Trends

- More challenging materials
- More challenging applications
- Larger castings – more use of castings for structural parts
- Greater automation
- Increased use of technology
- Increased productivity
- Right first time
- Faster turnaround
- More prototyping
- More innovation
- Greater sustainability & resource efficiency
- Increased environmental controls

https://char.gy/about

Where the Castings Industry uses AM:

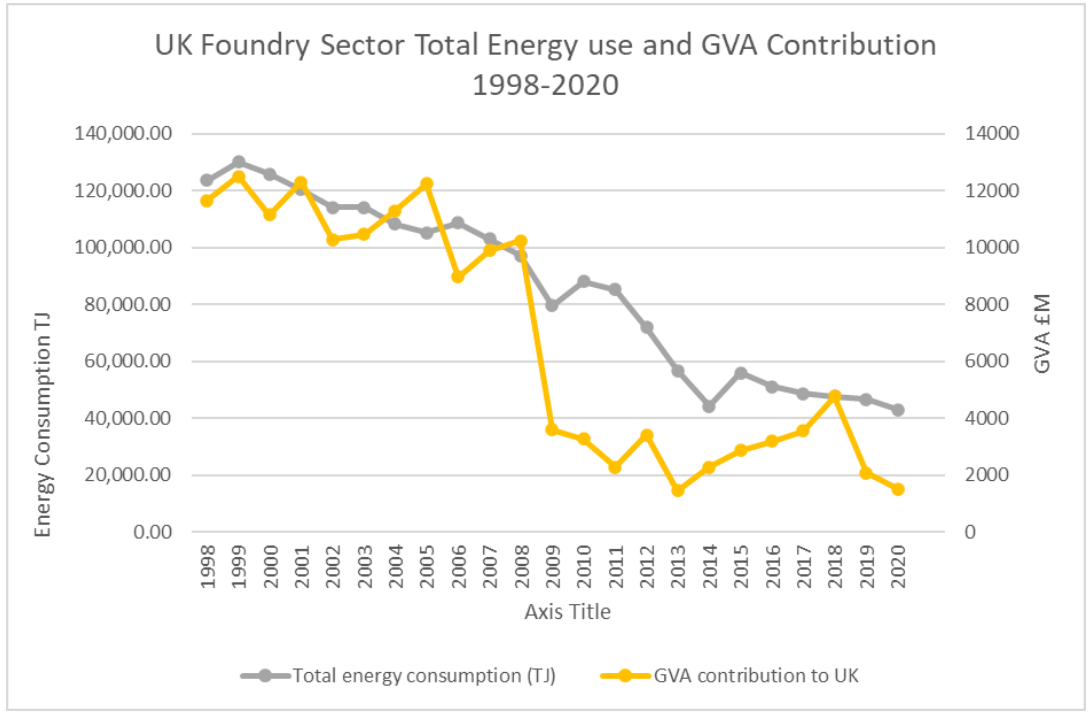
Rapid prototyping / small series production

- Printing patterns and tooling - PMMMA
- Printing sand moulds and cores – sand printing
- Printing parts of moulds/cores – sand printing
- Printing jigs and fixtures for measuring /machining – resins?/pmmma
- Printing replacement parts for metal dies – metal printing
- Resurfacing dies using additive layer technologies
- Large-scale printing with recyclable printing medium, to reduce need for pattern storage (Weir Minerals project with the MTC).

Opportunity for the castings industry

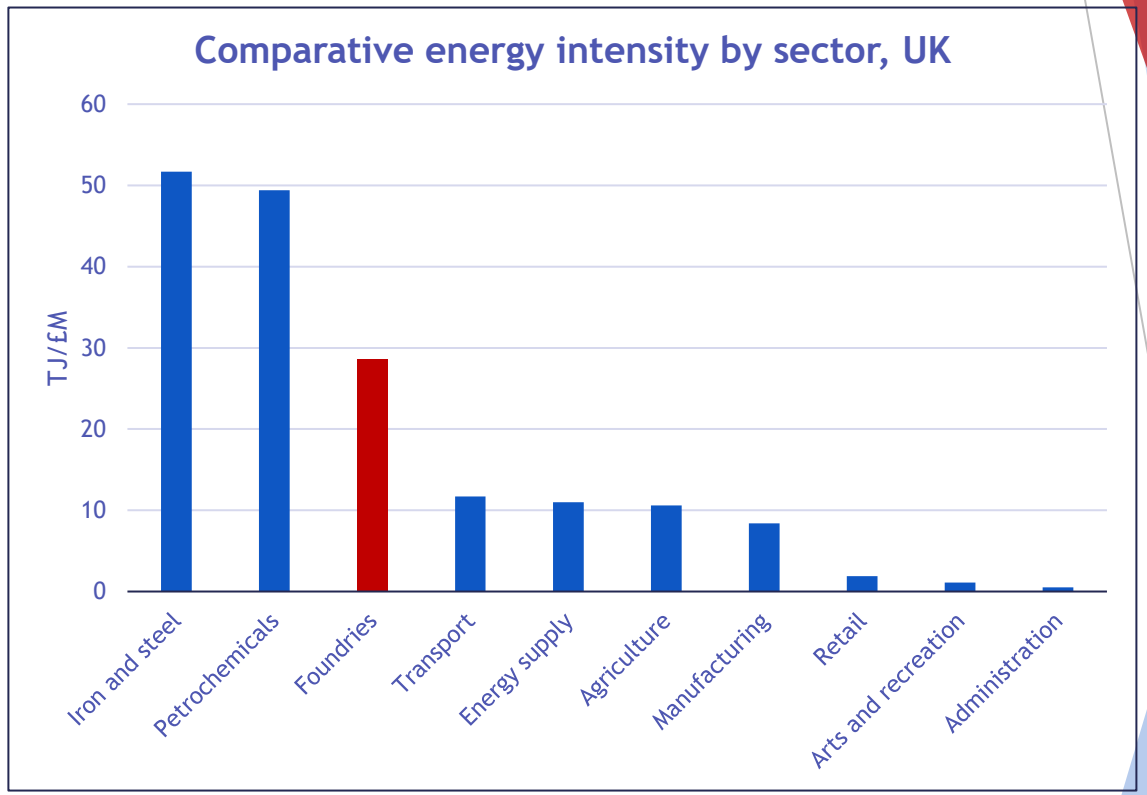
About the UK Industry

- 350 foundries, across the UK
- A strategic and ‘sovereign’ industry for the country
- Medium sized businesses
- Around 23000 jobs
- £2bn GVA (but down from £12bn in 2000)
- Emissions reduction as a side-effect of lost jobs, reduced national and regional wealth and economic resilience.



Industry Trends

- Foundries are ten times more energy intense than office-based businesses and energy can easily account for 20% of turnover
- UK industrial energy prices are sometimes more than three times those of global competitors
- Competitor economies are using decarbonisation to protect their industry



Source: ONS 2023

Some of the recent challenges

Transport delays, increased paperwork for exporting/importing, increased costs and shortage of some key raw materials – eg esters, base oils, steel scrap, Al ingot…..

Impact of COVID-19 on key markets and supply chains.

Castings industry was deemed 'critical' so work continued throughout 2020 and 2021

Build Back Better: UK Govt "plan for growth' sets out plans to support growth through significant investment in infrastructure, skills and innovation, and to pursue growth that levels up every part of the UK, enables the transition to net zero, and supports our vision for Global Britain."
Pub: March 2021

Grand Challenges

- **Artificial Intelligence and data**
- **Ageing society**
- **Clean growth**
- **Future of mobility**

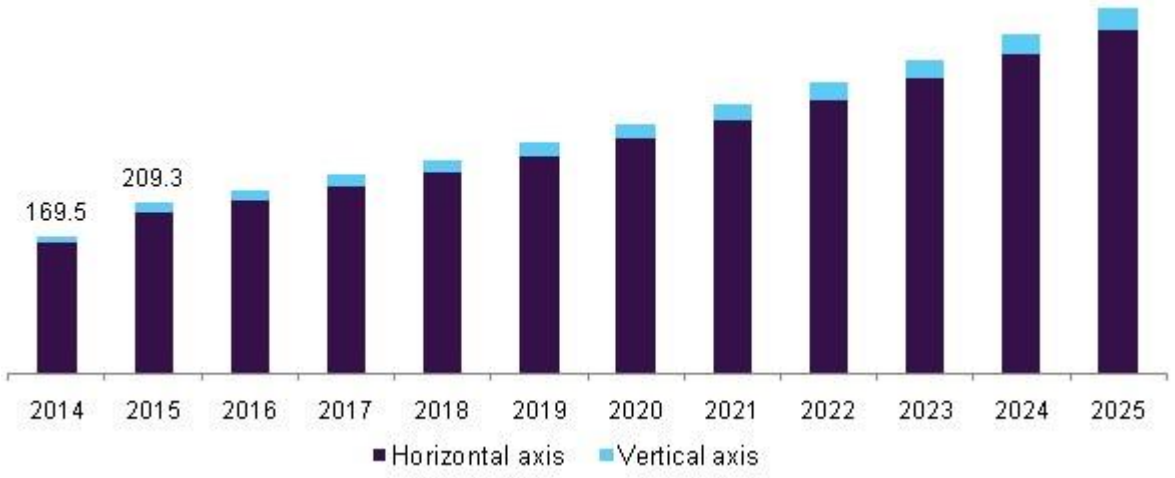
Net Zero Strategy – build back greener,
Pub Oct 2021

CAST METALS FEDERATION

Why Casting - New Opportunities

F4OR
Fit For Offshore Renewables

https://ore.catapult.org.uk/what-we-do/supply-chain-growth/f4or/



U.S. wind turbine casting market by type, 2014 - 2025 (USD Million)

https://www.grandviewresearch.com/industry-analysis/wind-turbine-casting-market

Some more of the ‘Good’

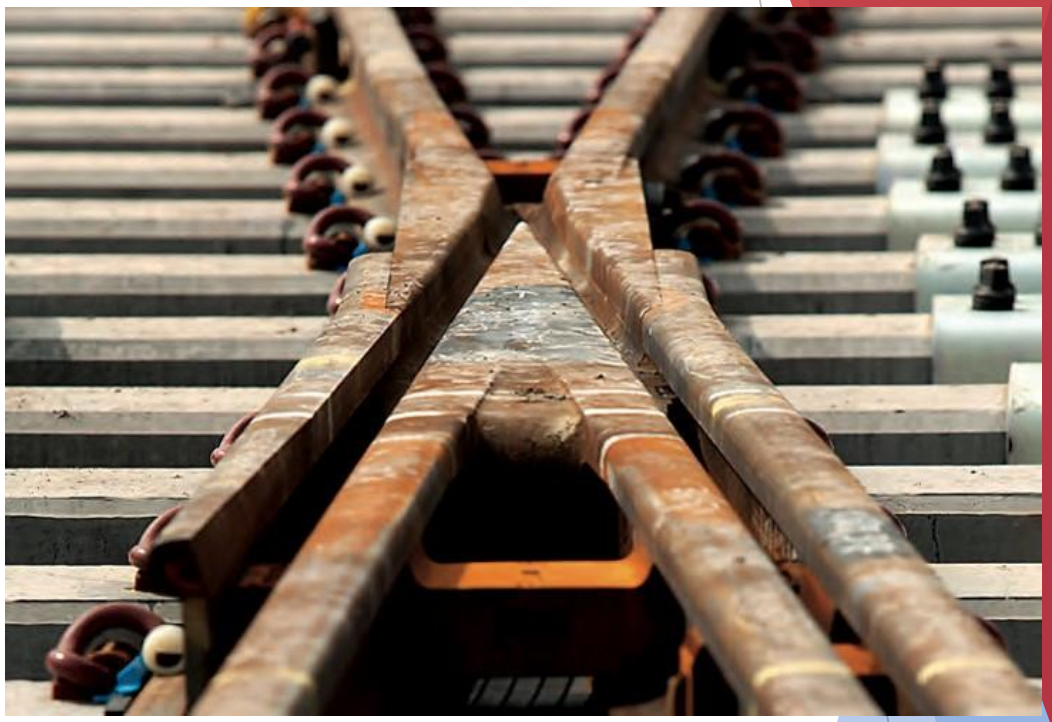
Sustainability – castings as part of the circular economy

The industry takes scrap metal and turns it into new components for the high value manufacturing supply chain – embedded carbon, less transport (global shipping)

METAL recycles forever™

https://www.metalrecyclesforever.eu/

Some of the Good

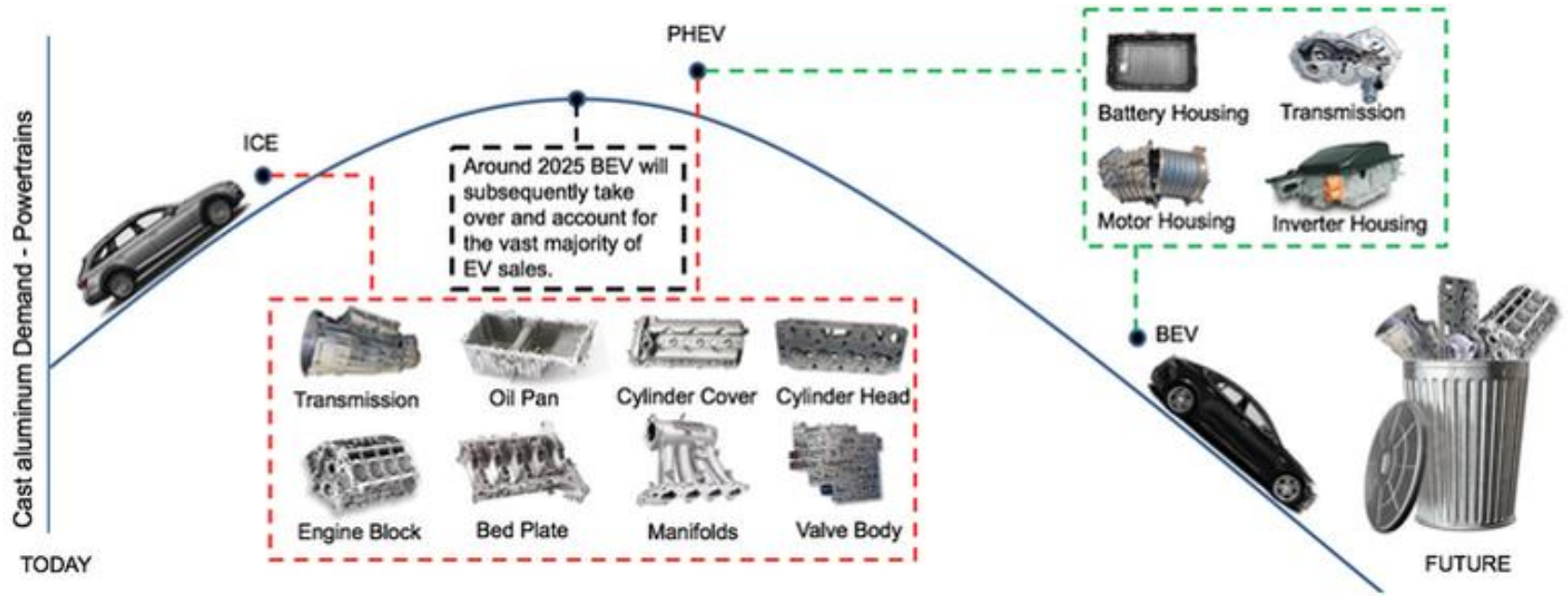


Progress Rail – South Queensferry

Source: https://www.progressrail.com/en/Segments/GlobalLocations/Europe/Foundry.html

Some of the Good

https://www.foundrymag.com/issues-and-ideas/media-gallery/21931800/electric-vehicles-and-the-prospects-for-aluminum-casting/slideshow?slide=3



GIGA Press - Tesla is now operating what is believed to be the “world’s largest casting machine” at its Fremont factory.

The electric SUV’s rear underbody is built with only two cast parts, compared to 70 parts for the Model 3.

Shots of molten aluminium weighing 80 kilograms are injected into the cold-chamber casting mould with a velocity of 10 metres per second. The cycle time is ~80–90 seconds, allowing an output rate of 40–45 completed castings per hour, or ~1,000 castings per day. (*https://en.wikipedia.org/wiki/Giga_Press*)

Management of Wastes

- Used foundry sand and refractory shell as well as metallurgical slags and extraction dusts.
- Landfill: increasing costs, reducing availability
- Beneficial re-use – in construction for instance, but there are significant barriers – cost, no incentive for users, transport/ location of waste, variability of product and legislation around ‘waste’.

Next few years for the UK foundry /casting industry

Increase diversity.

Health and safety focus.

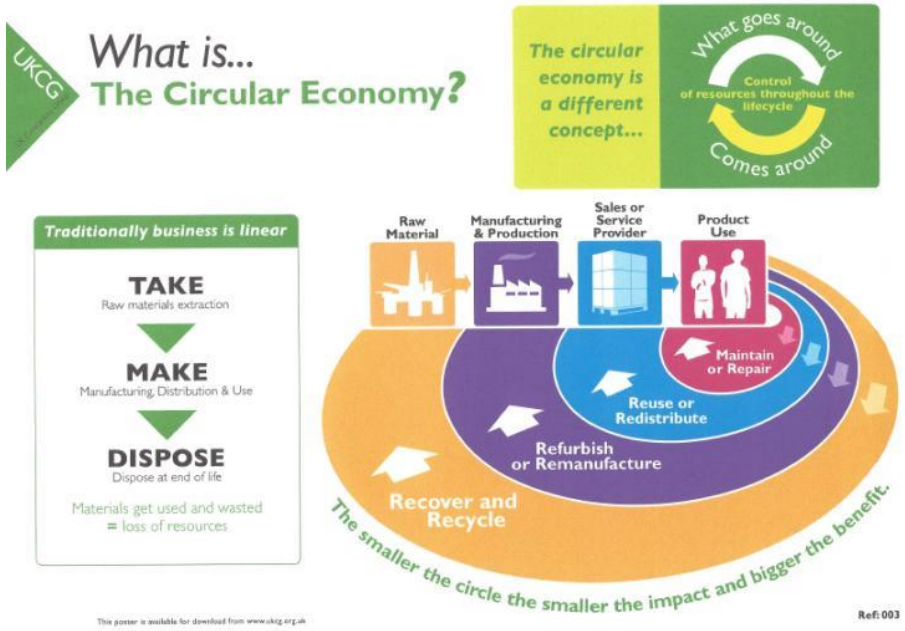
Increased use of automation and robotics to increase productivity.

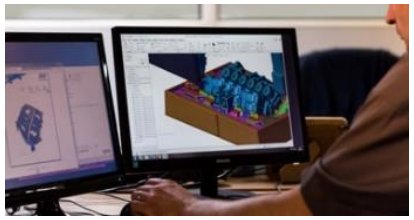
Generate a positive image – and then communicate it

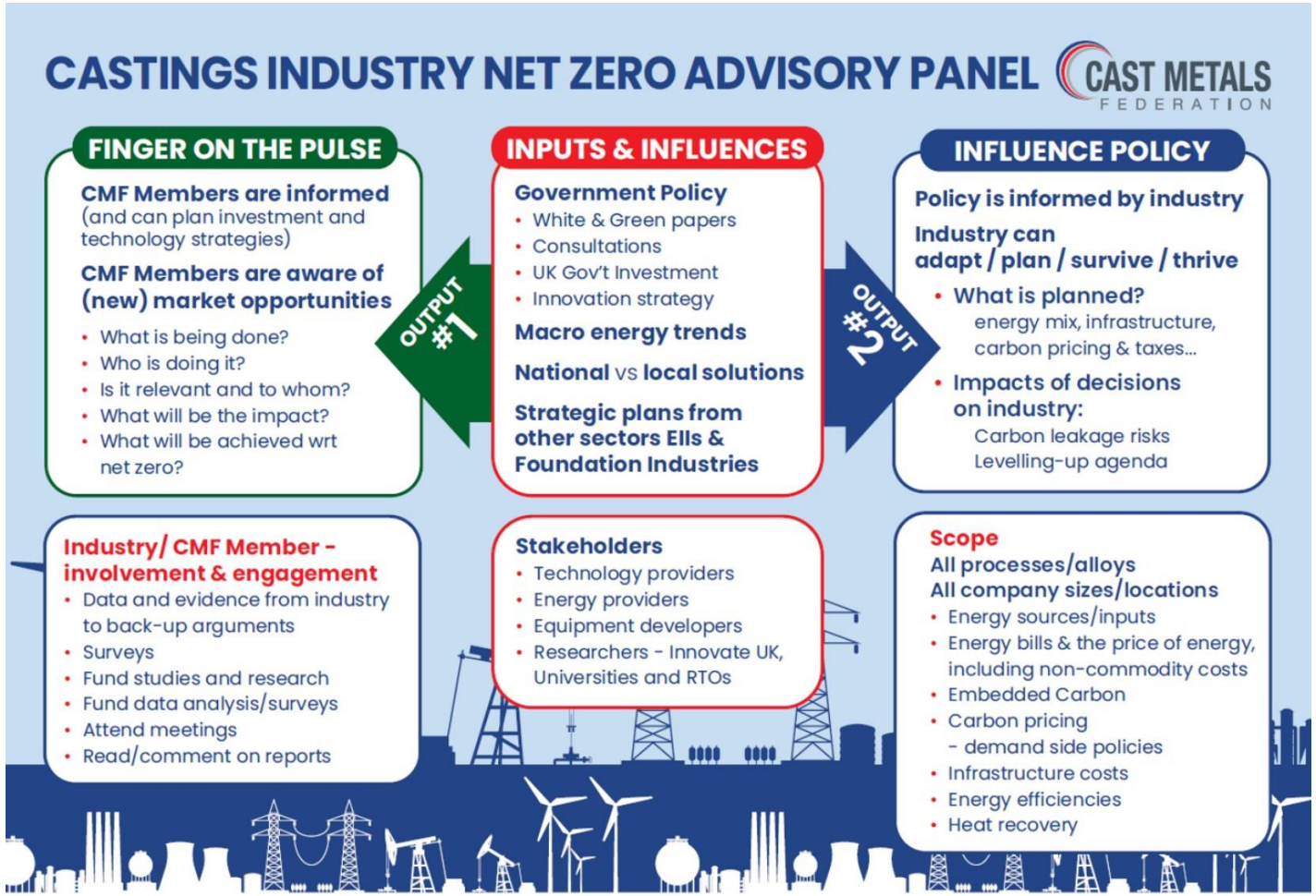
Good jobs - well-paid careers with leadership opportunities

Focus on contribution / relevance to modern society:

- Circular Economy - re-cycling & re-use of scrap metal
- Public procurement – local sourcing
- Avoiding carbon leakage, energy efficiency….
- Competitiveness - levelling up, jobs.






CASTINGS INDUSTRY NET ZERO ADVISORY PANEL
CAST METALS FEDERATION
FINGER ON THE PULSE
CMF Members are informed (and can plan investment and technology strategies)
CMF Members are aware of (new) market opportunities
• What is being done?
• Who is doing it?
• Is it relevant and to whom?
• What will be the impact?
• What will be achieved wrt net zero?
OUTPUT #1
INPUTS & INFLUENCES
Government Policy
• White & Green papers
• Consultations
• UK Gov't Investment
• Innovation strategy
Macro energy trends
National vs local solutions
Strategic plans from other sectors EIIs & Foundation Industries
OUTPUT #2
INFLUENCE POLICY
Policy is informed by industry
Industry can adapt / plan / survive / thrive
• What is planned? energy mix, infrastructure, carbon pricing & taxes...
• Impacts of decisions on industry: Carbon leakage risks Levelling-up agenda
Industry/ CMF Member - involvement & engagement
• Data and evidence from industry to back-up arguments
• Surveys
• Fund studies and research
• Fund data analysis/surveys
• Attend meetings
• Read/comment on reports
Stakeholders
• Technology providers
• Energy providers
• Equipment developers
• Researchers - Innovate UK, Universities and RTOs
Scope
All processes/alloys
All company sizes/locations
• Energy sources/inputs
• Energy bills & the price of energy, including non-commodity costs
• Embedded Carbon
• Carbon pricing - demand side policies
• Infrastructure costs
• Energy efficiencies
• Heat recovery

Does the UK Value Manufacturing?

- Annual output worth £191 billion to the economy overall
- Exports to EU more than double the value of those to the US
- Manufacturing still in the driving seat when it comes to exports and R&D
- World's 10th largest exporter and 7th largest for trade
- Average pay in manufacturing remains significantly higher than services and economy overall
- UK remains in top ten manufacturing nations at ninth place.

Source: https://www.makeuk.org/insights/publications/uk-manufacturing-the-facts-2020-21

"..the UK manufacturing sector supported a total GDP contribution of £446 billion—equivalent to 23 percent of the UK's total economy."
"… UK manufacturing sector supported a total of 7.4 million jobs in 2016, equivalent to 21 percent of the UK total"

Source: https://www.mta.org.uk/system/files/resource/downloads/20180405%20MTA%20report%20-%20final%20v2.pdf

INDUSTRIAL STRATEGY

Industrial Strategy launched – then withdrawn …..

COVID-19 legacy around National resilience – strategic importance of local supply chains and security of supply for national infrastructure?

Powering our Net Zero Future - Energy White Paper, Pub Dec 2020 (CP 337):

Create a sustainable future for UK manufacturing industry through improved energy efficiency and the adoption of clean energy technologies.

Establish the UK as a world leader in the deployment of CCUS and clean hydrogen, supporting up to 60,000 jobs by 2030.

Ensure that the transformation of our industrial sectors supports jobs, higher skills and new business opportunities across the country

Introduce a UK Emissions Trading Scheme which will be the world's first net zero emissions trading scheme, and will underpin the decarbonisation of energy in the UK

"By 2050, emissions from industry will need to fall by around 90 per cent from today's levels."

Net Zero Strategy – Build Back Greener. pub Oct 2021 (CP 337)

This strategy builds on [the 10 point plan for a green industrial revolution] approach to keep us on track for UK carbon budgets, our 2030 Nationally Determined Contribution, and net zero by 2050. It includes:

- **our decarbonisation pathways to net zero by 2050, including illustrative scenarios**
- **policies and proposals to reduce emissions for each sector**
- **cross-cutting action to support the transition**

Use the transition as part of a wider levelling up strategy, via an integrated strategic approach to Build Back Better (read build back greener) – and avoid carbon leakage*.

- Carbon Capture Utilization and Storage
- Clean Hydrogen
- UK Emissions Trading Scheme

** "Carbon leakage refers to the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints. This could lead to an increase in their total emissions".*

Source: https://ec.europa.eu/clima/policies/ets/allowances/leakage_en#:~:text=Carbon%20leakage%20refers%20to%20the,increase%20in%20their%20total%20emissions

Transforming Foundation Industries (TFI) Challenge

"This challenge will transform the UK's Foundation Industries so that they are internationally competitive in manufacturing products vital for our economy in an environmentally sustainable way." – UKRI.

Foundation Industries – **metals**, ceramics, bulk chemicals, glass, paper and cement.

TFI Network+ - £2M mainly aimed around cooperation between academic community

Transforming Foundation **I**ndustries **Re**search and Innovation Hub - fund a new cross-sector and multidisciplinary research centre to accelerate the development and adoption of new technologies and business models within the Foundation Industries – **TransFIRe** - led by Cranfield.

https://www.cranfield.ac.uk/press/news-2021/cranfield-to-lead-foundation-industries-green-recovery-research-consortium
https://gtr.ukri.org/projects?ref=EP%2FV054627%2F1

Net Zero Challenge

- Cost of energy – energy unit costs – energy is already higher for businesses in the UK
- Carbon accounting, pricing and taxes - CBAM
- Grid & infrastructure connection costs is a barrier to carbon reduction projects
- Price volatility
- Investment risk
- Fuel switching – natural gas to other (hydrogen, bio fuels….)

But

Castings industry already contributes through its re-use of secondary raw materials, eg ferrous scrap, secondary aluminium (value in embedded carbon).

Ferrous sector has already electrified – so efficient and relatively easy to be 'green' (?)

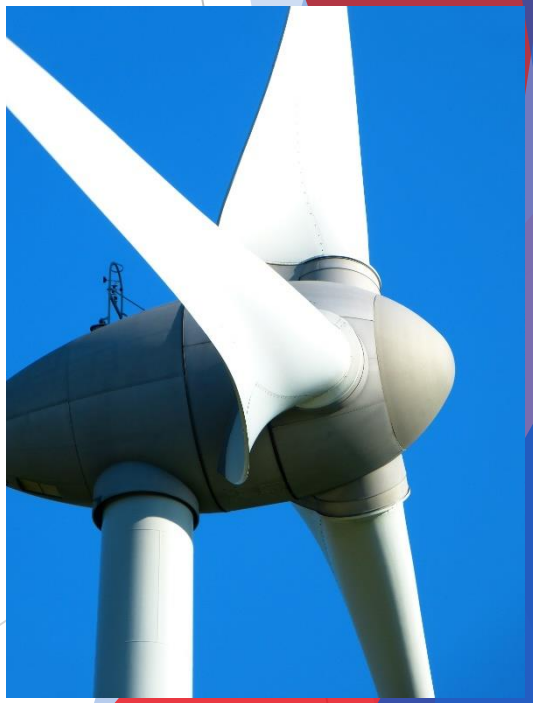
Non-ferrous sector still heavily reliant on natural gas.

Need to avoid carbon leakage.

Net Zero as an Opportunity?

Castings as lower carbon products -

- **What we make as an industry**
- **Who we supply as an industry**
- **How we make it**



Make it sustainably.

Make it locally, to reduce global transport.

Consider jobs, skills and income for the UK - levelling up.
Consider sovereign security and resilience.

The right thing to do.

Picture credit – Dreamstime ref 93949503

Who am I?

CEO of the **Cast Metals Federation**

Degree in Metallurgy – BSc Hons, then PhD in Fatigue & Fracture at Cranfield University

CMF is the Trade Association for the UK Castings Industry: representing and supporting foundries in the UK.

- Our Members are companies in the UK castings industry - Foundries and some suppliers.
- 85% of UK production in membership.

Chair - IS0 TC 25 - cast irons and pig irons.

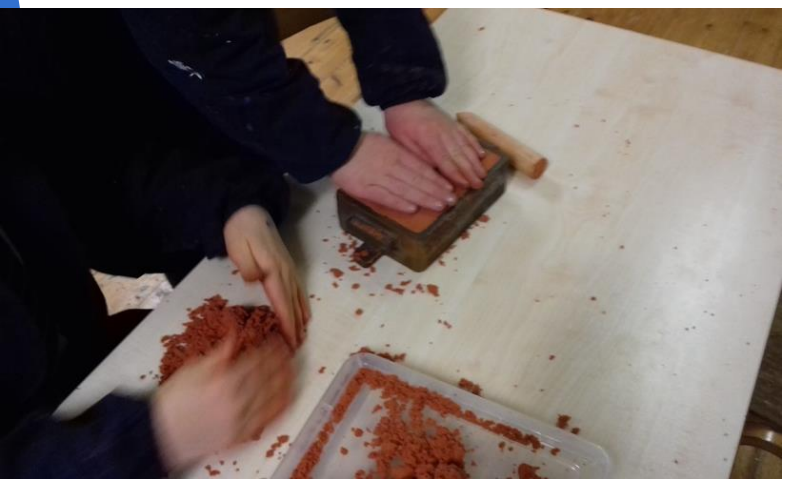
Chair of World Foundry Organisation Working group on Training & Professional Development.

Last 20 years spent in industry associations with a particular focus on skills and people development

Next few years will be spent on:

- Competitiveness & innovation;
- Skills & diversity;
- Sustainability & net zero.

CAST METALS FEDERATION



CASTING THE FUTURE

Casting the Future Foundry Kit

Transportable ‘Foundry in a Box’ kit for use in schools, with teacher pack.

New website to support with downloadable resources and VR experience

https://castingthefuture.com

Where to find out more:

Cast Metals Federation: www.castmetalsfederation.com

Casting the Future – CMF Videos

- Casting the Future - the role of metals (and foundries)
- Casting the Future Foundry kit – for use in schools and colleges
- Net Zero Webinar, Apprenticeships…. and more.

https://www.youtube.com/@CastingtheFuture/playlists

Thank-you

Any questions?