FIVE

Regulation and Innovation

Understanding the regulatory opportunities and barriers to innovation in the Foundation Industries

Contents

AMION CONSULTING

Civikas.

1 Introduction

1.1 Overview

FIVe commissioned AMION and CIVIKAS to undertake a research project into the regulatory barriers to innovation within the Foundation Industries. This will support FIVengage's future activities and will provide research-based insights to support future interventions or activities.
The primary objective of this research is to gain a deeper understanding of the nature of regulatory barriers that impact innovation in the Foundation Industries. By identifying these barriers, the research will identify interventions that can make a positive difference to regulatory processes and facilitate innovation. This research will also contribute to the body of knowledge on regulatory science, providing valuable insights that can influence future policy and regulatory frameworks.

1.1.1 FIVengage

FIVengage is dedicated to advancing regulatory science and promoting innovation through strategic collaborations with partners. These collaborations aim to develop research that aligns with regulatory standards while accelerating the innovation process. This partnership approach leverages collective resources and expertise to establish robust regulatory frameworks that support and expedite scientific and technological advancements. The pillars of FIVengage are:

Collaboration: To work with partners to develop research to deliver regulatory science that will accelerate innovation.

Education: Identify the training required to up-skill the innovation value chain and deliver targeted training as a valued education partner.

Communication: Build a trusted network to influence policy through the publication of research and innovator-informed evidence.

1.1.2 The Foundation Industries

The Foundation Industries comprising cement, metals, chemicals, ceramics, paper and glass, share both similarities and differences in their innovation and regulatory processes. While they all contribute significantly to the UK economy, each sector faces unique regulatory challenges and innovation dynamics. Over a third of businesses in these sectors have not introduced any innovations in the past three years[1], indicating a significant hesitance to adopt new technologies and processes. This reluctance stems from various factors, including regulatory hurdles, high compliance costs and inconsistent regulations which affect each industry at different parts of the innovation lifecycle. Whilst each sector faces its own specific regulatory challenges, many issues are common across all industries. Addressing these cross-cutting regulatory barriers is crucial for fostering a more conducive environment for innovation. By understanding and overcoming these obstacles, the Foundation Industries can enhance their competitiveness, support the UK's economic goals and contribute more effectively to the nation's innovation landscape.

1.1.3 UKRI Regulatory Science & Innovation Network Funding

This project has been funded through the Regulatory Science and Innovation Network competition delivered by Innovate UK as part of UKRI. It aims to develop proposals for virtual networks of expertise in regulatory science, which will generate research-based evidence and insights.

1 https://www.enterpriseresearch.ac.uk/wp-content/uploads/2021/02/ERC-Report-Innovation-Readiness-in-UK-Foundation-Industries.pdf

Regulatory science focuses on developing new tools and approaches to enhance regulatory decision-making throughout product lifecycles, such as approvals, ongoing safety and performance monitoring. By fostering collaboration, this investment seeks to promote innovation through the development of policies that enable agile and proportionate regulation. This report is part of the 'Discovery Phase' of an Innovate UK competition. The competition is divided into two phases:

Discovery Phase: During this initial phase, collaborations of UK-based organisations can apply for grant funding of up to £50,000 to build relationships, gather background information and data and develop a detailed proposal for the Implementation Phase. Innovate UK will fund up to 30 initial collaborative innovation projects, fully covering the total project costs.

Implementation Phase: Only successful applicants from the Discovery Phase will be invited to apply for the Implementation phase. In this subsequent phase, the focus will shift to executing the developed proposals, creating and deploying new tools, data sets and approaches that will contribute to regulatory decision-making and policy development. A proposal for the implementation phase has now been submitted.

1.2 Our approach

To inform this research report, a series of primary research activities, including three workshops and separate stakeholder consultations, was conducted. An initial workshop explored the extent to which regulatory barriers hinder organisational ambitions, innovation and progress to support the network, while a second and third workshop identified further priorities and examined potential steps to address these barriers. The primary research examined existing regulatory frameworks and their impact on innovation across various sectors. The methodology also encompassed a literature review of existing studies and reports on regulatory barriers to innovation which complemented the primary research.

1.3 Report structure

This report is structure as follows:

Section 2. A broad review of the literature provides the basis for the development of a framework for assessing regulatory issues in the Foundation Industries.

Section 3. Themes within framework are explored in discussions with stakeholders and key issues emerge.

Section 4. A series of next steps are proposed.

The Appendices provide an overview of participants and the details of workshop conversations.

2 Research framework

2.1 Introduction

An industry and academic literature review was undertaken to understand the scope of regulatory issues and establish the parameters for our primary research consultation.

The output of this review is an assessment of the categories, types and dimensions of regulation that are most relevant to the Foundation Industries.

Our thinking in this regard has been shaped by a wide range of academic and industry research. A brief summary of these is set out below, followed by a description of the research framework.

2.2 Drivers of regulation

Regulation affects every aspect of our lives as Fig.1 (right), developed by the National Audit Office (NAO)[2], illustrates.

Regulation is also addressing some of the most pressing challenges and enabling some of the greatest opportunities of our times, including climate change, global trade and competitiveness.

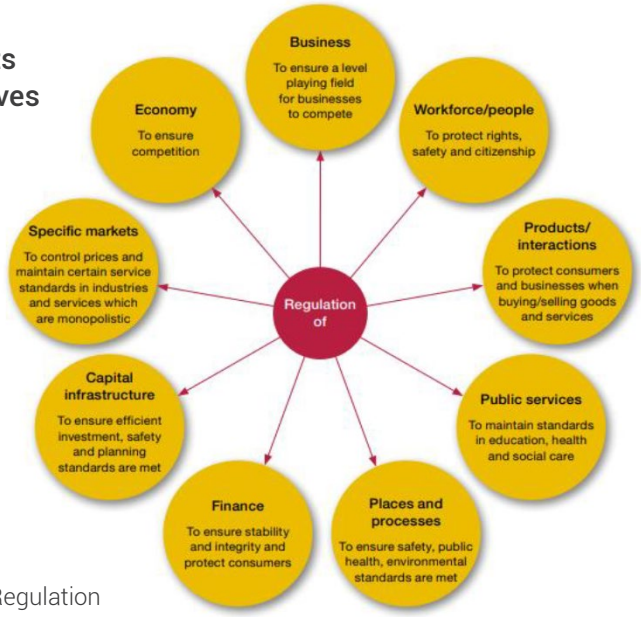
2.2.1 EU Net Zero emissions

The EU Net Zero Industry Act is thought to present several challenges for the UK in the post-Brexit landscape.

The Act seeks to enhance Europe's manufacturing capacity for clean technologies and sets a target for 40% of the EU's annual deployment needs to be produced within the EU by 2030. This approach underscores the EU's commitment to strengthening its own green technology sector but the shift could also impact the UK by increasing the competitive pressure on its industries, particularly those that are also engaged in producing or utilising clean technologies.

Both the EU and the UK (by 2027) are also implementing Carbon Border Adjustment Mechanisms (CBAMs), which impose costs on imports with high carbon footprints. While these mechanisms are designed to ensure fair environmental standards, they may also act as trade barriers, increasing costs for industries and potentially disrupting global supply chains.

Fig.1 Regulation affects many aspects of our lives



Source: NAO: Objectives of Regulation

2 A Short Guide to Regulation. National Audit Office. September 2017

2.2.2 UK Net Zero emissions

With the UK no longer part of the EU, it faces the risk of being disadvantaged in a market where EU regulations may set higher standards that could influence international trade patterns and competitiveness and create new trade barriers. High compliance costs could place additional pressure on UK sectors, such as steel production, potentially making it harder for them to compete with EU-based counterparts who benefit from supportive policies and a more integrated market.

The UK's climate policy is centred on achieving ambitious carbon reduction goals while fostering innovation and economic growth. As part of its commitment to the Paris Agreement, the UK has set a legally binding target to reach net-zero greenhouse gas emissions by 2050. This goal is supported by a range of policies and strategies aimed at reducing emissions across various sectors, including energy, transport and manufacturing.

The government's approach includes investing in green technologies, enhancing energy efficiency and promoting sustainable practices. Key initiatives, such as the "Clean Growth Strategy" and the "Net Zero Strategy," outline specific actions and investments to transition towards a low-carbon economy, aiming to balance environmental objectives with economic competitiveness.

2.2.3 Global trade

Global regulatory changes, including non-EU countries' implementation of non-tariff barriers and various international policies, could impact the UK's Foundation Industries. Non-tariff barriers, which restrict trade without imposing direct tariffs, may hinder the growth of sectors like steel by complicating market access. Examples such as the US's anti-dumping duties and the Inflation Reduction Act highlight the competitive pressures faced by UK industries.

The US anti-dumping duties, which impose tariffs on imports deemed unfairly cheap, can discourage innovation by making it less appealing for companies to export to the US or invest in new products. This protectionist measure, while safeguarding local industries, can create barriers that stifle competitive dynamics and innovation.

The US Inflation Reduction Act represents a major policy shift with its heavy investment in clean technologies. This substantial funding aims to enhance the US's green technology sector, potentially giving it a competitive edge over European and UK industries that may struggle to match this level of investment. As US firms benefit from such support, EU and UK companies could face challenges in competing on a global scale.

2.2.4 Enhancing UK competitiveness

Global regulatory changes are significantly impacting international trade and industry. This could impede future growth and will require the UK to develop effective trade defences and adapt its regulatory approach to maintain competitiveness and support industry growth.

The UK's exit from the EU presents an opportunity to reshape its regulatory framework, potentially simplifying or creating an environment for barriers to innovation to be reduced.

The previous UK government's "Smarter Regulations" programme[3] aimed to streamline regulatory processes, reduce business burdens and foster

3 Smarter Regulation: one year on (HTML version) - GOV.UK (www.gov.uk)

a more innovation-friendly environment. The Labour Government seems to be taking a similar approach to regulation, signalling its intention to address the complexity of regulations in several sectors including power, transport, urban planning and product safety.

This approach could help mitigate some of the challenges faced by industries affected by EU regulations. Although the King's Speech referred to the establishment of an Industrial Strategy Council, there was no accompanying legislation but, by developing a regulatory landscape that supports innovation and reduces unnecessary complexities, the UK has the potential to attract investment in clean technologies and strengthen its position in the global market.

2.3 Regulation and the Foundation Industries

As the Foundation Industries cover many sectors and sub-sectors, the corresponding regulatory issues are wide and varied.

To try to understand these issues and the impact of regulation on the Foundation Industries, we have looked at regulation through two different lenses: first, regulations linked to Foundation Industries and second, the influence of regulation across the innovation life-cycle.

2.3.1 Regulation by Foundation Industry

Each of the Foundation Industries face distinct regulatory challenges. These sectors encounter barriers that can hinder innovation, such as stringent environmental and safety regulations. Below we examine some these sectors and their regulatory obstacles and their impact on industry

South Wales Industrial Cluster The South Wales Industrial Cluster (SWIC) has overcome complex regulations across different sectors through collaboration. By uniting industries like steel, oil and energy, SWIC fostered a culture of innovation, developing cutting-edge technologies and processes to meet decarbonisation goals. This regulatory agility enables companies to experiment, adopt sustainable practices and ultimately drive forward Wales' transition to a low-carbon economy.

advancement and competitiveness. The list is not exhaustive and some of these issues do also apply to other sectors too.

- **Glass:** In the glass industry, regulatory barriers revolve around energy efficiency and environmental standards. The development of advanced glass formulations, such as those designed to improve building insulation and reduce energy consumption, often requires extensive testing and regulatory approval. These stringent requirements can slow the pace of innovation and increase costs, deterring investment in new technologies. Additionally, global competition and varying standards across regions can further complicate market access for innovative glass products. Stricter import regulations based on environmental criteria in non-EU countries could limit the ability of UK and EU manufacturers to introduce their new products internationally, presenting a significant challenge to growth and technological advancement in the sector.

- **Chemicals:** The chemical industry faces considerable regulatory challenges due to the focus on safety and environmental impact. While these regulations are essential for ensuring public health, they can also create substantial barriers to innovation. The lengthy and costly approval processes for new chemicals can hinder the development of safer and more sustainable products. Moreover, global competition intensifies these issues; for instance, the US Inflation Reduction Act's substantial investment in clean technologies could draw investment away from the UK and EU. Non-tariff trade barriers, such as stringent import regulations based on environmental concerns, could further restrict market access for innovative chemical products. Addressing these barriers requires streamlined regulatory processes and targeted incentives to support ongoing innovation in the chemical sector.

- **Metals:** There are industry concerns regarding the impact of evolving climate regulations on investment decisions. For example, steel producers face uncertainty due to the possibility of stricter climate policies beyond 2030, creating a regulatory environment that hinders their willingness to invest in new technologies. The lack of clarity regarding future regulations acts as a barrier to innovation, as companies are hesitant to commit resources to projects with uncertain returns. This hesitation is particularly problematic in an industry with high upfront costs for adopting cleaner technologies, which are crucial for meeting carbon reduction targets and enhancing overall sustainability.

- **Cement:** For industries like cement production, innovation is not just a goal but a necessity for sustainability and long-term viability. Achieving net-zero emissions is a formidable challenge, as the current process relies heavily on fossil fuels. The industry's plan involves increasing the use of alternative raw materials, fuels, and recycled materials, alongside advancements in carbon capture and decarbonisation technologies. Innovation in these areas is essential for the sector to not only reach but surpass net-zero emissions by 2050. Moreover, innovation drives competitiveness by enabling the development of new, more sustainable products and services and reducing operational costs. This holistic approach to innovation ensures that industries can meet regulatory requirements, enhance their market position, and contribute positively to environmental goals, thus supporting broader economic growth and societal benefits.

- **Ceramics:** The ceramic industry[4] faces significant regulatory challenges due to the overlap of political and legal factors. Political elements,

4 https://www.mdpi.com/2071-1050/15/16/12230

governed by government policies, often clash with legal aspects, including laws and regulations stated in industry roadmaps. A few areas are apparent in the literature:

» The current policy focuses on measuring emissions solely during production rather than over the entire life cycle of ceramic products. This gap risks driving consumers towards ceramics from countries with less stringent environmental standards or towards less durable products with higher annualised emissions, undermining the UK and EU economies and contributing to carbon leakage.

» The industry's engagement with various regulations, such as the EU Emissions Trading Scheme (EU ETS), the Industrial Emissions Directive (IED) and numerous climate-related laws creates a complex compliance environment. These regulations, while essential for promoting environmental sustainability, can also lead to increased costs and competitive disadvantages if not matched with international standards and protections against unfair trade practices.

  A harmonised, life-cycle approach to carbon assessment and better alignment with global regulatory frameworks are crucial for ensuring fair competition and achieving sustainable production goals.

» Research by Khalil et al[5] shows that "the ceramic industry would like policymakers to provide a supportive regulatory framework, which includes a collection of rules and regulations (for example,

Glass industry, regulation and innovation Stricter EU packaging regulation is forcing the glass industry to look for new ways to reduce carbon emissions. Using more energy-efficient electric and hybrid furnaces allows glass manufacturers to increase their use of recycled materials. Whilst this is setting new industry standards, the increased cost of production means that buyers require incentives to purchase 'greener' products over cheaper but less sustainable alternatives. Incentives are something the sector struggles to persuade governments to introduce. The glass industry has tackled regulatory hurdles by embracing innovative technologies. Stricter EU packaging waste regulations for exporters prompted companies to explore electric and hybrid furnaces. This shift, driven by the need to reduce carbon emissions, has led to breakthroughs in sustainable glass production, such as more energy-efficient methods and increased use of recycled materials, setting new standards across the industry.

5 Khalil, A.M.E.; Velenturf, A.P.M.; Ahmadinia, M.; Zhang, S. Context Analysis for Transformative Change in the Ceramic Industry. Sustainability 2023, 15, 12230. https://doi.org/10.3390/su151612230

health and safety regulations, quality standards, trade legislation, etc.) aimed at promoting the development and growth of the UK's ceramic industry". The research shows concerns about UK ceramic manufacturing being globally competitive and to "consider the increasing threat from imports that would lead to carbon and job leakage to countries outside the UK and EU".

- **Minerals:** Although not technically a Foundation Industry, the systematic recording of mineral waste production and a better understanding of its properties is needed as a starting point to encourage its use. With the increase in drive towards resource efficiency, circular economy, industrial decarbonisation and net zero, it is likely that there will be even greater regulations in the future as well as the expectation from consumers for an efficient extraction and use of mineral resources[6].

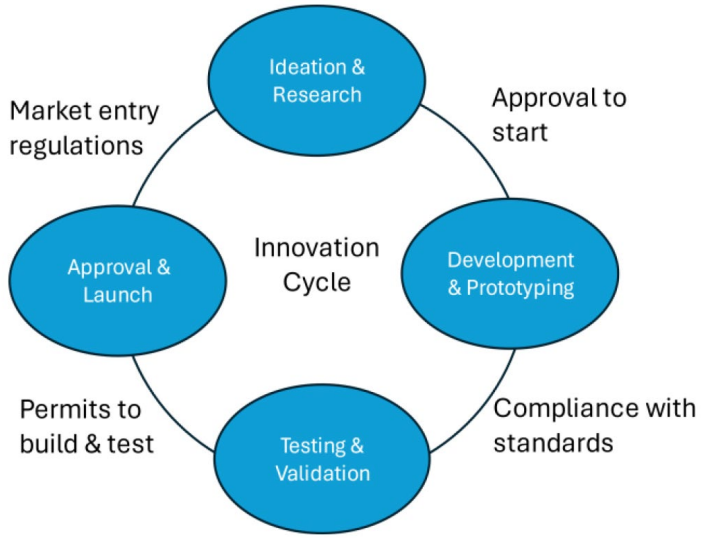
2.3.2 Regulation and innovation

Innovation has long been an imperative for the survival of knowledge-based companies across various sectors. Innovation drives the development of new products and services, enhances efficiency and reduces costs, which are all crucial for maintaining a competitive edge in the global market.

The relationship between innovation and regulation is complex. For example, the innovation lifecycle (Fig. 2) includes distinct stages and, within each, stakeholders face a complex mix of regulatory challenges and opportunities. For example:

6 https://www.mdpi.com/2673-4605/15/1/80

Fig. 2 Regulation & Innovation



Source: NAO: Objectives of Regulation

- In the ideation and research phase, innovators often struggle with stringent approval processes, freedom of information requests[7] that challenge commercial confidentiality and limited access to test data.

- During development and prototyping, a new product may have to comply with multiple standards that also vary across different markets. The high costs of compliance is often too high a barrier for smaller

7 In the ideation and research phase, innovators often struggle with stringent approval processes. In addition, the use of public funds for R&D comes with a risk that a freedom of information request will challenge commercial confidentiality requiring test data to be published. This acts as a disincentive.

companies.

- In the testing and validation stage, a project often faces the paradox of having to test new products whilst adhering to the multiple existing regulatory parameters that it seeks to change. For example, independent monitoring to ensure compliance with emissions regulations, during the test phase can be time-consuming and costly.

- For approval and launch (commercialisation), innovators face challenges such as complex approval pathways and market entry restrictions. Clear, predictable approval processes can facilitate faster market entry and reduce uncertainties.

- Post-market, rigid surveillance requirements can limit innovation but flexible regulatory frameworks that support iterative improvements and responsive monitoring can foster continuous innovation and ensure ongoing compliance.

Research by Nesta[8] also identified regulatory issues and opportunities across the innovation lifecycle, in other adjacent sectors that also help inform our framework. Key themes are set out in Table 1 below.

8 The Compendium of Evidence on the Effectiveness of Innovation Policy Intervention, Manchester Institute of Innovation Research (MIoIR)

Table 1. Regulation and innovation in adjacent sectors

Markets/Sectors	Innovation lifecycle	Type of regulation and associated dimensions of relevance
Chemicals, Pharmaceuticals and biotechnology	Pre-approval/ Pre-market screening. (Ideas stage of the life cycle)	**Enhancing competition** • Negatively impacts smaller companies compared to larger ones, more able to cope with the regulatory burden • Positively encourages more R&D into the use of the products to secure approval • Negatively impacts smaller companies entering foreign markets due to high costs of regulation to gain entry **Market entry** • A higher degree of regulatory flexibility (i.e. in non-regulated sectors) and/or not using novel substances, increases new entrants and encourages innovation (Concrete) • Greater stringency in less competitive markets increases innovation. A 10% decrease in approval times for a new drug, 'increased the R&D spend of pharmaceutical companies by 1% to 2%.' **Pricing** • Drug price controls reduce R&D intensity 'well before the regulation is in effect' • Controls shift the emphasis to cheaper (less intensive R&D) and patentable innovations
	End of pipe regulation (Final stage of the life cycle)	**Enforcement** • Positive impact on innovation – where focussed on discharge/emission of toxic substances, re-use and recycling with evidence of 'significant cost-savings' for companies affected • Negative. Can delay development/release of new innovations
Automotive	Pre-approval/ Pre-market screening.	**Competition** • Positive impact on innovations to create lighter and more fuel-efficient cars • Limited or no impact on innovations to successfully 'commercialise electric vehicles.'
	End of pipe regulation	• Positive impact on innovation to comply with tighter controls on emissions • End of Life Vehicle Directive has diverted innovation to 'short-term and incremental technological trajectories rather than more radical and sustainable product innovation.'

Nuclear/Electric	Pre-approval/ Pre-market screening.	**Health & Safety** • Regulators take a less flexible approach to licensing plants with a poor safety record. This negatively impacts innovation due to greater uncertainty of compliance and delay in licensing
		Pricing • R&D support, tax and other investment incentives, quantity obligations, tradable certificates have a positive impact on innovations in renewable energy

2.4 Developing our framework

The impact of regulation on individual industries and through the innovation cycle is complex and multifaceted.

Impacts vary significantly by sector, based on the stage of innovation, the type of regulation, the company's capacity to comply in a timely way and the degree of enforcement that is applied[9]. These factors underscore the necessity of developing and applying a framework to better understand how regulations can both enable and hinder the Foundation Industries.

Nesta, in collaboration with researchers at University of Manchester, examined the influence of various types of regulation on innovation[10]. The study looked at social, economic and institutional regulations and reviewed empirical research to identify the positive incentives of regulations and the negative compliance burdens. In summary, the research found that:

- Economic regulations often aim to promote innovation by shaping market conditions and driving competition.
- Social regulations, meanwhile, influence the broader market environment and can drive demand for innovative solutions.
- Institutional regulations link the legal framework directly to innovation processes, ensuring that regulatory measures align with the goals of fostering technological advancement.

Understanding these cross-cutting themes is essential for creating a balanced approach that supports industry growth and innovation. Set out below (in Table 2), is our draft framework, it includes:

- Three categories of innovation based on the Nesta report.
- Ten types of regulation, based on the Nesta and NAO definitions,
- Dimensions of regulation, based on the Nesta and NAO research and how these might be considered in relation to the different stages of the innovation lifecycle.

We used this framework to develop broad categories of questions and to help us map responses to the regulatory issues that stakeholders in the Foundation Industries are concerned about as they consider how regulation acts as an enabler or, or brake on innovation, now and in the future.

9 https://ippr-org.files.svdcdn.com/production/Downloads/strong-foundation-industries_summary_March2016.pdf

10 The Compendium of Evidence on the Effectiveness of Innovation Policy Intervention, Manchester Institute of Innovation Research (MIoIR)

Nesta definitions	Nesta and NAO	Nesta
Categories of regulation	**Types of regulation**	**Dimensions of the regulation to be considered***
Economic regulations Promoting innovation	Enhancing competition	• Innovation is enhanced with positive incentives and low compliance costs. • Innovation is diminished with low or no incentives and high compliance costs. • Regulation tries to balance imitation with innovation in competitive markets (batteries).
	Antitrust, Mergers & Acquisitions	• Restrictions on collaboration increase costs and reduce investment in innovation. • These regulations isolate companies from short-term pressures (equity markets) and fosters innovation to promote a company's value. • Isolation may also reduce 'the disciplining pressure of the market' that encourages innovation within a corporation.
	Market entry (costs of entry and compliance)	• Positive for incumbents (particularly those operating close to the technology frontier), by reducing competition and de-risking investment in innovation. • A barrier for new entrants and a negative incentive for innovation, particularly in markets (like FI's), where competition is already low.
	Pricing incentives or caps	• Positive when securing a minimum price (revenue) or reduced demand-side risk. • Negative, when a price cap impacts on quality/safety.

Social regulations Shaping market conditions	Environmental protection	• Positively drives innovation toward protecting the environment / limit damage. • Improves international competitiveness by driving exports of the proven innovation. • Restricts innovation when there are high costs of compliance.
	Planning and licensing	• Complex approval processes delay the introduction of new innovations. • High costs of permits and licenses can discourage investment in new technologies. • Uncertainty due to changing or unclear regulations makes investment risky. • Long wait times for approvals can postpone the launch of new products. • Restrictive zoning and land use rules limit development opportunities. • Rigid requirements may not accommodate new or unconventional technologies. • Excessive bureaucracy and paperwork slow progress down and hinder creativity. • Inconsistent regulations across different areas complicate compliance and impede innovation.
	Health & Safety	• Positive for innovation by creating temporary barriers to entry. • Negative impact if innovation threatens safety.
	Consumer protection	• Positive impact on innovation when supported by minimum safety standards to encourage adoption.

Institutional regulations Links the legal framework to innovation	Liability	• If liabilities rules are too strict, incentives to innovate are reduced. • Liabilities can improve acceptance and diffusion of new products, in turn creating innovation incentives
	Employment protection	• Job security may increase incentives to innovate. • Risk of companies having to adjust in the event of failures (i.e. redundancies), may make employers more cautious. Bigger companies are more able to mitigate these risks. • A culture of high-quality, incremental innovation requires consensus-building decision-making most prevalent in more coordinated or controlled labour markets (Germany). • Deregulated labour markets (UK, USA) do not have these controls/protections and create the conditions for more radical (riskier) innovations. • R&D spend tends to be higher in industries 'implementing a rather decentralised wage-bargain regime.'
	Intellectual property (patents and copyright)	• Strong patent protection encourages innovation. • Weak protections favour a rapid and wide diffusion of inventions. • Regulation tries to balance imitation with innovation in competitive markets (batteries). • SMEs have limited knowledge of the IP system, finding it too complex and expensive to use.
	Procurement law	• Higher standards increase the cost of compliance and the price of goods and services. • Procurement rules need to balance value for money against cheaper, potentially less safe, higher embedded or carbon-emitting imports. • Clearer guidance for public procurement could explain and account for the cost of a product and help support a market for high quality British Foundation Industry goods and help the UK transition towards a low carbon economy without falling foul of EU state aid rules[11].

11 Strong-foundation-industries_summary_March2016.pdf (svdcdn.com)

Several factors determine how regulations shape the landscape of innovation, influencing whether they act as a barrier or an enabler in various sectors and stages of technological advancement. The impact of regulations will differ depending on:

- The sector within which the regulation is being applied and level of demand for the product or service. High market demand for innovative solutions can drive companies to innovate despite regulatory constraints.

- The technology 'frontier' in which the business or organisation is positioned. This includes the technology readiness level at which the business is operating. Those closer to the frontier 'are less negatively influenced by regulation.'

- The size and age of the organisation or business. Larger businesses might be able to cope better (see next). Younger businesses have less experience but are more flexible.

- The extent to which businesses can be supported to respond to changing regulations. This might include mentoring or support from peers working in clusters, training to improve awareness of the implications of changing regulation, and training to equip employers and employees to respond positively to the opportunities that regulations can present.

- The timescales of regulation. In the short-term, a requirement to comply with regulations is a burden and, in the long-term, is regulation specific.

- Enforcement (stringency of regulation). A more flexible or 'smart' approach to regulation may encourage more 'radical' innovative approaches and lead to new competitive opportunities or advantages. Tighter controls may only encourage incremental innovation to achieve compliance.

3 Emerging Priorities

3.1 Introduction

Regulatory frameworks play a crucial role in shaping the landscape for Foundation Industries. While regulations are essential for protecting the environment and public health, it is important to strike a balance to ensure they do not stifle investment, innovation and the overall competitiveness of these vital sectors.

Most regulatory drivers are interconnected with - and affected by - one another which is why we have developed the framework to start to understand these connections and identify the issues and opportunities of most relevance to the Foundation Industries.

Below are a range of quotes from the primary research that highlight some of the challenges and opportunities that participants expressed. This is followed by a summary of the issued raised by participants.

Table 3. A selection of comments and quotes form interviewees

Economic	Social	Legislative
If we are able to emphasise the real extra value from these new products, then we might be able to extract more revenue. *Quite often we don't think about the consequences or needs [for regulation] when transitioning to the next TRL and, when you hit these regulatory barriers, they may be much higher than you first considered, and your business case goes out of the window.* *Tax incentives (breaks) for customers who opt for lower carbon embodied materials would transform not just glass, but steel, cement everything.*	*I have seen examples of emissions to air regulations impeding the roll-out of new technology as the Environment Agency appeared risk averse or unable to address a new situation.* *It is unworkable to treat a 12-month small project in the same way as a million tonnes per year recycling site.* *The challenges around circular economy are commercial and regulatory.*	*But I think most of the regulations, …you don't have any choice but to comply with … like permits for emissions to air and things like that. You have to comply.* *Universities, have an extremely wide interpretation of IP ownership, some are sensible, some are nonsensical, and we just have to work our way through it (Glass)* *Typically if we can get an agreement done in six months, it's incredible. It usually runs up to a year or two years before we get an agreement in place.* *There is a lack of resources to support regulatory negotiation and navigation.*

3.2 Economic regulations in the Foundation Industries

Economic regulations are designed to stimulate competition and force companies to be more innovative in terms of controlling costs and developing new products and services for existing and new markets, that are competitively priced. The below economic regulation related points were identified in the research:

Market entry

- **Regulatory burden on new entrants:** new businesses and startups often face significant regulatory hurdles that can impede their ability to innovate. Streamlining regulatory processes and providing support for startups can facilitate their entry and growth in the market.
- **Compliance and standards:** different markets require materials to meet varying standards, creating additional regulatory burdens. Advocating for cross-sector standards and updating them regularly can support innovation and market adoption.
- **Sector-specific challenges:** for example, in the cement sector, innovation is ongoing, such as using recycled materials but product testing remains costly and time-consuming. The use of sandboxes, to provide sector-specific testing facilities could alleviate some of these challenges.
- **Challenges for startups:** The lack of available funding for start ups, and their limited capacity to bid for these funds, is slowing the rate of innovation and preventing products from reaching the market.

Pricing & incentives

- **High costs for bringing new products to market** and limited access to capital for SMEs constrain innovation. Directing government budgets to support innovation and creating market incentives for low-carbon products could stimulate progress.
- **Regulatory impact on market dynamics:** regulations can sometimes suppress demand for new products if they do not incentivise innovation or are poorly targeted, such as in the case of plastics packaging tax. Supportive investment regulations are necessary to drive innovation effectively.
- **Market demand and customer incentives:** companies may be reluctant to invest in innovative, low-carbon products if there is insufficient market demand. Providing tax incentives for customers and educating them about the benefits of low-carbon options can stimulate market demand and support innovation.
- **Regulatory barriers hinder the fair pricing of waste-derived products:** the higher cost of production often prevents waste materials from being economically valued as inputs for production, limiting investment in recycling solutions[12].
- **Investment abroad.** The international nature of these sectors means UK-based businesses, often with Global business ownership, might preferentially invest in R&D abroad if it is subsidised and quicker, potentially leading to de-industrialisation in the UK.

12 https://www.mdpi.com/2071-1050/15/16/12230

Other related issues arising

- **Training and skills:** vocational and academic training often lag behind industry needs, impacting competency and innovation. Improving and aligning training standards with industry requirements is crucial for supporting future advancements.
- **Access to capital:** economic regulations can include financial incentives for innovation but SMEs in Foundation Industries often struggle with reduced access to capital. Strengthening support structures and creating funding opportunities can help these companies compete and innovate.
- **Regulatory flexibility:** regulations that are too rigid can stifle innovation by enforcing outdated methods or technologies. Flexible, outcome-based regulations that focus on achieving goals rather than prescribing methods can encourage more creative solutions.

3.3 Social regulations in the Foundation Industries

Social regulations encompass rules and guidelines aimed at protecting the environment, ensuring public health and safety and fostering equitable consumer practices. Social regulations influence innovation towards environmental protection and the health and safety of employers, employees and consumers. These regulations significantly impact the Foundation Industries and their innovation efforts. The below social regulation related points were identified in the research:

Circular Economy Innovation CELSA, a steel producer, embraces circular economy principles by controlling its supply chain, enhancing scrap processing and reducing Scope 3 emissions. Their focus on whole-life carbon reduction, asset reutilisation, and strategic partnerships illustrates the potential for transforming steel production and construction into more sustainable practices. However, challenges arise from regulatory barriers like PAS 2080, which demands rigorous whole-life carbon assessments. These standards, though essential, are often seen as cumbersome and untested, complicating the shift to circular methods. Despite these hurdles, CELSA seeks to demonstrate the tangible value of circularity by navigating these regulatory complexities.

Environmental protection (general comments)

- **High carbon emissions:** the Foundation Industries generate nearly half of all industrial carbon emissions and need to quickly transform to ensure sustainability.

- **Regulatory inflexibility:** no flexibility in the implementation of regulations can impede new technology roll-outs, as risk-averse agencies might struggle to address new situations.

Recycling / licenses

- **Challenges in plastics recycling:** recycling regulations present challenges, particularly for plastics, with processes like gasification and pyrolysis requiring higher value markets for recycled materials.

- **Costly licensing for material reuse:** obtaining end-of-life licenses to reuse materials is time-consuming and costly, suppressing investment in low-carbon products.

Planning & Permitting

- **Need for specialist facilities:** specialist facilities are required for companies to trial new technologies at scale; without these, sectors struggle to demonstrate and secure investment for decarbonising manufacturing processes.

- **Slow permitting processes:** slow processes in obtaining permits and permissions for production facilities can delay innovation, although recent regulation reforms may encourage faster decision-making.

Industrial clusters and permitting: industrial clusters face challenges with place-based emissions and permitting, requiring better coordination to ensure permits for carbon capture and future industrial clusters.

Health & Safety / Consumer protection

- **Health and safety compliance**: compliance with health and safety standards is crucial, particularly for safe materials and procedures concerning heat capture.

- **Delays in consumer protection regulations:** consumer protection regulations can delay new or updated labelling agreements, sometimes taking up to 10 years, impacting product innovation and market entry.

3.4 Institutional regulations in the Foundation Industries

Institutional regulations are designed to link the legal framework to innovation. Institutional regulations significantly influence innovation within the Foundation Industries by shaping the legal frameworks and collaborative environments necessary for research and development. These regulations address issues like intellectual property rights and partnerships between businesses and academia, which can either facilitate or hinder technological advancements and market competitiveness. Key points identified in the research include:

Intellectual Property

- Onerous IP agreements: Intellectual property (IP) agreements between businesses and academia can be too burdensome for small businesses, making collaboration difficult.

- Wide interpretation of IP ownership: Universities often have a broad and sometimes unreasonable interpretation of IP ownership, complicating agreements.

- Lengthy agreement processes: Finalising IP agreements can take six months to two years, delaying innovation and collaboration efforts. Companies may walk away from potential collaborations if IP deals take too long , universities also miss out on valuable partnerships and innovations.

- Need for standard contracts: Standard contracts, like those recommended by Innovate UK (IUK), should be amended and adopted to streamline IP agreements. Providing businesses with more support to negotiate IP arrangements can facilitate smoother collaborations and innovation.

- The role of innovation: For those involved in these lengthy negotiations, a question arose as to the end-use of the IPR being protected. Was the IPR being used to achieve an organisations strategic objective (securing better research ratings and R&D tax credits), or developing innovative products to make UKPLC more competitive?

R&D Agreements

- Resource advantage for larger companies: Larger companies can afford to invest in early-stage research with universities and scale up innovations, unlike smaller businesses.

- Reduced incentive for R&D: The complexity and time required for IP agreements reduce the incentive for companies to engage in collaborative research and development.

3.5 Cross cutting

A series of cross-cutting themes have been identified:

Regulatory alignment across jurisdictions

- Regulatory divergence and alignment: Differences between the UK, EU, and other trading partners, such as the US Inflation Reduction Act benefiting US businesses and the forthcoming UKCBAM implementation, create uncertainty and competitive challenges for UK industries.

- US Competitive edge: The US can favourably compete with cheaper imports, especially from China, due to supportive regulations, while Europe lags in proposing equivalent measures.

- UK-EU Carbon Border Adjustment Mechanism (CBAM): The EU's CBAM has been announced, with the UKCBAM expected by 2027 but its impact on UK businesses remains unclear.

Regulatory sandbox

- **Regulatory sandboxes:** Sandboxes provide a controlled environment for developing innovative products without disclosing sensitive details, but they need balancing to ensure high standards are maintained to avoid future issues.

- **Testing** sandboxes across different UK jurisdictions in a uniform manner would allow for comparable results and broader implementation. Ensuring that regulatory sandboxes promote innovation pace while maintaining high safety and quality standards is crucial to avoid unintended long-term consequences.

- **Information exchange:** Sandboxes facilitate a free exchange of information within a closed system involving operators, regulators and innovators, building trust and maintaining control.

- **Permitting Processes:** Post-trial permitting adds costs and serves as a barrier to innovation; combining permitting with trials in sandboxes could streamline the process.

Skills and training

- **Driving regulatory reform and fostering innovation in the Foundation Industries** necessitate a combination of specialised skills, industry experience and robust testing facilities.

- The skills and capacity needed for these activities requires a commitment to advancing STEM education and training. The ceramic industry is facing significant challenges due to a shortage of personnel with STEM backgrounds, which hampers transformative change. This shortage is exacerbated by the sector's recent shrinkage and uncertain future, which has undermined its ability to attract and retain skilled talent.

- The historical tendency to subcontract maintenance work in industries like steel and chemicals has also diminished the incentive to train new recruits and limited the availability of apprenticeships, further exacerbating skills shortages[13]. Management and leadership skills are crucial in overcoming these barriers, as they directly impact innovation activity and the sector's willingness to collaborate[14].

- Addressing these issues requires targeted investment in both skills development and industry infrastructure. Strengthening industry experience, expanding testing facilities and developing clear pathways for decarbonisation will be essential to drive the long-term sustainability and competitiveness of the Foundation Industries, which in turn will attract new talent and provide resources for recruitment and training.

3.6 Overall conclusions

The impact of regulation on innovation is both sector and company specific and this requires further work to understand how regulation can be used to enable innovation in each of the Foundation Industry sectors.

The main challenges for all six sectors are timely and cost related. This relates to the cost of entry and compliance, understanding and managing inconsistencies in existing legislation, particularly environmental regulations to reduce carbon emissions and the UK relationship to international laws in this regard, as well as the role that IP plays in enabling innovation. Interestingly, issues of product liability (except compliance and health and safety), employment protection and procurement law were not raised or considered important by interviewees when prompted.

13 https://www.mdpi.com/2071-1050/15/16/12230

14 https://www.enterpriseresearch.ac.uk/wp-content/uploads/2021/02/ERC-Report-Innovation-Readiness-in-UK-Foundation-Industries.pdf

Key points from the research highlight several critical issues and potential solutions within economic, social and institutional regulations affecting the Foundation Industries:

Economic regulations – promoting innovation by shaping market conditions and driving competition.

- **Compliance and standards:** Varying compliance standards across markets create additional regulatory burdens. Advocating for and implementing simplified cross-sector standards, while regularly updating them, would streamline the regulatory landscape, support innovation, and facilitate market adoption.

- **Economic and financial support:** High costs and limited capital access for SMEs impede innovation. Strengthening economic support structures and providing targeted funding opportunities can help these companies compete and drive innovation effectively. Securing funding for regulatory innovation is particularly important to counterbalance financial support directed at European competitors.

Social regulations - influencing the broader market environment and driving demand for innovative solutions.

- **Permitting:** Slow permitting processes for setting up production facilities and implementing new technologies are significant barriers to innovation. Regulatory reforms focused on expediting these processes are essential to encourage faster decision-making and support industrial growth. Addressing issues related to the cost and speed of testing, alongside implementing mandatory targets for collection and recycling, will enhance the efficiency of innovation and help overcome the challenges of scaling from lab to commercial stages.

- **Environmental and health standards:** Social regulations focused on environmental protection and public health, such as those addressing carbon emissions and safe material use (particularly in recycling), are crucial for sustainable innovation. However, inflexible frameworks can hinder new technology rollouts and increase costs.

- **Place-based issues:** Effective coordination of planning and place-based regulations, such as those affecting industrial clusters and carbon capture, is crucial for innovation. Improved management of these regulations can facilitate the development of new technologies and support industrial advancement. Additionally, addressing the lack of skills for testing and overcoming scaling challenges will be vital for fostering technological progress.

- **Training and skills:** Aligning vocational and academic training with industry needs is essential to bridge the skills gap and support future advancements. Enhancing training standards will ensure a competent workforce capable of meeting industry demands and addressing the current lack of skills for testing.

Institutional regulations – using the legal framework to ensure regulations foster technological advancement.

- **Intellectual property agreements:** Onerous IP agreements between businesses and academia can obstruct collaboration. Streamlining IP arrangements through standard contracts and providing additional support can facilitate smoother partnerships and drive innovation.

- **Regulatory flexibility:** Rigid regulations can stifle innovation by enforcing outdated methods. Flexible, outcome-based regulations that focus on achieving objectives rather than dictating specific methods can foster creative solutions and support new entrants in the market.

- **Sandboxes:** Regulatory sandboxes can provide controlled environments for developing innovative products while protecting the public and safeguarding sensitive commercial details. They address challenges like high costs and lengthy product testing, especially in sectors such as cement. By facilitating concurrent trials and permitting processes, sandboxes streamline innovation and promote faster market entry. Maintaining high standards and integrating regulatory flexibility within these sandboxes are crucial to avoiding future issues and supporting effective innovation.

Support for Business-led Regulatory Networks

There is a need for advocacy networks to navigate complex regulatory challenges and shape policy effectively. Developing capacity for systemic thinking and generating high-quality data on regulatory impacts will support informed decision-making and drive positive regulatory change. Additionally, exploiting differences in regulations to create commercial opportunities, as seen in other sectors, can help fast-track innovations and enhance competitiveness. To be successful, interviewees wanted to be reassured that the correct level of sponsorship was in place, to give the network credibility, and that sufficient funds were in place to ensure the work of the group could be sustained in the longer term.

4 Next steps

A series of principles and next step activities are identified in this section which have emerged from the research.

4.1 Principles for FIVe

In advancing regulatory practices and fostering innovation, a series of principles and next steps are essential for ensuring that regulations support rather than hinder progress. These principles offer a strategic framework for exploring and implementing effective solutions in the evolving landscape of Foundation Industries.

1. **Framing regulation as an opportunity:** Viewing regulation as a collaborative effort rather than a constraint can transform it into a driver of growth. By promoting flexibility, collaboration and information-sharing, regulators can help businesses navigate compliance challenges more effectively. Encouraging innovative approaches to regulatory compliance and developing standards that support rather than stifle innovation can create a more conducive environment for technological advancements.

2. **Network building and partnerships:** Strengthening networks and partnerships among individuals, organisations, and key bodies - such as IDRIC, MPA, IUK and Business Connect - is crucial. These collaborations enhance resource sharing and collective problem-solving, leveraging diverse expertise to drive innovation. Robust networks can also facilitate knowledge exchange, align efforts across sectors and support the development of more cohesive regulatory strategies.

3. **Continued Research:** The research base is not comprehensive and conducting further academic and industry research on key topics, themes, and priorities provides valuable insights into the regulatory impacts on innovation. These assessments help inform policy development and ensure that regulatory frameworks align with both current and future innovation trends. By integrating research findings into policy-making, regulators can create frameworks that are more responsive to the needs of innovators and the realities of emerging technologies.

4. **Utilising data to inform decisions:** From permitting and testing to commercialisation - data-driven insights enable regulators to make informed policy decisions that balance the need for innovation with safety and efficacy. Collecting and analysing data on regulatory impacts helps refine policies and ensures that they effectively support technological advancement and market needs.

5. **Focus upon Net-Zero:** Positioning regulation as an enabler of decarbonisation aligns regulatory goals with broader net-zero ambitions. Harmonising UK and EU regulations can streamline processes and create a unified approach to achieving decarbonisation targets. More realistically, integrating sustainability across all activities can support the transition to a low-carbon economy and drive innovation in green technologies.

6. **Maintaining dialogue:** Continuous engagement with government bodies, regulators, businesses and consumers throughout the innovation lifecycle is vital in the development of good regulation and innovative products and services. Regular updates, consultations and feedback loops help ensure that regulatory frameworks adapt and evolve in sync with technological advancements and market needs and can help align regulatory actions with industry needs to ensure that regulations are practical and achievable.

Appendix A – Engagement

Fig 3. Next steps for the Foundation Industries Regulatory Network
We would like to thank the following organisations for their advice and guidance throughout the research.

- BASF
- Brunel University
- Cambridge Electric Cement
- CELSA Group
- Centre for Process Innovation Limited,
- Cornishlithium
- Exeter University
- Glass Futures/Foundation Industries Ventures
- Industrial Decarbonisation Research and Innovation Centre (IDRIC)
- Innovate UK
- Institute of Materials, Minerals and Mining
- Leeds University
- Legal and General
- Manchester University, Henry Royce Institute
- Materials Processing Institute
- mineral products association
- Nippon Sheet Glass Co., Ltd.
- Royal Institution of Chartered Surveyors
- Sheffield University
- Unimetal

Appendix B – Workshop outputs

4.3 Workshop 1 – 4th June

A workshop held on 4th June focused upon unpacking the topic of regulatory barriers to innovation in Foundation Industries centred upon the following themes and topics:

- During the workshop, participants emphasised the critical importance of adhering to health and safety regulations, particularly regarding safe materials and procedures in processes involving heat capture. The workshop also identified the complexity of environmental regulations, noting how they can impede the roll-out of new technologies. Participants cited examples of regulatory bodies being risk-averse or ill-equipped to handle novel situations. Key considerations included waste permitting, managing emissions to avoid environmental harm and the challenges posed by stringent recycling regulations, which can hinder innovation and small-scale projects.

- Investment and funding regulations emerged as significant concerns, with challenges related to public subsidy control and the legal aspects of funding innovative projects. Participants called for clearer investment regulations to better support innovation. Discussions also delved into the complexities of using waste materials in new products, such as the need for end-of-life licenses and adherence to building control regulations in concrete binders. The slow process of creating and updating standards to match technological advancements was noted, as well as the regulatory complexities arising from different standards for the same material across various sectors.

- The workshop highlighted the impact of inadequate academic pathways, standards and the necessity for recognised and accredited qualifications to ensure industry competency and support innovation. Participants stressed the importance of advocacy networks to navigate regulatory challenges and the impact of slow permit processes on innovation and commercialisation. Additionally, the uncertainty and challenges of adapting to EU-UK regulatory differences post-Brexit, particularly in the context of the Carbon Border Adjustment Mechanism (CBAM), were identified.

- Participants identified significant regulatory barriers throughout the Technology Readiness Levels (TRL) "scale", especially during piloting and commercialisation stages. Emphasising the need for high-quality data to influence regulatory decisions, they called for considering regulatory impacts throughout the research and development lifecycle. The workshop also explored the potential to exploit regulatory differences for commercial opportunities, drawing on examples from other sectors like well-being, where regulatory flexibilities have fast-tracked innovations.

- The workshop highlighted the disproportionate impact of regulatory requirements on small and medium-sized enterprises (SMEs), often hindering their innovation and development. Complexities and delays in obtaining planning permits were noted as a significant barrier to the speed of innovation and commercialisation. The necessity for standardisation to ensure uniformity and compliance across the industry was underscored, along with the challenge of meeting existing regulations designed around incumbent products or methods, which can stifle new innovations.

- Specific issues like the plastics packaging tax, which creates problems for certain plastic manufacturers due to poorly targeted regulations,

were also identified, emphasising the need for regulatory frameworks that support rather than hinder innovation.

4.4 Workshop 2 - 24th June

- As the second workshop on the 24th June began with an exploration of regulatory science framing, focusing on the Foundation Industries. Regulation was noted to cover various business activities, including employment rights, competitiveness and consumer interactions. Three main themes emerged: economic regulation, social regulation and legal regulation. Economic regulation aims to promote innovation through standards and pricing incentives but outdated standards were seen as hindrances.

- Social regulation encompasses health and safety, consumer protection, environmental protections and permits, with slow processes for permits and end-of-life certificates highlighted as significant obstacles. Legal regulation includes government legislation and compliance issues, impacting regulatory adherence. The need for a regulatory science network was discussed, aimed at gathering evidence, understanding legislation impacts and advocating for regulatory positions. These points set the stage for further discussions and feedback.

- A major challenge identified was the issue of cheaper imports, which impact the market for low-carbon products. European manufacturers, facing higher production costs, struggle to compete with these inexpensive, high-carbon imports. Within the glass industry, the importance of coatings was underscored as vital for profitability and sustainability. Innovations in coatings are essential to meet customer demand, particularly in sectors like automotive. Additionally, the role of universities in providing early-stage research was highlighted, with collaboration seen as a means to bridge gaps in fundamental research and innovation.

- Digitalisation and computational discovery in materials research were noted as significant accelerators of innovation, reducing trial and error, especially in the glass industry. However, challenges around intellectual property (IP) ownership with universities can complicate collaborations. Streamlining IP agreements was suggested as a way to enhance collaborative efforts and innovation output.

- The workshop addressed the substantial cost of achieving net zero emissions, highlighting that companies are unlikely to make significant investments in low-carbon products without a clear willingness from customers to pay more. This customer demand is crucial; without it, businesses may find it challenging to justify the investment to their shareholders. The discussion emphasised that effective regulations could play a key role in incentivising customers to choose low-carbon products. Suggestions included tax breaks or other incentives to drive consumer demand and support companies' sustainable practices.

4.5 Workshop 3 - 11th July

- A third workshop on the 11th July saw participants discuss various strategies and challenges associated with reducing carbon emissions in the industrial sector. The workshop emphasised the importance of collaboration between different organisations, including the example of the South Wales Industrial Cluster (SWIC). A key focus was on the relationship between reserved and devolved powers within the Welsh government and how this impacts industrial decarbonisation efforts.

SWIC and Net Zero Industry Wales were commended for their efforts in coordinating planning and permitting with regulators and local authorities.

- The discussion also covered the necessity for material-based rather than performance-based regulation for materials such as cement, the need to update environmental regulations to accommodate new technologies such as carbon capture, and the importance of establishing clear permitting standards for sub-sectors (for example, the glass industry).

- The cumulative impact of emissions from industrial clusters and the limitations of carbon capture technology were highlighted, with calls for better coordination in permitting to ensure future clusters can obtain the necessary permits.

- The workshop also explored the implementation of the EU Net Zero Industry Act and the Carbon Border Adjustment Mechanism (CBAM) in the UK, noting that sector-specific trade associations would play a crucial role in this process.

- Chemical recycling was identified as a promising approach to handle mixed plastics, reducing front-end costs and identifying high-value markets for recycled materials. The processes of gasification and pyrolysis were discussed, with an emphasis on the need for appropriate regulation.

- Looking at solutions, the importance of evidence-based policy making, data sharing and building trust with regulators was underscored, with sandboxes being suggested as a means to facilitate secure and confidential data exchange.

Appendix C – Workshop analysis within the framework

Economic Regulation

Types of Economic Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
Compliance with regulations and standards	General issue • The same material is required to meet different standards to be used in different markets (such as buildings or automotive).	• Extra regulatory burden for the producer of the source material.	Advocate for cross-sector standards. • Standards should be updated more frequently to encourage innovation and market adoption particularly where standards can help translate the theory of a circular economy into practical action https://bbia.org.uk/wp-content/uploads/2017/06/BSI_BS8001_FLYER_Final_interactive-version.pdf
	Plastics • Standards are restricting the development of new markets. For example new materials could drive new product designs for bottles. But these would not comply with current standards.	• Whilst there is an appetite for a glass bottle reuse system standard specifications do not provide incentives to widen the range of designs, and so suppress demand	• Introduce a glass reuse scheme. • *Suppliers would be very much in favour [of reuse] and unless there was a kind of regulation to force them to do that, they wouldn't support it because of the investment*

Types of Economic Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
	Cement Sector • In the cement sector all standards (i.e. BS8500) are voluntary. They provide guidance for best practice. • They are complementary to European standards (for example EN206), which are now harmonised and mandatory. • There are regular reviews of standards to incorporate new products. Standards and regulations are keeping up with innovation. For example, lots of innovation with low carbon products for example using recycled powders to replace (Portland) cement in concrete. • The industry tends to be frustrated with progress but, generally speaking, there is nothing stopping consumers using new materials.	NA	NA

Types of Economic Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
	Cement sector • The whole industry is moving towards performance testing of materials. A new standard Flex 350 will be published next year by BSI says 'do anything you want with concrete'. • The focus is on bringing down the % of carbon in clinker. The focus of innovation at the moment is on recycling concrete into cement. EU standards allow for recycling cement but this project will go beyond EU standards. • There are also examples of using reclaimed clay and also pottery as a clinker material Aggregate Industries get fired up for recycled pottery | Agg-Net	• This requires the constant testing/ modelling of materials to meet specific performance criteria. • Product testing is expensive and time consuming. It can take two to three years for assurance to be completed and longer if there is no reference material against which to compare the new product and these need to be assured for use in 100 years' time (BSI 500 provides guidance on longevity). • There are challenges for startups in this environment. 'Startups like to talk a lot and get publicity and hopefully help them with funding but they don't really know what they're going to do when they get the funding.' Consequently 'we're not seeing any real breakthrough materials'. • 'There is a huge challenge for anyone wanting to change the chemistry and come up with models about what is going to happen [with that material] in 50 years.'	• The sandbox approach can help reduce these burdens.

Types of Economic Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
Pricing, incentives or caps	• It costs a lot of money to bring a new product to market. • The FI industries are primarily made up of SMEs who have reduced access to capital and skills for innovation https://www.mdpi.com/2071-1050/15/16/12230 • European co-ordinated market institutions offer greater support to their Foundation Industries.	• Innovation by companies that can move more quickly due to their size, are being constrained and losing market share to competitors at home and abroad.	• Government should direct new or surplus budgets to support innovation and clustering in the supply chains. • https://ippr-org.files.svdcdn.com/production/Downloads/strong-foundation-industries_summary_March2016.pdf
	• There needs to be a market for innovative products • *What is the incentive for customers to buy glass with the lowest embodied carbon?* • *Regulation for me means incentivising the customer*	• *If the market demand is not there companies will be forced to invest [in low carbon products] for the sake of investing. Profits might not come for thirty years' time and company's may not last that long.*	• Educate the customers to stimulate demand. • Tax incentives (breaks) for customers who opt for lower carbon embodied materials *would transform not just glass, but steel, cement everything.*

Types of Economic Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
	• Vocational and academic standards are not meeting industry requirements. • A lack of incentives for businesses to create training pathways, impacting overall competency in the sector. • *There's some feedback from businesses, manufacturing businesses that sometimes the vocational standards and maybe even the academic standards aren't quite developing the skills and experience required. On a day-to-day basis*	• Training and upskilling is suppressed when regulations are designed around incumbent products/methods and do not encourage innovation	• Necessity for qualifications that are recognised and accredited to ensure industry standards. • Importance of having relevant and updated training standards to support innovation
	• Challenges related to public subsidy control and legal aspects of funding innovative projects.		• Necessity for clear investment regulations to support innovation.
	• Plastics packaging tax for certain types of plastic manufacturers.	Poorly targeted regulations creating issues for the industry.	

Social Regulation

Types of Social Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
Environmental protection (regulations, licensing and permits)	General • The Foundation Industries generate nearly half of all industrial carbon emissions and need to quickly transform to ensure we live in a sustainable way. • (see EU Net Zero Industries Act)	• FIs that do not transform will face increasingly strict regulations to reduce emissions. These will drive up costs and make production uneconomic.	• Specialist facilities are required that enable companies to trial new technologies at scale. Without such facilities, sectors struggle to demonstrate new technologies at a commercially relevant scale and therefore cannot secure the investment needed to change production processes that will decarbonise their manufacturing processes. • Scaling-up technologies for the Foundation Industries - Henry Royce Institute
	General • No flexibility in the implementation of regulations, for example, in managing emissions and ensuring no negative environmental impacts; for example, while capturing waste heat.	• *'I have seen examples of emissions to air regulations impeding the roll-out of new technology as the Environment Agency appeared risk averse or unable to address a new situation.'*	

Types of Social Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
Recycling regulation/ licenses/permits	• Challenges related to plastics recycling	• The recycling process include gasification and pyrolysis (see Chemical Recycling 101 (bpf.co.uk)). 'Cracking' produces a range of hydrocarbons that can be used for a range of products (including oil and gas). • Need to identify higher value markets for plastics recycled in this way; for example paint, industry packaging and automotive – what are the regulatory implications for these new end products?	• There is a need to think about regulation in this area. Emerging standards for hydrogen are currently linked to natural gas regulation. Is this appropriate?
	• End of life licenses are required to reuse materials. These are time-consuming and costly to acquire.	• Cost and time-delays can supress investment in new (low-carbon) products.	• Look at ways to streamline the licensing processes
	• Recycling or upcycling waste is not suitable for R&D projects. *'It is unworkable to treat a 12-month small project in the same way as a million tonnes per year recycling site.'*	• Impact of regulatory barriers on the speed of innovation and commercialisation.	• Need to be able to adjust permits and licences depending on the purpose of collection. Example is plastics recycling.

Types of Social Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
Planning and permitting	• Slow process in obtaining permits and permissions for setting up production facilities. *'can take over 2 years.'* • In the cement sector, it is an 'onerous process'. Although not so much of a challenge because there are already 10 UK sites and unlikely to be others in the pipeline. The process for permitting has recently been changed to encourage faster decision-making.		• May 16th regulation reform proposals may change this
Emissions and permitting	• Industrial clusters – place-based emissions and permitting.	• The cumulative impact of industrial clusters on emissions and the limits of carbon capture.	• Require better coordination to ensure permits for carbon capture are planned so that new clusters in the future can obtain the relevant permits. • SWIC have done quite a lot to coordinate planning and permitting with regulators and local authorities (Net Zero Industry Wales are also taking a lead on this).
Health & Safety	Importance of ensuring safe materials and procedures, especially concerning heat capture.		Compliance with health and safety standards to protect workers involved in the process.
Consumer protection	Agreeing or changing the product description can take time	Delays of up to 10 years to get agreement to a new/updated labelling	FIVe/FISC advocate for industries and educate standards agencies on impact of delays. Example: Science Creates

Institutional Regulation

Types of Institutional Regulation	Dimensions of the regulation to be considered*		
	Issue/context	Impact	Remedy
Intellectual property	• IP agreements in place between businesses and academia may be too onerous for small businesses. • *Universities, have an extremely wide interpretation of IP ownership, some are sensible whilst some are nonsensical and we just have to work our way through it (Glass) Typically if we can get an agreement done in six months, it's incredible. It usually runs up to a year or two years before we get an agreement in place (Glass).* • Larger companies can afford to invest in innovation and to employ universities at early TRLs. The company will then scale up because the universities don't have the expertise.	• Less incentive to engage and invest in collaborative R&D. • Companies walk away from collaboration if deals are taking too long to agree. – innovations are not developed and both parties lose out. • *And there's been at least two or three cases in the recent past where we've had to walk away, and the universities have lost out.*	• Get standard contracts (like the ones IUK recommend), amended. • Provide businesses with more support to negotiate IP arrangements.

www.fiventures.org