IChemE's response to Invest 2035: the UK's modern industrial strategy

The Institution of Chemical Engineers (IChemE) is the qualifying body and learned society for chemical, biochemical, and process engineers in the UK and worldwide, with over 31,000 members. Our mission is to champion the input of chemical engineers to create a sustainable future.

3. How should the UK Government incorporate foundational sectors and value chains into this analysis?

A helpful framework for thinking about the value of foundational sectors to the industrial strategy is the one found in the ONS's UK input-output analytical tables, which sets out how various parts of the economy are linked.

In addition, a systems thinking approach would provide a helpful way to help incorporate the foundational sectors into the analysis, and would provide a way to map the demands being placed on them (for instance, mapping out the various potential demands being placed on scarce feedstocks such as biomass or finite industrial facilities such as refineries). As the foundational sectors will be supporting a wide range of economic activity, it will be important to have a clear picture of this in the analysis. Systems thinking also provides a way to help think through the complex interconnections and synergies between the various foundational sectors. Given the large number of pre-existing Government strategies that relate to both the growth-driving and foundational sectors set out in the industrial strategy, systems thinking also has a role to play in helping map out how these various strategies interact and highlighting potential tensions between them (for instance, the Government currently supports several developing energy sectors which are partly in competition with each other and there is value in unpicking how the Government wants to approach this.)

Specifically, chemicals should be incorporated into the analysis of the industrial strategy as a critical enabler of both present and future economy activity. Chemicals play an essential role in the production of about 95% of all manufactured goods and underpin most of the growth driving sectors identified in the strategy.

The Government has inherited a strategic vacuum on chemicals policy. The last chemicals strategy was in 1999 and the previous Government promised a new strategy in 2018. This is an important gap, meaning that opportunities for coordination and leadership are missed, and businesses are less able to be confident in (and plan around) the future direction of travel for the country. It is important that there is a strategic cross-Government approach on chemicals because the chemicals capacity of the country is finite (in terms of raw materials, facilities and workforce), and there are many competing demands that are being placed on these. For example, there are several Government strategies at present that make significant demand on biomass, but it would not be possible for the UK to meet all its possible biomass demand simultaneously. The industrial strategy presents a natural opportunity to push forwards with this strategic thinking as well as to develop thinking on a materials strategy.

Given the importance of foundational sectors to the UK's economy, they should be seen not just as enablers for growth, but also as critical and strategic infrastructure and as crucial for all three of the economic security objectives set out in the Industrial Strategy. For example, having a robust independent capacity in producing chemicals reduces the UK's geostrategic dependence on other countries.

4. What are the most important subsectors and technologies that the UK Government should focus on and why?

The UK Government should focus on areas where :

(a) the UK has particular strengths (particularly comparative advantages) that can be exploited to pursue the objectives of the industrial strategy
(b) the input of the subsector is critical to supply chains in growth-driving sectors or achieving broader objectives of the strategy
(c) where there is particular scope to drive economic growth
(d) the Government can build on successful pre-existing strategic commitments or investments and where there would be particular value in the Government signalling ongoing commitment to promote confidence and the ability to plan of investors and companies.

This response focuses on the three growth-driving sectors where IChemE has particular expertise (advanced manufacturing, clean energy industries and life sciences).

Advanced Manufacturing

The chemicals industry:

The UK has a strong and established chemicals industry, with developed industrial clusters, academic expertise, and a skilled workforce. The industry accounts for 17.5% of UK business Research and Development (R&D) spending, contributes £61bn in exports, supports around 500,000 jobs, and is unusually productive, with a Gross Value Added (GVA) 302% higher than the UK average. This industry should be given particular focus due to its foundational role in providing the inputs required across the growth-driving sectors. Whatever novel chemicals or materials or technologies are critical to the economy of the future, they will all be composed of chemicals which will have to be produced somewhere and the UK chemical industry has the capacity to fulfil this role.

Clean Energy Industries

The importance of energy as an enabler of all other economic activity makes it crucial to emphasise in the industrial strategy.

Offshore Wind

The UK has considerable competitive advantages in offshore wind that should be fully exploited as part of the industrial strategy. The UK's favourable geographic location, which provides strong and consistent winds to harness for renewable energy, and historic Government efforts to promote this industry (for instance the Offshore Wind Net Zero Investment Roadmap), have resulted in the UK having one of the world's largest markets for wind energy, with significant installed capacity in both onshore and offshore wind farms, a highly skilled workforce, and a well-developed and expanding industry. (Link) The industrial strategy should make the most of this inheritance.

This industry is expected to have a significant economic impact, employing over 100,000 people by 2030 with each new large offshore wind farm adding £2-3 billion to the economy, (Link) and with investment in new offshore wind projects expected to create an economic opportunity worth up to £92 billion for the UK by 2040 (https://www.owic.org.uk/news/offshore-wind-industry-unveils-industrial-growth-plan-to-triple-supply-chain-manufacturing)

Batteries and Energy Storage

Batteries and energy storage are crucial components of the clean energy transition (e.g. for helping balance supply and demand, providing backup power or facilitating decentralised energy systems) and the UK is well positioned internationally in this field. The Renewable Energy Country Attractiveness Index (RECAI) ranked the UK battery energy storage system market the third most attractive internationally for investment, and recent research found that the UK has the third largest grid-scale battery energy storage capacity. The UK's battery industry is an important job creator: it currently supports around 170,000 jobs, and this number is expected to grow to 270,000 jobs by 2040 (Link)

The UK battery strategy has been an important catalyst for activity in this area and should be built upon in the industrial strategy.

Carbon Capture, Utilization, and Storage (CCUS)

Carbon Capture, Utilization, and Storage (CCUS) is a broad range of technologies aimed at capturing CO_2 emissions from industrial processes, power generation, or other sources, and then either storing it underground or finding ways to use it in various products or processes. It includes capture, storage, and utilization (e.g., converting CO_2 into chemicals, fuels, or building materials).

The UK has a geographical advantage in CO_2 storage, with one of the world's largest storage capacities (the potential to safely store up to 78 billion tonnes of CO_2 under its seabed) (https://www.gov.uk/government/publications/carbon-capture-usage-and-storage-a-vision-to-establish-a-competitive-market/carbon-capture-usage-and-storage-a-vision-to-establish-a-competitive-market) Crucially, the UK has potential for CO_2 storage capacity in areas that are adjacent to existing industrial capacity (e.g. in the North Sea and Liverpool Bay).

The CCUS sector has significant economic potential, with UK CCUS exports being projected to be able to support 48,000 direct high-skilled jobs and £4.3 billion in GVA per year by 2050.

To achieve the net zero objectives of the strategy alongside the growth and economic security objectives, CCUS will be essential, particularly for hard to abate industries. Analysis by the International Energy Agency, the International Panel on Climate Change and others conclude that the lowest cost pathway to deep reductions in global emissions will require the deployment of a portfolio of low emission technologies including CCUS. The former Government's CCUS Vision has been reignited with the recent announcement of funding for two sites, and this support should be continued going forward.

Relatedly, bioenergy with carbon capture and storage (BECCS) has an important role to play in meeting the net zero ambitions of the industrial strategy. BECCS involves capturing and permanently storing CO_2 from processes where biomass is converted into fuels or directly burned to generate energy, providing a way to remove CO_2 from the atmosphere as plants absorb CO_2 as they grow. This is an important tool, as it results in net-negative emissions whereas CCUS is typically focused on mitigating emissions. Given that in the foreseeable future there will be some emissions that are too difficult or costly to prevent, it will be important to have some ability to offset these to achieve net zero. This is explored in recent work by the energy systems catapult.

Hydrogen

The United Kingdom has several competitive advantages for its hydrogen industry, for instance access to the skills of the UK energy workforce, world leading academic institutions and industrial clusters, being well positioned to access international demand, and access to sites for potential hydrogen storage.

The hydrogen industry is expected to create 100,000 jobs and contribute £13 billion to the UK's GDP by 2050 (Link)

The 2021 hydrogen strategy instigated a programme promoting UK hydrogen production, including funding and a decision to support blending of up to 20% hydrogen by volume into the GB gas distribution networks. Several major projects are currently underway, including the HyNet North West project, which aims to produce, store, and distribute hydrogen in the North West of England, and the East Coast Cluster, which focuses on deploying CCUS and hydrogen production in Teesside and Humberside. The UK is working on developing the necessary infrastructure to support hydrogen production and distribution, such as hydrogen pipelines, storage facilities, and refuelling stations for hydrogen-powered vehicles. The UK is also home to the Institution of Chemical Engineers, which is leading an international alliance with the American Institute of Chemical Engineers (AIChE) to support industry's adoption of hydrogen as an energy carrier in the drive to net zero.

Life Sciences

Biopharma and Pharma Manufacturing

The UK is a global leader in pharmaceuticals and a number of related fields such as biopharmaceutical, cell and gene therapies, precision manufacturing and vaccine manufacturing (Link). This brings considerable benefits to the UK economy, representing a GVA of £19.2 billion, supporting over 126,000 jobs and generating £26.1 billion in exports. It is also has an important part to play in the Government's wider mission to build an NHS fit for the future.

The UK's pharmaceutical sector is boosted by the presence of numerous American multinationals who have established a foothold in the UK due to lack of linguistic barriers compared to other countries, access to European markets, the presence of an advanced research infrastructure and similar legal and commercial regimes.

Engineering biology

The 2023 Science and Technology Framework identified engineering biology as one of the "five critical technologies" on which the UK should focus. This is a field where the UK has particular strengths, being "second only to the US" in synthetic biology research excellence and investment, although this status is threatened by international competition. There is significant economic potential in the field: biological applications are estimated to unlock $2 to $4 trillion in annual direct global economic impact by 2030 to 2040 (see also). It has been noted that because engineering biology is a platform technology, it holds out the promise of expanding into new areas that are not currently considered part of the bioeconomy, such as DNA data storage. The 2023 National Vision for Engineering Biology, set out an approach involving £2 billion of Government investment over 10 years.

5. What are the UK's strengths and capabilities in these subsectors?

The UK has a number of strengths and capabilities that are shared across a range of subsectors. These include:

- Comparative advantage in the field of chemical and process engineering with a strong record of innovation dating back to the industrial revolution, world-leading research, (53 UK universities have chemical engineering departments and three of the top ten chemical engineering departments globally are in the UK.) industrial innovation, world leading clusters of industrial activity, and skilled workers. Chemical and process engineers are pivotal to achieving the ambitions set out in Invest 2035, working across the growth-driving sectors from pharmaceuticals to energy, to deploy cutting edge technologies at scale, and turn promising new research and innovations into large scale commercial successes. Chemical engineers are the masters of scale up and will be vital in achieving the industrial strategy's ambitions in boosting the UK's growth.
- World-leading academic and research institutions
- Access to abundant wind power
- Highly developed industrial clusters (which bring advantages such as enhanced collaboration and innovation among nearby companies, greater supply chain efficiency due to reduced transport costs and access to a concentrated pool of skilled labour)
- Wealth of existing talent and skills in the UK workforce.
- Highly developed industrial expertise among established industries
- Historic/recent Government support for many of these subsectors, and several pre-existing strategies to direct activity

Advanced Manufacturing

Chemicals industry:

- The UK has a strong and established chemicals industry, with highly developed industrial clusters (e.g. the North West, Teesside, Humberside, the Solent, South Wales and Grangemouth) academic expertise, and a skilled workforce.
- The industry accounts for 17.5% of UK business R&D spending
- The UK chemical industry is unusually productive, with a GVA 302% higher than the UK average. (Link)

Clean Energy Industries

Offshore Wind

- A key strength of the offshore wind industry in the UK is its workforce (it currently employs 32,000 people) and the significant expertise possessed by its companies.
- The UK is a global leader in offshore wind, with several of the world's largest offshore wind farms. This leadership position attracts investment and expertise from around the world
- The UK is at the forefront of technological advancements in offshore wind, including floating wind turbines and improved turbine efficiency

- There is considerable dynamism and activity in this sector, with RenewableUK, the Offshore Wind Industry Council, The Crown Estate and Crown Estate Scotland pursuing a plan to triple offshore wind manufacturing capacity over the next ten years. (https://www.offshorewindscotland.org.uk/news/2024/april/17/uk-offshore-wind-industrial-growth-plan-published/)

Batteries and Energy Storage

- The UK's battery industry has a significant workforce: it currently employs 170,000 people, and this number is expected to grow to 270,000 by 2040 (Link)
- The UK has strengths in research and development in battery production with institutions like the University of Oxford, Cambridge and UCL leading advancements in battery technology.
- There is strong UK demand for UK battery production. A recent Faraday Institution report predicts that there will be demand for ten UK-based gigafactories (large, high volume battery manufacturing facilities) by 2040, each producing 20 GWh per year of batteries.
- The UK has an established strategy for the battery and energy storage sector.

Life Sciences

Biopharma and Pharma Manufacturing

- The UK is home to some of the world's leading pharmaceutical companies, including AstraZeneca, GlaxoSmithKline, and Pfizer.
- The UK has several innovation hubs and research centres focused on pharmaceutical manufacturing, such as those in Oxfordshire, Northumberland, Swindon, and Slough, which drive technological advancements and collaboration.
- The UK is a leading destination for clinical trials, with over 42,000 patients recruited to industry clinical trials in 2022/23. This robust clinical trial infrastructure supports the development and testing of new pharmaceuticals.
- The UK invests heavily in pharmaceutical R&D, with over £9 billion invested annually. This investment drives innovation and the development of new drugs and treatments.
- The UK has strengths in several areas such as vaccine manufacturing and gene therapy.

6. What are the key enablers and barriers to growth in these subsectors and how could the UK Government address them?

Many enablers and barriers to growth are shared across these subsectors. Some of the key barriers are listed below, together with interventions to address them where IChemE has expertise. Later, some specific barriers and enablers are considered growth areas.

- High cost of energy in the UK compared to other countries.
- Workforce shortages. The UK faces a shortfall of 37,000 to 59,000 people each year in core engineering roles that are vital to delivering the new technologies and innovations and

manufacturing that underpin the UK's present and future economic activity. There is a need to retrain and upskill the existing workforce, as well as attracting more young people to enter it.

- The Government should partner with Professional Engineering Institutions, which have strong links to industry and academia – and who have intimate knowledge of the emerging needs of industry and skills gaps - to develop and grow the UK's STEM workforce.
- The Government should produce a workforce strategy that covers the key engineering fields such as chemical and process engineering that are of foundational importance to the industrial strategy. This needs to recognise that most of the workforce of 2035 is already in employment, so opportunities for (re)training will be important, as will finding ways to make the most of the existing skilled workforce in areas such as oil and gas.
- The Government should prioritise chemical and process engineering education and training at all levels – supporting significant expansions in technical and apprenticeship, undergraduate and postgraduate, and post-doctoral routes as well as reinstatement of 'National Engineering Scholarships', designed to encourage and enable young people from currently under-represented groups to engage
- Brexit-Related Challenges impose additional costs and uncertainties on businesses. These include regulatory divergence (which can require navigating different standards and additional paperwork) or uncertainties over the UK's future policy direction (both on micro and macro levels) which make it harder for businesses to make long term investment plans with confidence.
- Providing a clear sense of the future direction of travel will help businesses and investors to plan with more confidence. While it might be politically difficult to establish and articulate a clear UK approach to the European Union (EU) in general, there is value in setting out the direction of travel in specific sectors, for instance on chemicals regulation.
- Difficulty diffusing technology and innovation across UK industry
- The Government should partner with Professional Engineering Institutions, which have knowledge of cutting-edge developments and emerging best practice as well as the convening power to bring together professionals working in their field, to help gather and disseminate new technologies and innovations. This could extend to supporting mentoring, visits and exchange schemes.
- Investors risk receiving mixed messages due to potential tension between Government strategies (e.g. investors might be uncertain about investing in a particular clean energy approach if they feel that the Government is also investing in a competing approach).
- The industrial strategy provides an opportunity to identify and address some of these strategic tensions.
- Cost and availability of raw materials
- The UK faces several challenges in scaling up promising innovations from the lab to commercial scale. These are considered in a distinct section below.

Scale up capacity

Chemical and process engineers are specifically trained at scaling up innovations in a way that is economically viable, sustainable and safe, yet there is a shortage of these professionals in the UK, so the availability of these skills is limited.

There is a lack of skills in commercialisation that are essential to turning promising innovations into successful commercial ventures. Researchers often suffer from a lack of entrepreneurial skills and poor understanding of the business environment. The Government should promote opportunities for developing these skills that include business management, effective communication, strategic planning, marketing and leadership. These opportunities could include setting or supporting up mentorship programmes, offering subsidised short courses or publishing documents that catalogue the journey of successful ventures.

The Government should support training opportunities to help academics work effectively with industry and should learn from the experience of encouraging existing programmes such as the "Ready for Industry" programme by the Industrial Biotechnology Innovation Centre and University College London's biochemical engineering MBI course. The Government could also facilitate industry-academia exchange programmes that promote knowledge transfer and foster a deeper understanding of the differing needs, challenges, and opportunities within each sector.

The UK does not have a sufficiently large or accessible infrastructure of innovation centres (which provide access to the right experts and equipment needed to move forward with product development) to support scale-up. For such innovation centres to work effectively they need to be accessible in several ways, including geographical location, range of equipment, organisational culture, specialist knowledge and payment model. The UK has the Centre for Process Innovation (CPI); with nine sites across the UK providing access to scale-up equipment supporting researchers on their journey to commercialisation by offering hands-on support with technical problem-solving, scale-up advice, and supply chain development. At present there are significant barriers to accessing the scale-up facilities at CPI due to the requirement for projects to be financially self-sufficient. As a result, many companies are forced to seek more cost-effective alternatives abroad. To avoid this cost barrier, an option could be to emulate the funding framework of Germany's successful Fraunhofer Institutes, who generate two-thirds of their budget with revenue from industry and publicly funded research projects which are acquired through competitive bidding. The German Federal Ministry of Education and Research, and the German states, contribute another third as base funding. Implementing a similar collaborative model in the UK could promote greater utilisation of such innovation centres by both emerging ventures and well-established corporations.

The Government should explore the case for setting up independent technology innovation centres around the UK that provide access to the right experts and equipment needed to move forward with product development. To be a success these centres will need to be accessible across a number of different dimensions including geographical location, range of equipment, organisational culture, specialist knowledge and – perhaps most importantly - payment model.

There is an underemphasis on applied research in the UK that makes the so-called 'valley of death' between initial research and market ready deployment of a technology wider than it needs to be. A greater emphasis on applied research, and engineering research would help make the 'valley of death' easier to bridge for promising innovations.

The Government should instruct UKRI to further emphasise applied research and engineering to support the developments that will most directly contribute to economic growth.

Clean Energy Industries

Offshore Wind

Enablers:

- Contracts for Difference (CfD): The CfD scheme provides long-term contracts that offer stable revenues to offshore wind developers, reducing financial risk and attracting investment
- UK Infrastructure Bank: This bank can invest across the capital structure, including senior debt and mezzanine financing, supporting the development of offshore wind projects
- Private Investment: The UK's attractive business environment and stable regulatory regime encourage private investment from both domestic and international investors

Barriers:

- Grid Constraints: The existing grid infrastructure is not fully equipped to handle the increased capacity from offshore wind projects, leading to delays and inefficiencies
- Planning and Consenting: The planning and consenting process for offshore wind projects can be lengthy and complex, creating delays and increasing costs

Batteries and Energy Storage

Enablers:

- UK Battery Strategy, which includes over £2 billion in funding for the development of zero-emission vehicles and their batteries
- Plans to reinstate solar PV and onshore wind back into the Contracts for Difference (CfD) scheme
- Changes to National Grid's Balancing Mechanism (BM) enabling smaller battery assets to access for the first time
- Access to Financing: the Government aims to incentivise battery investment through Government-backed finance programmes that are predictable and sustained, for example through the British Business Bank ("BBB"), UK Infrastructure Bank ("UKIB") and UK Export Finance ("UKEF")
- Initiatives like the UK Battery Industrialisation Centre are crucial for training and upskilling the workforce

Barriers:

- Supply Chain Reliability: The UK's battery supply chain is still developing, and there are concerns about the reliability and availability of critical materials like lithium
- Infrastructure (grid) requires updating and further developments

CCUS

Enablers:

- Government Investment: The UK Government has committed £22 billion to the broad roll-out of CCUS projects
- Green Industries Growth Accelerator (GIGA) Fund: The £960 million GIGA fund supports sectors like hydrogen and CCUS, aiming to seize growth opportunities through the transition

to net zero (https://www.gov.uk/government/news/major-boost-for-hydrogen-as-uk-unlocks-new-investment-and-jobs?lang=en-gb)

Barriers:

- Regulatory Hurdles: Navigating the complex regulatory landscape and obtaining necessary permits can be time-consuming and challenging
- Delays in the development of CO_2 grid and clusters with some challenges associated with certain sites locations (e.g. incineration plants)
- Technological Challenges: Integrating carbon capture technologies into existing industrial processes requires significant technical expertise and innovation
- Complex funding and grant system, which favour only established and large businesses.
- Strong adverse public opinion
- Lack of clarity of pricing supporting schemes and price of carbon for the medium and long term

Hydrogen

Enablers:

- Trade Potential: The UK is well-positioned to become a major player in the global hydrogen market with a strategic location, existing infrastructure, and abundant renewable energy resources.
- Technological Innovation: The UK is at the forefront of hydrogen technology, with research and development focused on improving hydrogen production, storage, and utilization (https://hydrogen-uk.org/wp-content/uploads/2024/05/Hydrogen-UK-Imports-and-Exports-Report-2024.pdf)
- Government Support: The UK Government has committed significant funding, including £2 billion for green hydrogen production projects. This support provides financial certainty and encourages private investment
- Green Industries Growth Accelerator (GIGA) Fund

Barriers:

- Lack of progress in energy supply infrastructure redevelopment
- Infrastructure Costs: Upgrading and developing the necessary infrastructure for hydrogen production, storage, and transport is costly and complex
- Complex Process Safety requirements

Life Sciences

Biopharma and Pharma Manufacturing

Barriers:

- High R&D Costs: The high costs associated with research and development can be a significant barrier, especially for smaller companies that may struggle to secure private capital investment.
- Global Competition: The UK faces increasing competition from other countries that are ramping up their domestic pharmaceutical manufacturing capabilities.

- Generics and Biosimilars: The rapid expansion of generics and biosimilars presents a considerable obstacle, particularly with the expiration of patents. This can lead to decreased prices and a decline in market share for original drug manufacturers

7. What are the most significant barriers to investment? Do they vary across the growth-driving sectors? What evidence can you share to illustrate this?

Please see question 6 above

8. Where you identified barriers in response to Question 7 which relate to people and skills (including issues such as delivery of employment support, careers, and skills provision), what UK Government policy solutions could best address these?

Please see question 6 above

9. What more could be done to achieve a step change in employer investment in training in the growth-driving sectors?

Please see question 6 above

10. Where you identified barriers in response to Question 7 which relate to RDI and technology adoption and diffusion, what UK Government policy solutions could best address these?

Please see question 6 above

11. What are the barriers to R&D commercialisation that the UK Government should be considering?

Please see question 6 above

15. How can investment into infrastructure support the Industrial Strategy? What can the UK Government do to better support this and facilitate co-investment? How does this differ across infrastructure classes?

The electricity grid is fundamentally important for all the high growth sectors and investing in it is therefore essential for the success of the industrial strategy. Similarly essential are telecoms infrastructure such as 5G / 6G upgrades to ensure full coverage the UK. This will have the knock-on effect of making SMART metering available across the country, which will allow industrial and

commercial users to shift their demand throughout the day and allow for better demand management on the part of the national grid.