CHEMISTRY COUNCIL

INDUSTRIAL STRATEGY

The Chemistry Council Sector Deal

Sustainable Innovation for a Better World

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Foreword

Chemistry-making and chemistry-using businesses are fundamental to the UK's manufacturing industries, producing the raft of everyday products we take for granted today. Chemistry is at the heart of most products and it is estimated that over 96% of all manufactured goods have chemical industry content, making the industry a major contributor to the UK economy and a key facilitator of change through innovation.

This sector generates £17.8Bn Gross Value Added (GVA), with a turnover of £48.7Bn.[1] It provides direct and indirect employment for around 400,000 people in many different regions of the UK, and invests significantly in science and engineering. The UK has a vibrant and competitive chemistry-using industry and has an important role to play in the transition to a low-carbon economy and ultimately Net Zero.

This industry is fundamental due to its presence across all stages of the supply chain. Chemistry-using businesses source new feedstocks and raw materials; manufacture intermediates and materials; and produce end products used day-to-day.

The Chemistry Council (CC) *has brought the sector together to produce a clear vision, identifying opportunities for growth and for collaboration.*

Innovation is at the heart of the CC. This Sector Deal focuses on implementation of the programmes and priorities outlined in the Strategy Document, maintaining innovation as a priority.

The Chemistry Council's vision is to build a better world by being at the forefront of commercialising sustainable chemistry innovations. These disruptive innovations will provide a sustainable, valuable and growing industry delivering both economic and societal benefit.

The Strategy sets out a compelling case for action from both industry and government to secure and build upon our competitive advantage in the global chemistry space, and deliver the growth and business opportunities identified in this report.

Several key projects, which will have immediate significant economic, societal and environmental benefits for the UK are highlighted in this document but the strategy is broader than individual projects, and it needs to be delivered as a long-term strategic programme. A step change, rather than business as usual approach, is required to transform the sector, and the Sector Deal will provide the vehicle to do this.

Steve Foots, *CEO Croda International and Chemistry Council Industry Co-chair*

[1] Office of National Statistics (ONS) Annual Business Survey (ABS) 2016 published Nov 2017

UK Industrial Strategy at a Glance

Industrial Strategy is Built on Five Foundations, Grand Challenges and Key Policies[2]

We will set Grand Challenges to put the UK at the Forefront of the Industries of the Future:

AI & DATA ECONOMY
We will put the UK at the forefront of the artificial intelligence and data revolution.

CLEAN GROWTH
We will maximise the advantages for UK industry from the global shift to clean growth.

FUTURE OF MOBILITY
We will become a world leader in the way people, goods and services move.

AGEING SOCIETY
We will harness the power of innovation to help meet the needs of an ageing society.

[2] HM Government, UK Industrial Strategy: Building a Britain fit for the future (2017)

CHEMISTRY COUNCIL INDUSTRIAL STRATEGY:

Executive Summary

The Chemistry Council's Strategy is a market led strategy aligned with the UK's four Grand Challenges. The market opportunity identified is around £200Bn, but a long-term plan and funding are required to deliver this opportunity.

A Market Led Strategy Identifying ~£200Bn of Opportunity

The Chemistry Council Strategy has a strategic action plan, set out in its 12 innovation programmes and 26 priorities, which will deliver sustainable growth for the Sector in the UK.[3] The Strategy needs to be delivered as a cohesive strategy and requires a long-term funding plan. The Strategy lays out ambitious targets to drive the sustainability agenda and to increase the Sector turnover by 50% by 2030.

The Chemistry Council Strategy: Sustainable Innovation for a Better World

The Chemistry Council Strategy, published in November 2018, lays out a vision to transform the industry through the development of a new generation of **sustainable materials and systems**. The Strategy sets out ambitious targets to drive economic growth from disruptive technology, to support the creation of new jobs in the regions and to facilitate a move to Net Zero.

It is a **'create and make'** strategy, supporting the creation and development of new materials in the UK but also, more importantly the deployment and manufacture of new technologies in the UK. The **'create and make'** approach ensures that investment in research is realised in the UK and that the research investment delivers skilled and stable jobs in regionally dispersed areas of the UK.

Key aspects to be delivered are:

(i) A new generation of sustainable materials for a variety of end uses.

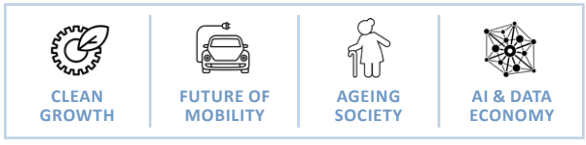
(ii) Materials and infrastructure critical to deliver the UK's Clean Growth agenda and move towards Net Zero.

(iii) Regional infrastructure to attract investment in new manufacturing facilities and skilled jobs into it's regional clusters.

Industry of Industries: Working in Partnership with Other Sectors

The Chemistry Council companies are found at all stages in the industrial supply chain, from upstream raw materials to downstream consumer products, and are therefore critical for both the Sector itself but also to underpin other Sector Strategies.[4]

Recent work has highlighted the importance of new materials for batteries required to deliver the Electric Vehicle (EV) Revolution. Critical and strategic materials need to be developed and manufactured in the UK otherwise the value created in the UK will be realised outside of the UK. The CC has a crucial role to play in supporting other Sector Strategies, such as the **Automotive, Lifesciences and Construction Sectors**, by delivering innovative materials and molecules. Therefore, this Sector Deal is important not only for the CC community but also to underpin other Sector Strategies.



Chemistry Council Sector Deal

The Chemistry Council is seeking a commitment to invest **£1Bn over 5 years**.

[3] Chemistry Council Strategy (2018) Sustainable Innovation for a Better World

[4] Divisions 20 50 21 of the Standard Industrial Classification: basic chemicals, agrochemicals, paints and coatings, soaps and detergents and cleaning preparations, toiletries and cosmetics, speciality chemicals for industrial use and pharmaceuticals

Chemistry Council Industrial Strategy at a Glance

Sustainable Innovation for a Better World[3]

The Chemistry Council Strategy, published in November 2018, lays out a vision to transform the industry through the development of a new generation of sustainable materials and the creation of carbon efficient systems.

The Strategy lays out ambitious goals to drive the sustainability agenda and to increase the Sector turnover by 50% by 2030. It is a 'create and make' strategy, supporting the creation of new materials in the UK but also, more importantly, the manufacture of disruptive technologies in the UK.

However, these targets will not be met without a comprehensive and coordinated strategy that is funded properly and managed centrally by industry.

IMPACT FOR THE UK: SIGNIFICANT TARGETS HAVE BEEN SET FOR 2030

DRIVING SUSTAINABLE INNOVATION...

75%
SUSTAINABLE PRODUCTS

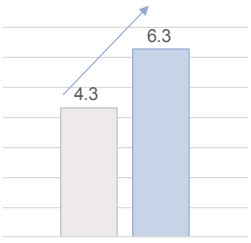
ELIMINATION
OF SINGLE-USE PLASTICS

NET ZERO
BY 2050

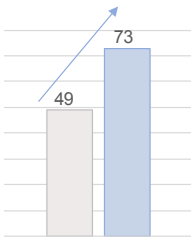
Aligned with the United Nations Sustainable Development Goals, with a focus on supporting the delivery of six of those goals.[5]

BRINGING ECONOMIC VALUE AND JOBS...

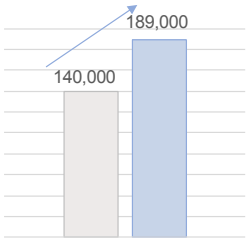
+£2Bn
ANNUAL INVESTMENT



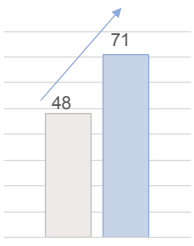
+£24Bn
TURNOVER



+49K
JOBS



+23Bn
EXPORTS



[5] UN General Assembly, Resolution adopted by the General Assembly, September 2015

The Chemistry Council: Industry of Industries

The Chemistry Council (CC) is a joint industry/government Council representing chemistry-based industry to government. The sector is one of the **most diverse** in the UK, providing products and infrastructure critical to the UK's Industrial Strategy and the target to reach **Net Zero** by 2050.

The Council represents the wider chemistry-based industry – one of the UK's largest and most diverse industry sectors, ranging from basic and specialty chemicals for industrial use to consumer chemicals. The sector is unique, linking critical parts of the supply chain – from energy and feedstocks (raw materials), to advanced materials, fine chemicals, life sciences and consumer products. It is the **'industry of industries'**, being both its own biggest customer and a provider of materials and technologies to other important sectors such as aerospace, automotive and construction.

VITAL TO THE ECONOMY

96% of all manufactured products use chemistry.

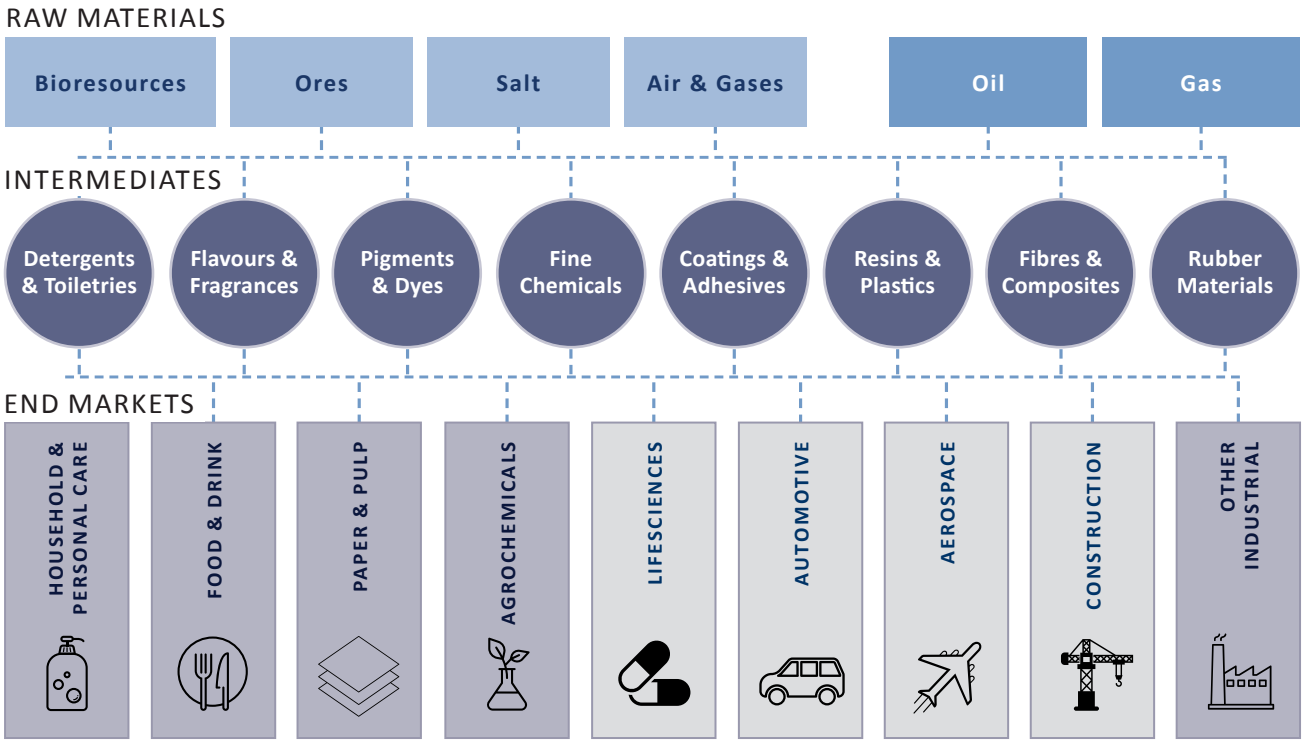
A VIBRANT AND COMPETITIVE SECTOR

£18Bn
GROSS VALUE ADDED

£49Bn
TURNOVER

400K
EMPLOYED

SUPPORTING ALL AREAS OF INDUSTRY



THE CHEMISTRY COUNCIL: INDUSTRY OF INDUSTRIES

INNOVATIONS IN CHEMISTRY

The chemical industry is both its own biggest customer and a provider of materials and technologies to other important sectors.

STEP CHANGE

MEDICAL

Designing and Manufacturing Treatments for an Ageing Population

LINK TO CHEMISTRY:

- Hip replacement cement – Polymethyl methacrylic
- Non-latex gloves – Nitrile butadiene rubber
- Antiseptic wipes – Benzalkonium chloride
- Sedative – Benzodiazepine
- Eye drops – Chloramphenicol
- Dentures – Polymethyl methacrylic
- Cough medicine – Dextromethorphan

AEROSPACE

New Aerostructures, Improved Joining Technologies, Better use of Composites and Multiple Materials

LINK TO CHEMISTRY:

- Seat fabrics – Polyamide
- Paint – Titanium dioxide
- Coatings – Methyl methacrylic
- Fuel tanks – High-density polyethylene
- Fuel additive – 2,4-Dimethyl-6-tert butylphenol
- Doors and frames – Carbon fibre

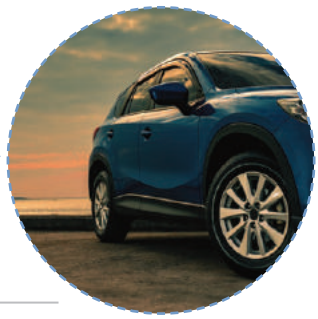
CONSTRUCTION

Establishing Lower Energy Buildings and Faster Build Times

LINK TO CHEMISTRY:

- PVC doors and windows – Polyvinyl chloride
- Paint – Titanium dioxide
- Insulation – Expanded polystyrene
- Perspex – Polymethyl methacrylic
- Tyres – Solution-styrene-butadiene rubber
- Safety hats – Acrylonitrile butadiene styrene
- Low voltage insultation – Low-density polyethylene

AUTOMOTIVE



Accelerating the Move to EVs, Through Innovative Battery Technology

LINK TO CHEMISTRY:

- Cathode – Metal oxide or phosphate containing lithium
- Anode – Graphite
- Electrolyte – Organic carbonates

Creating Lighter Vehicles, Reducing Emissions and Improving Range of EVs

LINK TO CHEMISTRY:

- Coatings – Methyl methacrylate
- Airbags – Sodium azide
- Bumpers – Polypropylene
- Headlamp lenses – Polycarbonate
- Tyres – Solution-styrene-butadiene rubber
- Screenwash – Ethylene-glycol
- Fuel tanks – High-density polyethylene
- Emission control – Catalysts

Key UK and CC Policies Include:

IDEAS

GOVERNMENT

- Raise total R&D investment to 2.4% of GDP by 2027.
- Increase the rate of R&D tax credit to 12%.
- Invest £725M in new Industrial Strategy Challenge Fund programmes to capture the value of innovation.

INDUSTRY

- Accelerating the rate of commercialisation of innovation in the UK, via a 'Create Accelerator'.
- Generating a new pipeline of sustainable materials for a variety of different applications.
- Generating sustainable products to support the focus on Clean Growth and Mobility of the Future.
- Commercialising disruptive technologies supporting Net Zero.
- Ensuring the underpinning science base is supported and developed.

INFRASTRUCTURE

GOVERNMENT

- Increase the National Productivity Investment Fund to £31Bn, supporting investments in transport, housing and digital infrastructure.
- Support electric vehicles through £400M charging infrastructure investment and an extra £100M to extend the plug-in car grant.
- Boost our digital infrastructure with over £1Bn of public investment, including £176M for 5G and £200M for local areas to encourage roll out of full-fibre networks.

INDUSTRY

PLACES

GOVERNMENT

- Agree Local Industrial Strategies that build on local strengths and deliver on economic opportunities.
- Create a new Transforming Cities fund that will provide £1.7Bn for intra-city transport. This will fund projects that drive productivity by improving connections within city regions.
- Provide £42M to pilot a Teacher Development Premium. This will test the impact of a £1,000 budget for high-quality professional development for teachers working in areas that have fallen behind.

INDUSTRY

- Facilitating inward investment by:

(a) Building marketing capabilities for each region.

(b) Ensuring strategic raw materials are in place, utilising new technology.

- Attract ten large (£50-250M) and ten smaller (£10-50M) commercial-scale chemical manufacturing facilities in the next five years, at an intervention rate of 10-15%.

- Increasing competitiveness of the location for existing manufacture and new manufacture by:

(a) Supporting cheaper forms of energy.

(b) Introducing cost competitive structures, such as private wire network arrangements.

(c) Establishing Free Ports.

Key UK and CC Policies Continued...

PEOPLE

GOVERNMENT

- Establish a technical education system that rivals the best in the world to stand alongside our world-class higher education system.
- Invest an additional £406M in maths, digital and technical education, helping to address the shortage of science, technology, engineering and maths (STEM) skills.
- Create a new National Retraining Scheme that supports people to re-skill, beginning with a £64M investment for digital and construction training.

INDUSTRY

- Engage with wider society and school children, in particular, to promote the industry through programmes such as Children Challenging Industry and the Catalyst Science Discovery Centre.
- Focus on training and developing STEM entrepreneurs of the future by scaling SCI's Bright SCIdea Entrepreneurs Challenge Programme.
- Ensure the sector has a strong pipeline of STEM graduates required to deliver its strategy.
- Work with Government and other organisations, such as Cogent and CIA, to continue to build the pipeline of apprentices for the sector.

BUSINESS ENVIRONMENT

GOVERNMENT

- Launch and roll out Sector Deals – partnerships between government and industry aiming to increase sector productivity. The first Sector Deals are in life sciences, construction, artificial intelligence and the automotive sector.
- Drive over £20Bn of investment in innovative and high potential businesses, including through establishing a new £2.5Bn Investment Fund, incubated in the British Business Bank.
- Launch a review of the actions that could be most effective in improving the productivity and growth of small and medium-sized businesses, including how to address what has been called the 'long tail' of lower productivity firms.

INDUSTRY

- Support the development, demonstration and deployment of new low-carbon technologies.
- Encourage the adoption of an 'Innovation Principle' in UK law.
- Support Clean Growth by building cost competitive and carbon efficient supply chains.
- Ensure strategic raw materials are identified and plans are in place to underpin inward investment.
- Develop strong partnerships with the key downstream sectors, and ensure they have access to a pipeline of new materials to support delivery of their sector strategies.
- Support SMEs and start-ups to grow and build critical mass.

Chemistry Council Response to Ideas:

Delivering Against the UK Grand Challenges

Chemistry builds molecules that define the functionality of a product. It is estimated that over 95% of all products have a chemistry component and, as such, the Sector is a key part of the future of the UK manufacturing sector. The Sector is already highly innovative, it spends significantly on research and development, and works with a range of UK Universities and Institutions.

Disruptive Innovation

The Chemistry Council's Innovation Programme aims to transform the Sector, driving step-change growth from the development and adoption of new products and processes. The programme is focused on delivering innovation that is **sustainable** by developing a pipeline of novel sustainable materials for a wide range of applications, including consumer, health and wellbeing, automotive and construction products, which are in support of the Clean Growth, Future of Mobility and Ageing Population Challenges.

Priority Projects

The CC Innovation Programme is extensive, covering all four challenges, but a number of priority projects have been identified and highlighted in the Appendices (pages 20-47). Success in the Innovation Programmes will lead to increased employment and investment boosting local economies, with potential for export and inward investment further enhancing the value potential. They are also vital to delivering Net Zero by 2050 goal.

MAP OF CC INNOVATION PROJECTS

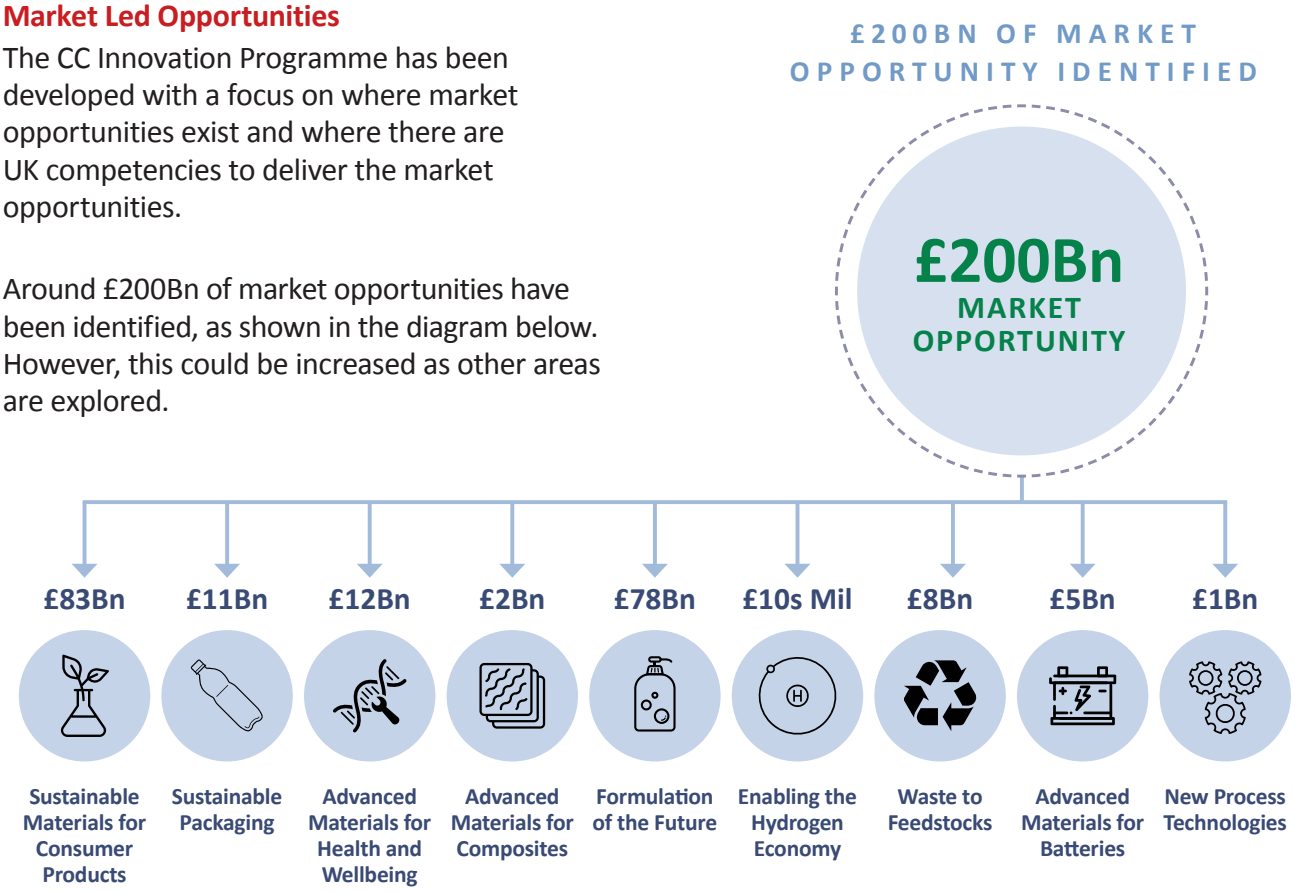
LINK TO UK INDUSTRIAL STRATEGY GRAND CHALLENGES	INNOVATION THEMES AND PROGRAMMES	
CLEAN GROWTH; AGEING SOCIETY; AI & DATA ECONOMY; FUTURE OF MOBILITY	Sustainable Materials and Molecules	Sustainable Materials for Consumer Products Sustainable Packaging Advanced Materials for Health and Wellbeing Advanced Materials for Composites Formulation of the Future
CLEAN GROWTH	Sustainable Systems/ Supply Chains	Waste to Feedstocks Industrial Symbiosis and Resource Efficiency
CLEAN GROWTH; FUTURE OF MOBILITY	Energy Transition & Climate Change	Enabling the Hydrogen Economy Advanced Materials for Batteries
AI & DATA ECONOMY	Digitisation and Big Data	Digitisation of Supply Chains New Process Technologies Big Data in Design

Market Led Opportunities

Market Led Opportunities

The CC Innovation Programme has been developed with a focus on where market opportunities exist and where there are UK competencies to deliver the market opportunities.

Around £200Bn of market opportunities have been identified, as shown in the diagram below. However, this could be increased as other areas are explored.



Transformative Infrastructure

The Clean Growth agenda is to transform the UK's economy **to reach Net Zero, whilst supporting economic growth.** New energy systems need to be developed in order to achieve this. These will require enabling infrastructure, some of which will rely heavily on the Sector to deliver. Infrastructure for the processing and recycling of materials, building new forms of energy, such as a hydrogen economy, and managing carbon in closed loop systems all require the CC and its community to deliver both innovation and investment.

Much of this infrastructure will be in the regions so the work of the CC Innovation Committee and Regional Committee will be heavily integrated.

Other Areas to Explore

The £200Bn market opportunity could increase as other areas are explored. There are opportunities for innovations in chemistry across a range of sectors including Construction, Marine, Aerospace, Infrastructure, AgriFood and Electronics.

£1Bn Sector Deal Overview

Sector Deals are Critical to the Commercialisation of New Technology

Sector Deals form an important part of the UK Industrial Strategy. Highlighted in the 2017 UK Industrial Strategy document they are the mechanism for ensuring the commercialisation of strategic projects required to underpin future industrial and economic growth.

They are designed to compliment other forms of funding but are critical for:

- Driving an Industry Strategy, ensuring an efficient use of resource.
- Ensuring significant strategic projects and disruptive technology platforms that otherwise would not be funded are not only developed but are exploited in the UK.
- Facilitating investment in critical enablers that are required to ensure success.
- Ensuring that the responsibility for the commercialisation of new scientific innovations are with the industry that have the expertise and capabilities required.

£1Bn Sector Deal Over 5 Years

This £1Bn Sector Deal proposal will be made up of £500M from Government and £500M matched funding from industry. The industry matched funding has already been committed.

£1Bn SECTOR DEAL

FACILITATING INVESTMENT AND GROWTH IN THE UK

This £1Bn Sector Deal proposal will be made up of £500M from industry and £500M from Government. This investment will fund key projects in 3 areas; Innovation, Regional Development and Skills.

› Innovation - The 'Create' Accelerator: Accelerating Innovation Into Industry

- Managing an extensive Innovation Programme developing:
  - Materials for Electric Vehicles/the Automotive Supply Chain
  - Infrastructure for Hydrogen Economy
  - Sustainable Materials and Systems for consumer products
  - Continuous Flow Technologies for pharmaceuticals
- Providing a one-stop-shop for SMEs to grow

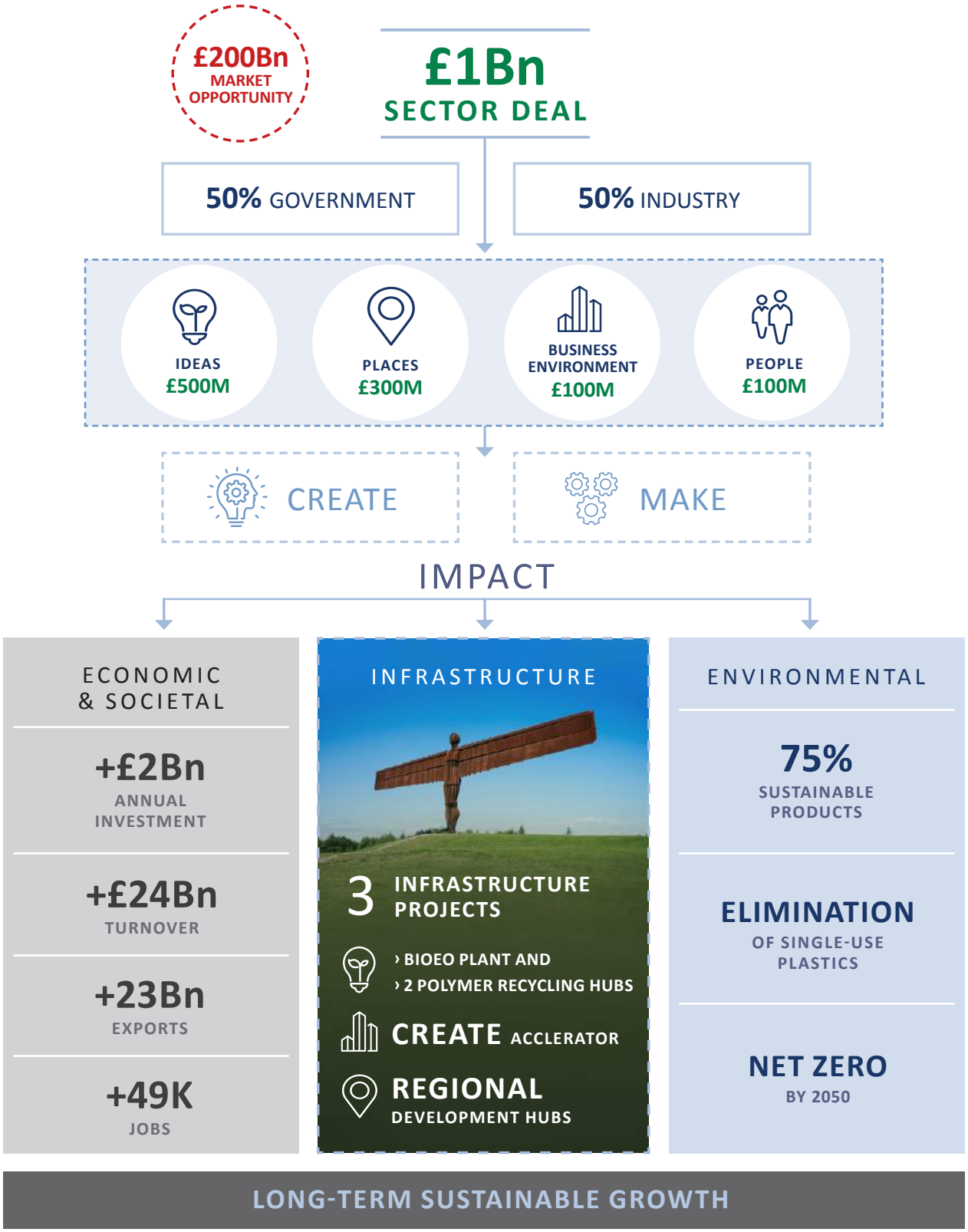
› Regional Development Hubs: Driving inward investment

- Including three transformative infrastructure projects: **Bio EO plant** in the UK and **two polymer recycling facilities** in the NE and NW

› Skills Development: Developing a Modern Workforce

- In both **'Create'** and **'Make'**

£1Bn Sector Deal Overview



Commitment and Governance

Chemistry Council Commitment

The Chemistry Council represents a diverse range of companies operating at various stages of the supply chain. These companies invest in research and development, and the scale up of new products and processes. They also work with many Universities and Institutions, including many UK Universities. A recent survey showed that a group of companies invest around £2.5Bn globally with only around 40% of this being in the UK[6]. This presents a real opportunity for the UK should the environment be right for investment post Brexit.

Collectively, the companies in the Chemistry Council have already committed **£500M of matched funding over 5 years** to support the projects outlined in this proposal.

However, Government support is also required to de-risk these significant projects and accelerate the innovation and commercialisation of these disruptive technologies.

Chemistry Council Sector Deal Board

A new governance structure will be established to manage the Sector Deal. A Sector Deal Board is proposed, consisting of representatives from government, the Chemistry Council and key stakeholders with an independent industry institution to manage and administer the resources. The Board will be responsible for overseeing the delivery of the Strategy, the management of funds and for monitoring performance.

The Chemistry Council companies are key in underpinning the Northern Powerhouse.

[6] SCI Company Investment Survey (2018)

Timeline to Implementation:

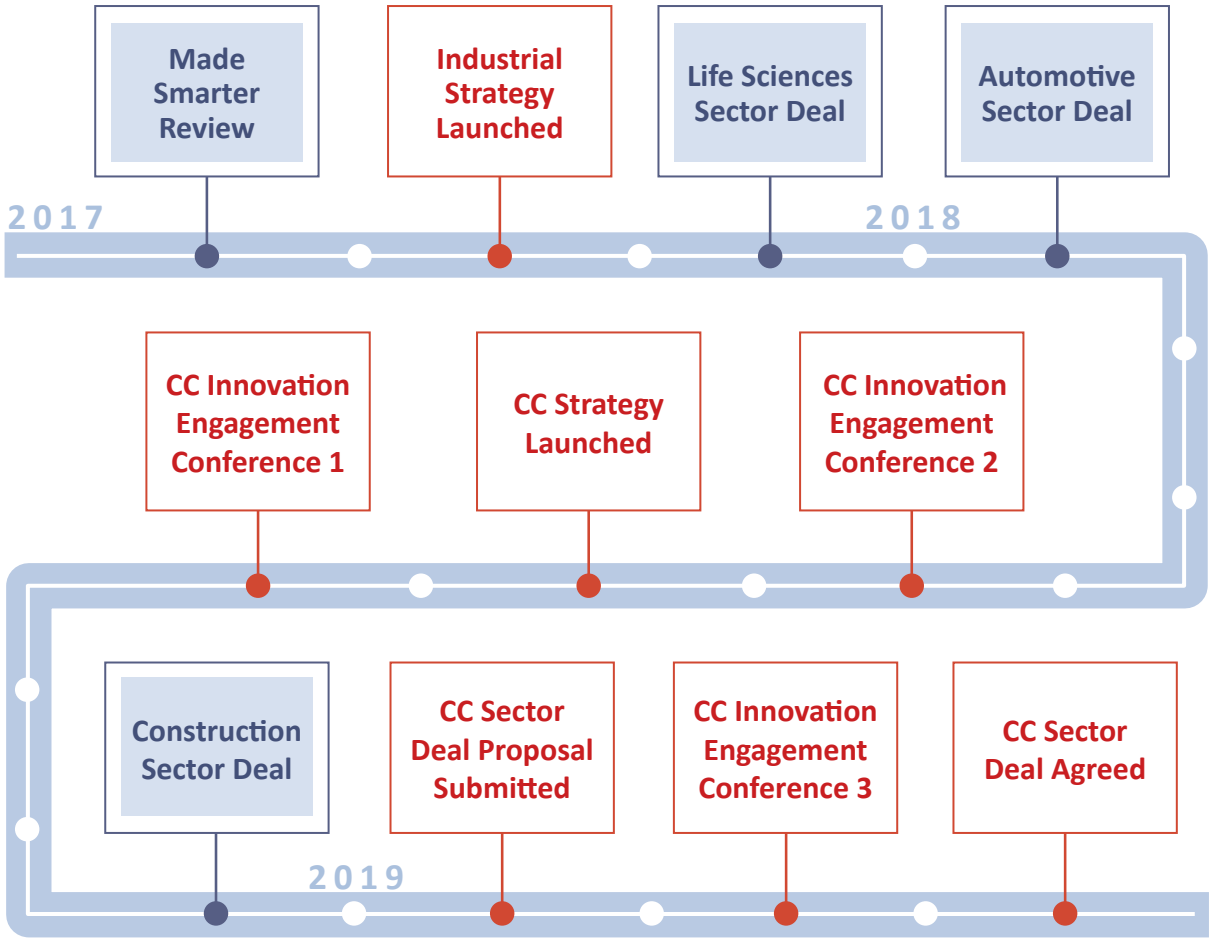
Path Towards a Sector Deal

The Chemistry Council has undergone an extensive process towards a Sector Deal. This has included the update of the 2013 Strategy Document and rebranding of the Chemistry Growth Partnership to the Chemistry Council.

A series of engagement events were included in the process to allow the wider sector to validate the Strategy and Innovation Projects.

With Government support, the Chemistry Council can implement this proposal starting January 2020, yielding significant economic, environmental and societal benefits to the UK by 2030.

DEVELOPMENT OF CC STRATEGY AND SECTOR DEAL



Contributors

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- Algaceuticals
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- Chemical Industries Association (CIA)
- Chemical Sciences Scotland (CSS)
- Chemicals North West (CNW)
- Cogent
- Contract Chemicals
- Croda
- Department for Business, Energy and Industrial Strategy (BEIS)
- Department for International Trade (DIT)
- Drochaid
- Dow
- E4tech (UK) Ltd
- GlaxoSmithKline (GSK)
- IChemE
- INEOS
- Innovate UK
- Inovyn
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- Ricardo plc
- Royal Society of Chemistry (RSC)
- Society of Chemical Industry (SCI)
- Scottish Enterprise
- Smart Separations
- Synthomer
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- Tees Valley Unlimited
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- UCL
- UK Catalysis Hub
- UK Research and Innovation (UKRI)
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- University of Leeds
- University of Lincoln
- University of Nottingham
- University of Sheffield
- University of Warwick
- University of York
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- WITNET Ltd
- Womble Bond Dickinson (UK) LLP
- Wyfold Ltd
- Yorkshire & Humber Cluster

CIA Chemical Industries Association
Working for chemical and pharmaceutical businesses

Thanks to CIA and SCI for their work on the development and creation of the Sector Deal.

SCI where science meets business

Appendices

APPENDIX 1: Ideas Projects

Delivering Net Zero: *Designing Sustainable Materials and Sustainable Systems*

The drive to sustainability requires new approaches. New sustainable materials need to be designed and new sustainable systems enabling cradle-to-grave-to-cradle materials management need to be created.

Options for developing sustainable materials include switching to bio based raw materials, however ensuring this approach does not take away critical resources from the food chain and designing new materials with enhanced sustainability profiles (for example more biodegradable, lower toxicity etc).

Closed loop systems (Circular Economy) from the manufacture of materials back to the recycling and reuse of those materials do not exist today and these will need to be designed and enabled, by the use of new positive regulation and incentives.

The challenges in creating new sustainable materials and sustainable systems should not be underestimated. The former requiring disruptive technologies and the latter requiring fundamentally new approaches for the UK. However, action is required if the UK is going to significant shift the dial towards Net Zero.

Sustainable Materials:

- Bio derived
- New processes
- Material redesign

Sustainable Systems:

- Recycle and reuse

The market opportunity in several areas already identified by the Chemistry Council is substantial and is shown below. However there are a number of significant market areas that have not been fully assessed yet, meaning that the opportunity for Chemistry is more significant.

Additional Areas Not Currently Covered:

There are opportunities not currently covered that will also yield significant market opportunities, and these are being investigated.

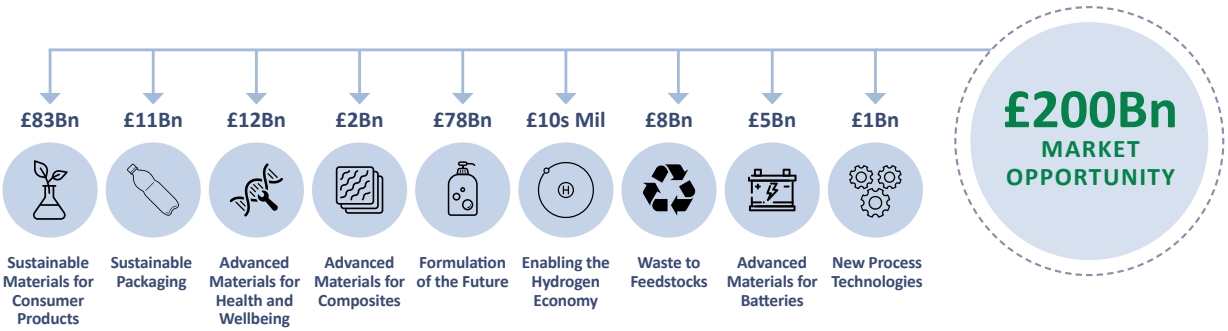
These include:

- AgriFood
- Construction
- Aerospace
- Marine

Underpins:

Fundamental underpins are also required, such as:

- Development of fundamental technologies e.g. Catalysis and Green Chemistry
- Certification and Standards
- Life Cycle Analysis

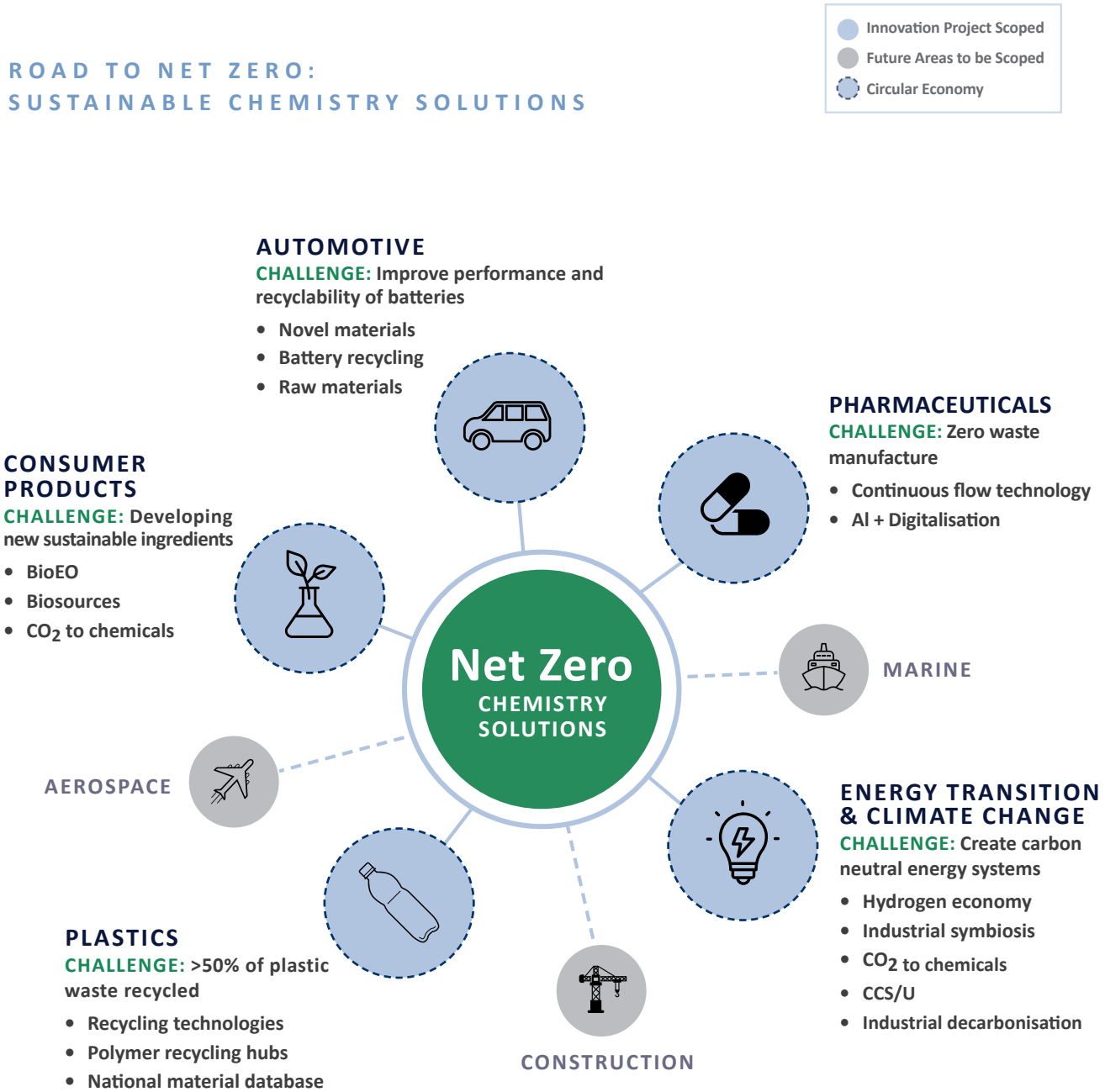


Ideas Projects Continued

The Chemistry Opportunity

The map below outlines the key market areas covered by this document.

ROAD TO NET ZERO:
SUSTAINABLE CHEMISTRY SOLUTIONS



Ideas Projects Continued

Developing Sustainable Materials for Consumer Products

Challenge: Developing a host of new ingredients for chemical processes which are more sustainable and have increased functionality.

Demands on products are rising, both in terms of functionality but also environmental profile, and a new wave of sustainable materials are required to meet societal needs. Developing a strong pipeline of new, innovative materials that are sustainable is at the heart of the Chemistry Council Innovation Strategy.

Growing Market

The sustainable materials market is a large, with the global market for consumer products alone estimated to be valued at over £500Bn[7]. The switch to sustainable materials is growing at pace. In 2017, consumer product companies claimed a total of over 10,000 consumer products were sustainable, this was compared to zero in 2002[8].

The market consists of a wide range of different products, such as surfactants and additives, and more sustainable alternatives need to be designed and then formulated into end products. The UK market alone is estimated to be worth £180Bn[9]. Products are supplied to a wide variety of end markets but the CC is seeking to focus initially on the Consumer Products market as this is where there is high growth, a need for technological changes and where the UK has particular strengths through an integrated supply chain.

The UK Opportunity

The Chemistry Council plans to realise this opportunity through developing and launching novel, sustainable ingredients. The challenge is to redesign product ranges based on new technology platforms, rather than individual products, and this will require significant investment to be committed over a minimum of 5 years.

The UK is well placed to develop and commercialise these materials having strong technology capabilities in the raw materials, the ingredients and the finished products, with companies operating at all stages of the supply chain.

Impact

The CC is looking to make a significant switch towards sustainable materials with **75% of ingredients used in UK manufactured products to be sustainable by 2030.** This work programme will support the UK's Bioeconomy Strategy[10] and will contribute to the goals laid on in the 25 year Environmental Plan[11].

Government Support Required

Significant investment is required from both industry and Government to both develop and commercialise new ranges of sustainable materials. £100M is sought to carry out technology screening studies and to drive a collaborative R&D programme. In addition, a further £150M is required to invest in new manufacturing facilities for strategic raw materials, such as Bio Ethylene Oxide (BioEO) (covered in pages 24-25), that will precipitate a fundamental shift in the technology base from fossil fuel based to bio based materials.

[7] Estimates from the Chemistry Council Innovation Committee

[8] GNPD Mintel

[9] UK Formulated Products Sector: Strategic Priorities 2018

[10] Growing the Bioeconomy: Improving lives and strengthening our economy (2018)

[11] A Green Future: Our 25 Year Plan to Improve the Environment (2018)

Ideas Projects Continued

Sustainability Solutions for Consumer Products
The consumer product market is one where there is a need for sustainable technology, however the area is complex as a multitude of ingredients are used across an extensive range of products.

The UK has a strong presence across this length of the supply chain and having raw material, intermediate and consumer companies all collaborating together will facilitate a significant shift that would otherwise not be achievable.

Three key areas for development have been identified, these being:

- Development of Sustainable Materials
- Development of Sustainable Packaging
- Enabling Smart Formulation of the New Materials

Developing Sustainable Materials for Consumer Products – aiming to identify and manufacture sustainable materials, targeting 75% sustainable consumer products by 2030. Within this area there is a call for Research, Development and Commercialisation (CR&D) funding to develop new sustainable ingredients.

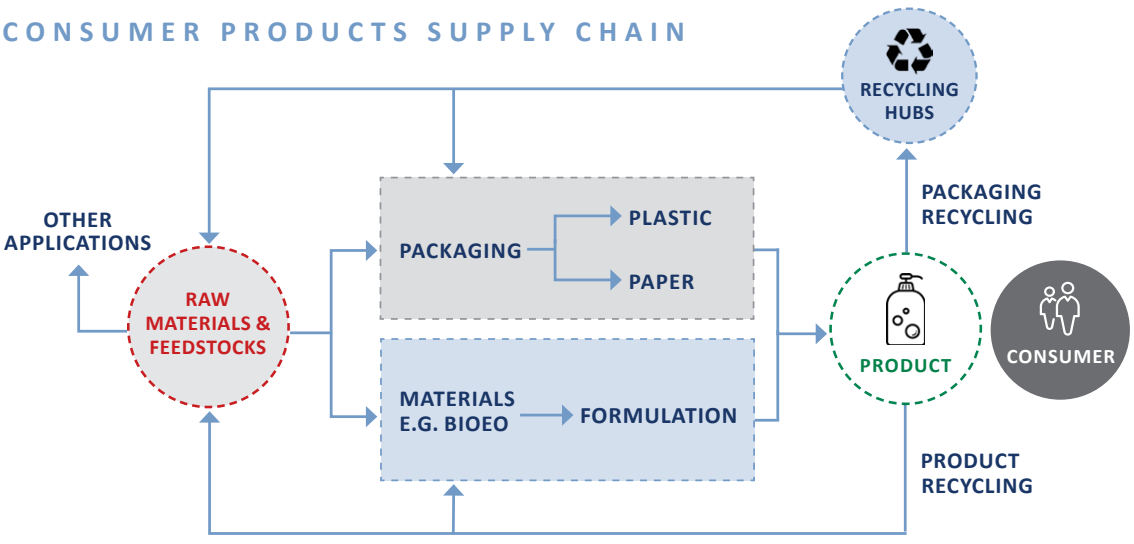
A specific project, which involves the manufacture of BioEO in the UK, has also been identified.

Smart Sustainable Packaging (SSP) – this is the switch to sustainable packaging. Funding for SSP is covered in the Industry Challenge Strategy Fund (ICSF) Wave 3, so is not included in this Sector Deal.

Formulation for the Future – all new ingredients need to be formulated into an end product. Formulation is a complex area as multiple ingredients, each designed to have their own functionality, need to be blended together whilst ensuring the overall functionality of the end product is delivered. Formulation is required across most industrial areas. Funding has already been given to establish a new Formulation Centre at Darlington providing important facilities for industry. This Centre alongside the Materials Innovation Factory at Liverpool University, are critical parts of the infrastructure for Formulation in the UK.

Whilst two out of these three areas have received funding, additional funding is required to develop a new wave of sustainable materials. This funding will provide the opportunity to disrupt the sector by creating sustainable materials and systems that will deliver consumer products but in a way that minimises impact on the planet's resources.

THE CONSUMER PRODUCTS SUPPLY CHAIN



Ideas Projects Continued

Sustainable Materials: Establishing BioEO Capability in the UK

Challenge: Re-establishing a strategic raw material in the UK, supporting investment and growth but based on sustainable, non-fossil fuel raw materials.

Ethylene oxide (EO) is a global strategic raw material, used in the production of an extended variety of intermediates. EO has been used in 30-40% of skin and hair care products launched in the last 20 years[12] and it is a critical raw material for over 40 industries. Replacing EO with a bio-based derivative would make a significant contribution to reaching the goal of making 75% of ingredients sustainable by 2030.

Growing Market

The global materials for consumer goods market amounts to over £500Bn. Each consumer product is made up of many ingredients and EO derivatives are a critical component of many ingredients. In 2016, the global EO capacity was 34.5M tonnes per annum, with a Compound Average Growth Rate (CAGR) of 4.3% in 2011-2016[13].

The UK Opportunity

Previously a major player in EO the UK no longer performs manufacturing, rather material is now imported.[14] The use of imported product has further weakened the supply chain reducing the consumption and use of EO and derivatives in the UK. The knock-on effect of moving derivative manufacture also out of the UK has been a loss of investment and skilled jobs.

Establishing a BioEO plant in the UK would provide a bio-based source of raw materials for the multitude of derivatives supplied into a wide range of end markets. It would spur a new generation of bio based derivatives that would find use in a range of consumer products. It would also provide an opportunity to grow exports.

The technology has already been developed and the supply chain to produce and consume BioEO and derivatives exists in the UK. Challenges around securing raw materials sources and de-risking the investment would need to be met. However, with the technology and the supply chain already in place, the time impact would be significantly shortened and a new plant could be operational within 5 years.

Impact

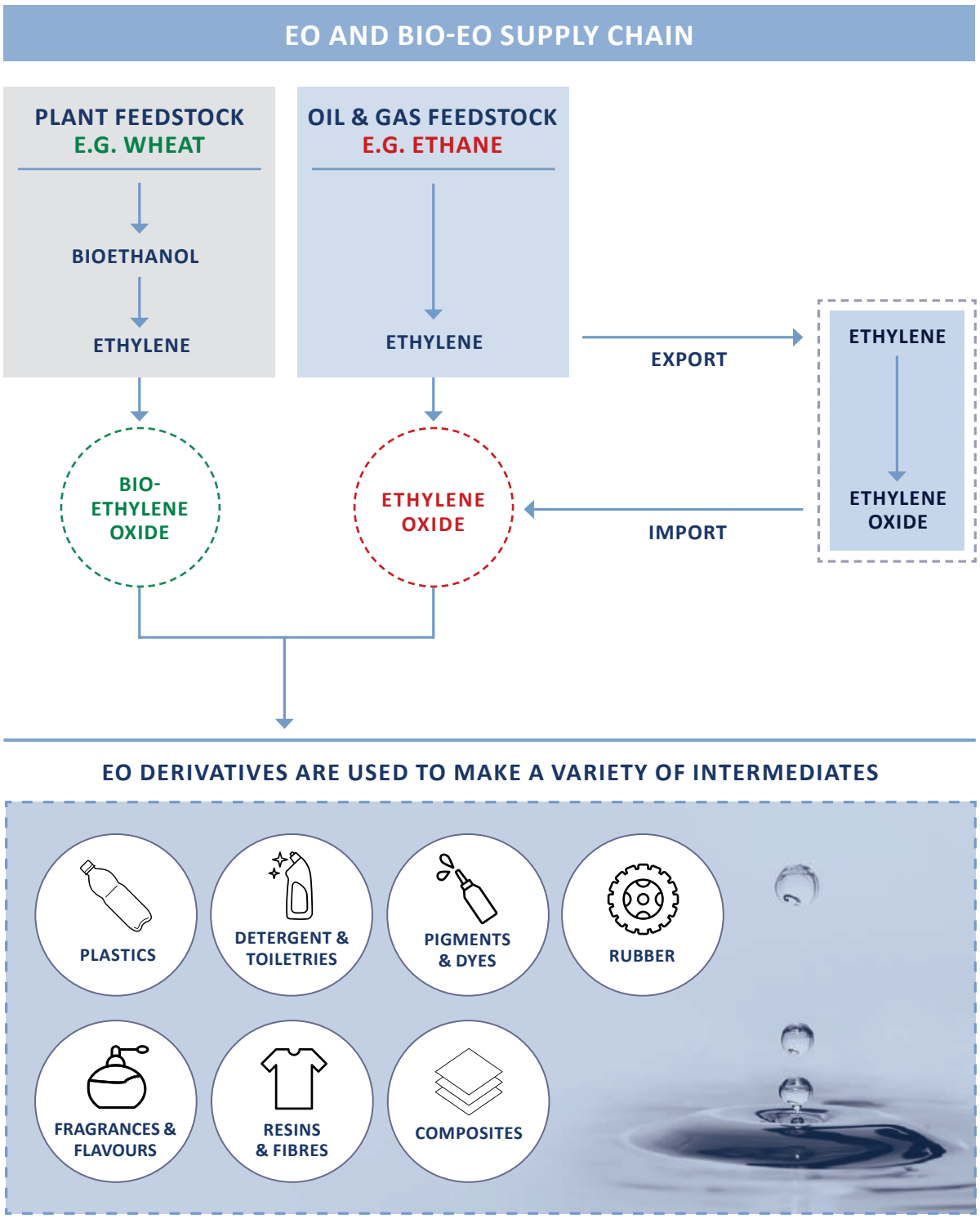
This delivery of a BioEO plant in the UK would have the single biggest impact in terms of moving towards 75% sustainable materials by 2030. It would involve investment of around £150M, bring over 200 new jobs and establish significant new exports, all of which will support the economy.

Government Support Required

For these targets to be achieved significant investment is required from both industry and Government to develop the investment case and to de-risk the investment.

[12] CRODA: Connecting to Faster Growth Markets (2018)
[13] The Global and China Ethylene Oxide Industry (EO) Report, 2017-2021
[14] United Nations Statistical Office

Ideas Projects Continued



Ideas Projects Continued

Materials for Mobility: Building an Integrated Automotive Supply Chain

Challenge: Improving the performance and recyclability of batteries through integrating the supply chain whilst reducing the negative impact on cost and sustainability.

2.4M new cars are purchased annually across the UK. In order to meet the government target outlined in the Air Quality Plan 2017, to end the sale of all new conventional petrol and diesel cars and vans by 2040, it is predicted that by 2030 64% of all new cars purchased annually will be electric.[15] However, there are battery performance, supply chain and recyclability challenges that need to be resolved in order to drive this transition towards low carbon transport. The opportunity for the UK to create a vertically integrated battery supply chain in the UK, from materials manufacture, through to battery and car manufacture in the UK, establishing the UK as a vibrant and competitive hub for electric vehicle and battery manufacture.

Growing Market

The rise of electric vehicles has generated a demand for greener battery technology resulting in a growing Li-ion battery market, which alone was valued as £27.5Bn in 2017[16]. The Li-ion battery market is expected to grow to over £55Bn in 2025 of which over £30Bn is predicted in electric cars and buses. As such, the battery market has an impressive growth rate (CAGR) of 19% per year to 2025.[16]

A recent independent report valued the UK chemistry and materials opportunity in support of this growing market at £4.8Bn by 2030[17], with the revenue from the chemical materials used in Li-ion batteries valued at £11.2Bn in 2017[16]. This is an opportunity to build a strong automotive supply chain, securing key materials, battery manufacture and EV car manufacture in the UK.

In addition Li-ion batteries have a lifespan of 8-10 years, after which they are either reused in non-automotive applications or go to landfill. There is a significant market to develop innovative recycling technology to recover the valuable raw materials inside batteries.

The UK Opportunity

Manufacturers of raw materials for batteries are predominantly in Asia, with China being the world's largest battery manufacturer, and there is strong competition from global competitors to be the first to innovate and make new materials.

Developing a local battery supply chain will provide better security for the UK manufacturing industry, notably the automotive industry, whilst ensuring that the UK is at the forefront of delivering critical battery technology. Battery technology is expected to play a key role in other areas such as short haul aviation and off-grid energy storage, supporting the move towards renewable energy, and developing the critical materials in the UK is important for security of supply and supporting the growth and development of these other industry sectors.

Improving Battery Performance

In order to realise these opportunities a step change in the battery technology is required. Targets include an increase in the power and energy density of batteries and improvements in the cost, charging time and temperature operating range of batteries required to drive an increased adoption of the technology.

[15] Faraday Institution: The Road to Electrification – from Internal Combustion Engine to the Battery Electric Vehicle (2019

[16] Avicienne Energy, Rechargeable Battery Market and Main Trends 2017 – 2025, pub. 2018

[17] AUTOMOTIVE BATTERIES: REPORT SUMMARY (April 2019)

Ideas Projects Continued

Improved Li-ion components able to hold increased charge, particularly electrode materials (inorganic materials like silicone and graphene actives, polymer binders and additives), as well as commercially viable next generation technologies (solid state, Li-S, Li-air, etc) need to be developed.

The solutions will come from chemists designing advanced materials for the cathode, anodes and other component parts of the battery that will meet the cost/performance requirements of the Automotive Industry.

Battery Recycle and Reuse

Further challenges lie ahead in the recycling and reuse of batteries, ensuring a true circular economy approach to EVs. Although not currently an identified issue yet in this nascent market rapid adoption of EVs will result in a corresponding issue of how best to manage the end of life of the batteries. This, coupled with the fact that batteries contain some components (rare earth metals such as cobalt and lithium) that are high value and rare, means that the recyclability of batteries could be a key enabler to competing and building value for the UK.

With a well-established Chemical Industry, the UK is in a strong position to develop the recycling processes and innovative technology required to recycle batteries. This approach could ensure that key raw materials are recycled and reused, ensuring security of supply of rare materials.

Lithium: Securing a Strategic Raw Material

Lithium is a critical raw material for the current Li-ion battery and has been identified as such by the UK government.

Lithium is mined in several countries around the world but concern is already mounting that forecast demand in EVs will outstrip supply and prices are already rising. In addition, security of supply at competitive cost will be critical to ensuring the UK can grow an EV market based on the current generation of Li-Ion batteries.

The UK actually has natural sources of lithium. The presence of lithium in Cornish mines is known and Cornish Lithium is expanding its operations in Cornwall. However it has been identified that the aquifers in the North Sea are also rich in lithium and the high concentrations could mean that cost effective extraction, with appropriate process technologies could be possible. However new extraction techniques may be required. Developing efficient and commercially viable extraction methods of lithium will further support both the Clean Growth agenda and the Future of Mobility.

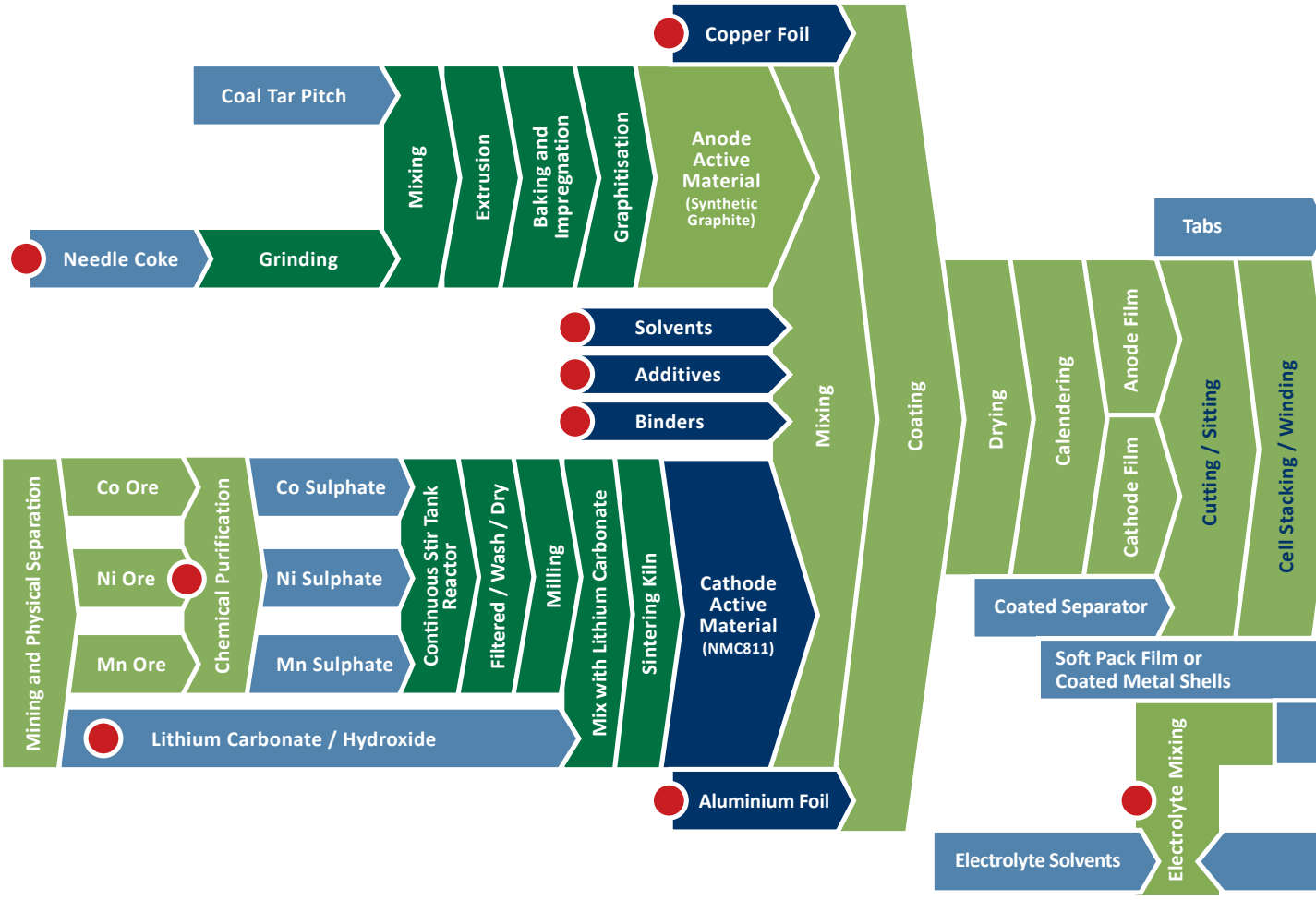
Impact

Ensuring an integrated UK battery and EV supply chain will increase the output and improve the competitiveness of the UK Automotive Industry, whilst providing opportunities for the Chemical Industry. This will in turn lead to increased tax revenue and the societal benefits of enhanced employment and skill retention within the UK.

Increased investment in battery technology will allow for the full replacement of internal combustion engines and enhanced storage of renewable energy, supporting the UK's Future of Mobility and Clean Growth Grand Challenges and the move to Carbon Neutral. This will be beneficial for the environment and reduce emissions resulting in improved air quality.

The Chemistry Council is **committed to developing a strong relationship with the Automotive Council** and collaboration across the two sectors is important for the delivery of both sector strategies.

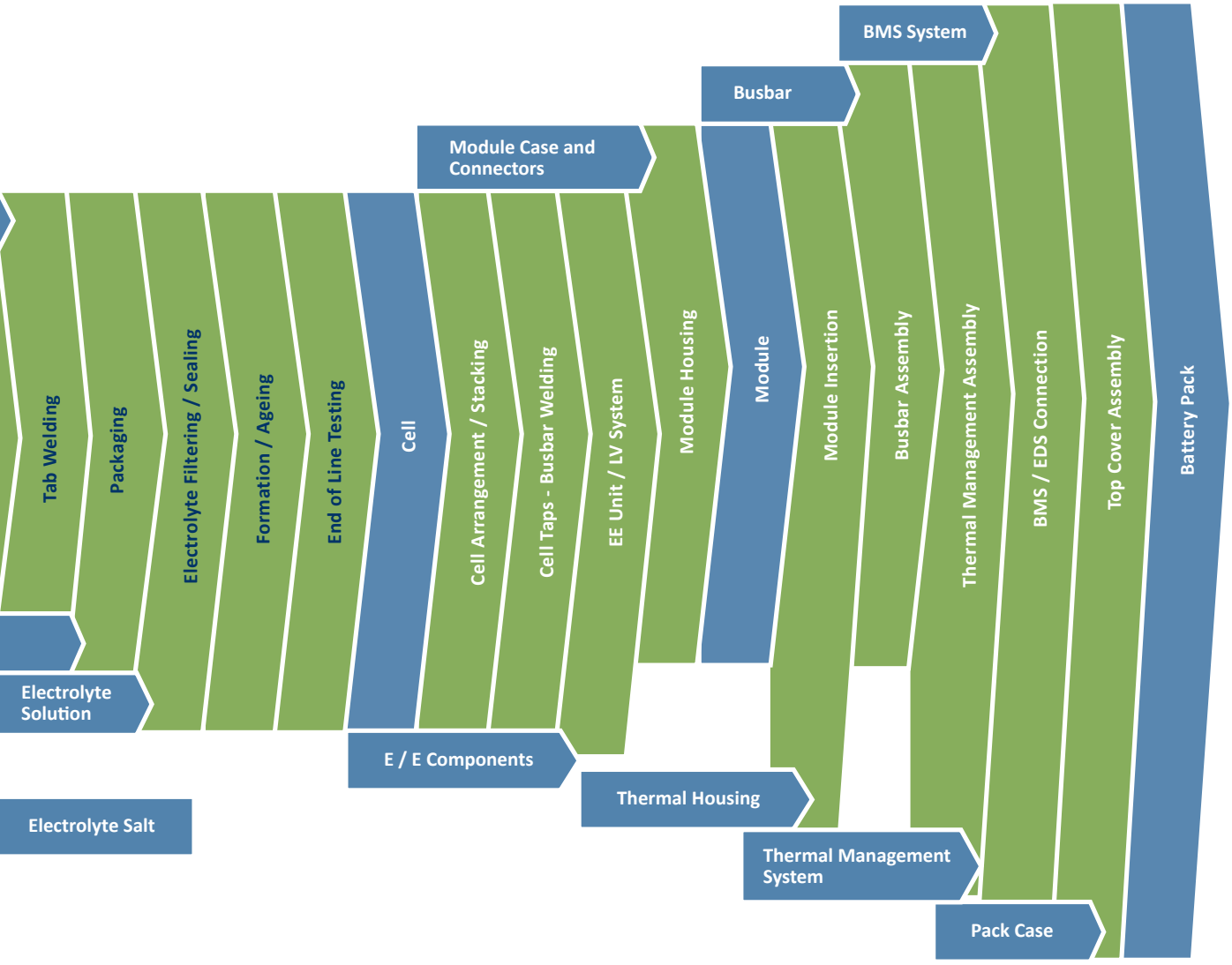
COMBINED AUTOMOTIVE + CHEMISTRY COUNCIL ROADMAP[18]



[18] Value chain structure, Automotive batteries, Produced by the Advanced Propulsion Centre UK and Innovate UK, Supported by KTN & WMG, University of Warwick, Authored by E4tech

£4.8Bn
ANNUAL POTENTIAL
FOR CHEMICAL SECTOR FROM SUPPLY CHAIN IN 2030

- Green panels indicate a manufacturing process
- Darker green panels indicate manufacturing processes where UK companies have indicated they are willing to invest if a strong demand signal is made by the UK automotive industry
- Blue panels indicate a semi-finished product
- Dark blue panels indicate a semi-finished product where UK companies have indicated they are willing to invest
- Red highlights indicate current UK activity that could be built upon in the future



Ideas Projects Continued

Government Support Required

Investment support is required in several areas, although it is recognised that significant funding has already been established via the Faraday Challenge and the UK BIC, both of which the Chemistry Council strongly supports.

Collaborative R&D

- £30M+ (2021-2024): innovative projects to develop novel battery chemicals and materials and continue to allow chemical sector to collaborate with automotive value chain to develop new supply capability.
- Short to medium term:
  - Li-Ion cathode improvements
  - Silicon / graphene anodes
  - Binders / solvents
  - Electrolyte additives / solid electrolytes
  - Separator materials
- Longer term:
  - Sodium Ion chemistries
  - Lithium Sulphur
  - Lithium metal anodes

Pilot and Scale-Up

- £30M (2020-2022): 3x kg materials scale up and testing facilities to allow chemicals sector to test and rapidly commercialise novel battery chemicals and materials.

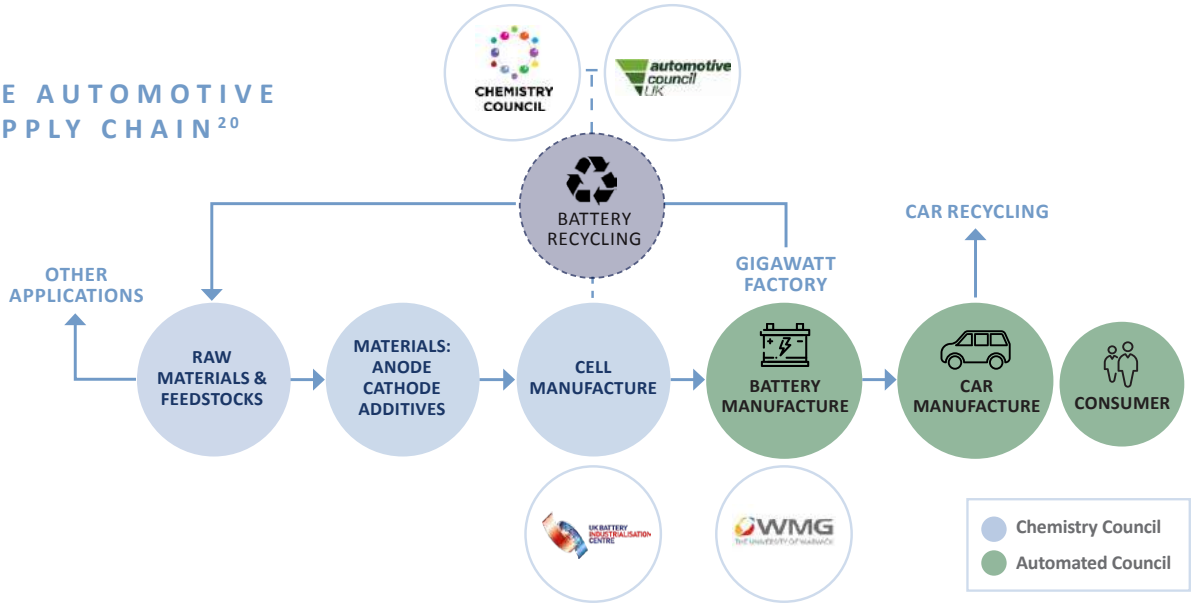
Battery Recycling Technology

- £20M (TRL 3-5) 2020-2025: innovative projects to develop novel recovery & recycling technologies, develop processes and products to utilise secondary raw materials and design for recycling, with provision for skills development.
- £220M (TRL 5-7) 2020-2030: £20M to allow demonstration at kg scale, then £200M (£100M matched) starting in 2025 to demonstrate at tonne scale to accelerate commercialisation.

Standards and Regulation

- £5M for standards and testing development (2021-2022): Funding to bring together chemical and battery sector to develop new standards for testing.[19]

THE AUTOMOTIVE SUPPLY CHAIN[20]



[19] Chemistry Council and Faraday Meeting refined output

[20] Adapted from WMG, University of Warwick - AUTOMOTIVE BATTERIES 101 (July 2018)

Ideas Projects Continued

Continuous Flow Technologies for Pharmaceuticals

Challenge: Developing continuous systems that self-regulate, self-analyse and self-optimise.

Batch reactors represent the current state of play across much of the fine, specialist and pharma sectors. Although considerable levels of control can be achieved using this technology a competitive advantage can be gained using flow chemistry when it coupled with AI control of key kinetic parameters.

Growing Market

The UK continuous flow market was valued at £786M in 2016, growing at 9.9% CAGR. Globally the market for continuous flow is predicted to reach £1.87Bn by 2025.[21]

Chemical and pharmaceutical manufacture is the UK's largest manufacturing export sector adding £17.8Bn GVA to the economy annually. Parts of this sector currently rely on batch reactors, in particular for the production of fine chemicals and pharmaceuticals. This valuable and growing market represents a significant opportunity to accelerate the adoption of continuous flow systems whilst optimising the process through combining advanced engineering and analytics with digital control through flow-systems.

The UK Opportunity

The transfer over to continuous flow represents a significant opportunity for parts of the UK Chemical Industry. The UK is already ranked 8th in global manufacturing, with a strong chemical industry.[22] This represents the significant manufacturing infrastructure in the UK alongside a growing understanding of the importance of digital skills by Universities and Industry. The cross-skill nature of this proposition (engineering, chemistry, digital) requires a highly skilled workforce and the UK is home to strong education infrastructure in engineering, chemistry and in-line monitoring. This capability will enable the adoption and optimisation of continuous flow technology and increase the UK's competitive advantage in this area.

Impact

Conducting complex chemical reactions under flow conditions offers numerous advantages for industry. The reduction in footprint and associated services brings down capital cost, the low reaction inventory and high level of containment give rise to safer operating conditions for hazardous and/or high energy chemistry and the resultant intensification of the approach gives improved sustainability metrics. In addition, this technology has been demonstrated to be effective in delivering a consistent quality for products. This project is seeking to build on these advantages by introducing AI-controlled self-optimisation of flow systems that would result in considerable timesaving in developing new products and processes.

Government Support Required

Government support is required in the form of scoping studies, CR&D funding and assets for digital design software.

[21] Grand View Research: Flow Chemistry Market Size Worth $2.39 Billion By 2025 (2019)

[22] https://www.themanufacturer.com/uk-manufacturing-statistics/

Ideas Projects Continued

Energy Transition & Climate Change: Industrial Decarbonisation

Challenge: Reducing the emissions produced by industrial clusters and energy intensive industries, whilst increasing cluster efficiency and facilitating a circular economy.

Chemical sites worldwide are known to be well-integrated and highly clustered. They have a long history of 'third party' collaborations which optimise processes and valorise side streams. The UK has a particularly strong profile of industrial clusters and local economic partnerships (LEPs), fuelling the optimisation and valorisation goals. Still a wide range of opportunities remain untapped - downstream and upstream – to realise higher product and process intensities, e.g. by joining forces across sectors, closing value chain loops, sharing services and experience. This collaborative growth model will play a vital role in reducing carbon emissions and meeting Net Zero by 2050.

Growing Market

More energy intensive industries, or Foundation Industries, include sectors such as metals, ceramics, glass, chemicals, cement and paper. Collectively the Foundation Industries manufacture over 28M tonnes of materials per year, 75% of the total materials manufactured in the UK[23]. These industries are very energy intensive, utilising a significant amount of raw materials and energy, producing a lot of waste (41.1M tonnes of the 222.9M tonnes of waste produced by the UK in 2016 was commercial and industrial waste[24]) and around 50M tonnes of CO_2 per year[25].

The UK Opportunity

The UK industrial Strategy, its established processing industry clusters (in particular chemical) and its active local economic partnerships (LEPs), ensure an efficient industrial environment for advancing cross-sectoral collaboration and optimisation with a sound business case. This is strengthened by UK's world class academic R&D institutes, especially in the fields of industrial engineering and processing in all stages of the supply chain.

Based on the current landscape of UK industrial clusters there are opportunities which need both a technical and managerial approach.

- **Technical Challenges –** interactions and exchanges of energy and materials between companies of different sectors usually need treatment prior to being reused, recycled or recovered. The required conversion technologies, however, often don't exist or can't be directly applied – because they are not the core activity of the company, they can't be implemented on a site, they require turnarounds or investments, or they don't have the right readiness level for application.
- **Managerial Challenges –** collaborative interactions require understanding of other process sectors and tackling of any legal, economic, spatial or social constraint resulting from a collaborative scenario.

Impact

Industrial symbiosis offers economic, environmental and societal benefits resulting from the reduction of emissions, energy and

[23] EII ISCF bid:
- WSP Parsons Brinckherhoff & DNV.GL. (2015). Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050 - Glass
- Unknown author. (2018). UK Steel Production
- Manoharan, Tharaniya. (2007). Characterisation of Mineral Wastes, Resources and Processing technologies – Integrated waste management for the production of construction material
- WSP Parsons Brinckherhoff & DNV.GL. (2015). Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050 - Ceramics

[24] DEFRA: UK Statistics on Waste (2019) Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/784263/UK_Statistics_on_Waste_statistical_notice_March_2019_rev_FINAL.pdf

[25] WSP Parsons Brinckherhoff & DNV.GL. (2015). Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050 - Ceramics

Ideas Projects Continued

resources, as well as waste optimisation or valorisation. Changing the flow of products, goods and services from a linear into a circular value chain adds value to all three corners of the triple-P triangle (people-planet-profit).

- **Economic:** valorisation of coproducts, new markets and business deals.
- **Ecologic:** emission and waste reduction, energy and resource efficiency, renewables integration.

Government Support Required

Scoping Studies

Funding is a supplied for scoping studies. Sector plants, products, processes, facilities and utilities should be mapped, assessed and challenged for use 'outside the comfort zone'.

CR&D and Cluster Management

A range of new conversion technologies for accepting non-conventional streams with added value in other sectors (or districts) need to be developed.

Policy

The legislation surrounding waste is outlined in the European Waste Framework Directive (WFD), most recently amended in 2008 and although its introduction came with a lot of benefits to UK company responsibility it also contains uncertainties which limit the reuse and recycle of some substances for modern day industry.

Ideas Projects Continued

Energy Transition and Climate Change: Hydrogen Economy

Challenge: Develop and scale novel technology to generate, store and transport hydrogen, to begin the establishment of a hydrogen economy in the UK.

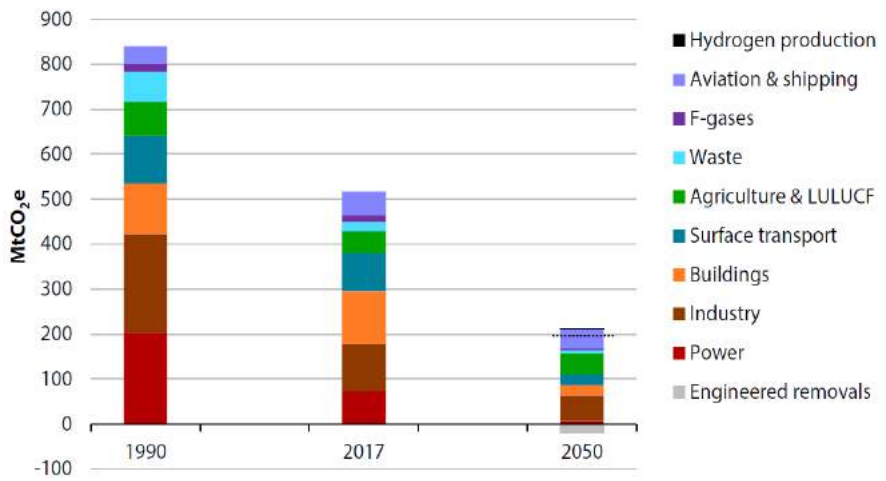
Following the advice provided by the Committee on Climate Change (CCC) in their recent 2019 report[26], the UK has amended the Climate Change Act, committing the UK to reducing greenhouse gas emissions by at least 100% of 1990 levels (net zero) by 2050[27]. Recent reports published by the CCC and the National Grid[28] have emphasised that developing a hydrogen economy is no longer just an option but a necessity if the UK is to meet these targets. However, there are several innovations around hydrogen generation, scale up, modelling and policy, which are needed to enable a hydrogen economy to be established in the UK, and to realise the export potential from technological leadership in this key global area.

Growing Market

Hydrogen is a flexible, low-carbon energy vector that can deliver across the heat, industry, power, transportation and storage sectors. As the global trend towards decarbonisation continues the market opportunity for a low-carbon energy source such as hydrogen grows significantly. The global market for energy storage is forecast to grow to US$7-10Bn by 2025[29] and a much larger market could be available if a hydrogen economy is developed – estimated at around $2.5 Trillion globally. The current UK market value of the hydrogen economy from early local deployment and export is of the order of tens of millions, and this is estimated to grow to hundreds of millions by 2025 and around $90Bn by 2050.[30]

Hydrogen generated from renewables and steam methane reforming (SMR)/ Autothermal

FIGURE 5.3.
2050 GHG Emissions in the Core Scenario Compared to 1990 and 2017



[26] Net Zero: The UK's contribution to stopping global warming, Committee on Climate Change (2019)
[27] The Climate Change Act 2008 (2050 Target Amendment) Order 2019
[28] Future Energy Scenarios (FES), National Grid (2019)
[29] IHS Markit report
[30] Estimation based on : 1) "Hydrogen and Fuel Cells: Opportunities for Growth - A Roadmap for the UK", by E4tech and Element Energy, November 2016, and references therein, 2)"Hydrogen Scaling Up – a sustainable pathway for the global energy transition", Hydrogen Council, November 2017

Ideas Projects Continued

Reforming (ATR) coupled with Carbon Capture and Storage (CCS) would enable a low-cost, low-carbon energy system. The CCC says that moving from an 80% GHG reduction target to 100% changes hydrogen "from being an option to an integral part of the strategy". Meeting the net zero target by 2050 will require a significant decrease in GHG emissions across all sectors, most notably power, buildings, transport and industry.[31] Hydrogen has a role to play across all of these sectors to enable the significant decreases in GHG emissions required, representing a significant market.

Globally, the UK is not the only country setting ambitious targets to reduce CO_2 emissions. The US, Sweden, Denmark and Norway have all set targets to achieve net-zero by years 2030 to 2050.[32] There are also additional targets under consideration in the EU, France and New Zealand. This represents a significant export market for hydrogen technology across the globe, estimated to generate $2.5 Trillion annual sales by 2050 and provide 18% of global energy.[33]

The UK Opportunity

It is clear that there is tremendous potential for the UK to take a leadership position in the embryonic area of the Hydrogen Economy and build on its already impressive global position in reducing carbon emissions from a number of sectors. The UK has scientists and engineers with the proven ability to innovate in this area as well as a thriving industry with the skills and capabilities to produce, handle and distribute this disruptive technology.

Outside of academic and industrial excellence, the UK is well placed in that its geology supports the long-term storage of hydrogen for inter-seasonal energy storage, as well as the storage of CO_2 from CCS infrastructure. Inter seasonal energy storage is essential to enable the increased use of renewables in energy generation, and hydrogen is one of the very few options for this. As world leaders in offshore wind with more installations than anywhere else in the world, the development of hydrogen as a storage mechanism offers a significant opportunity to the UK. In addition, the UK has a well-developed gas network connecting the whole country and around 85% of its dwellings.

Carbon Capture Utilisation and Storage (CCUS) is a major enabler for hydrogen generation through Advanced Gas Reforming. In their latest report the CCC emphasise that CCUS is essential to reach Net Zero, and this is reflected in the discussions around frameworks, targets, funding streams and taskforces established by Government from now until 2030. Through projects such as the Hydrogen Supply Competition and Hy4Heat, the Government has committed around £100M in this area to date, but much more is needed to enable the UK to stay ahead of the growing competition from other countries and to accelerate the development of hydrogen to ensure the net zero target is met.

Economic benefits will come from the leading position that the UK develops in the technologies to enable this broad energy transition, driving both a domestic and an export market, since lots of other countries are also starting to make commitments to Net Zero GHG on the 2030-2050 timeframe. However, for the UK to realise this opportunity it has to move quickly as there are countries, including China, Japan and South Korea, who have invested

[31] BEIS (2019) 2017 Greenhouse Gas Emissions, Final Figures; CCC analysis
[32] Net Zero: The UK's contribution to stopping global warming, Committee on Climate Change (2019)
[33] Hydrogen Council (2017) "Hydrogen scaling up: A sustainable pathway for the global energy transition"

Ideas Projects Continued

significantly in the hydrogen economy already. China intends to have over 1M fuel-cell electric vehicles (FCEV) on its road in 2030, supported by over 1,000 Hydrogen Refuelling Stations (HRS). Last year Chinese FCEV subsidies totalled $12.4Bn. In addition, China has deployed more renewable energy than any other country, but its utilisation is low, opening the possibility of using some of this electricity to generate hydrogen to drive elements of a hydrogen-based economy, including FCEV transportation.

Developing the technology and supply chain to ensure that the UK effectively monetises the technology will avoid repetition of the Li-ion battery story, in which the Li-ion battery was invented in the UK, but the majority of the revenues have been made in Asia. This will require understanding of how a Hydrogen Economy could practically be established in the UK, and some of this work could be carried out by the Chemistry Council.

Impact

Modelling of hydrogen scenarios for the CCC has shown that by 2050, 60% of the energy required by domestic, commercial and industrial heat users could be supplied by hydrogen through conversion of the gas distribution network. Several environmental benefits would accompany this movement, including a reduction in GHG emissions from the residential sector from 29 $MtCO_2$/yr in CCC's central scenario to 3 $MtCO_2$/yr25 and a substantial improvement in air quality. Introducing hydrogen to our energy system would majorly contribute to the UK's CO_2 and climate change targets.

On a societal level, the move towards the Hydrogen Economy will provide employment for many of those currently engaged in the automotive and Oil and Gas sector; this provides job creation in a number of regional centres associated with these industries, such as Scotland, Wales, the Midlands, the North West and North East of England.

There is also a significant economic benefit to investing in the hydrogen economy, as predicted by South Korea following their $2.2Bn investment announced in 2018 (see page 37).

Ideas Projects Continued

CASE STUDY -
The Predicted Impact of Investing in a Hydrogen Economy in South Korea

South Korea's Ministry of Trade, Industry, and Energy announced in June 2018 that along with private entities it would invest $2.2Bn through public-private partnerships to speed up development of the FCEV ecosystem in the country by 2022. The government plans to use subsidies to reduce the cost of FCEVs to around $25K by 2025, around half the current price, and to reduce the market price of hydrogen to $2.50/kg.

In addition, Hyundai has announced plans to invest $6.5Bn in FCEV production facilities and related R&D activities by 2030 to produce 500k FCEVs in 2030. The government aims to generate $36Bn worth of added value a year and create 420,000 new jobs in the market by 2040.

Ideas Projects Continued

Uses of Hydrogen Across Sectors:

As recognised in the Road to Zero report published in 2018[34], hydrogen has a role to play across many different sectors, not just transport. Many countries are taking steps towards achieving an integrated hydrogen society, with hydrogen being utilised across the economy as a whole:

- **Industry** – hydrogen can be used as an industrial feedstock for chemical reactions. Combining hydrogen and carbon dioxide to produce hydrocarbons would facilitate the production of sustainable materials, resulting in the reduction of virgin feedstocks.
  - o $H2 + CO_2$ = chemicals
  - o Hydrogen could also be used to heat industrial buildings, generate heat for thermal processes and provide the reducing atmosphere for steel manufacture.
- **Energy** – hydrogen can act as a low-carbon source of dispatchable power that can be used to supplement periods of low generation from renewables.
- **Transportation** – hydrogen fuel cells can power heavy goods vehicles (HGVs) and trains, which need to travel long distances and so are unlikely to be powered by batteries. They are also a very good option for fleet vehicles such as taxis and other cars that travel long distances and require high uptime, since fuel cell vehicles are more cost effective for long range applications and refuel much more quickly.
- **Residential** – hydrogen can be a low emission, energy efficient way to heat our homes and commercial buildings.

Government Support Required

In a number of areas, such as the deployment of hydrogen at scale, there is a need to "learn by doing", and the cost of projects to do this at the required scale requires Government support – industry simply doesn't have the funds to do this. Alongside financial support, policy support reduces the risk of investments, enabling industry to invest with more confidence. Some of the key chemistry-driven project areas that would benefit from funding within this Sector Deal are outlined below:

Collaborative R&D

- Innovative approaches to utilising hydrogen as an industrial feedstock to produce sustainable chemicals.
- Innovative approaches to generate and purify clean hydrogen at scale, including carbon negative production approaches such as hydrogen from biomass or waste gasification.

Scale-Up

- Collaborative technology development and innovation to work alongside large-scale demonstration programs such as those using hydrogen to decarbonise industrial clusters.
- Approaches to support the decarbonisation of current industrial manufacturing processes.

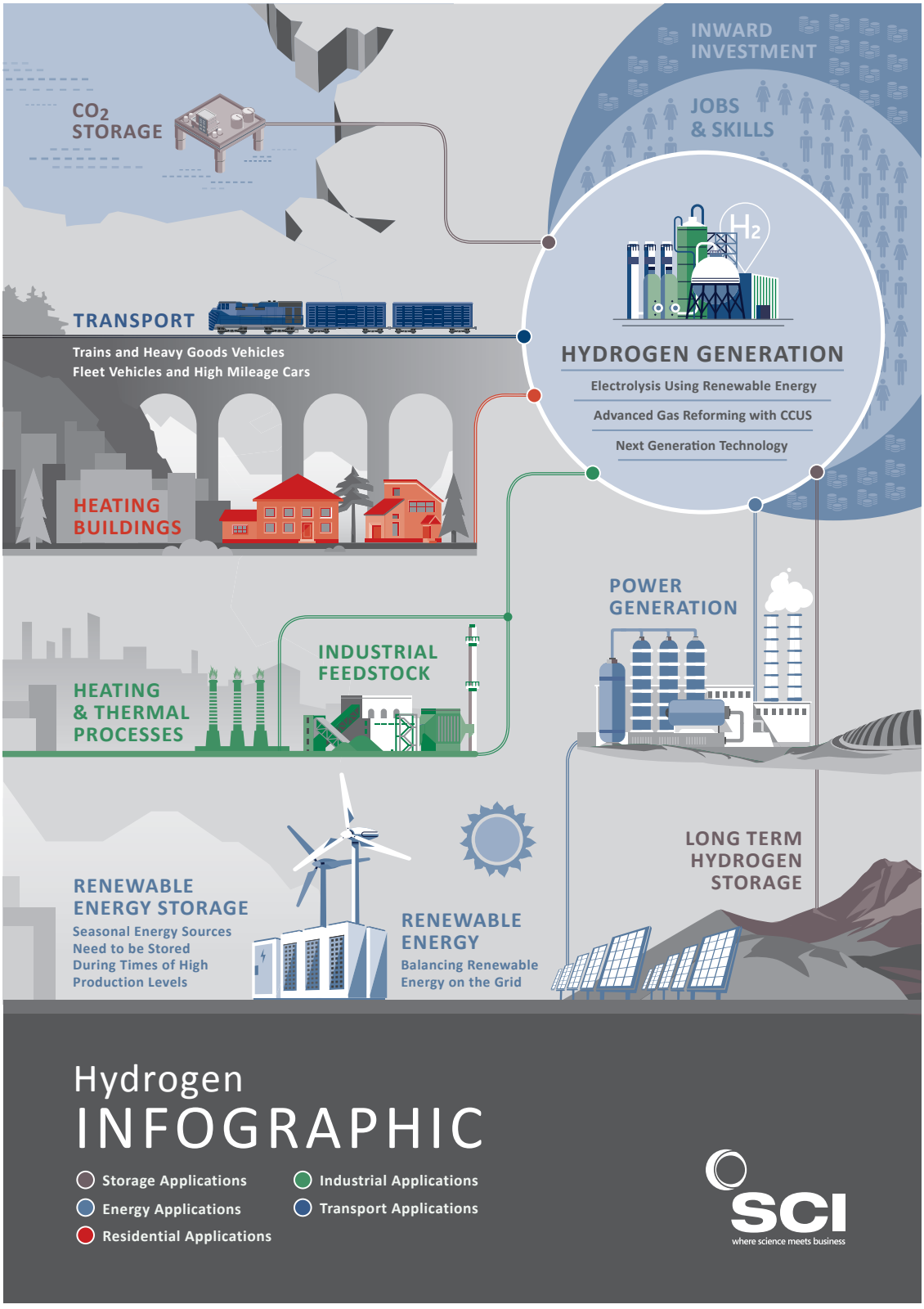
Modelling and Policy

- Energy systems and hydrogen modelling projects to define and cost the best ways to integrate hydrogen across its various potential usage sectors (energy storage, heat, transport, power generation, industrial processes).

£30M pa over 5 years will be required to drive projects in these areas to aid the transition to a hydrogen economy.

[34] HM Government, The Road to Zero (2018)

Ideas Projects Continued



Ideas Projects Continued

Digitisation of Supply Chains

Challenge: Develop the technologies required to create a prototype digitised supply chains in the UK.

Today product development through the supply chain consists of a series of mostly independent steps to generate the end product.[35] Incorporating digital technology throughout the supply chain would allow companies across the supply chain to share information on the products and components – from raw materials to finished product. This would assist with the management of products – both from a security and cashflow point of view as well as end of life / recycle management.

Growing Market

A survey across 200 operations executives found that three quarters of supply chain leaders believe more digitisation is needed.[36] This growing demand is driven by a number of factors:

1. **Improved Productivity –** digital technologies haven been shown to significantly improve productivity in manufacturing processes and business.
2. **Improved Cashflow Management –** by digitalising supply chains companies increase the efficiency and information flow between companies.

The UK Opportunity

The supply chains in the chemistry-using industries in the UK are very complex, often crossing borders several times before the final product is produced.

The introduction of extensive checkpoints when the UK leaves the European Union could increase the intricacy of the supply chains further. This makes innovation in digital technologies to improve interconnectivity across each manufacturing stage more important now than ever.

This demand alongside the expertise the UK has in digitisation enables us to take advantage of this opportunity. There are a variety of digital technologies which need to be developed to fully integrate the supply chain. Molecular tagging is one of these breakthrough digital technologies. Molecular tagging can be applied to chemistry-using industries to identify, target and track products through each stage of the supply chains.

Impact

The establishment of a digitised supply chain will enable increased efficiency and productivity across supply chains, provide greater transparency and the mechanism to manage the end of life and recycle processes, being more secure and sustainable supply chains.

Government Support Required

Government support is required for collaborative research projects to develop technologies, such as molecular tagging, and a protoype digitised supply chain.

[35] https://www.strategyand.pwc.com/media/file/Industry4.0.pdf

[36] https://www.consultancy.uk/news/16341/three-quarters-of-supply-chain-leaders-believe-more-digitisation-is-needed

Ideas Projects Continued

Big Data in Design

Challenge: Harnessing the power of Big Data to improve the efficiency, speed and scope of design, accelerating innovation.

The creation of new and disruptive digital technologies has led to increased productivity, efficiency and creativity across many sectors. This technology is growing at an unprecedented rate with Big Data and the Internet of Things predicted to be worth £322Bn to the UK by 2020[37]. A use of big data which is less explored is its use in designing new molecules and materials with the potential to be used across a whole host of sectors including pharmaceuticals and consumer products. This application of big data could improve the efficiency of discovery, resulting in accelerated innovation and reducing the associated costs.

Growing Market

There has been a significant increase in big datasets in chemistry over the past decade and this is accelerating due to the emergence of novel techniques to collate the data more efficiently.[38] As these datasets grow in areas such as kinetics, catalysis and molecular design,[39] big data will more accurately predict the outcome of reactions, reducing the need for extensive, expensive, experimental testing. The chemicals produced in this process could feed into a wide variety of markets such as automotive, aerospace, life sciences, construction and home and personal care.

According to a Forbes analysis 53% of companies in 2017 are adopting big data analytics, up from 17% in 2015.[40] The impact of data is beginning to be realised and understood by industry. A study by the World Economic Forum and Accenture, showed that digital technology could bring the industry a $550Bn benefit over 10 years—while reducing CO_2 emissions by 100M tonnes.[41]

The UK Opportunity

Many UK organisations are utilising big data to optimise production. An area less explored is using big data in design. The UK has a very impressive research base and a high calibre of academics and universities. This environment represents a significant opportunity to transform the research and testing process, from materials and pharmaceuticals, to formulation.

Challenges exist in that large datasets are required but these are also commercially sensitive so need to be handled by an independent body without the desire or need to create commercial value from these datasets.

Impact

Utilising big data in design would increase speed of design and development of new molecules and products. This in turn could result in an increase in production of innovative products, boosting the UK economy.

Government Support Required

The Chemistry Council is looking for support to develop a prototype materials and formulation database, to be used for materials design in the first instance.

[37] Report for SAS: The Value of Big Data and the Internet of Things to the UK Economy
[38] https://onlinelibrary.wiley.com/doi/full/10.1002/minf.201600073
[39] https://www.nap.edu/read/25191/chapter/1
[40] https://www.forbes.com/sites/louiscolumbus/2017/12/24/53-of-companies-are-adopting-big-data-analytics/
[41] https://www.accenture.com/us-en/insight-power-plant-operations

Ideas Projects Continued

Key Underpins: The Create Accelerator - Boosting Innovation and Collaboration

Challenge: Bringing industry together in a coordinated way to accelerate innovation for the benefit of society.

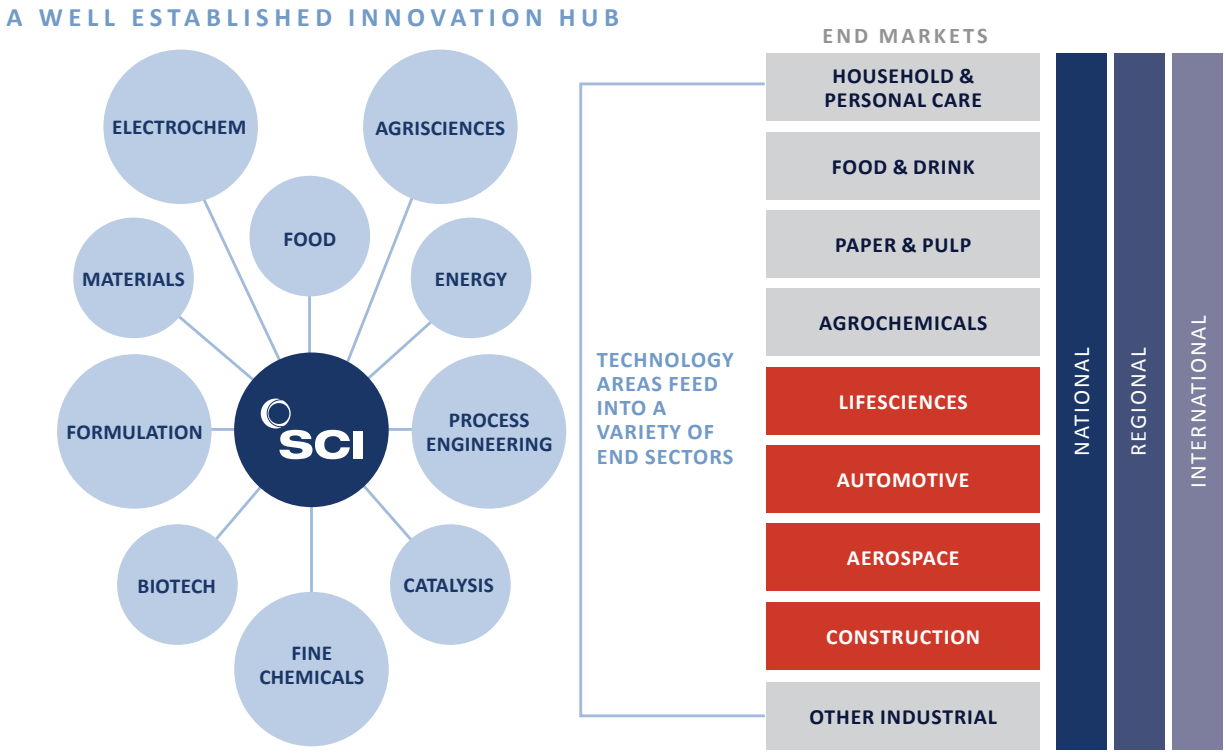
The Society of Chemical Industry (SCI) was established in 1881 to act as an innovation hub for the chemistry related industry. Working across academia and industry the organisation already has extensive activities in promoting and developing emerging technologies, building networks and collaborations, and in supporting the next generation of scientists and entrepreneurs.

Accelerating Impact through a Coordinated Approach

The sector is very diverse, as reflected in the activities within the Sector Deal. In order to maximise efficiencies and impact from funding it is intended to manage the innovation programme via SCI, reporting to the Sector Deal steering committee.

This will involve:

- Managing the CC Innovation Programmes ensuring resources are in place.
- Building communities and collaborations across academia and industry to develop and commercialise disruptive technologies.
- Launching and hosting the SME Accelerator (see page 45).
- Ensuring other critical underpins (such as Catalysis, Green Chemistry, Process technologies) are fully supported.
- Developing Certification and Standards.
- Delivering skills programmes building the next generation of STEM entrepreneurs.



APPENDIX 2: Business Environment Projects

Establishing the SME Accelerator

Challenge: Establishing a SME Accelerator to equip SME's with the tools to grow in the UK.

There are currently over 2,000 SMEs across the UK working in science-based areas, from Materials and Chemicals to Agrisciences and Pharmaceuticals.[42] These SMEs generate significant revenue for the UK economy, however, they often aren't able to access the support they need to grow. As part of the Sector Deal the Chemistry Council would like to establish an SME Accelerator for the Sector. This facility would accumulate a variety of services in one place to give SMEs the tools to grow.

Growing Market

Over 2,000 SMEs have been identified in the UK as working in the chemistry-making or chemistry-using industry. Around 68% of all companies across the UK are generating a revenue of between £0-1M pa. This is a significant market with the capability to grow with the right investment, although it is recognised that not all SMEs as seeking high growth.[43]

However, establishing and growing start ups in the science-based industries is complicated, as the technology often takes many years to develop, patent and often significant investment is required ahead of any material positive cashflows.

The UK Opportunity

The UK has a unique opportunity here. Over 40 businesses are started in Britain every hour, due to the encouraging environment which has been established for entrepreneurs. However, reports such as the Patient Capital Review have shown that in order for these businesses to scale up in the UK more support is required. This support needs to be continuous as the process to scale is long and can be many years until profits are realised.

A SME accelerator would act as a one stop shop for start-ups and SMEs, covering the following functions:

- Provide support for staff recruitment and training.
- Provide specialist advice related to the Sector (e.g. IP, scale up and regulation).
- Provide a service to confidentially connect start-ups with larger organisations who may be able to help accelerate the technology.
- Sign-posting to funding rounds.
- Provide advice on the facilities available to SMEs in the UK (e.g. via Catapults or other parts of the innovation ecosystem).
- Manage a SME vouchers system (funding) to assist SMEs to access the UK's available facilities and capabilities.
- Provide mentoring and connections.

SMEs are distributed across the UK, with the South East acting as a noticeable hotspot of activity for SMEs. The SME Accelerator would be run by SCI and would bring together existing activities carried out by SCI but would seek to scale them by providing dedicated resource to manage the SME Accelerator. SCI has the infrastructure and capability in place to connect with SMEs from all across the UK to assist them in scaling up.

Impact

Encouraging scale up of SMEs in the UK will result in significant economic benefit for the UK.

Government Support Required

The SME Accelerator will require £50M of investment to set up and run.

[42] National Survey of 13 technology sectors, April 2019 – Gibson Index Ltd, including Agrisciences, Biotech & Pharma, Chemicals, Cosmetics, Materials, Plastics & Composites and Processing.

[43] National Survey of 13 technology sectors, April 2019 – Gibson Index Ltd

APPENDIX 3: Place Projects

Creation of a Regional Development Hub

Challenge: Encouraging inward investment into clusters will help the sector grow by around £30Bn by 2050.

Currently there is little resource focused on attracting investment into the key clusters – Teesside, Humber Bank, Runcorn / Ellesmere port and Grangemouth. The Regional Development Hub will build capability in the regions by supporting regional development through effective marketing and de-risking the investment needed for large-scale projects such as new plant and processes.

Growing Market

As the UK exits the European Union it is important that the UK offers an attractive business environment, encouraging homegrown business to grow, invest in larger projects and attract external investors from overseas. Surveys have shown that up to 30% of firms are planning to leave the UK or have done so already.[44] As areas which understand industry, have appropriately skilled people and can provide synergies with existing companies, cluster parks are viewed highly favourably by inward investors. These benefits are currently under-advertised.

There are also many large scale, collaborative projects for the chemical industry to advertise, which could attract inward investments. There are new emerging opportunities such as utilising bio-resources, waste and recycling and low carbon technologies and secure supply chains. However, de-risking these opportunities is necessary if they are to take place. The Regional Development Hub will look into the implementation of one or more de-risk models, particularly for projects that require collaboration or demonstration facilities.

The UK Opportunity

The UK, particularly the key chemical sector clusters, has the infrastructure, skills and innovation hubs to be attractive for expansion of the sector. Clusters are especially attractive for the development of new low carbon processes, industrial symbiosis and heat recovery, projects that often need high degrees of collaboration.

However, the UK is often considered a high cost place to do business due to high energy costs and a stringent regulatory regime. This alongside the risk of investment and lack of resource has resulted in UK cluster parks that have not grown to the extent as they have done elsewhere.

De-risking investment coupled with effective showcasing of the UK's capabilities represents a great opportunity to grow the clusters to be amongst the best in Europe.

Impact

The development of resources for clusters will attract inward investment into the UK from overseas. Bringing new companies to these areas will facilitate innovation and increase turnover and employment in the regions. Collaborative projects, requiring demonstrator facilities, would potentially create tens of thousands of high skilled jobs in places with relatively high unemployment.

[44] Institute of Directors survey (2019) https://www.theguardian.com/politics/2019/feb/01/one-three-uk-firms-activate-plans-move-operations-abroad-no-deal-brexit-iod-survey

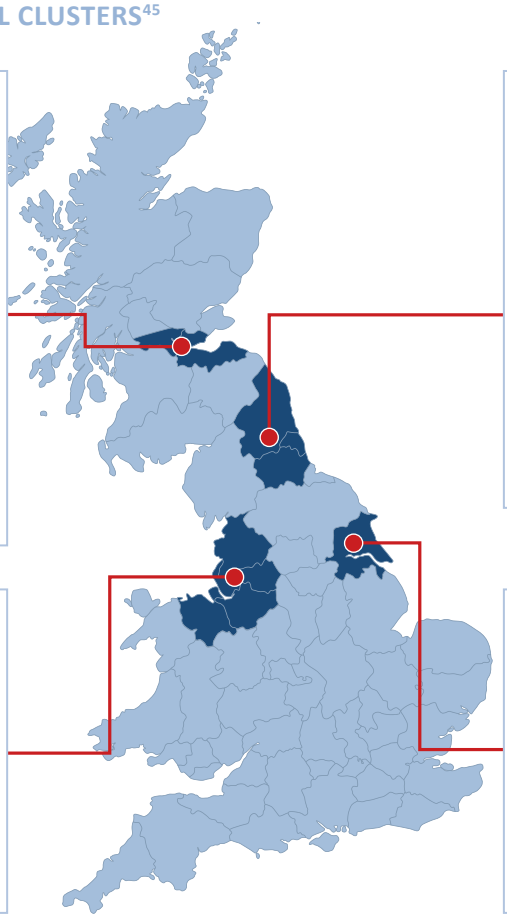
Place Projects Continued

Additional experience from investing in cluster parks shows that they produce lower emissions, less waste and use less energy per tonne of product than for similar non-clustered industry.

Government Support Required

Government support is required to provide resources to more effectively market the regional clusters globally, and to de-risk investment opportunities.

MAP OF FOUR KEY REGIONAL CLUSTERS[45]



SCOTLAND

Chemical Sciences SCOTLAND

Representative: Chemical Sciences Scotland
GVA: £1.4Bn
Employed: 10,200
Turnover: £3.1Bn
(All stats for SIC 19,20,21 in 2016)

Key Facilities:
- Large Scale Manufacture
- CMAC Future Manufacturing Research Hub
- Industrial Biotechnology Innovation Centre
- Forth Valley College
- Medicines Manufacturing Innovation Centre

NORTH EAST

nepic

Representative: NEPIC
GVA: £2.1Bn
Employed: 39,000
Turnover: £12Bn

Key Facilities:
- Large Scale Manufacture
- Wilton Complex and Centre Science Park
- CPI (National Biologics Manufacturing Centre & Printable Electronics Centre)
- Materials Processing Institute
- TWI. Technology and Training Centre

NORTH WEST

Chemicals northwest

Representative: Chemicals Northwest
GVA: £6Bn
Employed: 37,000
Turnover: £11Bn

Key Facilities:
- Range of Manufacturing from Petrochemicals to Specialities
- Ellesmere Port Complex

YORKSHIRE & HUMBER

CATCH YCF

Representative: CATCH and YCF
GVA: £1.8Bn
Employed: 21,000
Turnover: £4Bn

Key Facilities:
- Skills Development Facility
- Saltend Chemical Park
- Chemical and Energy Industries

NORTHERN POWERHOUSE

Total Turnover in Northern Powerhouse ≈ £27Bn

Number of Companies ≈ 728

Number of Employees ≈ 96,000

Note: It should be noted that while the sector is not entirely contained within these four clusters, they are important for driving growth, establishing new technologies at a commercial scale and supporting inward investment.

[45] Office for National Statistics (2015) licensed under the Open Government Licence v.3.0. Contains OS data Crown copyright. Updated from consultations with the Chemistry Council Regions Working Group (2018)

Ideas Projects Continued

Elimination of Single-Use Plastics: Recycling and Reuse of Plastics

Challenge: Developing and scaling the technology required to increase the volume of plastic which is recycled rather than landfilled or incinerated.

An estimated 95% of plastic value (estimated at £60-90Bn per annum) is lost to waste entering the environment, being landfilled, or incinerated. The issues with the use and disposal of single-use plastics have been recently uncovered and there is an urgent need to address this challenge globally. However, plastics are critically important materials for a wide variety of applications, therefore whilst elimination in some consumer applications may be possible the ability to recycle and reuse them is a pressing need.

Growing Market

The call for the elimination of single-use plastics is growing globally. In some applications replacement of plastics may be possible but there are many applications where plastics will be required and will remain the product of choice. The opportunity to utilise and find value from plastic waste is a growing market, with a £65Bn predicted waste processing and materials recovery market by 2030.[46]

Today an estimated 95% of plastic value is lost to waste entering the environment, being landfilled, or incinerated. This represents a significant opportunity by creating new feedstock, reducing the demand for fresh fossil feedstock and reducing overall CO_2 emissions. However, there are a significant number of challenges to be addressed in order to make significant recycling and reuse of plastics a reality as highlighted below.

Capture and Segregation

In order to valorise plastic waste streams, systems for the reporting and monitoring of waste streams and the collection and segregation of plastic waste would need to be in place. These systems do not currently exist in the UK.

Development of New Technologies

Whilst some technologies exist to recycle certain plastics, many are not currently recyclable at scale and for value. New technologies need to be developed and scaled up in order to create useable and valuable feedstocks.

Positive Incentives to Drive Adoption of Recycled Plastics

Recycled plastics as a feedstock may not be attractive for some manufacturers due to issues, such as contamination and/or the costs associated with recycling, making reuse not commercially attractive. Positive incentives are an important tool to drive recycle and reuse.

The UK Opportunity

The Chemistry Council is uniquely placed to deliver against this challenge being both the recyclers of plastics and also the potential users of recycled plastic as a new feedstock.

In order to make significant plastic recycle and reuse a reality in the UK, several projects need to be funded and driven forward.

Monitoring, Collection and Segregation of Plastic Waste

The CC will work with the ONS to develop the National Materials Database (NMD), starting the process of identifying, monitoring and categorising plastic waste arising across the UK.

It is proposed that plastics are a priority area for the NMD project.

[46] Smart Sustainable Packaging ISCF Wave 3 bid

Ideas Projects Continued

Establishing Two Plastics Recycling Hubs

As part of the Sector Deal, two new Recycling and Reuse Hubs are established, one in the North East of England and one in the North West of England. The Hubs will utilise existing infrastructure and facilities but will seek to attract in additional capabilities in order to be able to handle the collection, segregation and processing of key polymeric materials.

Collaborative R&D

A collaborative R&D programme is launched to find new technologies to recycle and valorise the top 10 plastic waste streams in the UK. Funding of £20M is sought to cover this area.

Positively Incentivise Carbon Recycling

It is critical that carbon recycling is driven as a positive activity. A new regulatory regime should be established but this has to seek to positively incentivise reuse rather than penalise non reuse. The 'polluter pays' principle is important but too simplistic to drive significant changes across the various stakeholder groups.

Impact

The recycling hubs will provide critical infrastructure for the handling and valorising of the plastic waste in the UK and provide a major step forward in the Clean Growth agenda. As well as reducing the amount of plastic going to landfill and ending up in our oceans, the establishment of a these facilities will lead to a reduction in plastic incineration, reducing the CO_2 emissions released into our atmosphere helping the UK to reach its CO_2 emission targets.

By recycling waste into sustainable feedstocks, these hubs would also make a significant impact in terms of moving towards 75% sustainable materials by 2030.

The plants will bring in investment and an estimated 500 new jobs will be created. Additional opportunities for processing plastic waste from Europe would also be explored.

Government Support Required

It is estimated that each Hub will require ~£100M of capital. Additional monies will be required to develop new process technologies targeted at recycling polymeric materials not currently capable of being recycled and reused today, and for testing and scale up facilities.

Specific Requirements Include:

- New fast analytical techniques to differentiate polymers.
- Logistics to get all the waste plastics to the hubs.
- Separation technologies and quality control to ensure we extract the maximum value from the streams.
- Agreed standards for use.
- Thorough evaluation of environmental and economic impact of the various ways of structuring this area.

Appendix 4: People Projects

Recruiting and Skilling to Create in UK

Challenge: Facilitating the take up of entrepreneurial programmes to accelerate the skilling of the innovators of the future and boost the value realised from these innovations.

Encouraging a new generation of innovators relies on the development of entrepreneurial skills from an early age. There are a variety of schemes which help build entrepreneurial skills across the UK, encouraging scientists to commercialise their innovation and turn it into a business. Over 40 businesses are started in Britain every hour. Promoting these schemes would accelerate the commercialisation of science further and increase the economical and societal value realised from innovation.

Growing Market

The UK is an innovative national economy, ranked 17th globally in 2018 according to the annual Bloomberg report.[47] However, the UK falls behind when it comes to commercialisation of R&D and realising the value from our research. The Bloomberg report ranked the UK 40th in terms of the value added by manufacturing as a percentage of GDP. This suggests that more support is required to encourage the commercialisation and manufacture of technology in the UK and entrepreneurial skills plays a clear role in this.

The UK Opportunity

The large number of innovators in the UK need to be supported by individuals with entrepreneurial skills, able to convert a good idea or innovation into a business.

The skills required to commercialise technology are different from those used in research so are currently not taught in UK schools or universities. UK companies identified 'entrepreneurial' as a key skill looked for in graduates.[48]

Impact

SCI works at the interface of academia and industry and runs a variety of programmes to support the recruitment of scientists and engineers into industry and builds entrepreneurial skills. Encouraging the take-up of SCI's Bright SCIdea Entrepreneurs Challenge Programme will accelerate the skilling of the innovators of the future and boost the value realised from these innovations.

CASE STUDY: The Bright SCIdea Challenge

SCI Launch the Bright SCIdea Challenge in 2017, a unique opportunity for students in the UK and Republic of Ireland to develop their business skills by turning a science-based innovation into a carefully planned and costed business plan.

Teams are tasked to use their technical knowledge from university and create a business opportunity that they can pitch to a panel of experts. All applications to the scheme receive free training in pitching, IP and market research from industry experts, including venture capitalists, entrepreneurs, and patent lawyers.

[47] Bloomberg Innovation Index (2018)
[48] CC Innovation Conference (Nov 2018)

People Projects Continued

Recruiting and Skilling to Make in UK

Challenge: Equipping graduates with new technical skills to secure the UK's place at the forefront of scientific research and innovation.

Technologies across the chemistry-making and chemistry-using industry are undergoing radical change, requiring new skills to facilitate innovation and accelerate commercialisation. This relies on a healthy pipeline of young scientists and engineers being established in the UK. For graduates to be industry-ready in this changing landscape requires them to have a depth of expertise whilst also having a diverse skillset and the flexibility to work with a rapidly increasing range of technologies.

Growing Demand

The innovation landscape is changing rapidly driving a need for workers with a wider range of skills, such as digital skills. This is reflected in the estimated 180,000-260,000 new scientific staff required for science-based industries by 2025,[49] including both experienced staff and new graduates. This trend is seen across industry, with research from CBI showing that three-quarters of businesses expect to increase the number of high-skilled jobs available at their firm.

In the first year of a four-year technical degree, 50% of what is taught will be outdated by the time the students graduate. Our inability to plan for future skills during education does not just start at university level either, as 65% of children beginning primary school now will end up in job roles that do not yet exist.[50]

The UK Opportunity

Ensuring UK's graduates are equipped with new technical skills, such as digital skills, will prepare the workforce for the advances in technology, helping to secure the stability of industry during the 'fourth industrial revolution.' This also represents an opportunity to maintain the skilled workforce required to preserve the UK's globally-competitive research-base.

Impact

This opportunity will increase the number of high-paid jobs in the industry and support the significant GVA the chemistry-making and chemistry-using industry contributes to the UK economy each year.

Government Support Required

- Addressing the specific need for more professionally accredited technicians and apprentices through an employer-owned, demand-led system facilitated by the Science Industry Partnership.
- Promoting training and qualifications that meet robust and professionally verified standards including the 'Cogent gold standard' as a brand for excellence in chemical industry skills.
- Reinforcing and strengthening improvements in higher level graduate, masters and post-graduate level training by working closely with the Institute of Chemical Engineers and the Royal Society of Chemistry to deliver this and accredit qualifications.

[49] SIP Skills Strategy (2015)

[50] https://www.universitiesuk.ac.uk/policy-and-analysis/reports/Pages/solving-future-skills-challenges.aspx