Entrepreneurs not Emissions

New business opportunities to fill the gap in UK emissions policy

UK FIRES

Entrepreneurs not Emissions

UK FIRES is a 5-year research programme funded by £5m of UKRI support and the subscriptions of an active and growing industrial consortium. With academics from six universities spanning from materials engineering through data science to economics, corporate strategy and policy and an industry consortium spanning from mining through construction and manufacturing to final goods.

UK FIRES stands for placing Resource Efficiency at the heart of the UK's Future Industrial Strategy. When we proposed UK FIRES, it was to focus on Resource Efficiency as the key means to reduce industrial emissions. However, in 2019, both houses of Parliament unanimously approved a change to the UK's climate change act to target zero emissions in 2050. This has been reinforced by recent Government targets for 2030 and 2035.

So, although we haven't changed our name to UK FIZES, our focus is now on placing Zero Emissions at the heart of the UK's Future Industrial Strategy.

UK FIRES takes a pragmatic approach: we focus only on technologies that are available to us today and exclude those that have yet to be proven at meaningful scale, since they simply may not be ready in time. In 2050 we aim to meet the energy demand of UK society by non-emitting electricity generation.

In December 2019, UK FIRES released the "Absolute Zero" report, a ground-breaking description of the operation of the UK with zero emissions by 2050, without relying on as as-yet un-scaled energy sector or negative emissions technologies. This pragmatic but striking view of the journey to zero emissions has attracted widespread interest including a full debate in the House of Lords in February 2020.

UK FIRES

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Forward

Rapid delivery on the Government's net zero commitment creates enormous opportunity for business innovation and growth both inside and outside of the energy sector.

In the past decade the UK's non-emitting supply of electricity has nearly doubled, mainly owing to the Government's commitment to wind and solar power. We already know that the delivery of net zero in the UK by 2050 will lead to further growth for UK businesses involved in non-emitting electricity supply and distribution. However, there is an even greater opportunity for new business growth, as we change the way we use energy.

A largely all-electric future creates tremendous opportunities for business innovation and growth in end-use applications, as we replace all fossil-fuel powered equipment in the next 29 years. We're also going to need to deliver radical new levels of energy efficiency, which in turn creates a whole other range of opportunities.

Whether in delivering information, advice and consultancy, manufacturing new goods compatible with zero emissions, installing new equipment for energy efficiency, or conserving the value in the energy-intensive bulk materials, this report reveals the space for an explosion of new business growth on our rapid journey to net-zero. It is a wake-up call for us all, in public and private sectors, to recognise and exploit the fullest set of opportunities for innovation created by the government's emissions-reduction targets.

The report was created from the expertise of twenty UK organisations with interests in Resource Efficiency, consulting 160 delegates with cross-sectoral interests in innovation. After revealing the wealth of innovation opportunity and looking at the champions and benefits that will drive growth, the second part of the report creates an invaluable survey of current activities on Resource Efficiency in the UK.

Following their ground-breaking work, Absolute Zero, the UK FIRES programme funded by UKRI have brought this report together as an inspiration. The transition to net zero is pressing and urgent. Delivering it is vital to us all and in between the two extremes of radical technology innovation and radical behaviour change there is an under-explored space for using existing technologies differently. This report reveals just how fertile that space will be.

Professor Paul Monks

Chief Scientific Adviser, BEIS

Executive Summary

The gap between the UK's emissions-reduction targets and its delivery policies creates a vast and largely unexplored space for entrepreneurship and business growth. Reaching zero emissions within one generation depends on electrification, but we won't have as much non-emitting electricity as we'd like. Without action, this means national energy poverty - but with foresight, now entrepreneurs can profit from the businesses that will give us great lives with less energy. This report reveals the breadth of this untapped opportunity for entrepreneurs.

The gap between rhetoric and action on climate change is widening, because we're looking in the wrong place for the solutions.

The UK is legally committed to having zero emissions in 2050, with around half the change delivered by 2030. To date, the government and its advisors have mainly talked about new energy infrastructure technologies to cut emissions. However, progress is so slow that it's now extremely unlikely that this approach will work: in the UK we have no commercial carbon capture and storage (CCS), no zero emissions hydrogen production, and no negative emissions technologies. Without question, we need to try to gain experience of new technologies as rapidly as possible, but the focus of policy must shift to ensure climate safety.

In the Absolute Zero report, UK FIRES set out a different approach to delivering zero emissions based on **today's** technologies. This involves closing any activities that cause emissions by their chemistry, including steel blast furnaces, cement kilns and ruminant farming. We then need to electrify all other energy uses, like cars, heating and industrial processes. However, at today's rates of growth in non-emitting electricity generation, by 2050 we will have only 60% of the electricity we'd like, so we need to plan to use less of it.

In one generation's time, we can be living well with zero emissions, with smaller, fuller electric cars, well-insulated homes, new forms of material conservation and new services like trains loaded with a mix of passengers and freight.

As we develop that different electrical future, a whole plethora of new businesses are going to grow and flourish. Whether it's delivering information and advice, installing energy efficient equipment, or producing plastics with electric processes, there is untold opportunity for business growth.

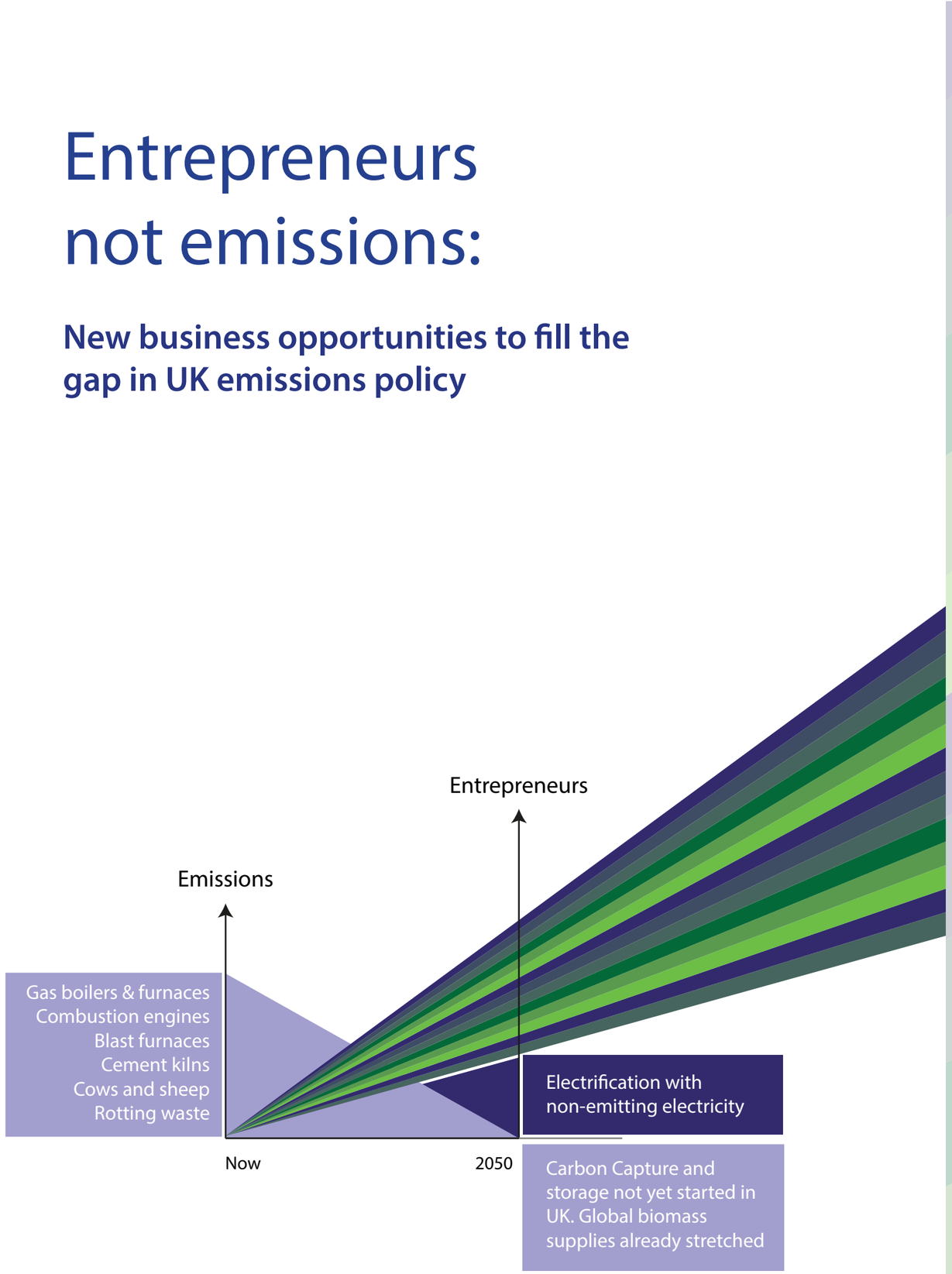
This report is a wake-up call. It points to the rich seam of entrepreneurial opportunity and business growth that will be revealed rapidly as the government's current plans fail to deliver. Whether for new entrepreneurs, or well-managed incumbents, the report shows that the restraints necessary to delivering zero emissions are themselves the breeding ground for new growth.

The report is the outcome of a brainstorming meeting at the UK FIRES Annual Form. 160 delegates from UK organisations, triggered by short talks from 20 UK activities around Resource Efficiency, shared creative thoughts on opportunities for business growth. The report presents the outcome of that creativity, followed by a survey of the UK organisations pushing forwards the agenda of zero emissions through resource efficiency.

The report presents a smorgasbord of untapped opportunity backed by a directory of agencies ready to support its realisation.

Entrepreneurs not emissions:

New business opportunities to fill the gap in UK emissions policy



Profit from providing great information
- Knowledge sharing
- Emissions analysis
- Matching users to service providers

Grow consultancy and advisory services
- Implementation planning, horizontal innovation
- Anticipating strategic advantage, managing risk
- Consumer/end-user advice and planning

New services for a zero emission world
- Equipment and asset sharing
- Delivering resilience
- Service platforms for mobility

Delivering new education and training
- Corporate education and training
- Learning resources for schools and universities
- Mentoring leaders and entrepreneurs

Economies of scale installing new infrastructure
- Rail and HGV electrification
- Last-resort electricity storage
- Tools to negotiate urban planning

Value in energy efficiency
- Deep-energy retrofits at national scale
- New couplings from supply to demand
- Small vehicles

Expanding UK manufacturing
- Compensating for rapid reduction in marine freight
- Electric material production
- Plant-based food

Renewal replaces new construction
- Adaption and upgrade of existing buildings
- Reconfigurable space with high utilisation
- Platform/modular forms of construction

Finance, investment and insurance
- New markets for constrained resources
- Long-pay-back project funding
- Risk-aware insurance and pensions

Substituting emissions intensive processes
- Electrification of industrial heat
- Wind-powered shipping
- New fertilisers

Great design with much less material
- Software to reveal cost-carbon trade-offs
- Repairs as the mainstream of manufacturing
- Economies of scale through modularity

More use with less spending
- Airbnb for vehicle capacity
- Mixed freight and passenger transport
- Matchmaker services for asset-sharing

More value for longer
- Online repair services
- Life-time guarantees
- Value from user-ship

A treasury of material value
- Material/component leasing
- Component archives
- Upcycling

Part 1: Entrepreneurial opportunities in delivering zero emissions

1. Which businesses are certain to grow as we approach zero emissions and are short of energy and materials?

Information provision

Negotiating responsibility for emissions, and planning and validating a journey to zero emissions depends on information. Despite a plethora of "carbon calculator" tools, there is as yet no dominant provider in this space. Unlike "calorie counters" which evaluate only the energy inside a single food package, carbon calculators must consider responsibility for both use and embodied emissions (those emitted while making goods). This is difficult because all emissions come from using equipment or agriculture, but almost all use is shared.

There is already a substantial market opportunity for the provision of the most trustworthy, most detailed information on responsibility for emissions, and this market will grow rapidly as pressure to act increases. Example applications include:

- Performance metrics for setting and monitoring corporate and government strategy;
- Product information – particularly where a code on a product leads to access to detailed and transparent evidence;
- Traceability – the creation of product, component or material "passports";
- Development and implementation of new product standards;
- Knowledge sharing partnerships, revealing various degrees of aggregated or individual emissions performance, in open comparison with public data, and for private evaluation of corporate options;
- Negotiating cross-border responsibilities to ensure comparability;
- Validating claims of past or current achievement in reducing emissions (as CarbonTracker have started to do with political commitments);
- Lobbying, marketing and influencing towards delivery of zero emissions;
- Visibility, integrity and transparency of government and corporate plans for reaching zero emissions – whether provided by the company/government or by independent monitoring and audit groups;
- Drawing attention to high-emissions blackspots;
- Linking information on the drivers of emissions to options to remove them, including marketing services for zero-emissions services and equipment;
- Given the complexity of the data behind emissions accounting, market success in information provision will depend on transparent accuracy delivered with interactive visualisation and accessibility.

In parallel, information about user experience will have equal value – reflecting the cost, difficult and reliability of different pathways to zero emissions. This may include:

- Consumer comparison-services – "Which?" or Moneysupermarket not just for the increasingly complex portfolio of power contracts, but for all services and products delivering zero emissions;
- Sharing knowledge and experience, for example of how to retrofit a home or reduce energy consumption, via variants of Wikipedia, Facebook or Creative Commons;
- Matching users to services – using overt or covert data collection to identify the key features of a particular user's context that reveal their most effective options for reaching zero emissions;
- Monitoring and revealing trends, where user-experience provides early indicators of new market trends or anticipates support for necessary regulation;
- Modelling that anticipates pathways of cost and emissions when choosing between a variety of user options or capital investments.

Consultancy and advisory services

On the journey to zero emissions, there is already demand, which will increase rapidly, for consultancy and advisory services: what are our options, and how can we deliver them most effectively?

For corporate clients, demand for consultancy services will certainly grow in:

- Anticipating strategic advantage and analysing risk on the rapid 29 year journey to zero emissions;
- Backup-up of the announcements and rhetoric of corporate emissions targets with detailed delivery plans;
- Strategy and planning for zero emissions in Small and Medium sized Enterprises (SMEs) who cannot afford a dedicated emissions team;
- Biomass strategy, including sourcing, accounting and monitoring from farm through use to disposal;
- Estate management, related to energy retrofits and decisions on building repair, alteration or extension;
- Energy efficiency analysis, including company-wide management of energy, materials and wastes;
- Supply chain analysis and design – sourcing and partnerships compatible with zero emissions. Writing zero emissions into procurement agreements;
- Horizontal innovation through technology transfer, trade and cross-sectoral learning. For example, oil drilling technology could be used to install district heat networks, ground-sourced heat pumps and gravity batteries;
- Responding to (potentially rapid) changes in emissions-related tax and regulation;
- Carbon accounting and emissions analysis, of products or projects, including options for design improvement. Linking carbon certification to other forms of quality assurance;
- Auditing of carbon accounting and plans, as a regular component of reports to investors.

For households, whether through personal consultancy, advisory bodies or community centres, demand will certainly grow in:

- Household energy retrofits and building alterations compatible with zero emissions spanning from design to contractor selection;

The Retrofit Playbook

The UK Green Building Council's report "The retrofit playbook" advises local and combined authorities on activities to support deep retrofits.

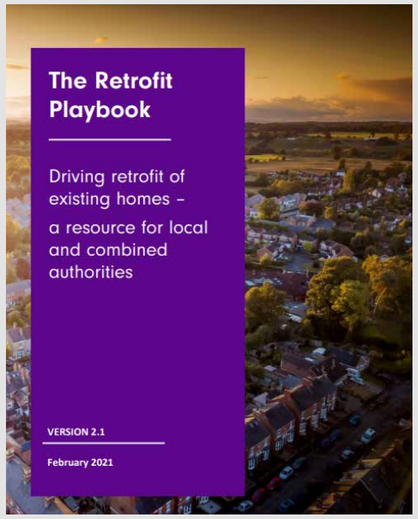


Image: Green Building Council

- Domestic energy management, including the integration of generation, flexible sourcing, storage and demand;
- Personal carbon emission tracking, following a personal journey to zero emissions; Personalised 'fitbit' lifestyle trackers for all aspects of lifestyle, incentivised through benefits e.g. health insurance, car insurance, travel insurance, home and buildings insurance;
- Consumer services helping individuals / households understand their climate impact and make changes to improve these, at as granular/specific level as possible. Services in this area still very generalised (e.g. Capture) and only just starting to utilise data from smart metering, location data, worn sensors etc.

Across business and domestic energy use, there remains rich potential for adopting best practice in technologies and use to reduce energy consumption – for example through better management of thermostats, or resolving unnecessary conflicts between heating and cooling. These markets will expand as electricity prices rise.

New services required to reach zero emissions

As well as information and advice, individuals and businesses living and working with zero emissions will require services that are as yet unfamiliar. Examples of service businesses likely to grow in the rapid journey to zero emissions include:

- Person-to-person sharing services – building on Airbnb to profit from under-used capacity in other assets, whether clothes, lawn-mowers, tool, built space, land, resources / secondary resources;
- Servitisation models for maximising the utilisation of capital assets across the manufacturing sector;
- Personal mobility as a service platform so people can use something like google maps to plan their cleanest multimodal journey;
- Connecting data and sharing knowledge for better use of existing resources. For example in the construction industry, information on the contents of buildings destined for demolition, could be matched with detailed models of buildings under construction nearby, to identify opportunities for reuse , and link them with appropriate guidance documents to companies able to exploit the opportunity;
- Tracking embodied emissions through supply chains particularly for primary raw materials, for example using Blockchain to validate certification of zero carbon metals or through use of battery passports;
- Transition support for emitting activities that must close, whether in fossil-fuel extraction, processing and combustion, emitting production of materials or ruminant agriculture;
- Adaptation and response to the impacts of global warming, whether through flood management, building protection, or diversifying resource suppliers.

Education and training

Given the urgency and scope of the challenge of delivering zero emissions in 29 years, there will be a rapid growth in demand for education at every level from Ministers to schools to boardrooms. Today's primary school pupils will only be in their 30s by 2050, so there is an urgent need to change education of university students and secondary school pupils who will be the managers of the 2050s. Equally, today's managers and workforce, who received no school or university training in the realities of zero emissions, need support to deliver the transition. The span of required education includes the whole system of emissions, the identification of options for zero-emissions living, and pathways to implementation including constraints such as deployment rates and material availability.

Demand for education and training resources, services and delivery will therefore grow in all the following areas:

- Corporate education at all levels in the realities of delivering zero emissions;
- Training and mentoring to help business leaders understand their path to zero emissions, including emissions analysis, business model, product development, market potential, deployment and leadership;
- Education and information programmes for householders on the real delivery of zero emissions within 29 years including advice on where to find service providers;
- Learning resources for primary and secondary schools and universities (across all disciplines) which can also be exported internationally;
- Retraining/upskilling the workforce required to deliver zero-emissions living, for example to retrofit the UK's entire building stock within 29 years;
- Skills development in deploying electrification and energy efficiency across all energy uses;
- Educating potential entrepreneurs in the breadth of opportunities to deliver zero emissions by 2050.

New infrastructure

The design of cities and towns, transport networks, and the electricity system radically influences our options for living with zero emissions and our total energy demand. Between now and 2050, all new infrastructure development must be designed to be compatible with zero emissions, or it will be a wasted investment. However, some existing infrastructure must also be modified to be fit for purpose. In the design, installation and operation of infrastructure, there is a wealth of opportunity for business growth.

In the electricity system:

- If non-emitting electricity generation continues to expand at the rate of the decade 2010-2020 while all emitting generation is closed, the UK grid will by 2050 be delivering around 50% more electricity, while coping with intermittency, overall shortages, and a more complex network of suppliers at all scales. This drives growth not just in the supply of familiar existing systems (turbines, cables, switchgear) but also in new control systems, auctions and pricing models based on short-term availability, and new responses to supply shortage;
- One response to deal with intermittency will be a growth in the services and systems of demand-side aggregation, both to support grid stabilisation (and hence reduce costs) and to reduce the risks of blackout for individual users;
- Electricity storage suffers from poor volume-energy density, and there are no solutions that can scale to deal with intermittency at national scale, but locally, demand for storage will grow at all scales, particularly as a last-resort defence against supply shortage. Liquid air and gravity storage systems are currently generating new interest, for example via startups Cryohub, Energy vault, and Gravitricity;
- Vehicle-charging infrastructure is already under intense discussion and will grow enormously as road vehicles are all electrified. It is more likely to be located in car parks than fuel stations, to allow time for charging, but this will create new opportunities to optimise the use of charging equipment for long-stay parking. Fast-charging may develop or may be substituted by battery-swapping. New businesses that bring charge to vehicles whose batteries have run flat away from charge points are guaranteed to develop;
- Only a third of the UK's rail network is electrified at present, so innovations that find new economics of scale in the rapid mass electrification of the remaining network will find a guaranteed market;
- More flexible deployment of solar panels, for example movable large panels for farmers, may allow new "crop rotation" to include generation in favourable seasons.

In transport networks:

- Most vehicles in the UK are mainly empty on most journeys, and most transport energy is used to propel the vehicles rather than the contents. Software and consultancy advice that supports a redesign of this whole system to minimise its energy inputs, spanning from urban commuting to rural connections, will find urgent and growing demand at all levels of system and vehicle planning and design;
- A specific and immediate opportunity for improved use of existing transport networks is to develop rolling stock and ancillaries that allow efficient partial switching between passenger and freight loading of existing trains – to maximise utilisation, and in particular as a mechanism to reduce demand for longer-distance road freight. As well as opportunities for growth in developing new equipment, this will lead to growth in demand for handling and distributing freight in short journeys from city-centre railway stations;
- A critical opportunity for conserving material value would be to use the empty return journeys of most freight vehicles for reverse logistics. Systems that allow a swich from "receiving" to "replacing" will find growing demand as anticipated material shortages drive increased demand for component and material conservation. This model could be operated by manufacturers (as Apple has begun to do) or by conventional or e-retailers;

Case Study: Gridserve

Gridserve is the UK's first service station designed solely for electric vehicles. providing charging infrastructure for cars, motorbikes, HGVs and buses in the form of an Electric Forecourt.

Image: Gridserve

- In zero-emissions 2050, we will likely see the closure of almost all aviation and a dramatic reduction in shipping, creating the need for radical new solutions to international movement of both people and freight;

- Software and analysis that applies at national scale the "hub and spoke" models of logistic design currently used by individual distribution companies, are likely to find markets related to national scale planning; for example to reveal the benefits of micro-hubs with new integrated last-mile delivery systems.

In Urban design, planning and construction:

- UK planning is currently fragmented, poorly co-ordinated and not aligned with zero emissions. There is already a market for tools and advice to inform coordinated decision making, to anticipate the emissions consequences of different design options, and to facilitate public discussion of preferences;

- Urban layout strongly determines transport requirements, and we are short of processes, systems and tools to negotiate planning choices that span from the comingling of commercial, industrial and residential users to the options for transport systems from walking, cycling, road to rail. Tools and expertise to facilitate these discussions will find an immediate market. The requirement for different combinations will then drive growth in construction and operation;

- The design, installation and maintenance of new forms of green space in urban settings, is likely to grow as demand for natural shading increases.

Earth Structures in Australia

Earth Structures in Australia, are pioneering new forms of zero carbon construction replacing concrete with rammed earth.

Image: Earth Structures

Reducing demand for energy

The UK is almost certainly entering an era of energy shortage, as we turn rapidly to electricity as our only energy source but are not deploying new non-emitting generation fast enough to supply our needs. This will create rapid growth in demand for energy efficiency, whether in building retrofits, smaller vehicles, and a transition to using material goods for longer, as material production reduces. Specific growth opportunities include:

- Rapid installation of deep building retrofits, ideally to passive standards, at domestic and commercial scale. This goal has been discussed for several years, but no large-scale supplier has yet emerged. The business opportunities include advice and design services, conventional contracting, new forms of supply (an "IKEA" of retrofit), new approaches to rapid installation and new funding models (including access to government schemes) to allow long paybacks from energy savings. The OUTPHIT project funded by the EU's Horizon 2020 programme, is creating demonstrators of this form of rapid retrofit to Passivhaus standards;

- Supply of zero-emissions building materials linked to skilled installers. Concrete-free footings and foundations for low-rise new-build and extension would an excellent entry-point into this market;

- Efficient retrofit of heat pumps of all types to replace gas boilers, including options for continued use of water radiators or conversion to ducted air. Certain growth in this market, will drive up demand for equipment manufacture, maintenance and repair in parallel with growth in installation;

- In parallel, as global temperatures continue to rise, demand for cooling is likely to increase: cooling contributes ~7% of today's global GHG emissions and this is predicted to rise to 20-25% by 2050 if action is not taken now. This creates a rapidly growing market for passive or efficient electric cooling solutions;

- Production and installation of technologies to make better use of hot water, whether through reduced demand, on-demand heating or more efficient heating and storage;

- As the complexity of intermittent electricity supply, domestic generation and storage, and the timing of different forms of demand increases, there will be a growing market for equipment and software to control, integrate and optimise domestic and commercial energy use;

- An alternative to scrapping cars and vans with combustion engines is to retrofit them with electric drive trains. https://www.newelectric.nl are pioneers of this area, giving new-life to otherwise low-value vehicles, while https://www.retroelectrics.co.uk/ are electrifying classic cars;

- Conventional refrigerants use in fridges, freezers and air conditioning units, have very high global warming impact, and as regulation in this area grows, there will be a growing market to re-fill such devices with ultralow impact refrigerants;

- Some energy conversion chains are unnecessarily inefficient, for example where wind power could be used for mechanical purposes (e.g. in large static equipment), or solar power used directly for heating, without the intermediate conversion to and from electricity. There will be a significant market for analysis that identifies these opportunities, and the deployment of systems and technologies to exploit them.

Steel in the USA

70% of the steel made in the USA is made by recycling in electric arc furnaces, with market leaders Nucor now able to produce the highest grades of sheet steel with more than 90% recycled content.

Image: Nucor

New demand for materials and manufacturing required to deliver zero emissions

Manufacturing in the UK will grow in response to three aspects of our journey to zero emissions: we won't be able to import as many goods as at present, due to the shortage of zero-emissions options for international freight; we won't be able to produce materials in the same way as we have in the past, as we eliminate emissions from process chemistry and high temperature heating; we will need new goods compatible with zero-emissions life. There are therefore many opportunities for manufacturing growth in the rapid journey to zero emissions by 2050. These include:

- Producing steel in electric arc furnaces by high-quality upcycling from our own scrap steel (we have enough of it but currently export most of it). There are many options for innovation and new business growth in ensuring the quality of recycled steel;

- Producing plastics and chemicals in new electric processes, to replace today's processes linked to producing fossil fuels from oil;

- Designing and manufacturing smaller goods that use less energy, for example, smaller cars and smaller domestic appliances;

- Manufacturing the equipment required to deliver an all-electric non-emitting energy supply and manage its insufficiency;

- Manufacturing the components and equipment required to deliver energy efficiency, including as detailed earlier;

- Manufacturing goods such as clothing, textiles and electronics that are currently mainly imported

- Growing and processing food to replace around half of the UK's diet that is currently imported;

- The demand for "e-tech" metals, the relatively more scarce metals essential to efficient electrification, will soar as the world turns to all-electric power. This points not only to a substantial profit opportunity in zero-emissions mining, but also to growth in any technology, process, service or system that supports improved conservation of value for these resources, through product or component life-extension, efficient design, or eventually focused recycling.

New demand for the services of the construction industry

Our demand for service from the construction industry will necessarily shift away from new-build, as the supply of cement and new steel is phased out. To a small extent this may be replaced by timber, although most structural timber used in the UK today is imported, but it is more likely that the focus of construction will shift towards renewal adaptation, extension and repurposing. Areas that are certain to grow during this change include:

- Whole-life carbon accountancy and certification for buildings and infrastructure projects. In particular, consultancy services will be required for assessment and reduction of emissions from small-medium scale construction projects, where the design team does not have in-house capability;
- 'Platform' or modular approaches to construction, based on current practice in the automotive sector, with components designed to interface with each other in varied configurations. This is essential to maintain the value of construction materials and components beyond their first life;
- Practices that enable construction with available used materials and components will find a growing market as conventional material supply declines. The concept of Inventory-Constrained Design (using what we have available, perhaps revealed by "amazon-like" real or virtual warehousing) turns structural design and architecture on its head and creates opportunities for new skills, services and software;
- The skills, components, systems and businesses that deliver low energy retrofits, extensions and building re-purposing;
- With rapidly reducing new-build, the opportunity to fitout buildings with reconfigurable furniture to allow more intense use is certain to grow;
- Structural timber manufacturing and design is likely to grow, subject to supply constraints.

Finance, investment and insurance

The current rhetoric of climate policy focuses on financing large energy infrastructure investments. However, the pragmatic approach in this report to delivering zero emissions in the UK within 29 years, reveals different opportunities for innovation in the finance sector.

- The insurance sector will be thriving as the target date for zero emissions approaches, as long term risks will increase rapidly unless sufficient action is taken. The understanding of deployment rates in the introduction to this report gives a basis for newly valuable risk modelling, and as risk premiums for fossil-emitting activities increase, this will increase the incentives for pragmatic deployment of the innovations of this report;
- New forms of preemptive insurance could build funds to replace emitting with non-emitting equipment (for example replacing boilers with heat pumps) as and when the existing emitting equipment fails;
- New financial services will be required as we shift to an all-electric energy system with insufficient supply, including hedging energy costs, forward procurement agreements and new responses to trading during short term shortages;
- UK FIRES has proposed ZERPAs a new form of tradeable procurement agreement for the three zero-emissions resources (non-emitting electricity, biomass and negative emissions technologies) to stimulate the flow of capital towards expanding supply, and to provide a basis for evaluating the risk behind corporate plans to reach zero-emissions operations;
- Vertically-integrated provision of green solutions will allow the finance sector not just to invest passively, but to be an active player non-emitting energy provision, product verification and service comparison linked directly to technology development and equipment procurement;
- There will be a market for new financial instruments integrated with supply chains that allow investors to hedge risks while making zero-emissions products and services economically competitive in the short term backed by long term investments;
- New information systems, data, analysis and services will be required to support valuation of zero-emissions projects and increase funding;
- New financing mechanisms could release much wider adoption of energy efficiency transformations, such as building retrofits, where payback periods are relatively long, but may shorten if as expected electricity prices rise with supply shortage.

ZERPAs

UK FIRES is proposing the creation of ZERPAs (Zero Emissions Resources Procurement Agreements) to allow corporates to prove their zero emissions commitments by pre-purchasing their future requirements for non-emitting electricity, biomass and negative emissions technologies. ZERPAs would allow investors to improve their valuation of climate related risk, will stimulate the supply of these three key resources, and will reveal incentives for alternative approaches to reaching zero emissions, such as those in this report.

All-electric glass

Most major glass furnaces are gas-fired, but allelectric melting has been successfully applied in the glass industry for decades, using immersed electrodes. German-based manufacturer Horn Glass have developed an all-electric concept that produces higher quality glass, at higher efficiencies than fossil-fired furnaces – making small furnaces more cost efficient.

Substituting emissions-intensive activities

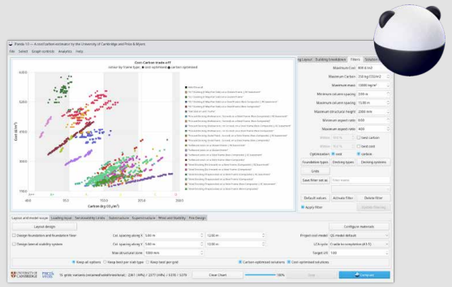
As well as innovations that reduce total demand for electricity, there will be a rapidly growing demand for innovations that replace activities that lead to emissions due to their chemistry, regardless of how they are powered:

- Industrial electrification will lead to rapid growth in demand for high-temperature electric heating, both of complete furnaces, and more locally – for example when pre-heating the equipment used in high temperature processes;
- All current production of cement leads to process emissions, so there will be a significant and rapid demand for any innovation that allows production of cement without emissions, given the very slow pace of CCS deployment;
- Current production of new glass leads to some process emissions, which must be avoided, and the carbon anodes in primary aluminium production must also be replaced creating immediate demand for product innovations;
- The use and application of biomass as an industrial material may expand, and may be compatible with zero emissions provided the danger to other species is not worsened due to total human appropriate of biomass, already at high levels. As agriculture turns away from ruminants, this will release biomass capacity, some of which may be available for new material production;
- Without sufficient non-emitting electricity or biomass to make synthetic fuels, international shipping faces a major contraction. Potentially electric batteries could sustain some shipping, but at high cost, with high demand for relatively scarce resources, and with high volume requirements. This points towards a renaissance of wind-powered shipping, and innovative companies like Oceanbird and Neoline are promoting a new era of sail that is almost certain to grow rapidly, particularly when retrofitted to existing ships;
- UK farms associated with cows and sheep will switch to other activities as we approach zero emissions, creating a significant market for the services and equipment of repurposing, as well as in the new products available from the released land. Given the likely shortage of international freight, these farms will find rapidly growing demand for alternative, particularly plant-based, foods;
- All current commercial fertilisers lead to emissions in production and release emissions in use. As they are banned on the rapid journey to zero emissions, there will be urgent growth in the market for non-emitting fertilisers, to sustain global food supplies;
- The imminent closure of the fossil-aviation industry will stimulate interest in electric flying, but with current battery technologies no one is developing long-haul electric flight. Aviation must therefore cease for some decades, during which there will be a rich market for expanded forms of remote business and personal connections, for international electric rail, and for new forms of vacation nearer to home which could also include some virtual elements.

As an appendix to considering the replacement of inevitably emitting activities, there will be rapid growth in the market for decommissioning the assets of the emitting past. Whether in the infrastructure of the fossil-fuel industry, or in the sectors that have depended on it, there is a substantial resource of land, materials (and capital) that can be redirected into the zero-emissions era, and profit for those able to deliver this.

PANDA

A joint project by Price and Myers and the University of Cambridge has developed the PANDA software, that reveals the cost-carbon trade-off of the earliest design choices made in new building construction. Funded by the British government through Innovate UK, PANDA software can assess the embodied carbon in thousands of design options at concept stage, allowing clients and their project teams to make informed decisions on construction and materials.



Product and system design to reduce material demand

Forthcoming shortage in new material supply will create rapid expansion in markets for materially efficient design and production, whether in the software and techniques of material optimisation and avoided specification or in the processing techniques of energy-efficient net-shape manufacture:

- Many material goods in the UK are over-specified, particularly where the bulk materials are so cheap, meaning that overall cost-minimisation promotes an increase in material specification to avoid some component of labour. One critical application of this, where new software, design and manufacturing processes will find new markets is in commercial construction. Most UK commercial buildings are substantially over-specified – whether by choosing unnecessary column spacing, over-specification of beams, or by excessive use of elements in bending that could instead be used in compression. PANDA, a new software tool developed by the UK FIRES and Price and Myers is being commercialised to address the first of these problems;
- In some cases 3D printing and additive manufacture may contribute, but these are generally energy intensive processes, and a larger area of opportunity is in the redesign of conventional material processing. For example, the deep-drawing process used in car body manufacture leads to average scrappage of 50% of all sheet metal purchased by the world's automotive industry. There is significant market potential for any innovation in tooling that will reduce this wastage;
- Many options for modular design could be applied to increase component and material value at end of life. This includes simplified access for component replacement, modularisation to bring the benefits of the economies of scale into otherwise one-off practices, or the opportunity for new equipment to separate high-value alloys at end of life.

Increased intensity of use to reduce material demand

Most buildings in developed countries are empty for two thirds of the week. Whether it's where we sleep, where we work or where we shop; we would have vast over-capacity in our built space if we could find how to use it more intensively. The same applies to many other assets – whether lawnmowers, industrial machining centres, or large yellow vehicles. Airbnb has demonstrated one business model for generating new revenue from improved asset utilisation. Many other options will find rapidly growing markets on the journey to zero emissions:

- Airbnb-style business models could be used to sell spare capacity in all forms of passenger transport, for example car-users could log their plans for a journey and rent spare seats to other registered users, with user feedback used to ensure good practice. Shorter term Airbnb-style leasing of spare domestic space – for example to accommodate one or two other office-style workers – may also be possible, along with similar models applied to warehousing;
- Business models based on leasing rather than ownership can facilitate asset utilisation, as demonstrated by Zip cars, and this approach could be extended to assets such as white goods, garden tools, cooking equipment etc through "libraries of things". Similarly, "last mile" journeys from rail stations, where individual user needs vary with time, can fit well with a leaseholder model where owners are motivated to improve maintenance and repair;
- Rolls Royce's famous "power by the hour" model extends this approach with lease-payments based on hours of use, and this model could for example be applied to the installation of heat-pumps, to reduce the initial outlay for householders, or to likely increasing demand for cooling, to drive out inefficient and badly maintained equipment;
- Shared ownership, whether in local communities, or among other social groups, can increase utilisation with a shared sense of responsibility for maintenance. www.wearwardrobe.co is one of many emerging businesses based on shared ownership or use of clothing, allowing users access to a greatly increased range of fashion, at reduced cost;
- Community centres and halls have always existed as shared assets for multiple users, and with increased remote working, there will be a growing market for local shared workspaces, recreating the social benefits of the office without the commuting;
- 'Matchmaker' services which facilitate B2B asset sharing, such as increasing capacity utilisation in expensive machining centres, could also be used for shared material purchasing and use, increasing utilisation;
- As well as multi-function built space, new approaches to design could increase the intensity of use of land, for example by placing solar roofs over parking lots, or designing new functions for the rooves of low-rise commercial and retail space.

A wider concept behind increasing intensity of use is to recognise the benefit of great public transport in reducing the total demand for individual vehicles. The principle of finding a well designed system that sufficiently replaces the benefit of individual ownership through shared public wealth, may well have wider beneficial applications.

Home working in 2020 / 2021

During the lockdown following COVID-19, many people worldwide found they could make better use of their living space, by combining work and living with new layouts.

Life extension of existing products to reduce material demand

Many products, such as furniture or kitchens, are discarded before they are worn out, because of changed user needs or fashion. Of those which are discarded when broken, such as domestic appliances, often the failure is of a very simple component: the most common reason for fridges to be discarded in the UK is that the tiny plastic cap that holds in the lubricant on one of the bearings of the main motor shaft has sprung off. However, the cost of labour for the repair exceeds the cost of replacing the fridge. There are therefore many opportunities for new business to profit in the forthcoming world of material restraint, by extending the life of existing products.

Where product life is determined by some form of failure:

- Virtual assistance, to support user-repair, rather than requiring a technician to visit the site, is already a rapidly growing sector, where the business profits from spare parts sales and can generate revenue from instructional online videos. As an example, https://www.fixyourownprinter.com is now in its 10th year and still growing;
- Techniques to protect against failure will find new markets. For example, extending the life of major structures through improved corrosion protection/coating technologies or protecting the leading edges of wind turbine blades from wear and fatigue to create more durable products will have increasing value;
- All final products should be considered as 'a cluster of components', each with a different lifespan, rather than a 'homogenous entity' that once it breaks down, comes to end-of-life and is replace by new. If product end-of-life is determined by predictable single components, electric car life is currently largely determined by the batteries, designs and supporting business models that promote efficient component and module exchange will flourish;
- New approaches to design can facilitate extremely rapid component and module replacement, as exemplified by Formula 1 cars, where many components can be replaced in seconds. Design agencies and component manufacturers that facilitate this rapid exchange are likely to see great market growth as material constraints drive us towards longer ownership;
- In severe material shortage, repair will become the mainstream activity of manufacturers, with new-build much less common. Businesses that innovate in the

systems, equipment and software that deliver new efficiency in component and module replacement, and subsequent component repair will find rapidly growing markets;

- As material shortage grows, new forms of transaction will give increased attention to life-time ownership costs, with guarantees linked to maintenance and repair standards;
- Community and high-street repair workshops and 'libraries of things' on local high-streets, as glamourised in the BBC's programme "The Repair Shop" will expand, with a mixture of non-profit and commercial offerings. This could be with service provided by experts, or a collection of equipment, information and training to allow self-service;
- Enthusiasts for sensing and artificial intelligence see great opportunity for increasing online diagnostics to anticipate repair needs, which will certainly find growing demand in some areas, particularly where failure could be dangerous, for example in wind turbines.

Where product life is determined by changing user needs or preferences:

- New business models that improve, modify or repurpose existing assets will thrive, for example in adding extra storeys to existing buildings or repurposing disused industrial buildings. In many cases, it is possible to retrofit or expand existing buildings to meet new requirements rather than replacing them. Anglia Water have developed a construction strategy pyramid, with "don't build" as the goal, to reinforce this principle;
- In the perpetual tension between standardisation and customisation in manufacturing, standardisation would facilitate repair and life extension, particularly if it allowed modular upgrades. The Smart Car was introduced with the idea of having exchangeable body panels, based on common connections – but a wider imposition of connection standards could lead to a much greater range of individual choice on customisation;
- End of life can be delayed indefinitely for many products, where they have developed a "meaning" or wider attachment beyond their function. Heritage buildings have this property, as do some personal gifts, symbolic goods and items where the user has exerted some form of "usership." Designing products that invite user participation could be a growing opportunity to support this approach. The Land Rover Defender exemplifies it, with 80% of all vehicles ever made still on the roads, and users increasingly drawn into repairing and then modifying an open and easily accessible product;
- To complement the earlier opportunity related to replacing "delivery" with "exchange", new forms of 'rag and bone' collection are likely to develop as a consequence of material shortages – both domestically and commercially. This could include buy-back companies, who purchase unwanted products and materials for recycling. Giving value to consumer goods, to encourage them to recycle, rather than throw away.

In the specific case of packaging, products may have been designed for single-use as they have lower value than the goods they carry. This points towards new business models based on guaranteed return, perhaps related to the replacement of "delivery" with "exchange" described earlier.

iFixit

iFixit is a global community of people helping each other repair things. It is a wiki-based site located in the United States that teaches people how to fix almost anything. Anyone can create a repair manual for a device, and anyone can also edit the existing set of manuals to improve them.

Material value - owning, returning, reusing, recycling – to reduce material demand

For materials with no zero-emissions primary production route, reuse or recycling will become the only source of supply as we approach zero emissions. While reuse is the least energy-intensive approach, it is likely only to apply at significant scale in construction, so will lead to growth in business models related to deconstruction, storage and preparation for reuse. Recycling is possible for many materials (though not, critically, for cement or thermosets, and hence most composites) but the quality of recycling depends entirely on the efficiency of material characterisation and separation. This points to two major areas of certain business growth.

The demand for deconstruction and reuse in construction will lead to business growth for:

- Businesses that lease higher value materials or components. Some examples of such leasing have begun, for example for aluminium cladding on short-term warehousing. Johnson Matthey use a model like this in recycling platinum catalysts. They don't make and own the catalysts but retain ownership of the platinum, so it is sent back to them for 'reconditioning' before being used again;
- Design and production of joints for demountable construction. Bolted shear studs for composite construction are a proven example of these, but there is space for much more innovation to maximise material value;
- Forensic deconstruction with efficient separation of components in old buildings (e.g. accurate cutting systems) with associated material handling and transport services;
- Storage of used materials, linked to new services matching supply to demand. These might be preemptive, for example like oil futures trading platforms, to allow matching of supply and demand before deconstruction begins, or reactive like eBay. New financing models may be required to value used stock, and then tailor deconstruction processes to likely demand. Equivalently, new design practices may be required to design new buildings based on available components;
- Services for archiving, cleaning, testing, recertifying and refurbishing components so they can become like-for-like substitutes for new materials to building designers;

The demand for the most consistent streams of material feed to recycling processes will lead to growth for:

- Business models that change user incentives at product end-of-life to support improved material stewardship;
- Disassembly specialists for complex assembled products focussed on extracting high value materials embedded in high performance equipment. For example, one of the key elements of critical mineral recovery is preventing the most valuable materials from getting caught up in the mass recycling supply chain;
- New approaches to maximising the value of complex used materials. For example high value metals could be remelted in an atomiser to make powder for making new components by additive processes;
- Increased data on product composition to facilitate efficient material separation;
- New forms of sensor technology to characterise the composition of multi-material assemblies to support the planning of disassembly and separation, and also to characterise the elements in mixed material waste streams as a precursor to separation;
- New forms of certification for recycled or reused material;
- New technologies for waste stream recovery (e.g. for recovering commercially viable ammonia from waste water, or for separating construction and demolition waste into aggregate, sand and paste);
- Aggregators of used materials;
- Landfill caching (where materials such as many plastics cannot be recycled effectively at present) or mining (where valuable materials have been cahed in the past).

2. Who is going to champion faster rates of change to reach zero emissions and how?

The opportunities for business innovation presented in this report are very likely to grow rapidly as we move towards our zero-emissions commitments. Current government plans for solutions based on novel energy infrastructure technologies are very unlikely to deliver on time, but public concern, driven by increasing evidence of extreme weather events, increasing positive feedbacks, evidence of increasing climate migration and the looming conflict of resource wars, will ensure that action accelerates. The fact that these opportunities exist now demonstrates that in many cases they are not currently recognised as being sufficiently profitable to attract entrepreneurship and investment. That will change, and here we anticipate some of the drivers of accelerated implementation.

Profit motive

In 2019, entrepreneurs scaling up production of PPE, hand-sanitiser, or the software for track and trace applications would have appeared to be taking on a high risk, yet would probably have been extremely profitable in 2020. The emergence of a global pandemic was anticipated by previous occurrences (SARS, swine flu etc) but we didn't know precisely when a virus with the impact of COVID-19 would emerge. In contrast, we know that the opportunities identified in this report are going to find markets, because we already know how climate change is going to drive changed preferences. This change has become particularly apparent in the new proaction of the finance community ahead of COP26. As a result, we can be confident that the business case for the innovations in this report is going to strengthen rapidly and many people will profit as it does.

Retroelectric

Retroelectric takes what is truly great about classic cars and improve upon the parts that aren't.

Image: Retroelectric

This includes:

- Entrepreneurs who pursue these opportunities early to establish brands, and influence policy processes to support adoption. Early developers may be able to influence government spending decisions, for example on testing and developing new approaches, or support policy developments that favour adoption of their solutions;

- Longer-term investors already study the climate mitigation plans of existing corporates, but cannot "solve the model" as it is unlikely that existing companies alone will be able to transform the economy sufficiently without substantial new market entrants. As investors become sharper at evaluating the risks of delivery in corporate rhetoric about zero emissions targets, they will need to find opportunities to invest in the more pragmatic solutions of this report, to reduce portfolio risks;

- Clients and customers will want to demonstrate their commitments to zero emissions by purchasing credible products and services compatible with their goals. This is already influential in the supply chain for construction, where client pressure to reduce the emissions of material production is influencing the producers of steel and cement;

- Existing businesses may find greater market certainty by making earlier commitments to zero-emissions products, as has happened in the global automotive sector, in response to the great uncertainty created by public concern over diesel emissions. In turn, this drives rapid change in existing supply chains: as companies become more confident that their products can function with zero emissions, they inevitably shift attention towards producing them without emissions;

- Brand-sensitive businesses whose marketing depends on customer expectations of trust will need to move ahead of average performance on the journey to zero emissions, to maintain their existing customer base. Similarly, companies that trade on a reputation for innovation, will want to demonstrate how their innovations are compatible with zero emissions;

- Suppliers of the materials, components, equipment required to support zero-emissions living and operation will naturally find market expansion. This is clearly apparent in the supply of equipment associated with wind and solar generation, and will rapidly extend to all other core elements of a zero-emissions future;

- Businesses subject to tightening product standards, planning permission or related regulation related to zero emissions will drive change to stay ahead of competitors. Rapid improvements in the energy efficiency of domestic fridges demonstrated this in the past, and the likelihood of a quick phase-out of gas boilers will equally drive rapid transition to electric heat pumps;

- Business operations will shift in response to changing costs, whether rapid increases in material costs as suppliers decarbonise, increased energy costs as electricity shortages become apparent, or increased regulatory costs associated with the emitting practices of the past;

- Businesses wanting to retain employee commitment and trust will need to transform ahead of average emissions-reduction performance, in order to retain staff;

- Customers concerned about rapidly accelerating rates of depreciation for goods incompatible with zero emissions future, whether emitting cars and appliances, or energy inefficient homes, will drive change through purchasing preferences, as will those who want to ensure their purchasing is compatible with a secure future for the next generation;

- Infrastructure owners and procurers (Network Rail, Highways England etc) will want to move more rapidly to zero emissions operations in response to rising expectations of users and funders.

Wardrobe

Wardrobe is a borrowing service that offers you easy and affordable access to luxury and vintage clothing.

Image: joinwardrobe.com

Influence

A quite different driver of accelerated change will be applied by those who seek to influence opinion and preferences. This includes:

- Corporate marketing, where as the public becomes more sensitive to the empty promises of greenwash, marketeers will need evidence of real change to sustain compelling messages of acceptability;

- Consumer information, which has been largely with-held by the government as it has pursued its techno-optimistic agenda, will proliferate as the public wants to understand more about ensuring climate safety. Translating Net zero targest into commitments to reduce emissions by 7% year-on-year is a great basis for identifying actions at meaningful but approachable scale, as is changing default offerings (for example defaulting to vegetarian menus, which can be overridden only by special request);

- Electioneering where given that the government has the right targets but not a credible plan to deliver them, opposition parties in particular will want to persuade voters of the credibility of their own plans;

- Older people, who are more familiar with austerity from their past, demonstrate increased appreciation of relationships over spending, and have a focused concern for the well-being of future generations;

- Journalists and media managers, who are ready to move on from sensationalist stories of fanciful inventions to support more truthful reporting on the meaningful transition to zero emissions, and demonstrate it in their selection of articles and advertisements. The range of formats that will act to influence more rapid change spans from news programmes through documentaries to soap operas;

- Protest groups such as school strikers and Extinction Rebellion have played an important role in raising the agenda of urgency, and can now move onto promote meaningful pathways to delivery.

Neoline

In a world where the energy and ecological transition is becoming a determining factor, NEOLINE aims to offer maritime transport solutions that combine operational relevance and energy sobriety and ains to move towards zero emission transport.

Social networks

We can make great use of informal networks that share inspiration, practical advice and provide support, such as:

- Community action groups, like the Swedish Flight-shame movement, which motivate action ahead of norms as an expression of social responsibility;
- Ethical campaigns, which have been effective in influencing material and labour sourcing in the fashion and electronics industries, will be able to raise public awareness of under-performing high-profile branded companies. When the public is convinced they 'vote with their money' they will also push businesses, government, charities, etc. to do the remaining work;
- Professional groups, such as UK FIRES, which challenge standard political and corporate mantras with evidence and the presentation of pragmatic alternatives;
- Colleagues at work or elsewhere who can provide sufficient voice to influence critical purchasing;
- Conversations with friends, exploring motivations and opportunities and sharing experiences;
- Local communities at risk of threat from climate change, whether through river flooding, winds, changed temperatures, sea surges or other damage;
- Local cooperatives, such as the one in the village of Swaffham Prior, can be effective in implementing zero emissions projects at appropriate local scales, developing local buy-in through wide participation;
- LETI the London Energy Transformation Initiative (LETI), a network of over 1000 built environment professionals has proved very effective. It is a volunteer group who have worked hard to create design guidance that resonates with the building and property worlds. RIBA has adopted its work.

Children and young people

The managers of 2050 are either currently in their early twenties or in secondary school, but have received little if any evidenced education about the options for realistic climate mitigation.

- Although the national curriculum briefly mentions the science of climate change, it has no requirements on the options for mitigation, nor their implementation;
- Professional bodies that accredit university courses could have a powerful influence on syllabi, ensuring that a holistic and evidenced education on climate mitigation is offered across all disciplines;
- Family life can be a significant driver of accelerated change, particularly when younger children are sufficiently well informed to question parental choices.

NGO's, Charities & philanthropists

While governments set targets but fail to develop plans to deliver on them, there is a fertile space for other groups to act to stimulate action:

- National and international non-government organisations and charities, are already at the forefront of defining pathways to change and promoting them, with the World Wildlife Fund at the forefront of trusted knowledge provision;
- Large charitable funds and philanthropists are also key stimulators of change, able to support early stage growth of the type of activities set out in this report.

Governmental agencies

The focus of this report is on private sector entrepreneurship. However, there are many opportunities for government at different scales to stimulate new business growth.

- Local authorities have many opportunities to support new zero-emissions business growth, whether through planning, supporting new jobs and skills, or as customers for new services;
- Local, regional and national government procurement (or the choice not to procure) can be a powerful stimulus for change, providing a guaranteed market for early stage business development;
- Cross-party parliamentary groups such as Peers for the Planet which are less constrained by party politics can support a more balanced view of trajectories to zero emissions, including reinforcing support for the forms of new business growth in this report.
- Standards organisations can have a significant influence on innovation by updating approaches that were designed for the emitting past, to focus certification on zero-emissions compatible products and services. For example, the British Standards relating to concrete are currently constraining the uptake of lower carbon concretes which do not contain original Portland cement;
- The UK's Catapult network has a super track-record of stimulating innovative businesses, and could accelerate deployment of many of the opportunities in this report;
- UKRI and Innovate UK have research and development funding that can be targeted at the opportunities in this report, for supportive research or early stage company development;
- National professional institutes and trade organisations can raise awareness of opportunities, stimulate networks and foster connections to nurture new businesses. They can equally play an important role in raising enthusiasm for younger and more innovative people to enter this field, and can exert 'cultural' influence by integrating realism about mitigation into membership requirements;
- Internationally, organisations like the UK Built Environment Advisory Group specifically seek to connect funding agencies with the skills base of the UK professional institutions to promote better built environment development in less developed countries.

Fix Your Own Printer

Fix Your Own Printer is an online community in which members of the public may submit technical questions and receive responses allowing them to make repairs to their own products, increasing product lifetime.

Image: CartridgeSave / Creative Commons

National Policy

A common feature of climate discussions with established businesses is that "we can't act until the government provides the right stimulus" which places an insurmountable burden on government processes, and there isn't time to wait for sufficient central action. For that reason, the forum leading to this report specifically attempted not to discuss national policy initiatives – but despite our best efforts, delegates couldn't restrain themselves from making suggestions!

Implementation and accountability mechanisms:

- The most important missing component of UK mitigation policy is a Delivery Authority with the budget and influence to direct efforts across all Whitehall functions at the real delivery of zero emissions according to the government's schedule;
- In parallel, an updated Green Book would allow the National Audit Office to ensure accountability across the civil service for spending decisions, to ensure every governmental investment is compatible with zero emissions.

In drawing attention to the problem of deployment rates, UK FIRES specifically recommends differentiating technologies which are already at sufficient commercial scale to be part of mitigation policy from those where we need to gain more experience. Many delegates described opportunities for government to develop and expand a programme of gaining such experience:

- The BEIS Energy Entrepreneurs Fund and the Industrial Energy Efficiency Accelerator are excellent mechanisms that could be expanded to gain more experience more rapidly;
- National policy both lags technology developments and has an implausible faith in their future potential. Cabinet level advice on the realistic deployment of different technology options has become an essential requirement for rational policy development;
- The legacy of technology agnosticism in policy has slowed progress in mitigation, where the number of options available to deliver a zero-emissions economy in the time available is in fact relatively limited;
- Make better use of universities which have or can develop the infrastructure to test new ideas/products to nearer commercial scale, in order to reduce implementation and accelerate deployment;
- Changes to tax and spending;

- Border adjustment mechanisms of some form and particularly for raw materials will be essential to allow zero-emissions production to flourish in the UK without being stifled by high-emitting imports;
- Changed tax priorities should include increased taxation on fuels, materials and waste matched with reduced labour taxes. Striking contradictions are currently provided by the absence of tax on air fuel, and the imposition of VAT on building refurbishment but not new build;
- The management of electricity prices through taxation must steer a difficult path between reducing overall demand in anticipation of shortage, while protecting vulnerable users from high prices;
- Infrastructure spending should be redirected from projects likely to increase energy demand and emissions (new roads or airports) to those likely to reduce them (electrified rail, expanded bus and cycle networks);
- Zero-emissions bonds could be a significant role in spreading the cost of zero emissions investments over longer periods, for example in building retrofits;
- Rigorous elimination of subsidies to emitters, including any government support at all for the fossil fuel industries, is essential.

Changes to regulation:

- The right legislation will accelerate innovation, as it has in the regulation to phase out combusting cars, and eventually regulation will be required across all emitting activities, just as with any other health and safety hazard. A roadmap of such regulation, based on emissions impact and the relative availability of alternative solutions, is a critical missing component of current mitigation policy;
- Regulation will be required to eliminate gas boilers (this could be implemented soon), current production of plastics, ruminant farming, conventional blast-furnace steel, cement production and aviation. Early publication of a roadmap would greatly facilitate a smooth transition.

Information and Leadership:

- The UK has no neutral supplier of well-evidenced information about mitigation options and their scale and deployment. Government provision and independent certification of such information would greatly enhance public understanding and subsequent debate;
- Based on good information, the government would be able to publish well-informed guidance on the full portfolio of options for reaching zero emissions, including those they currently find less palatable, in order to bring forwards the necessary public debate about preferences;
- Clear and consistent Government signalling about its commitment to delivering zero emissions is essential to provide the certainty and conviction required to lead the public through an unprecedented transition.

3. What upsides/co-benefits can we find while reducing emissions?

The rapid transition to zero emissions will not lead to benefits for everyone in all aspects of their lives, and will cause difficulty for some. For example, jobs and investments in unavoidably emitting industries will be lost and families currently spread across continents have one generation to co-locate, before fossil fuel aviation ends. However, there are many potential gains to be found in the transition:

- Individual lifestyles may be improved, through better air quality, reduced noise and pollution, reduced congestion, improved local facilities and improved road safety;
- Some aspects of diet may improve in the transition to largely plant-based eating, although this depends on access and affordability;
- A shift from disposable commodity products to lower volumes of higher quality goods may lead to improved well-being. For example, higher quality low-energy housing is reported to give greater occupant satisfaction through good design. Acts of "usership" in maintaining, repairing and adapting higher quality products can be highly satisfying;
- Reduced travel, for example through remote working, can release more leisure time, reduce household expenditure and create the opportunity for more local social life;
- Acts of leadership at all scales in making the transition to zero emissions can be beneficial for self-esteem, collaboration and collective identify;
- Replacing GDP as an indicator of national wellbeing with a more balanced set of figures of merit can support a range of community benefits, including recognition and value in service, better job design, improved work-life balance and a more fluid mix of voluntary, part-time and full-time work from qualification to beyond current retirement;
- Resubstitution of human effort for currently powered activities, in transport or elsewhere, may offer physical and mental health benefits;
- Infrastructure that supports local living, including safe walking and cycling and better distributed local services can lead to a more rooted sense of place;
- Better urban design can improve drainage and maintain more diverse natural habitats;
- Tree-planting and rewilding can create more varied and attractive landscapes, and this can be amplified as the shift to less meat-intensive diets releases farmland currently used for fodder;
- Better remote working and connection allows a more dispersed distribution of employment, education, wealth and opportunities for growth and for some activities will increase conventional measures of productivity;
- More local living could lead to stronger communities, reduced sense of helplessness in the face of the climate crisis, a shared sense of purpose, shared conservation of local assets, and more participation in collective decision making. A sense of community effort with a shared goal, as was very apparent in the first COVID-19 lockdown, could be a powerful mechanism for releasing the rich range of opportunities revealed in this report;
- New forms of corporate governance compatible with zero emissions, could include re-thinking models of participation, collective decision making and ownership;
- New skills will be required and valued to operate zero emissions living effectively, and the IP, services and products described in this report will find new markets and new wealth;
- Transforming material production to be sourced primarily domestically will increase material security and national resilience and improve the balance of trade.

Finally, as the UK has sought to assert global leadership through its target setting, it will achieve much greater respect through delivering on those targets, by identifying, growing and then exporting the knowledge, skills and systems of real zero-emissions life.

Part 2: Resource Efficiency activities in the UK

The Alliance for Sustainable Building Products

About Us

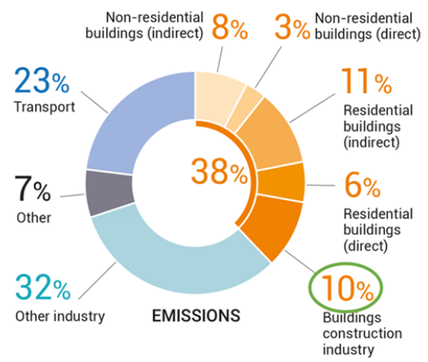
The Alliance for Sustainable Building Products (ASBP) is a non-profit, mission driven organisation, with an ever-growing membership alliance of forward-thinking companies and institutions from across the built environment sector.

Business growth and zero emissions

The focus of Targeting Zero is on assessing, advising, and reducing embodied and whole life carbon emissions from the built environment. I have authored or co-authored, the RICS Professional Statement on Whole Life Carbon assessment, the RIBA Whole Life Carbon guidance and the GLA's New London Plan's Whole Life Carbon Guidance and contributed to UKGBC, LETI and other publications. I am chair of the Whole Life Carbon Network which is working to improve consistency in carbon reporting and has just released 'Carbon Definitions'. All the above are aimed at evolving carbon assessment and reporting to be more accurate, reliable and consistent to help us transition to a zero-carbon economy.

The standard claim is that some 10% of UK emissions are due to embodied carbon from the Buildings Construction Industry. However, that 10% is certainly an underestimate as it only includes the emissions from some of the relevant industry sectors like steel, cement, aluminium etc, but not all, and does not include transport. The true figure is therefore likely to be somewhere between 10% and 20%. A key point is that approximately a third of these embodied emissions can be reduced for no cost within current knowledge and technology. Yet this 'easy win' is not being exploited.

An important part of optimising whole life carbon is to understand the relationship between embodied and operational emissions, i.e. the embodied costs of operational benefits. To maximise carbon reductions, we need to make sure that the embodied carbon costs of say insulation or PV's is minimised in relation to the savings or contributions they make. To enable this equation to be fully understood, it is necessary to be able to turn future energy use projections into future in-use carbon projections. This has not yet been achieved.



From GABC: Global Status Report for Buildings and Construction 16 December 2020. Global Emissions from different sectors, 38% = 'built environment' but see comments above.

The Carbon Trust

About Us

Our mission is to accelerate the delivery of a sustainable, low carbon economy by helping businesses, governments and organisations across the globe to reduce carbon emissions and increase resource efficiency. We have a global team of more than 200 sustainability experts, including engineers, financiers and policy specialists, and almost two decades of experience in the climate change sector. From launching the world's first carbon footprint label to establishing a flagship Offshore Wind Accelerator programme, the breadth and depth of our knowledge is unrivalled.

Every day, we work with new technologies, markets and business models – making the case for change based on evidence and facts. We cut through uncertainty to provide insights that support better, often bolder, decisions.

We are committed to accelerating the development of new technologies and innovations, taking the lead in transformational projects. Whether designing and managing complex partnership projects or supporting businesses on their net zero journeys – we help our partners and clients succeed.

Business growth and zero emissions

To accelerate the transition to zero emissions by 2050 we give clarity to ambition. For example, our Climate Action Pathway for Net Zero Cooling report lays out for the first time a vision for action to address uncontrolled growth in cooling emissions, which are projected to be 20-25% of total GHG emissions by 2050.

Through our leadership of UK government industrial cleantech acceleration programmes, we help industry to overcoming barriers to transition and leverage drivers that promote business growth. For example, the Industrial Energy Efficiency Accelerator helps proven industrial innovators demonstrate high-impact emissions reducing technologies in real-world situations. Through our guidance of the Energy Entrepreneurs Fund we help cleantech innovators prepare for commercial growth. Today a strong wave of UK technology innovation is moving forward to support the transition to 2050.

CE-Hub

About Us

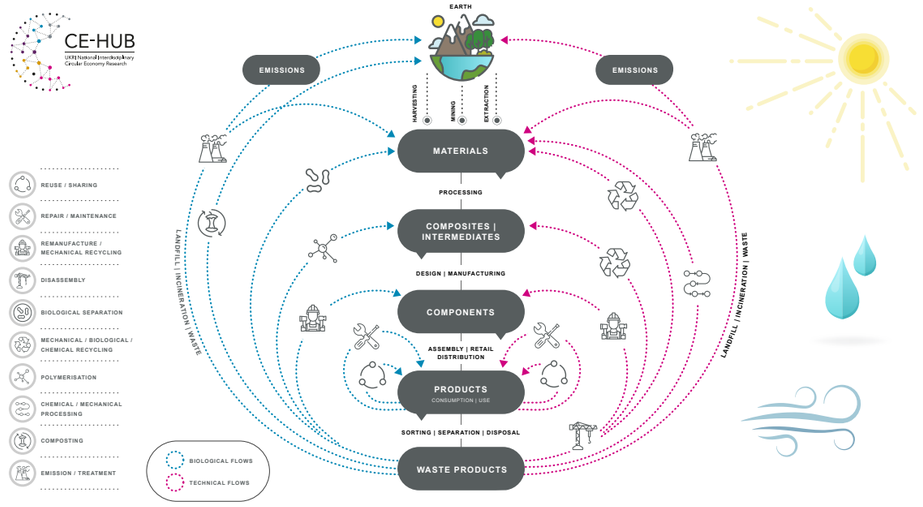
The National Interdisciplinary Circular Economy Research (NICER) Programme is a £30M UKRI investment that aims to accelerate and scale-up the UK's transition to a Circular Economy. The programme consists of five centres of excellence, involving 34 leading UK universities, focusing on the resource flows of Textiles, Metals, Mineral-Based Construction Materials, Chemicals and Technology Metals, and an integrating Circular Economy Hub (CE-Hub).

The CE-Hub aims to harness and scale-up the UKs leading research capabilities, providing the evidence base, inspiration and capacity to accelerate the transition towards a global circular economy. In addition to progressing research and innovation associated with the circulation of each resource flow the NICER Programme, launched in January 2021, is enabling new collaboration between Business, Policy and Academia across value chains to realise integrated system level change. The CE-Hub will develop a National Circular Economy Observatory to provide a digital representation and analysis tool to better understand critical resource flows across the UK and informing evidence-based decision making at multiple levels including business, industrial sector and national policy. We will also create a Circular Economy Knowledge Platform to coordinate and curate evidence from across the academic and industrial community in the form of case studies, methods and tools to support and direct circular economy implementation.

Business growth and zero emissions

The CE is a simple, yet compelling framework based on a set of clear principles that decouple resources from economic growth through innovation and entrepreneurship. Analysis has indicated that scaling up circularity provides a multi-billion economic opportunity, driving up resource productivity, driving down material costs, improving resource security and reducing negative externalities and their human and environmental costs. In the wake of COVID-19 there is a significant opportunity for a more sustainable and resilient recovery that can 'Build Back Better'. Recent reports propose that moving to a more CE can provide an essential element of the UK's recovery plan, delivering increased clean growth, net jobs, higher resilience and regenerate natural capital.

To drive a CE at scale across value chains in the UK requires a systematic and systemic approach including: the future design of materials, components, products, services and infrastructure; business models that promote access and performance over ownership; closed loop and reverse logistics and whole system enablers and innovation, including the use of data, emerging technologies and behaviour change. Creating and capturing circular value requires a shared vision of a future CE, a common understanding of the key drivers, solutions and building blocks, a stronger scientific evidence base and systemic innovation. The CE-Hub will provide an overarching point of convergence for academic CE research and applied innovation. Furthermore, we will coordinate engagement with key stakeholders to build a long-term community to deliver CE value creation and provide national leadership.



Centre for Climate Change and Social Transformations

About Us

The CAST Centre recognises that people are at the heart of the society-wide changes that are needed to address climate change. Rapid transformations to a more sustainable society can only be achieved if these are undertaken with the support and involvement of the people that will be affected by them. Our view is that people have capacity as agents of change to bring about a low-carbon future in a variety of interlocking ways. This might be as a concerned community member acting to promote active travel, as a business leader finding ways to enable more sustainable practices, or as a citizen expressing their opinions on policy proposals and technological innovations.

Business growth and zero emissions

Across our range of research and outreach activities, we are focusing on people as agents of change. Crucially, we can't impose solutions on people; we know from the gilets jaunes, fuel duty and other protests that this won't work. We need to start from where people are now and work closely with them to create and test out bold visions of the society we want. Mobilising people requires understanding how their values translate into both action and inaction. This means listening closely to people's views and concerns as part of our work examining what low-carbon futures could look like, and through the nationally-representative public surveys we are conducting across the life of the Centre. As part of our research looking at how successful changes have been achieved in the past, we are looking at how people have driven change from the ground up to achieve positive outcomes. We are also working closely with communities and organisations to implement and trial new approaches for reducing emissions. Effective communication and interaction with people across society is essential for ensuring our research insights are taken up elsewhere, and we have a series of projects that set out to do this.

The Centre for Sustainable Road Freight

About Us

The Centre is a collaboration between Cambridge and Heriot-Watt Universities and organizations in the freight and logistics sectors, with a major 5-year grant from EPSRC.

Its purpose is to research engineering and organizational solutions to make road freight economically, socially and environmentally sustainable. The centre has a £5.8 million funding for the first 5 years.

A vital feature of the Centre is its close links with the freight industry. Of the first five year's funding, £4.4 million will come from the Engineering and Physical Sciences Research Council and £1.4 million from the industrial consortium. The consortium includes key freight operators such as John Lewis, Tesco, DHL and Wincanton, along with vehicle industry partners, including Volvo, Goodyear, Firestone among others, who help set the research agenda and spearhead the adoption of the results by the road freight industry.

The research team brings together road freight vehicle engineering expertise from the Department of Engineering at the University of Cambridge, and logistics expertise from Heriot-Watt University's Logistics Research Centre: to explore ways to make road freight economically, socially and environmentally sustainable.

The overall aims of the Centre are to:

- research the sustainability of road freight transport: from tactical to strategic, fundamental to applied, micro and macro-level perspectives;
- develop innovative technical and operational solutions to road freight transport challenges;
- develop tactics and strategies to meet Government emissions-reduction targets for the road freight sector, mapping out ways to provide an 80% reduction in CO2 emissions due to road freight transport by 2050

Business growth and zero emissions

The best way to achieve very deep reductions in CO2 emissions from the road freight sector is to combine highly-focussed vehicle engineering with systematic improvements to freight distribution systems: optimizing vehicles in parallel with logistical tasks. This is the focus of the Centre. The engineers at Cambridge are delighted to be collaborating with the UK's foremost freight logistics research centre at Heriot-Watt University and with a set of truly excellent industrial partners.

Centre for the Understanding of Sustainable Prosperity

About Us

Our guiding vision for sustainable prosperity is one in which people everywhere have the capability to flourish as human beings—within the ecological and resource constraints of a finite planet. A prosperous society is concerned not only with income and financial wealth, but also with the health and wellbeing of its citizens, with their access to good quality education, and with their prospects for decent and rewarding work. Prosperity enables basic individual rights and freedoms. But it must also deliver the ability for people to participate meaningfully in common projects. Ultimately, prosperity must offer society a credible and inclusive vision of social progress. The over-arching goal of CUSP is to contribute to that essential task.

Nick Mohlo is the executive director of the Aldersgate Group, a cross-economy organisation whose business members have a collective global turnover of around £550bn. The work of the group focuses on developing policy positions to tackle major environmental challenges in a way that is environmentally effective and can deliver economic benefits. The group's work covers a wide range of environmental policy issues including climate and energy policy, resource efficiency, natural capital, skills, trade and green finance.

Business growth and zero emissions

We are looking at sustainable finance from various angles—our research aims to develop a powerful new framing of investment in terms of a meaningful 'commitment to the future'. This framing is motivated in part by the lessons from the financial crisis, where speculative, short-term investment was instrumental in undermining financial stability, and in part by the investment needs inherent in the transition to a sustainable, low-carbon economy. Resource productivity, low-carbon infrastructure and the protection of habitats and ecosystems all demand a new portfolio of investment with new governance and facilitating conditions.

Our research aims both to understand the macro-economic challenges posed by this new portfolio and also to explore the pragmatic innovations needed to deliver it. In pursuit of these goals we are (i) developing new economic models of sustainable finance and (ii) engaging with stakeholders at the local, national and international level to transform the insights arising from this research into practice. Our modelling aims to explore issues as varied as: the stranding of conventional (fossil fuel) assets; the stability of financial (and social) returns on sustainable assets; and the relevance of new local and community-led finance for sustainable prosperity. Our stakeholders include businesses, policy-makers, parliamentarians, civil society organisations and the wider public.

C-THRU

About Us

The bold ambition of C-THRU is to deliver foresight on the future interventions and innovation opportunities in the petrochemical sector required to minimize greenhouse gas (GHG) emissions. This will be achieved by delivering the world's most comprehensive, reliable and transparent account of current and future emissions for the global petrochemical sector. This account and the underlying modelling methods, tools and data will support strategic policy and business decision-making to promote the sustainability of the petrochemical sector, making it compatible with climate change mitigation goals.

The data tools and methods created by C-THRU will enable the anticipation of demand, use and waste generation of a wide range of petrochemicals, testing the future impacts of various strategic shifts in the industry. This will detail the key petrochemical products and applications that could enable a transformation in the configuration of value chains with less emissions. Within possible configurations, we will test the conditions under which the shift of oil and gas from fuels to chemicals and plastics is compatible with climate change mitigation goals. It will equally assess the impact on GHG emissions of future improvements in process efficiency, switches to new process routes and novel decarbonization technologies.

www.c-thru.org

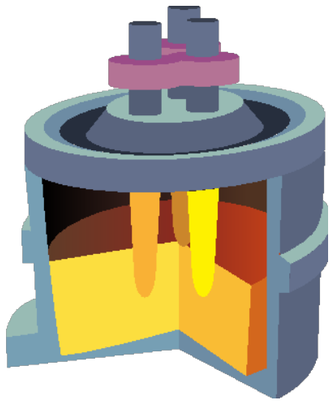
Business growth and zero emissions

Industry is proving to be a challenging sector to decarbonise. Yet, the falling costs and potential scalability of wind power and solar PV, coupled with the electrification of UK industry, provides a promising pathway to deliver decarbonisation.

The average carbon intensity of the UK grid has fallen rapidly over the last 10 years driven by the phase out of coal-fired electricity generation and its replacement with renewable power. Various scenarios suggest that UK grid electricity could be completely decarbonise well before 2050, with strong market support from the Contracts for Difference (CfD) scheme.

Electricity already makes up around 35% of final energy use in UK industry, mostly to drive machines, control processes, and for cooling. Some industrial processes such as aluminium smelting, steel scarp melting and induction heating already use electrically, where costs and thermodynamics are favourable. However, process heat is mostly provided by burning fossil fuels (i.e. coal, oil or gas), while for some processes carbon is required as a reactant (i.e. reduction of iron ore to iron), both which release carbon emissions.

Studies indicate that up to 80% of industrial energy demand can be electrified using already established technologies, by converting low/medium temperature applications such as cooling, space heating, steam generation, and drying, and high temperature furnaces. New technologies under development for chemicals, cement and steel could lead to complete electrification of industrial processes.



Green Alliance

About Us

Green Alliance is a charity and independent think tank that focuses on achieving ambitious leadership for the environment across a number of policy areas – greening the economy, climate and energy, natural environment, and resource stewardship. Our work on resources often focuses on improving resource efficiency and driving a more circular economy, both ideas that offer considerable potential for green growth. It's been estimated that improving resource use in UK manufacturing could add £10 billion to the sector's profits, and we know that investors are becoming more aware of the risks of not improving the use of some critical materials – nine out of ten investors would rule out or reconsider investment where supply chain risks have not been addressed. Beyond manufacturing, there are also plenty of potential jobs in circular economy activities like reuse, repair, remanufacturing and recycling.

Business growth and zero emissions

Our work with WRAP estimated that an ambitious approach could create more than 500,000 jobs of various skill levels, up and down the country. Government policy hasn't effectively grasped these opportunities. Reasons include its focus on the supply of energy to meet climate change targets – decarbonising energy supply and developing new technologies. It also includes its too often siloed approach to policymaking – the resources agenda is largely looked after by Defra, which tends to focus on waste, and BEIS is only recently beginning to embrace the agenda, while other departments like Treasury and MHCLG lag further behind. Our recent report, Targeting success, argued that a cross-economy target to reduce resource use – as exists for greenhouse gasses – would more helpfully focus minds and approaches. This would need to be supported by specific plans for different sectors, as they face different resource challenges, as well as for resource streams like critical raw materials.

Government Office of Science

About Us

The Government Office for Science advises the Prime Minister and members of the Cabinet, to ensure that government policies and decisions are informed by the best scientific evidence and strategic long-term thinking. We ensure and improve the quality and use of scientific evidence and advice in government, through advice and projects, and by creating and supporting connections between officials and the scientific community. We work closely with teams across the Civil Service, including the recently-announced Office for Science and Technology Strategy, responsible for development and delivery of the Government's climate and Net Zero policies, ensuring that rigorous challenge is brought to bear as policies are developed. In this role, we can highlight the work of academic groups developing the evidence base for particular approaches to managing future climate change, including zero emissions approaches.

Business growth and zero emissions

In June 2019, the UK became the first major country to legislate for a net-zero target for carbon emissions by 2050. Government needs to shape policies and regulations to create a market environment that increases consumer and business demand for low-carbon solutions and encourages sustainable private sector investment decisions. Policies across all areas of government interact to influence the transition of the whole economy towards net zero.

In a letter to the Prime Minister sent in January 2020, the Council for Science and Technology (CST) explores how a systems approach might be used to inform government thinking and proposes 9 recommendations focused on 3 areas:

- developing the analytical capability, flow of information, and reporting needed to inform decisions
- maximising the contribution of technology, mobilise financial systems and galvanise international collaboration
- strengthening the institutions, governance frameworks and leadership structures needed across central government to galvanise action to achieve net-zero

Henry Royce Institute

About Us

The Henry Royce Institutes was established to bring together UK academia and industry to undertake low TRL research, allowing the UK to grow its world-leading research and innovation base in advanced materials science. Alongside this Royce's vision of Advanced Materials for a Sustainable Society highlights that materials are at the centre of the global challenges we face, especially the shift to net-zero in a truly circular economy.

Royce's Materials Challenge roadmaps including Materials for the Energy Transition focus on the key technical challenges the materials science community must address. Royce offers the capability and collaboration environment for industry and academia enabling accelerated discovery, testing and characterisation of materials, components and systems. Data centric methods combined with dedicated, state-of-the-art capabilities, networks and skills development programmes, are underpinned by our brokering of partnerships between industry and academia. The overall purpose is to support new opportunities and accelerate the translation of innovation.

Business growth and zero emissions

Advanced materials are of course a key enabler and already contributing to our progress towards a number of critical areas on the road to net-zero. This includes research into materials that will deliver major advances in efficient energy storage to boost capacity while reducing reliance on critical materials, new fuel cell membrane development to exploit hydrogen and more efficient solar cells to harvest sunlight. Hydrogen in particular will play a significant role in driving the net-zero agenda and materials developments are crucial in its safe and commercially production, distribution, storage, and utilisation, tackling problems such as reduced reliance on precious metals for catalysis. For our buildings we need new and improved materials that significantly contribute to low carbon construction, to insulation and novel efficient technologies for novel heating and cooling such as caloric materials. To increase energy efficiency in our rapidly expanding digital world we need a radical transition to low loss electronics derived from ultra-efficient electronic materials.

Materials innovation is a bedrock, however technology translation and impact will come from porous interfaces with other technologies. Royce is therefore stimulating new research collaboration and skills development cutting across traditional disciplines with a science for solutions focus.

The Interdisciplinary Centre for Circular Chemical Economy

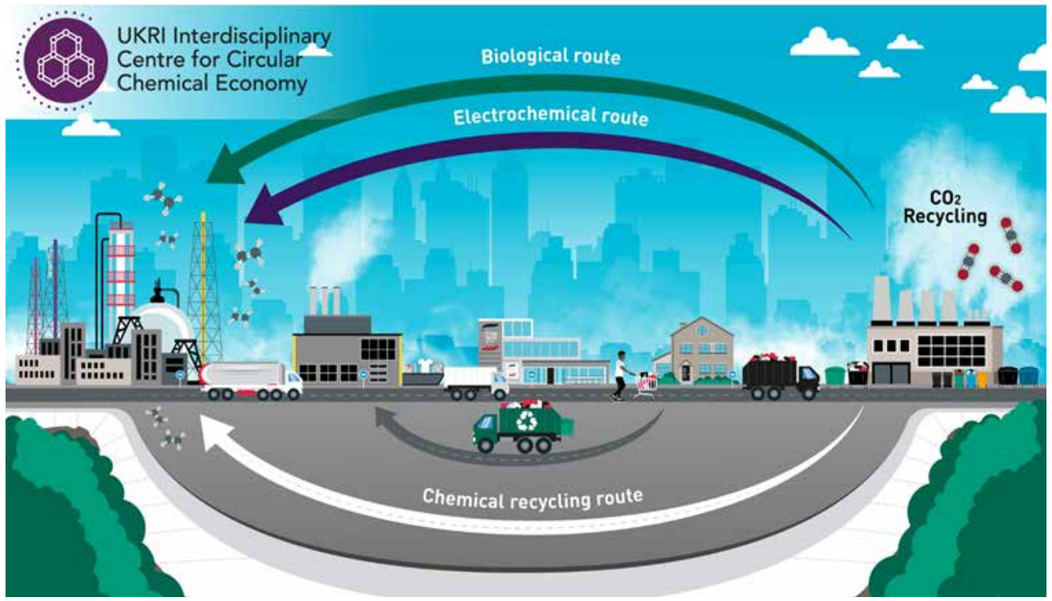
About Us

With an average annual turnover of ~ £32 billion, corresponding to a gross value added (GVA) of £12.6 billion in 2019 and 99,000 direct jobs, the UK chemical sector makes a significant contribution to the UK's economy. In the chemical sector, primary petrochemicals are readily converted into a wide range of bulk chemicals and intermediate products. These form the fundamental building blocks for the manufacture of a wide variety of useable consumer goods.

The overall vision of the CircularChem Centre is to transform the UK chemical industry's linear supply chain model into a fossil-independent, climate-positive and environmentally friendly circular economy. This will be achieved by creating a novel circular resources flow of olefins and their complementary feedstocks to replace the current linear olefins supply-demand network. The Centre will take leadership to tackle the national & global challenges of reducing carbon emissions and achieving resource security not only within the chemical industries, but also impacting a wider range of sectors and communities that use, distribute and recycle chemical-based products.

Business growth and zero emissions

To maintain the UK's global competitiveness, it is vital to reduce its greenhouse gas emissions and identify alternative sustainable feedstock. With 18.4 million tonnes of CO_2 emissions, the sector is the UK's second highest industrial emitter, and accounted for 16.5% of all industrial energy use in 2012. The IPCC has advised an immediate transition from fossil-derived feedstocks. Moreover, most commodity chemicals are currently produced from fossil-derived petrochemicals, with little chemical recycling and recovery. The current linear approach of the UK chemical industry is incompatible with UK emissions and sustainable growth policies. Therefore, a threat to this £12.6 billion p.a. industry exists since it is clear that the industry no longer has the option of business as usual.



The Interdisciplinary Centre for CircularMetal

About Us

The International Resource Panel (2019) has forecast that by 2050, global resource extraction will increase to 177Gt/year, global population to 10.2bn and GHG emission to 60Gt/year. This is leading to a head-on collision between the shrinking global ecosystem and the expanding human economy. Urgent actions are required to mitigate this catastrophic collision. Circular economy approaches provide effective mechanisms to decouple economic growth and rising living standards from resource consumption and environmental damage. Metallic materials are the backbone of manufacturing and the fuel for economic growth. Our ambition is to make the UK the first country in the world to realise full metal circulation.

The Centre, led by Professor Zhongyun Fan – BCAST, Brunel University London. Principal investigator/director of the EPSRC Future LiME Research Hub, a national centre of excellence in liquid metal engineering; has assembled a truly interdisciplinary academic team from Brunel University London, UCL and University of Warwick (including macroeconomics, industrial sustainability, business management, artificial intelligence, product design, metallurgical science and materials engineering) and a strong industrial consortium involving the full range of the metals supply chain that are working to accelerate this transformation!

This team includes amongst others; Professor Raimund Bleischwitz, Chair in Sustainable Global Resources at University College London (UCL) and Director of the UCL Bartlett School of Environment, Energy and Resources (UCL BSEER). He is Co-I on two UKRI Circular Economy Centres on metals and construction materials starting January 2021.

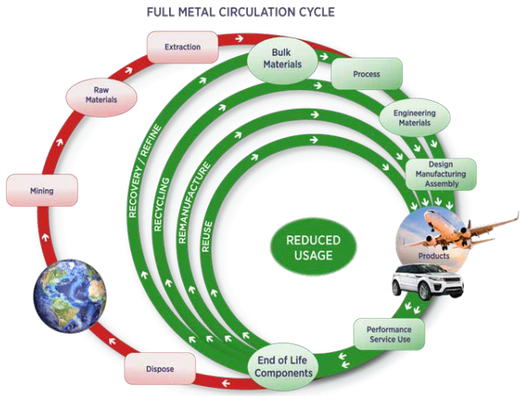
We will conduct macroeconomic analysis of metal flow to identify circularity gaps and to develop pathways/policies/regulations to bridge them. We will develop circular business models, circular design principles and enabling technologies to underpin this transition. We will work closely with the wider academic and industrial communities, policy makers and the general public to deliver the widest possible impact of circular economy. CircularMetal programme will provide the capability and pathways to eliminate the need for metal extraction, resulting in an estimated £100bn addition to the UK economy over the next 10 years.

Business growth and zero emissions

As a foundation industry, metals underpin the competitive positions of every industrial sector. The UK metals industry comprises:

- 11,100 companies
- Employs 230,000 people
- Directly contributes £10.7bn to the UK GDP
- Indirectly supports a further 750,000 employees and some £200bn UK GDP

Transforming the metals industry from current largely linear economy to a circular economy plays a critical role in delivering the government's industrial strategy for clean growth, and reaching net zero carbon emissions in 2050. Our ambition is to make the UK the first country in the world to realise full metal circulation. CircularMetal will provide the capability and pathways to eliminate the need for metal extraction, resulting in an estimated £100bn addition to the UK economy over the next 10 year.



The Interdisciplinary Circular Economy Centre in Technology

About Us

The Interdisciplinary Circular Economy Centre in Technology Metals, led by experts from the Camborne School of Mines, is one of five new centres announced by the Government on 11 November 2020.

Funded as part of a £22.5 million Government investment, it explores how to create a circular economy for the technology metals such as cobalt, rare earths and lithium that are essential in all clean and digital technologies including electric cars and wind turbines.

The centre aims to develop a new cycle, right from the first stages of extraction, to enable secure and environmentally-acceptable circulation of these crucial materials within the UK economy.

Business growth and zero emissions

The Centre will brings experts from the Universities of Exeter, Birmingham, Manchester, Leicester and the British Geological Survey, as well as 40 partner companies and organisations.

As well as researchers from the Camborne School of Mines, Exeter also provides expertise from the Environment and Sustainability Institute, the Renewable Energy department and the Business School.

The Centre applies circular economy principles to every aspect of mineral use in clean and digital technologies, including the initial extraction stage.

The research started with a case study of the industry ecosystem in Cornwall. With its exploration projects for the technology metals, lithium, tin and tungsten, the region has the opportunity to lead in whole systems circular economy actions for these metals.

The five new UK Research and Innovation (UKRI) Interdisciplinary Circular Economy Centres across the UK are dedicated to exploring how the reuse of waste materials in the textiles, construction, chemical and metal industries can deliver huge environmental benefits and boost the UK economy.

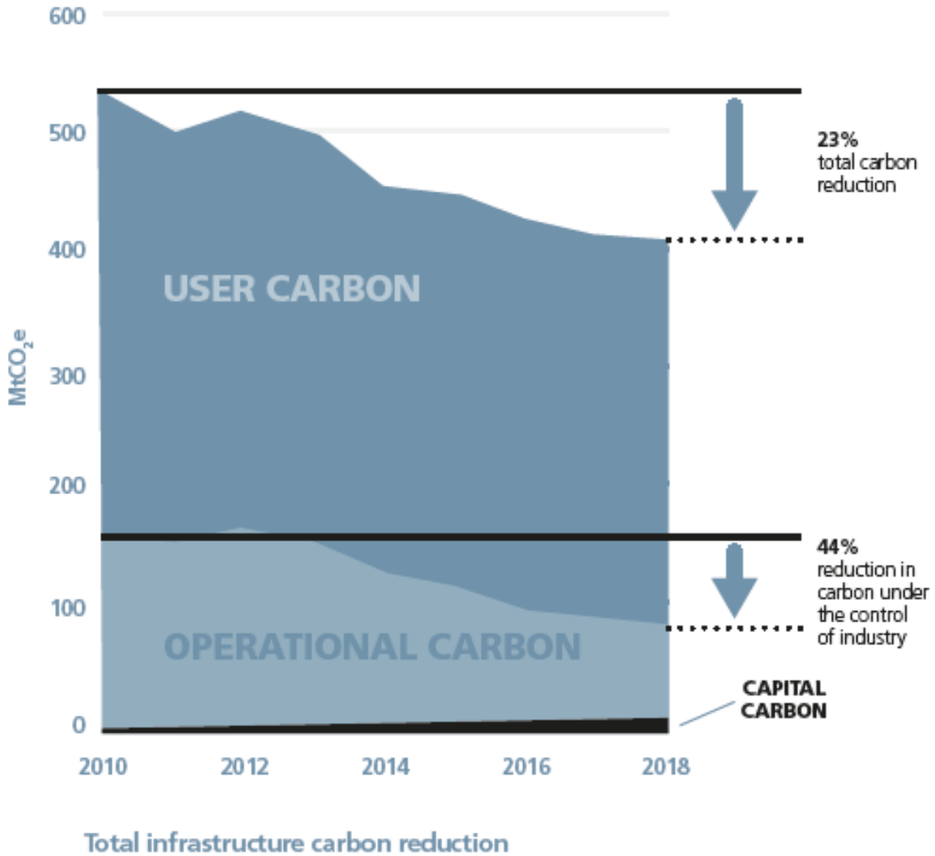
The Institution of Civil Engineers

About Us

The Carbon Project is a collaborative programme, led by ICE, to deliver rapid progress towards net zero carbon across all infrastructure systems, programmes and projects by 2050. We are focused on specific areas of technical practice where the civil engineering community has the greatest potential to support carbon reduction: Meaningful measurement, building new capabilities and transforming existing system-level emissions. We are focused on specific areas of technical practice where the civil engineering community has the greatest potential to support carbon reduction: Meaningful measurement, Building new capabilities and Transforming existing system-level emissions.

Business growth and zero emissions

The ICE is a huge advocate that building anything must be sustainable in the broadest sense of the word and the twin emergencies of climate change and biodiversity necessitate a total change in how everything is done – in order to create a new economy supported by new infrastructure systems to ensure that people can be happy, healthy and fulfilled, while respecting the limits of the planet to sustain us. The ICE recognises the responsibility and obligation for civil engineers to lead in promoting these new systems for infrastructure. It is important that climate change, the failures in our biodiversity systems, the need to create a fairer society and the necessity for more resilience are tackled together and holistically as we don't have time to tackle any of them individually.



Total infrastructure carbon reduction

The Institution of Structural Engineers

About Us

Structural engineers are the professionals charged with the efficient use of materials such as concrete, steel and timber, and the Institution of Structural Engineers has been working tirelessly since 2019 to put sustainability on a par with our enduring commitment to structural safety.

We are working closely with our members whilst supporting the transition to zero emissions in the UK by 2050. We recognise the continued need to provide buildings and infrastructure for the UK's inhabitants, but this must be done in a way that is less harmful to our planet, which can be achieved by:

1. Building fewer new buildings;
2. Using less new material and energy when we do build;
3. Prioritising use of materials that do less harm to the planet.

All three actions serve to reduce consumption, develop new technologies and drive opportunities for materials industries – supporting green economies whilst reducing emissions. To help our members align with these ambitions, we are providing them with guidance, tools and training around these topics. In the last year we have published over 60 free guidance articles at www.istructe.org/climate-emergency, as well as The Structural Carbon Tool – a free carbon calculator for members and non-members alike.

Business growth and zero emissions

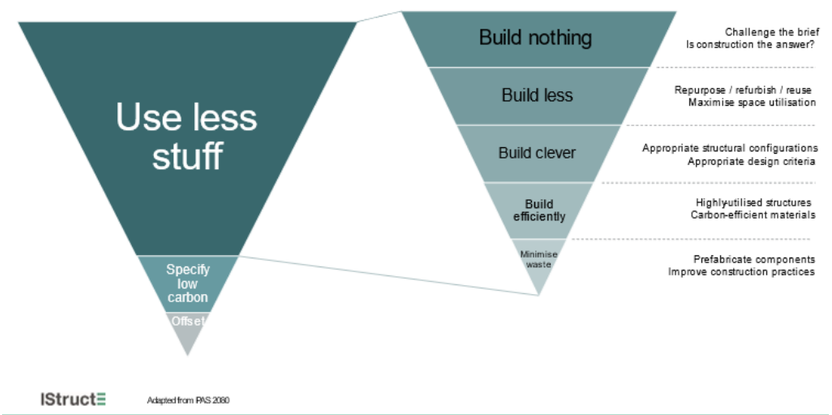
At the IStructE, we recognise that the design of the built environment is moving towards a new paradigm of creating more for less. More functional space for less building area. More material for less carbon. More uses from less material.

In order to prepare our membership for this, we are setting new standards for chartered engineers: updating our code of conduct, our education standards, and our requirements for attaining Chartered Member status.

We are doing this to prepare for a future where the businesses that thrive are the ones that can create more for less. We already see commitments being made by developers and financers to drive down the emissions of the construction that they are responsible for, and our engineers are well-placed to respond to this.

We foresee growth in the retrofit and life-extension market, with engineers employed to help enable clients to make their existing assets last for longer. We envisage a tipping point for circular-economy thinking in the next decade or two, with demolition contractors transforming into disassembly contractors, and materials stockists moving towards being material re-stockists. And then we see the potential for teams of researchers, manufacturers and builders to work together to bring new technologies and materials to site through accelerated research into practice.

Responding to the climate emergency will take ingenuity, willpower, and the appetite to do new things – and we are proud to be playing a role in leading this change.



Manufacturing using Advanced Powder Processes

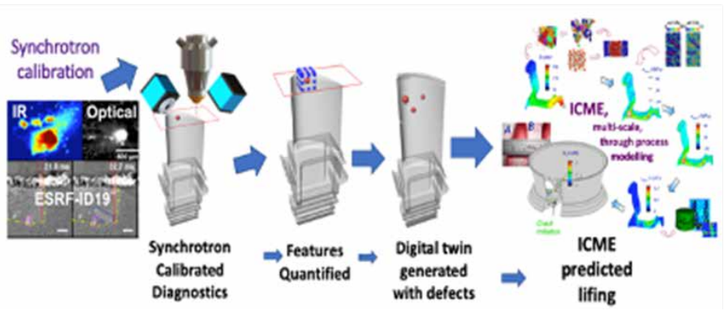
About Us

MAPP's vision is to deliver on the promise of powder-based manufacturing processes to provide low energy, low cost, and low waste high value manufacturing route and products to secure UK manufacturing productivity and growth. MAPP has drawn together a community of leading UK researchers and industrial and Innovation partners to work together in solving some fundamental challenges limiting the uptake of new and emerging technologies related to the manufacture of engineered components from powders. MAPP works across multiple material types seeking to recouple manufacturing process development with the underpinning materials science. Our research programme spans the fundamentals of powder materials, advanced in-situ process monitoring and characterisation, and new approaches to modelling and control including development of intelligent sensors and use of Machine Learning and physical modelling – linking these to overcome the obstacles to the wider adoption of advanced powder processing technologies.

The demand for resource efficiency and reduced waste, coupled with issues of material scarcity and the environmental impact of manufacturing and material production have become significant drivers of change. Rapid developments in powder-based processes, coupled with innovations across materials science, have the potential to facilitate manufacture of new product forms with complex structures, enhanced performance, and functionality. Technologies such as FAST (Field Assisted Sintering Technologies) can significantly reduce processing time in comparison with conventional powder processing routes while Additive Manufacturing, in its many forms, can produce components with improved function whilst simultaneously reducing the material used in the final product. Powder-based routes can generate components, materials, and structures, which in many cases exhibit superior properties to those manufactured by traditional routes, at the same time as delivering significant reductions in energy consumption and the waste generation. In addition, many commercially important materials can only be produced from powders.

Business growth and zero emissions

Furthermore, conventional materials shaping, and processing can be hugely wasteful and energy intensive. Typical aerospace buy-to-fly ratios of 10-20% mean much of the costly highly engineered starting materials destined for high value components ends up as scrap. Even with well-structured materials circulation strategies in place to recondition and recycle process scrap, the energy use, CO2 emitted, and financial costs associated are ever more prohibitive and unacceptable. Our view is that we can no longer accept the traditional paradigm of manufacturing where excess energy use and high levels of recycling / down cycling of expensive and resource intensive materials are viewed as inevitable and the norm and as a goal we are seeking to drive powder-based processes to the point where 100% of the starting material is incorporated into engineering products with high confidence in the final critical properties. However, challenges remain – these processes are difficult to control, powder manufacture can be wasteful and some current practices generate waste streams that are comparable with conventional processing routes.



PassivHaus

About Us

The Passivhaus Trust is an independent organisation that provides leadership in the UK for the adoption of the Passivhaus standard and methodology. Its aim is to promote the principles of Passivhaus as a highly effective way of reducing energy use and carbon emissions from buildings in the UK, as well as providing high standards of comfort and building health.

"Passivhaus is the leading international low energy design standard. With over 65,000 buildings completed to this standard across Europe, it offers a robust, proven and cost-effective method to help the UK achieve its challenging carbon reduction targets for the built environment sector."

Chris Herring, Chair, Passivhaus Trust

Passivhaus buildings provide a high level of occupant comfort while using very little energy for heating and cooling. They are built with meticulous attention to detail and rigorous design and construction according to principles developed by the Passivhaus Institute, and can be certified through an exacting quality assurance process, which eliminates the performance gap between how we expect our buildings to perform at design stage and what actually happens in reality once they are built.

The cheapest, and most sustainable, energy is the energy you do not use in the first place.

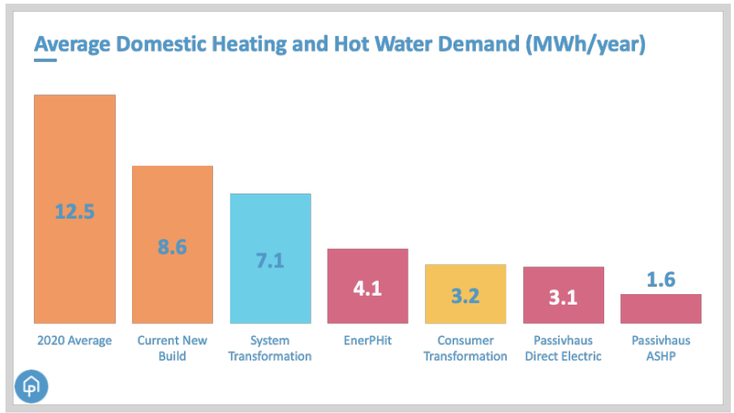
Through careful fabric first design and construction, building owners can significantly improve the comfort and quality of their buildings, while significantly reducing energy use. In fact, buildings designed to Passive House standards use up to 90% less energy than a traditional building and 75% less heating energy than a standard new build.

Business growth and zero emissions

The increased focus on the Climate Emergency has led to a stream of declarations to achieve Net Zero. Setting a Zero Carbon target for our new housing would be a clear and bold step to achieve genuine emissions reductions. If the zero carbon 'boundary' is expanded beyond the individual building to the national level, then achieving a net zero operational carbon built environment is possible if the fabric efficiency levels of our new homes are increased to Passivhaus levels.

When considering how to define a Zero Carbon building, it is essential to take into account the complete picture of how the building will use energy as well as the impact of the seasonality of renewable generation. Research undertaken by the Trust shows that Passivhaus is the only realistic way to achieve Zero Carbon without massive renewable energy expansion coupled with a significant investment in grid capacity. However, even when using Passivhaus as a mechanism to significantly increase efficiency, achieving a Zero Carbon built environment is only really viable if the system boundary is extended beyond individual buildings. Recent reports have forecast that we now only have a few years left to reduce emissions enough to avoid a catastrophic rise in global temperatures. Significantly reducing the emissions of our buildings is vital if the UK is to make a meaningful contribution and would lead by example when many countries are also struggling to understand how to reduce emissions sufficiently.

The graph shows that current new build standards are not sufficient to meet the requirements of National Grids Future Energy Scenarios, blue and yellow bars, published in 2020. To meet the consumer transformation scenario (yellow bar) every building in the UK, not just our new buildings, would have to meet Passivhaus levels of performance.



We have to take action on Climate Change to make sure our buildings in the UK and around the world are sustainable. The Passivhaus Standard gives us our tool in the building sector to meet our Climate responsibilities and deliver buildings suitable for our Net Zero future.

Transport Studies Group

About Us

Since 1973 the Transport Studies Unit has established an international research reputation in transport research.

Based within the world-leading School of Geography and the Environment at the University of Oxford, the TSU approaches global transport challenges from social science and holistic perspectives. This approach allows TSU researchers to ask questions that might not be asked in other sectors, building a comprehensive picture of the complex challenges facing transport today and in the future. Our position within Geography and the University fosters interdisciplinary collaboration with researchers in other parts of the University and based elsewhere.

Business growth and zero emissions

The transport sector is the UK's biggest source of CO_2 and widely seen as one of the most difficult to decarbonise. Delivering absolute zero emissions in transport will be challenging and require deep and rapid system change in not only the transport but also the energy/electricity and information technology sectors. Businesses have a key role to play in the required transition, and the UK is a fertile ground for start-up companies offering new mobility concepts related to, for instance, electric vehicle charging, shared mobility and mobility-as-a-service. Experience has shown that collaboration with local authorities, established firms and research institutions (both universities and private sector organisation) helps those start-up companies to learn and grow rapidly. Much of this learning takes place in practical experiments, funded by organisations like Innovate UK, government departments and the European Commission. These experiments allow for testing of equipment and services with end users and better understanding of what changes to services, business models, regulation and (local) government and company-internal procedures are required. They also allow start-up companies an opportunity to bring in further contracts and funding. In the presentation I will briefly reflect on experiences of working in various consortia for testing out business models and mobility concepts, and the benefits that working with research institutes for monitoring and evaluation and with other organisations can bring to start-up and more established firms seeking to contribution to the low-carbon transition in urban transport.

TransFIRE

About Us

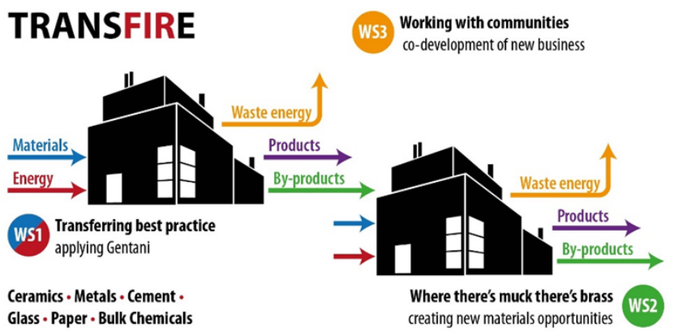
TransFIRe (Transforming Foundation Industries Research and Innovation hub) has been developed in response to the Industrial Strategy Challenge Fund call to transform the Foundation Industries, namely: Chemicals, Cement, Ceramics, Glass, Metals and Paper. These industries produce 75% of all materials accounting for about 10% of the UK total CO2 emissions. UKRI has allocated £4.7 M for three years to the Hub to work with universities, research organisations and industry to assist with technology development and transfer, new business developments and new opportunities in materials and technologies to help to achieve the Net Zero 2050 target.

TransFIRe is a consortium of 20 academics from 12 universities, 50 companies and 14 non-governmental organisations related to the sectors, with expertise across the foundation industries as well as energy mapping, life cycle and sustainability, industrial symbiosis, computer science, AI and digital manufacturing, management and business, social sciences and technology transfer. TransFIRe is led by Professor Mark Jolly, Director of Manufacturing at Cranfield University.

Business growth and zero emissions

TransFIRe would initially focus on three major challenges:

- Transferring best practice – applying "Gentani": Across the foundation industries there are many processes that are similar like comminution, granulation, drying, cooling, heat exchange, materials transportation and handling. Using the philosophy Gentani – minimum resource needed to carry out a process – this research would be to benchmark and identify best practices considering resource efficiencies (energy, water etc.) and environmental impacts (dust, emissions etc.) across sectors and share information horizontally.
- Where there's muck there's brass – creating new materials and process opportunities: Fundamental to the transformation of our Foundation Industries will be the development of new and novel materials and processes that enable cheaper, lower-energy and lower-carbon products. Through supporting a combination of fundamental research and focussed technology development, the Hub will directly address these needs. For example, all sectors have material waste streams that could be used as raw materials for other sectors in the industrial landscape with little or no further processing. There is great potential to add more value by "upcycling" waste through further processes and to develop new materials and alternative by-products from innovative processing technologies with less environmental impact. This requires novel industrial symbioses and relationships, sustainable and circular business models and governance arrangements.
- Working with communities – co-development of new business: Large volumes of warm air and water are produced across the sectors providing opportunities for low grade energy capture. Working with communities we will identify the potential for co-located businesses (district heating, market gardening etc.). This research will investigate the potential from societal, environmental, technical, business and governance perspectives.



UK Energy Research Centre

About Us

The UK Energy Research Centre (UKERC) carries out world-class, interdisciplinary research into sustainable future energy systems.

Funded by the UK Research and Innovation Energy Programme, UKERC is a consortium of top universities with a whole systems research programme that informs UK policy development and research strategy.

Currently in its fourth phase running from 2019-2024, UKERC delivers an ambitious programme of research on the challenges and opportunities for delivering the transition to a net zero energy system and economy. The programme brings together engineers, natural scientists and social scientists to generate evidence that informs real-world decisions.

UKERC research explores the technical, economic, policy, environmental and social dimensions of the energy transition, encompassing major themes on global energy challenges and their implications for the UK; the role of local and regional energy systems; interdependencies between energy systems and the environment; decarbonisation of specific sectors including transport, heat and industry; and transitions in energy infrastructures.

The programme is complemented by a set of national capabilities. These carry out systematic evidence reviews, host and curate energy data, map and monitor public engagement with energy systems, and improve the transparency and understanding of energy models. UKERC also supports the wider energy research community in the UK by promoting engagement with other stakeholders, supporting career development and capacity building, and enhancing international collaboration.

Business growth and zero emissions

The transition to a net zero energy system will require the transformation of existing energy infrastructures and the development of new ones. Major investment will be required that will take many years to be delivered. However, the energy transition pathway remains uncertain and, for much of the infrastructure, the related institutional arrangements are still under debate. Research in this theme will focus on the challenges associated with energy infrastructure transitions, including commercial structure, regulations, policies and public attitudes.

UK FIRES

About Us

UK FIRES is a 5-year research programme funded by £5m of UKRI support and the subscriptions of an active and growing industrial consortium. With academics from six universities spanning from materials engineering through data science to economics, corporate strategy and policy and an industry consortium spanning from mining through construction and manufacturing to final goods.

UK FIRES stands for placing Resource Efficiency at the heart of the UK's Future Industrial Strategy. When we proposed UK FIRES, it was to focus on Resource Efficiency as the key means to reduce industrial emissions. However, in 2019, both houses of Parliament unanimously approved a change to the UK's climate change act to target zero emissions in 2050. This has been reinforced by recent Government targets for 2030 and 2035.

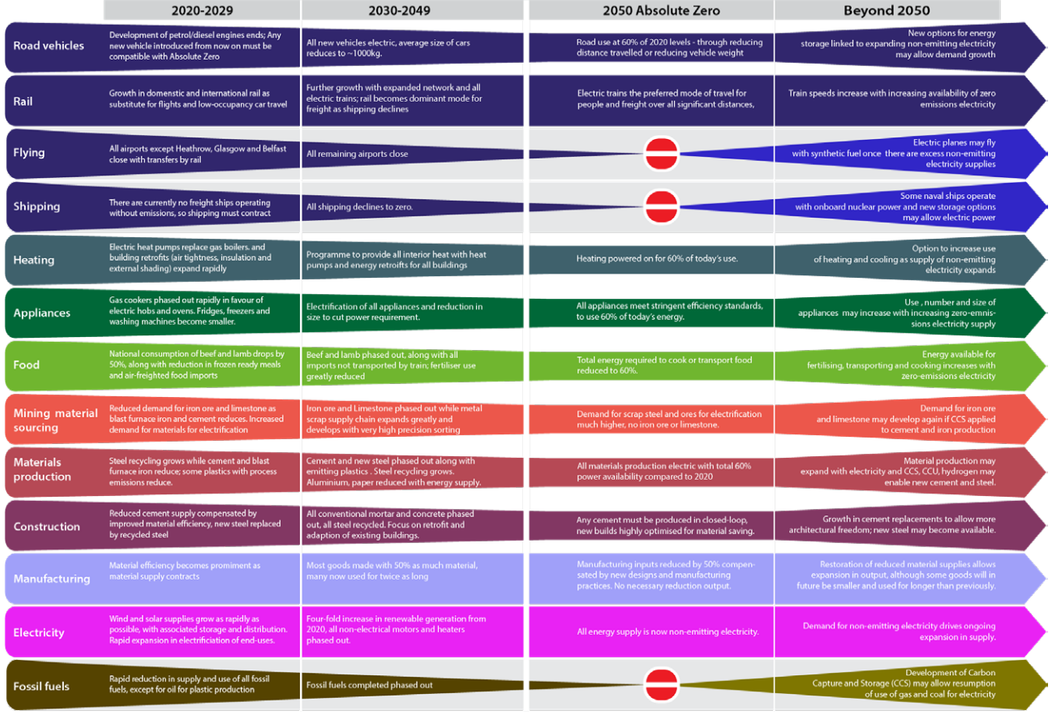
So, although we haven't changed our name to UK FIZES, our focus is now on placing Zero Emissions at the heart of the UK's Future Industrial Strategy.

UK FIRES is led by Professor Julian Allwood.

Business growth and zero emissions

UK FIRES takes a pragmatic approach: we focus only on technologies that are available to us today and exclude those that have yet to be proven at meaningful scale, since they simply may not be ready in time. In 2050 we aim to meet the energy demand of UK society by non-emitting electricity generation.

In December 2019, UK FIRES released the "Absolute Zero" report, a ground-breaking description of the operation of the UK with zero emissions by 2050, without relying on as as-yet un-scaled energy sector or negative emissions technologies. This pragmatic but striking view of the journey to zero emissions has attracted widespread interest including a full debate in the House of Lords in February 2020. Following the report, at the request of the UK Catapults, the UK FIRES team have been working through industry-focused workshops to develop five sectoral innovation reports to reveal the wealth of business growth opportunity revealed by the Absolute Zero analysis. These will be released during 2021.



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