

An abstract graphic consisting of several overlapping, translucent blue rings that spiral inward from the left towards the center of the page. The rings are set against a dark blue background, creating a sense of depth and movement.

Cryogenics Impact Summary Report

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This short report, a summary of a longer study on the impact of cryogenics carried out by WECD on behalf of the Science and Technology Facilities Council (STFC), summarises the size and significance of the cryogenics community in the UK and the importance of STFC's contributions to this field.

Cryogenics is an enabling low-temperature technology rooted in the application of physics and thermodynamics. The UK has a particularly strong cryogenic academic and business community, established over the last 60 years. This exceptional community is growing and thriving, and delivers substantial economic impact to the UK economy. Cryogenics is also supporting future potential scientific advancements and economic activity in a wide range of sectors.

Cryogenic systems find application in fields as diverse as food freezing, manufacturing and engineering, medicine and life sciences, satellite applications, astronomy, space exploration, the transport and storage of liquefied natural gas, energy, avionics, defence and security, as well as wide-ranging applications in superconductivity. Based on supply chain analysis, we estimate that sectors broadly associated with cryogenics represent 17% of the UK economy. **The total (direct and indirect) GVA contribution of cryogenics-related activities to the UK economy is around £324 million per yearⁱ.**

In addition, we estimate that cryogenic-related economic activities could contribute between **£1.6 billion and £3.3 billion to the UK economy in the next 10 years**, with STFC, its university partners and industry all being key players in delivering this growth.

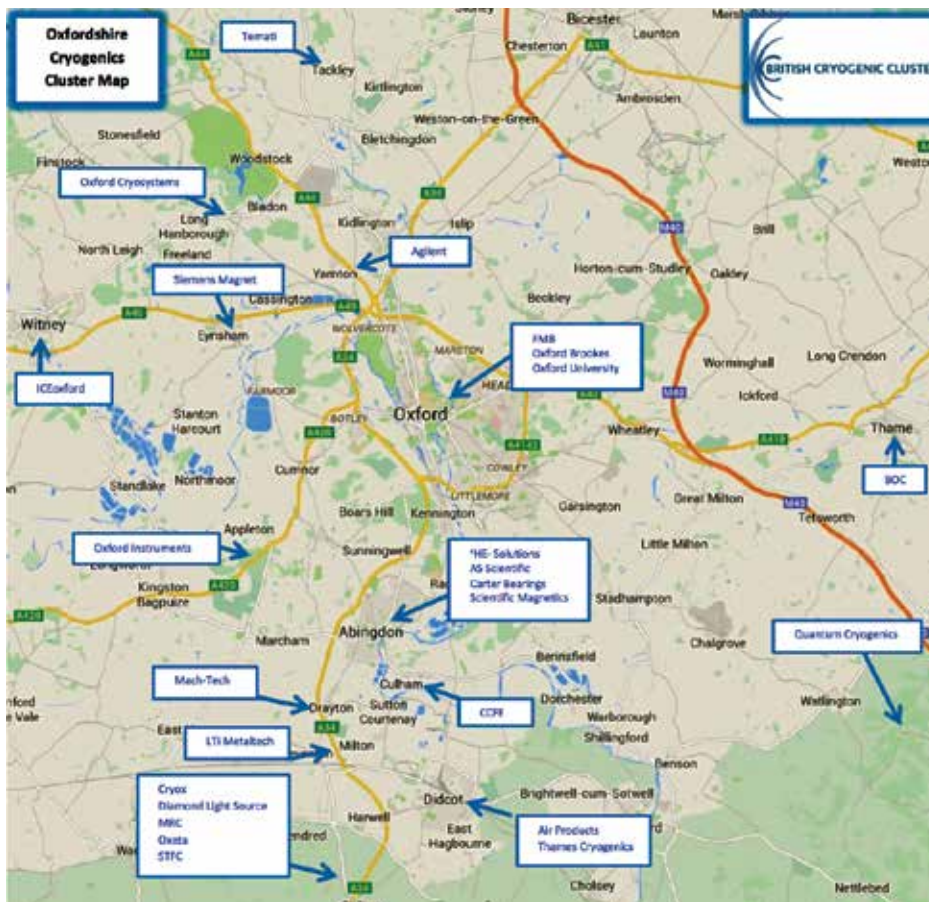


Figure 1: Oxfordshire Cryogenics Cluster map, provided by the British Cryogenics Cluster (<http://bcryo.org.uk>)

ⁱ Calculations on cryogenic industry size and future potential carried out by WECD

STFC is at the heart of cryogenics research and technology development in the UK. As one of Europe's largest research organisations, STFC supports scientists and engineers worldwide in fundamental research and applied technology that can have short-and long-term impacts. STFC is unusual in that it funds research in universities alongside delivering fundamental and applied research through its own laboratories. In particular, STFC plays an important role in developing early stage cryogenic technologies that may be commercially uncertain for private investment.

STFC's cryogenics capabilities are wide-ranging. It operates world-class facilities requiring and deploying cryogenics expertise, helps develop new technologies, and provides long-term research funding to support scientific areas that are reliant on cryogenics. In fact, the UK's cryogenics cluster is centred on Oxfordshire, and emanated from the interaction between STFC's Rutherford Appleton Laboratory (RAL), the University of Oxford and industry, ranging from specialist SMEs to global businesses. We estimate this cluster to contribute £97 million to the UK economy annually (based on 68 companies employing 615 employees)ⁱ. STFC also supports this cluster through the provision of cryogenics infrastructure at RAL and a wider range of support activities which foster collaborations between research and industry.

The evidence reviewed for this report shows that STFC is playing a major role in supporting and developing the £324 million cryogenics sector in the UK, particularly in the development of new, high-value, technologically challenging areas of cryogenics. There is also potential for substantial future growth.

A selection of examples in the report highlight STFC's long term leadership role in cryogenics-related work in the UK and worldwide, and the resulting scientific, economic and social impacts. Although it has not always been possible to quantify the scale of these impacts within this study, the case studies clearly demonstrate that impacts generated by



Cryogenic equipment is used in particle accelerators worldwide. Credit: STFC

cryogenics expertise supported by STFC are substantial at the UK and global level. Examples include:

- **Improving Life and Health** - STFC has played a major role in the development of superconducting magnets, which are used in the majority of today's Magnetic Resonance Imaging scanners. This industry supports 2,200 UK jobs in manufacturing and £137 million GVA, as well as savings to the UK economy of over £170 million per yearⁱⁱ.
- **Expanding Future Energy Sources** - STFC is supporting the development of the Dearman Engineⁱⁱⁱ, an engine that by 2025 could potentially deliver net savings of £113 million, improving UK energy security, local air quality and reducing carbon emissions by 1,284,000 tonnes of CO₂ emissions. It could also provide a new market for industrial gas producers worth £26 million per year^{iv}.
- **Championing UK Engineering Capabilities** - STFC is working with a specialist UK engineering company to help them move into the market for cryogenic equipment used in particle accelerators around the world. No UK company is yet in this market but a conservative estimate of sales for this company could be €1 billion over the next 10 years.

ⁱⁱ The economic impact of physics research in the UK: Magnetic Resonance Imaging (MRI) Scanners (2012)

ⁱⁱⁱ <http://www.dearmanengine.com/#!partners/c34m> (2014)

^{iv} Calculations based on predications from Centre for Low Carbon Futures (2014) Liquid Air on the Highway.

UK IMPACT OF CRYOGENICS

Annual employment and GVA impacts generated by UK-wide cryogenic activities



118
ASSOCIATED
COMPANIES



1,487
PEOPLE
EMPLOYED



£170m
TOTAL DIRECT
GVA



£324m
TOTAL DIRECT &
INDIRECT GVA

STFC's cryogenic teams also contribute an estimated £11 million per annum to the UK economy through operational impacts i.e. their employment (direct economic impact) and spending of their salaries within the economy.

**10 Years
ahead**

Projecting direct impact forward for next 10 years indicates cryogenics-related activities could contribute between £1.6 billion and £3.3 billion to the UK economy¹ with STFC, its university partners and industry all being key players in delivering this growth.

¹ Estimates vary depending on different assumptions made about the growth of the UK economy and sectors of high relative importance to Cryogenics e.g. medical, superconductors, manufacturing.

Sectors broadly associated with cryogenics represent 17% of the UK economy, these sectors collectively generate £1 in every £10 GVA in the UK economy.

Source: UK Annual Business Survey, 2013



Energy



Manufacturing &
materials



Defence &
Security



Space Science &
Astronomy



Research



Food



Healthcare

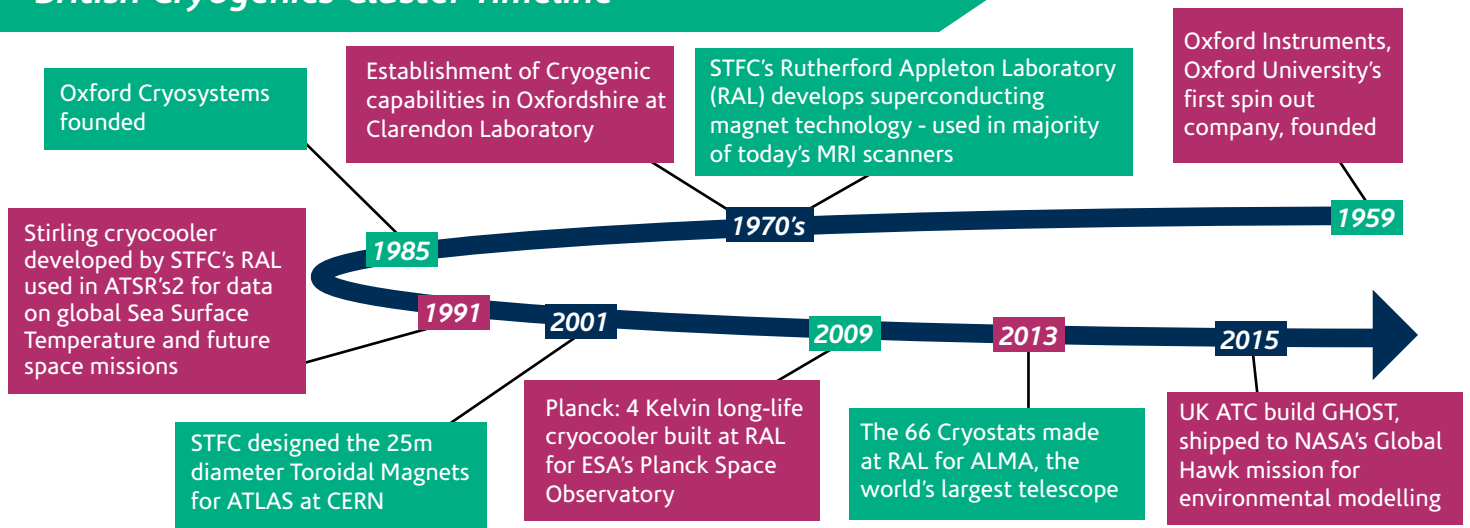


Transport

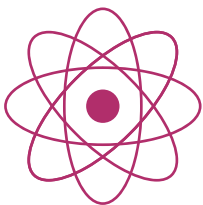
STFC's leadership role in cryogenics underpins a range of impacts, which are substantial and global in their reach. Our cryogenics expertise supports the next generation of particle accelerators, underpinned by our knowledge of superconducting radio frequency cavities. As well as designing and building cryogenically-cooled instruments, we also provide long-term research funding to support the UK's world-lead in astronomy and space science.



British Cryogenics Cluster Timeline



Future technological advancements in cryogenic-related activity



Quantum Computing



Next-generation particle accelerators



Superconducting wind turbine generators



Rapid chilling killing bacteria in food

“

The work with STFC has pushed our boundaries – we've invested in new specialised equipment and employed another nine skilled mechanical engineers. It has given us the confidence to start up our own R&D programmes – something we wouldn't have done on our own without STFC... enabling us to ...compete on the global stage.

Neil Shakespeare, CEO, Shakespeare Engineering Ltd.

The shipping of GHOST to NASA is an important milestone in transferring technology developed for astronomy to innovative instruments for Earth observations. It will offer the UK additional capabilities to deploy GHOST or similar instruments on our own national airborne research platforms.

Professor Gillian Wright, UKATC Director.

It [the British Cryogenics Cluster] gives a wider structure in which to operate, support and exchange experience... few years ago during the helium crisis, the cluster was able to raise awareness of the importance of helium supply to the industry

British Cryogenics Cluster Company.

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This infographic is based on a review commissioned by the Science and Technology Facilities Council (STFC) and conducted by Warwick Economics & Development. The report presents an overview of UK Cryogenics capabilities including the role of STFC, together with an assessment of the economic impacts of the technology on the UK economy.

- **Making Space Missions Possible** - STFC is responsible for funding early R&D in space science working closely with the space industry which helps ensure that the UK remains competitive in this area. The space industry is a major UK success story, growing to 106,000 jobs and £10.8 billion GVA in 2014^v. Different types of cryocoolers for space exploration have been developed over time by STFC teams with a variety of applications. In addition, STFC provides engineering design and testing of complete cryogenic systems for space missions including Planck and the Herschel Space Observatory.
- **Monitoring and Understanding Environmental and Climate Changes** - Cryogenics plays an important role in better understanding of environmental and weather related issues. STFC teams have led and/or contributed to a wide range of UK and international projects including: GHOST a world-first project to build an instrument for environmental modelling; and Along Track Scanning Radiometers, that provide data on global Sea Surface Temperature which contributes to our understanding of global warming. Improved weather forecasting through satellite data has been valued at £400 million -£1 billion per year^{vi}.
- **Leading in Ground-Based Astronomy** - STFC teams are key partners in internationally leading telescopes. For example, the Atacama Large Millimetre Array, with cryostats for the 66 antennae made at RAL and the development of instruments with cryogenic cooling and cryostat systems for the Very Large Telescope. STFC is also playing a lead role in developing cryogenic systems for next generation telescopes such as the European Extremely Large Telescope and the Square Kilometre Array; UK industry have already won contracts in these projects.



Global Hawk with STFC's GHOST instrument onboard. Credit NASA.

- **Accelerating Global Scientific Developments** - Cryogenics is a fundamental technology for a wide range of scientific facilities including particle accelerators and lasers, with the UK playing a world-leading role, hosting, ISIS and the Diamond Light Source in the UK and funding UK access to international research facilities including CERN. The products processed, treated or inspected by particle accelerators globally are estimated to have a collective annual value of more than £312 billion^{vii}. There have been several cryogenic contracts from CERN which have been won by UK companies.

For example, AS Scientific, a UK company and global supplier of low temperature engineering equipment won several contracts from CERN that led to an invitation to join a large consortium for work at ITER^{viii} on a €53 million project, with an expected share of £1-2 million. Temati, a UK SME has been supplying CERN for ten years, with highly sensitive carbon ceramic sensors for a number of different experiments and Wessington Cryogenics, a UK company supplies specialist gas storage tanks to customers including CERN.

^v UK Space Agency (2014) The Size & Health of the UK Space Industry (2014)

^{vi} Oxford Economics The Case for Space: The impact of space derived services and data (2009)

^{vii} Accelerators for America's Future (2010)

^{viii} International Thermonuclear Experimental Reactor - an international project to design and build an experimental fusion reactor.



This artist's rendition of the SKA-MID dishes in Africa.
Credit: SKA Organisation

Many UK companies state that the impact of winning contracts from international facilities is often greater than anticipated, as it boosts a company's reputation, enables development of new products and allows business to be won elsewhere, leading to a bigger return on investment.

Furthermore, STFC cryogenics-related work is resulting in wider benefits to society over and above advancements in research and creation of businesses, jobs and national wealth. These include:

- **Investment in national skills capabilities** - by offering a critical mass of expertise in key areas and sectors that put the UK at the forefront of scientific exploitation and substantial potential economic gains for UK businesses.
- **Fostering collaborations between science, research and industry including with SMEs** – through a wide range of support activities e.g. testing facilities, office space, co-ordination and networking events such as the British Cryogenics Cluster and the Cryogenics Cluster Days.

- **Championing local and regional economic development and inward investment** – the cryogenics infrastructure built around STFC operations is an important anchor for businesses, their expansion, co-location and inward investment, which is welcome by both industrialists and scientists.

In addition to the case studies above, there are potential impacts of cryogenics that could have substantial future impact. STFC scientists follow these developments closely in order to identify future potential for scientific and technological exploitation. Examples include Rapid Surface Chilling™, a new cryogenic approach developed by BOC and Bernard Matthews Ltd which results in reduction of *Campylobacter* counts by 90-95%^{ix}; cryogenically cooled superconducting wind turbine generators which could lead to global savings of £9.3 billion^x and experiments in the cryogenic cooling of microchips which could have application in energy defence and security.

This summary report highlights the significance of cryogenics, an enabling technology, to the UK economy, research community and industry. As funders and deliverers of research and research infrastructure, STFC and other publically-funded research organisations play a key role in realising the impact of these technologies over the long term. Whilst it is not possible to put an overall figure on the impact of STFC's underpinning role in cryogenics technology, it is clear that STFC's long term leadership role has resulted in social and economic impact as well as, advancements in research and technology.

^{ix} <http://www.boconline.co.uk/en/processes/food-freezing-and-chilling/rapid-surface-chilling/rapid-surface-chilling.html> (2014)

^x Calculations based on predictions from Global Wind Energy Council

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Joint Astronomy Centre, Hawaii.



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