Nesta...

CaSE
Campaign for Science and Engineering

IT'S 4GROWTH

RE-INVESTING THE UK'S TECHNOLOGY WINDFALL

Later this year the Government will begin to auction the UK's 4G mobile spectrum. Industry experts predict this could raise up to £4 billion. This windfall is a timely reminder of the importance of technology to the UK's prosperity. It is also an opportunity to invest in our future.

The UK has a rich scientific and technological history. Britain's innovators gave the world radio, mobile phones, and the World Wide Web. Without these inventions we wouldn't be using the 4G spectrum, let alone raising money from it.

The success of these technologies depended not just on brilliant research and commercial acumen, but also on the right public support. Marconi's demonstration of 'wireless telegraphy' in 1886 was backed by the General Post Office. The government funded Sir Tim Berners-Lee, the scientist who invented the Web at CERN. James Clerk Maxwell, whose pioneering insights into electromagnetism underpin today's wireless communications, made many of his breakthroughs in the British university system.

These technologies and others like them are essential to the UK's future. Economists have shown that two-thirds of economic growth results from innovation. The world needs new technologies in order to meet the challenges of the 21st century, from climate change to food security.

Today we need a new generation of researchers, inventors, and entrepreneurs to help create an economy fit for the future, and the right infrastructure to support them. This report is an urgent call for the 4G technology windfall to be invested in the people and systems that can get our economy growing again.

From training new science and maths teachers, to creating new funds to help innovative businesses, £4 billion could revolutionise the UK.

The proceeds of the auction are a return on past generations' investments in technology. The responsible way to use it is to reinvest them in technology. It's time 4Growth.

INTRODUCTION

The UK is home to a fifth of the world's top 20 universities. Our scientists have won seven Nobel prizes in the last five years. With less than 1 per cent of the world's population, we produce 14 per cent of the world's highest-impact science. Pound-for-pound, we're the most efficient researchers in the G8.

We're home to some of the world's most innovative and dynamic companies, from ARM to GlaxoSmithKline and from Dyson to Rolls-Royce, and we're finally seeing increasing numbers of young people studying science, maths, and engineering.

There's growing consensus from the major political parties that the state needs to take an active role in supporting economic growth and the technologies that make it possible. The UK's future cannot depend on low-skilled jobs or natural resources. Innovation and high-tech growth are critically important.

So what's missing? Why are we still struggling for growth? Why do we invest less in research and development (R&D) than the US, Germany, or Japan?

THE PROBLEM

In part, it's a failure to commercialise research and turn top-quality science into marketable technology. Only 45 per cent of UK R&D is funded by businesses, compared to over 60 per cent for the US, Germany, and Japan – even though innovation led to two-thirds of all UK economic growth in the years 2000–2008, and fast-growing, innovative businesses create the majority of jobs.

However, this isn't simply a failing of business. Particularly since the economic crash, even companies that want to innovate have found it difficult to get the necessary finance. Banks are deleveraging and wary of risky businesses, while venture capital is thin on the ground.

Evidence from around the world shows that innovation works best where the state plays a supportive role, taking risks that businesses won't and helping bridge the 'valley of death' between invention and commercialisation. The governments of innovative countries like Finland, Israel and Korea work alongside researchers, entrepreneurs and big businesses to help bring new technologies to market.

Even in the US, that bastion of free markets, public research and government procurement play a big role in driving innovation. It was a government agency – the now $3 billion-a-year Defence Advanced Research Projects Agency (DARPA) – which set out to create the Internet, just as it seeded Silicon Valley before it.

In the life sciences, the Human Genome Project is just beginning to bear fruit. In time, it will create entirely new healthcare markets in personalised medicine and drugs worth an estimated $452 billion. But the Human Genome Project would have been impossible without UK government funding.

And to pick a more recent example from another field, what about Team GB? At the 1996 Olympics in Atlanta, we won a solitary gold medal, finishing 36th in the overall rankings. The subsequent years saw an investment of money and ambition, with an additional £300 million invested since 2008. In 2012, Team GB won 29 gold medals, finishing third.

PLAN FOR THE LONG TERM

Governments are bad at coping with windfall revenues. Around the world we've seen examples of sudden discoveries of natural resources leading to huge inflation. The use of the UK's North Sea oil revenues by successive governments to fund current expenditure led to inflation and a strong pound, hurting the UK's manufacturing sector.

But there are exceptions. The Norwegian government got around these problems by putting their oil revenue into an endowment to ensure that the benefits of the windfall, like its contributing factors, accrue over a long time.

The UK needs to adopt a similar approach, balancing long-term investment and immediate action. In the words of Science Minister David Willetts, *"We enjoy the fruits of investment by earlier generations ... and we have a similar obligation to generations coming after us,"* with the role of government being to *"help sustain the contract between the generations"*.

So backing science and innovation fits the bill perfectly. In the short term the UK benefits from unlocking intellectual capital and turning it into marketable products, signaling to investors that backing British innovation is a smart bet, and stimulating the advanced manufacturing and service industries that we'll need to make the plan a reality.

In the longer term, investing in science replenishes our store of intellectual capital. It helps create a new generation of inventors and innovators ready to take advantage of today's research, and furnishes infrastructure – both physical and intellectual – that we will benefit from for years to come.

There are those who say we can't afford to plan for the long term in a time of crisis. But the 2008 financial crash demonstrated just how brittle our economy had become. We don't know when the next shock will come, or what shape it will take, but can't waste time in diversifying and strengthening our economy.

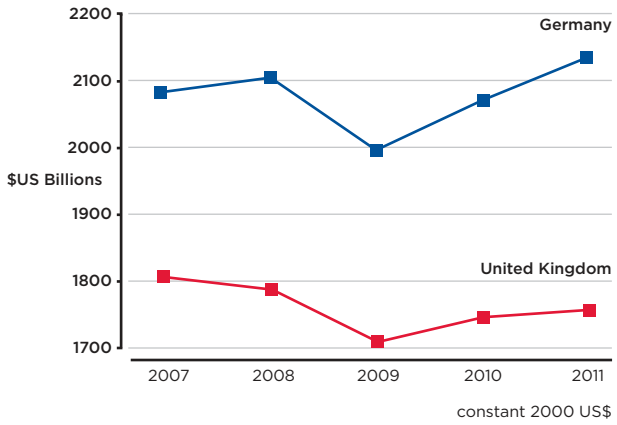
1835 Samuel Morse invents the Morse code, with the US federal government co-funding the first intercity telegraph line.

1861 James Clerk Maxwell publishes his *On Physical Lines of Force*, containing the equations describing how an electric field can generate a magnetic field and vice versa – predicting the existence of radio waves.

STRONG ECONOMIES GET IT

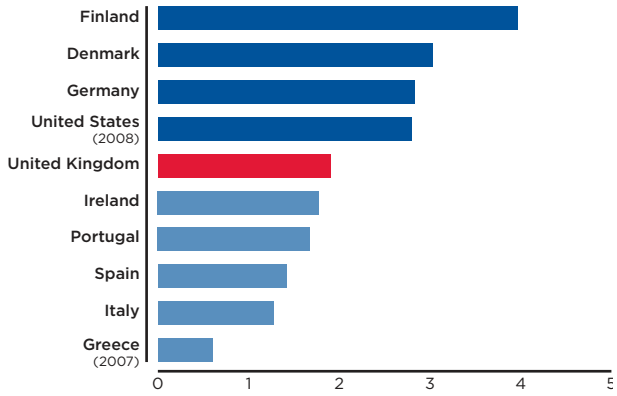
It's no coincidence that Germany weathered the financial crisis better than most European economies.

Fig. 1: Comparison of GDP in Germany and the UK



Even as Germany's centre-right government brought in austerity cuts after the financial crisis, they singled out research as an area not just to protect, but to expand. Spending at the Federal Ministry of Education and Research has risen almost 20 per cent since 2010.

Fig. 2: R&D as percentage of GDP, 2009



Sweden has recently unveiled plans to increase its science budget by 13 per cent, China's spending is up 13.4 per cent this year compared to last and even France plans to increase spending on higher education and research by 2.2 per cent in 2013. In contrast, the nations with stubbornly low research investment are the ones in most difficulty: Portugal, Ireland, Italy, Greece, and Spain all spend less than 1.8 per cent of their economy on R&D.

IT CAN WORK HERE TOO

When the UK promotes innovation and research, it works spectacularly well. More foreign-funded R&D takes place in the UK than in any other country, as overseas firms recognise the UK's expertise. In 2007, the UK had an overall current account deficit of nearly £40 billion, but R&D bucked the trend with an almost £2 billion surplus.

Microchips designed by Cambridge-based ARM sit inside around 95 per cent of the world's smartphones, including Apple's iPhone. And every £1 of initial investment in – for instance – cardiovascular research gives the UK a continuing annual benefit of 39p, year on year.

Technology policy in the UK has in the past lurched between the extremes of central planning and laissez-faire. Both approaches have had their failures. The middle way is for government to do what society and the private sector cannot, in order to enable them to do more.

By reinvesting the proceeds of the 4G auction the Government would be doing precisely this.

Training and supporting talented innovators, building knowledge infrastructure, being ambitious about what we want from technology, and fixing gaps in finance are all areas where we know the government needs to show leadership.

The following pages show how the Government could revolutionise the UK's science and innovation landscape, transforming us into a high-tech nation and a stronger, more diverse economy.

1880 Alexander Graham Bell sets up the first 'Bell Labs' – with the proceeds of an innovation prize awarded to him by the French government for the invention of the telephone.

1898 The Marconi Company opens the world's first radio factory in Chelmsford, Essex, employing over 6,000 people during WWII.

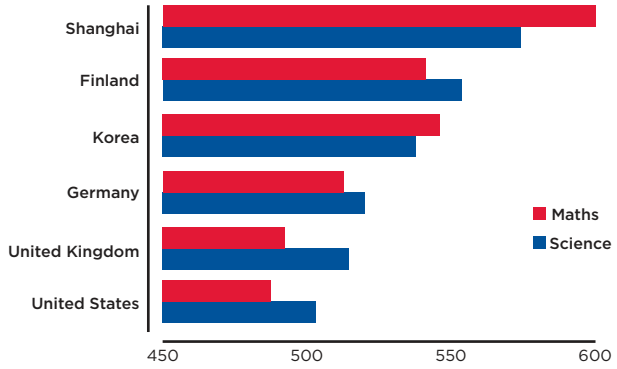
1909 Marconi is awarded a Nobel Prize for contribution to radio telegraphy.

PEOPLE & SKILLS – £750 MILLION

Investing in science and technology means investing in people. The UK needs more great scientists, engineers, researchers and designers to help our businesses innovate and invent, and to power our world-leading universities. More than two in five UK employers struggle to recruit enough of them, and skills shortages mean that companies will go overseas in the search for talent. We face growing competition from countries like China and India where there are half a million new engineering graduates alone every year.

Just as importantly, the UK needs to educate its children to thrive in a world that's being transformed by new technologies. This involves improving how we teach science, maths and technology. It also means getting children to work not just with their brains but with their hands, and educating a new generation of makers.

Fig. 3: International school attainment – OECD PISA



All of this requires long-term investment, not short-term fillips. We call on government to put £750 million of the proceeds into a ten-year fund to invest in education and research. This would generate around £90 million a year in real terms, which could be invested to:

Fund more early-career researchers – £30 million a year

Research shows that funding early-career researchers brings big economic benefits: their skills are well recognised, and demanded by both academia and businesses. The Royal Society's University Research Fellowships offer eight years of funding to the best graduates as they start their research careers, but are vastly oversubscribed.

For £30 million a year we could offer an additional 75 early career fellowships each year to the best researchers, focusing on areas where funding is scarcer, like the physical sciences or interdisciplinary research.

Foster a new generation of researchers through excellent teaching – £30 million a year

The Programme for International Student Assessment (PISA) ranked the UK 28th and 16th for maths and science respectively, out of 65 developed countries. We came behind nations like Estonia, Poland, and Slovenia. At primary school level only 3 per cent of teachers hold a specialist degree and Initial Teacher Training (ITT) qualification in science – we desperately need more. Luckily, there is a quick fix – the joint Institute of Physics/Department for Education scholarships of £20,000 have led to a record-high in physics teacher recruitment, with 115 extra in 2012.

For £30 million a year we could replicate this success and train 1,500 teachers in other shortage areas, like maths and computer science, so we can give the next generation the skills they need to thrive in the future.

Make it easier for researchers to move from industry to academia – £10 million a year

We need to get more of the UK's top research commercialised and brought to the market. Researchers in industry know how to do this and we need to share that knowledge with academics. But it can be hard for universities to hire researchers from industry, because of the way funding is allocated.

For £10 million a year we could majority-fund (80:20) 20 five-year positions in universities for researchers from industry, massively increasing the UK's potential for business/academic collaboration.

Bring the brightest researchers in the world to the UK – £20 million a year

We're a small country – we're only ever going to produce a minority of the world's top researchers on our own. So we need to continue to attract scientific stars from around the world if we're going to do the same with global investment.

1922 The BBC is created as a private company by a consortium of radio manufacturers. Four years later it is given a Royal Charter as a state broadcaster.

1925 AT&T and Western Electric co-fund a research division, Bell Labs, with the proceeds of their telegraphy and phone businesses.

1926 John Logie Baird demonstrates the first working TV at London's Bar Soho; the following year, a public subscription aids the creation of the Baird Television Development Company.

For the last 12 years Canada has run a highly successful Research Chairs program to attract the best scientists. Their chairholders produce better, higher-impact research, and more of it.

For £20 million a year we could attract not just Research Chairs, but ten entire research groups to the UK, providing a huge increase in our global research competitiveness.

FINANCE – £500 MILLION

Businesses matter for innovation. They are responsible for over 60 per cent of the UK's investment in R&D. They take the entrepreneurial risks necessary to bring products to market and they create jobs. But since 2008, investment in innovation by businesses has fallen sharply (see Figure 4). A plan for sustainable growth needs to create the right conditions for innovative and entrepreneurial businesses to thrive.

When it comes to innovation, one of the most important conditions is finance. Banks are deleveraging and wary of the risks involved in innovation. Venture capital is hard to obtain. This makes it hard to bridge the 'valley of death' between research and commercialisation, and discourages businesses from innovating. The proceeds from the 4G windfall can help address these issues.

Smart awards – £300 million

The Technology Strategy Board's SMART award provides grants to innovative early-stage technology companies, encouraging them to undertake high-risk technology projects. The awards have been in existence in one form or another since the late 1980s, and evaluations show that they work. They are significantly oversubscribed.

£300 million would roughly double the size of funding available for SMART awards over a three-year period, helping more small innovative businesses develop new profitable products.

Backing early-stage tech businesses – £200 million

Finance for businesses matters too. Businesses need finance not just to start up, but to scale and grow. Finance allowing start-ups to grow remains in short supply, particularly for non-Internet tech businesses whose need to fund risky technological development can mean they miss out on venture capital funding.

A £200 million co-investment fund, based on models that work like the Enterprise Capital Funds and the angel co-investment fund, would lever in private finance to give high-tech businesses the finance they need to grow. The Bio-medical Catalyst fund launched last year, co-funded by MRC and the TSB, provides one model for a fund that addresses both academic and business needs for technology development funding.

Fig. 4: We're in the middle of an Innovation Strike

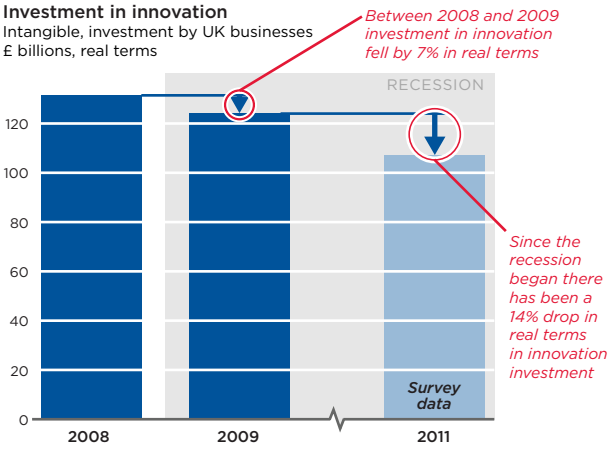
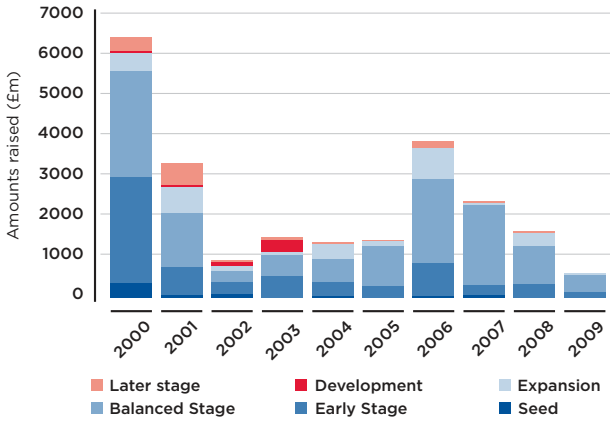


Fig. 5: Venture capital fundraising is low – VC raised in UK, £m



1954

USSR launches Sputnik; Soviet competition forces the US to create the Defence Advance Research Projects Agency (DARPA).

1962

The first communication satellite, Telstar 1, enters into service thanks to the combined efforts of AT&T, Bell Telephone Laboratories, NASA, and the British and French post offices.

DEMAND FOR EMERGING TECHNOLOGIES – £1.25 BILLION

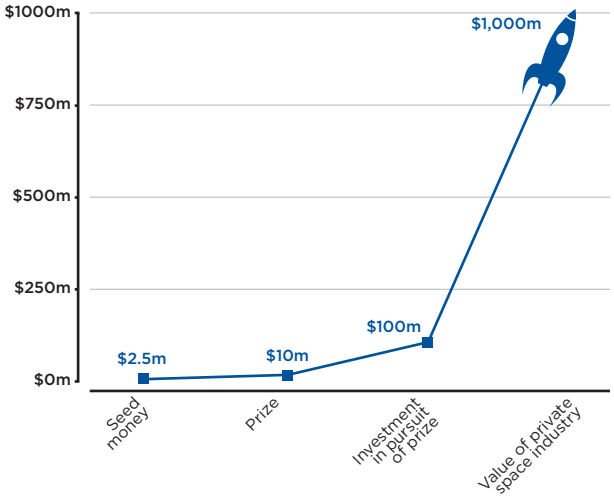
Skilled people and infrastructure are critical, but will only take us so far. At some point, we need to challenge and incentivise our research and innovation base to meet the goals that are important to us. Many of history's most important technologies have been demanded and supported by society.

By using market forces to drive and shape innovation, the Government can ensure that past and current developments in fundamental research are translated into benefits for the economy and society.

Challenge prizes – £100 million

By incentivising successful innovation, challenge prizes can unlock huge sums of private capital to meet technology goals – and they stimulate research that wouldn't have taken place otherwise. The Ansari X-Prize for the first reusable spacecraft was worth $10 million, but succeeded in unlocking $100 million in investment. Other prizes have led to affordable genetic tests and smartphone-based medical diagnoses.

Fig. 6: Economic effect of the Ansari 'X' Prize



They were originally pioneered in the UK, with the success of the government-sponsored Longitude Prize, the 300th anniversary of which falls next year, underpinning British sea power in the 18th and 19th centuries. But for a long time, they were a minority interest. New prizes would encourage UK entrepreneurs to exploit the presence of our world-leading research centres, and potentially help drive the Government's vision for a 'Tech City' in East London.

For £100 million, the UK could launch a decade of high-profile prizes, inspiring a generation of new innovators and bring their ideas to bear on the challenges of the future.

Technology procurement – £1.15 billion

The US government has for decades used its own spending to help innovative small businesses and to encourage the development of new technologies. The arm's length Defense Advanced Research Projects Agency (DARPA) funded research that led to the Internet, PCs, Graphical User Interfaces, GPS, drones, and self-driving cars. The Small Business Innovation Research programme (SBIR) channeled US procurement budgets to provide early funding for tech giants like Amgen, Qualcomm and Genzyme.

For £1.15 billion, the UK could put in place two measures to make a big difference to innovative businesses and technology development.

Firstly, it could create a true equivalent to the US SBIR programme. The UK Small Business Research Initiative (SBRI) works in a similar way to the US version but at a far smaller scale. It channels a few million pounds of procurement a year rather than the £250 million that experts estimate is necessary to make a material impact on small high-tech businesses. The most effective way to scale the programme up is for the Treasury to co-fund government departments who use it, an approach already being used on a small scale with the Department of Health. Co-investing £500 million over five years would, after a two-year ramp-up, channel £250 million a year to innovative businesses.

Secondly, we could establish a UK Vision Agency – an arm's length advanced research projects agency along the lines of DARPA, tasked with solving societal challenges through technology. £650 million would provide funding for five years to research and develop solutions to three major technological challenges, and at the same time pulling research through from the lab to the marketplace.

1969 Data is exchanged for the first time on ARPANET, the precursor to the Internet created by US government-funded DARPA.

1991 The first website and web browser are developed by Tim Berners-Lee at CERN, the international research institute co-funded by the UK government.

1995 The MP3 file format, along with the commercial software to encode music files with it, is released by the Fraunhofer Society, one of Germany's state-funded research networks.

INFRASTRUCTURE – £1.5 BILLION

Few countries have the expertise and ability to build world-class, cutting edge science and technology infrastructure. The UK is one of them. We should make the most of that advantage by building and exploiting knowledge infrastructure fit for the 21st century.

Technology demonstrators – £285 million

The UK funds less technological development and proof-of-concept research than many other countries. This makes it harder to get new technologies to market. Technology demonstrators can help scale-up radical new innovations, combine existing ones, and encourage investment.

For instance, the University of Bath's technology incubator facilities cost just over £0.5 million but led to businesses worth £10 million and created 160 local jobs. And the Technology Strategy Board has £25 million in funding available for showing what 'Future Cities' – which address urban challenges using integrated technology – might look like, lessons from which could be used worldwide.

£285 million for more of these demonstrators would ensure that companies with good ideas but limited funds can gain support on a competitive basis, and solve the problem of us not supporting the pre-investment, proof-of-concept work essential to bridging the 'valley of death'.

New research facilities – £1.2 billion

The UK's historical investments into facilities and infrastructure have kept us at the forefront of science. The £2.5 million Engin-X instrument at ISIS (used to measure stress in crystalline materials) is just one example – scientists from 24 countries have paid us to use it, producing 250 research papers. And EDF Energy used Engin-X to demonstrate the integrity of repair welds in four nuclear reactors – this deferred the decommissioning and replacement of two nuclear power stations, which would have cost around £3 billion. Providing access to world-leading equipment brings economic benefits. Between 2005 and 2010 the innovation campuses at Harwell and Daresbury attracted inward investment of £220 million and international investment of £310 million.

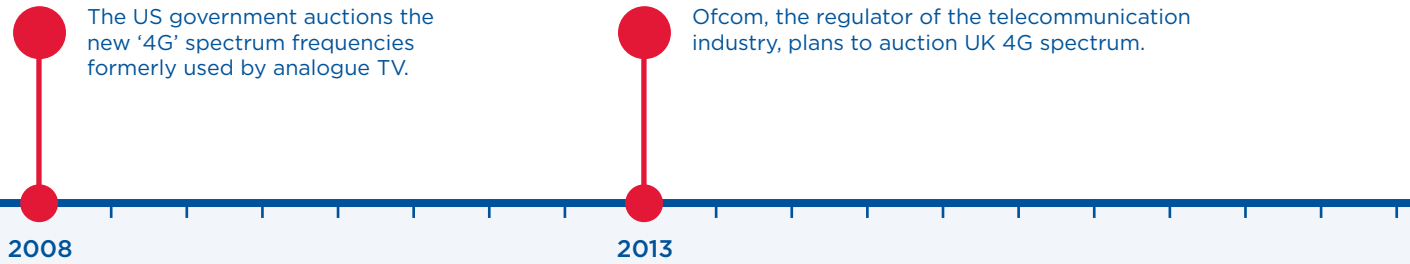
We already have a rigorous programme for selecting investment into new capital facilities, led by Research Councils UK. For £1.2 billion we could enable them to invest in the next generation of world-leading facilities and infrastructure, ensuring the UK remains a hub for global science and investment.

Facilities for makers – £15 million

Inspiring a new generation of entrepreneurs, engineers, makers and doers is critical to making the most of our investments in science and infrastructure. In the last few years, several centres have emerged throughout the country to provide access to new making technologies such as 3D printing, to get kids interested in making things, either with physical or digital tools, and to provide opportunities to acquire new skills for the wider community.

Building on the pioneering work of places like FabLab and MadLab in Manchester, the Institute of Making and London Hackspace, and many more, we propose funding for a national network of local centres for makers. These centres would provide access to the latest tools and technologies, reach out to schools and the community to develop these essential digital skills, and develop training appropriate to the needs of technology businesses and entrepreneurs.

For £15 million, we could fund equipment and running costs for local hackspaces and maker labs across the country to provide a venue for inventors, designers, students and schoolchildren to get to work making and doing, putting innovation at the heart of local communities.



HOW £4 BILLION FOR SCIENCE AND TECHNOLOGY COULD BOOST GROWTH

Re-investing the proceeds from the 4G technology windfall in four key areas would transform the UK's ability to produce and commercialise research:

People and skills – £750 million

Unless the UK is home to the world's top researchers, inventors and entrepreneurs, we won't be competitive in modern markets – let alone be creating the entirely new markets of tomorrow. And businesses consistently say they need employees with science and maths skills, while the trend away from low-skills industries is only going to quicken.

To make sure we can meet the demands of the 21st century, we need to train more people in science and technology, as well as unlock the potential of our existing researchers.

Our plan would give the UK new research fellowships for early-career scientists, an elite network to attract the world's best researchers, and 1,500 extra science teachers every year.

Infrastructure – £1.5 billion

We already know that investing in the future by building lasting infrastructure can give an immediate boost to the economy – except the debate so far has been dominated by transport infrastructure, such as the High Speed 2 rail link, Crossrail, and new airport capacity.

Let's not forget our knowledge infrastructure. By building research and development facilities, and a national network of local centres for makers, we can make Britain the global hotspot for science and technology investors and innovators.

Our plan would boost the UK's engineering sector right away by accelerating existing plans to upgrade and build new scientific labs, and make it a world leader in the long term by establishing a programme of new, high-profile technology demonstrators.

Demand for technology – £1.25 billion

4G is the result of successful translation of fundamental research into commercial technology. Sometimes this translation needs to be catalysed, or even driven, by the state. For instance, although the Web was invented by a British scientist, the underlying architecture of the Internet was deliberately built by the US government agency DARPA – and the impact has been enormous.

There are similar stories for the Apollo Space Programme and Human Genome Project – technological megaprojects which subsequently delivered huge consumer benefits, but were originally driven by governments.

Our plan would put the UK at the heart of developing tomorrow's technologies by funding new challenge prizes (like the Ansari 'X' Prize), helping small businesses come up with innovative solutions for government contracts, and establishing a new Vision Fund for directed technological research.

Finance – £500 million

We want more companies to be developing new technologies, but it's hard for them to get the financial backing to do so. Our banking and investment sectors are too conservative and short-termist when it comes to backing science and technology-based firms. Although capital raised by UK businesses increased by 335 per cent between 1998 to 2007, investment in innovation only went up by 54 per cent.

The government can help fix this by reducing the risk for investors and reassuring technology-intensive sectors that the UK is interested in innovation for the long run. This could unlock billions of pounds of private funding in the high-tech economy.

Our plan is to ramp-up the highly successful SMART awards which incentivise high-performing small businesses to conduct research and development, and to create a co-funded venture capital scheme specifically aimed at science and technology investments.

All references can be found online at **www.its4growth.co.uk/report**

CaSE Campaign for Science and Engineering

Sign the petition at **its4growth.co.uk**

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