Engineering UK 2016

Synopsis, recommendations and calls for action

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When it comes to boosting UK productivity, the engineering sector is in a very strong position. In 2014, engineering generated £455.6 billion GDP for the UK. It employed 5,529,000 people (two thirds of whom are practising engineers and technicians) and supported 14.5 million jobs in the UK. It is 68% more productive than the retail and wholesale sector. Every time a new job is created in engineering, two more jobs are created elsewhere in the UK. If engineering can meet the forecasted demand for new vacancies, it would generate an additional £27 billion GDP per year: the equivalent of building 1,800 new secondary schools or 110 new hospitals. In short, a rebalanced economy built on a growing engineering base will be a more productive economy.

The economy and productivity

Productivity is the challenge of our time. It is what makes nations stronger, and families richer. Growth comes either from more employment, or higher productivity.

Productivity is enormously important. A country's capacity to produce goods and services is dependent on the size of its workforce, the size of its capital stock, and total factor productivity (how efficiently it uses labour and capital). Increases in productivity are also essential if the budget deficit is to be eliminated during the current parliament. Yet productivity remains low. The UK 'productivity puzzle' is perhaps the biggest impediment to long-term growth. In 2013, the UK's labour productivity gap with other G7 countries was the widest since 1992 (17 percentage points), despite unemployment dropping to 5.7%. Economists suspect cheap labour/labour hoarding, economic uncertainty, mis-measurement, lack of investment, and sector-specific issues are common factors.

However, the UK was the fastest growing G7 economy in 2014. From April to June 2015, GDP was estimated to have been 5.2% higher than pre-crisis peak in 2008, and engineering's output has rebounded back above its 2007 level. Indeed, the total number of all registered enterprises in the UK grew by 4.4% between 2013 and 2014, to 2,263,645, while registered engineering enterprises grew by 5.6% to 608,920. Of the engineering enterprises registered in the UK, 79.5% employed 0-4 people. Just 0.4% of all engineering enterprises employed more than 250 people yet, between them, these companies employed 42.4% of those working for an engineering enterprise.

Engineering sectors produce the majority of the nation's exports and play an essential role in supporting the UK's international competitiveness by investing in research & development and innovation – a vital part of sustaining the UK's long-term economic performance. Indeed, the gross value added of engineering businesses is larger than the retail and wholesale, and financial and insurance sectors combined, as well as being 68% more productive (GVA/person) than the retail and wholesale sector.

In the year ending March 2014, engineering enterprises in the UK generated turnover of £1.21 trillion, an increase of 3.4% on the previous year. Of all devolved nations, Scotland saw the greatest growth in engineering enterprise turnover since 2009, with the amount growing by 15.6% (after a decline of 3.9% between 2013 and 2014). In 2014, engineering enterprises in London fared better than any other region, with the highest revenue (£268.1 billion) and growth of £30 billion (13.0%) from 2013.

Recent analysis from the Institute for Public Policy Research (IPPR) supports the case for the creation of a rebalanced economy built on a growing engineering base. The research concluded that the key to restoring productivity growth is to shift job-creation towards higher-productivity sectors, while encouraging firms to invest more to boost the productivity of their existing workforces.

The government has also stepped in. Its plan for raising productivity focuses on encouraging long-term investment in boosting infrastructure, skills and knowledge and in promoting a dynamic economy that encourages innovation and helps resources flow to their most productive use.

The engineering sectors are well placed to boost UK productivity, contributing an estimated £455.6 billion to Gross Domestic Product (GDP) in 2014: 27.1% of the £1,683 billion total UK GDP. This contribution is expected to increase to £608.1 billion by 2022. In 2014, engineering employed 5,529,000 people, two thirds of whom (approximately 3.6 million) were practising engineers and technicians. A further 1,341,524 were working in the wider economy.

The engineering sectors are also estimated to have supported an aggregate 14.5 million jobs in 2014, representing 55% of UK employment. Furthermore, for every new engineering job, two additional jobs are created in the economy. Meeting the forecasted demand for new vacancies would generate an additional £27 billion per year: equivalent to the cost of building 1,800 secondary schools or 110 new hospitals.

For every £1 in Gross Value Added (GVA) generated in engineering sectors, £1.45 is generated elsewhere within the UK economy. The total GVA impact of engineering sectors in 2014 was an estimated £995.7 billion: equivalent to 66% of UK GVA and a GDP contribution of £1,116.8 billion. The total tax contribution made by engineering sectors is estimated at £117.8 billion for the 2013/14 tax year: equivalent to 24% of total HMRC receipts over the same period.

However, the engineering sectors depend on several things. They need a good supply of professionally-skilled people – in particular graduates and technicians – to meet forecasted demand. They need a robust science and engineering research base. Finally, they need a fiscal system that encourages existing

businesses to flourish, new businesses to form and inward investment from overseas.

Education and training boosts productivity as well as transforming the lives of individuals. Discussion around skills shortages and productivity often centres on the supply of graduates. While this is still a major factor, our new research shows that the aggregate productive contribution to the UK economy from the 49,500 engineering, manufacturing and technology (EMT) apprentices that completed in 2013/14 amounted to £1.6 billion in 2014 prices. In actuality, the 10-year productive contribution of the 371,000 level 3 and 4 EMT apprentices that completed between 2005 and 2014 amounted to £12 billion (2014 prices), equivalent to 8% of UK GVA growth during the same period.

Furthermore, it was found that the net lifetime earnings premium associated with an EMT level 3 apprenticeship is approximately £111,900 (2014 prices): only 26% lower than the high net lifetime earnings premium associated with an engineering degree (£151,300). It appears that the long awaited apprenticeship renaissance in engineering at least has begun. This is reassuring now that government is intending to enshrine in law its commitment to create three million apprenticeships by 2020.

Skills demand and supply

Engineering ranked within the top five in-demand sectors for permanent placements for most of 2015. However, the UKCES Employer Skills survey showed that the science, research, engineering and technology professionals' category (SOC sub-major group 21) had the highest ratio of Skills Shortage Vacancies of any of the 25 occupational sub-major groups. At 43%, it is almost double the overall average of 23%. In a CBI survey, 44% of engineering, science and hi-tech firms reported difficulties in finding experienced recruits with the right STEM skills. In the last two decades, an hour glass effect has developed in the UK, with 2.3 million more high-skilled jobs, 1.8 million more low-skilled jobs and 1.2 million fewer middle-skilled jobs. At senior levels, female representation on UK boards has increased over the last year, so that now 18% of the directors on FTSE 250 boards are women. Most are non-executive directors.

The scale of the challenge is clear. Our extension to Working futures 2012-2022 shows that over this period, engineering companies will need to recruit 2.56 million people: with 257,000 of them being new vacancies. The largest proportion of job openings will occur in engineering enterprises within construction and the information and communications sectors (27.3% each).

Within this overall demand, 1.82 million of these workers will need engineering skills; pro rata, that is an average of 182,000 people per year. And within the engineering-related demand, 56,000 jobs per year are needed at level 3 (Advanced Apprenticeship) and 107,000 at level 4+ (HND/C, foundation degree, undergraduate or postgraduate and equivalent). Yet only 27,000 people are entering engineering occupations with level 3 Advanced Apprenticeships, and only 66,000 at level 4+. Our analysis of the supply data shows an annual shortfall of 29,000 people with level 3 skills and 40,000 with level 4+ skills.

Clearly, there are significant challenges in addressing this annual shortfall of 69,000. More positively, we know that practising engineers and technicians are very employable. New analysis shows that two thirds of employees in engineering enterprises are engineers and technicians, plus a quarter of all engineers and technicians are gainfully employed outside of engineering enterprises.

However, we remain concerned that the critical shortfall of specialist STEM teachers trained to a sufficient level remains a threat to meeting the forecasted demand for engineers and technicians.

Demographics and immigration

Population changes are having a significant effect on the numbers of people at key points in education and work. The number of teenagers will dip then grow. For example, the number of 16-year-olds has already fallen from 769,344 in 2012 to 698,330 in 2015. This will continue to a low of 744,771 in 2018, before recovering to 765,921 in 2022. The numbers of both 21- and 65-year-olds will reduce substantially over the short-to-medium term, with the number of 21-year-olds decreasing 14.0% from 875,604 in 2012 to 753,024 in 2022. Total population will steadily increase from 63.7 million in 2012 to 68.0 million in 2022 (a 6.7% increase).

Engineering has been highlighted as a priority by the Migration Advisory Committee (MAC). The newly added job titles on its shortage list relate to the aerospace, railway, electronics, mining, automotive manufacturing and design, and the civil nuclear industries. It is the MAC's view that this reflects increasing demand for specialist engineering skills continuing to outstrip potential supply: partly as a result of insufficiently joined-up activity in this sector on the part of employers and public bodies.

International student immigration was an issue that we covered in some detail in last year's report. One year on, it is still causing controversy and looks set to continue to do so. It is therefore worth restating the IPPR's viewpoint that, "the Government should abandon the net migration target as it is a bad measure for policy: it creates a perverse incentive for cutting international student numbers, and is incompatible with the growth of one of the UK's crucial export industries." Indeed, engineering sectors produce the majority of the nation's exports with manufacturing accounting for 44% of UK exports.

Secondary level education and training

Between 2002 and 2012, the number of individuals with level 4+ qualifications rose by over 5 million (an 11 percentage point rise), while those below level 2 fell by over 3 million (an 11 percentage point fall). These changes happened as the number of 19- to 64-year-olds increased by nearly 3 million. In the second quarter of 2015, there were 871,000 18- to 24-year-olds not in employment, education or training (NEET). The number of 16- to 17-year-old NEETs dropped to 53,000, influenced by the education participation age increase to 18.

Eligibility for free school meals (FSM) is an indicator of child poverty. Data from governmental sources shows that between October 2014 and March 2015, there were 550,000 secondary school students eligible for free school meals in the UK. The Social Mobility and Child Poverty Commission found that almost twice as many children eligible for FSM achieved good GCSEs in English and maths in 2013 than in 2005. Yet, they remained half as likely to progress to university. The Sutton Trust found that students from disadvantaged backgrounds who were in the top 10% at the end of primary education may typically attain, on average, half a grade lower than their advantaged peers at GCSE. Analysis in subject take-up by the Open Public Services Network shows that access to subjects such as triple science and language GCSEs varies enormously, with young people in poor neighbourhoods either denied access or strongly encouraged not to take up certain subjects. This may in part be due to the influence of school and college performance tables.

The secondary education system in the UK is undergoing exacting reform aimed at increasing the rigour and simplicity of qualifications at level 2. Since the reforms, entries to the more traditional – and challenging – science subjects have fallen. Entries to GCSE chemistry in England, Wales and Northern Ireland have fallen by 3.3%. Biology entries are 1.9% down. Significantly, physics entries have fallen by 2.6%, from 137,227 to 133,610 – and, when Scotland is included in the figures (GCSE and equivalent qualifications), that drop increases to 8% or 175,503 entries. In contrast, entries to GCSE mathematics increased by 3.4% in England, Wales and Northern Ireland, from 736,403 to 761,230. Furthermore, whilst the numbers are still relatively small, a greater number of pupils than ever are studying newer STEM subjects at GCSE, such as computing, engineering and further additional science.

The importance of Key Stage 4 qualifications is given additional significance by some very interesting research undertaken by The Centre for the Analysis of Youth Transitions (CAYT), who looked at the extent that schools have an effect on their pupils' HE decisions. The Centre concluded that the focus of 'widening participation' efforts on the basis of secondary school characteristics should be to ensure that pupils from all schools make the right choices over the subjects and qualifications they take at Key Stage 4, and that they maximise their chances of getting good grades at this level. This is because good grades in highly-regarded subjects and qualifications at Key Stage 4 are associated with a higher probability of staying in education beyond the age of 16 and doing well at Key Stage 5. In addition, they continue to be significantly associated with HE participation decisions and university outcomes, even after accounting for subsequent measures of attainment. The latter of these provides pupils with a curriculum equivalent to separate physics, chemistry and biology GCSEs.

Across all subjects, AS level entrants declined slightly in 2015. However, compared with 2014, entries to AS mathematics increased slightly by 2.2% (to 165,311), while AS further mathematics entries increased by 10.1% (to 27,034) and computing entries were up by 16.6% (to 13,510). Achievements improved in 2015 too, with the proportion of students achieving a grade A-C at AS level up for all subjects except physics, which dropped only slightly to 36,985 (down 0.6%).

At A level, entrant numbers to STEM subjects increased slightly in 2015, to 850,749. Most of the increase was in mathematics, which attracted an extra 4,000 students (92,711 in total). Physics entrants, however, decreased

very slightly to 36,287. Computing, further mathematics and mathematics were in the top 10 most popular of all A level subjects. For all STEM subjects, just over three quarters of the candidates achieved A*-C grades.

It should be noted that A levels and other qualifications at level 3 are an important bridge connecting compulsory and tertiary education. It is at this point that the first of several leaks in the supply of future female engineers arises. Whilst 48.8% (65,221) of those studying physics at GCSE are female, this figure drops to 23.6% (15,192) at AS level and only 21.5% (7,801) at A level. This decline occurs despite higher female attainment, which means some of the best and brightest students are being lost at this early stage.

Finally, whilst it is still too early to see the results, it should also be noted that AS and A levels will be decoupled. This means that AS results will no longer count towards an A level in the way they do now. AS and A levels will be assessed at the end of the course and courses will no longer be divided into modules

The numbers of students completing engineering and related BTEC courses and vocational qualifications offered by OCR at level 2 decreased markedly in the last year, down 37.3% to 160,305. There has, however, been growth at level 3 for BTECs in STEM subjects, with 359,340 completions in 2015 (an increase of 3.5%).

In Scotland in 2015, the A-D achievement rate for physics, biology and chemistry in new National 5 qualifications increased. Students in Scotland also took the new Higher qualifications in 2015: compared to the old Highers, entries increased slightly to 23,348 in 2015. The proportion of those achieving grades A-C increased slightly for chemistry and biology and decreased slightly for physics.

Higher education

In 2013/14, 6.9% of all higher education students (159,010) were on engineering and technology courses. The number of engineering and technology students has increased slightly (by 1.3%), while the total number of university students declined by 7.8% during the preceding five years. Provision of engineering course places is concentrated, with ten universities accounting for a quarter of total acceptances.

Students are taking more diverse routes into HE. For example, 18-year-olds in England are 20% more likely to enter HE with a BTEC this year than last. The numbers of female applicants for engineering courses increased by over a quarter on 2013/14, from 8,940 to 11,330 (26.7%). However, it still attracted the lowest proportion of female applicants after computer sciences.

There has been a shift in the popularity of engineering sub-disciplines, from electronic and electrical engineering, production and manufacturing engineering, and civil engineering, to chemical, process and energy engineering (17.5% increase to 6,235 in the last year) and general engineering (28.8% increase to 11,060 in the last year).

Of HE qualifications awarded in engineering and technology in 2013/14, 43.8% were awarded to international students – a number significantly higher than the average of 26.1% for all subjects. This represents a significant potential leak in the pipeline of future engineers in the UK economy, as international students are much less likely to progress to employment in the UK after graduation.

The numbers of qualifications obtained in engineering and technology has remained relatively steady, with 50,185 in 2013/14 – a 0.3% decline from 2012/13. Engineering and technology first degree achievements are at an all-time high, with 25,870 first degrees awarded in 2013/14. However, only 15% of engineering and technology first degrees were awarded to females. This proportion increased to 23.9% for postgraduate degrees and 24.4% for doctorates.

In 2013/14, there were 8,540 students enrolled on HND programs, around a quarter of whom were studying engineering and technology subjects. 10,205 students were entered into HNC programmes accounted for 10,205 of these, with 54.2% studying an HNC in engineering and technology. Engineering and technology was the second most popular of all STEM subjects for foundation degrees, with 3,015 entrants in 2013/14. While entrants to HNDs and foundation degrees have declined over the last six years, those to HNCs have increased. For HNDs and foundation degrees, most student entrants were full time. For HNCs, most were part time. In 2013/14, there were 6,795 completions for engineering level 4 and 5 BTEC HNCs and HNDs, an increase of 10% on the previous year.

The non-continuation rate for engineering and technology in higher education was 5.6% and was slightly higher for males (5.9%) than females (4%). Not having mathematics or physics A levels doubled the likelihood of a student not continuing compared with those who had both, with the non-continuation rate increasing from 3.3% to 7.2%.

Engineering and technology accounts for the lowest proportion of female staff members of any higher education cost centre, at 17.3% in 2013/14. This may negatively affect female perceptions of both the subject and sector in general.

Despite demand for HE engineering courses (against the context of higher education fees), the pool of those with level 4+ engineering qualifications (66,391), is still well below the annual projected shortage of 107,000. It is also substantially lower than the figure of 82,000 reported in last year's report. Closer analysis reveals that this precipitous decline was predominantly driven by a reduction of those graduating from other subjects who went on to work in engineering occupations. For example, the supply of graduates from tier two subjects fell by 30.4% from 26,663 in 2012/13 to 18,547 in 2013/14. Likewise, the tier three supply number fell by 45% from 15,194 in 2012/13 to 8,349 in 2013/14. This decline was largely driven by a fall in the number of those studying part time, which fell by 19,580 between 2012/13 and 2013/14.

Engineering and technology graduates enjoyed a full time employment rate in 2013/14 of 65.0%, higher than the level for all subjects (57.8%). Overall, 65.5% of UK engineering and technology graduates were working in an engineering occupation. However, only just over half of female graduates went into engineering occupations, compared with two thirds of their male colleagues. Within six months of graduating, those with a degree in engineering and technology enjoyed the second highest average starting salaries of all subjects. At £27,079, they were just behind medicine and dentistry, but well above the average starting salary for UK-domiciled graduates in all subjects (£22,205) and almost equal to the UK national average salary (£27,271). At a time when student debt is increasing, the earnings premium associated with a degree in engineering and technology cannot be overstated. However, females still earn less than their male counterparts (£25,959 vs £27,260).

Notably, it is not only those with a degree in engineering who contribute to the supply of future engineers. Our analysis shows that over 70% of graduates in architecture, building and planning were working in an engineering related role in 2013/14, as well as the majority of those graduating from computer science (54.1%).

Apprenticeships and further education

In 2013/14, around 3.9 million learners were engaged in government-funded education or training in the FE and skills sector. An estimated 850,000 were apprentices and 10,500 learners were on traineeships (pre-apprenticeship programmes). Around 28% were in STEM subjects. Within these, the numbers of NVQ/SVQs and VRQs declined, as this qualification been retired and replaced by QCF qualifications. In England, while overall achievements at all levels for engineering-related qualifications declined by 1.3% this year to 53,110, achievements at level 3 increased by 5.4% to 21,140.

The government has ambitious plans to boost the quantity of apprenticeships and, in contrast to recent years, the number of young people starting an apprenticeships is again on the rise.

However, with a projected shortfall of over 28,000 level 3 engineering technicians, the recorded number of 27,195 apprenticeship achievements at level 3, needs to more than double to meet demand

While the total number of apprenticeship starts in England fell by 13.7% between 2012/13 and 2013/14, starts in apprenticeships related to engineering subjects remained stable at 93,780. This represents 21.3% of all apprenticeship starts. Of these engineering-related apprenticeships, Higher Apprenticeship starts increased 42.9% to 1,000, while level 3 Advanced Apprenticeship starts declined by 14.4% to 33,340. Across all subject areas and for all engineering-related sector subject areas (where data is available), success rates were slightly lower in 2013/14 than in 2011/12.

In Scotland, the number of engineering-related framework starts fell slightly between 2012/13 and 2013/14, to 7,887. Within this, however, the number of female starts fell considerably, from 783 to 282. Starts at level 2 declined, while those at levels 3 and 4 increased. Over all, the number of engineering-related achievements fell from 6,534 to 5,729.

In Wales, the Pathways to Apprenticeships (PtA) programme finished in 2013/14. In 2012/13, 1,075 learners completed the programme and 16% of those progressed onto an apprenticeship. Science, engineering and manufacturing technologies had the highest rate of progression at 38%, however, this was a slight decrease from the 40% progression rate reported in 2011/12. In 2013/14, 1,570 apprentices completed an engineering-related apprenticeship at level 3, a slight increase on the previous year.

In Northern Ireland, the number of apprenticeship starts fell considerably between 2012/13 and 2013/14 to 5,409. (Much of this came from the drop in those aged 25 or older as a result in funding changes). In 2014, there were 1,170 on an engineering-related framework at level 3, an increase from the previous year.

Teacher quantity and quality

The education of the future workforce needs to be underpinned by a highly valued and highly skilled teaching profession. The current reality, however, does not reflect this need.

In 2014 in England, there were 229,000 teachers of STEM subjects serving Key Stages 3 to 4. The number of those teaching physics (6,400) is significantly lower than the headcount for chemistry (7,500) and biology (8,800) and mathematics (33,400). While it is estimated that 1,000 new physics teachers are required each year, only 200 were recruited in 2014. Wales and Scotland also reported fewer physics teachers than chemistry or biology teachers.

There are also too few teachers with specialist subject knowledge at all stages of education. More than 20% of mathematics and chemistry teachers, a third of physics teachers and more than half of computing teachers in state-funded schools in England have no relevant post-A-level qualification in the subject they are teaching. A £67m package to increase the number of mathematics and physics teachers by 2,500 has been launched by the UK government.

Research highlights the difference that high quality teachers make. For example, research from the Sutton Trust showed that for poor students, the difference between a good teacher and a bad teacher is the equivalent to a whole year's learning. Research from UCL (based on data from around 10,000 students) shows that females are less confident in their answers in physics than males and that teacher encouragement is associated with higher self-concept. It indicates that high-aspiring females are less likely to receive teacher encouragement than high-aspiring males.

UK industries strengths and opportunities

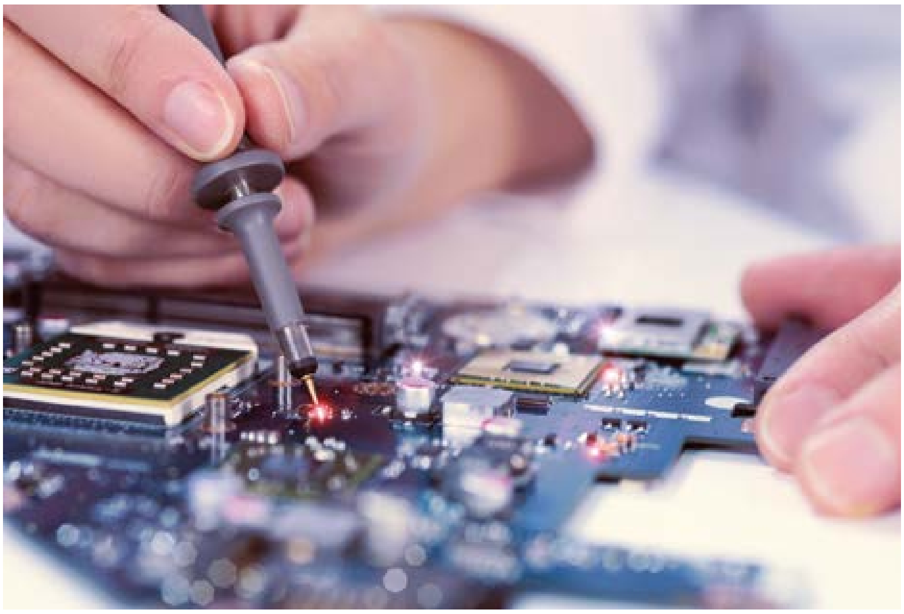
In a number of engineering sub-sectors – nascent or well established – the UK is strong, and could use that strength to boost UK productivity.

Some have already made a big contribution to the economy. In 2014 Agricultural science and technology made an estimated contribution of £96 billion or 7% of gross value added and employed 3.8 million people. The UK retail sector employed 2.8 million people – about 10 % of all UK employment – across almost 300,000 establishments. It contributed 10% to overall UK GVA, approximately 5% of GDP, and had a turnover of £1,211 billion. Construction contributed £83.0 billion in economic output – 6% of the total – and employed 2.15 million people in 2013. If you include construction-related services and products and materials, the industry contributed nearly 7% of GVA and over 9% of employment. The digital and creative sector has grown rapidly in recent years, and contributed £134 billion in GVA to the UK economy – almost 9% of total UK GVA – in 2014. It employed 2.1 million people in 2012.

Making a slightly smaller but still very substantial contribution to the UK economy, from 2000-2013 the automotive sector accounted for an average of 0.7% of UK GVA and 5.9% of UK manufacturing jobs. The automotive sector employed 731,000 people and invested £1.7 billion in R&D in 2013. As a whole, low carbon renewables supported over 460,000 jobs and had a 2013 turnover of £122 billion. Universities contributed £39.9 billion, equivalent to 2.8% of GDP, in 2011 and directly employed 378,250 people. Oil and gas UK estimates the total number of employees involved in the UK upstream oil and gas supply chain to be 450,000, including 200,000 employees directly involved. It generated over £35 billion of turnover in 2012. Aerospace employed around 230,000 people within the supply chain, with annual revenues over £24 billion. Life sciences employed 176,000 people with an estimated £51 billion UK turnover.

Other sub-sectors are worth noting for their rate of growth or expected growth potential. They include automotive, which bucked EU growth trends, and aerospace, thanks to demand for aircraft being at record levels globally. Despite its size, agri-tech is one of the world's fastest growing markets. The digital and creative sector has grown rapidly and is expected to need 1.2 million new workers between 2012 and 2022. Life sciences is forecast to grow by 36.4% between 2011 and 2016.

There are also sectors with large investments such as in nuclear power, which between 2010 and 2014 invested around £2.5 billion. There are development plans for at least 12 nuclear reactors on five different sites by 2030. Overall,



almost £37 billion has been invested in renewable energy since 2010. The 2013 capital investment of £14.4 billion in the UK's oil and gas reserves was the highest it has been for 30 years.

Some nascent industries could also make a big contribution to the UK economy. The Institute of Directors (IoD) claims that shale gas production could satisfy one third of the UK's annual gas demand at peak output by 2030 and could create 74,000 jobs. The Centre for Economics and Business Research (CEBR) estimates that the big data marketplace could create 58,000 new jobs in the UK between 2012 and 2017. A recent report from Deloitte estimates that the direct value of public sector information alone to the UK economy is around £1.8 billion per annum, with wider social and economic benefits bringing this up to around £6.8 billion. Geographically, 61% of UK growth is generated by city regions. If the UK's top 15 metros were to realise their potential, it is estimated they would generate an additional £79 billion growth.

Innovate UK has identified several high-potential emerging technologies worthy of support. These are: energy-efficient computing; energy harvesting; non-animal technologies for drug and chemical development; emerging imaging technologies; graphene; quantum technologies; and synthetic biology.

Manufacturing

Manufacturing makes up 10% of UK GVA and 54% of UK exports, and directly employs more than 2.5 million people. While productivity has not returned to pre-2008 levels, it continues to compare favourably to that in the services industry and the economy as a whole. Despite a projected decline in overall employment, GVA is expected to increase from £138 billion in 2012 to £160 billion in 2022, with the manufacturing share of the UK GVA remaining relatively constant.

There are approximately 1.3 million people employed in the advanced manufacturing industries in the UK. Advanced manufacturing is often reported as an area of significant potential growth for the UK economy. A high proportion (44%) of the advanced manufacturing workforce holds high-level qualifications (qualifications at level 4 and above). This is a much higher proportion than for manufacturing as a whole (31%) and slightly higher than for the economy as a whole (41%).

The trend of reshoring manufacturing has strengthened. Over the past two years, reshoring has added £600 million to the UK economy and created approximately 10,000 new jobs.

Research and development

Scientific, engineering and technological research and development will play a critical dual role on the global stage. Economically, they will help countries boost their productivity and competitiveness. And ethically, they are vital in addressing the on-going global challenges of climate change and creating a low carbon economy: ensuring access to clean water, providing adequate food supply and preparing for the growing and ageing population.

The UK still punches above its weight in research. With just 0.9% of global population, the UK represents 3.2% of R&D expenditure, 4.1% of researchers and 15.9% of the world's most highly-cited articles. Through the Science and Innovation Strategy, the government has committed £5.9 billion capital spend to support UK scientific excellence to 2021. However, the UK lags behind international competitors when it comes to spending on research and development. Businesses, universities and the government together spend around 1.6% of GDP on R&D – much less than the 2.8% spent in the US and Germany, 2.2% in France, and the agreed European target of 3%.

The first UK Research Excellence Framework (REF) was undertaken by the four UK higher education funding bodies, to determine the distribution of research funding from 2015/16 onwards. Overall, quality was judged, across all 1,911 submissions, to be 30% world-leading (4*), 46% internationally excellent (3*), 20% internationally recognised (2*) and 3% nationally recognised (1*). Following this, Technopolis examined in detail the engineering Units of Assessment within the REF2014, finding that 70% of all engineering-related research outputs were classified as world-leading (4*) or internationally-excellent (3*).

Perceptions of engineering careers and engagement

Young people's perceptions of engineering careers form a crucial front in the battle for ensuring an adequate supply of engineers and technicians. And they are improving across a range of metrics. In 2015, 43% of 11- to 14-year-olds believe that a career in engineering is desirable, while 49% of 15- to 16-year-olds say that they would consider a career in engineering. Just five years ago, the corresponding figures were 27% for desirability and 37% for consideration of a career.

This improvement has, in part, been the result of the STEM community influencing the influencers. Perceptions of desirability among educators remained relatively steady from 2012-2014, before increasing dramatically in 2015 from 57% to 79%. Also, when asked which one engineering development of the last 50 years has had the greatest impact on them, around three in five (61%) adults could do so, compared with 38% in 2010. This is despite the fact that respondents would have been using a computer, smartphone or tablet to complete the survey online.

The improvement in perceptions of engineering has coincided with an unprecedented expansion in school engagement activities among the STEM community. Almost all of these activities are predicated on several underlying theories which have formed a relatively unified strategy; that is, a focus on improving enjoyment of STEM – especially among 11- to 14-year-olds – as well as effective contextual careers guidance linked to the curriculum.

The focus on enjoyment is informed by a large evidence base that has shown it to be as significant as attainment in a pupil's likelihood to pursue that subject further. Research commissioned by the Department for Business, Innovation and Skills suggested that "enjoying a subject is key to taking it further". EngineeringUK's own research has looked at student subject decision-making at age 14 and 16, and identified that 89% of those asked said that enjoyment of a subject influenced their decision to select it at GCSE or A level.

There is much research to suggest that the 11- to 14-year-old age group is both the most likely point at which young people can lose interest in STEM and at which interventions can have the greatest effect. The *ASPIRES* study showed that enjoyment decreases year-on-year among Year 6 to Year 9 students (10- to 14-year-olds). Qualitative data suggest that the significant drop-off in Year 9 is due largely to an increasing focus on exams and written work, at the expense of practical activities – particularly in the run-up to GCSEs.

Alongside enjoyment of subjects, aspiration is likely to be a reliable indicator of a young person's future career, and there is a large body of evidence to show that interest in science is formed by the age of 14. Students who had an expectation of science-related careers at that age were 3.4 times more likely to earn a physical science and engineering degree than students without this expectation.

At a top-line level, the engagement strategy can be summarised as an attempt to encourage young people in three ways:

1. Inspiration (from employer role models and educators in STEM)
2. Aspiration (to pursue STEM subjects and careers)
3. Application (to STEM qualifications and careers)

This year, results from the annual Engineers and Engineering Brand Monitor have suggested a key specific addendum to this strategy: focus on pay. The top three responses given by all pupil ages when asked which factors were most important to them when deciding a career were "something I'm interested in", "pay" and "enjoyment". Girls in the 17- to 19-year-old group were most likely to rate pay as an important factor, with three quarters (75%) doing so. Despite this, when asked what they believe to be the average starting salary of a graduate engineer, 17- to 19-year-olds underestimated the real figure (£27,079) by around 27% (a mean of £19,744) and females by around 30% (a mean of £18,995). Parents and teachers were also likely to underestimate the average salary of a professional engineer significantly, meaning that both young people and their influencers require more accurate information.

The current knowledge of engineering careers among STEM teachers is particularly concerning: the EEBM has revealed that while three in five (58%) of those who teach 14- to 19-year-olds have been asked for careers advice about a job in engineering in the last year, just two in five of all STEM teachers (37%) felt confident giving advice on engineering careers, while 34% said that they were not confident.

In relation to career guidance itself, it's vitally important to make the links between education and work clear. The University of Warwick has shown that students don't make these links between the curriculum and future careers and that students don't know that triple science is either desirable or essential for some STEM careers.

This is supported by young people themselves. An Institution of Engineering and Technology (IET) survey showed that the most popular potential ways to promote engineering among young people were "school trips to see what engineers do" (67%) and "visits to school from engineers" (56%). The importance of this type of engagement cannot be overstated. A 2012 survey for the Education and Employers Taskforce showed that "the 7% of young adults surveyed who recalled four or more [employer engagement] activities while at school were five times less likely to be NEET and earned, on average, 16% more than peers who recalled no such activities."

Employers surveyed in the CBI/Pearson survey felt that the biggest barrier to engagement was a lack of guidance and support on how to make work experience worthwhile (28%). A lack of interest among educational institutions (25%), educational institutions interested but unsure how employers can help (22%), not enough employee interest in working with educational institutions (16%), and not being sure how to make contact with educational institutions (11%) were also mentioned. Tomorrow's Engineers is designed to address these concerns, providing guidance, on a regional basis, for employers in carrying out their engagement activities and ensuring that employers and educational institutions are communicating effectively.

Career information is a crucial part of The Big Bang Fair and Tomorrow's Engineers. Only 23% of girls aged 11-14 and 25% of those aged 15-16 surveyed in the EEBM knew what to do next in order to become an engineer. However, figures for Big Bang Fair attendees were more than double that, at 49% and 51%. Females aged 11-14 who attended The Big Bang Fair 2015 were around three times more likely to know what people working in engineering do (46% vs 16%) and twice as likely as those responding to the EEBM to view a career in engineering as desirable (52% vs 26%). Key Stage 3 students who attended the in-school aspiration programme, Tomorrow's Engineers, were also much more likely to be knowledgeable about what engineers do than their EEBM counterparts (50% vs 25%). This included a large increase among Key Stage 3 female students (43% vs 16%). More than half (51%) of 15- and 16-year-olds said that The Big Bang Fair had motivated them to choose physics as an option when they had the choice, including 38% of female students. Currently, just 2% of 18-year-old female students in England, Wales and Northern Ireland enter A level physics exams. There was also a positive impact on influencers, with attending teachers (82%) who were 44% more likely than their counterparts surveyed in the EEBM 2014 (57%) to believe that a career in engineering is desirable. They were also much more likely to be confident in giving advice about science, engineering and technology careers.

There are three overriding messages from the report. Firstly, that engineering and skilled engineers make a significant contribution to the UK economy and its productivity as well as working towards mitigating the grand global challenges of climate change, ageing populations, food, clean water and energy. Secondly, that the UK at all levels of education does not have the current capacity or the required rate of growth needed to meet the forecast demand for skilled engineers and technicians by 2022. Thirdly, through concerted and co-ordinated action, the engineering community and employers in particular can make a demonstrable difference by working with schools and colleges to inspiring future generations to pursue relevant qualifications and go on to careers in engineering.

Recommendations and calls for action

Increasing the supply: recommendations 1, 2 and 3

1. A doubling of the number of engineering and technology and other related STEM and non-STEM graduates who are known to enter engineering occupations. This is vital to meet the demand for future engineering graduates and to meet the additional shortfall in physics teachers and engineering lecturers needed to inspire future generations of talented engineers.
2. A doubling of the number of young people studying GCSE physics as part of triple sciences or further additional science or equivalent and a growth in the number of students studying physics A level (or equivalent) to equal that of maths. This must have a particular focus on increasing the take-up and progression by girls.
3. A two-fold increase in the number of Advanced Apprenticeship achievements in engineering and manufacturing technology, construction planning and the built environment, and information and communications technologies – with particular emphasis on 18- to 24-year-olds.

Provision of high quality, engineering engagement interventions and coordinated careers inspiration and information: recommendations 4 and 5

4. Provision of high quality, engineering engagement interventions and careers inspiration for all 11- to 14-year-olds. This should include opportunities for every child between 11 and 14 years old to have at least one engineering experience with an employer. This inspiration must highlight the value placed on STEM skills, promote the diversity of engineering careers available and provide real life engineering context.
5. Support for teachers and careers advisors delivering careers information so that they understand the range of modern scientific, technological and engineering career paths, including vocational/technician roles. It is vital that our education system recognises the employer value placed on STEM subjects and that young people have the opportunity to experience a 21st century engineering workplace for themselves.

Calls for action:

It is imperative that no talent is wasted. Governments in each of the devolved nations need to ensure joined-up education policies that deliver easy-to-follow academic and vocational pathways for our young people within schools and colleges. This will ensure maximum throughput in STEM subjects and into engineering careers.

We need a coordinated approach led by government and supported by the engineering community, business and the education sector to make sure that the vital need for more trained specialist physics and mathematics teachers is met.

The engineering community must recognise and address the fact that, despite numerous campaigning initiatives over the past 30 years, there has been no significant advance in the diversity or make-up of the sector. In particular, the gender participation of women into engineering must change.

Focussed action towards the co-ordination, quality, reach and impact of engineering engagement interventions by the whole engineering community and business and industry which is supported by government is essential. Building and consolidating of existing programmes is necessary to positively influence the perceptions and subject choices of young people and get more of them interested in a career in engineering. Programmes such as Tomorrow's Engineers have made it evident that this is best achieved through ensuring coordinated support and partnerships via local, regional and national STEM employers.