

# NORTHERN POWERHOUSE: CHEMICAL & PROCESS SECTOR

Science and Innovation Audit

AUTUMN 2018



# Foreword

**This audit sets out to assess the chemical and processing sector innovation ecosystem across the Northern Powerhouse. The vision and impact of the study is to ensure that the Northern Powerhouse contributes to the successful delivery of the Strategy for Chemistry fuelled growth and by 2030 for chemistry using industries to increase their contribution to the UK economy from £195billion to £300 billion.**

**The purpose of the Audit is therefore to identify the networks, skills, capabilities and facilities needed to ensure continued global competitiveness and to identify actions that the consortium can take or investment needed to fully realise the vision.**

This Science and Innovation Audit, clearly places both the Northern Powerhouse and the chemicals and process sector as key contributors to the UK's growth.



The chemicals sector is a hidden gem of British manufacturing, at once globally competitive and at the same time an integral part of many supply chains across the wider advanced manufacturing sector. It is essential to build on existing critical mass, both within industry and our excellent innovation ecosystem and where possible reshore activity and invest in new value adding activities. Future growth is dependent on developing and promoting globally the strength which a combined Northern Powerhouse manufacturing and research proposition can bring.

**JAKE BERRY**  
MINISTER FOR THE  
NORTHERN POWERHOUSE

This Science and Innovation Audit is a clear mandate for businesses, Government and Universities within the chemicals and process sector across the Northern Powerhouse to unite to deliver the shared goals and new delivery mechanisms recommended in the report.



The Northern Powerhouse chemicals and process proposition articulated in this audit is a powerful tool to reacquaint many investors, academics and business people across the UK and beyond of what we have here in the North: An industry of global scale and competitiveness which can fuel our next industrial age.

**PAUL BOOTH**  
CHAIR OF TEES VALLEY  
LOCAL ENTERPRISE PARTNERSHIP

# Introduction

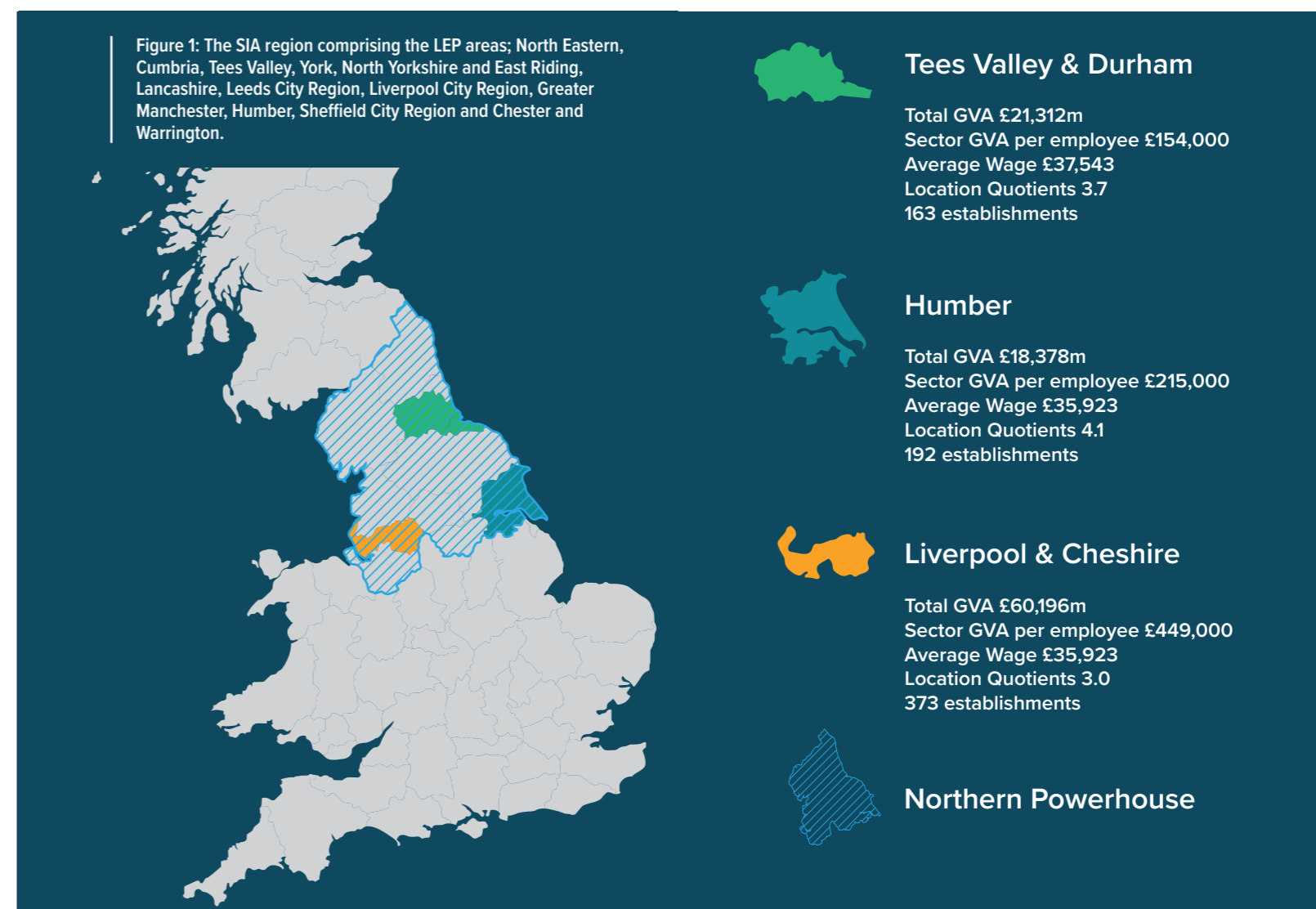
In autumn 2015 the UK Government announced regional Science and Innovation Audits (SIAs) to catalyse a new approach to regional economic development. SIAs enable local consortia to focus on analysing regional strengths and identify mechanisms to realise their potential.

This Science and Innovation Audit has been developed to identify the global competitiveness of the chemicals and process sector across the Northern Powerhouse (NPH). The SIA has reviewed for the first time, the pan Northern Powerhouse chemicals and process sector industrial proposition and the continuing fitness of purpose of the associated regional innovation ecosystem.

The SIA recognises the maturity of the sector and existing support structures and seeks to future proof its global competitiveness by identifying emerging technological opportunities and their consequential requirements on the regional innovation ecosystem.

## Geographic Coverage

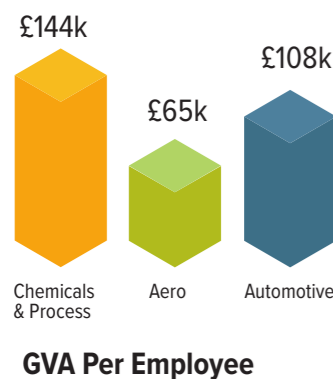
The audit geography is the Northern Powerhouse which covers all 11 North of England Local Enterprise Partnership (LEP) areas. The area is shown in Figure 1. Allowing for overlap of these areas means the effective Science and Innovation Audit geographic area comprises the three North of England regions (North East, North West and Yorkshire and Humber) plus the Sheffield LEP districts that lie within the East Midlands region.



# The Chemical and Process Sector

The chemical and process sector encompasses the range of industries in which raw materials are processed through chemical conversions to give finished products. The sector inputs to a range of chemistry using industries in sectors such as aerospace and automotive through the provision of coatings, adhesives, rubbers and plastics, as well as providing intermediary ingredients to the pharmaceutical, cosmetics, agrochemical, personal care, paint and home care sectors.

Whilst the upstream chemicals and process sector accounts for approximately £28bn, 15.8% of manufacturing output, it has a downstream impact on approximately £212bn or 90% of the UK manufacturing sector. The sector accounts for 140,000 employees, 6% of UK manufacturing workforce. Workers in this sector make a significant contribution to the UK economy with an average GVA per employee of £144,000, significantly higher than both the aerospace (£65,000/ employee) and automotive (£108,000/ employee) sectors<sup>1</sup>.



## International context

Global chemical sales in 2016 were led by China (€1,331bn), USA (€476bn) and Germany (€185bn). The UK continues to be a significant player in the global chemicals market, presently ranked 10th with €60bn sales<sup>2</sup>.

The most significant growth has been in the emerging markets in China, India and Brazil. The global market is expected to grow by a further 3% in the next 20 years as Asian and Middle Eastern demand and capacity continues to grow. By 2030, Asia is expected to account for almost two thirds of the global chemical industry market<sup>3</sup>.

Demand for chemicals, particularly intermediate and finished goods, continues to expand both in Britain and globally. However, what is in question is the UK's ability to meet both indigenous and export demand, as increasing competition from both East (e.g. China) and West (e.g. USA) is driving down revenues and making it harder for UK-based firms to compete in the global marketplace.

The chemicals and process sector has traditionally had a very strong export orientation, presently representing 18% of UK export trade. Figure 3 (overleaf) shows an upward trend in trade over the period 1996 to 2017<sup>4</sup>. 2013 was the first unfavourable imbalance in trade for the chemicals and related products sector. This fall can largely be attributed to a number of Astra Zeneca products going off patent in 2011/12<sup>5</sup>.

The reduction in exports has been across the board including price sensitive sub sectors such as the manufacture of organic chemicals, pharmaceuticals and fertilisers and nitrogen.

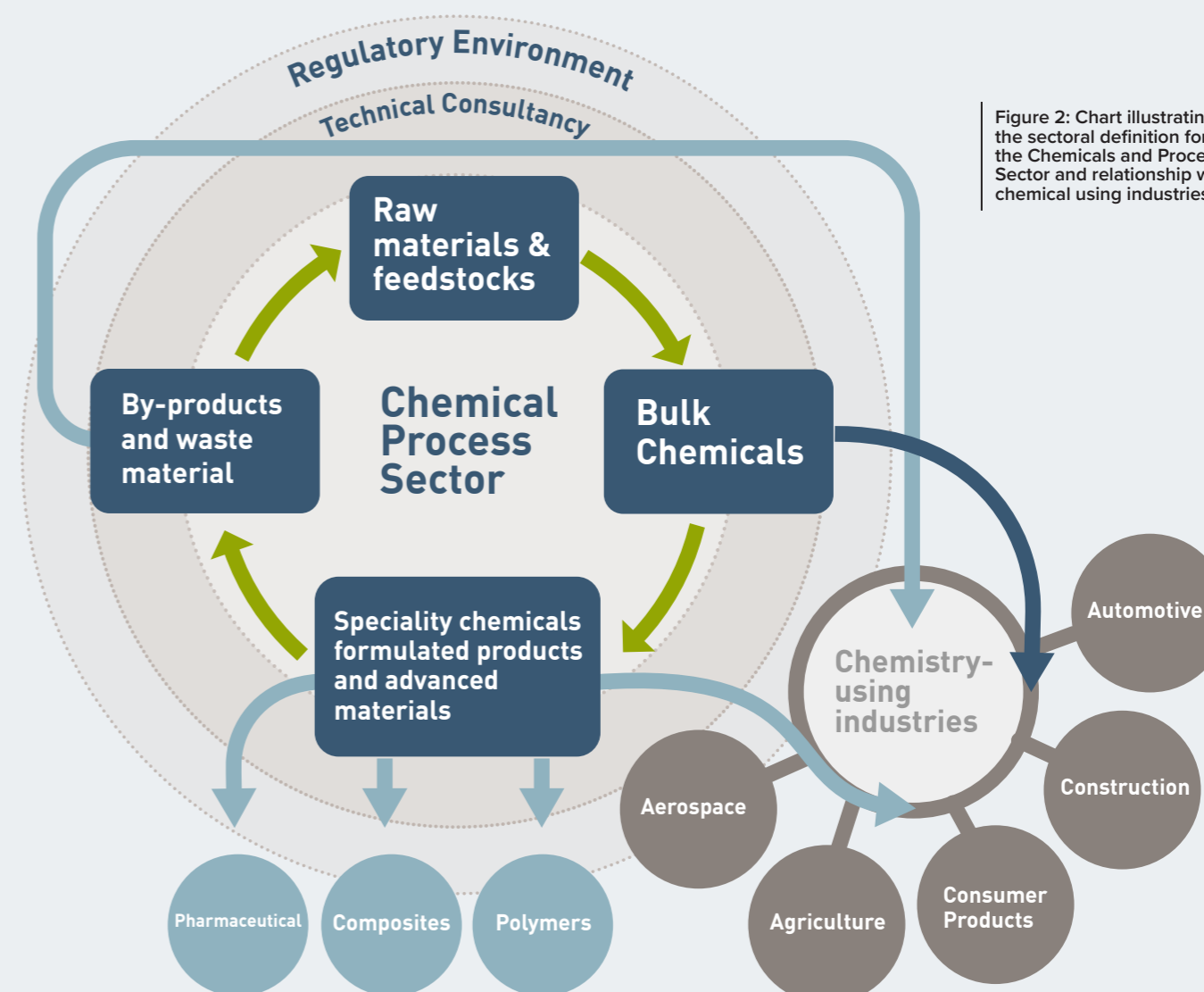


Figure 2: Chart illustrating the sectoral definition for the Chemicals and Process Sector and relationship with chemical using industries.

## Export Activities by Country

Country	Sales (Billion €)	Population (Million €)	Sales per head of population (€)
China	1,331	1,415	941
US	476	326	1,460
Germany	185	82	2,256
Japan	140	127	1,102
South Korea	113	51	2,216
France	70	65	1,077
India	76	1,354	56
Taiwan	63	23	2,739
Spain	63	46	1,370
UK	60	66	909
Brazil	59	210	281
Netherlands	55	17	3,235
Italy	52	59	881

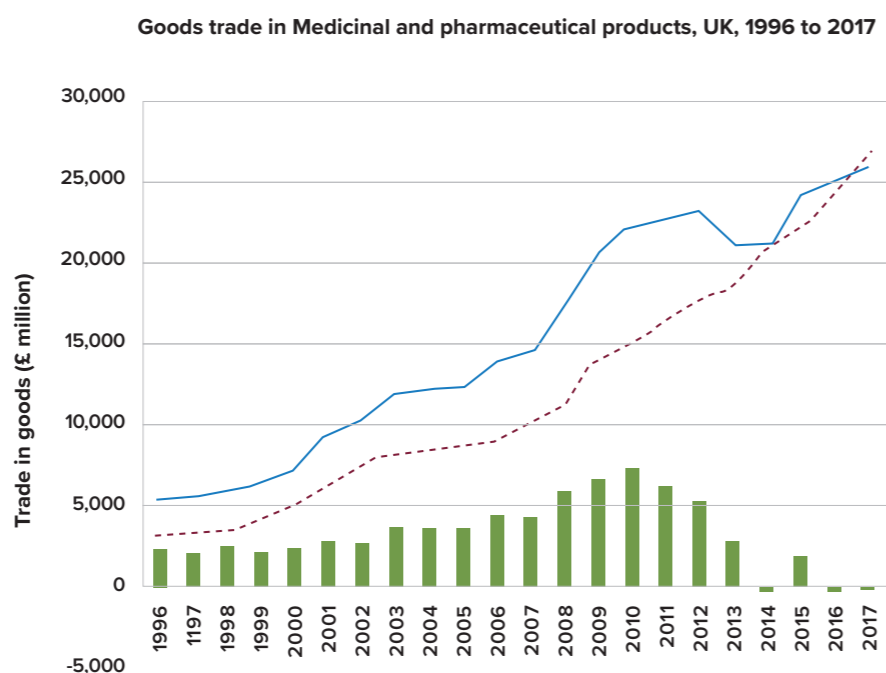
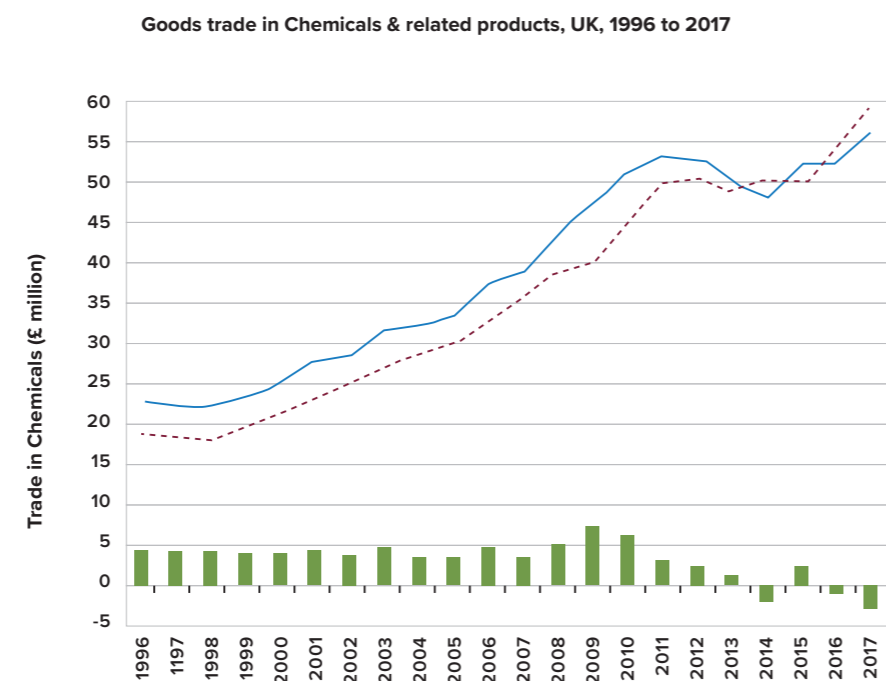


# Net Trade for Chemical Products

The reduction in exports has been across the board including price sensitive sub sectors such as the manufacture of organic chemicals, pharmaceuticals and fertilisers and nitrogen.

The UK chemical sector is facing a challenge of diminishing cost competitiveness due to increasing costs related to energy and feedstocks particularly in relation to lower value intermediary goods. The knock-on effect of reduced production of these goods leads to greater fragmentation of existing supply chains and a diminished export orientation across the sector. This decline in export orientation may have a causal effect on the level of innovation activity undertaken and be a consequence of reduced indigenous investment in Research and Development and Innovation.

Figure 3: Net Trade for the Chemicals and related products 1996-2017.



## Sector characteristics

The chemicals and process sector across the UK and particularly in the Northern Powerhouse is mature, both in the technology being used and also the sectoral age profile. There are relatively few new business start-ups and the churn rate is low (i.e. few company closures). In addition, the sector is highly concentrated <sup>6</sup>.

- The top four large firms account for 16.5% of total sector employment, 38% of turnover;
- The top seven large firms account for 23% of total sector employment, 41% of turnover.

Overall the chemicals sector has a higher proportion of mid-sized businesses (£25-£500million annual turnover) <sup>7</sup> than the economy as a whole. Most mid-sized companies are indigenously owned and generally compete in terms of price.

The proportion of SMEs is at variance to the wider economy in which there are circa 88% micro and 98% small enterprises compared to circa 12% micro and 30% small enterprises for the chemicals sector. There is also greater variance in the composition of the sector by scale than between sectors, with the pharmaceutical sector having the greatest preponderance of micro enterprises, which reflects the higher number and proportion of new starts within this subsector.

The sector has a high proportion of mid-sized and large-scale companies, with the former generally delivering intermediate goods to the latter for subsequent exporting. There is a significant proportion of the larger companies under international ownership with, in some cases, a perception of “branch plant” status with higher value adding functions such as headquarters and research bases sited overseas.

Whilst large firms account for over two-thirds of turnover, the mid-sized firms also make a significant contribution (26.4%) to turnover for the sector, however they only contribute around 4% of R&D expenditure <sup>6</sup>. The low level of R&D spend within the mid-sized and small enterprises suggests an imbalance within the sector, skewed towards the larger firms. This has highlighted the need to encourage greater take up of innovation, in particular by mid-sized enterprises, with interventions being tailored to meet their specific characteristics.



# Our Vision

“To ensure that the Northern Powerhouse contributes to the successful delivery of the Strategy for Chemistry Fuelled Growth that by 2030, chemistry using industries will increase their contribution to the UK economy from £195 billion to £300 billion”.

Our vision is that over the next 12 years, the Northern Powerhouse chemicals and process sector will:

- Be the most competitive location, by building upon its existing highly efficient bulk chemicals infrastructure, further driving down costs through accessing (existing and emerging) affordable feedstocks and utilising nascent technologies;
- Regain lost export markets and re-shore the production of high value intermediary goods and R&Di functions of locally based global concerns;
- Diversify into new geographic and sectoral supply chains;
- Deliver more knowledge transfer between industry of all size and ownership structure and the regional innovation ecosystem to enhance productivity and ensure global competitiveness;
- Be a globally recognised centre for the application and testing of industrial digitisation and circular economy solutions to the chemicals and process sector; and
- Lead the adoption of bio-processing solutions for chemicals production.

# Key Strengths

## Strong and connected clusters

At £13.40bn GVA, the NPH contributes 48% of the UK's chemical production and is by far the largest region in terms of output for the sector. In addition, the sector contributes 26.5% of all NPH manufacturing GVA, compared with the UK average of 21.2%<sup>8</sup>.

The Northern Powerhouse chemicals proposition is based upon three strong clusters interlinked by strong East-West supply chains and associated pipeline connectors of key raw materials:

- Tees Valley and County Durham;
- Humber LEP area; and
- A combination of Cheshire and Warrington and Liverpool City Region LEP (Cheshire and Merseyside).

These sub areas have a location quotient of 3.4, compared with 1.8 across the NPH as a whole against the average of 1 for the UK as a whole.

The region has a strong tradition in exporting, dominated by the large companies and supplied by largely indigenously owned mid-sized and smaller companies.

## Highly trained and responsive workforce.

The NPH employs 44% of the UK Chemical and Process sector work force<sup>9</sup>. The NPH Universities provide a quarter of the UK science, technology, engineering and mathematics graduates representing a significant opportunity to meet local demand for professional talent. In 2016/17, 39% of all chemical sciences apprenticeships were started in the NPH<sup>10</sup>. The demand for apprenticeships is high. Data from the Working Futures report<sup>11</sup> shows a trend towards a more highly skilled workforce both within the NPH and nationwide.

Centres for Doctoral training (CDTs) represent strong vehicles for engagement with industry and also train postgraduates as future employees within the sector. There are presently 9 Centres for Doctoral Training (CDTs) in support of the sector with a further 6 under application.





## An asset-rich innovation ecosystem

The effectiveness of the innovation ecosystem of the NPH was assessed using the following key variables: perspectives of academic research quality, University engagement with industrial base, business R&D spend, Government innovation support, Intellectual Property filed and Research and Technology Organisations' (RTO) activity.

The NPH region contains 32 higher education institutions with 522,000 students<sup>12</sup> and includes the N8 research partnership of eight research intensive Universities (Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle and York)<sup>13</sup>. While the Northern Powerhouse is a comparatively small region, it has a number of individual academic institutions which have international status and continue to attract significant UK and foreign research investment.

The leading academic research institutions within the SIA area demonstrate strong research quality across all six sub-sectors of the chemical and process industry with particular strengths highlighted in materials sciences, chemical synthesis, chemical measurement, atmospheric physics and chemistry<sup>14</sup>.

This high-quality research on an individual institutional level indicates that there is strength in depth across the chemical process sector within the SIA area that should be utilised to deliver innovation and further enhance the region.

Figure 4 presents the analysis of research quality (as measured by the field weighted citation index) across the key innovation needs identified across all six chemical and process sub-sectors against publication quantity for the Universities within the SIA. The combined scale and quality of research outputs if deployed collectively would outstrip larger national comparator institutions several-fold.

There is a northern cluster of nationally and internationally important Catapults and other National Innovation Centres that support the chemicals and process sector. The key players are the Centre for Process Innovation (CPI), the Materials Processing Institute, TWI, the Royce Centre and Materials Innovation Factory. Driven by the needs of industry, these innovation centres work closely with academia and industry to foster and encourage innovation in key areas.

The innovation strength of the chemical sector is reflected in the predominance of patents filed on chemical sector technologies, which represents 38% of all patents filed in the NPH. The NPH exhibits a particularly strong specialisation when compared with the rest of the UK in basic materials chemistry, macromolecular & polymer chemistry, materials & metallurgy, surface coating and technologies<sup>15</sup>.

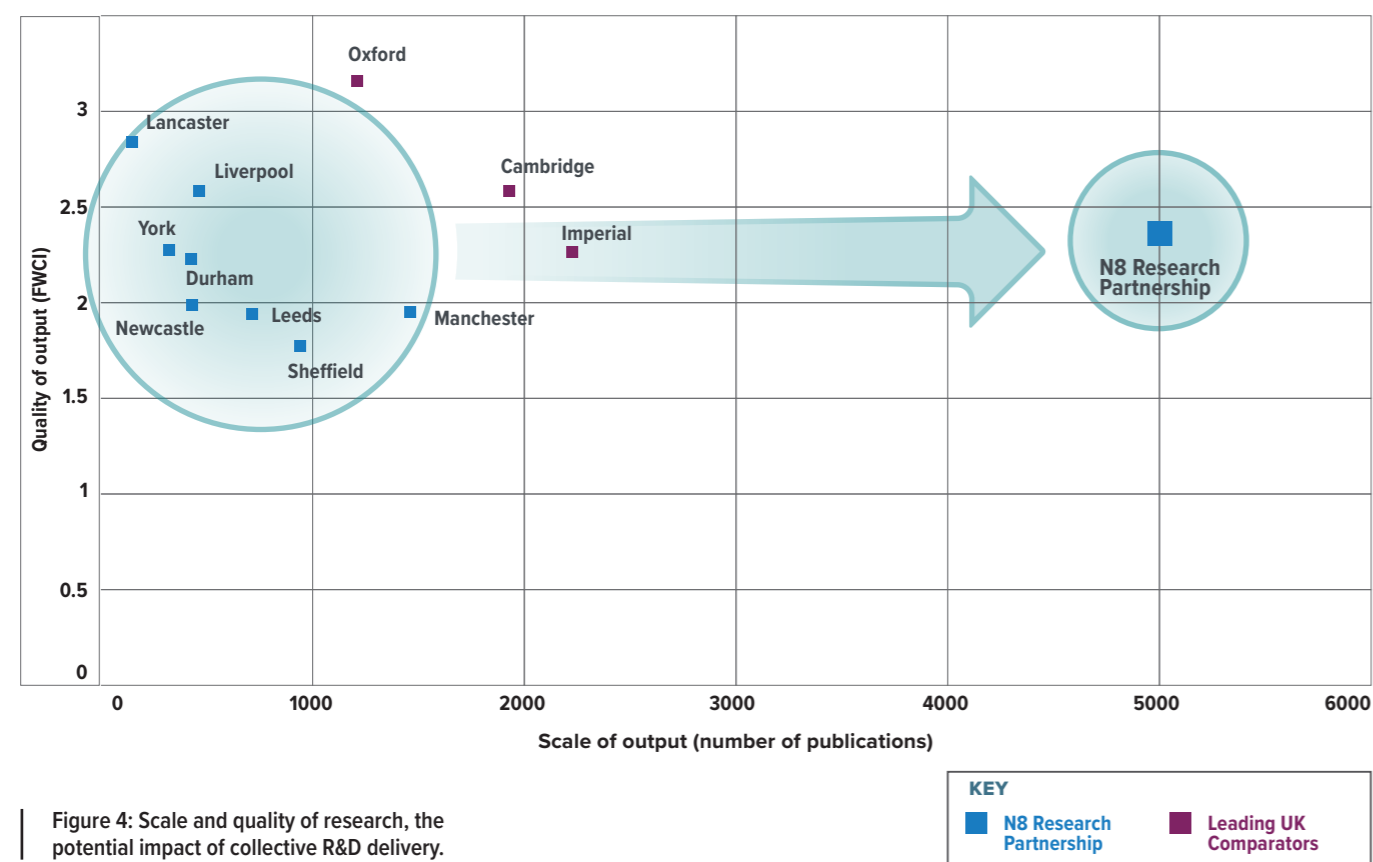


Figure 4: Scale and quality of research, the potential impact of collective R&D delivery.

## Growth Opportunities

The SIA has identified a number of growth opportunities:

- Increase in demand in global markets for intermediate and higher value adding goods
- Use of nascent technologies and new energy feedstocks
- Increased demand for reshoring and use of circular economy solutions
- Opportunities for the use of industrial digitisation
- Opportunities to utilise sectoral free trade zones in conjunction with block chain solutions
- Opportunities to use Northern Powerhouse international networking
- New models for commercialising technologies: public/private partnerships and associated financing mechanisms
- Significant opportunities for scale and growth particularly in mid-sized companies through supply chain/export diversification.

Benchmarking against best practice in international comparator regions\*, as illustrated in Figure 5 assumes that if cumulatively delivered, the Northern Powerhouse vision has the potential to contribute £23bn of additional output to the UK economy, dependent on the following components and interventions:

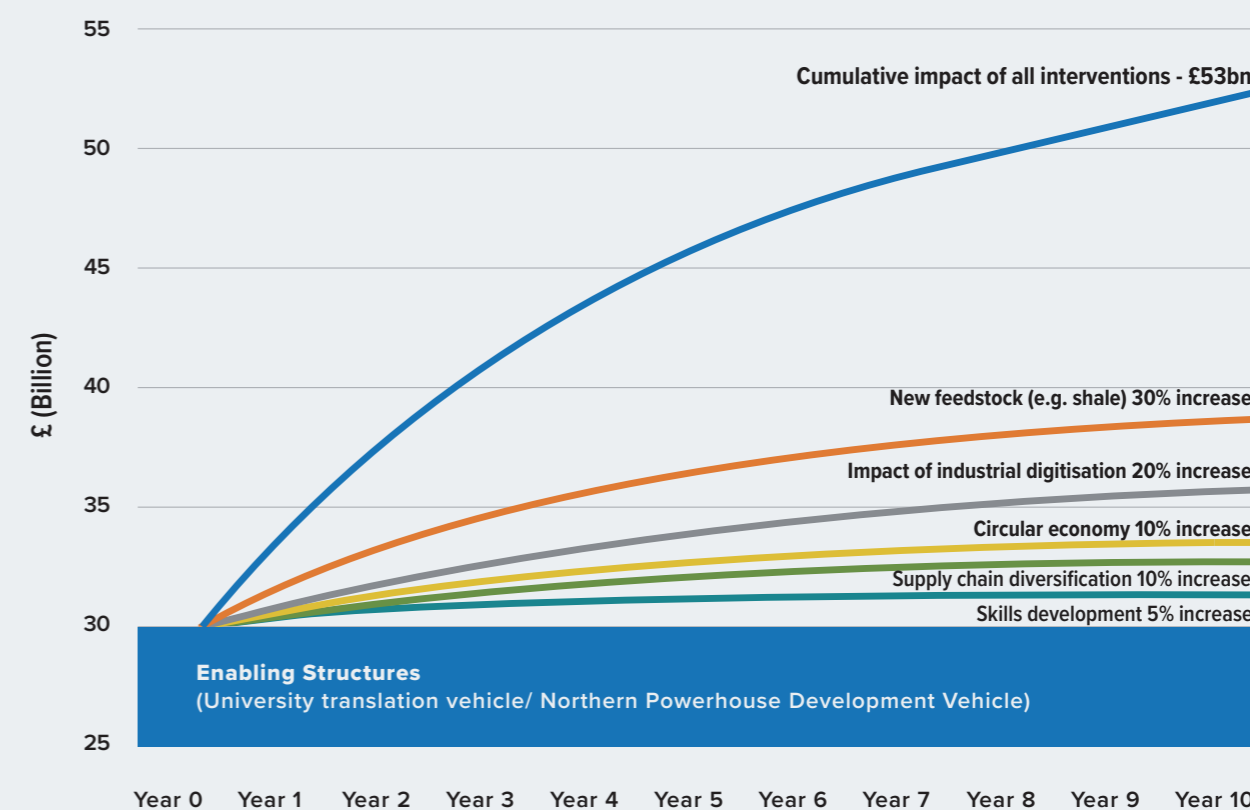
- **New feedstocks** could increase output by **30%**
- **Industrial digitisation** could increase output by **20%**
- **Supply chain diversification** could increase output by **10%**
- **Circular economy** could increase output by **10%**
- **Skills development** could increase output by **5%**

Strong enabling structures are proposed to deliver this vision including the development of:

- Northern Powerhouse Development Vehicle.
- A coordinated University translation vehicle, working closely with the RTOs and industry.

\* Rheinessen-Pfalz; Antwerp- Rotterdam; Geleen; Gulf Coast (USA); Singapore; and Busan (formerly Pusan) South Korea

FIGURE 5: GROWTH TRAJECTORIES OF POTENTIAL INTERVENTIONS





# Gap Analysis

We have utilised TOWS (Threats, Opportunities, Weaknesses and Strengths) analysis to develop workable solutions to the opportunities/challenges identified in the SIA. Table 1 summarises the key conclusions:

**Table 1: TOWS analysis of opportunities and challenges**

Internal Strengths and External Opportunities (S-O)- how can they use the strengths to benefit from existing external opportunities?	Internal Weaknesses and External Opportunities (W-O)- how can they use opportunities to overcome the organisation's internal weaknesses?	<p><b>Key ambitions/proposals</b> In response to the findings the following proposals have been developed:</p> <p>Develop a unique selling point for the Northern Powerhouse in conjunction with associated mechanisms and institutions to promote the region and ensure global competitiveness, including a Sectoral Free Trade Zone Proposition;</p> <p>Masterplan for Northern Powerhouse development, building the capabilities and skills to deploy the following supports:</p> <ul style="list-style-type: none"> <li>■ Development of new feedstocks;</li> <li>■ Impact of industrial Digitisation/Sectoral Free Trade Blockchain Solution;</li> <li>■ Supply chain consolidation and diversification;</li> <li>■ Impact of the circular economy; and</li> <li>■ Development of a programme of support for leadership training/talent attraction and retention.</li> </ul> <p>Building upon these proposals, Table 2 sets out an ambitious action plan to deliver major growth to the sector.</p>
Need to match local research strengths to emerging global demand for R&Di; and	High feedstock costs, opportunity to use circular economy solutions; and	
Increasing global demand for chemicals, with enhanced opportunities for reshoring due to levelling out of costs in Far East.	Fragmented supply chains, opportunity to use circular economy and industrial digitisation to promote local sourcing.	
Internal Strengths and External Threats (S-T) how can they benefit from their strengths to avoid or lessen (potential) external threats?	Internal Weaknesses and External Threats (W-T)- how can they minimise weaknesses and thus avoid potential threats?	
Loss of management and leadership skills in region: Address perceptions of lack of critical mass within the sector and overcome denudation of higher value-added functions; and	Address local of local intermediaries, develop capacity and growth ambition of local management; and	
Increased R&Di being undertaken out with of the region, need to highlight the research proposition of Northern Powerhouse and also attract private sector R&Di back into the region.	Too few new entrants, development of patient/risk capital to promote start-ups.	

# Action Plan

**Table 2: Proposed Action Plan**

Intervention	Implementation
<b>Acting at Global scale</b>	<b>NPH Chemicals and Process Sector Development Vehicle:</b> Augmenting existing sectoral representative bodies, it will be tasked with delivering an enhanced business support function, including but not limited to: supply chain /export diversification and foreign direct investment. Success will be enhanced added value being delivered within the NPH.
<b>Unifying the innovation ecosystem</b>	<b>Technology translation:</b> Creation of an innovation delivery system to valorise the academic research base and maximise the economic impact on the sector. Establish an integrated science and technology innovation network (a 'knowledge-based growth hub') integrating with the innovation scale-up of CPI and the other specialist Research Organisations in the NPH. This to provide a strong, agile translational interface accelerating the translation of University research into Industry, closely coordinating with the N11 local enterprise partnerships and science/business parks to drive infrastructure provision in support of relevant inward investment.  <b>Accelerate Technology Commercialisation:</b> This would require new venture capital funding to commercialise research and provide finance for emerging companies and initiatives to promote clustering and sharing between the public and private sectors.
<b>Increasing productivity through new feedstocks, the use of nascent technologies and decarbonisation</b>	<b>Resource Efficiency: Develop new feedstock base for chemical industry:</b> Consider the options that (existing and emerging) affordable feedstocks (e.g. hydrogen, carbon dioxide, shale gas) may give the North. Recognise the opportunities that the bio-economy presents to feedstock and product development as well as the strength of companies in the NPH. This would require feasibility studies and a roadmap for industry development, as well as aligning the different stakeholder interests.  <b>Accelerate the move towards industrial digitisation.</b> Northern chemicals sites could provide testbeds for the trialling of industrial digitisation and 5G solutions to address issues related to fragmentation.  <b>Develop the circular economy proposition to mitigate feedstock concerns.</b> Northern chemicals sites could provide a base for new industries. This would require active engagement with the players developing these industries, as well as the development of a number of pilot / demonstrator projects.
<b>Consolidating and diversifying supply chains</b>	<b>Programme of support aimed primarily at mid-sized chemical companies,</b> including provision of skills, innovation and networking support for diversifying supply chains.
<b>Delivering skills to meet sector ambition</b>	<b>Programme of support to develop talent across the NPH.</b> Development of an integrated training and skills programme, primarily focused on the coordinated delivery of apprenticeships, including: recruitment, training and placement across the region. This will be primarily aimed at mid-sized businesses across the region.  In addition, work with existing knowledge providers to impart specialist leadership and technical training driven by industry. This will in large part be driven by emerging technological absorptive incapacity in, for example the circular economy and industrial digitisation.  The integrated model would address the issue of emerging fragmentation across the sector and will therefore significantly benefit both business and individuals if cross-company apprenticeships could be supported.



# Networking & Collaboration

The SIA has been delivered through a core project delivery group led by the Tees Valley Combined Authority (TVCA). This group comprised representatives from the TVCA, Durham and Teesside Universities, North East Process Industry Cluster (NEPIC), Centre for Process Innovation (CPI), Materials Processing Institute (MPI) and TWI, with representation from Innovate UK and the BEIS appointed SIA consultants, Technopolis.

An initial desk-based review of secondary research identified a number of gaps in existing knowledge of the sector within the Northern Powerhouse, which in line with the original hypotheses, necessitated extensive primary research including: Stakeholder Interviews; International benchmarking against six comparator national and sub-national entities; and 3 Stakeholder workshops. The SIA has networked extensively through close consultation and engagement with

- HEI Research institutions: 15 Universities formed the core consortium, including the N8 research partnership of the eight research intensive Universities within the NPH (Durham, Lancaster, Leeds, Liverpool, York, Manchester, Newcastle and York) and also a further seven key additional NPH Universities with strong links to the chemicals and process sector including Teesside, Bradford, Chester, Huddersfield, Hull, and Northumbria and Sunderland.
- Economic Development agencies: The project delivery lead, Tees Valley CA has liaised with the 11 LEPs that reside within the NPH, with close engagement with the locations of the key chemical clusters in the Humberside LEP and Liverpool City Region LEP respectively.
- National Innovation Centres: CPI, MPI, TWI and the Royce Centre and Materials Innovation Factory through their Manchester and Liverpool University leads.
- Sectoral bodies, NEPIC has acted as the lead coordinating sectoral body, working with counterparts in Chemicals NW, HCF-CATCH and YCF. Input on the important pharmaceutical intermediates sub-sector has been provided through the First for Pharma organisation.
- The Chemistry Growth Partnership (CGP) has been consulted in the audit through engagement with their secretariat, the Chemistry Industries Association. Alignment has also been through CGP Board member, Paul Booth's Chairmanship of the SIA project delivery group. The SIA has coordinated its evaluation of the key innovation themes with the work undertaken by the Innovation Committee of the Chemistry Growth Partnership on key priorities for innovation and investment and indeed has undertaken further

analysis for the CGP on a UK wide assessment of key innovation parameters as supporting evidence for the sector deal proposal currently being prepared for Government.

- Industrial consultation has been through the sector bodies and also through one to one interviews with businesses conducted as part of the stakeholder interview activity.
- Other key consultees have included Innovate UK, the KTN, EPSRC, the Smart Specialisation Hub, and the BEIS chemical sector team.

The SIA has built upon the learning in the SIAs in Waves 1 and 2. Several common themes run through these audits in particular, the importance of coordinated innovation and business support; strategic investment and access to finance; and recognition of the sector identity through a single body. These closely align with the conclusions arising from our work.

There are very clear technological linkages in particular with the work of the Applied Digital SIA in the application of digitisation to the chemicals and process sector and both working groups have closely collaborated in developing their conclusions and actions and have agreed to continue to work collaboratively as they move into implementation phase post-completion of the audit.

The SIA has identified the Circular Economy and resource efficiency as strong enablers that cut across the key sub-sectors as a means of reshoring activity and driving growth. This is showing close alignment with messaging on the importance of eco-innovation and clean growth within the North West Coastal Arc Clean Growth SIA. Both groups have been in preliminary discussions and will seek to continue dialogue on coordinated and collaborative interventions post-completion of the audit phase

## Full report

The full report; The Northern Powerhouse Chemicals and Process Sector: A Science and Innovation Audit Report sponsored by the Department of Business, Energy and Industrial Strategy can be downloaded from [www.teesvalley-ca.gov.uk/research-intelligence/sia](http://www.teesvalley-ca.gov.uk/research-intelligence/sia)

# References

1. **Office for National Statistics**, Annual Business Survey: 2016 Provisional Results, 2017.
2. **CEFIC**, Landscape of the European Chemicals Industry, 2018. Available: <https://www.chemlandscape.cefic.org/>
3. **CEFIC**, Facts and Figures 2017 of the European Chemical Industry, 2017. Available: <http://www.cefic.org/Facts-and-Figures/>
4. **HM Revenue & Customs**, HM Revenue & Customs Trade Statistics, Available: <https://www.uktradeinfo.com/Statistics/Pages/Statistics.aspx>
5. **Astra Zeneca**, 2013 Annual Report, 2013. Available: <https://www.astrazeneca.com/investor-relations/annual-reports.html>
6. **Bureau van Dijk**, ORBIS Database, Available: [https://orbis.bvdinfo.com/version-2018523/home\\_serv?product=OrbisNeo](https://orbis.bvdinfo.com/version-2018523/home_serv?product=OrbisNeo)
7. **Department for Business, Energy & Industrial Strategy**, The Mid-sized Businesses Growth Review, 2012.
8. **Office for National Statistics**, Nominal and real regional gross value added (balanced) by industry, ONS, 2017.
9. **Office for National Statistics**, Annual Business Survey - Regional Results 2015, 2017.
10. **Skills Funding Agency**, The Skills Funding Agency (SFA) Full Year Data Cube February 2018, 2018.
11. **UK Commission for Employment and Skills**, Working Futures 2014-2024, 2016. Available: <https://www.gov.uk/government/publications/uk-labour-market-projections-2014-to-2024>.
12. **Higher Education Statistics Agency**, HESA - Higher Education Statistics Data, 2017. Available: <https://www.hesa.ac.uk/data-and-analysis/students>
13. **N8 Research Partnership**, N8 Research Partnership, Available: <https://www.n8research.org.uk/>
14. **SCOPUS**, Citation Analysis 2013-2017 of Chemicals Literature, Available at <https://www.scopus.com/search/form.uri?display=basic>
15. **EPO-PATSTAT**. Worldwide Patent Statistical Database (Spring 2017 version).