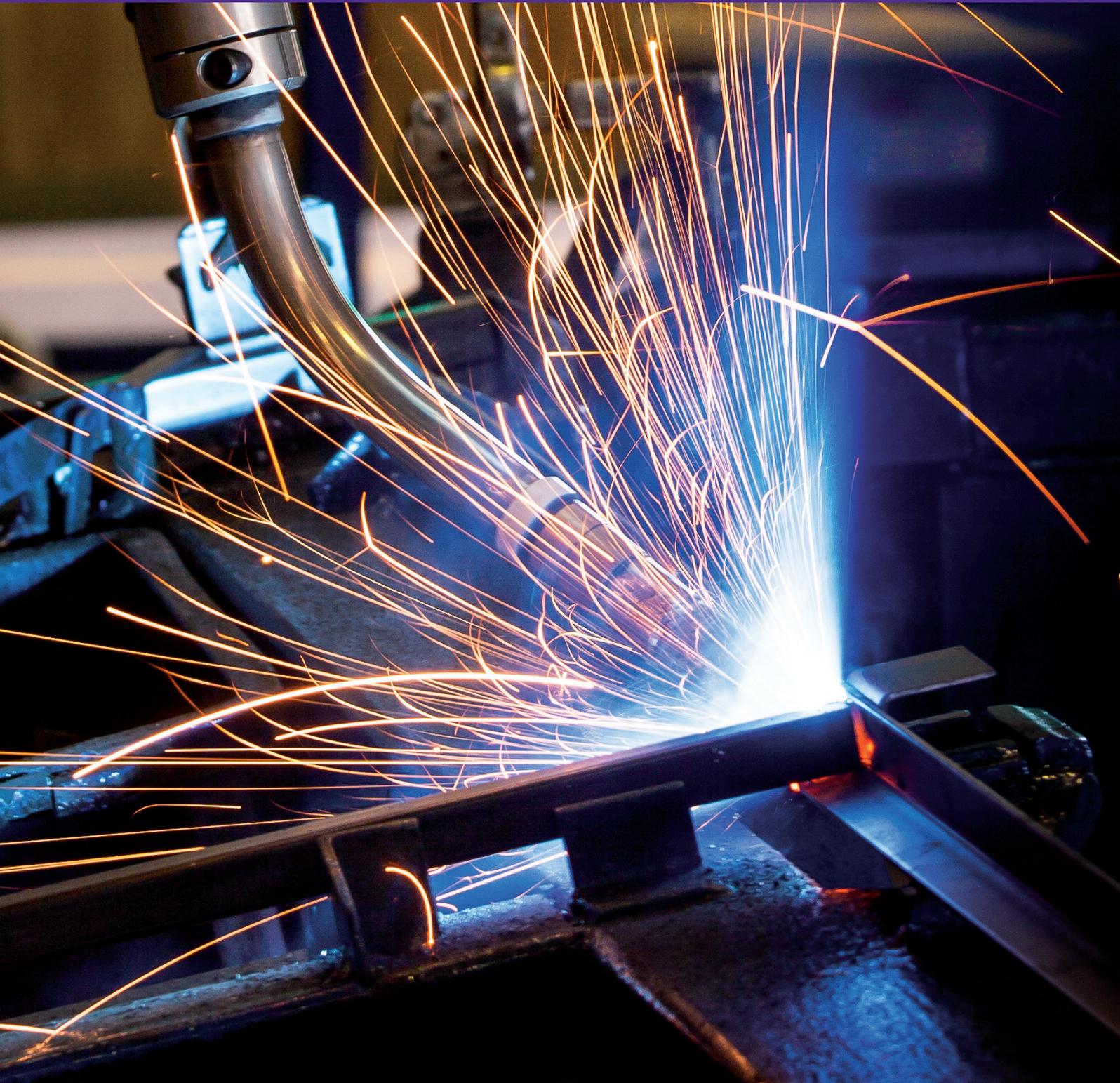


# The role of physics in supporting economic growth and national productivity in Wales



The Institute of Physics is a leading scientific membership society working to advance physics for the benefit of all.

We have a worldwide membership of more than 50,000, from enthusiastic amateurs to those at the top of their fields in academia, business, education and government.

Our purpose is to gather, inspire, guide, represent and celebrate all who share a passion for physics. And, in our role as a charity, we're here to ensure that physics delivers on its exceptional potential to benefit society.

Alongside professional support for our members, we engage with policymakers and the public to increase awareness and understanding of the value that physics holds for all of us.

Our subsidiary company, IOP Publishing, is world leader in scientific communications, publishing journals, ebooks, magazines and websites globally.

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# Foreword

In an uncertain economic climate, it is more important than ever for Wales to recognise and support areas that can be relied upon to deliver results.

Physics is one of those areas, and is one where Wales has an established and effective base.

It is home to many internationally leading researchers with key roles in major international collaborations and it serves as a base for many businesses that have built significant success on physics-based knowledge and technologies.

The work presented in this report from the Centre for Economic and Business Research is the most comprehensive analysis yet undertaken of the role of physics in the growth and productivity of industries in Wales. It demonstrates that physics is not just the source of inventions and ideas, but also the means by which the country's economic health can be secured.

The data in this report show that physics-based industries have a major impact on the creation of quality employment and increased productivity.

However, the economic prosperity that physics brings does not happen without the continued support of the education, research and skills infrastructure. The strength of current physics-based businesses in Wales is built on past investment in cutting-edge physics, and we know that it is often the basic, curiosity-driven research of today that inspires and underpins the applications and technologies of tomorrow.

For Wales to continue to benefit from a high-technology, high-productivity economy in the future then it must continue to invest in physics today – in schools, in higher and further education, in research and in the businesses that thrive on the fruits of physics.

The Institute of Physics is working with communities and stakeholders across the country to ensure that the benefits of physics are recognised and that the investment necessary for prosperity is secured.

The analysis in this report is pivotal to this effort.

**Professor Andrew Evans**

Chair, IOP Wales

# Physics in the Welsh economy



**£56,978**

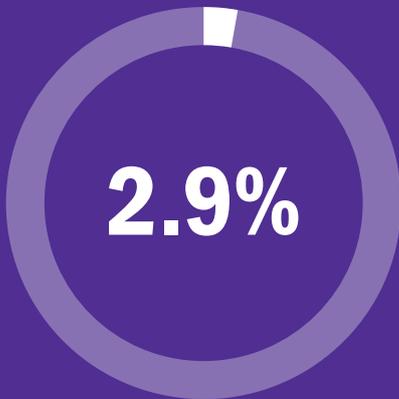
Someone employed in Welsh physics-based industries contributed an average of £56,978 a year in value added over 2011-13



**£5.2 bn**

Physics-based industries accounted for £5.2 bn in gross value added (GVA) in 2013

GO TO PAGE 8



Annual growth averaged 2.9% between 2011 and 2013



**84,000**

Employment in Welsh physics-based industries reached almost 84,000 in 2015



**£9.2 bn**

Physics-based industries generated turnover of £9.2 bn in 2013



That's a 10% share of the Welsh economy in 2013

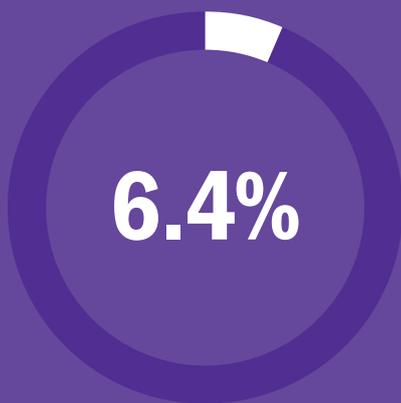
Add in indirect effects and overall GVA rises to

**£10.7 bn**

£5.2 bn

+ £5.5 bn

GO TO PAGES 10-12



That's a 6.4% share of all employment in Wales

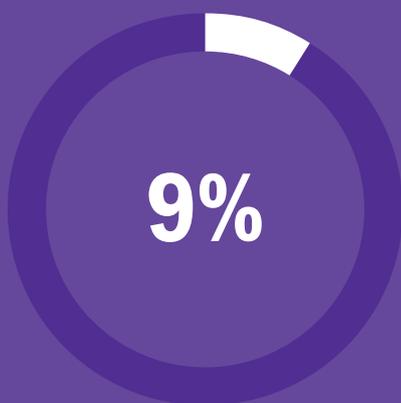
Add in indirect effects and overall jobs rises to

**200,650**

83,830

+ 116,820

GO TO PAGES 13-15



That's a 9% share of the turnover of the entire Welsh business economy

Add in indirect effects and overall turnover rises to

**£18.6 bn**

£9.2 bn

+ £9.4 bn

GO TO PAGE 16

# Introduction

This report examines the contribution and importance of physics to the economy of Wales, through the lens of the industries that rely on physics for their existence, and how these industries play an important role in enhancing productivity, boosting economic growth and increasing prosperity. The analysis spans the period 2011-13 with some additional data from 2014 and 2015.

When using absolute indicators, we compare the contributions of Wales's physics-based industries with other sectors, such as manufacturing, construction and retail, and also with other UK nations.

Physics-based industries can be defined as the industries in which the use of physics – in terms of technologies and expertise – is critical to their existence. This means that the industries considered are those in which workers with some training in physics would be expected to be employed, and in which the industrial activities themselves rely heavily on the theories and results of physics to achieve their commercial goals.

This research provides a thorough and comprehensive examination of the role of physics-based industries in the Welsh economy. The report presents a range of analyses demonstrating different aspects of the value they bring.

One of the main goals of the research was to demonstrate how physics-based industries contribute to national productivity, economic growth and the broader prosperity agenda. This, alongside the ongoing contributions made by these industries as measured by contributions to annual GDP and employment, is designed to demonstrate the impact of physics on the real economy.

The purpose of the research was also to provide a range of comparisons, including:

- How the economic indicators vary across different categories or groupings of physics-based industries
- How the economic indicators for physics-based industries vary between Wales and the other nations of the UK in absolute terms
- How the indicators for physics-based industries compare with other important sectors of the Welsh economy

The appendix provides a full list of physics-based industries.

**Centre for Economics and Business Research,  
London 2017**



# Contributions to productivity, economic growth and prosperity

Future prosperity is reliant on growth in the economy. This, in turn, depends on the quantities of the factors of production employed (specifically, labour and capital) and the efficiency with which those quantities are utilised. Growth can be sustained by increasing the amounts of labour and/or capital that are used. But, as additional units of these factors are added, the amount of additional output as a result tends to diminish. Only increases in the level of technological progress can offset this decline in growth that occurs as economies mature and diminishing returns to labour and capital set in.

We examine how physics-based industries' contribute to productivity and economic growth through the lens of average levels of labour productivity, investment in R&D, and international trade.

The analysis suggests that physics-based industries' labour productivity is significantly higher than any of these other broad sectors. The notable exception is manufacturing, in stark contrast to what was observed for the UK as a whole, and for England.

## Productivity per employee

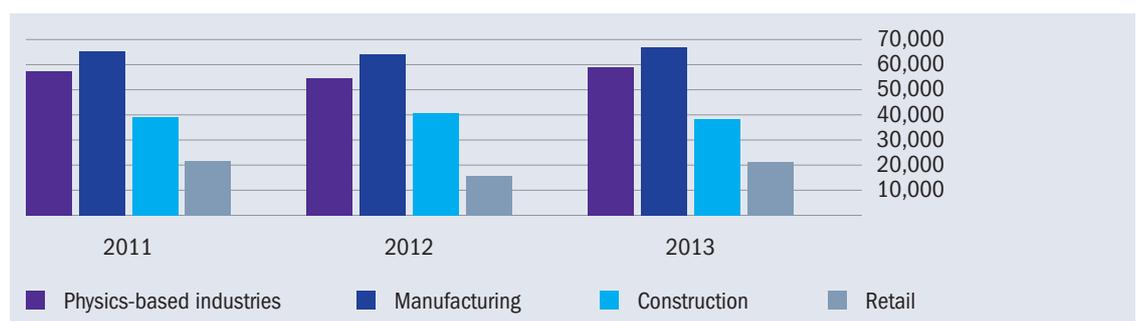
Throughout the period under consideration, a person employed in Welsh physics-based industries contributed an average of £56,978 a year in value added. This is markedly above the Welsh construction sector's average labour productivity levels, which averaged £39,298. Physics-based industries' average is double the equivalent estimate of £19,512 for Welsh retail.



**£56,978**

A person employed in Welsh physics-based industries contributed an average of £56,978 a year in value added

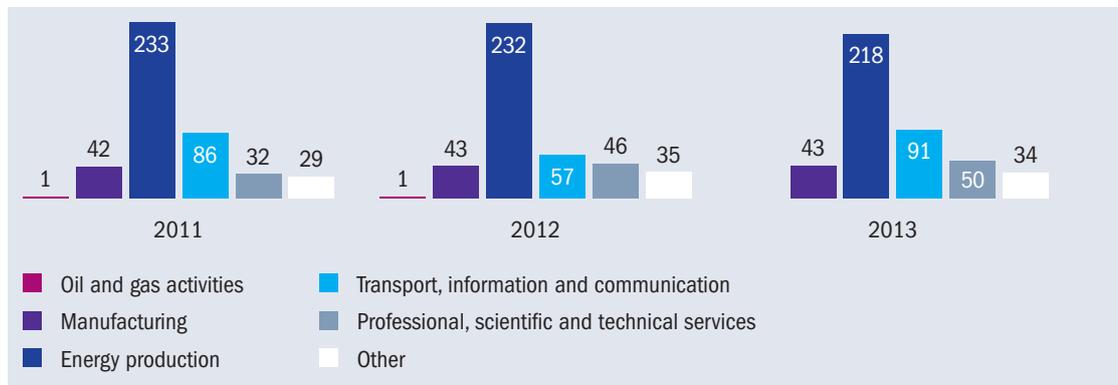
Apparent labour productivity (value added per person employed per year) (£)



The reasons for this are apparent from the figure opposite, which shows the absence of any contribution from the very high value added oil and gas extraction industries. While there is a strong contribution from energy production in Wales, the other categories of physics-based industry are also associated with lower values of

the labour productivity than observed for the UK or England as a whole. This serves to pull down the physics-based industry average relative to broader manufacturing, but also highlights the importance of physics-based energy production to the Welsh economy.

## Labour productivity within different physics-based industries (£'000)



## Real productivity growth in the physics-based industries

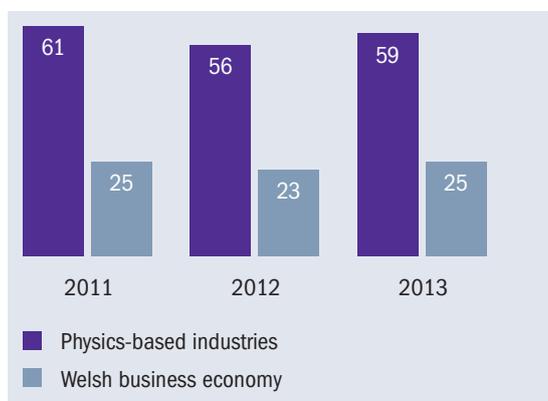
We have also sought to provide a high-level examination of real labour productivity growth in the Welsh physics-based industries. Estimates of GVA per person employed in the physics-based industries between 2011 and 2013, all expressed in 2013 prices, are shown below. This shows a decline of 2.9% over the period but a 5.2% rise between 2013 and 2014.

The physics-based industries' average GVA per person employed is significantly greater (more than double, even with energy production stripped

out) than that of Wales's economy as a whole. Growth over the period averaged 0.9%, but reached 8.1% between 2012 and 2013. This is stronger than that estimated for physics-based industries, but the whole-economy growth estimate is taken from a lower base.

There is a stark difference between physics-based industries and the economy-wide average for Wales when considering GVA per hour worked. Again, this analysis points to physics-based industries' important role in driving productivity in the Welsh economy.

## Real GVA per person employed in the physics-based industries and the Welsh economy (£'000)



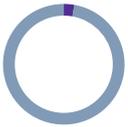
## Real GVA per hour worked in the physics-based industries and the Welsh economy (£)





**£5.2 bn**

Physics-based industries accounted for £5.2 bn in GVA

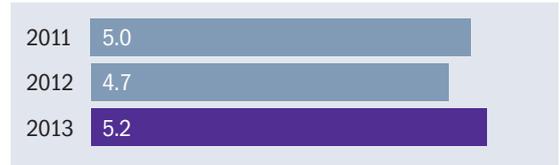


Annual growth averaged 2.9% between 2011 and 2013

# Physics based industries' GVA contributions to GDP

Physics-based industries made a £5.2 bn GVA contribution in 2013. Annual growth averaged 2.9% between 2011 and 2013. While average growth over the period is on a par with that experienced by UK and English physics-based industries, 2013 growth in those in Wales is far greater (although from a lower base).

GVA in physics-based industries (£ bn)



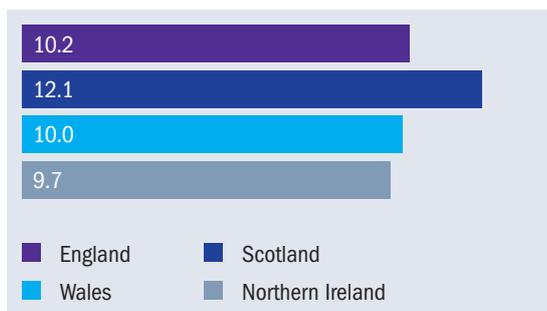
Physics-based GVA as a share of total business economy GVA, across UK nations (%)



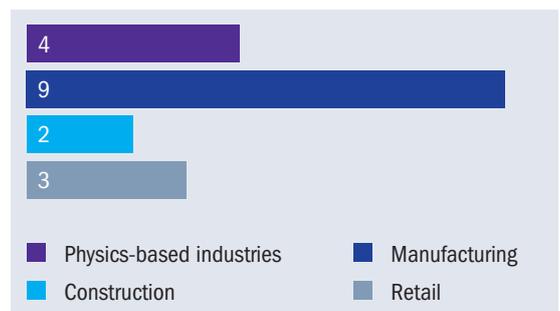
Welsh physics-based industries' GVA contributions are compared with other UK regions and our comparator sectors below. On this measure and in contrast to turnover, physics-based industries surpass the wider retail sector. The difference between physics-based industries

and the broader Welsh manufacturing sector is also not nearly as stark as it appears from turnover. These are strong indicators for the productivity of Welsh physics-based industries, although we suspect that there are probably underestimates inherent in the raw turnover data.

Share of GVA impact by region, 2013 (%)



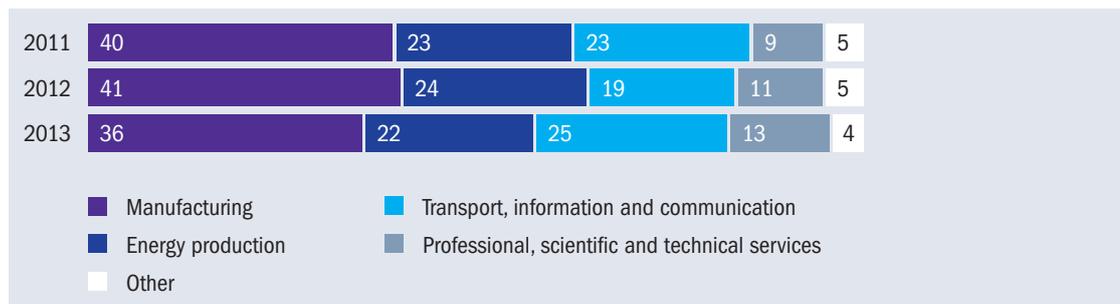
Selected sectors' shares of Wales's GVA at basic prices, 2013 (%)



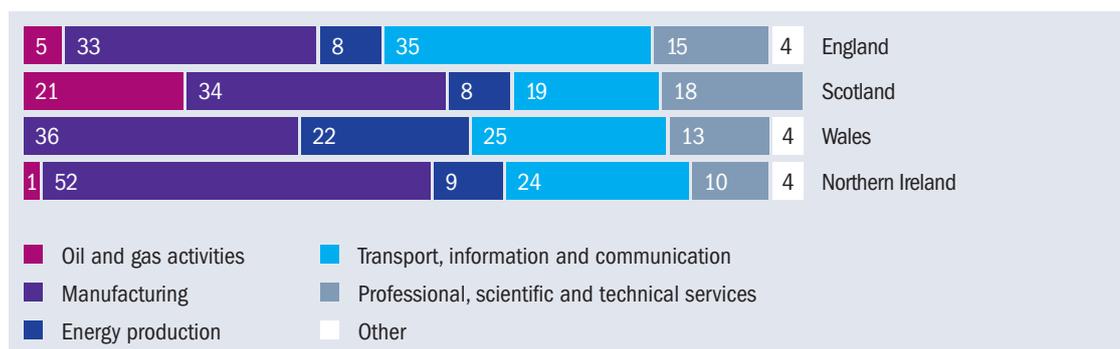
The bulk of physics-based industries' GVA contribution is accounted for by manufacturing. Energy production is significantly more important in GVA terms than in turnover terms, while transport

and communications are also important. Physics-based professional services appear to be increasing in importance as a category.

### GVA composition in physics-based industries (%)



### Composition of physics-based industries across UK nations, 2013 (%)



The graph above compares the composition of the Welsh physics-based industries GVA terms with those of England, Scotland and Northern Ireland. The striking feature here is the relative importance of energy production, in GVA terms,

to the Welsh economy compared to in England and Scotland. Similarly striking is the relative unimportance of oil and gas to England and Wales compared to Scotland.

## Physics based industries' GVA contributions to GDP continued

### Physics-based industries' GVA multiplier (= 2.05)

Direct impact:  
**£1.00**

Expenditure on the physics-based sector triggers the physics industry's supply response. In providing its services, the physics industry generates additional value added. Assume sufficient expenditure to generate £1 of GVA. This £1 of GVA is the direct GVA impact of the relevant increment in expenditure on physics-based industry.

Indirect impact:  
**£0.62**

To increase its supply, the physics-based industry must increase its demands on its suppliers, who increase demands on their suppliers and so on down the supply chain. This generates the indirect impact, an increase in GVA throughout the supply chain of £0.62 for every additional £1 of GVA in the physics-based industry.

Induced impact:  
**£0.43**

The combined direct and indirect impacts have an impact on household income throughout the economy, through increased employment, profits etc. A proportion of this income will be respent on final goods and services, producing a supply response by the producers of these goods/services and further impacts through their supply chains. This produces the induced impact of £0.43 for every additional £1 of GVA in the physics-based industry.

£5.5 bn

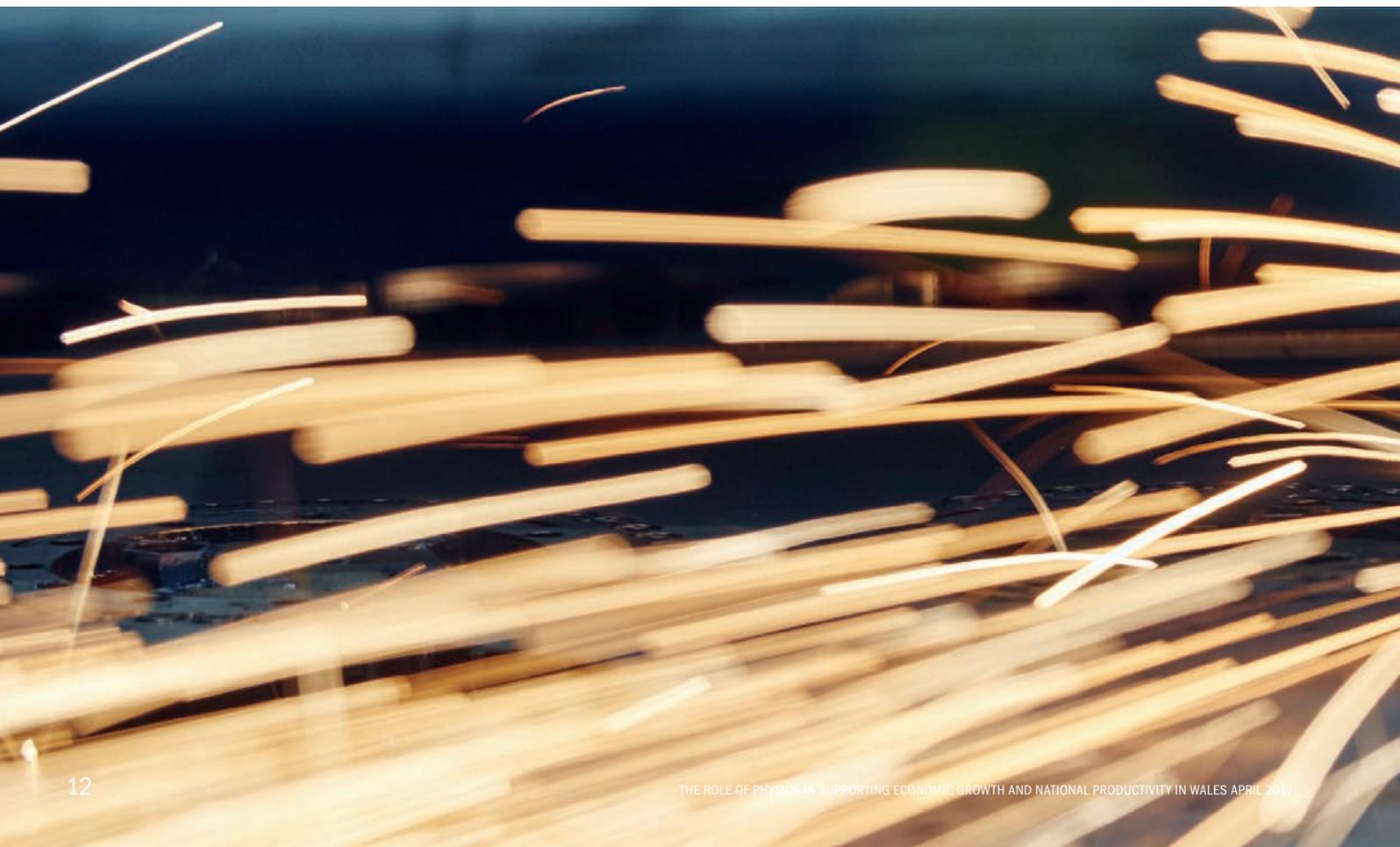
Add in indirect effects and overall GVA rises to

**£10.7 bn**

Physics-based industries' GVA contribution rises to £10.7 bn once indirect and induced multiplier impacts are included. Our multiplier estimate for the Welsh physics-based industries is again low relative to that for the UK or for England. This is again a reflection of the leakages of indirect

supply chain and induced employee spending impacts from Wales to the rest of the UK, most likely England.

Combining this with the Welsh physics-based industries' direct GVA contribution of £5.2 bn produces an aggregate GVA contribution of £10.7 bn.





**84,000**

Employment in Welsh physics-based industries reached almost 84,000 in 2015



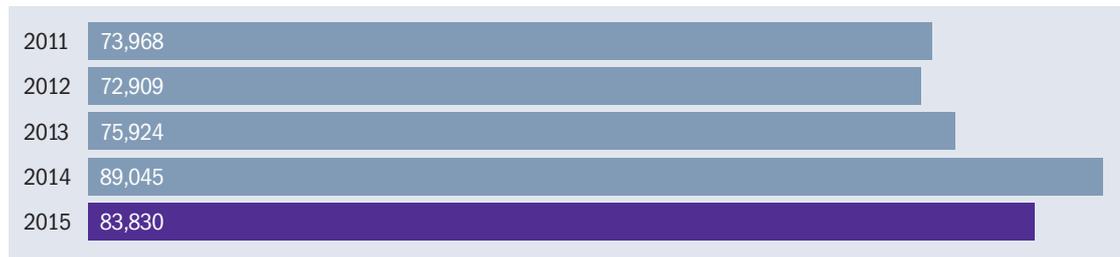
That's a 6.4% share of all employment in Wales

# Employment

Estimates suggest that employment in the Welsh physics-based industries reached almost 84,000 in 2015, amounting to a 6.4% share of all employment in Wales. This was a 6% decline on

the previous year, following growth in excess of 17% in 2014. Employment growth has averaged a healthy 3% annually between 2011 and 2015.

## Employment in Welsh physics-based industries



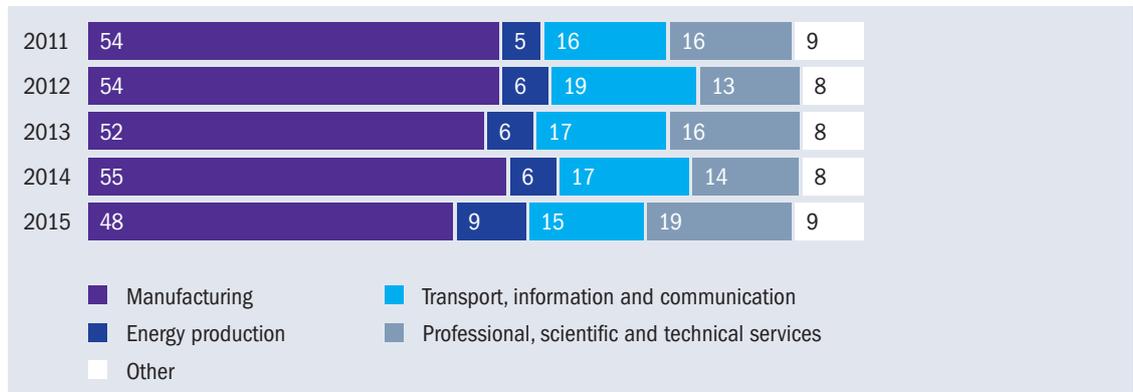
Large shares of employment in the physics-based industries are accounted for by manufacturing activities (a 48% share recorded in 2015), meaning that the performance of the broader Welsh manufacturing sector and of physics-based industries can be expected to be closely intertwined.

Transport and communications and physics-based professional services are also significant, with shares of 15% and 19% of the physics based industries' employment in 2015, respectively, and with the latter overtaking the former in the same year.



## Employment continued

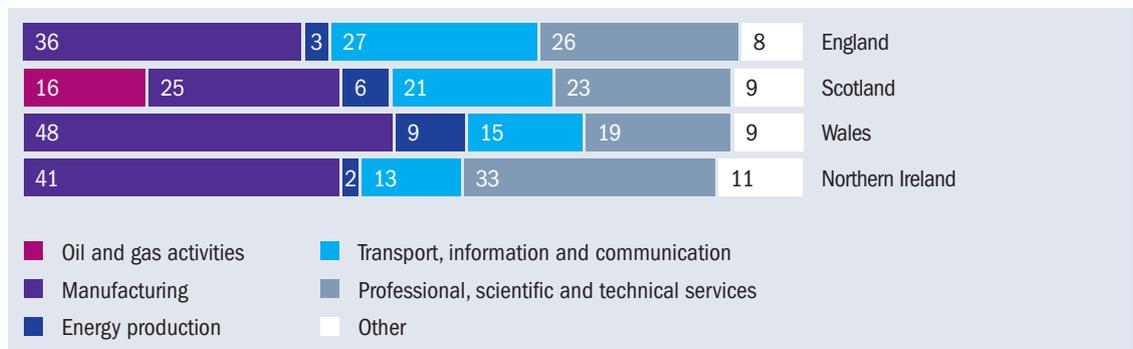
### Employment composition in Wales's physics-based industries (%)



The graph below compares the industrial structure of employment in Welsh physics-based industries compared with England, Scotland and Northern Ireland. Manufacturing accounts for the highest share in all countries, but is dominant in Wales, accounting for 52%. Other notable differences

include the relative importance of oil and gas activities as an employer in Scotland, and the relative unimportance of physics-based transport and communications and professional services in Wales compared to England and Scotland.

### Employment composition in physics-based industries across UK nations, 2015 (%)



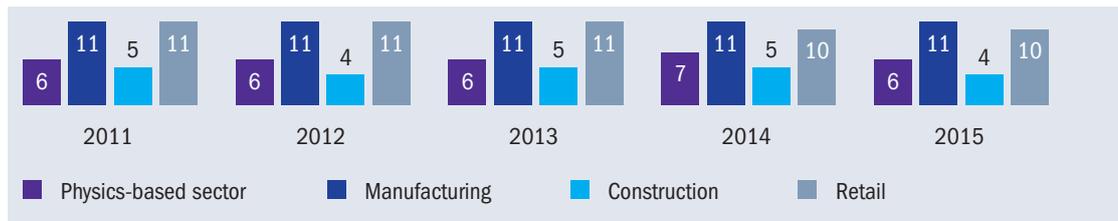
Energy production is the other broad sector of note represented within Welsh physics-based industries but despite low shares of employment, energy production contributes much more significant shares of physics-based industries'

GVA contributions to GDP (22% in 2013). Energy production can therefore be expected to be an important driver of productivity in Welsh physics-based industries.

The physics-based industries' contribution to Welsh employment is shown alongside comparator sectors below. The difference between the physics-based industries and the broader manufacturing

sector more closely reflect the differences in GVA generated by these sectors. With construction and retail, the differences are more akin to the differences in turnover.

### Selected sectors' shares of Wales's employment (%)



Physics-based industries' activities also support jobs in the wider economy. This ripple or multiplier effect is created when physics-based industries purchase intermediate inputs from other sectors of the economy, the activity thereby supporting indirect jobs in their supply chain. When the direct and indirect employees of physics-based industries spend their earnings in the wider economy, it supports induced jobs in the sectors that supply final goods and services to households.

The bespoke input-output models produced for this study suggest an employment multiplier of 2.39. This suggests that an additional 116,820 jobs can be attributed to the indirect and induced employment impacts of physics-based industries. This in turn suggests an aggregate contribution to employment in Wales amounting to 200,650 when these indirect and induced multiplier impacts are accounted for. This is again lower than estimates for England and for the UK as a whole, suggesting that a part of both types of impact is felt outside of Wales – mostly in England.

116,820

Add in indirect effects and overall jobs rises to

**200,650**

### Physics-based employment multiplier (= 2.39)

**Direct impact:**  
**1.00 job**

Expenditure on the physics-based industries' supply response. In providing its services, the physics-based industry hires additional staff. Assume sufficient expenditure to generate one additional job. This job is the direct employment impact of the relevant increment in expenditure on the physics-based sector.

**Indirect impact:**  
**0.81 jobs**

To increase its supply, the physics-based industry must increase its demands on its suppliers, who increase demands on their suppliers, and so on down the supply chain. This generates the indirect impact, an increase in employment throughout the supply chain of 0.81 jobs for every additional job in the physics-based sector.

**Induced impact:**  
**0.58 jobs**

The combined direct and indirect impacts have an impact on household income throughout the economy, through increased employment, profits, and so on. A proportion of this will be respent on final goods and services, producing a supply response by the producers of these, and further impacts through their supply chains. This produces the induced impact of 0.58 jobs for every additional job in the physics-based sector.



**£9.2 bn**

Physics-based industries generated turnover of £9.2 bn

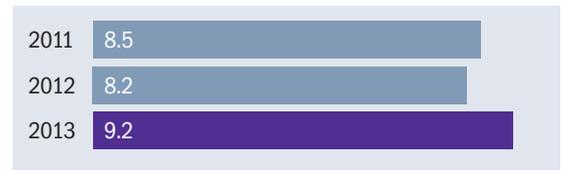


That's a 9% share of the turnover of the entire Welsh business economy

## Turnover

Physics-based industries generated turnover of £9.2 bn in 2013. This represents significant growth of 12.4% on the 2012 estimate of £8.2 bn and follows a 3% decline in 2011, when turnover was measured at £8.5 bn.

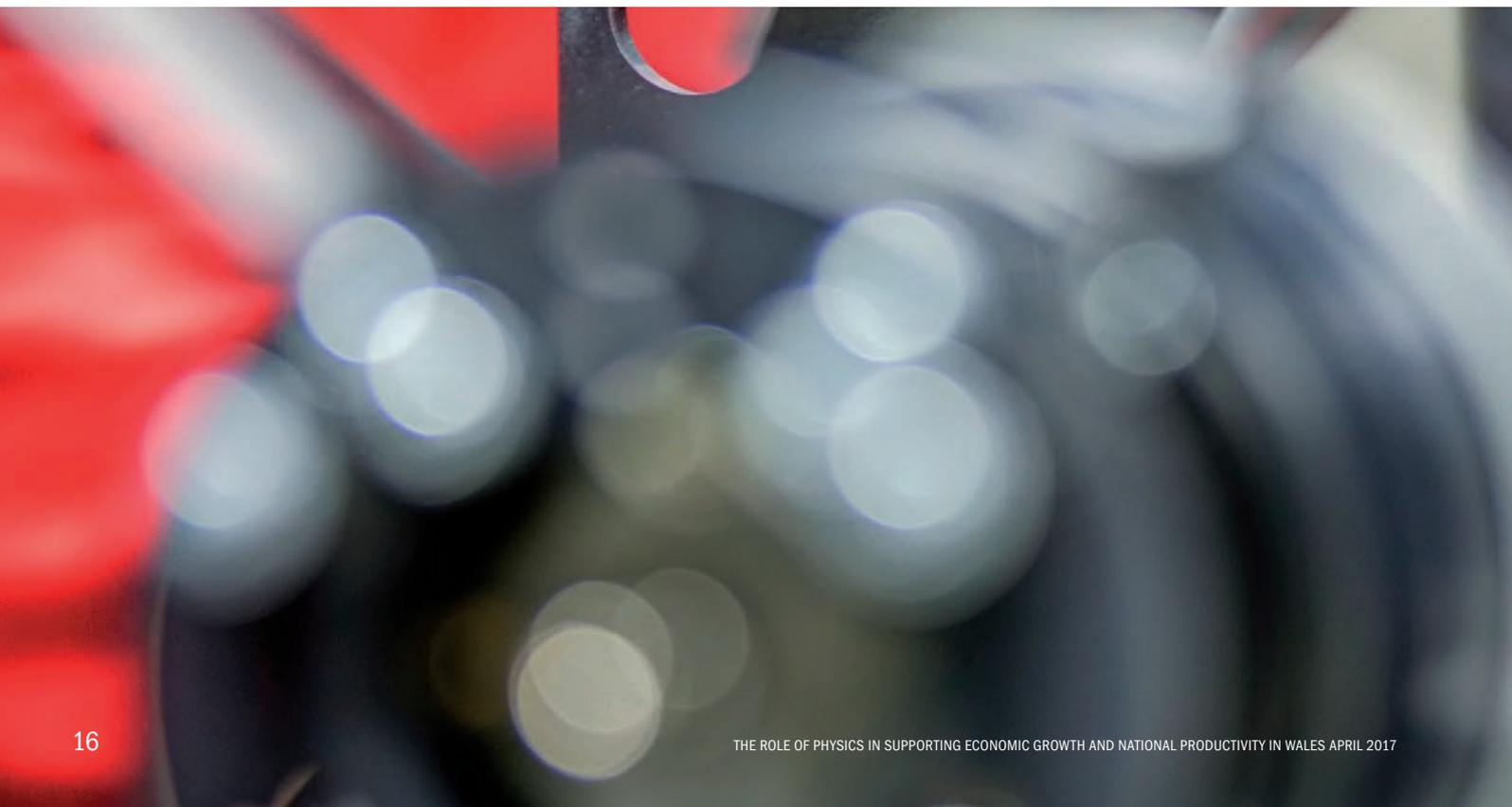
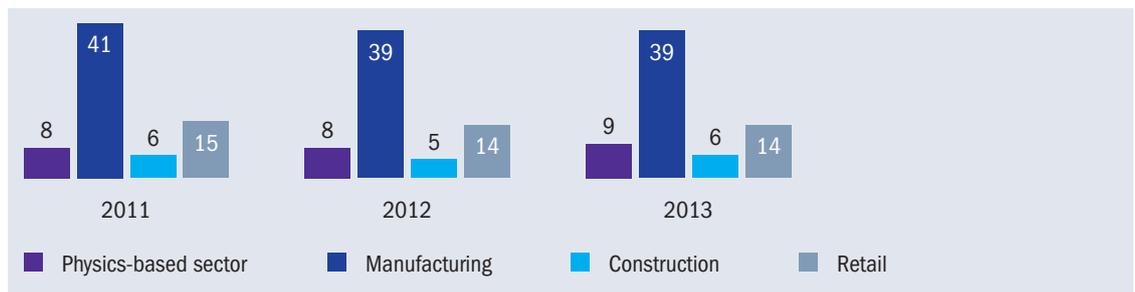
**Turnover in physics-based industries (£ bn)**



Welsh physics-based industries' turnover is compared with sectors of manufacturing, retail and construction. The turnover of physics-based industries, when taken together, measures larger

than the Welsh construction sector. The latter shows a trend of -0.1% annual average growth in contrast to a rate of 4.7% for the physics-based industries.

**Turnover in selected Welsh sectors (£ bn)**



Despite its dominance, the broader Welsh manufacturing sector has been in decline since 2011, with annual growth averaging -2.4%. This decline is dwarfed only by that of the Welsh retail sector (-6.4% a year).

The turnover generated in physics-based industries reached a total of £9.2 bn in 2013, constituting a 9% share of the turnover of the entire Welsh business economy. The turnover multiplier illustrates our estimate of the indirect

and induced gross output multiplier impacts associated with the productive activities of physics-based industries.

Combining this with the direct turnover contribution of £9 bn produces an aggregate turnover contribution of £18.6 bn.

This analysis points to the important role of physics-based industries in driving productivity levels and growth in the Welsh economy.

**Physics-based industries gross output (turnover) multiplier (= 2.02)**

<p><b>Direct impact:</b> <b>£1.00</b></p> <p><b>Indirect impact:</b> <b>£0.60</b></p> <p><b>Induced impact:</b> <b>£0.42</b></p>	<p>Expenditure on the physics-based sector triggers the physics-based industry's supply response. In providing its services, the physics-based industry produce additional output. Assume sufficient expenditure to generate £1 of output. This £1 of output is the direct output impact of the relevant increment in expenditure on physics.</p> <hr/> <p>To increase its supply, the physics-based industry must increase its demands on its suppliers, who increase demands on their suppliers and so on down the supply chain. This generates the indirect impact, an increase in output throughout the supply chain of £0.60 for every additional £1 of the physics-based industry's output.</p> <hr/> <p>The combined direct and indirect impacts have an impact on household income throughout the economy, through increased employment, profits etc. A proportion of this income will be respent on final goods and services, producing a supply response by the producers of these goods/services and further impacts through their supply chains. This produces the induced impact of £0.42 of output for every additional £1 of the physics-based industry's output.</p>
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£9.4 bn

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Add in indirect effects and overall turnover rises to **£18.6 bn**



# Appendix

## Table of physics-based industries

Definitions of physics-based industries used in this report are given below alongside their standard industrial classification code.

Code	Description	Code	Description
06.10	Extraction of crude petroleum	30.11	Building of ships and floating structures
06.20	Extraction of natural gas	30.20	Manufacture of railway locomotives and rolling stock
09.10	Support activities for petroleum and natural gas extraction	30.30	Manufacture of air and spacecraft and related machinery
20.13	Manufacture of other inorganic basic chemicals	30.40	Manufacture of military fighting vehicles
21.20	Manufacture of pharmaceutical preparations	30.91	Manufacture of motorcycles
23.44	Manufacture of other technical ceramic products	32.50	Manufacture of medical and dental instruments and supplies
24.46	Processing of nuclear fuel	33.11	Repair of fabricated metal products
25.40	Manufacture of weapons and ammunition	33.12	Repair of machinery
25.99	Manufacture of other fabricated metal products n.e.c.	33.13	Repair of electronic and optical equipment
26.11	Manufacture of electronic components	33.14	Repair of electrical equipment
26.12	Manufacture of loaded electronic boards	33.15	Repair and maintenance of ships and boats
26.20	Manufacture of computers and peripheral equipment	33.17	Repair and maintenance of other transport equipment
26.30	Manufacture of communication equipment	33.20	Installation of industrial machinery and equipment
26.40	Manufacture of consumer electronics	35.11	Production of electricity
26.51	Manufacture of instruments and appliances for measuring, testing and navigation	35.12	Transmission of electricity
26.60	Manufacture of irradiation, electro-medical and electrotherapeutic equipment	35.13	Distribution of electricity
26.70	Manufacture of optical instruments and photographic equipment	38.12	Collection of hazardous waste
26.80	Manufacture of magnetic and optical media	38.22	Treatment and disposal of hazardous waste
27.11	Manufacture of electric motors, generators and transformers	43.22	Plumbing, heat and air conditioning installation
27.12	Manufacture of electricity distribution and control apparatus	51.22	Space transport
27.20	Manufacture of batteries and accumulators	52.21	Service activities incidental to land transportation
27.31	Manufacture of fibre optic cables	52.22	Service activities incidental to water transportation
27.32	Manufacture of other electronic and electric wires and cables	52.23	Service activities incidental to air transportation
27.33	Manufacture of wiring devices	60.1	Radio broadcasting
27.40	Manufacture of electric lighting equipment	61.1	Wired telecommunications activities
27.51	Manufacture of electric domestic appliances	61.2	Wireless telecommunications activities
27.90	Manufacture of other electrical equipment	61.3	Satellite telecommunications activities
28.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	61.9	Other telecommunications activities
28.21	Manufacture of ovens, furnaces and furnace burners	62.09	Other information technology and computer service activities
28.23	Manufacture of office machinery and equipment (except computers and peripheral equipment)	71.11	Architectural activities
28.25	Manufacture of non-domestic cooling and ventilation equipment	71.12	Engineering activities and related technical consultancy
28.29	Manufacture of other general-purpose machinery n.e.c.	71.2	Technical testing and analysis
28.49	Manufacture of other machine tools	72.11	Research and experimental development on biotechnology
28.99	Manufacture of other special-purpose machinery n.e.c.	72.19	Other research and experimental development on natural sciences and engineering
29.10	Manufacture of motor vehicles	74.2	Photographic activities
29.31	Manufacture of electrical and electronic equipment for motor vehicles	74.9	Other professional, scientific and technical activities n.e.c.
		84.22	Defence services
		95.12	Repair of communication equipment

**Authorship and acknowledgements**

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**For further information contact:**

**IOP** Institute of Physics

76 Portland Place, London W1B 1NT

Tel +44 (0)20 7470 4800

Email [policy@iop.org](mailto:policy@iop.org)

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