The Importance of Physics to the Welsh Economy
The Institute of Physics is a leading scientific society. We are a charitable organisation with a worldwide membership of more than 45,000, working together to advance physics education, research and application. We engage with policymakers and the general public to develop awareness and understanding of the value of physics and, through IOP Publishing, we are world leaders in professional scientific communications.
Physics-based businesses are critical to the Welsh economy. They employ 40,000 people, 3.5% of the Welsh workforce, and contribute £2.3 bn to the economy in gross value added (GVA) – nearly 10% of the national economic output.

The share of GVA from physics-based businesses in Wales is higher than that in the UK as a whole, clearly demonstrating the significant value of physics-based businesses in Wales. Half of all jobs in physics-based sectors in Wales were in manufacturing in 2010, with increasing contributions from the physics-based engineering, telecommunications and construction sectors.

While these physics-based sectors have made a significant contribution to the economic environment in Wales, the story is not wholly positive. Between 2008 and 2010 there was a 10% fall in employment in physics-based sectors in Wales, and a £300 m fall in GVA.

If Wales is to recover economically and prosper, physics-based innovation is vital. The jobs market is changing from traditional manufacturing towards high-technology, high-value industries. This can clearly be seen in the energy sector: Wales is home to nuclear power stations, on- and off-shore wind farms, hydroelectric generators and solar-cell manufacturers, all dependent on physics and physics-trained people, and all demonstrating Wales’ commitment to new and renewable energy technologies. In this and other sectors, physics-based businesses are driving innovation and growth.

But these physics-based businesses can’t do it on their own. To succeed, Wales must have a ready supply of physics-trained workers and a stable and sustained research funding environment. This, combined with an environment that promotes innovation, will allow physics-based businesses and Wales to thrive.

Professor Sir Peter Knight
President, Institute of Physics
### The Importance of Physics to the Welsh Economy

<table>
<thead>
<tr>
<th>40,000</th>
<th>40,000 people are employed in physics-based sectors in Wales.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.72%</td>
<td>Physics-based businesses directly contribute 9.7% of Wales’ economic output (£2.3 bn), greater than the contribution of physics-based business to the UK economy.</td>
</tr>
<tr>
<td>49%</td>
<td>The share of manufacturing jobs in Welsh physics-based sectors is 49%.</td>
</tr>
<tr>
<td>£3.4 bn</td>
<td>Including indirect and induced effects, the contribution of physics-based sectors to the economy in Wales was £3.4 bn in 2010.</td>
</tr>
</tbody>
</table>

3.7% of the Welsh workforce are employed in physics-based sectors, contributing 9.7% of the total Welsh economic output.
This report examines the contribution of physics to the Welsh economy between the years 2005 and 2010 (the last year of available data). This report incorporates changes in statistical definitions that have taken place since the last report to reflect the changing structure of the Welsh and UK economies.¹

The focus of this report is Wales, however, Deloitte has also produced equivalent reports for the economies of the UK, Scotland, Northern Ireland and Ireland, and these are available to download from the IOP website at www.iop.org.

Drawing on Office of National Statistics (ONS) datasets and our own bespoke modelling analysis, the contribution physics-based sectors made to the Welsh economy between 2005 and 2010 has been analysed.

Using the agreed definition of physics-based sectors, as outlined in the methodology annex, a smaller proportion of Welsh economic activity, as measured by direct jobs (around 3.5% in 2010) is devoted to physics than the UK average, around 4% in 2010. However, these sectors contribute proportionately more direct GVA to the Welsh economy, nearly 10% between 2005 and 2010, compared with the UK (8.5% over the same period).

EXECUTIVE SUMMARY

Magnox Limited specialises in overseeing safe energy generation and is responsible for the decommissioning of nuclear power stations. There are 10 Magnox nuclear power sites in the UK, including three in Wales at Wylfa, Maentwrog and Trawsfynydd. Magnox also operates a hydro power plant at Maentwrog.

Magnox is committed to reducing the need for fossil fuels for energy generation in Wales, and is using physics knowledge and technology to do so. Through the use of nuclear energy, Magnox has prevented the production of more than 200 million tons of carbon dioxide (CO₂) at the Wylfa site alone and more than 70 million tons of CO₂ at Trawsfynydd.

Moreover, the safe decommissioning of nuclear power stations relies on a profound understanding of the fundamental working of such sites. A number of Magnox’s 2500 employees are physicists who are involved with the technical development of the processes for decommissioning, ensuring that this is done both safely and efficiently.

Magnox says that further physics-based R&D in nuclear energy generation could provide new approaches for the safe operation of nuclear power stations. It could also enhance the development of more cost-effective and time-efficient routes for the decommissioning of old power stations.

“Physics is fundamental to understanding the operation of a nuclear power station and safe electricity generation.”

Credit: Magnox Ltd

Physics is fundamental to understanding the operation of a nuclear power station and safe electricity generation.
This chapter assesses the importance of physics-based sectors to the Welsh economy in terms of jobs, turnover and gross value added (GVA). The focus of this chapter is the direct impact of physics-based sectors. Chapter 3 contains further details of indirect and induced impacts — those occurring through the upstream supply chain and through consumer spending. Our methodology for estimating these numbers and any adjustments made to the data can be found in the Annex.

2.1. Direct jobs

There are nearly 40,000 direct jobs in Welsh physics-based sectors

In this section the number of direct jobs in physics-based sectors is explored. In particular, the range of physics-based sectors in the Welsh economy and how many people are employed in them. The trends in jobs in the physics-based sectors are analysed and compared across other sectors in Wales.

As shown in figure 2.1, our analysis estimates that there were approximately 40,000 direct jobs.
in physics-based sectors in Wales in 2010. This is slightly down from a peak of around 44,000 jobs in 2008 and is likely to be reflective of the wider economic downturn following the financial crisis.

Our analysis suggests that there was a fall of more than 3% in the total number of jobs in the UK between 2008 and 2010 and an equivalent fall in UK physics-based sectors of nearly 6%. Over this same period, the total number of jobs in Wales declined from 1.20 million in 2008 to 1.15 million in 2010 – a fall of nearly 4% – and the fall in the number of direct jobs in Wales physics-based sectors was nearly 10%. This larger than average fall in the number of jobs may be explained by the composition of industries that make up physics-based sectors that include large shares of manufacturing industries, which have been particularly exposed to the economic downturn.4

Figure 2.2 shows the breakdown of physics-based employment in Wales. Similar to the rest of the UK, manufacturing jobs comprise the main share of Welsh physics-based-sector jobs (49% in Wales versus 52% in the UK). The shares of other sectors are also similar to the rest of the UK.

The share of physics-based jobs in Wales is below the average share of jobs in physics-based sectors across the UK, and construction in Wales, however, remains above that of the share in finance, banking and insurance in Wales as seen in figure 2.3 and has consistently been the case since 2005, as shown in figure 2.4.

**Figure 2.2: Share of employment in physics-based sectors by broad sector, Wales, 2010**

- **manufacturing**: 49%
- **architectural and engineering activities**: 16%
- **telecommunications**: 9%
- **construction**: 8%
- **transport**: 5%
- **electricity production and distribution**: 4%
- **technical testing and analysis**: 2%
- **R&D**: 2%
- **defence activities**: 2%
- **oil and gas activities**: 1.5%
- **recycling and waste and other services**: 1.5%

Source: Deloitte analysis using Business Register Employment Survey and Annual Business Survey
**Figure 2.3:** Average share of total employment, 2005–2010

![Graph showing average share of total employment for physics-based sectors in Wales, physics-based sectors in the UK, finance, banking, and insurance in Wales, and construction in Wales from 2005 to 2010.](image)

Source: Deloitte analysis using Business Register Employment Survey and Annual Business Survey

**Figure 2.4:** Share of total Welsh and UK employment, longitudinal analysis, 2005–2010

![Graph showing share of total Welsh and UK employment for physics-based sectors in Wales, physics-based sectors in the UK, finance, banking, and insurance in Wales, and construction in Wales from 2005 to 2010.](image)

Source: Deloitte analysis using Business Register Employment Survey and Annual Business Survey
2.2. Gross value added

Direct GVA in physics-based sectors has begun to recover, but remains below 2008 levels.

The following section uses gross value added (GVA) to measure the economic contribution of physics-based sectors to the Welsh economy. GVA is a more accurate measure of the contribution to the economy than turnover because it does not include intermediate consumption.

Figure 2.5 charts trends in direct GVA from physics-based sectors in Wales between 2005 and 2010. GVA peaked in 2008 but has since fallen, with 2010 levels being marginally less than 2009 levels.

The GVA attributable to physics-based sectors in Wales was higher than in the UK over the period 2005–2010, as shown in figure 2.6 comparing the GVA of physics-based sectors in both Wales and the UK with finance, banking and insurance, and construction in the UK.

Box 2.2: What is value added?

The measure used to evaluate the economic contribution of physics-based sectors is gross value added (GVA). The Organisation for Economic Co-operation and Development (OECD) defines GVA as the value of output less the value of intermediate consumption. It is analogous to gross domestic product.

The GVA analysis presented herein is based on domestic use input/output tables from the ONS.
**Figure 2.6: Comparison of average share of Welsh and UK direct GVA from physics-based sectors, 2005–2010**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Wales</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics-based sectors in Wales</td>
<td>9.72</td>
<td>8.50</td>
</tr>
<tr>
<td>Physics-based sectors in the UK</td>
<td>11.34</td>
<td></td>
</tr>
<tr>
<td>Finance, banking and insurance in the UK</td>
<td></td>
<td>7.32</td>
</tr>
</tbody>
</table>

Source: Deloitte analysis using Business Register Employment Survey and Annual Business Survey

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**Telynau Teifi: playing to the rhythm of physics**

Telynau Teifi, based in Llandysul, south-west Wales, is a harp manufacturer, creating bespoke harps for clients across the UK. It is a small team, directly employing only nine people; however, Telynau Teifi works in close collaboration with highly qualified physicists from Cardiff and Swansea universities to develop its harp to produce the best quality sound. Telynau Teifi not only manufactures harps but is always striving to improve the acoustic and mechanical output of each instrument to optimise each aspect of the mechanical components and create the perfect sound for its customers. Physicists from Cardiff and Swansea universities are researching finite elemental analysis, structural analysis and composite materials to further improve the sound quality of each instrument manufactured. In addition to improving the instrument’s pitch, further physics research may lead to the development of stronger and lighter harps.
2.3. Productivity

Productivity in Welsh physics-based sectors has remained stable, but well ahead of the UK average.

While productivity, as measured by GVA per worker, in Welsh physics-based sectors is higher than the UK average across all sectors (£58,000 versus £36,000), it is only marginally higher than the construction sector and behind the UK average for both physics-based sectors, and finance, banking and insurance.

Figure 2.7 shows that over time, productivity has remained flat in Welsh physics-based sectors, with compounded average growth (CAGR) being less than 0.5% – compared with a CAGR of more than 3.5% across all sectors in the UK.

2.4. Conclusion

This chapter has considered the contribution of physics-based sectors to the Welsh economy in terms of direct jobs and direct GVA generated in 2010. The analysis has resulted in the following key findings.

- There are more than 40,000 direct jobs in physics-based sectors in Wales. A large number of these jobs are related to engineering and architecture activities, manufacturing and oil and gas.
- Physics-based sectors contributed more than £2 bn in GVA, which is a higher proportion of total GVA than in the UK.
- Productivity (as measured by GVA per worker) is higher in Welsh physics-based sectors than the UK average.

Figure 2.7: Productivity (GVA per worker), longitudinal analysis, 2005–2010 (current prices)

Source: Deloitte analysis using Business Register Employment Survey and Annual Business Survey
This chapter presents the indirect and induced impacts of physics-based sectors in Wales (collectively referred to as incremental effects). The methodology for calculation is outlined in the Annex.

3.1. Incremental effects

The economic footprint of Welsh physics-based sectors expands when one considers their wider impacts across the supply chain and on consumer spending.

In addition to the direct impacts in terms of jobs and GVA described in Chapter 2, there are a number of other ways that these sectors contribute to the Welsh economy. For example, a “ripple” or “multiplier” effect can be created by a business in a physics-based business sourcing supplies from the wider economy or through an employee spending their wages in other sectors. Accordingly, we consider:

- The indirect impact of physics-based sectors on the Welsh economy – changes in employment, productivity and income in associated industries that supply inputs to physics-based sectors.
- The induced impact of physics-based sectors – spending by households in the overall economy as a result of direct and indirect effects from the generated economic activity of physics-based sectors and associated sectors.

Together, indirect and induced impacts are known as incremental impacts. These impacts constitute the overall multiplier effect of the physics-based sectors on the Welsh economy. This takes account of the proportion of activity in other sectors of the economy that are supported by the intermediate demand of physics-based sectors, as well as the spending of employees in physics-based sectors.

Figure 3.1 summarises these impacts in terms of jobs and GVA between 2005 and 2010 in Wales. The number of incremental jobs attributable to physics-based sectors in Wales in 2010 is estimated to be nearly 25,000 with the incremental GVA exceeding £1 bn. The trends in incremental GVA and jobs follow that of direct GVA and jobs, i.e. a fall in 2008 following the financial crisis, with a small recovery in 2010.

3.2. Conclusion

Combining direct and incremental impacts gives a total contribution of physics-based sectors of 65,000 jobs and nearly £3.5 bn GVA. Of this:

- 70% of total GVA attributable to physics-based sectors was direct GVA and 30% was indirect and induced (incremental) GVA; and
- 62% of total jobs attributable to physics-based sectors were directly in physics-based sectors and 38% were in the wider economy.

Figure 3.1: Indirect and induced jobs and GVA, longitudinal analysis, 2005–2010

Source: Deloitte analysis using Business Register Employment Survey and Annual Business Survey
4.1. Measuring the impact of physics in the economy

As was recognised in the 2007 UK report, the pervasiveness of physics makes it hard to reach a single conclusive definition. For the purposes of this report, we have agreed the following broad categories for what can be considered physics.

Following the 2007 report, physics is seen as having an impact on the UK economy through three main routes.

● As a science – through employees who are in occupations that are engaged in physics as a scientific discipline. This includes teachers, academics and other researchers.
● In a role that uses expertise beyond the science – through businesses that employ staff who use expertise from physics.
● Through technologies that have been developed based on the science – through employees who use technologies based on an understanding and application of physics.

These routes have an impact on those sectors of the economy that use and generate physics knowledge (physics-based sectors). In turn, the employees in these sectors generate turnover, which has wider spill-over effects that can impact across the entire economy. These spill-over effects can be measured in terms of jobs and gross value added (GVA), as well as the number of new businesses, export performance, R&D expenditure and FDI. There might also be broader social impacts of

Box 4.1: What is physics?

Broadly speaking, physics can be split into the following categories:

● Astronomy and astrophysics
● Chemical physics
● Materials physics
● Nanotechnology
● Optics and photonics
● Superconductivity
● Biophysics
● Electricity and magnetism
● Mechanics
● Nuclear, particle and high-energy physics
● Semiconductor physics
● Thermodynamics

Source: Deloitte

Figure 4.1: Physics logic chain
The key metrics used to measure the impact of physics on the UK economy in this report are:
- Jobs supported by physics in direct, indirect and induced terms.
- GVA due to physics in direct, indirect and induced terms.
- Turnover of physics-based sectors in direct, indirect and induced terms.
- Value of exports of physics-based sectors.
- Number of businesses and jobs attributable to physics (directly, indirectly and induced).
- Productivity of physics-based sector employees (£ per employee).
- R&D expenditure of physics-based sectors.
- Business failures and start-ups attributable to physics-based sectors.
- Foreign direct investment in physics-based sectors.

Where appropriate, we also make comparison with other sectors and internationally.

4.2. Our approach
To measure the impact of physics on the UK economy, we have carried out a three-stage approach.
- Confirm definitions and data collection – collecting data from public sources and ensuring it is consistent.
- Economic modelling and data analysis – using a bespoke input-output model of the UK economy and component nations to quantify the economic impact of physics.
- Policy analysis and reporting – drawing out key insights and trends since the 2007 report.

Below we briefly set out the steps involved in each stage. Specific assumptions used to calculate individual metrics are not detailed here – they are contained in the relevant footnote when the results are presented.

Definitions
The first step in this stage is to identify which sectors of the economy can be classed as “physics-based” sectors. To recall, these are those sectors of the economy where the use of physics is critical to their existence. In hypothetical terms, the counterfactual scenario of there being no physics would imply these sectors not existing as they are dependent on physics.

It is important to note that the definition of physics-based sectors refers to the use of physics rather than the background of employees. For example, there may be many physics graduates in the professional services sector, but because they do not make direct use of physics this sector would not be classed as physics-based. In contrast, an employee involved in the manufacture of fibre-optic cables may not have a physics qualification, but their work directly uses physics knowledge and is hence a physics-based sector.

The criteria used to identify physics-based sectors are the same as in 2007, namely:
- Is expertise from the field of physics required?
- Is technology that uses advanced principles of physics required?
- If the use of physics is required, how dependent is the sector on it?

To isolate physics-based sectors, we have used the Standard Industrial Classification (SIC) in segmenting the UK economy. Established in 1948, the SIC classifies businesses and other statistical units by the type of economic activity in which they are engaged. The UK SIC is a hierarchical five-digit system, with the latest revision occurring in 2007. The SIC first divides the economy into broad sections with these sections then disaggregated a further four times to reach a more detailed picture.

Table 4.1: Example SIC(2007) classification

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section C</td>
<td>Manufacturing (comprising divisions 10 to 33)</td>
</tr>
<tr>
<td>Division 13</td>
<td>Manufacture of textiles</td>
</tr>
<tr>
<td>Group 13.9</td>
<td>Manufacture of other textiles</td>
</tr>
<tr>
<td>Class 13.93</td>
<td>Manufacture of carpets and rugs</td>
</tr>
<tr>
<td>Subclass 13.93/1</td>
<td>Manufacture of woven or tufted carpets and rugs</td>
</tr>
</tbody>
</table>

Source: ONS
**Table 4.2: List of classes used in the definition of physics-based sectors**

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.10</td>
<td>Extraction of crude petroleum</td>
<td>30.20</td>
<td>Manufacture of railway locomotives and rolling stock</td>
</tr>
<tr>
<td>06.20</td>
<td>Extraction of natural gas</td>
<td>30.30</td>
<td>Manufacture of air and spacecraft and related machinery</td>
</tr>
<tr>
<td>09.10</td>
<td>Support activities for petroleum and natural gas extraction</td>
<td>30.40</td>
<td>Manufacture of military fighting vehicles</td>
</tr>
<tr>
<td>20.13</td>
<td>Manufacture of inorganic basic chemicals</td>
<td>30.91</td>
<td>Manufacture of motorcycles</td>
</tr>
<tr>
<td>21.20</td>
<td>Manufacture of pharmaceutical preparations</td>
<td>32.50</td>
<td>Manufacture of medical and dental instruments and supplies</td>
</tr>
<tr>
<td>23.44</td>
<td>Manufacture of other technical ceramic products</td>
<td>33.11</td>
<td>Repair of fabricated metal products</td>
</tr>
<tr>
<td>24.46</td>
<td>Processing of nuclear fuel</td>
<td>33.12</td>
<td>Repair of machinery</td>
</tr>
<tr>
<td>25.40</td>
<td>Manufacture of weapons and ammunition</td>
<td>33.13</td>
<td>Repair of electronic and optical equipment</td>
</tr>
<tr>
<td>25.99</td>
<td>Manufacture of other fabricated metal products n.e.c.</td>
<td>33.14</td>
<td>Repair of electrical equipment</td>
</tr>
<tr>
<td>26.11</td>
<td>Manufacture of electronic components</td>
<td>33.15</td>
<td>Repair and maintenance of ships and boats</td>
</tr>
<tr>
<td>26.12</td>
<td>Manufacture of loaded electronic boards</td>
<td>33.17</td>
<td>Repair and maintenance of transport equipment n.e.c.</td>
</tr>
<tr>
<td>26.20</td>
<td>Manufacture of computers and peripheral equipment</td>
<td>33.20</td>
<td>Installation of industrial machinery and equipment</td>
</tr>
<tr>
<td>26.30</td>
<td>Manufacture of communication equipment</td>
<td>35.11</td>
<td>Production of electricity</td>
</tr>
<tr>
<td>26.40</td>
<td>Manufacture of consumer electronics</td>
<td>35.12</td>
<td>Transmission of electricity</td>
</tr>
<tr>
<td>26.51</td>
<td>Manufacture of instruments and appliances for measuring, testing and navigation</td>
<td>35.13</td>
<td>Distribution of electricity</td>
</tr>
<tr>
<td>26.60</td>
<td>Manufacture of irradiation, electromedical and electrotherapeutic equipment</td>
<td>38.12</td>
<td>Collection of hazardous waste</td>
</tr>
<tr>
<td>26.70</td>
<td>Manufacture of optical instruments and photographic equipment</td>
<td>38.22</td>
<td>Treatment and disposal of hazardous waste</td>
</tr>
<tr>
<td>26.80</td>
<td>Manufacture of magnetic and optical media</td>
<td>43.22</td>
<td>Plumbing, heat and air-conditioning installation</td>
</tr>
<tr>
<td>27.11</td>
<td>Manufacture of electric motors, generators and transformers</td>
<td>51.22</td>
<td>Space transport</td>
</tr>
<tr>
<td>27.12</td>
<td>Manufacture of electricity distribution and control apparatus</td>
<td>52.21</td>
<td>Service activities incidental to land transportation</td>
</tr>
<tr>
<td>27.20</td>
<td>Manufacture of batteries and accumulators</td>
<td>52.22</td>
<td>Service activities incidental to water transportation</td>
</tr>
<tr>
<td>27.31</td>
<td>Manufacture of fibre-optic cables</td>
<td>52.23</td>
<td>Service activities incidental to air transportation</td>
</tr>
<tr>
<td>27.32</td>
<td>Manufacture of other electronic and electric wires and cables</td>
<td>60.10</td>
<td>Radio broadcasting</td>
</tr>
<tr>
<td>27.33</td>
<td>Manufacture of wiring devices</td>
<td>61.10</td>
<td>Wired telecommunications activities</td>
</tr>
<tr>
<td>27.40</td>
<td>Manufacture of electric lighting equipment</td>
<td>61.20</td>
<td>Wireless telecommunications activities</td>
</tr>
<tr>
<td>27.51</td>
<td>Manufacture of electric domestic appliances</td>
<td>61.30</td>
<td>Satellite telecommunications activities</td>
</tr>
<tr>
<td>27.90</td>
<td>Manufacture of other electrical equipment</td>
<td>61.90</td>
<td>Other telecommunications activities</td>
</tr>
<tr>
<td>28.11</td>
<td>Manufacture of engines and turbines, except aircraft, vehicle and cycle engines</td>
<td>62.09</td>
<td>Other information technology and computer service activities</td>
</tr>
<tr>
<td>28.21</td>
<td>Manufacture of ovens, furnaces and furnace burners</td>
<td>71.11</td>
<td>Architectural activities</td>
</tr>
<tr>
<td>28.23</td>
<td>Manufacture of office machinery and equipment (except computers and peripheral equipment)</td>
<td>71.12</td>
<td>Engineering activities and related technical consultancy</td>
</tr>
<tr>
<td>28.25</td>
<td>Manufacture of non-domestic cooling and ventilation equipment</td>
<td>71.20</td>
<td>Technical testing and analysis</td>
</tr>
<tr>
<td>28.29</td>
<td>Manufacture of other general-purpose machinery n.e.c.</td>
<td>72.11</td>
<td>Research and experimental development on biotechnology</td>
</tr>
<tr>
<td>28.49</td>
<td>Manufacture of other machine tools</td>
<td>72.19</td>
<td>Other research and experimental development on natural sciences and engineering</td>
</tr>
<tr>
<td>28.99</td>
<td>Manufacture of other special-purpose machinery n.e.c.</td>
<td>74.20</td>
<td>Photographic activities</td>
</tr>
<tr>
<td>29.10</td>
<td>Manufacture of motor vehicles</td>
<td>74.90</td>
<td>Other professional, scientific and technical activities n.e.c.</td>
</tr>
<tr>
<td>29.31</td>
<td>Manufacture of electrical and electronic equipment for motor vehicles</td>
<td>84.22</td>
<td>Defence activities</td>
</tr>
<tr>
<td>30.11</td>
<td>Building of ships and floating structures</td>
<td>95.12</td>
<td>Repair of communication equipment</td>
</tr>
</tbody>
</table>
of the economy. Table 4.1 provides an example.

There are 21 sections, 88 divisions, 272 groups, 615 classes and 191 sub-classes. The UK SIC system is consistent and comparable with the European NACE system and United Nations international standard industrial classification (ISIC) system.

Using the aforementioned criteria, Deloitte has worked with the Institute of Physics to identify which classes (four-digit SIC) can be identified as “physics critical”, i.e. is physics-based. Given the fine granularity of this level of SIC, for most cases it is a binary choice whether a sector is physics critical or not. However, in some larger classes (such as defence activities) an adjustment is necessary to recognise that there will be a proportion of jobs that do not involve physics.7

Table 4.2 sets out the classes chosen to be included in the definition of physics-based sectors. These classes are not the same as those used in the 2007 report. This is for two reasons. The main reason is that subsequent to the analysis being carried out for the 2007 report, the UK SIC codes were revised (from SIC(2003) to SIC(2007)). The SIC(2007) has consolidated and re-categorised certain sectors on the basis of economic trends and the evolution of the UK economy. Hence, the list of sectors used for this report will differ from the 2007 report.8 Second, since 2007 the critical use of physics has changed, with some sectors becoming more dependent on physics (due to new discoveries and technologies) and others becoming less dependent. The above classes reflect this change.

**Data collection**

The data used in this report to construct the impact metrics have predominately come from publicly available sources. These include the:

- ONS Annual Business Survey
- ONS Business Register and Employment Survey
- ONS Business Demography
- Insolvency Service data
- ONS Supply and Use tables
- OECD trade statistics
- ONS Foreign Direct Investment data
- ONS Business Enterprise Research and Development

Where appropriate, adjustments have been made to allow for comparability between surveys and between time periods.

**Economic modelling and data analysis**

Having collected the data and identified which sectors can be categorised as physics-based, we were able to construct a number of impact metrics, such as R&D expenditure and exports. To calculate the total number of jobs attributable to physics and GVA, we have made use of our established Deloitte UK input-output model to approximate supply-chain linkages.

This UK input-output model allows us to quantify three different categories of input:

- The direct impact of physics – those initial and immediate economic activities (jobs and GVA) generated by physics-based sectors (often referred to as first-round impacts because they coincide with the first round of spending in the economy).
- The indirect effect of physics – changes in employment and income in associated industries that supply inputs to physics-based sectors.9
- The induced effect of physics – spending by households in the overall economy as a result of direct and indirect effects from the generated economic activity of physics-based sectors and associated sectors.10

The process behind constructing bespoke input-output models for the UK and constituent nations is complex11 and involves creating a “Leontief Inverse” matrix to generate relevant multipliers and differentiating between financial flows and economic outcomes, such that the analysis only represents additional economic activity, compared with the counterfactual case of there being no physics. In this case, a detailed counterfactual case is not necessary given the definition of physics-based sectors implying these sectors not existing in the absence of physics.

**Policy analysis and reporting**

The final stage of our methodology has involved identifying trends in the results and discussing them with relevant stakeholders to provide further context.
## Glossary of Key Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>Broad impacts</td>
<td>Wider impacts caused by the activities of businesses and employees in physics-based sectors. These impacts can sometimes be quantified and assigned a monetary value in GVA and job terms.</td>
</tr>
<tr>
<td>Direct impact of physics</td>
<td>Those initial and immediate economic activities (jobs and GVA) generated by physics-based sectors (often referred to as first-round impacts because they coincide with the first round of spending in the economy).</td>
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<tr>
<td>Foreign direct investment (FDI)</td>
<td>Investment by a company in a country different from that in which the company is based.</td>
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<tr>
<td>Gross value added (GVA)</td>
<td>A measure of the value of goods and services produced by a business, industry, sector or region of the economy. The Organisation for Economic Co-operation and Development defines gross value added as the value of output less the value of intermediate consumption. It is analogous to gross domestic product.</td>
</tr>
<tr>
<td>Indirect impacts</td>
<td>Changes in the number of jobs and GVA in associated industries that supply inputs to physics-based sectors (sometimes referred to as “supply-chain” impacts).</td>
</tr>
<tr>
<td>Induced impacts</td>
<td>The spending by households that results in changes to the number of jobs and GVA due to direct and indirect impacts.</td>
</tr>
<tr>
<td>Narrow impacts</td>
<td>The economic impacts caused by the activities of businesses and employees in physics-based sectors. These traditionally cover jobs and GVA generated. These are the sum of direct, indirect and induced effects.</td>
</tr>
<tr>
<td>Physics-based sectors</td>
<td>Those sectors of the economy where the use of physics – in terms of technologies or expertise – is critical to their existence. The choice of which sectors constitute physics-based sectors was agreed and reflects previous definitions and changes to nomenclature and SIC. A list of sectors that make up the list of physics-based sectors can be found in the Annex.</td>
</tr>
<tr>
<td>Standard Industrial Classification (SIC)</td>
<td>First introduced in the UK in 1948, this is a framework for classifying business establishments and other statistical units by the type of economic activity in which they are engaged. There are a number of levels of the classification, with subsequent levels becoming more detailed.</td>
</tr>
<tr>
<td>Standard Occupational Classification (SOC)</td>
<td>A common classification framework of occupational information for the UK on the basis of skill level and skill content.</td>
</tr>
<tr>
<td>Standard Industrial Trade Classification (SITC)</td>
<td>The OECD defines this as a statistical classification of the commodities entering external trade. It is designed to provide the commodity aggregates required for purposes of economic analysis and to facilitate the international comparison of trade-by-commodity data.</td>
</tr>
</tbody>
</table>
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