The Importance of Physics to the Economies of Europe

A study by Cebr for the period 2011-2016

Executive summary of an analysis prepared by Cebr - Centre for Economics and Business Research for the European Physical Society

European Physical Society
September 2019

FOREWORD

Since its establishment in 1968, the European Physical Society (EPS) has held a dual role of learned society and federation of national member societies. After 50 years, the EPS has 42 member societies and represents a very large and varied community of physicists. One of the main objectives of the EPS is to give them a coherent voice despite the existence of many educational, scientific, social and geographic diversities.

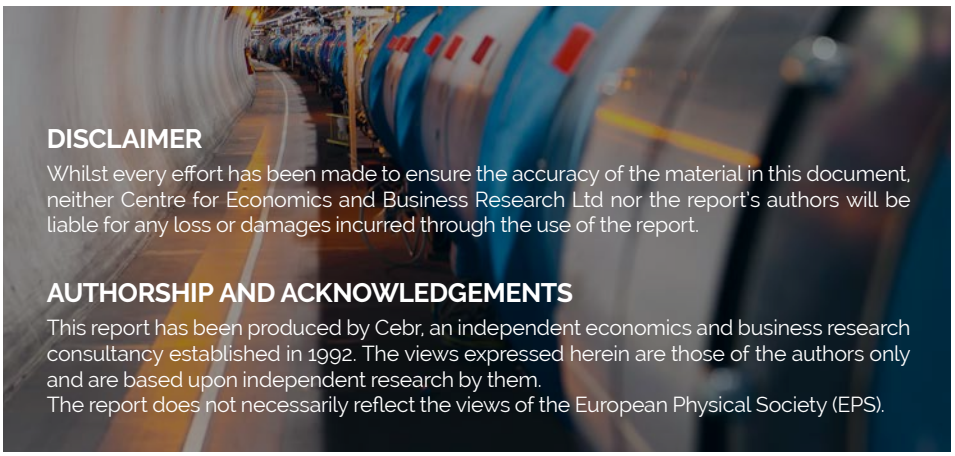
Europe has a long lasting tradition of strength in science and technology, and today hosts many of the most important national and international physics research laboratories. Physics is vital to European culture. The new European research program Horizon Europe is being launched to reinforce the intimate link between basic science and technological applications to favour Europe's progress in research and innovation, a major challenge for the future.

Along this line, key questions arise: how important is physics to the economies of European countries? And how worthwhile is it to maintain and increase investment in physics? To address these issues the EPS has commissioned an independent economic analysis from the Centre for Economics and Business Research (Cebr), using statistics available in the public domain through Eurostat. This is the second study, following on the first which was published in 2012. It covers 31 European countries – the EU28 countries, plus Iceland, Norway and Switzerland. Under examination is the 6-year period 2011-2016, 2016 being the most recent year for which official data are simultaneously available for all these countries. The Cebr analysis is contained in a detailed report which was, while the most important results are highlighted here in this Executive Summary. Please see www.eps.org/physicsandeconomy for further details and downloads.

This 6-year snap-shot of the European economy shows that the physics-based industrial sector generated over 16% of total turnover and over 12% of overall employment within Europe's business economy. To give some context to these numbers, the turnover per person employed in the physics-based sector substantially outperforms the construction and retail sectors, and physics-based labour productivity (expressed as gross value added per employee) was significantly higher than in many other broad industrial and business sectors, including manufacturing. The European physics-based sector was also highly R&D intensive and were more resilient in comparison with the wider economy. The thorough analysis of European data, contained in the full Cebr report, can provide us with a deeper understanding of the many achievements and drawbacks within the physics-based sector in the recent past.

Our hope is that the message conveyed by the EPS through the study performed by Cebr will be inspiring for the future, both at the European and national levels, making a convincing case for the support for physics in all of its facets, from education to research, to business and industry.

Petra Rudolf
President of the European Physical Society



AUTHORSHIP AND ACKNOWLEDGEMENTS

This report has been produced by Cebr, an independent economics and business research consultancy established in 1992. The views expressed herein are those of the authors only and are based upon independent research by them.
The report does not necessarily reflect the views of the European Physical Society (EPS).

EXECUTIVE SUMMARY

What is physics?

Physics is the branch of science concerned with the nature, structure and properties of matter, ranging from the smallest scale of elementary particles, to the Universe as a whole. Physics includes experiment and theory and involves both fundamental research driven by curiosity, as well as applied research linked to technology. Physics often provides the foundations for other disciplines, and plays a central role in many different sectors of industries.

What are physics-based industries?

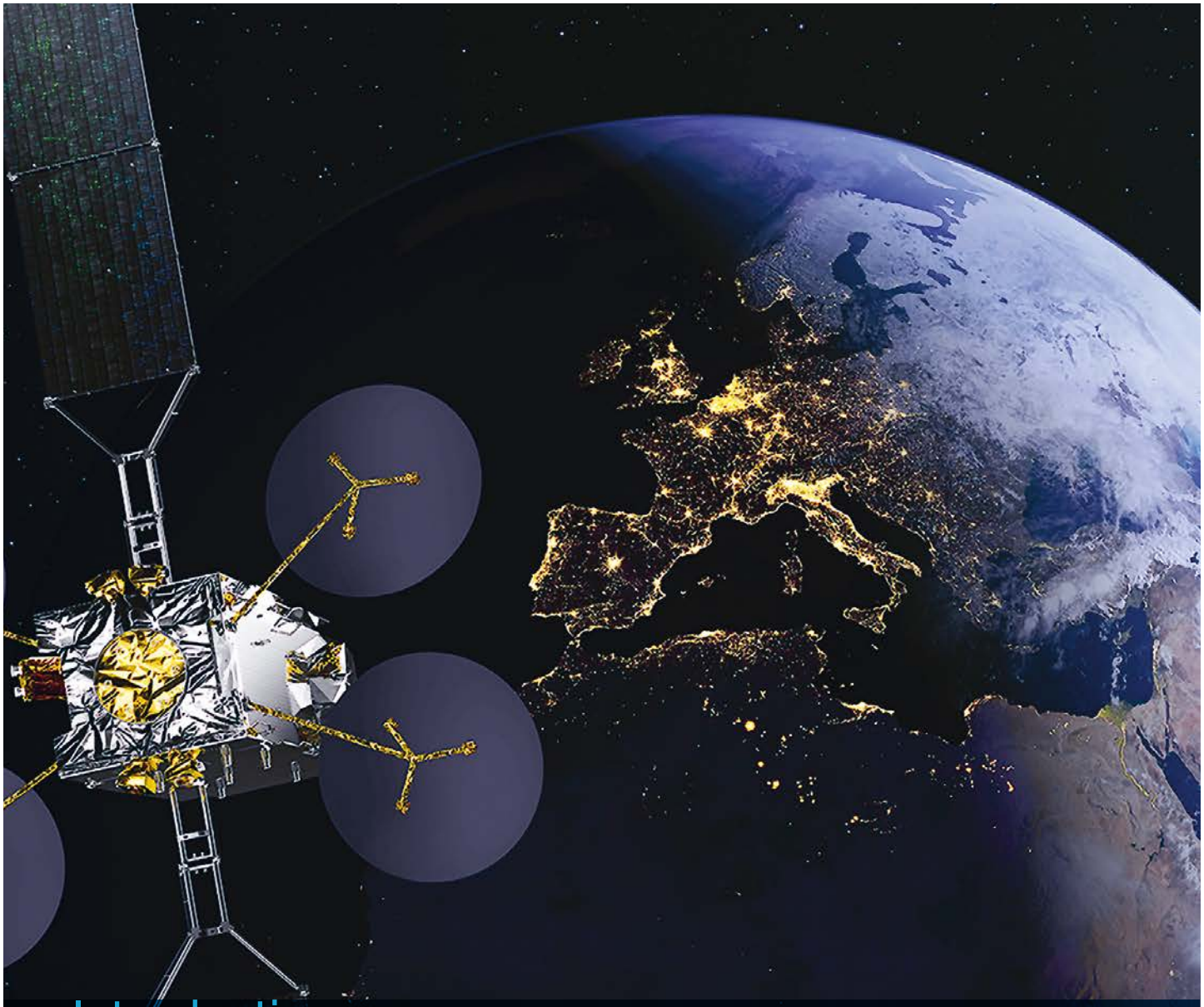
Physics-based industries are defined as those sectors of the European economy where the use of physics – in terms of technologies and expertise – is critical to their existence.

This means that the industries considered are those where workers with some training in physics would be expected to be employed and where the activities would be expected to rely heavily on the theories and results of physics to achieve their commercial goals. The list of physics-based industries analysed in this report was obtained from the statistical nomenclature standard NACE (Rev. 2) that is used to classify the different economic activities of the European Union.

The analysis here was based on a subset of 72 NACE codes amongst a total of over 700. Those activities considered include to varying degrees the sectors of electrical, civil, and mechanical engineering, energy, information technology and communications, design and manufacturing, transportation, medicine and related life-science fields, and technologies used in space. These are listed on the inside back cover of this Summary. Depending on the particular datasets analysed in different parts of this study, the size and importance of physics-based industries to the wider European economy were estimated using different comparators of 'business economy' and 'whole economy'. The latter represents a larger comparator than the former which does not include, for example, agriculture, financial, public administration and other non-market services. Under NACE (Rev. 2), there are 65 broad industries categories in the 'whole economy', 49 of which are covered by the 'business economy'.

Complete details of methodology are provided in the appendices to the main report.

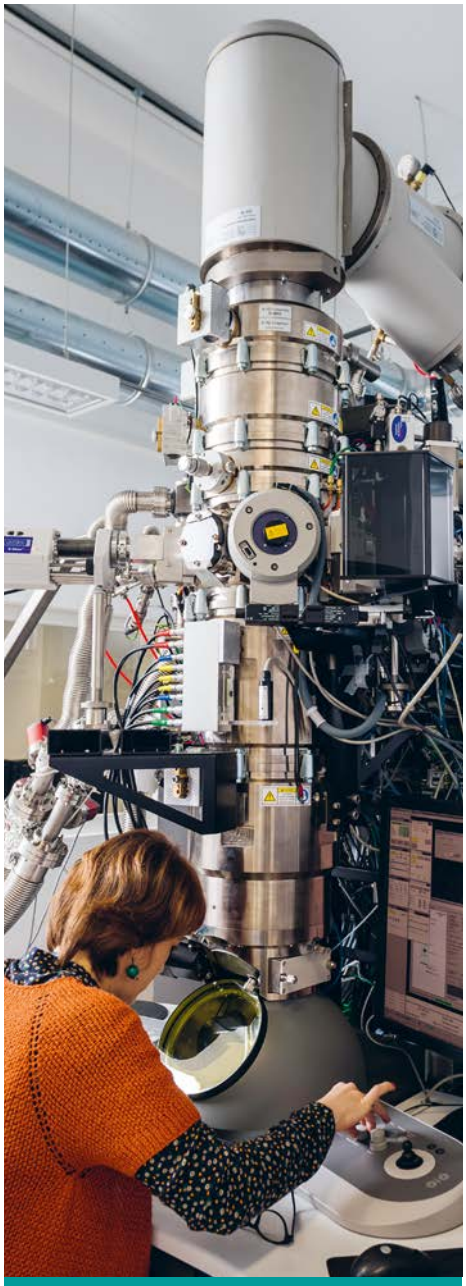
PHYSICS OFTEN PROVIDES THE FOUNDATIONS FOR OTHER DISCIPLINES



Introduction

This Summary describes an analysis of the contribution of the discipline of physics to the economies of Europe over the six-year period 2011-2016 inclusive. The analysis has been prepared by the Centre for Economics and Business Research (Cebr) in order to provide the European Physical Society with an assessment of the importance of physics to the economies of Europe.

The focus of this report is the 28 countries of the European Union (EU28), together with Iceland, Norway and Switzerland, three of the four members of the European Free Trade Association (EFTA). Unless otherwise indicated, the term Europe will be used throughout this Summary to refer to these 31 countries. The report examines the economic contributions of physics using many different measures of economic growth and prosperity, and is based entirely on data that is in the public domain, primarily through Eurostat, the European Union's Statistical Service. The research highlights the value generated by physics-based industries to the economic prosperity of Europe.



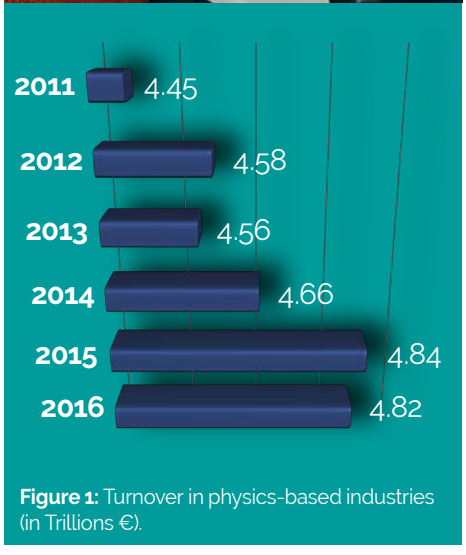
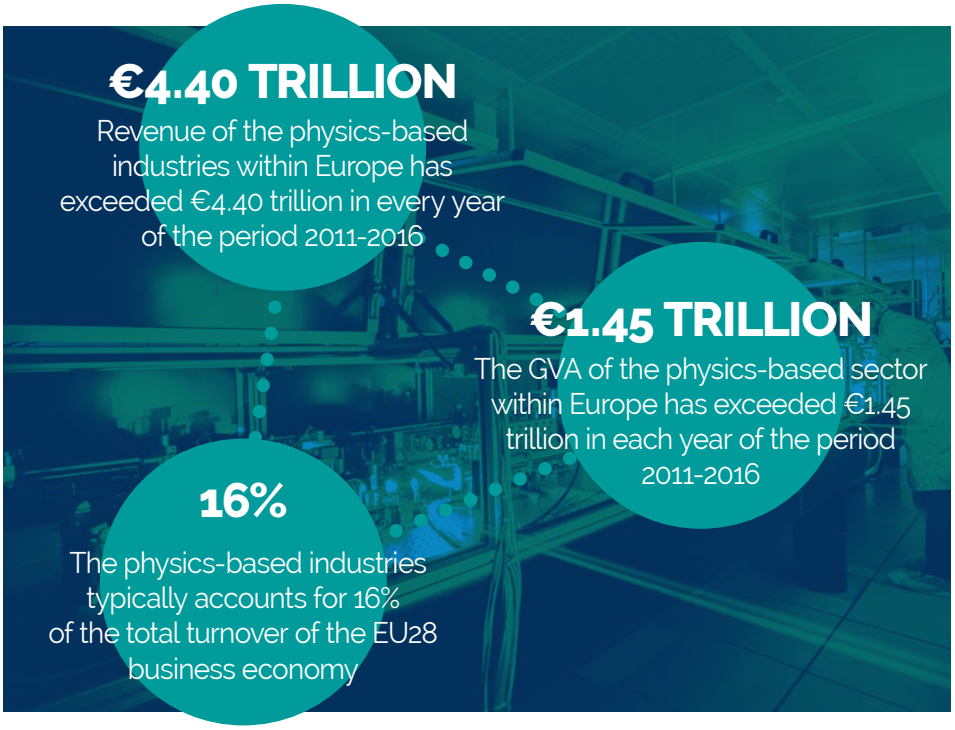


Figure 1: Turnover in physics-based industries (in Trillions €).

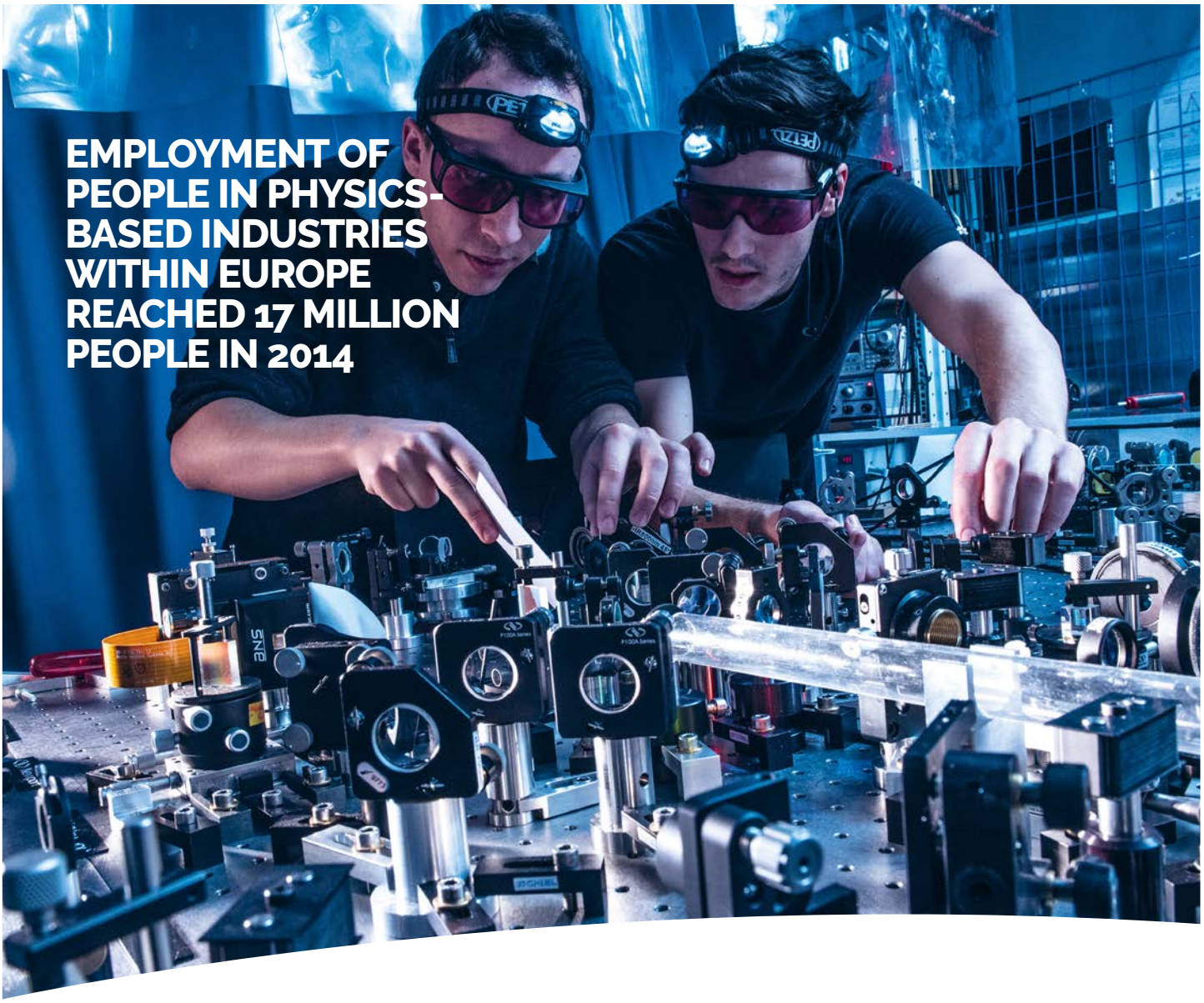


Physics-based industries contributes significantly to the economies of European countries and to the European economy as a whole

The turnover (or revenue) of the physics-based industries within Europe has exceeded €4.40 trillion in every year of the period 2011-2016. The maximum turnover of nearly €4.84 trillion was in 2015 which, despite a minor blip in 2013, has been rising steadily from €4.45 trillion in 2011. The data suggest a slight decline in 2016 to €4.82 but other less volatile indicators suggest that this is a poor indication of performance. [Figure 1] shows the turnover in physics-based industries in Trillions €.

The physics-based sector typically accounts for 16% of the total turnover of the EU28 business economy, which is more than the gross turnover contribution of the entire retail sector. [Figure 2a] shows the percentage distribution of physics-based industries turnover between the different countries of Europe for the year 2016. The major economies of Western Europe clearly dominate. Similar geographical distributions are observed for all other years in the period of study.

Gross Value Added (GVA) is a measure of the value generated in the production of goods and services and is the official measure of how sectors of the economy contribute to GDP. The GVA of the physics-based industries within Europe has exceeded €1.45 trillion in each year of the period 2011-2016, reaching a high of €1.65 trillion in 2016 (an increase from 2015, in contrast to turnover). The physics-based sector contributes just over 12% of the total GVA of the EU28 economies, a greater fraction than either the construction, financial or retail sectors.



Physics creates over 17 million high-skilled jobs in Europe

Employment of people in physics-based industries within Europe reached 17 million people in 2014.

Maximum employment of 17.8 million people was in 2016, a substantial increase from the 16.7 million estimated for 2011. The 2016 level represents more than 12% of Europe's total business economy employment.

Employment and GVA data can be combined to estimate relative workforce productivity in the physics-based sector compared with other sectors within Europe. The period 2011-2016 saw an average GVA per employee of €90,800 per annum in the physics-based industries.

This level is higher than for the manufacturing sector and substantially outperforms the construction and retail sectors.

[Figure 2b] compares the GVA per employee contribution of physics with other sectors of the European economy.

Turnover per employee in the physics-based sector over the same period averaged €253,000 per annum.

This also compares very favourably to other sectors and is over twice the equivalent figure for the construction industries. The physics-based sector can therefore continue to be viewed as a highly productive part of the European economy.

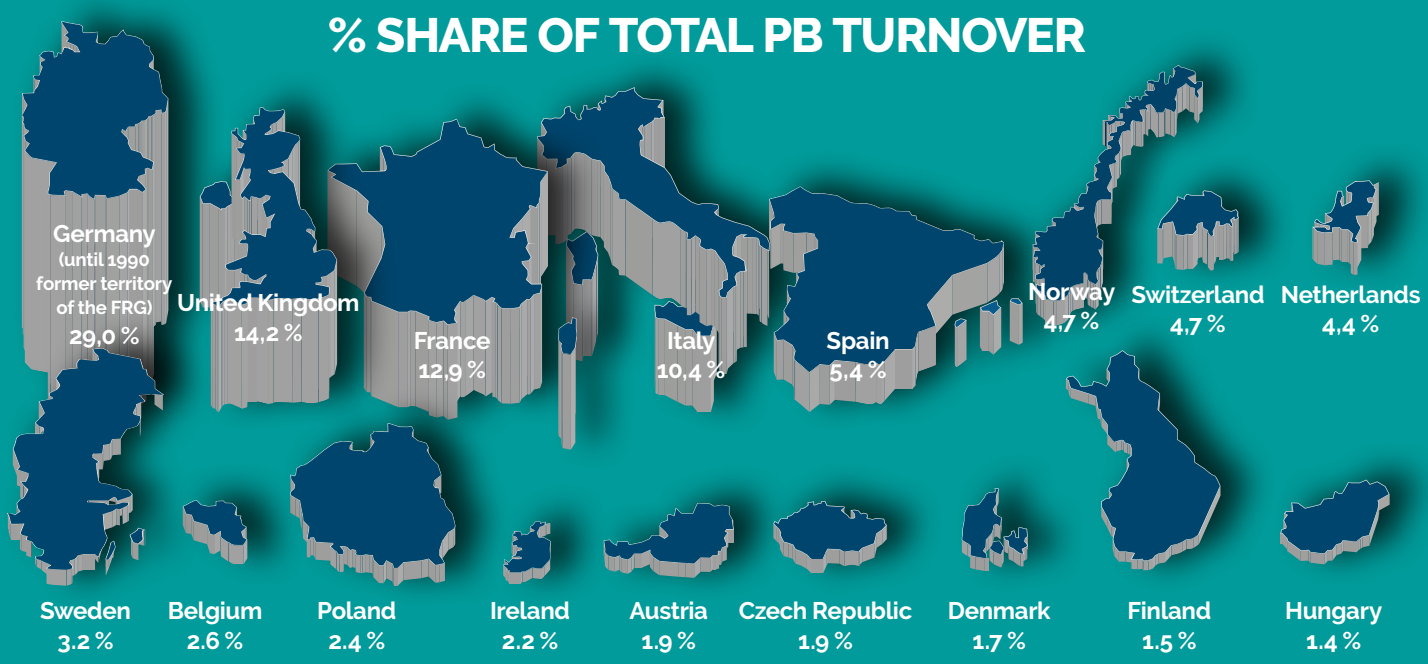


Figure 2a: percentage distribution of physics-based industries turnover in different countries of Europe (2016)

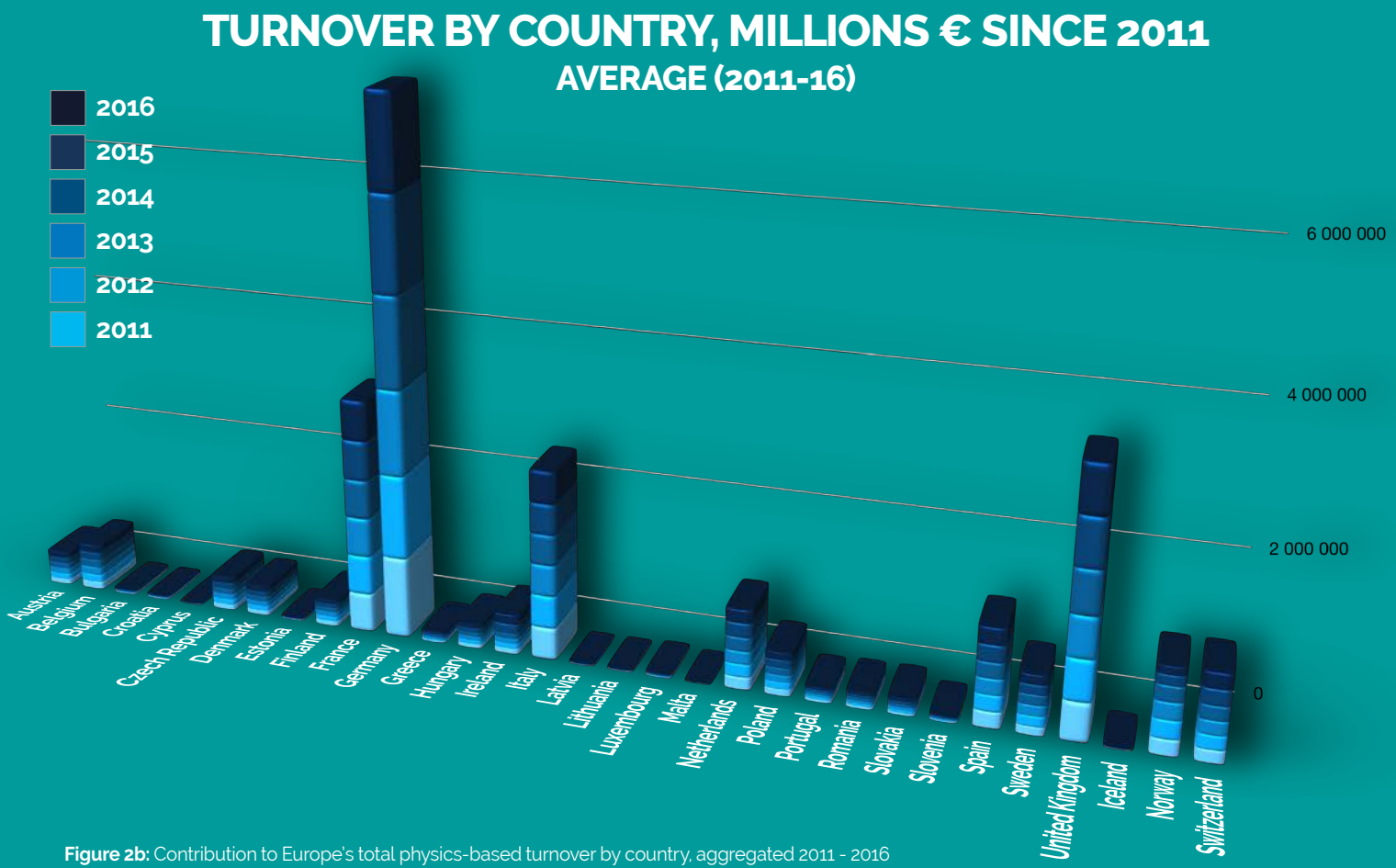


Figure 2b: Contribution to Europe's total physics-based turnover by country, aggregated 2011 - 2016

THE THREE MAJOR CONTRIBUTIONS TO PHYSICS-BASED GVA IN EUROPE WERE FROM MANUFACTURING INFORMATION & COMMUNICATION

Physics contributes to a broad range of economic activities in Europe

It is important to understand that different sub-sectors of physics-based industries contribute different levels of added value. Averaged over the 2011-2016 period, the three major contributions to physics-based GVA in Europe were from manufacturing (42.5%), information & communication (14.1%), followed by professional, scientific & technical activities in physics-based fields such as architecture, engineering and R&D (14.1%). This distribution can be seen in [Figure 3].

The distributions in employment data are broadly similar. Averaged over the period 2011-2016, the dominant areas of physics-based employment were manufacturing (48.9%), professional, scientific & technical activities (20.6%), and information & communication (9.6%).

Professional, scientific & technical activities continued to provide the area of strongest employment growth during the years 2011-16 in terms of absolute numbers, with the number of persons employed rising by over 500 thousand.

Other physics-based sub-sectors contributing to GVA and employment are transportation, energy production, oil & gas activities, and the treatment of hazardous materials.

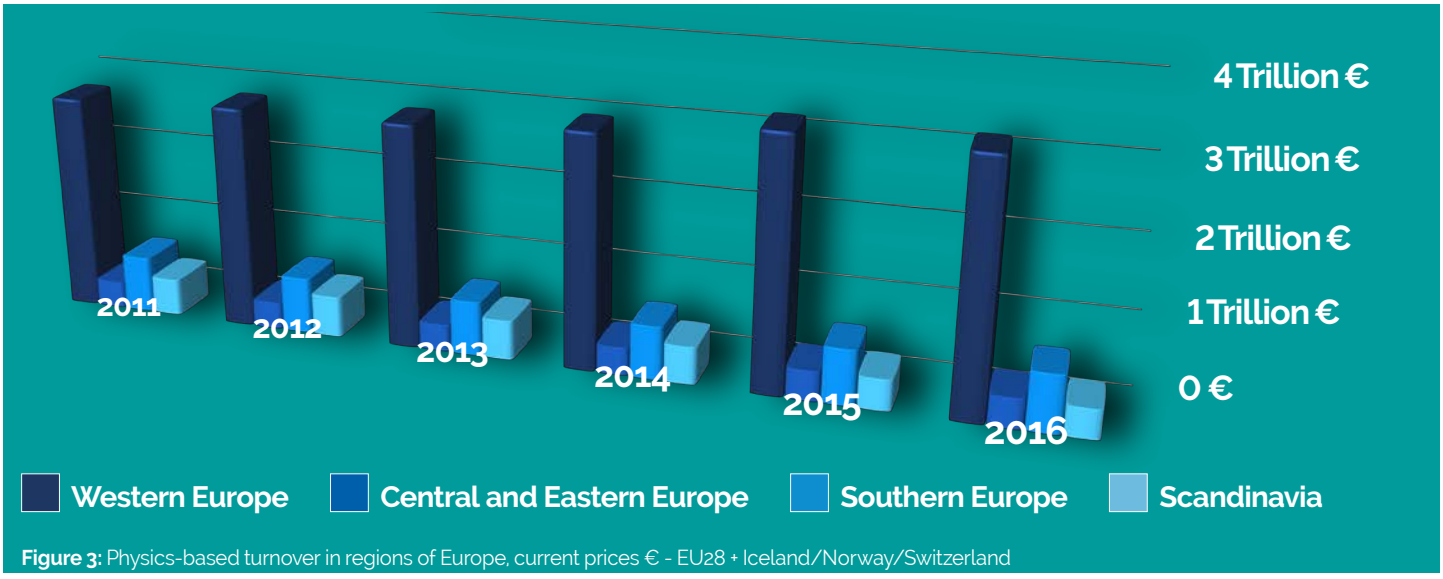


Figure 3: Physics-based turnover in regions of Europe, current prices € - EU28 + Iceland/Norway/Switzerland

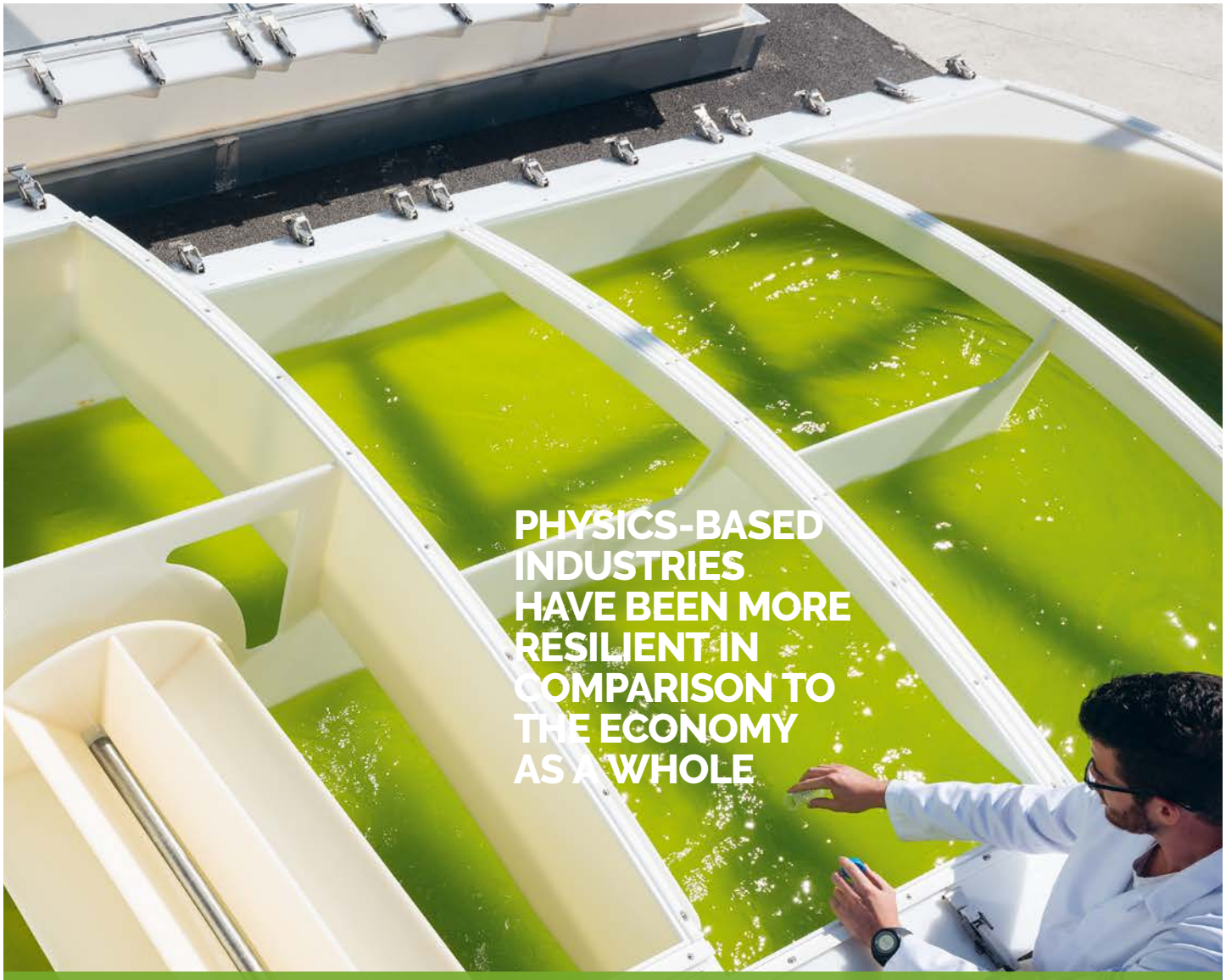
FOR EVERY €1 OF PHYSICS-BASED GVA, THE EU28 ECONOMY GAINS €2.64

Multiplier impacts

The activities of the physics-based sector also impact on the wider economy. For example, the production of physics-based goods and services can have a significant knock-on 'upstream' effect throughout the supply chain when, for example, a physics-based enterprise purchases other goods and services as inputs for their own business. These create a multiplier effect, impacting employment, GVA, and output.

Regarding the latter, this means that for every €1 of physics-based output, a total of €2.49 output is generated throughout the EU28 economy as a whole.

The employment multiplier is higher again at 3.34, which means that for every job in physics-based industries, a total of 3.34 jobs are supported in the economy as a whole by these industries.



Business start-ups and failures

Analysis of business start-up (birth) and failure (death) rates within the EU28 show a slight decline in physics-based enterprise creation over the period 2011-2015. In 2011, new physics-based enterprises were created at a rate of 10.8%, implying around 11 new start-ups for every 100 existing physics-based enterprises. By 2015 however, this rate had declined to 10.4%, which is closer to 10 new enterprises for every 100 already in existence.

Note that this latter figure is slightly lower than the 10.8% birth rate across all sectors of the European economy in 2015 and has been lower every year since 2011. This may suggest greater entry barriers (*e.g.* the need for higher initial investment) than for other sectors in the wider economy. The observed trend in the creation of physics-based enterprises over the period 2011-2015 was also accompanied by a relatively stable rate of physics-based enterprise insolvency at 8.8%.

However, it is important to note that insolvency rates amongst physics-based enterprises was markedly lower than in the total European economy in the period 2011-2013. The EU28 economy-wide death rate was almost 10% in 2011, but had dropped to 9.1% by 2015. This might suggest that physics-based industries have been more resilient in comparison to the economy as a whole, especially around the time of the European debt crisis in 2012, but that, since 2014, wider enterprise resilience has improved with the macroeconomic upturn.

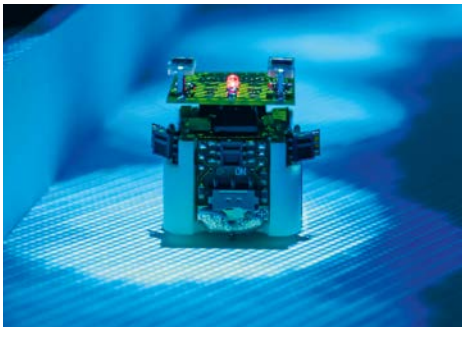
R&D ACTIVITIES ARE AN IMPORTANT INVESTMENT FUNCTION IN THE ECONOMY

Investment and R&D

Research and development (R&D) activities are an important investment function in the economy, leading to innovation in new technologies and products and generating economy-wide growth. Unsurprisingly, the European physics-based sector is highly R&D intensive. Physics-based sector expenditure on R&D within the EU28 exceeded €22 billion in every year of the period 2011-2016. The maximum R&D expenditure of €26 billion was in 2015, which accounted for over 66% of the external (B2B) spending of all sectors of the EU28 economy on scientific R&D as an intermediate input.

The absolute magnitudes presented here only provide a partial picture as they do not incorporate external spending on R&D for investment purposes – likely to be a substantial share of a recorded total of €258 billion across all sectors of the EU28 economy. Neither do the numbers capture 'in-house' R&D spending and investment, which is also likely to be significant in the physics-based industries.

THE EUROPEAN PHYSICS-BASED SECTOR IS HIGHLY R&D INTENSIVE



PHYSICS-BASED GOODS AND SERVICES CONTRIBUTED, ON AVERAGE, 44% OF ALL EXPORTS FROM THE EU28 DURING THE PERIOD 2011-2016

International exports

It is interesting to compare how the contribution of physics-based goods and services to total exports in Europe compares with similar data for other some of the individual EU28 economies.

[Figure 4] compares the EU28's physics-based exports with those of selected other countries, illustrating the proportion of overall exports that physics-based products and services account for.

Physics-based goods and services contributed, on average, 44% of all exports from the EU28 during the period 2011-2016, which is comparable to the levels observed for Britain, France and across the Eurozone. It is markedly lower than Germany's rate of over 53% but is a good chunk higher than Italy's average rate of less than 36%.

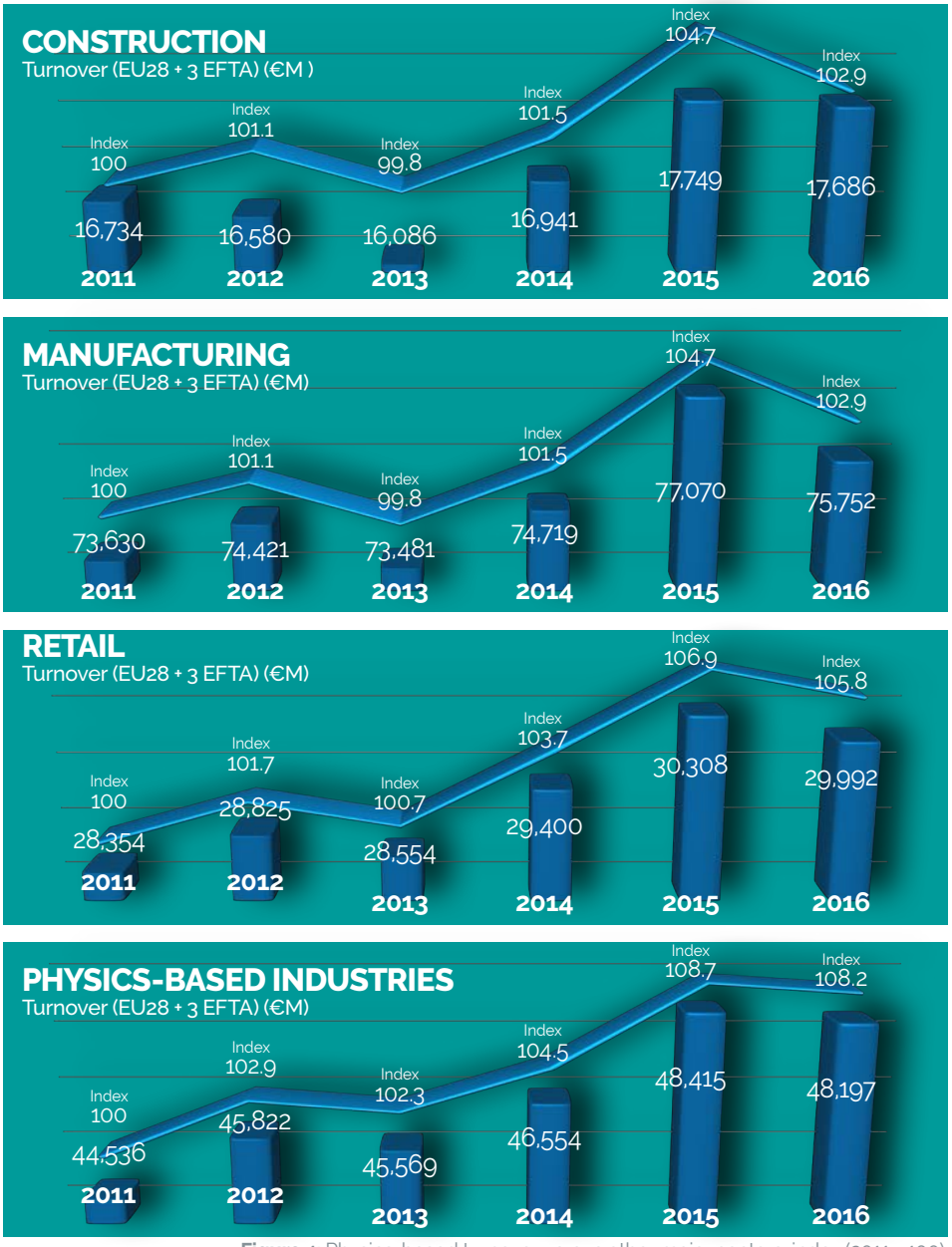


Figure 4: Physics-based turnover versus other major sectors, index (2011 = 100)

CONCLUDING REMARKS

The detailed analysis performed by Cebr for the 2011-2016 period allows the role that physics makes to the European economy to be meaningfully compared to other sectors such as manufacturing, construction and retail. Using analysis of measures such as turnover, GVA, employment and multiplier impacts, the summary presented above clearly highlights the importance of physics to the European economy. It is clear that businesses in the physics-based sector continue to contribute significantly to employment, innovation and growth in Europe.

• Appendix I provides a short compendium of national-level estimates underlying the aggregate results that are the focus of the report.

• Appendix II provides the updated list of industries that have been defined as physics-based for the purposes of our study. It separately identifies the changes in this list – both inclusions and exclusions.

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APPENDIX I: COMPENDIUM OF NATIONAL-LEVEL RESULTS

Here we present our estimates of turnover, employment and GVA in each of the countries analysed as part of this study. Please note that the column totals may not sum due to rounding.

	Turnover in physics-based industries, € million, current prices					
	2011	2012	2013	2014	2015	2016
Austria	78,825	81,107	83,077	80,666	82,356	85,656
Belgium	109,209	109,288	114,482	112,669	113,041	111,290
Bulgaria	10,110	10,776	10,667	10,845	12,258	12,880
Croatia	10,115	9,623	9,260	9,521	9,826	9,613
Cyprus	2,496	2,444	2,273	2,429	2,397	2,460
Czech Republic	77,678	79,873	77,924	80,435	84,349	88,506
Denmark	67,873	69,297	69,237	70,673	74,524	79,474
Estonia	5,807	6,065	6,551	6,336	6,131	6,317
Finland	69,484	68,730	67,688	64,036	58,567	56,152
France	544,670	548,878	547,011	540,733	556,088	560,988
Germany	1,137,553	1,169,996	1,189,339	1,268,581	1,325,371	1,307,483
Greece	20,372	23,642	24,255	22,152	31,414	30,933
Hungary	58,463	55,432	55,294	58,566	64,694	61,511
Ireland	77,678	73,209	71,047	77,394	129,898	135,383
Italy	452,436	454,630	436,294	427,118	428,427	451,051
Latvia	4,095	4,542	4,532	4,300	4,278	4,261
Lithuania	4,518	4,666	4,934	4,956	5,145	5,536
Luxembourg	8,893	8,496	8,678	8,250	10,717	11,491
Malta	1,498	1,605	1,749	1,963	2,144	2,377
Netherlands	178,751	182,368	181,248	193,010	199,435	186,669
Poland	98,338	97,293	97,272	101,386	110,503	105,603
Portugal	37,676	35,132	33,862	33,408	33,340	33,654
Romania	35,939	34,699	37,512	38,509	41,033	40,650
Slovakia	34,454	37,914	39,122	39,272	42,389	43,921
Slovenia	13,746	13,732	13,759	14,399	14,326	14,593
Spain	233,760	226,284	223,731	218,765	232,326	234,369
Sweden	121,421	145,035	145,085	142,256	135,504	133,533
United Kingdom	541,127	573,145	567,888	603,965	671,526	666,016
Iceland	3,334	3,401	3,364	3,605	3,872	4,054
Norway	230,345	255,738	238,291	217,922	137,651	116,945
Switzerland	182,964	195,115	191,439	197,322	217,987	216,376
Total	**4,453,627**	**4,582,156**	**4,556,863**	**4,655,442**	**4,841,517**	**4,819,747**

Source: Eurostat SBS, Cebr analysis

APPENDIX II: NACE REV. 2-BASED DEFINITION OF PHYSICS-BASED ACTIVITIES

List of industries defined as physics-based

Code	Description
6.1	Extraction of crude petroleum
6.2	Extraction of natural gas
9.1	Support activities for petroleum and natural gas extraction
20.13	Manufacture of other inorganic basic chemicals
21.2	Manufacture of pharmaceutical preparations
23.44	Manufacture of other technical ceramic products
24.46	Processing of nuclear fuel
25.4	Manufacture of weapons and ammunition
25.99	Manufacture of other fabricated metal products n.e.c.
26.11	Manufacture of electronic components
26.12	Manufacture of loaded electronic boards
26.2	Manufacture of computers and peripheral equipment
26.3	Manufacture of communication equipment
26.4	Manufacture of consumer electronics
26.5	Manufacture of instruments and appliances for measuring, testing and navigation
26.6	Manufacture of irradiation, electro-medical and electrotherapeutic equipment
26.7	Manufacture of optical instruments and photographic equipment
26.8	Manufacture of magnetic and optical media
27.11	Manufacture of electric motors, generators and transformers

Code	Description
27.12	Manufacture of electricity distribution and control apparatus
27.2	Manufacture of batteries and accumulators
26.8	Manufacture of magnetic and optical media
27.11	Manufacture of electric motors, generators and transformers
27.31	Manufacture of fibre optic cables
27.32	Manufacture of other electronic and electric wires and cables
27.33	Manufacture of wiring devices
27.4	Manufacture of electric lighting equipment
27.51	Manufacture of electric domestic appliances
27.9	Manufacture of other electrical equipment
28.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
28.23	Manufacture of office machinery and equipment (except computers and peripheral equipment)
28.25	Manufacture of non-domestic cooling and ventilation equipment
28.29	Manufacture of other general-purpose machinery n.e.c.
28.49	Manufacture of other machine tools
28.99	Manufacture of other special-purpose machinery n.e.c.
29.1	Manufacture of motor vehicles
29.31	Manufacture of electrical and electronic equipment for motor vehicles
30.11	Building of ships and floating structures

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