RESEARCH REPORT

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ECONOMIC FOOTPRINT AND R&D FOOTPRINT FOR GRAPHENE FLAGSHIP

Measurement of the economic impact relating to Graphene Flagship's R&D activities and impact related to Graphene consortium.

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Appreciation
This project was commissioned by Graphene Flagship.

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Management Summary

Objective and main results

The Graphene Flagship is a collaborative research and innovation project initiated to develop the market for the use of graphene and its related products. Graphene is a carbon-based material with extraordinary physical and technical properties. Because of such properties, graphene has multiple applications in the energy, construction, health, transport, and electronic sectors.

The Flagship was launched in October 2013 and was one of the first two Future Emerging Technologies (FET) Flagships launched by the European Commission. Since its launch, it has been funded both by the European Commission as well as the EU member states and associated countries. The Flagship has brought together academic and industrial researchers to create and commercialize new technologies based on graphene and related layered materials. Flagship's core consortium consists of approximately 170 academic and industrial research groups in 22 countries. Other than academic partners and members, many companies are also associated with the flagship.

This effort has created and will continue to create economic value and support employment opportunities in Europe and beyond. Therefore, the main aim of this study is to estimate the economic impact of the Graphene Flagship in Europe and globally since its inception, including its market share and projection up to 2030. Respectively, the study quantifies the economic value in terms of the gross value added (GVA), i.e., contribution to Gross Domestic Product (GDP), and the jobs supported by Graphene's research and development (R&D) and related business activities from 2014 to 2030.

The main information used by this study to conduct the analysis is the invested budget (including both public and private investment in R&D) of the Graphene Flagship from 2014 up to 2023, which was about €1.4 billion while excluding the investments from the market share estimation and the market projection. In addition, an estimate for Graphene's current and projected European market share is being used. This data is then translated into the rationale of the system of national accounts, resulting in the economic key figure of GDP contribution and jobs supported along Graphene's global supply chain. For the impact analysis, a widely recognized input-output method for quantifying economic effects in the supply chain is being used.

It is to note that though the study estimates the global impact of the flagship, however, the key results presented below focus on Graphene's R&D and business activities' economic impact on the EU27 member countries.

MAIN RESULTS

THE EUROPEAN COUNTRIES ARE THE EPICENTER OF THE GRAPHENE FLAGSHIP

OUT OF THE TOTAL €5.9 BN CONTRIBUTED BY GRAPHENE TO THE WORLD GDP BETWEEN 2014 AND 2030, €3.8 BN WILL BE IN THE EU27 – GRAPHENE'S ECONOMIC IMPACT IN THE EU27 REPRESENTS 65 PERCENT OF ITS GLOBAL IMPACT.

TOTAL GDP CONTRIBUTION FACTOR OF 1.7 IN THE EU27

FOR EVERY EURO OF GDP CONTRIBUTED BY THE FLAGSHIP IN EU27 DIRECTLY, AN ADDITIONAL €1.7 WILL BE SUPPORTED IN THE EU27 BASED ON INTER-INDUSTRY AND INTER-COUNTRY LINKAGES.

THE FLAGSHIP WILL SUPPORT 38,400 JOBS IN THE EU27

OUT OF THE TOTAL 81,662 JOBS SUPPORTED BY GRAPHENE IN THE WORLD BETWEEN 2014 AND 2030, 47 PERCENT WILL BE IN THE EU27.

TOTAL EMPLOYMENT FACTOR OF 2.15 IN THE EU27

FOR EVERY JOB CREATED BY THE FLAGSHIP IN EU27 DIRECTLY, AN ADDITIONAL 2.15 JOBS WILL BE SUPPORTED IN THE EU27 BASED ON INTER-INDUSTRY AND INTER-COUNTRY LINKAGES.

HIGHEST IMPACT IN THE EU27 FOR THE ELECTRONIC AND EQUIPMENT INDUSTRY

FROM ALL THE SECTORS, THE ELECTRONICS AND EQUIPMENT SECTOR WILL MAKE 60 PERCENT OF THE TOTAL IMPACT OF GRAPHENE IN THE EU27, BOTH IN TERMS OF GDP CONTRIBUTION AND EMPLOYMENT SUPPORTED.

1 Introduction

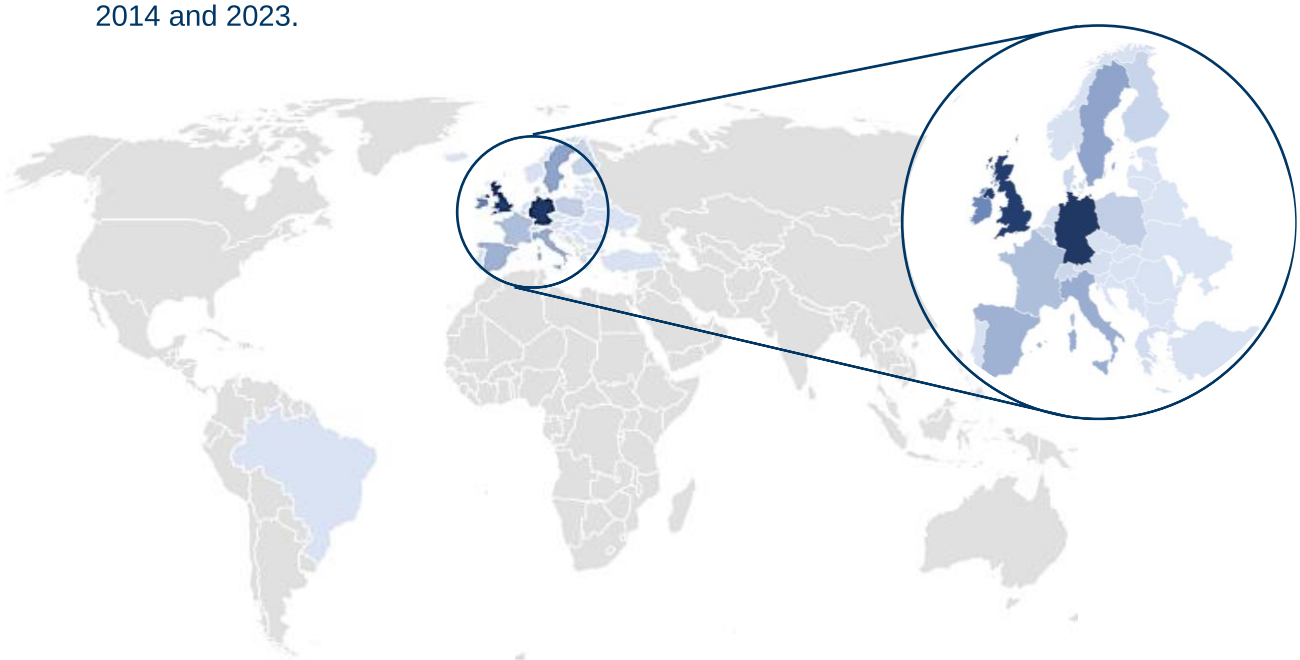
This study was commissioned by the Graphene Flagship, which is a collaborative research and innovation project, to examine the impact of the research and development activities undertaken by the Flagship in the European economy and selected countries.

The Flagship was launched in October 2013 and was one of the first European Commission's future and Emerging Technology Flagships, whose mission was to address larger scientific and technological challenges through long-term, multidisciplinary research, and development efforts. Witnessing the high potential in graphene and its layered materials, the European Commission supports the program. The Flagship has brought together academic and industrial researchers to create and commercialize new technologies based on graphene and related layered materials. The core consortium consists of approximately 170 academic and industrial research groups in 22 countries and its core projects have 165 partners and more than 90 associated members. In addition, the project has a vast number of associated members that are incorporated in the scientific and technological work packages. The program is divided into a total of 19 work packages, 15 on research and innovation and the rest on operative management aspects. Based on these work packages, the economic sectors were assigned to the core and associated partners of the program to estimate their economic impact.

The Flagship with its wide-spread coordination within and outside the EU has created economic value and supported employment opportunities in the past ten years. The aim of the study is to estimate this economic value added and employment supported by the research and development (R&D) activities of the Graphene Flagship. The study not just estimates the impact of the program since its inception till date, but also the impact of the current and future European market for Graphene until 2030. The analysis provides the split of the impact in terms of direct as well as indirect and induced effects (so-called spillover effects), which are triggered by Graphene's members' consumption of materials and services and employee compensation. The impact is analyzed in terms of GDP contribution and employment. Therefore, this study provides an outlook of the impact of the public funding received by the Graphene Flagship on Europe and selected countries.

The study here, computed the impact of Graphene's 225 core partners, 70 partnering projects involving 310 core partners/associated members, 36 Centers and 20 companies in total from 2014[1] to 2023. In addition to this, the value of Graphene's European market was estimated between 2014 and 2024 followed by the impact of projected European market between 2025 and 2030. As a result, the analysis refers to the economic impact of €402 million[2] of funds the core partners received, €112 million budget of the partnering projects, €460 million funding received by the centres and an investment of €468 million done by companies. This totals to a sum of €1.4 billion received by the Flagship in the form of fundings and investments between 2014 and 2023.

Figure 1: Graphene Flagship's review of funding flow by country between 2014 and 2023.



Source: Data received from the Graphene Flagship.

Among the 37 countries that had been a part of the Graphene Flagship in terms of funding or investment, a total of €1.4 billion funds received, Germany has received the highest amount of funds (€436 million), followed by United Kingdom (€395 million), Ireland (€140 million), Sweden (€96 million) and Italy (€83 million) (Figure 1).

1 Though the program officially started in October 2013 but for the sake of convenience we use 2014 in this whole study report.

2 The European Union funding to the program is meant to be €500 million, however, €100 million has not been covered in this study because that amount is a promised sum for the future.

Figure 2: Summary of the data used to estimate impact of Graphene.

Entity Type	Number of entities	Total Investment/Funding or Value (in €)
Core Partners	225	402 million
Partnering Projects	70	112 million
Graphene Related Material (GRM) Centres	36	460 million
Companies	20	468 million
European Market Estimate (by countries) from 2014 to 2024	20	256 million
European Market Projection (by countries) from 2025 to 2030	20	1,1152 million

Source: Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

2 Graphene’s Impact on EU27

This chapter presents the key findings from the economic impact of Graphene’s R&D activities and European manufacturing activities on the EU27 countries. This considers the analysis of the program since the initialization of the program in 2014 including a market projection in Europe up to 2030. The GDP contribution and the employment supported are the key indicators measured.

2.1 GDP contribution

The Graphene Flagship will have created a total GDP contribution of €3.8 billion[3] between 2014 and 2030 in the EU27 countries because of its business and R&D activities[4]. This represents 65 percent of the total GDP contributed by the program globally. The global impact of the program includes both the direct and the spillover impact in all the countries and along the global supply chain, which is €5.9 billion[5].

€3.8 bn

total Graphene’s R&D and business activities GDP contribution supported in EU27.

Figure 3: Direct and spillover GDP contribution effects of Graphene Flagship on the EU27 countries (2014-2030).

3 This includes the impact of funding and investments received by Graphene from 2014 to 2023, Graphene’s European market value between 2014 and 2024 and the projected European market from 2025 to 2030.

4 Since the impact analysis considers global inter-industry and inter-country linkages, this includes the impacts occurring in the EU27’s because of EU27’s activities’ global supply chain. This can be further explained through an example. If Germany and India are trading between each other. Then the impact of the Indian manufacturer on Germany will be included in the impact on EU27.

5 The impact for the rest of the world with respect to EU27 can be found in the appendix of this study.

Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

The direct[6] GDP contribution created in EU27 is estimated to be of €1.4 billion between 2014 and 2030 and €2.4 billion in the form of spillover effects[7] in EU27 (Figure 3). Additionally, it can be stated that for every Euro of GDP contribution directly created by Graphene's R&D activities in EU27, a further €1.7 of value will be created along the EU27's supply chain between 2014 and 2030. This can be termed as a GDP contribution factor as well which is, GDP contributed to the global supply chain (spillover effect) for every GDP contributed directly.

€1.7:1

for every euro of GDP contributed directly, created by Graphene's R&D and business activities in the EU27, an additional of €1.7 is supported along the EU27's supply chain.

The impact created by the program, if compared to the public investment[8] received by the program, can be concluded as 5 times. This means, for every Euro of direct funding[9] received by the European Commission, the program created €5 of impact in the EU27. The investment here is referred to the €316 million given directly to the core partners of the flagship by the European Commission which is then compared to the €1.6 billion of GDP contributed by all the entities (core partners, partnering projects, GRM centres and companies) involved in Graphene[10] at the EU27 level.

Upon the further breakdown of results in terms of partner status[11] the GDP contributed by Graphene's project European market[12] will be the highest (€1,800 million) (Figure 4) followed by the impact of participating companies (€630 million), core partners (€520 million), current European market value (€400 million), GRM centres (€320 million) and partnering projects (€160 million).

6 Direct impact includes impact from Graphene's own R&D and economic activities or production in the EU27 countries. Graphene's own production involves the production done directly by its core partners, partnering projects, GRM centres, companies, current market estimate in Europe and the projected market. This does not include the impacts through the supply chain.

7 Spillover effects include the indirect and induced effects. The indirect effects are triggered by ripple effects along the global supply chain and the induced effects by the disposable income's triggered business activity.

8 In addition to the public investment received from the European Commission, the program also received public funding by the EU Member States. The program's business activities were also supported by private funding.

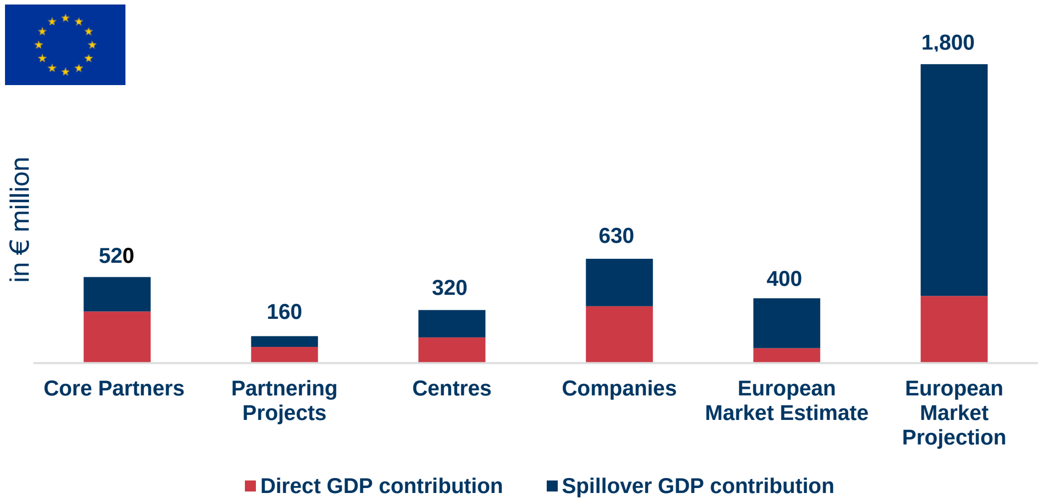
9 The direct funding received here by the European Commission is the funding received by Graphene's core partners directly.

10 Note: The €1.6 billion of GDP contribution does not include the impact of current and projected European market estimates.

11 The partner status means that they can be either a core partner or part of a partnering project, or a centre, or company, part of a European market estimate or European market projection.

12 The estimation and projection of Graphene's European market has been done using the Graphene's global market estimates provided by Fraunhofer-Institut für System- und Innovationsforschung ISI. The average of estimates from 25 different market studies has been used.

Figure 4: GDP contribution of Graphene on EU27 by project status.



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Graphene's European market estimate, both current and projected, have a higher GDP contribution factor[13] than Graphene's core partners, partnering projects, centres, and companies. Both in the European market estimate and projection, for every Euro of GDP contributed directly to the European market, a further €3.5 of value will be created in terms of GDP contribution along the EU27's supply chain.

€3.5:1

for every euro of GDP contributed directly created by Graphene's current and projected market activities in the EU27, an additional of €3.5 is supported along the EU27's supply chain.

2.2 Employment

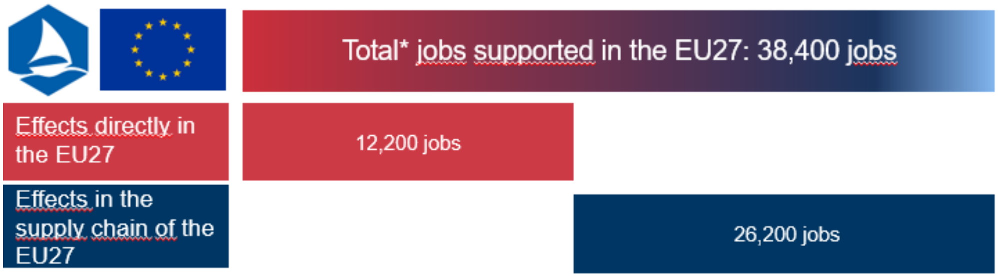
Graphene's business and R&D activities have supported the EU27's labour market. The total employment supported in the EU27 by Graphene's activities will be 38,400 (Figure 5), out of which 12,200 will be supported directly and 26,200 in the EU27's supply chain between 2014 and 2030. This represents 47 percent of the total employment supported globally by the program. The global impact of the program includes both the direct and the spillover impact in all the countries and along the global supply chain supports 81,662 jobs.

38,400

jobs supported by Graphene's R&D and business activities in EU27 since its inception.

13 GDP contributed to the global supply chain (indirect and induced) for every GDP contributed directly.

Figure 5: Direct and spillover employment effects of Graphene Flagship on the EU27 countries (2014-2030).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

The graph above also represents an employment factor[14] of 2.1, which means for every job directly created, a further 2.1 spillover employment will be supported along the supply chain in the EU27.

The impact created by the program, if compared to the public investment[15] received by the program, can be concluded as 50 times. This means, for every Euro of direct funding[16] received by the European Commission, the program will have supported 50 jobs in the EU27. The investment here is referred to the €316 million of funding received only by the core partners of the program against the 15,650 jobs supported by all the entities (core partners, partnering projects, GRM centres and companies) involved in Graphene[17] in the EU27.

2.1:1

for every 1 job supported directly by Graphene's activities, an additional 2 jobs are supported along the EU27's supply chain.

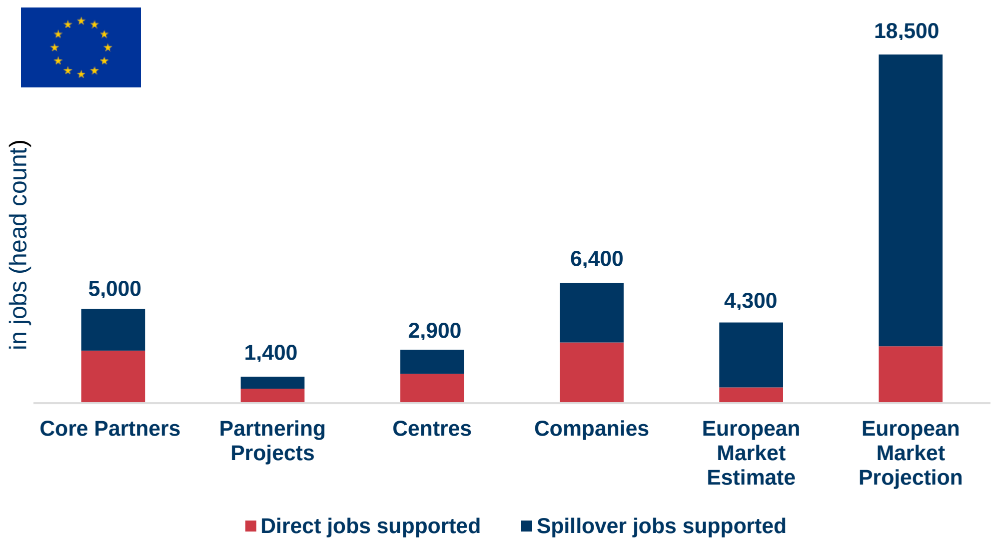
14 Employment or job supported in the global supply chain (indirect and induced) for every job supported directly.

15 In addition to the public investment received from the European Commission, the program also received public funding by the EU Member States. The program's business activities were also supported by private funding.

16 The direct funding received here by the European Commission is the funding received by Graphene's core partners directly.

17 Note: The €1.6 billion of GDP contribution does not include the impact of current and projected European market estimates.

Figure 6: Jobs supported by Graphene in EU27 by project status.



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

If the total impact is estimated by the status[18] of the entity involved in the program, the largest number of jobs supported in EU27 between 2014 and 2030 will be in the Graphene's projected market in EU27 countries, followed by companies, core partners, Graphene's current European market, centres, and partnering projects (Figure 6).

Graphene's European market estimate, both current and projected, have a higher employment factor[19] than Graphene's core partners, partnering projects, centres, and companies. In the European market projection, for every job supported directly in the European market, a further 5.1 jobs will be supported in terms of employment supported along the EU27's supply chain.

5.1:1

for every job supported directly by Graphene's projected market activities in the EU27, an additional of 5.1 jobs will be supported along the EU27's supply chain.

2.3 Impact by country

Graphene's presence has been important in the EU27 countries, both because of their contribution to the technology as well as the financial support by the European Commission. This sub-section provides the country-level breakdown

18 This implies to the nature of partnership or involvement in the Graphene Flagship. They are broadly divided into core partners, partnering projects, companies, Graphene and Related Material (GRM) Centres and the current and projected Graphene's European Market.

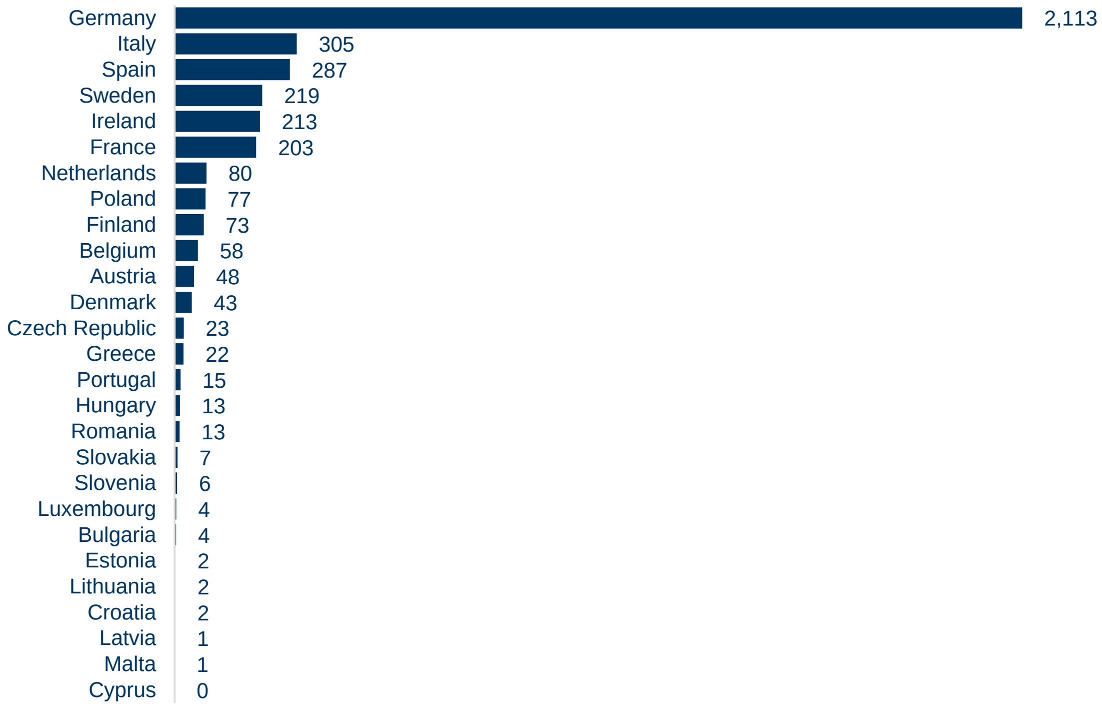
19 Employment supported in the global supply chain (indirect and induced) for every employment supported directly.

of the impacts of Graphene Flagship in the EU27 in terms of GDP contribution and employment supported.

2.3.1 GDP contribution

Among all the countries in the EU27, the impact on Germany will be the highest of the program between 2014 and 2030. The total GDP contribution impact in Germany will be €2,112 million, followed by Italy €304 million, Spain €287 million, Sweden €220 million, and Ireland €210 million (Figure 7).

Figure 7: GDP contribution impact on EU27 by country (in € million).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

However, based on the GDP contribution factor (i.e., in the form of spillover effects), Slovakia will be the highest with a factor of 27. This means that for every €1 created in terms of GDP contribution directly in Slovakia, €27 will be created at the supply chain as spill over effect in Slovakia. This is followed by Romania, with a GDP contribution factor of 13, Czech Republic, 9, Netherlands, 8 and Hungary,6 (Figure 8).

Figure 8: GDP contribution factor[20] in the EU27 by country[21].

Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

2.3.2 Employment

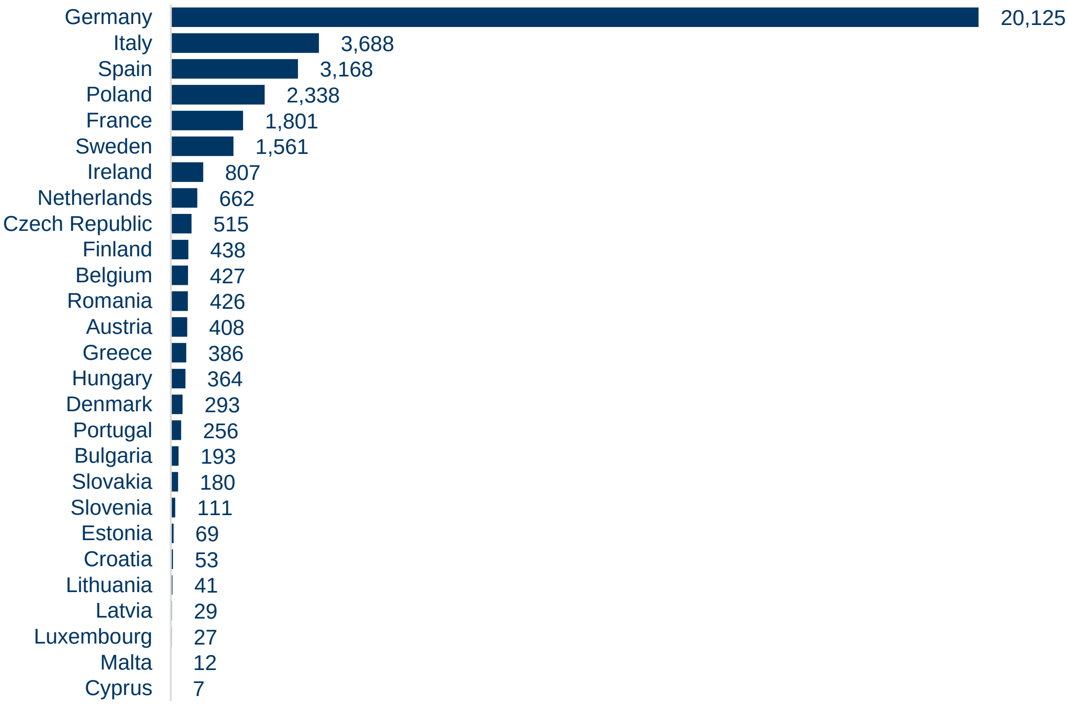
The impact in terms of jobs supported is also the highest in Germany, similar to that of the GDP contribution. Out of the total 38,400 jobs supported by the program in the EU27, 52 percent will be in Germany which equals to 20,125 jobs, followed by Italy (3,688 jobs), Spain (3,168 jobs), Poland (2,340 jobs), and France (1,800 jobs) (Figure 9)[22].

20 GDP contribution factor shows the GDP contribution in Euro per one unit of economic production value.

21 This shows the countries that have been impacted by the Graphene's activities in the EU27 and not the countries that were responsible for the impact.

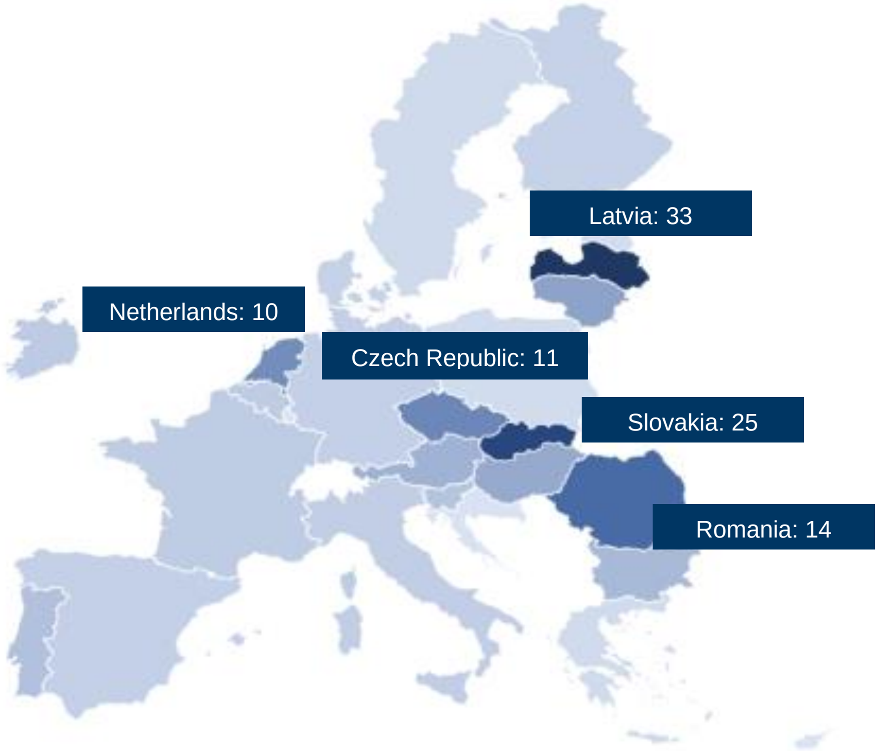
22 This is to note that these numbers represent the impact on these countries but not impact of these countries. Thus, it can be stated that these numbers represent the impact of Graphene's R&D and business activities in EU27 on these EU27 countries.

Figure 9: Jobs supported in the EU27 by country (in head count).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Figure 10: Employment factor[23] in the EU27 by country[24].



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Considering the employment factor (i.e., in the form of spillover employment supported), Latvia will have the highest among the 27 countries, with a ratio of 33. This translates to that for every 1 job supported directly in Slovakia, there are 33 jobs that will be supported in the supply chain of Latvia. This is followed by an employment factor of 25 in Slovakia, Romania, 14, Czech Republic,11, and Netherlands, 10 (Figure 10).

2.4 Impact by sector

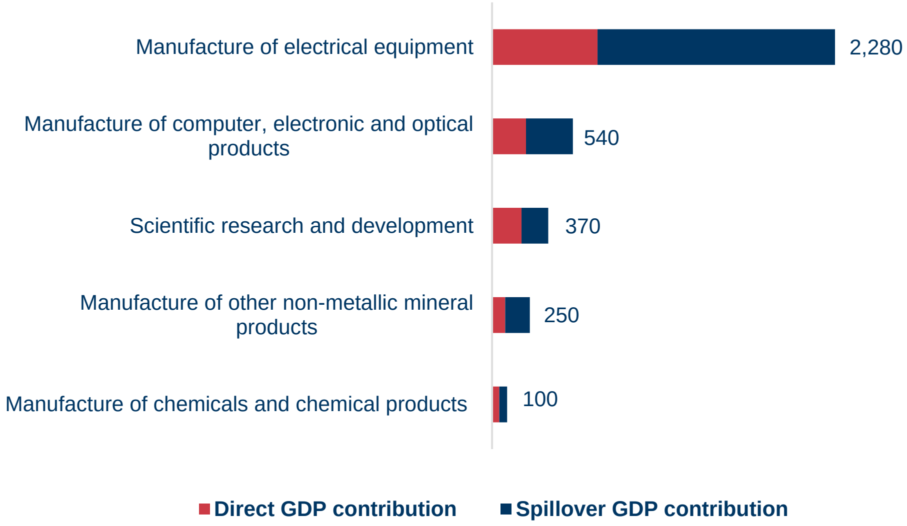
The impact in the EU27 can be represented by industry or sector as well. The analysis shows, in terms of GDP contribution, the highest impact will be in the

23 This represents persons in head count per one unit of economic production value.

24 This is to note that these numbers represent the impact on these countries but not impact of these countries. Thus, it can be stated that these numbers represent the impact of Graphene's R&D and business activities in EU27 on these EU27 countries.

electrical equipment sector[25], followed by the computer, electronic and optical products, and scientific R&D, manufacture of other non-metallic mineral products and manufacture of chemicals and chemical products[26] (Figure 11). The sectoral classification is based on the Statistical Classification of Economic Activities in the European Community, commonly known as NACE. This is the standard industrial classification system used in the European Union.

Figure 11: GDP contributed in the EU27 by top five sectors (in € million).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

The top five sectors will make more than 90 percent of the GDP contributed in the EU27. Apart from these sectors, the remaining will be the coke and petroleum industry, pharmaceutical industry, the rubber and plastics industry, metal products industry, machinery, motor vehicles, the automobile industry, other transports, and consultancy activities.

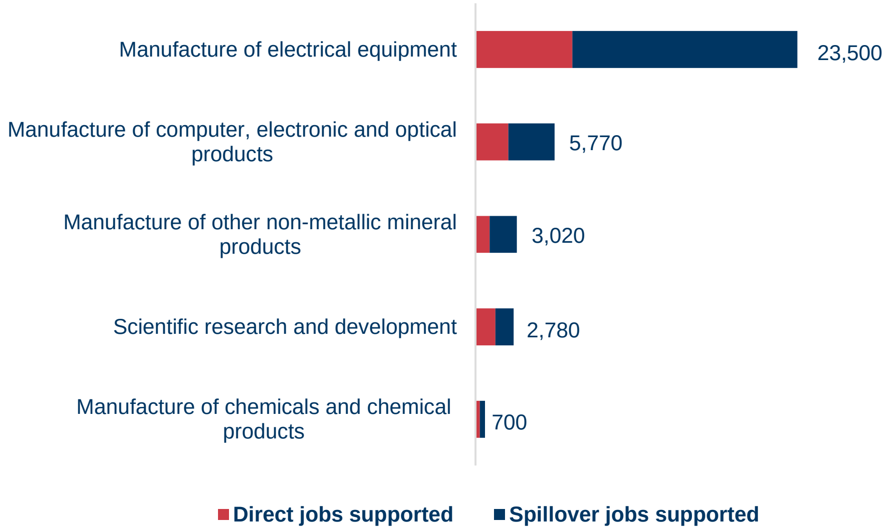
Similarly, in the case of employment, the manufacturing of electrical equipment sector will make up the largest part of the total employment supported among all the fourteen sectors that are related to the program. This will be followed by the computer, electronic and optical products, manufacture of other non-metallic

25 According to the NACE codes, the computer, electronic and optical products is C26, electrical equipment sector is C27, scientific R&D is M72, manufacture of chemicals and chemical products is C20, and manufacture of other metallic mineral products is C23.

26 This analysis is based on the economic sectors of Graphene's all partners since its inception, Graphene's current European market estimate (2014-24) and Graphene's projected European market (2025-2030).

mineral products and scientific R&D, and manufacture of chemicals and chemical products[27] [28] (Figure 12). Again, these top five sectors will make more than 90 percent of the total employment supported in the EU27.

Figure 12: Employment supported in the EU27 by top five sectors (in head count).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Among all the sectors, both in GDP contributed and employment supported, the manufacturing of electrical equipment sector alone makes 60 percent of all the sectors.

27 According to the NACE codes, the computer, electronic and optical products is C26, electrical equipment sector is C27, scientific R&D is M72, manufacture of chemicals and chemical products is C20, and manufacture of other metallic mineral products is C23. Thia sectoral classification is based on the Statistical Classification of Economic Activities in the European Community, commonly known as NACE. This is the standard industrial classification system used in the European Union.

28 This analysis is based on the economic sectors of Graphene's all partners since its inception, Graphene's current European market estimate (2014-2024) and Graphene's projected European market (2025-2030).

3 Graphene's Impact on Europe and selected countries

This chapter presents the key findings from the economic impact of Graphene's R&D activities and European manufacturing activities on Europe and selected countries. This considers the analysis of the program since its initialization in 2014 including a market projection in Europe up to 2030. The GDP contribution and the employment supported are the key indicators measured.

3.1 GDP contribution

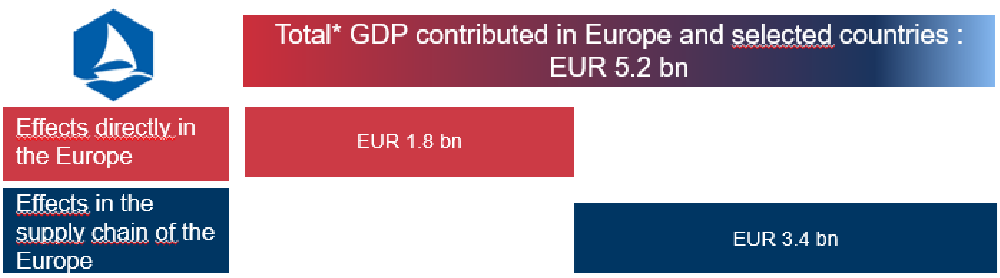
The impact measured occurring here is due to the business and R&D activities of the Graphene Flagship that were directly occurring in the European countries and in a few non-European countries.

The Graphene Flagship will have created a total of €5.2 billion between 2014 and 2030 in a total of 37 countries[29] because of its business and R&D activities. This represents 88 percent of the total GDP contributed by the program globally since its inception. The global impact of the program includes both the direct and the spillover impact in all the countries and along the global supply chain, which is €5.9 billion.

€5.2 bn

total Graphene's R&D and business activities GDP contribution supported in Europe and selected countries.

Figure 13: Direct and spillover GDP contribution effects of Graphene Flagship on Europe and selected countries (2014-2030).



29 These include the countries that are associated with Graphene in form of core partners and partnering projects that are Armenia, Austria, Belgium, Bulgaria, Belarus, Brazil, Switzerland, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, UK, Greece, Croatia, Hungary, Ireland, Iceland, Israel, Italy, Lithuania, Latvia, Netherlands, Norway, Philippines, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Sweden, Turkey, Taiwan, Ukraine

Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

€1.9:1

for every euro of GDP contributed directly, created by Graphene's R&D and business activities in Europe and selected countries, an additional of €197 is supported along Europe's supply chain.

Out of the total impact of €5.2 billion, €1.8 billion will be the direct[30] effect on these 37 countries in terms of GDP contribution and €3.4 billion spillover[31] effect along the supply chain (Figure 13). Therefore, it can be stated that for every Euro of GDP contribution directly created by Graphene's R&D activities in Europe and few countries, a further €1.9 of value will be created along the global supply chain between 2014 and 2030. This can also be referred to as a GDP contribution factor.

The impact created by the program, if compared to the public investment[32] received by the program, can be concluded as 6 times. This means, for every Euro of direct funding[33] received by the European Commission, the program created €6 of impact in the Europe and selected countries. The funding here refers to the €402 million received by the core partners involved in the program, which is then compared to the €2.4 billion of GDP contributed by the core partners, partnering projects, GRM centres and companies involved in the program in Europe and few non-European countries.

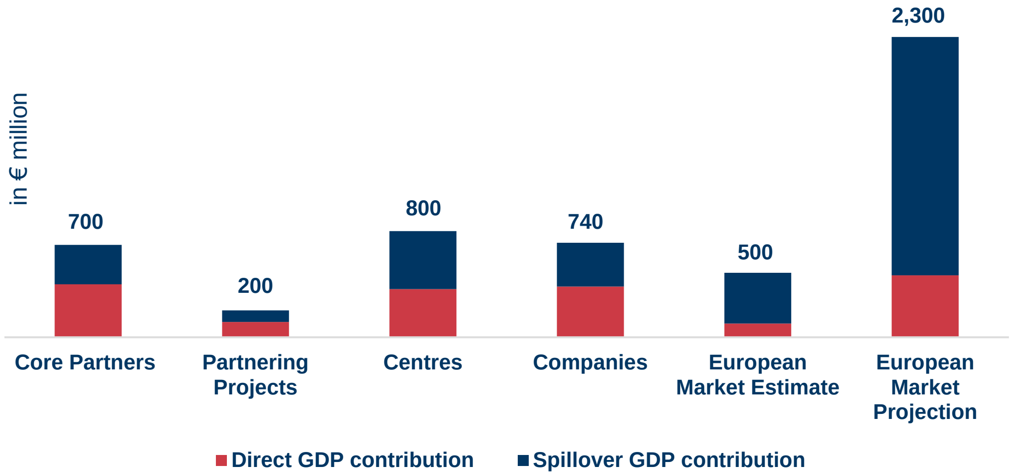
30 The direct impact includes the impact from Graphene's R6D and economic activities directly in the European and selected countries.

31 Spillover effects include the indirect and induced effects. The indirect effects are triggered by ripple effects along the global supply chain and the induced effects by the disposable income's triggered business activity.

32 In addition to the public investment received from the European Commission, the program also received public funding by the EU Member States. The program's business activities were also supported by private funding.

33 The direct funding received here by the European Commission is the funding received by Graphene's core partners directly.

Figure 14: GDP contribution of Graphene on Europe and selected countries by status.



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

These results can be disaggregated by the status of Graphene's members (Figure 14). According to the estimates, Graphene's projected European market (2025-2030) will have the highest economic impact in terms of GDP contribution and the highest spillover effect. This represents that for every Euro of GDP contribution directly created by Graphene's R&D activities in the European market, a further €3.8 of value will be created in terms of GDP contribution in the along the European supply chain. After the European market projection, GRM centres will have created the highest GDP contribution since the Flagship's initialization, followed by the participating companies, core partners, the current European market, and partnering projects.

€3.8:1

for every euro of GDP contributed directly created by Graphene's projected market activities in Europe, an additional of €3.8 is supported along Europe's supply chain.

3.2 Employment

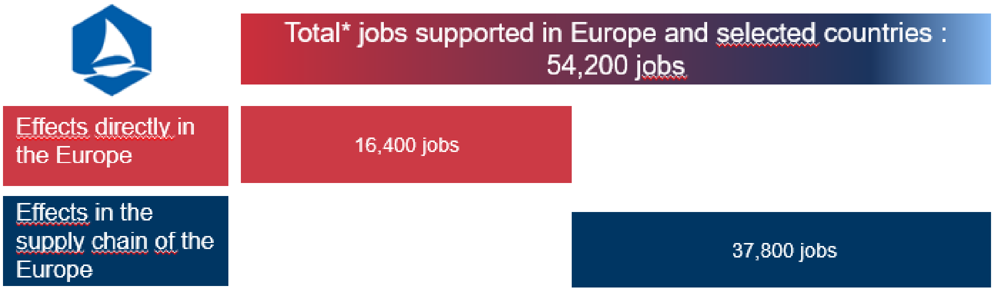
In addition to the GDP contribution, the Graphene Flagship will also contribute to the European labor market. It will support employment directly in Europe and indirectly along its supply chain.

54,200

jobs supported by Graphene's in Europe and selected countries.

Between 2014 and 2030, Graphene will have supported in total 54,200 jobs in the Europe and selected countries, out of which 16,400 jobs will be directly in Europe and the rest in its supply chain (Figure 15). This makes up 66 percent of the total jobs supported by the program globally. The global impact of the program includes both the direct and the spillover impact in all the countries and along the global supply chain that supports 81,662 jobs.

Figure 15: Direct and spillover GDP employment effects of Graphene Flagship on Europe and selected countries (2014-2030).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

The ratio of the direct and spillover jobs supported represents an employment factor of 2.3, which means for every job directly created, a further 2.3 jobs in the form of spillover effects will be supported along the supply chain.

2.3:1

for every 1 job supported directly by Graphene's activities in Europe, an additional 2 jobs are supported along Europe's supply chain.

The impact created by the program, if compared to the investment[34] received by the program, can be concluded as 61 times. This means, for every Euro of direct funding[35] received by the European Commission, the program will have supported 61 jobs in Europe and selected non-European countries. The investment here is referred to the €402 million of funding received only by the core partners of the program against the 24,800 jobs supported by all the entities (core partners, partnering projects, GRM centres and companies) involved in Graphene[36] in Europe and selected countries.

Disaggregated at the status level, Graphene's projected European market (2025-30) will support the highest number of jobs along with a high spillover effect (Figure 16). Similar to the GDP contribution, the participating GRM centres will have supported the highest number of jobs, followed by companies, core partners, the current European market, and partnering projects.

The employment factor is also high for Graphene's market (both current and projected), that is, for every job directly created by Graphene's activities in the European market, a further 4 jobs will be supported along Europe's supply chain.

4:1

for every job supported directly by Graphene's projected market activities in the Europe, an additional of 4 jobs will be supported along the Europe's supply chain.

---

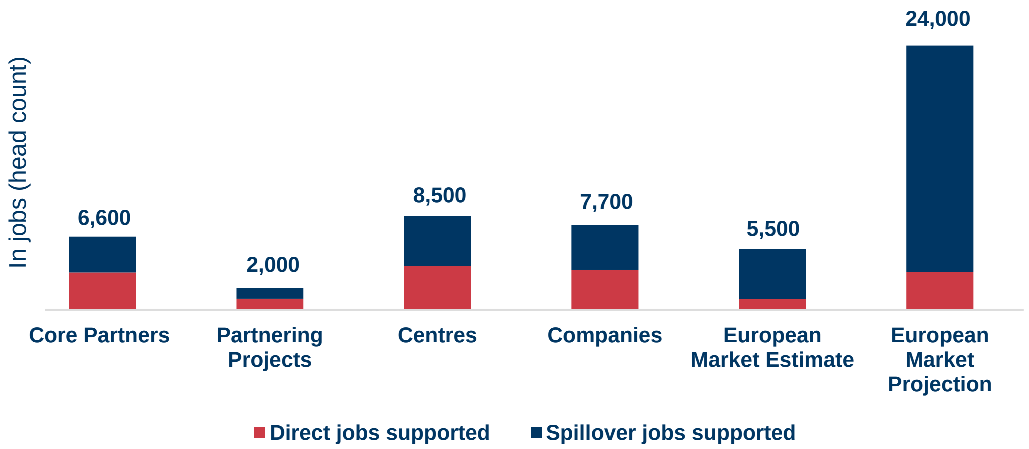
34 In addition to the public investment received from the European Commission, the program also received public funding by the EU Member States. The program's business activities were also supported by private funding.

35 The direct funding received here by the European Commission is the funding received by Graphene's core partners directly.

36 Note: The €1.6 billion of GDP contribution does not include the impact of current and projected European market estimates.

This employment factor will be followed by Graphene's participating GRM centres with a factor of 1.2, companies, 0.9, partnering projects, 0.7, and core partners, 0.7.

Figure 16: Jobs supported by Graphene in Europe and selected countries by status.



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

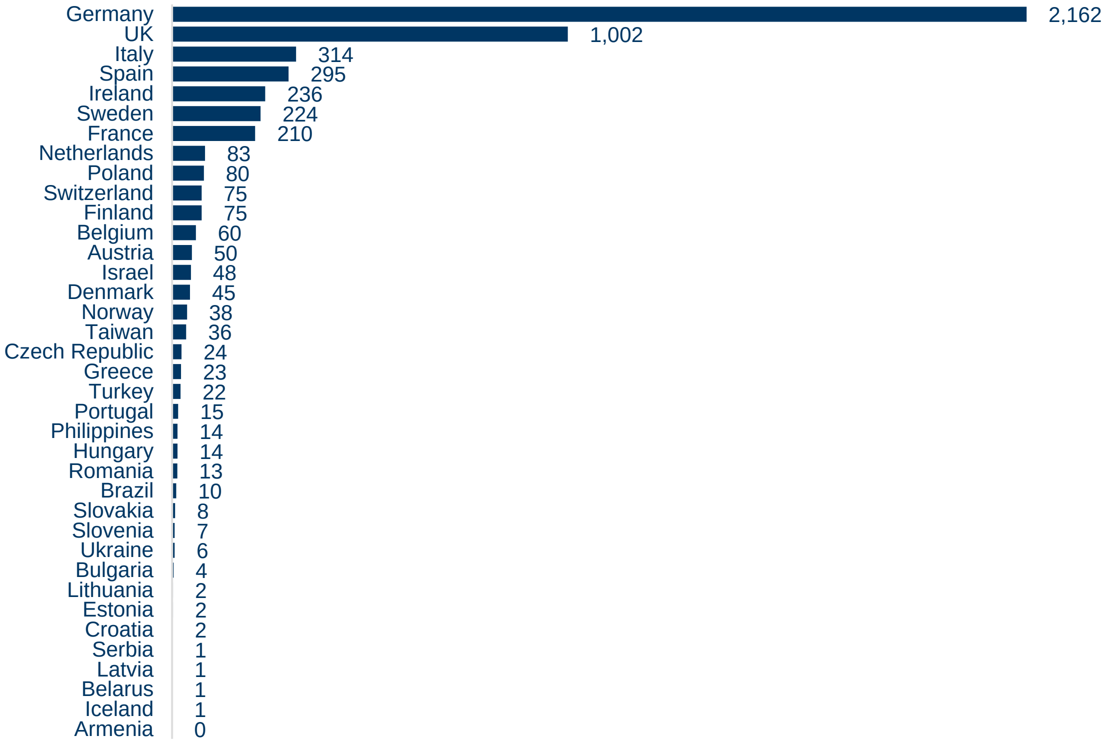
3.3 Impact by country

Similar to the EU27 region, the core impact of the Graphene Flagship has been on Europe and a few selected countries that have been directly engaged in the program. This sub-section provides this country-level breakdown of the impacts of Graphene Flagship in Europe in terms of GDP contribution and employment supported.

3.3.1 GDP contribution

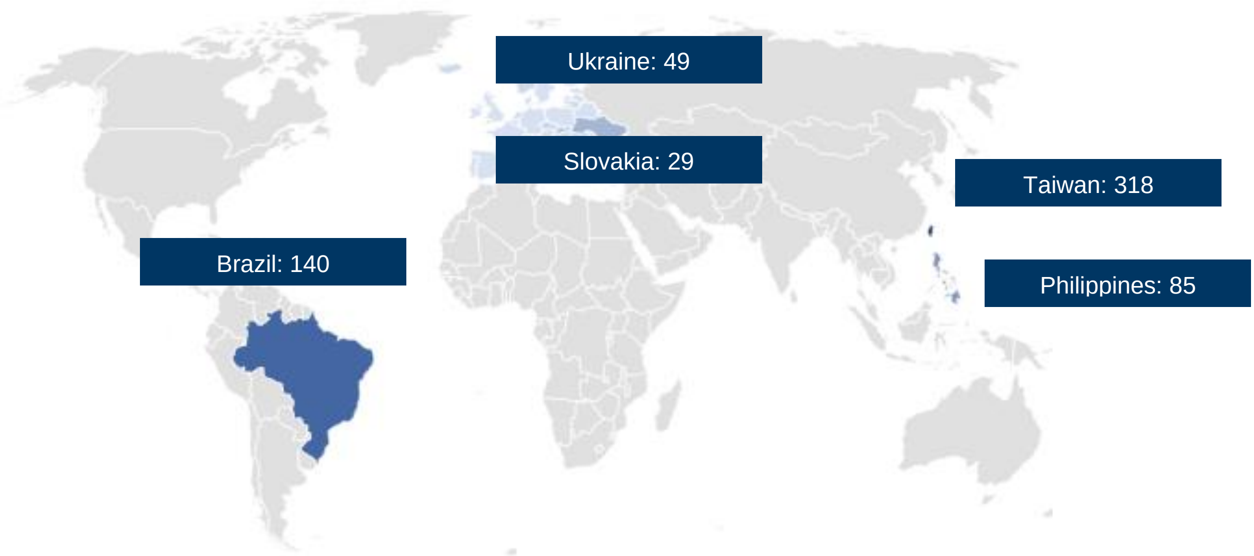
Among all the countries in this basket of 37 countries, the impact on Germany will be the highest of the program between 2014 and 2030, similar to that in the EU27. The total GDP contribution in Germany will be €2,162 million, followed by United Kingdom €1,001 million, Italy €313 million, Spain €294 million, and Ireland €235 million (Figure 17).

Figure 17: Direct and Spillover GDP contribution triggered by the Graphene Flagship in Europe and selected countries (in € million).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Figure 18: GDP contribution factor[37] in the Europe and selected countries[38].



37 GDP contribution factor shows the GDP contribution in Euro per one unit of economic production value.

38 This shows the countries that have been impacted by the Graphene's activities in Europe and few selected non-European countries and not the countries that were responsible for the impact.

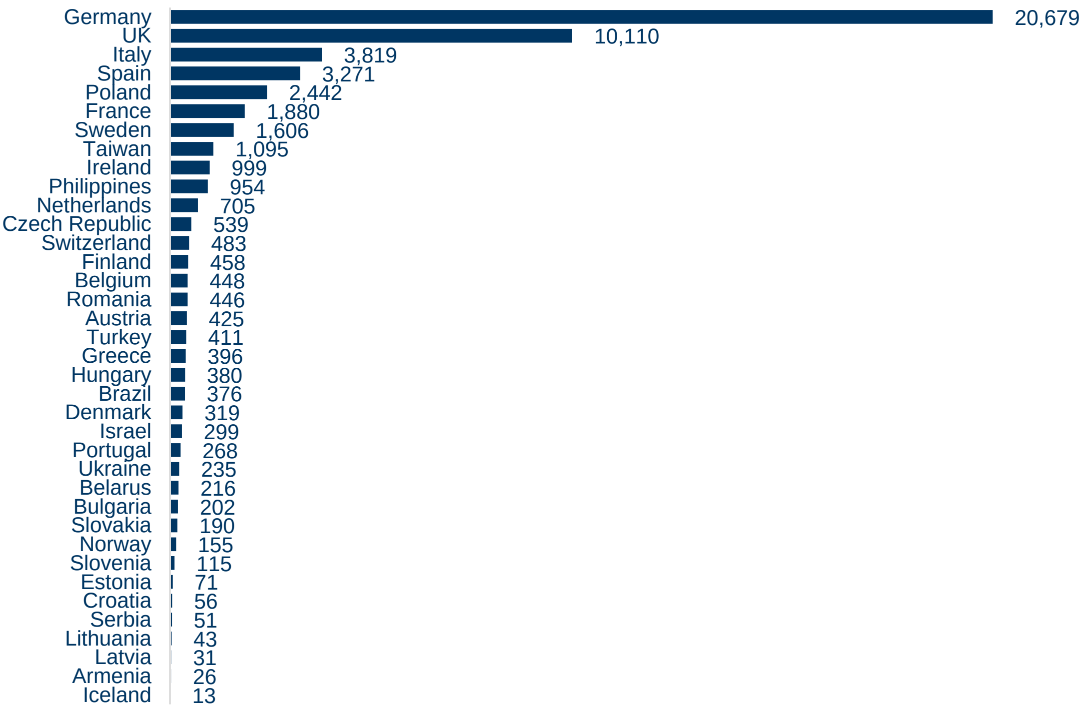
Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

However, based on the GDP contribution factor (i.e., in the form of spillover effects), Taiwan will have the highest factor of 318. This means that for every €1 created in terms of GDP contribution directly in Taiwan, €318 will be created at the supply chain indirectly in Taiwan (Figure 18). This is followed by a GDP contribution factor of 140 in Brazil, 85 in the Philippines, 49 in Ukraine, and 29 in Slovakia.

3.3.2 Employment

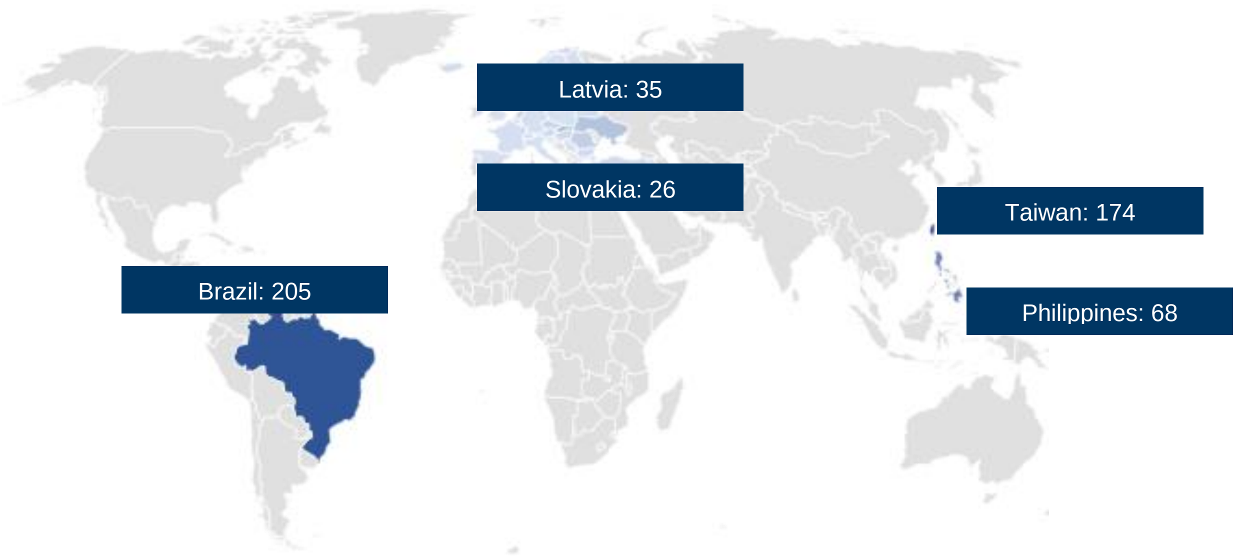
Similar to the GDP contribution, the impact of the program in terms of employment is the highest in Germany. The program will support in total 20,680 jobs between 2014 and 2030, followed that by UK (10,110 jobs), Italy (3,819 jobs), Spain (3,271), and Poland (2,442) (Figure 19).

Figure 19: Direct and Spillover jobs supported by the Graphene Flagship in Europe and selected countries (in head count).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Figure 20: Employment factor[39] in the Europe and selected countries[40].



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Though the total absolute number of jobs are the highest in Germany, UK, and Italy, the employment factor along the supply chain will be the highest for Brazil, i.e., 205. This means for every job that will be supported directly in Brazil, 205 jobs will be supported along Brazil's supply chain. This will be followed by an employment factor of 174 in Taiwan, 68 in the Philippines, 35 in Latvia, and 26 in Slovakia (Figure 20).

3.4 Impact by sector

The impact in the European and selected countries can be represented by industry or sector as well (Figure 21). The analysis shows, in terms of GDP contribution, the highest impact will be in the electrical equipment sector, followed by the computer, electronic and optical products, manufacture of other non-metallic mineral products, scientific R&D, and manufacture of chemicals and chemical products [41]. These top five sectors will make more than 90 percent of the

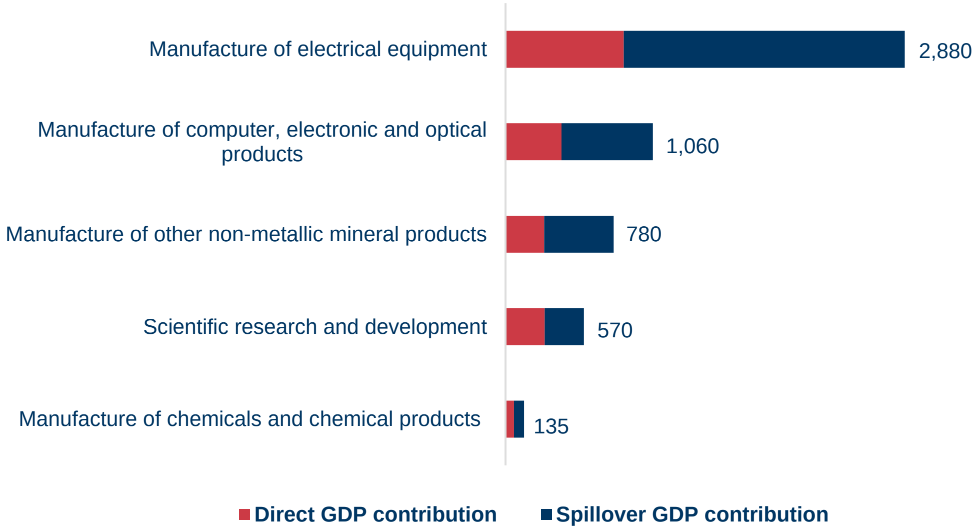
39 This represents persons in head count per one unit of economic production value.

40 This is to note that these numbers represent the impact on these countries but not impact of these countries. Thus, it can be stated that these numbers represent the impact of Graphene's R&D and business activities in Europe on these European countries.

41 This analysis is based on the economic sectors of Graphene's all partners since its inception, Graphene's current European market estimate (2014-2024) and Graphene's projected European market (2025-2030).

GDP contributed to the region. This sectoral classification is based on the Statistical Classification of Economic Activities in the European Community, commonly known as NACE. This is the standard industrial classification system used in the European Union.

Figure 21: GDP contributed to the European and selected countries by top five sectors (in € million).



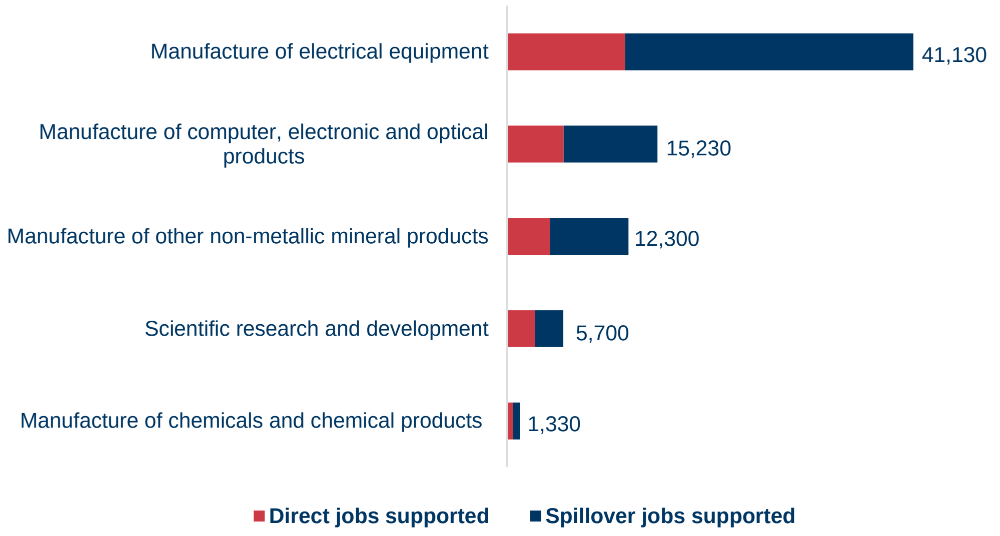
Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Apart from these sectors, the remaining will be the coke and petroleum industry, pharmaceutical industry, the rubber and plastics industry, metal products industry, machinery, motor vehicles, the automobile industry, other transports, and consultancy activities.

Similarly, in case of employment, the manufacturing of electrical equipment sector will make up the largest part of the total employment supported among all the fourteen sectors that are related to the program. This will be followed by the computer, electronic and optical products, manufacture of other non-metallic mineral products, scientific R&D, and manufacture of chemicals and chemical products [42] (Figure 22). Again, these top five sectors will make more than 90 percent of the total employment supported in the EU27.

42 This analysis is based on the economic sectors of Graphene's all partners since its inception, Graphene's current European market estimate (2014-24) and Graphene's projected European market (2025-2030).

Figure 22: Employment supported to the European and selected countries by top five sectors (in head count).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Among all the sectors, both in GDP contributed and employment supported, the manufacturing of electrical equipment sector alone is 50 percent of all the sectors.

4 Outlook

This study measures the impact of Graphene's European R&D and business-related activities on the global economy. By investing around €1.4 billion into Graphene's European R&D and business activities[43], the funding entities will have contributed €5.9 billion to the world GDP and supported 81,400 jobs around the world between 2014 and 2030 – of which 65 and 47 percent occurred in the EU27, respectively[44]. Thus, the Graphene Flagship[45] has already successfully contributed towards supporting the European graphene market, which is growing at an annual rate of 30 percent[46].

However, in the past ten years, not just Europe but other parts of the world have also benefited from the technological advances made by the Graphene Flagship. This has been anticipated by various market studies where emerging markets like India, China, Malaysia, Thailand, and Taiwan, due to their increased manufacturing operations in industries related to graphene's main impact, such as the electronics, computer, and optical product sector, will have a critical role to play in the global graphene market[47]. A small portion is already captured by the existing study since the Graphene Flagship has project partnerships with Taiwan and the Philippines. The study also shows that the program will have high spillover effects in China, USA, India, and Russia, both in terms of GDP contribution and jobs supported. The USA is another country with a huge market potential. The country is home to the largest graphene industry in the whole of North America and already is a key exporter of graphene-based products to other countries that do not have the potential to produce graphene[48].

43 The €1.4 bn public and private investment in the program are excluding the investments from the market share estimation and the market projection.

44 The share of the economic impact in terms of GDP contribution and employment inside the EU27 region is not the same due to a more labor-intensive production of the supply chain outside the EU27 compared to the EU27.

45 The Flagship has been progressively developing graphene technologies and already 30 percent of the program's current budget is being allocated to company led initiatives that have the goal to produce industrial prototypes using graphene and layered material in the coming recent years.

46 This refers to the annual global market growth rate. The growth rate was estimated using the global market estimates of Graphene between 2018 and 2023 retrieved from 25 global market studies provided by the Fraunhofer-Institut für System- und Innovationsforschung ISI.

47 Acumen (2019). Graphene Market (By Product: Graphene nanoplatelets, Graphene oxide, Others; By Application: Electronics, Composites, Energy, Others) - Global Industry Size, Share, Trends and Forecast 2019 - 2026

48 GVR (2020). Graphene Market Size, Share & Trends Analysis Report by Application (Electronics, Composites, Energy), By Product (Graphene Nanoplatelets, Graphene Oxide), By Region, And Segment Forecasts, 2020 – 2027.

Furthermore, the demand for the material is not just anticipated to be driven by the electronic industry but also from demand across industries such as marine, automotive, and aerospace and of course the scientific research and development sector, which will constantly remain an important industry involved in graphene's applied R&D. Moreover, the excellent properties of graphene like its durability, strength, conductivity, and toughness, are the major reasons for the growth of its usage, i.e., it is 200 times[49] stronger than steel and relatively more robust than diamond. These features will propel the growth of the material not just from the bigger companies but demand from small and medium-sized enterprises will also spur growth of the material and its technologies.

Finally, due to the nature of technology, R&D and business-related activities based on the industrial application of graphene will have their regional hotspots in terms of the concentration of GDP and labor market contribution in different parts of the world. The economic impact of these activities and their regional hotspots are yet to be captured by a global level impact analysis.

Apart from regional coverage, this study is also distinct in terms of the methodology used. The availability of studies that assess the economic impact of publicly funded projects is sparse. The methodologies used in these studies are also different, thus lack comparability especially with this study.

49 https://graphene-flagship.eu/graphene/news/graphene-a-nobel-story/

Appendix

I. Methodology

In this study, Graphene Flagship's both direct and spillover GDP contribution has been estimated in accordance with the the system of national accounts (SNA). According to SNA, the GDP is viewed as an aggregate measure of economic value added that can be compiled via three ways: the production (also called output), the income, and the expenditure approach. Behind these three approaches lies the idea of product balances. This means that the same amount of final value produced to use within an economy must be distributed for intermediate consumption, final consumption, capital formation (including changes in inventories), and exports to avoid double-counting. The national product balance can be stated as such:

$$output = \ intermediate\ consumption + final\ consumption + capital\ formation$$ [50]

i. Output Approach

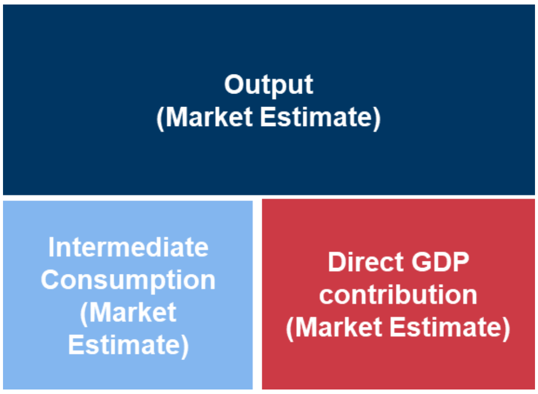
$$GDP\ contribution = Output - Intermediate\ consumption$$

This approach shows how much value is contributed at each stage of production. It is calculated by summing the GDP contribution of all economic actors. GDP contribution for each economic actor is calculated based on output and intermediate consumption. This approach was followed to estimate the GDP contribution of Graphene's European market estimates and European market projections (Figure 23).

---

50 According to the SNA, 2008 statistical framework of the European Communities, International Monetary Fund, Organization for Economic Cooperation and Development, United Nations and World Bank, the output is defined as the goods and services produced by institutional units in which labor and assets are used to transform inputs of goods and services. Moreover, all output must be such that it can be sold on markets or at least be capable of being provided by one unit to another, with or without change. Intermediate consumption consists of goods and services used up in the course of the production within the accounting period. Final consumption consists of goods and services used by individual households or the community to satisfy their individual or collective needs and wants. The activity of gross fixes capital formation is restricted to institutional units in their capacity as producers, being defined as the value of their acquisitions less disposals of fixed assets.

Figure 23: Output approach to estimate GDP contribution.



Source: WifOR-illustration based on the European System of National Accounts 2010 (implemented in 2014).

Therefore, the direct GDP contribution was estimated as:

$$GDP\ contribution = European\ Market\ Estimate\ \times GDP\ contribution\ ratio$$

Here, GDP contribution ratio is the GDP contributed per Gross Output. The country and sector specific ratios are used to estimate the GDP contribution.

The employment supported directly is also estimated using a similar employment ratio, wherein employment ratio is the number of employees supported per Gross Output. This employment ratio is then multiplied with the European Market estimate and European Market projection to estimate the direct employment supported.

$$Employment\ ratio = \frac{Number\ of\ employees}{Gross\ output}$$

$$Direct\ Employment = European\ Market\ Estimate\ \times Employment\ ratio$$

ii. Income Approach

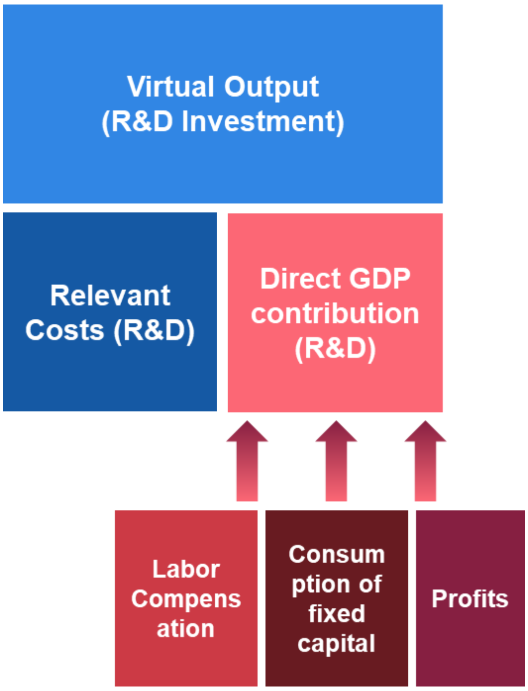
$$GDP\ contribution = Compensation\ of\ employees + Consumption\ of\ fixed\ capital + other\ taxes\ minus\ other\ subsidies\ on\ production + Net\ Operating\ Surplus\ Value$$

This approach measures GDP contribution by adding the incomes that industries need to pay to the different production factors, i.e., labor and capital, that contribute to the output. Additional elements are taxes and subsidies and profits or net operating surplus. However, in case of the capitalization of research and development activities, the income approach is recommended because of the lack of data to estimate using the output approach (

Figure 24). This approach follows international guidelines by the OECD and the recommendations of the European system of national accounts, thus is in line and directly comparable to international macroeconomic figures[51].

The system of national accounts (SNA) provides a binding framework for calculating a country's GDP. Starting from September 2014, research, and development (R&D) services are no longer recorded purely production inputs[52]. Instead, a revision implemented in 2014 included the recommendation to treat R&D as contributor to economic growth and creator of a capital asset. The revision fundamentally changed the valuation of R&D: R&D expenditure must now be categorized as intellectual property, which creates an economic value for the economy regardless of its possible return. This change in definition alone led to an upward correction of the GDP of several countries in 2014.

Figure 24: Income approach to estimate GDP contribution.



Source: WifOR-illustration based on the European System of National Accounts 2010 (implemented in 2014).

51 Compare with the European system of national accounts, ESA 2010, Eurostat, European Commission, European Union, 2013 and the Manual on measuring Research and Development in ESA 2010, Eurostat, European Commission, European Union, 2014.

52 Meaning that R&D is treated as intermediate consumption and is assumed to be completely consumed in the value chains of the users in the current business cycle. For references see: System of National Accounts 2008; European system of accounts ESA 2010; Frascati Manual 2015, OECD; Forschung und Entwicklung in den Volkswirtschaftlichen Gesamtrechnungen, VGR, Destatis; Erhebung für Forschung und Entwicklung, Stifterverband; Identifikation der Unternehmen mit F&E Aufwendungen, Schweizerische Eidgenossenschaft that are completely consumed in the value chains of the users in the current business cycle, but as gross fixed capital formation that are used in several production cycles.

The personnel cost was provided from Graphene's database, however for the remaining direct GDP of R&D components, the virtual gross mark-up technique (VGM) was used based on country- and industry-specific estimates. The VGM ratio is an average industry markup ratio based on data published by OECD for each industry per country and reflects the national differences in personnel cost, capital intensity and profitability of an industry with regards to total industry personnel cost per country. The statistical industry VGM ratio per country is multiplied with a company's or an organization's personnel cost for research & development per country to receive the Virtual gross margin (VGM) on country level. Here the VGM was estimated as:

$$VGM_{industry=}\frac{GVA_{(country,industry)} - compensation\ of\ employees_{(country,industry)}}{compensation\ of\ employees_{(country,industry)}}$$

Then, this VGM was multiplied with Graphene's personnel cost for R&D activities. Consequently, the direct GDP contribution yields:

$$Direct\ GDP\ contribution = Personnel\ Cost\ \times (1 + Virtual\ Gross\ Markup)$$

Like the employment calculated for the European market estimate and European market projection, the employment of Graphene's R&D activities supported directly was estimated using the employment ratio, which was then multiplied with the personnel cost that represents compensation of employees where,

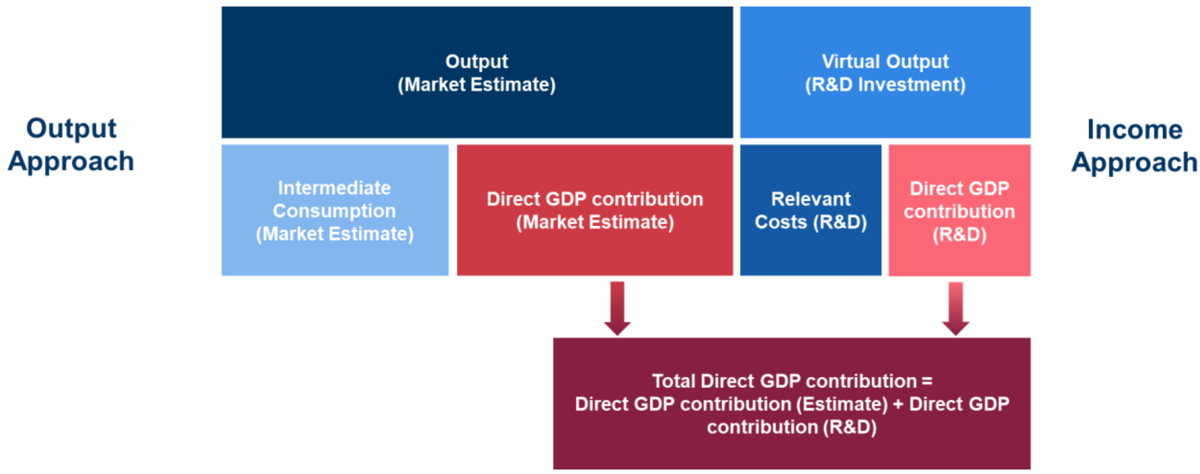
$$Employment\ ratio = \frac{Number\ of\ employees}{Compensation\ of\ employees}$$

$$Direct\ Employment = Personnel\ cost\ \times Employment\ ratio$$

iii. Income and Output approach combined.

The two approaches combined provide the holistic view of estimating GDP contribution for both Graphene's R&D activities and Graphene's European market estimates and European market projections (Figure 25).

Figure 25: Combined methodologies of investment in R&D and market estimates.



Source: WifOR-illustration based on the European System of National Accounts 2010 (implemented in 2014).

In addition to the direct effects, the study not just estimates the direct effects of Graphene's activities but also the indirect and induced effects occurring in the supply chain, combinedly called the spillover effects. The indirect effects triggered due to the purchase of material and services along the supply chain and the induced effects are triggered due to the demand occurring from the disposable income of people employed. The computation formulae for indirect effects are:

i. $Indirect\ GDP\ contribution = Other\ Cost^{53} \times GDP\ contribution\ multiplier\ (indirect)$

ii. $Indirect\ EMP = Other\ Cost\ \times GDP\ contribution\ multiplier\ (indirect)$

wherein, GDP contribution multiplier is the GDP contributed per spent by country and sector, where the spent here is the demanded production throughout the supply chain by the purchase of goods and services either by the companies or the households.

The induced effects are estimated as:

i. $Induced\ GDP\ contribution = \big((1 - Tax\ wedge) \times Personnel\ Cost\big) + Other\ Cost) \times (GDP\ contribution\ multiplier(induced))$

ii. $Induced\ EMP = \big((1 - Tax\ wedge) \times Personnel\ Cost\big) + Other\ Cost) \times (EMP\ multiplier(induced))$

wherein, the employment multiplier is the employment supported per spent by country and sector, where the spent here is the demanded production throughout the supply chain by the purchase of goods and services either by the companies or the households.

iv. Input-output modelling for supply chain analysis

In Input-Output-Modelling, the entire value chain of the company or organization can be accounted for. The estimations are based on primary financial data (a detailed list with region-specific information regarding the amount and type of goods purchased and sold) that are then translated into economic indicators. As both approaches deliver valuable results, efforts were made to match bottom-up and top-down approaches (Beylot, Corrado, and Sala 2019[54]). Integrating results from bottom-up assessments into the top-down Input-Output-framework allows to enhance data quality while not restricting the scope of analysis.

53 For European market estimates and projections, intermediate consumption has been used as a proxy based on the IO-Model benchmark.

54 Antoine, B., Corrado, S., and Sala, S. (2019), Environmental Impacts of European Trade: Interpreting Results of Process-Based LCA and Environmentally Extended Input–Output Analysis towards Hotspot Identification. The International Journal of Life Cycle Assessment, July. https://doi.org/10.1007/s11367-019-01649-z.

Input-Output analysis was originally developed by Wassily Leontief (Leontief 1936[55]) to describe the industrial structure of an economy and understand how changes in one economic sector may affect other sectors. Leontief is known for his research on IO-Analysis and earned the Nobel Prize in Economics for his development of its associated theory in 1973. Applying the technique of IO-Analysis, it is possible to trace the inputs of production along the entire supply chain. This allows for the calculation of upstream impacts of a company or an organization. In addition to the direct effects, which describe the immediate effects directly generated by a company or an organization, input-output analysis allows for the calculation of (indirect) upstream effects. Upstream effects arise due to the input the company or the organization demands from other economic agents. Order placements result in an increase of economic activity at commissioned agents and their suppliers. This stimulus increases the gross value added (GVA) and other key figures along the supply chain, which are summarized under the term upstream effects. The model comes with an array of assumptions[56], however it is widely agreed that it is well suitable for impact analysis.

The basis for the calculation of indirect effects can be illustrated by the following equilibrium equation:

$$x = Ax + y \rightarrow x = (I - A)^{-1}\, y \quad (1)$$

where x represents the vector of total gross output of a sector and y represents the vector of final demand and includes domestic consumer spending, assets, changes in inventories and exports. A represents the matrix of intermediate consumption per unit of output.

Equation (1), with $L = (I - A)^{-1}$being the Leontief inverse, can be determined by the following mathematical transformation:

$$x = Ax + y$$

$$y = x - Ax$$

$$y = (I - A)x$$

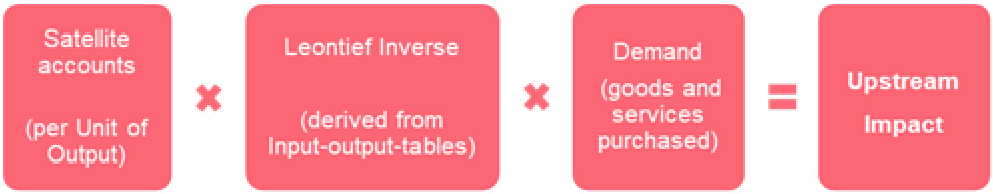
since $(I - A)^{-1} \times (I - A) = 1$, with I being the identity matrix, $x = y\,(I - A)$ equals $x = (I - A)^{-1}\, y$.

55 Leontief, Wassily W. (1936). Quantitative Input and Output Relations in the Economic Systems of the United States. The Review of Economics and Statistics 18 (3): 105. https://doi.org/10.2307/1927837.

56 The assumptions of the Leontief model are: 1) Constant returns to scale, meaning that regardless of the level of production, the same quantity of inputs is needed per unit of output. 2) No Supply Constraints, meaning there are no restrictions to raw materials, services or other inputs such as employment. 3) Fixed Input Structure: meaning that there is no input substitution in response to a change in output.

With x, the output triggered by a given demand y, the corresponding GVA can be derived using country and sector specific ratios of GVA to output. Other effects (e.g., employment) are calculated analogously using respective satellite accounts (Figure 26). In simple terms the indirect (upstream) impact of a company or an organization is the result of the multiplication of three components.

Figure 26: Components of upstream calculation.



Source: WifOR illustration.

As shown in Figure 26, the calculation of upstream impacts requires input-output tables to derive the Leontief Inverse, corresponding satellite accounts, and a detailed purchasing list / other costs of the company or the organization under investigation.

II. Impact on rest of the world other than the impact on EU27

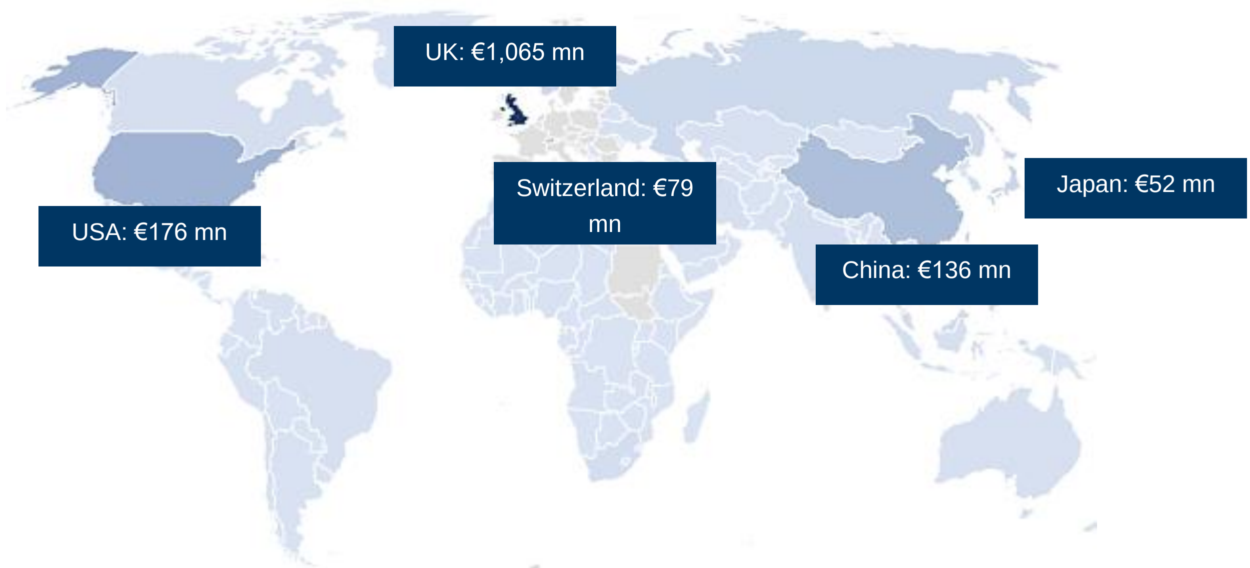
This section addresses the impact of the Graphene Flagship on all the countries of the world other than the EU27 that are directly a part of the program. These results include the impact on 161 countries in total which is based on the WifOR's global multiregional IO-model that includes 188 countries in total. The Graphene Flagship will have supported a total of €2.1 billion between 2014 and 2030 in the rest of the world because of its business and R&D activities. This concludes that 65 percent of the global impact of the program is impacting the 27 countries of the EU27 and only 35 percent takes place in the rest of the world.

Figure 27: Direct and spillover GDP contribution effects of Graphene Flagship in the Rest of the World with respect to the impact on EU27 (2014-2030).

Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI. Note: RoW: Rest of the World with regards to the EU27 countries.

Figure 27 shows that the program will contribute €2.1 billion in terms of GDP contribution in all the countries except the EU27 countries, out of which €0.4 billion will be in the countries directly and €1.7 billion as spillover effects in the global supply chain. This means that for every euro of GDP contributed directly by Graphene's R&D activities in the countries, a further €3.7 of value will be created along the global supply chain between 2014 and 2030. Therefore, the GDP contribution factor for the rest of the world with respect to EU27 countries is 3.7.

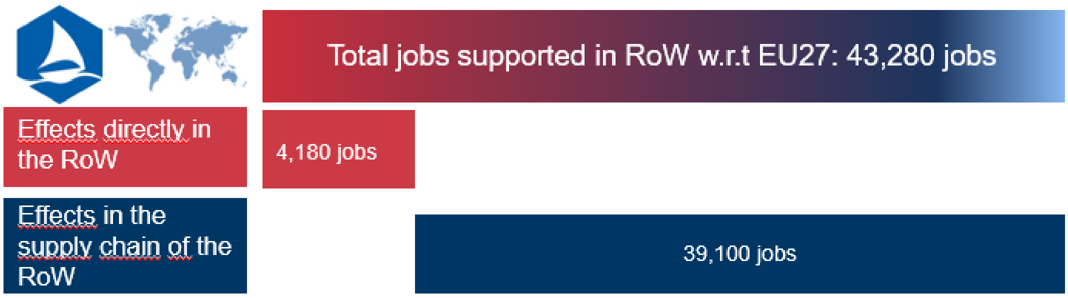
Figure 28: GDP contribution by country in the Rest of the World with respect to the impact on the EU27 countries.



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

Furthermore, the employment supported by the program equals 43,280 jobs in total in the rest of the world with respect to the impact on the EU27 (Figure 29). Out of the total jobs supported, 4,180 jobs will be supported directly in 161 countries of the world, and 39,100 jobs will be supported indirectly in the supply chain of these countries.

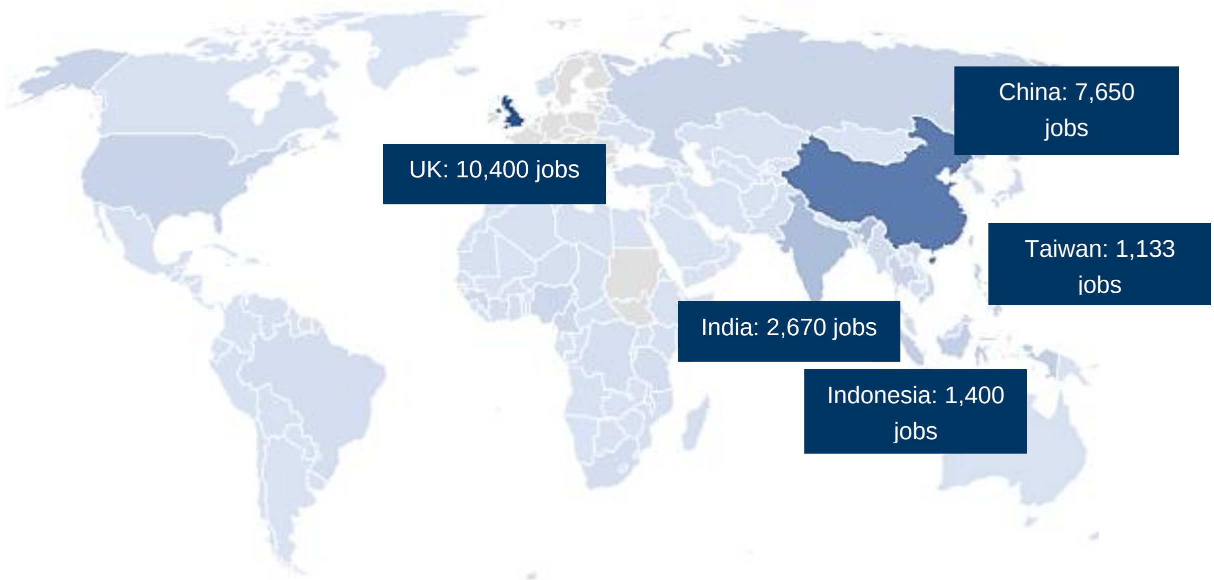
Figure 29: Direct and spillover employment supported by the Graphene Flagship in the Rest of the World with respect to EU27 (2014-2030).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI. Note: RoW: Rest of the World with regards to the EU27 countries

This shows that 47 percent of the total employment supported by the program in the world lies in the EU27 and rest 53 percent in the rest of the world. The impact also shows that for every job supported directly in the 161 countries, 9.4 jobs will be supported indirectly in their supply chain. Therefore, the employment factor for the rest of the world with respect to EU27 countries is 9.4.

Figure 30: Employment supported by country in the Rest of the World with respect to EU27 countries.



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

III. Impact on Rest of the World with respect to Europe and selected countries

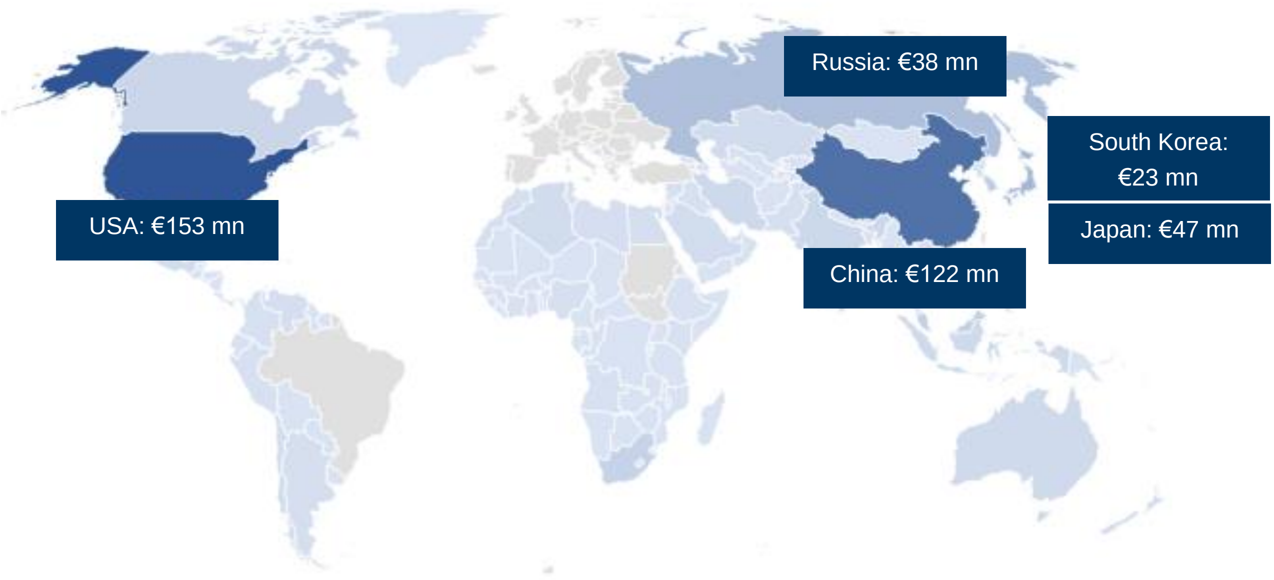
This section reflects on the global impact of the Graphene Flagship on all the countries of the world except Europe and selected countries that are directly a part of the program. These results include the impact on the 188 countries except for the 37 countries included in Europe that are a part of the Graphene program. This totals 151 countries. The Graphene Flagship's impact on the rest of the world (RoW) will have supported a total GDP contribution of €685 million between 2014 and 2030 in 151 countries because of its business and R&D activities. This means that 88 percent of the global impact occurs in the 37 European and selected countries of the program and only 12 percent takes place in the rest of the world.

Figure 31: Direct and spillover GDP contribution effects of Graphene Flagship in the Rest of the World with respect to Europe and selected countries (2014-2030).

Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI. Note: RoW: Rest of the World with regards to Europe and selected countries.

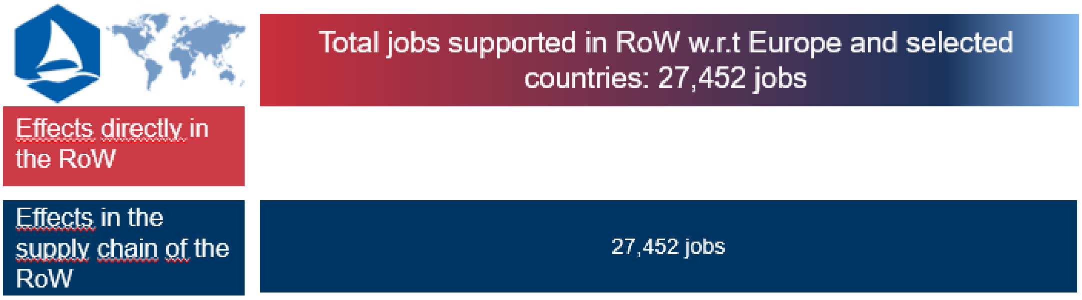
This shows that the program will contribute €685 million in terms of GDP contribution in the rest of the world when deducting the 37 countries in Europe that the program covers, and the total GDP contribution will be in the form of a spillover effect in the global supply chain, thus having no direct effect (Figure 31).

Figure 32: GDP contributed by country in the Rest of the World with respect to Europe and selected countries.



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

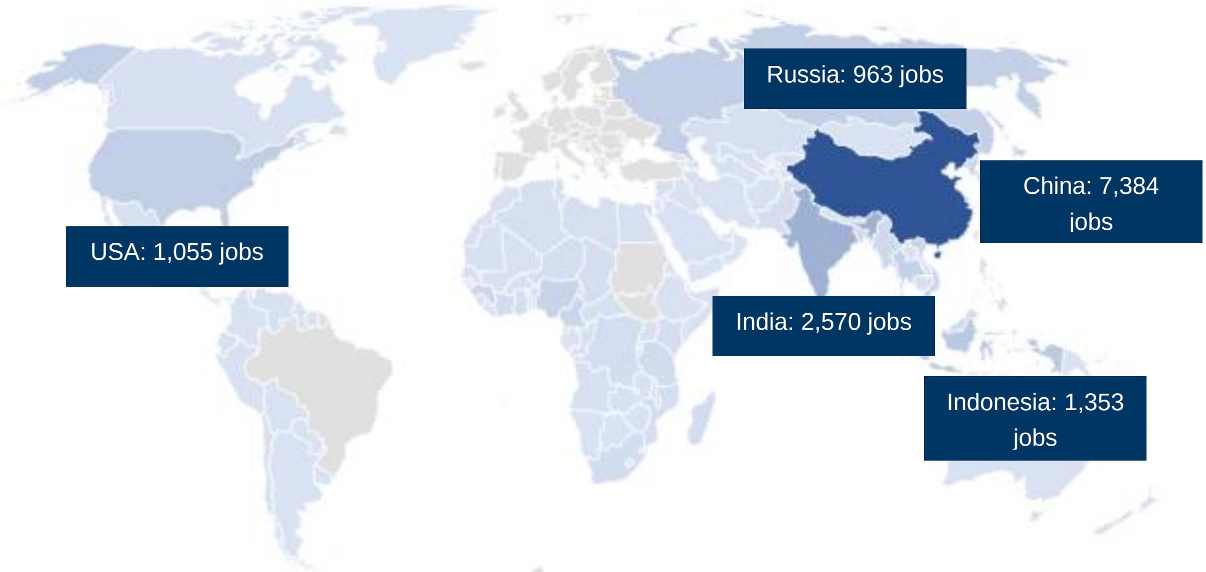
Figure 33: Direct and spillover employment supported by the Graphene Flagship in the Rest of the World with respect to Europe and selected countries (2014-2030).



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI. Note: RoW: Rest of the World with regards to Europe and selected countries.

The employment supported by the program equals 27,452 in total in the rest of the world with respect to the European and selected countries of the program (Figure 33). All the jobs supported jobs will be supported in the supply chain of the rest of the world and none directly.

Figure 34: Employment supported by country in the Rest of the World with respect to Europe and selected countries.



Source: WifOR's own calculations. Data on investment per project by status from Graphene and European market estimate data from Fraunhofer-Institut für System- und Innovationsforschung ISI.

IV. Assumptions

During the study a few assumptions have been made, especially at the data input level. Also, since the study's data was fragmented by entities, that is, at the level of core partners, partnering projects, companies, GRM centres, European market estimates, and European market projects, the assumptions varied according to these classifications. The assumptions for the different data sets by their statuses were:

i. Core Partners

The first assumption was that the Work Packages (WPs) have been used as a reference to the economic sector of each core partner. The Flagship has a total of 19 WPs and with a mutual agreement with Graphene, these WPs were assigned to each NACE code or economic sector. Then based on which core partner belongs to which WP, the NACE codes[57] were assigned.

57 The sectoral classification (mentioned in brackets against every sector name) is based on the Statistical Classification of Economic Activities in the European Community, commonly known as NACE. This is the standard industrial classification system is used in the European Union.

Figure 35: Work Packages by economic sector or NACE code.

	Theme	NACE	Additional suggestions
WP1	Enabling Research	M72	
WP2	Spintronics	C26	
WP3	Enabling Materials	M72	
WP4	Health and Environment	M72	
WP5	Medical Technologies	C26	C21 (for clinical trials only)
WP6	Sensors	C26	
WP7	Electronic Devices	C26	
WP8	Photonics and Optoelectronics	C26	
WP9	Flexible Electronics	C26	
WP10	Wafer-Scale Integration	C26	
WP11	Energy Generation	C27	D35 (for Enel Green Power only)
WP12	Energy Storage	C27	
WP13	Functional Foams and Coatings	C20	
WP14	Composites	C20	
WP15	Production	C23	
WP16	Innovation	M74_M75	
WP17	Dissemination	M69_M70	
WP18	Management	M74_M75	
WP19	Industrialisation	M72	

Source: Comprehended by WifOR and Graphene.

The second assumption was that the partners that have been involved in multiple work packages, the most significant NACE[58] (in terms of amount of funding) was assigned to them out of all the NACE codes belonging to the WPs. However, there were a few partners for which no sector could be assigned due to lack of information, in this case, they were assigned to the most common economic sector 'manufacture of computer, electronic and optical products' or 'C26' (in terms of share of funding). This is based on the highest budget share among all the sectors.

Finally, the total funding received by each core partner was split between personnel and other cost to estimate the economic effects. But since the cost split of every partner or entity involved was not provided, the overall cost split of the phase (FP7, C1, C2, C3 and 2D-EPL) based on which phase they belong to, was assumed to be theirs as well.

58 The acronym NACE, Nomenclature of Economic Activities (or in French; classification des activités économiques), designates the integrated classification system for products and economic activities. NACE codes provide a framework for the collection and presentation, based on economic activity, of a wide range of statistics in economic fields such as production, employment, national accounts, and others.

ii. Partnering Projects, Companies, and GRM Centres

Every partnering project under Graphene constitutes of both or either core partners (CPs) or associated members (AMs). However, the funding received by each core partner or associated member was not provided in the data. Therefore, it was assumed that the project funding has been equally divided among the AMs and CPs involved in the project for Partnering Projects (both FLAGERA and non-FLAGERA[59]). There were some partners and members for which no information on the funding could be found, it was assumed that they had their own funding. The economic sectors for the partnering projects were assigned based on the sector of their WPs, the process similar to the core partners. However, for the GRM centres the economic sector was assigned based on the sector of their hosting organization. For the companies, this was done based on the nature of their own economic activity.
The total funding of these entities was also split in personnel and other cost based on the average split share of the core partners. Lastly, the status of the organizations has been considered as of 1.1.2023.

iii. European Market Estimates and Projections

Graphene's European market value both current (2014-2024) and projected (2025-2030) had to be estimated by country and economic sector to estimate their economic impacts. However, the available data was on global market from 2018 to 2026. This data was adopted from the 25 global market studies[60] provided by the Fraunhofer-Institut für System- und Innovationsforschung ISI. The average of these 25 market studies was used and the interpolation and extrapolation was done using Compound Annual Growth Rate observed between 2018 and 2026. Based on one estimate provided for Graphene's European market value and if the share of the European market remains same in the global market, Graphene's European market value from 2014 to 2024 and projections from 2025 to 2030 were estimated.

Now this European market estimates were split by country and sector. The vendor countries and their corresponding NACE were adopted from the data tables made using the investment or funding information received by every core partner or associated member from Graphene, however only the companies that belonged to these statuses were considered for estimation. The total budget referred to here was the sum of the total budgets of the core partners and the total funding of the partnering projects, centres, and companies. The countries, Armenia, Brazil, Iceland, Israel, Taiwan, and Philippines were eliminated as the focus

59 https://graphene-flagship.eu/collaboration/partner-with-us/partnering-projects-associated-with-the-graphene-flagship/

60 List of studies provided by the Fraunhofer-Institut für System- und Innovationsforschung ISI on market estimate of Graphene: Graphene_Market Value

of market value and projections was to cover only EU27 and other European countries and that too only companies. Lastly, since the global and European market estimates were estimated in USD and the data received from Graphene on funding per core partner or associated member was in EUR, an average exchange rate of 0.85074[61] from 2013-2021 was used to convert the data in USD to EUR.

iv. Assumptions for calculations

- **Direct impacts**

The GDP contribution is based on industry averages by country and sector. Same for employment supported, that industry averages are used by country and sector. For all the entities belonging to Belarus, Ukraine's industry averages were used for them for the assurance of data quality.

- **Spillover impacts**

The input-output model was used that covers 56 sectors across 188 countries. The economically extended input-output model for GDP contribution and the socially extended input-output model for employment was used.

V. Review of comparative studies

This study has tried to answer one key question that is, what are the economic benefits of public funding supporting research and development. Though many studies have tried to answer the same question, but because of the uniqueness of this study due to its methodology and scope, it cannot be compared to any other similar study. However, here few studies with a similar objective that have been reviewed.
Based on the objective, there are multiple approaches or methodologies that can be applied. The three most accepted ways are econometric studies, surveys, and case-studies[62]. This study, on the Graphene Flagship, has used an approach based on econometrics that includes the use and analysis of large statistical databases and establish economic linkages using statistical techniques.

Many studies have computed the rate of return of public R&D to estimate the economic benefits of a publicly funded program. Mansfield et al.[63] computed the private and social internal rates of return of 17 industrial innovations. The results showed that the social rate of return

61 https://data.oecd.org/conversion/exchange-rates.htm

62 Martin, B.R. and Tang, P. (2006), The Benefits of Publicly Funded Research, Commissioned by The University of Manchester Intellectual Property Limited, Science and Technology Policy Research, University of Sussex, Brighton, UK.

63 Mansfield, E., Rapoport, J., Romeo, A., Wagner, S., and Beardsley, G. (1977), Social and private rates of return from industrial innovations, Quarterly Journal of Economics, 77, 221-240.

exceeded the private return, wherein the median social rate of return was 56 percent, and the median private rate of return was 25 percent. Mansfield[64][65][66] focused on the impact of academic research and concluded that the rate of return from academic research to be 28 percent[67]. Toole [68] showed that in a biomedical industry, a one percent increase in the stock of public basic research leads to a 2 to 2.4 percent of increase in the number of commercially available new compounds. Another important example was of a case-study by Griliches [69] on the calculation of the social rate of return to research in hybrid corn. All the private and public R&D expenditure on hybrid corn between 1910 and 1955 were aggregated and a projected future return was calculated. A perpetual annuity of USD 7 per dollar spent on R&D was estimated or an equivalent internal rate of return equalizing R&D expenditures and net social returns of 35 to 40 percent was estimated.

Another substantial part of economic impact measuring studies is the estimation of spill-over effects of public funding into industrial R&D. Bresnahan [70] estimated the welfare gains from the reduction in the price-performance ratio of computers used in financial services. The value of the computer price-reducing innovation was inferred from the willingness to pay by the firm and its customers. The spillover effect estimated from the adoption of mainframe computers in the financial sector was at least five times compared to the expenditure in it in 1972. Since the R&D spillover effects can be international as well, Coe and Helpman [71] estimated the international R&D spillover effects on total factor productivity (TFP). The study was conducted for 22 countries and the share of imports from the sending country as weights to aggregate R&D was used. Its rate of return to R&D was estimated to be 123 percent for the G-7 countries and 85 percent for the other 15 countries, and the spillover return from G-7 was 32 percent, implying that roughly a quarter of the benefits from R&D in G-7 countries can be attributed to their trading partners.

64 Mansfield, E. (1991), Academic research and industrial innovation, Research Policy, 20, pp.1-12.

65 Mansfield, E. (1995), Academic research underlying industrial innovations: sources, characteristics and financing, Review of Economics and Statistics, 77 (1), pp. 55-62.

66 Mansfield, E. (1998), Academic research and industrial innovation: an update of empirical findings, Research Policy, 26, pp. 773-776.

67 Hall, B.H., Mairess, J., and Mohnen, P. (2009), National Bureau of Economic Research working paper Measuring the Returns to R&D, NBER, Cambridge, MA, USA.

68 Toole, A. (1999), The impact of federally funded basic research on industrial innovations: Evidence from the pharmaceutical industry. Stanford Institute for Economic Policy Research, Stanford, C.A, SIEPR Discussion paper No. 98-8.

69 Griliches, Z.. (1995), R&D productivity, in P. Stoneman (ed.), Handbook of Industrial Innovation, Blackwell Press, London, pp. 52-89.

70 Bresnahan, T. (1986), Measuring spillovers from 'technical advance", American Economic Review, 76, 741-755.

71 Coe, D. T., and Helpman, E. (1995), International R&D Spillovers, European Economic Review, 39, 859-887.

Like the finding of this study, the results of these studies clearly state that publicly funded R&D programs have a positive benefit on the economy exceeding the initial funding and/or investment. However, because of different methodologies used and the use of different measuring metric of economic benefits, this study's results cannot be directly compared to the already existing studies.

VI. Limitations of the study

This study has a number of limitations. The economic impact estimates for the program are based on the data received from the Graphene Flagship for the different entities involved. In order to structure the data in a usable form to estimate the economic impact, a few assumptions had to be made because of unavailability of information and heterogeneity of data available. Thus, there lies scope for refinement subject to data quantity. For example, the study was unable to estimate the impacts of the members associated with the program that had their own or private or third-party funding in the partnering projects. Furthermore, it was assumed that all the core partners and members associated with the partnering projects received an equal amount of funding as a part of the program. Therefore, the results of the impact of the partnering projects may be conservative estimates and the study underestimates the full economic impacts created by them.

As part of its strategy to expand the industrial use of the material, the Flagship has been associated with many companies to boost the manufacturing of graphene and its related materials. These collaborations are often supported by private investments made by these companies, but this study is unable to capture the actual impact of all these private investments. This has been due to the lack of data despite attempting to reach out directly to the companies that have a 'standing-on-shoulder' effect[72]. This impelled the study to estimate the value of the 'standing-on-shoulder' effects using the already existing data on the companies involved in the project as either core partners or associated members. The volume of graphene's global and European market estimate was used as a base to estimate the country-wise market value. The initial market value used was the average of 25 global level studies that determined the global turnover of graphene. However, the country-wise split of the market value was done based on the knowledge already available on the involved companies and small and medium-sized enterprises (SMEs) provided by Graphene (i.e., from Table 1 and Table 2). Therefore, this approach falls short of encompassing the actual value of graphene's industrial market because of the unavailability of real data on companies' private investment.

72 The 'standing-on-shoulder' effect is the impact created by the use of past inventions to boost the current rate of inventions. More the effect, faster the growth will be. In this case, the companies or organisations that had used the inventions related to graphene or its related materials or the products made out of the material to further produce or invent new products, would have had 'standing on shoulder 'effects.

Regarding the regional coverage of Graphene's market, only the European market has been considered due to the lack of reliable data available to estimate global level estimates of graphene. There were possible blind spots in the estimates provided at the global level as well. The quality of the results provided by the global level studies was also unreliable because only a very limited number of companies were used to estimate the global level market estimates and the estimates were also extrapolated. Thus, the market value exercise was restricted to the European market. However, there is a vast global market for graphene and its related products that already exists in other parts of the world like North America and Asia. This market is also growing at a very large pace and a huge opportunity exists for graphene to expand its horizons, especially on the industrial usage front. Therefore, this is a major limitation of this study as the regional scope of the project is limited to Europe.

The comparability of this study with other studies is also a limitation. This is due to the fact that this study uses a different approach compared to the prior studies even with the same objective. Firstly, there is a clear limitation on the number of studies available that assess the economic impact of projects supported by public funds. Secondly, the Input-Output approach used by the available studies is distinct from the one used by this study.

Finally, the model to assess the economic impact also has limitations. They are, first, constant returns to scale, meaning that regardless of the level of production, the same quantity of inputs is needed per unit of output. Second, no supply constraints which means there are no restrictions on raw materials, services, or other inputs such as employment. And the third, fixed input structure, i.e., there is no input substitution in response to a change in output.

Therefore, despite being a comprehensive analysis on the economic impact of the Graphene Flagship, this study is subject to a few limitations that can be enhanced with an extension of the analysis taking into consideration some of the limitations highlighted above.

VII. List of entities by their type

i. Core Partners

S. No.	Entity Name
1	Aalto Korkeakoulusaatio Sr
2	Abb Ab
3	Airbus Defence and Space Gmbh
4	Internacional De Composites Sa
5	Airbus Helicopters
6	Airbus Operations Sl
7	Aixtron Limited
8	Aixtron Se
9	Amalyst Limited

10	Arcelormittal Espana Sa
11	Gesellschaft Fur Angewandte Mikro Und Optoelektronik Mit Beschrankterhaftung Amo Gmbh
12	Grupo Antolin-Ingenieria Sa
13	Atherm
14	Aurel Spa
15	Avanzare Innovacion Tecnologica Sl
16	Bruno Baldassari & Fratelli Spa
17	Barnices Y Pinturas Modernas Sociedad Anonima
18	Basf Se
19	Bedimensional Spa
20	Bioage Srl
21	Bayerische Motoren Werke Aktiengesellschaft
22	Universitaet Fuer Bodenkultur Wien
23	Robert Bosch Gmbh
24	Breton Spa
25	Boston Scientific Limited
26	Christian-Albrechts-Universitaet Zu Kiel
27	Commissariat A L Energie Atomique Et Aux Energies Alternatives
28	Consorcio Centro De Investigacion Biomedica En Red M.P.
29	Centro De Investigacion Cooperativa De Energias Alternativas Fundacion, Cic Energigune Fundazioa
30	Asociacion Centro De Investigacion Cooperativa En Biomateriales- Cic Biomagune
31	Stiftelsen Chalmers Industriteknik
32	Consorzio Nazionale Interuniversitario Per Le Telecomunicazioni
33	Cnm Technologies Gmbh
34	Crayonano As
35	Consiglio Nazionale Delle Ricerche
36	Centre National De La Recherche Scientifique Cnrs
37	Composites Evolution Limited
38	Confinis Ag
39	Centro Ricerche Fiat Scpa
40	Cambridge Raman Imaging Ltd
41	Agencia Estatal Consejo Superior Deinvestigaciones Cientificas
42	Chalmers Tekniska Hoegskola Ab
43	Dallara Automobili Spa
44	Fundacion Donostia International Physics Center
45	Metrohm Dropsens Sl
46	Dsm Ahead Bv
47	Delta Tech Spa
48	Danmarks Tekniske Universitet
49	Ericsson Ab
50	Enel Green Power Spa
51	Emberion Ltd
52	Emberion Oy
53	Eidgenossische Materialprufungs- Und Forschungsanstalt
54	Epcos Ag
55	Ecole Polytechnique Federale De Lausanne
56	Fondation Europeenne De La Science

57	Eidgenoessische Technische Hochschule Zuerich
58	Evonik Operations Gmbh
59	Friedrich-Alexander-Universitaet Erlangen-Nuernberg
60	Fondazione Bruno Kessler
61	Flexenable Limited
62	Fondazione E. Amaldi
63	Fundacion Para La Investigacion, Desarrollo Y Aplicacion De Materiales Compuestos
64	Finisar Germany Gmbh
65	Tyoterveyslaitos
66	Albert-Ludwigs-Universitaet Freiburg
67	Idryma Technologias Kai Erevnas
68	Fraunhofer Gesellschaft Zur Foerderung Der Angewandten Forschung E.V.
69	Friedrich-Schiller-Universitat Jena
70	G24 Power Limited
71	Guger Technologies Og
72	Galvani Bioelectronics Limited
73	Graphmatech Ab
74	Graphene-Xt Srl
75	Grinp Srl
76	Graphenea Semiconductor Sl
77	Greatcell Solar Italia Societa' A Responsabilita' Limitata
78	Glaxosmithkline Research and Development Ltd.
79	Elliniko Mesogeiako Panepistimio
80	Horiba France Sas
81	Interactive Wear Ag
82	Fundacio Institut De Ciencies Fotoniques
83	Fundacio Institut Catala De Nanociencia I Nanotecnologia
84	Icon Lifesaver Limited
85	Consorci Institut D'investigacions Biomediques August Pi I Sunyer
86	Infineon Technologies Ag
87	Ihp Gmbh - Innovations for High Performance Microelectronics/Leibniz-Institut Fuer Innovative Mikroelektronik
88	Fondazione Istituto Italiano Di Tecnologia
89	Institut Fur Korrosionsschutz Dresden Gmbh
90	Fundacion Imdea Nanociencia
91	Interuniversitair Micro-Electronica Centrum
92	Institute Of Mechanics, Bulgarian Academy of Sciences
93	Imperial College of Science Technology And Medicine
94	Inbrain Neuroelectronics Sl
95	Istituto Nazionale Di Fisica Nucleare
96	Belarusian State University
97	Institut National De La Sante Et De La Recherche Medicale
98	Instituto De Tecnologias Quimicas Emergentes De La Rioja Asociacion
99	Italcementi Fabbriche Riunite Cemento Spa
100	Siec Badawcza Lukasiewicz - Instytut Technologii Materialow Elektronicznych
101	Ustav Fyzikalni Chemie J. Heyrovskeho Av Cr, V. V. I.
102	Karolinska Institutet
103	Karlsruher Institut Fuer Technologie
104	Leonardo - Societa Per Azioni

105	Lufthansa Technik Aktiengesellschaft
106	Libre Societa A Responsabilita Limitata
107	Lithops Srl
108	Linkopings Universitet
109	Laboratoire National De Metrologie Et D'essais
110	Multi-Channel Systems Mcs Gmbh
111	Medica S.P.A.
112	Mellanox Technologies Ltd - Mlnx
113	Max-Planck-Gesellschaft Zur Forderung Der Wissenschaften Ev
114	Micro Resist Technology Gesellschaft Fuer Chemische Materialien Spezieller Photoresistsysteme Mbh
115	M-Solv Ltd
116	Energiatudomanyi Kutatokozpont
117	Research And Development of Nanomaterials And Nanotechnology Nano Techlab Ltd
118	Asociacion Centro De Investigacioncooperativa En Nanociencias Cic Nanogune
119	Nanosc Ab
120	Naturality Research & Development
121	Nawatechnologies
122	Nanesa Srl
123	Nokia Solutions and Networks Uk Limited
124	Nokia Oyj
125	Novalia Limited
126	Npl Management Limited
127	Nokia Solutions and Networks Gmbh &Co Kg
128	Nokia Solutions and Networks Italia Spa
129	University College Dublin, National University of Ireland, Dublin
130	Oxford Instruments Nanotechnology Tools Limited
131	Philips Gmbh (De)
132	Printed Electronics Limited
133	Phi-Stone Ag
134	Pixium Vision
135	Politecnico Di Milano
136	Politecnico Di Torino
137	Polymem S.A.
138	Philips Electronics Nederland B.V. (Nl)
139	Prognomics Ltd
140	Queen Mary University of London
141	Qurv Technologies S.L.
142	Repsol Sa
143	Rf360 Europe Gmbh
144	Rijksuniversiteit Groningen
145	Rheinisch-Westfaelische Technische Hochschule Aachen
146	Siemens Aktiengesellschaft
147	Singulus Technologies Ag
148	Scuola Internazionale Superiore Di Studi Avanzati Di Trieste
149	Schaffhausen Institute of Technology Ag
150	Sixonia Tech Gmbh
151	Stichting Katholieke Universiteit
152	Societe Nationale De Construction Aerospatiale Sonaca Sa

153	Sorbonne Universite
154	Spac Spa
155	Stmicroelectronics Srl
156	Sabanci Universitesi
157	Suss Microtec Lithography Gmbh
158	The Provost, Fellows, Foundation Scholars & The Other Members of Board Of The College Of The Holy & Undivided Trinity Of Queen Elizabeth Near Dublin
159	Technion - Israel Institute of Technology
160	Fundacion Tecnalia Research & Innovation
161	Casals Cardona Industrial Sa
162	Temas Ag Technology and Management Services
163	Temas Solutions Gmbh
164	Toyota Motor Europe Nv
165	Universita Degli Studi Di Roma Tor Vergata
166	Trevira Gmbh
167	Thales
168	Technische Universiteit Delft
169	Technische Universiteit Eindhoven
170	Technische Universitaet Chemnitz
171	Technische Universitaet Dresden
172	Technische Universitat Dortmund (De)
173	Technische Universitat Hamburg
174	Technische Universitaet Muenchen
175	Technische Universitaet Wien
176	Universidad Autonoma De Barcelona
177	Universitaet Augsburg
178	Universitat Basel
179	Universidad Carlos Iii De Madrid
180	The Chancellor Masters And Scholarsof The University Of Cambridge
181	Universite Catholique De Louvain
182	University College London
183	Universidad De Castilla - La Mancha
184	Universite De Strasbourg
185	Ita-Suomen Yliopisto
186	Universitaet Hamburg
187	University Of Lancaster
188	Universite Libre De Bruxelles
189	Universite De Montpellier
190	Umea Universitet
191	Universidade Do Minho
192	Philipps-Universität Marburg
193	Universite De Namur Asbl
194	Universitaet Bielefeld
195	Alma Mater Studiorum - Universita Di Bologna
196	Universitaet Der Bundeswehr Muenchen
197	Universite De Geneve
198	Universitaet Bremen
199	Universite De Lille
200	The University of Manchester

201	Universita Degli Studi Di Padova
202	Universita Di Pisa
203	Universita Degli Studi Di Salerno
204	Universita Degli Studi Di Trieste
205	Uniwersytet Warszawski
206	Universidad De Zaragoza
207	The University of Nottingham
208	Panepistimio Kritis
209	Panepistimio Ioanninon
210	University Of Sunderland
211	The Chancellor, Masters And Scholars Of The University Of Oxford
212	Universitaet Regensburg
213	The University of Sheffield
214	Tartu Ulikool
215	Universitaet Ulm
216	Universitat Zurich
217	Veoneer Sweden Ab
218	Versarien Plc
219	N Vision Systems and Technologies Sl
220	Varta Microbattery Gmbh
221	Varta Micro Innovation Gmbh
222	Teknologian Tutkimuskeskus Vtt Oy
223	The University of Warwick
224	Walter Pak Sl
225	Politechnika Warszawska

ii. Partnering Projects

S. No.	Partnering Project	Organisation Name	Entity Type
1	2DCHEM	UNIVERZITA PALACKEHO V OLOMOUCI	Associated Member
2	2Dfun	Bilkent University	Former Associated Member
3	2Dfun	Oxford Instruments	Core Partner
4	2Dfun	Interuniversitair Micro Electronica Centrum vzw	Core Partner
5	2Dfun	Katholieke Universiteit Leuven	Associated Member
6	2Dfun	Technische Universiteit Eindhoven	Core Partner
7	2DHetero	IHP GmbH – Leibniz Institut für innovative Mikroelektronik	Core Partner - Former Associated Member
8	2DHetero	IEMN (CNRS & University of Lille)	Core Partner
9	2DHetero	University of Namur	Associated Member
10	2D-NEM	RWTH Aachen University	Core Partner
11	2D-NEM	RWTH Aachen University	Core Partner
12	2D-NEM	Graphenea Semiconductor S.L.	Core Partner
13	2D-NEM	KTH Royal Institute of Technology	Associated Member

14	2D-SbGe	Friedrich-Alexander-Universität Erlangen-Nürnberg	Core Partner
15	2D-SbGe	Universidad Autonoma de Madrid	Former Associated Member
16	2D-SbGe	Faculty of Information Studies Novo Mesto	Former Associated Member
17	2DSOTECH	Technische Universität München	Associated Member
18	2DSOTECH	University of Regensburg	Core Partner
19	2DSOTECH	University of Groningen	Core Partner
20	2DSOTECH	Chalmers University of Technology	Core Partner
21	2DSOTECH	Budapest University of Technology and Economics	Associated Member
22	2DSOTECH	Institute of Experimental Physics, Slovak Academy of Sciences	Associated Member
23	3D-Photocat	Universidad de Alicante	Associated Member
24	3D-Photocat	Transilvania University of Brasov	Associated Member
25	3D-Photocat	EPI-SYSTEM SRL	Associated Member
26	3D-Photocat	Universidade Federal de Sao Paulo	Other
27	CERANEA	Fraunhofer IKTS	Core Partner
28	CERANEA	Hungarian Academy of Sciences, Centre for Energy Research	Core Partner
29	CERANEA	Slovak Academy of Sciences	Associated Member
30	CO2 DETECT	Amo GmbH	Core Partner
31	CO2 DETECT	Fundació Privada Institut Català de Nanotecnologica	Core Partner
32	CO2 DETECT	KTH Royal Institure of Technology	Associated Member
33	CO2 DETECT	SenseAir AB	Former Associated Member
34	COEx-An	University of Rome Tor Vergata (URTV)	Core Partner
35	COEx-An	The CNR Institute SPIN (SPIN)	Core Partner
36	COEx-An	University of Exeter (UNEXE)	Associated Member
37	COEx-An	University of Eastern Finland (UEF),	Associated Member
38	COEx-An	University of Iceland (UI)	Former Associated Member
39	COEx-An	Research Institute for Nuclear Problems of Belarusian State University (INP BSU)	Former Associated Member
40	COEx-An	Yerevan State University (YSU),	Former Associated Member
41	COEx-An	De La Salle University (DLSU),	Other
42	COEx-An	V.Lashkaryov Institute of Semiconductor Physics, National Academy of Sciences of Ukraine (ISP),	Former Associated Member
43	DeGraph	University of Trieste	Core Partner
44	DeGraph	Helmholtz Institute Freiberg for Resource Technology (HZDR-HIF)	Associated Member
45	DeGraph	University of Strasbourg	Core Partner
46	DeGraph	CNRS	Core Partner
47	DeGraph	Graphenea	Core Partner
48	DeGraph	University Castilla-La-Mancha	Core Partner
49	DeGraph	Institute of Microbiology, Bulgarian Academy of Sciences	Associated Member
50	DeMeGRaS	CNRS/ L2C	Core Partner
51	DeMeGRaS	University of Regensburg	Core Partner
52	DeMeGRaS	Chalmers University of Technology-MC2, Quantum Device Physics Laboratory	Core Partner
53	DIMAG	Hamburg University - Physics Department	Core Partner - Former Associated Member

54	DIMAG	CNRS	Core Partner
55	DIMAG	KU Leuven, Laboratory for Semiconductor Physics	Associated Member
56	DIMAG	KU Leuven- Institute for Nuclear and Radiation Physics	Associated Member
57	DIMAG	Unviersity of Nova Gorica-Laboratory of Quantum Optics	Associated Member
58	DISETCOM	University of Tor Vergata	Core Partner
59	DISETCOM	University of Salerno	Core Partner
60	DISETCOM	University of Eastern Finland	Associated Member
61	DISETCOM	Belarusian State University	Former Associated Member
62	DISETCOM	Center for Physical Sciences and Technology (FTMC)	Associated Member
63	DISETCOM	UAB TERAVIL	Associated Member
64	DOLPHIN	Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW)	Associated Member
65	DOLPHIN	Commissariat à l'Energie Atomique, French Atomic and Alternative Energy Commission, Laboratory on New Energy and Nanomaterials (CEA/LITEN) (new PI)	Core Partner
66	DOLPHIN	The University of Manchester	Core Partner
67	ENPHOCAL	Max Planck Institute for Polymer Research (MPIP)	Core Partner
68	ENPHOCAL	Interuniversity Microelectronics Centre (Imec)	Core Partner
69	ENPHOCAL	Ghent University (UGent)	Associated Member
70	ENPHOCAL	Catalan Institute of Nanoscience and Nanotechnology (ICN2)	Core Partner
71	EPIGRAPH	Linköping University	Former Core Partner - Former Associated Member
72	EPIGRAPH	RISE SICS AB	Associated Member
73	EPIGRAPH	Aix-Marseille Université UMR INSERM 1106 / INS - Institut de Neurosciences des Systèmes	Former Associated Member
74	EPIGRAPH	Foundation for Research and Technology Hellas (FORTH) / Institute of Electronic Structure and Lasers (IESL)	Core Partner
75	ETMOS	CNR-Institute for Microelectronics and Microsystems (IMM)	Core Partner
76	ETMOS	Universita degli Studi di Palermo	Associated Member
77	ETMOS	CNRS-Centre de recherche sur l'Hétéro-Epitaxie et ses Applications (CRHEA)	Core Partner
78	ETMOS	Hungarian Academy of Sciences- Institute for Technical Physics and Materials Science Research, Centre for Energy Research	Core Partner
79	ETMOS	Slovak Academy of Sciences- Institute of Electrical Engineering	Former Associated Member
80	GATES	Pfeiffer Vacuum SAS	Former Associated Member
81	GATES	CEA/LITEN/DTNM	Core Partner
82	GATES	Universidad de Zaragoza (UNIZAR)/INA	Core Partner
83	GATES	National Hellenic Research Foundation (NHRF)	Former Associated Member
84	G-IM-MUNOMICS	Ankara University	Associated Member
85	G-IM-MUNOMICS	University of Sassari	Former Associated Member
86	G-IM-MUNOMICS	University of Trieste / Chemical and Pharmaceutical Sciences Department	Core Partner
87	G-IM-MUNOMICS	University Hospital Cologne	Former Associated Member

88	G-IM-MUNOMICS	Centre National de la Recherche Scientifique of Strasbourg / Immunopathologie et Chimie Thérapeutique	Core Partner
89	G-IM-MUNOMICS	University of Manchester / Institute of Inflammation and Repair, FMHS	Core Partner
90	GLADIATOR	Horiba Jobin Yvon S.A.S	NA
91	GLADIATOR	CEA - Commissariat à l'energie atomique et aux energies alternatives	Core Partner
92	GLADIATOR	Aixtron Ltd.,	Core Partner
93	GLADIATOR	Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung e.V., Germany	Core Partner
94	GLADIATOR	Aixtron SE	Core Partner
95	GLADIATOR	Suragus GmbH	Associated Member
96	GLADIATOR	Amcor Flexibles Singen GmbH	NA
97	GLADIATOR	Leibnitz-Institut für Oberflächenmodifzierung	Former Associated Member
98	GLADIATOR	Graphenea S.A.,	Core Partner
99	GLADIATOR	Sgenia Soluciones SL	NA
100	GLADIATOR	Danmarks Tekniske Universitet	Core Partner
101	GLADIATOR	Det Nationale Forskningscenter for Arbejdsmiljo	NA
102	GLADIATOR	Amcor Flexibles Kreuzlingen	NA
103	GLADIATOR	Amanuensis GmbH	NA
104	GLADIATOR	Aristotelio Panepistimo Thessalonikis	Former Associated Member
105	GLADIATOR	Organic Electronic Technologies	Former Associated Member
106	GO-FOR-WA-TER	University of Patras, Department of chemical engineering	Associated Member
107	GO-FOR-WA-TER	Chalmers University of Technology, Department of Industrial and Materials Science	Core Partner
108	GO-FOR-WA-TER	Sabanci University, Integrated Manufacturing Technologies Research and Application Center	Associated Member
109	GO-FOR-WA-TER	National Research Council (CNR)-Institute for Organic Synthesis and Photoreactivity	Core Partner
110	GRAFIN	Chalmers University of Technology	Core Partner
111	GRAFIN	AXONIC	Former Associated Member
112	GRAFIN	Universitat Autònoma de Barcelona	Core Partner
113	GRAFIN	Catalan Institute of Nanoscience and Nanotechnology	Core Partner
114	GRAFIN	Boğaziçi University	Associated Member
115	GraNitE	Consiglio Nazionale delle Ricerche (CNR) / Istituto per la Microelettronica e Microsistemi (IMM)	Core Partner
116	GraNitE	STMicroelectronics	Core Partner
117	GraNitE	TopGaN	Former Associated Member
118	GraNitE	CNRS/Centre de Recherche sur l'Hétéro Epitaxie et ses Applications (CRHEA)	Core Partner
119	GRANSPORT	Karlsruhe Institute of Technology	Former Core Partner
120	GRANSPORT	Freie Universität Berlin	Former Associated Member
121	GRANSPORT	Commissariat à l´Energie Atomique (CEA) Grenoble	Core Partner
122	GRANSPORT	Radboud University (RU) / Institute of Molecules and Materials (IMM)	Associated Member
123	GRANSPORT	Uppsala University	Associated Member
124	GRAPHAR	Photonics Networks and Technologies Laboratory – CNIT (Consorzio Nazionale Interuniversitario per le Telecomunicazioni)	Core Partner

125	GRAPHAR	University of Cambridge	Core Partner
126	GRAPHAR	TECHNION	Core Partner
127	GRAPHAR	Mellanox	Core Partner
128	GRAPH-EYE	University of Cambridge	Core Partner
129	GRAPH-EYE	University of Antwerp	Associated Member
130	GRAPH-EYE	Foundation for Research and Technology Hellas, FORTH	Core Partner
131	Graphtivity	The Italian Institute of Technology, Dept. of Neuroscience and Brain Technologies (NBT)	Former Core Partner
132	Graphtivity	Institut d'Electronique, de Microélectronique et de Nanotechnologie (IEMN)	Former Core Partner
133	Graphtivity	Ruhr Universität Bochum, Department of Chemistry and Biochemistry, Chair of Analytical Chemistry	Former Associated Member
134	Graphtivity	Université catholique de Louvain / Institute of Information and Communication Technologies, Electronics and Applied Mathematics	Core Partner
135	Graphtivity	Brains On-line	Former Associated Member
136	Graphtivity	University of Groningen; Department of Pharmacy	Core Partner
137	Graphtivity	International Centre of Biodynamics	Former Associated Member
138	GRASAGE	RWTH Aachen University	Core Partner
139	GRASAGE	Textile Research Institute (AITEX) – Technical Fiber and Nanotechnologies Research Group	Former Associated Member
140	GRASAGE	Maastricht University / Aachen-Maastricht Institute for Biobased Materials	Former Associated Member
141	GRASAGE	KU Leuven	Associated Member
142	GRIFONE	Consiglio Nazionale delle Ricerche (CNR), Istituto per la Microelettronica e Microsistemi (IMM)	Core Partner
143	GRIFONE	Linköping University (LiU), Department of Physics, Chemistry and Biology (IFM)	Former Core Partner - Former Associated Member
144	GRIFONE	Technical Physics and Materials Science, Centre for Energy Research, Hungarian Academy of Science (MTA EK MFA)	Core Partner
145	GRMH2TANK	University of Kiel, Faculty of engineering, Institute for Material Science - Functional Nanomaterials	Core Partner
146	GRMH2TANK	Brandenburgische Technische Universität Cottbus Senftenberg (BTU) Fakultät 5	Former Associated Member
147	GRMH2TANK	Leibniz - Institut für Polymerforschung Dresden e.V., Abt. Verarbeitungsprozesse (Dep. Processing)	Former Associated Member
148	GRMH2TANK	GLEXYZ Engenharia Investigação e Desenvolvimento Unipessoal LDA	Former Associated Member
149	GRMH2TANK	ONERA	Former Associated Member
150	H2O	Friedrich Schiller University Jena	Core Partner - Former Associated Member
151	H2O	Ludwig-Maximilians-Universität	Former Associated Member
152	H2O	University of Twente	Former Associated Member
153	H2O	Chalmers University of Technology	Core Partner
154	HiMagGraphene	Max Planck Institute of Solid State Research Stuttgart / Department: Nanoscale Science (Group of K. Kern)	Core Partner
155	HiMagGraphene	CNRS/Institut Néel/UPR2940	Core Partner
156	HiMagGraphene	Departamento de Fisica de la Materia Condensada. Universidad Autonoma de Madrid	Former Associated Member

157	ICG	Mellanox/Nvidia, Israel	Core Partner
158	ICG	Simtal nano coatings	Associated Member
159	ICG	Bar Ilan University	Associated Member
160	iSpinText	Department of Physics, Budapest University of Technology and Economics	Associated Member
161	iSpinText	Chalmers tekniska hoegskola AB/Microtechnology and Nanoscience	Core Partner
162	iSpinText	University of Konstanz, Department of Physics	Former Associated Member
163	iSpinText	Zernike Institute for Advanced Materials, University of Groningen	Core Partner
164	iSpinText	Department of Physics, University of Basel	Former Core Partner
165	LaMeS	Potsdam University /Helmholtz Zentrum Berlin	Former Associated Member
166	LaMeS	CNRS National Centre for Scientific Research	Core Partner
167	LaMeS	Uppsala University	Associated Member
168	LA-SERGRAPH	Karlstad University	Associated Member
169	LA-SERGRAPH	Foundation for Research and Technology Hellas (FORTH) / Institute of Electronic Structure and Lasers (IESL)	Core Partner
170	LA-SERGRAPH	University Hasselt	Other
171	LA-SERGRAPH	Interuniversity Micro-Electronics Centre (IMEC)/Thin-Film PV	Core Partner
172	LA-SERGRAPH	University of Ljubljana	Associated Member
173	LEGOCHIP	University of Bologna (UNIBO)	Associated Member
174	LEGOCHIP	Catalan Institute of Nanoscience and Nanotechnology (ICN2)	Core Partner
175	LEGOCHIP	University of Santiago de Compostela/Center for Research in Biological Chemistry and Molecular Materials (CIQUS)	Associated Member
176	LEGOCHIP	University of Manchester/ School of Chemical Engineering and Analytical Sciences	Core Partner
177	MARGO	University Sapienza of Rome, Physics Department, Nonlinear Photonics Laboratory	Associated Member
178	MARGO	University Cattolica del Sacro Cuore	Associated Member
179	MARGO	CSIC - Public Laboratory	Core Partner
180	MARGO	OTENET	Associated Member
181	MECHANIC	Fundacia Privada Institut Catala de Nanotecnologica	Core Partner
182	MECHANIC	Avanzare InnovaciónTecnológica S.L	Core Partner
183	MECHANIC	Universite Catholique de Louvain	Core Partner
184	MECHANIC	Chalmers University of Technology	Core Partner
185	MECHANIC	Izmir Institute of Technology	Associated Member
186	MECHANIC	Universita' degli Studi di Cagliari	Former Associated Member
187	MECHANIC	National Research Council of Italy, CNR-ISOF	Core Partner
188	MELODICA	Consiglio Nazionale delle Ricerche, Instituto SPIN	Core Partner
189	MELODICA	National Centre of Scientific Research (NCSR) -Demokritos	Former Associated Member
190	MELODICA	Babes Bolyai University (Institute of Physics Ioan Ursu)	Former Associated Member
191	MELODICA	University of Liège	Former Associated Member
192	MINERVA	Uppsala University	Core Partner

193	MINERVA	Catalan Institute of Nanoscience and Nanotechnology (ICN2)	Core Partner
194	MINERVA	University Claude Bernard Lyon 1 (UCBL)	Associated Member
195	MINERVA	Université Catholique de Louvain (UCLouvain)	Core Partner
196	MNEMOSYN	Max Planck Institute of Microstructure Physics: Halle (MPIH)	Core Partner
197	MNEMOSYN	Catalan Institute of Nanoscience and Nanotechnology (ICN2)	Core Partner
198	MNEMOSYN	SPINTEC-CEA	Core Partner
199	MNEMOSYN	Centre Interdisciplinaire de Nanoscience de Marseille (CINaM)	Associated Member
200	MNEMOSYN	Interuniversity Microelectronics Centre (IMEC)	Core Partner
201	MNEMOSYN	Ankara University	Associated Member
202	MORE-MXENES	IFM, Linköping University (LiU)	Former Core Partner - Former Associated Member
203	MORE-MXENES	Laboratoire des Matériaux et du Génie Physique, Gre-noble Institute of Technology (Grenoble INP)	Former Associated Member
204	MORE-MXENES	Institut Néel (INEEL)	Core Partner
205	MORE-MXENES	UCLouvain	Core Partner
206	MULTISPIN	Izmir Institute of Technology - Photonics /Computational and Experimental NanoTechnology group (IZTECH / CENT)	Associated Member
207	MULTISPIN	Institut de Science et d'Ingénierie Supramoléculaires (ISIS)	Core Partner
208	MULTISPIN	Budapest University of Technology and Economics (BME)	Associated Member
209	MULTISPIN	Asociación - Centro de Investigación Cooperativa en Nanociencias – CIC NANOGUNE (CIC nanoGUNE)	Core Partner
210	MX-OSMO-PED	Dresden University of Technology	Core Partner
211	MX-OSMO-PED	University of Strasbourg	Core Partner
212	MX-OSMO-PED	University of Nova Gorica	Associated Member
213	MX-OSMO-PED	University of Mons	Associated Member
214	NanoElMEM	University of Maribor	Former Associated Member
215	NanoElMEM	University of Nova Gorica	Associated Member
216	NanoElMEM	Abalonyx	Associated Member
217	NanoElMEM	Norwegian University of Science and Technology,	Former Associated Member
218	NanoElMEM	Chang Gung University	Other
219	NeuroStim-Spinal	FORTH	Core Partner
220	NeuroStim-Spinal	Tecnalia	Core Partner
221	NeuroStim-Spinal	University Complutense of Madrid	Associated Member
222	NeuroStim-Spinal	University of Aveiro	Associated Member
223	NeuroStim-Spinal	Graphenest	Associated Member
224	NeuroStim-Spinal	Stemmatters	Associated Member

225	NeuroStim-Spinal	Radboud University Medical Centre	Associated Member
226	NOC2D	University of Manchester,	Core Partner
227	NU-TEGRAM	Ecole nationale supérieure d'ingénieurs de Caen & Centre de recherche	Former Associated Member
228	NU-TEGRAM	Universität Duisburg - Essen, Fakultät für Physik	Former Associated Member
229	NU-TEGRAM	Universität Duisburg - Essen, Lehrstuhl für Technische Chemie II	Former Associated Member
230	NU-TEGRAM	University of Twente Science and Technology	Former Associated Member
231	NU-TEGRAM	Ruđer Bošković Institute	Former Associated Member
232	OPERA	MPG-MPIP	Core Partner
233	OPERA	Ecole Normale de Paris Saclay- Laboratoire Aimé Cotton	Associated Member
234	OPERA	CEA- NIMBE	Core Partner
235	OPERA	CNRS-LPENS	Core Partner
236	OPERA	CMN-UMONS	Associated Member
237	PeroGaS	Istituto Italiano di Tecnologia (IIT)/Nanochemistry Department	Core Partner
238	PeroGaS	Bar Ilan University	Associated Member
239	PeroGaS	Foundation for Research and Technology Hellas (FORTH) / Institute of Electronic Structure and Lasers (IESL)	Core Partner
240	PHONAMP	Institute of Physics in Belgrade	Former Associated Member
241	PhotoTBG	Rheinisch-Westfaelische Technische Hochschule Aachen (RWTH)	Core Partner
242	PhotoTBG	ICFO	Core Partner
243	PhotoTBG	Eidgenoessische Technische Hochschule Zurich (ETHZ)	Core Partner
244	POLYGRAPH	University of Padova	Core Partner
245	POLYGRAPH	Centro Ricerche Fiat S.C.p.A. (CRF)	Core Partner
246	POLYGRAPH	SAIREM SAS	Former Associated Member
247	POLYGRAPH	HMG Paints Ltd	NA
248	POLYGRAPH	Institute for Occupational Medicine	Former Associated Member
249	POLYGRAPH	Queen Mary University of London	Core Partner
250	POLYGRAPH	Robnor Resins Limited	Former Associated Member
251	POLYGRAPH	BAE Systems (Operations) Ltd	Former Associated Member
252	POLYGRAPH	NetComposites	Former Associated Member
253	POLYGRAPH	SP Sveriges Tekniska Forskingsinstitut	Former Associated Member
254	POLYGRAPH	NETZSCH-Feinmahltechnik GmbH	NA
255	POLYGRAPH	Ytron Process Technology GMBH & COKG	NA
256	POLYGRAPH	Avanzare Innovacion Tecnologica SL	Core Partner
257	PROSPECT	UNISTRA	Core Partner
258	PROSPECT	University of Nova Gorica - Laboratory of Organic Matter Physics (LOMP)	Associated Member
259	PROSPECT	University of Mons/ Center for Innovation and Research on Materials and Polymers CIRMAP	Associated Member
260	PROSPECT	Chalmers University of Technology	Core Partner

261	RES-CUEGRAPH	NEURINNOV SAS	Associated Member
262	RES-CUEGRAPH	Institut National de Recherche en Informatique et Automatique	Associated Member
263	RES-CUEGRAPH	Universitat Autònoma de Barcelona	Core Partner
264	RES-CUEGRAPH	Catalan Institute of Nanoscience and Nanotechnology	Core Partner
265	RES-CUEGRAPH	Boğaziçi University	Associated Member
266	SiGNAL	CealTech AS, Norway	Associated Member
267	SiGNAL	The University of Oslo	Associated Member
268	SiGNAL	Institute for Energy Technology (IFE)	Associated Member
269	SIMPLANT	Fritz Haber Institute of the Max Planck Society	Core Partner
270	SIMPLANT	CNRS, Laboratoire de physique des interfaces et des couches minces, École Polytechnique, Paris-Saclay University	Core Partner
271	SIMPLANT	Thales Research & Technology	Core Partner
272	SIMPLANT	KU Leuven, Laboratory of Solid State Physics and Magnetism	Associated Member
273	SIMPLANT	KU Leuven - Institute for Nuclear and Radiation Physics	Associated Member
274	SIO Grafen	VINNOVA	NA
275	Sograph	Fundación IMDEA Nanociencia	Core Partner
276	Sograph	CNRS/UMPHY	Core Partner
277	Sograph	Soleil Syncrothron	Associated Member
278	Sograph	Istituto P.M. srl	Former Associated Member
279	SographMEM	Namlab GmbH	Associated Member
280	SographMEM	Forschungszentrum Jülich GmbH	Associated Member
281	SographMEM	Fundacion IMDEA Nanociencia	Core Partner
282	SographMEM	ALBA-CELLS	Associated Member
283	SographMEM	CNRS-Thales	Core Partner
284	SographMEM	Synchroton soleil	Associated Member
285	SographMEM	Universite Catholique de Louvain	Core Partner
286	TAILSPIN	Lund University / MAXIV laboratory	Former Associated Member
287	TAILSPIN	Leibniz Universität Hannover / Institut für Festkörperphysik	Former Associated Member
288	TAILSPIN	Max Planck - Institut für Festkörperforschung	Core Partner
289	TAILSPIN	Eindhoven University of Technology / Physics Department	Core Partner
290	TAILSPIN	University of Groningen/ Zernike Institute of Advanced Materials	Core Partner
291	TATTOOS	RWTH Aachen University	Core Partner
292	TATTOOS	CNRS	Core Partner
293	TATTOOS	Université Catholique de Louvain	Core Partner
294	To2Dox	Max Planck Institute	Core Partner
295	To2Dox	Forschungszentrum Jülich GmbH	Associated Member
296	To2Dox	CNRS-Thales	Core Partner
297	To2Dox	Universidad Complutense Madrid	Associated Member
298	To2Dox	Agencia Estatal Consejo Superior de Investigationes Cientificas	Core Partner

299	To2Dox	University of Latvia	Associated Member
300	TOPO-GRAPH	Technical University of Delft, QuTech	Core Partner
301	TOPO-GRAPH	Budapest University of Technology and Economics, Dept. of Physics	Associated Member
302	TOPO-GRAPH	Instituto de Ciencia de Materiales de Madrid (Consejo Superior de Investigaciones Científicas)	Core Partner
303	Trans2DTMD	Jacobs University Bremen	Former Associated Member
304	Trans2DTMD	Technische Universität Dresden/Theoretical Chemistry	Core Partner
305	Trans2DTMD	U. Antwerpen/Physics Department/Condensed Matter Theory	Associated Member
306	Trans2DTMD	Universiteit Twente/Faculty of science	Former Associated Member
307	Trans2DTMD	Universidad del País Vasco/Department of Materials Science/Faculty of Chemistry	Associated Member
308	TUGRACO	CNR-Istituto Nanoscienze	Core Partner
309	TUGRACO	University of Siegen	Former Associated Member
310	TUGRACO	Universitat Politècnica de Catalunya	Former Associated Member
311	UltraGraf	Complutense University of Madrid	Associated Member
312	UltraGraf	University of Porto	Former Associated Member
313	UltraGraf	University of Aveiro	Associated Member
314	UltraGraf	Sphere Ultrafast Photonics	Former Associated Member
315	VEGA	Chalmers University of Technology (CUT)	Core Partner
316	VEGA	Université d'Orléans/CNRS	Core Partner
317	VEGA	Jožef Stefan Institute (JSI)	Associated Member
318	WHISKIES	Institute of microelectronics of Barcelona	Former Core Partner
319	WHISKIES	Regemat3D SL	Associated Member
320	WHISKIES	Université libre de Bruxelles-Microgravity Research Centre	Core Partner
321	WHISKIES	The Chancellor, Master and Scholars of the University of Cambridge (UCAM)	Core Partner
322	WHISKIES	Queen Mary University	Core Partner
323	WHISKIES	University of Brighton	Associated Member
324	WHISKIES	Flexenable LTD	Core Partner
325	WHISKIES	CRIL LTD	Core Partner
326	WHISKIES	Footfalls and heartbeats LTD	Associated Member
327	WHISKIES	Institute for microsystems and microelectronics (CNR)	Core Partner
328	WHISKIES	Biomedical Sciences Department (UNIPD)	Core Partner
329	WHISKIES	Optosmart srl	Associated Member
330	WHISKIES	GSNET SRL	Associated Member
331	WHISKIES	Technological University Dublin	Associated Member
332	WHISKIES	Optrace LTD	Associated Member
333	WHISKIES	Fraunhofer Institute	Core Partner
334	WHISKIES	University of Bremen	Core Partner
335	WHISKIES	Mjr Pharmjet GMBH	Associated Member

iii. Graphene Related Material (GRM) Centres

S. No.	GRM Centre	Hosting Organisation
1	Two-dimensional Photonics Fabrication Facility	Heriot-Watt University
2	2D Materials Lab	Tel-Aviv University
3	The Aachen Graphene & 2D-Materials Center	RWTH Aachen University and AMO GmbH
4	Advanced Materials and BioEngineering Research Centre	Trinity College Dublin: CRANN and the Trinity Centre for Bioengineering
5	Graphene Centre at University of Surrey	Advanced Technology Institute (ATI)
6	The Centre for Nanosciences and Nanotechnology	Paris-Saclay University
7	Center of Excellence for Advanced Materials and Sensing Devices,Research unit: Science of Graphene and Related 2D Structures	Institute of Physics
8	Cambridge Graphene Centre	University of Cambridge
9	Centre of Graphene and Innovative Nanotechnology	Institute of Electric Materials Technology (ITME)
10	Center of MicroNanoTechnology	EPFL
11	Centre for Nanostructured Graphene	Technical University of Denmark
12	Centre for Research on Adaptive Nanostructures and Nanodevices	Trinity College Dublin
13	FORTH Graphene Centre	Greek Foundation for Research and Technology (FORTH)
14	Graphene and 2D Semiconductors Laboratory	Information and Communication Technologies Research Centre of the University of Granada
15	Graphene Applications Innovation Centre	The Centre for Process Innovation (CPI)
16	Graphene Engineering Innovation Centre	University of Manchester
17	IIT Graphene Labs	Italian Institute of Technology (IIT)
18	Graphene Center Dresden	Technical University of Dresden
19	Graphene Centre at Chalmers	University of Chalmers
20	Centre for Graphene Science	University of Exeter and the University of Bath
21	The Royce: Capitalising on the investment	University of Manchester
22	Interface Analysis Facility	Max Planck Institute for Solid State Research
23	Central facility for investigations of growth, structure, and electronic properties of graphene using low-energy electron microscopy (LEEM)	Technische Universität Chemnitz
24	NanoScience Facility	University of Leeds
25	Laboratory for X-ray Nanoscience and Technologies	Paul Scherrer Institut
26	NanoAccess - integrated facility for thin-film engineering & in-situ nano-lab	Technische Universiteit Eindhoven
27	Nano-Electronics Centre	University of Surrey
28	The National Graphene Institute	University of Manchester
29	The National Graphene Metrology Centre	National Physical Laboratory (NPL)
30	Otaniemi research infrastructure for micro- and nanotechnologies	Aalto University
31	Platform for Nanoscale Advanced Materials Engineering (P-NAME)	University of Manchester
32	The Physical Sciences Data Science Service (PSDS)	University of Southampton

33	SPINtronique et TEchnologie des Composants Labora-tory	CEA
34	National Facility for Advanced Electron Microscopy (SuperSTEM)	University of Leeds
35	Multidisciplinary Research Platform for Nuclear Spins far from Equilibrium	University of Southampton
36	Center for Nanotechnology and Nanomaterials (WSI-ZNN)	Technical University of Munich

iv. Companies

S. No.	Company
1	AEH Innovative Hydrogel
2	Bedimensional
3	Blackleaf
4	Cambridge Raman Imag-ing
5	Carbon Waters
6	Durham Graphene Sci-ence (DGS)
7	ELKEM
8	Emberion
9	First Graphene
10	G2O Water Technologies
11	Grapheal
12	Graphenea
13	Graphmatech
14	Haydale
15	InBrain
16	Integrated Graphene
17	Paragraf
18	Skeleton
19	Skeleton Technologies
20	Versarien

Indicators Glossary

GDP Contribution or Gross Value Added (GVA)	The GDP Contribution or GVA describes a company's contribution to the gross domestic product (GDP). The value added is the key figure for measuring a country's economic development and it's prospective of growth and economic welfare.
Direct (Economic) Effects	Direct effects refer to the direct contribution of a company to the economy. What did the company generate in terms of economic value? These direct effects are reflected in the economic output of a company, or its value added (see below) or the number of employed persons.
Indirect (Economic) Effects	The production activities of a company require purchased materials and services. Such purchased materials and services in turn result in increased production among suppliers who also require purchased materials and services for their own production process. The cascading effects that develop as a result (e.g. employment, gross value added) are referred to as the indirect economic effects of the enterprise.
Induced (Economic) Effects	Induced effects refer to those economic effects that result from renewed spending of directly and indirectly generated incomes.
Intermediate Consumption	Value of goods used for further processing and/or purchased materials and services for downstream economic sectors.
Research and development	Research and development (R&D) are regarded as a decisive factor for long-term economic growth and is particularly important in a resource-poor economy like Germany.
NACE (Statistical Classification of Economic Activities)	NACE is a classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g., production,

	employment and national accounts) and in other statistical domains developed within the European Statistical System (ESS).
Employment supported	Employment supported by a company means the absolute number of jobs supported by the company. This can be both directly and indirectly or along the global supply chain.
GDP contribution factor	GDP contribution created in the global supply chain (indirect and induced) for every GDP contribution created directly.
Employment factor	Employment (job) supported in the global supply chain (indirect and induced) for every employment (job) supported directly.
GDP contribution per Investment	The total GDP contributed compared to the total amount of investment or funding received in the program. The total GDP contribution is the sum of both direct and spillover effects divided by the total investment received by the program. This gives the metric to know the amount of GDP contributed per Euro of investment in the program.
Employment per Investment	The employment supported compared to the total amount of investment or funding received in the program. The employment supported is the sum of both direct and spillover effects divided by the total investment received by the program. This gives the metric to know the number of jobs or employment supported per Euro of investment in the program.
Spillover Effects	The sum of indirect economic effects and economic effects induced by private consumption are called economic spillover effects.
Virtual Gross Markup (VGM)	VGM ratio is an industry markup ratio published by OECD for each industry per country. The VGM ratio is both country and industry specific and reflects the national differences in personnel cost, capital intensity and profitability of the pharmaceutical industry with regards to total industry personnel cost per country. The statistical industry VGM ratio per country is then multiplied with a company's or organization's personnel cost for research & development / country to receive the Virtual gross margin (VGM) on country level.
Tax Wedge	Tax wedge is defined as the ratio between the amount of taxes paid by an average single worker (a single person at 100% of

	average earnings) without children and the corresponding total labor cost for the employer.

WifOR is an independent economic research institute that emerged from a spin-off of the Department of Economics and Economic Policy at the Technical University of Darmstadt. We see ourselves as an academic partner and think tank on a global level. WifOR's research fields include economic, environmental, and social impact analyses as well as labor market and health economic research.

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