



Study on BBI JU project portfolio and KPIs validation Executive Summary

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Bio-Based Industries Joint Undertaking

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Executive Summary

The overall purpose of the report is to present an assessment of the BBI JU project portfolio's contributions and impacts in relation to the BBI JU programme objectives and EU policy goals and a validation confirming and verifying the achieved results and impacts reported by the completed projects' documentation.

The Bio-Based Industries Joint Undertaking (BBI JU) is a public-private partnership (PPP) between the EU and the Bio-based Industries Consortium (BIC) dedicated to realise the European bioeconomy potential, turning different types of biomass¹ into greener everyday products through innovative technologies and biorefineries, which are at the heart of the bioeconomy. The BBI JU funds projects under four actions:

- Research and Innovation Actions (RIA) – on a technology readiness level (TRL²) 3-5 – focused on filling the gaps in technological innovation: dedicated projects on the development of specific technologies and concepts needed to make the value chains work and demonstrating the principles in pilot installations.
- Demonstration projects (DEMO) – target TRL level 6-7 – providing the final proof that a process, product manufacture, and necessary supply chain are technologically and economically feasible before the commercial phase commences.
- Flagship projects (FLAG) – target TRL level 8 – covering the entire value chain, aiming at establishing first of their kind biorefineries to produce bio-based products using sustainable feedstock supply, guaranteed market uptake, and the integration of the value chain into existing rural and industrial infrastructures.
- Coordination and Support Actions (CSA) addressing cross-cutting challenges and supporting the creation of value chains.

Overall conclusion

The BBI JU project portfolio demonstrates strong international partnerships of industrial sectors and academic institutions that have developed and demonstrated innovative and advanced biotechnologies with great potential to enhance the European bio-based economy as well as a sustainable transition to a society less dependent on fossil-based materials. The portfolio of projects involves multiple partners with complementary competences from the primary sector (agriculture, aquatic sector, food-sector, and forestry), chemical industry, technology

¹ The origin of the biomass used in BBI JU projects is multiple: agri-food side streams and residues, sustainably sourced forest biomass, (micro and macro) algae, fisheries and aquaculture residues, organic municipal solid waste and waste water, CO₂ from bio-based operations, among others sources of biological renewable resources

² BBI JU RIAs address typically TRLs 3 (proof of concept), TRL 4 (validation in lab) and TRL 5 (validation at pilot level). DEMO project work in the range of TRL 6 (integrated system demonstrated at a industrially relevant environment) and TRL 7 (demonstration at an operational environment). FLAGs aim at reaching TRL 8 (system complete and qualified, at a pre-commercial scale).



providers, consultancy companies, and research/academic institutions. All projects involve international partnerships.

As such, the BBI JU programme has, through the supported projects, played a significant role in broadening the bio-based perspective to new areas of research and innovation and laid the foundation for new bio-based markets, e.g., by designing new value chains. Even though all results have not yet been industrially or commercially utilised, the BBI JU programme has supported the development of stronger research and innovation capacity that can address coming challenges in the development of a more bio-based economy. Further, the knowledge creation has also fed into the EU policies aiming at a greener transition, especially regarding biodiversity, and to a profound recognition of the environmental and socio-economic potential within bio-based production.

Assessment of the BBI JU projects portfolio

Based on a sample of 50 on-going and completed projects, the BBI JU projects portfolio has carried out comprehensive and thorough research and innovation activities that have contributed significantly to the generation of new knowledge and solutions of vital importance for the development of an EU bio-based economy. Particular attention must be paid to the technical results and their promising environmental impacts. Furthermore, the BBI JU programme has, especially in the DEMO- and FLAG-projects, managed to link the technical results (development of new bio-based processes and products) to innovation activities and new cross-sectoral value chains. The experiences gained by these projects outline feasible roadmaps for reaching the market with new bio-based raw materials or products.

In accordance with one of its objectives, the BBI JU has contributed to “the systemic transformation of the bio-based industry in Europe”. However, full utilisation and implementation of the promising results depends on the market and industry dynamics and synergies that may take time to evolve and cannot be controlled by programme intervention itself.

Overall, the assessment shows that BBI JU projects achieve their objectives related to the development of new products and technologies that hold great commercial potential as well as environmental and socio-economic benefits. Most projects perform well with regards to the fulfilment of the key project objectives. The projects’ documentation typically presents evidence – thorough testing/experimental data – that the developed processes and substances are energy-efficient, beneficial to the environment and health, and that their functional qualities can replace fossil-based materials.

The project portfolio has developed sustainable utilisation of biomass.

An essential, overall purpose of BBI JU is to develop and apply advanced biotechnologies to convert biomass into high value-added chemicals and materials. The assessment shows that



the project portfolio has developed better utilisation of biomass in several ways, among others by developing:

- *Better use of biomass feedstock or residue from agriculture, agro-food sector, forestry, or aquatic sector.* The projects have developed technologies for the extraction and isolation of new materials and substances with environmental and health benefits that are competitive to fossil-based materials. Viewed from a future perspective, the new materials and substances may pave the way for new applications, products, and markets.
- *Better extraction of substances/chemicals from biomass.* The projects have developed new applications of cellulose and cellulose conversion, better extraction and use of chemical components of hemicellulose, and demonstrated extraction of biomolecules, polysaccharides or proteins from biomass such as micro- and macroalgae (seaweeds) or other materials for use in industries.
- *Better processing of biomass - using more efficient methods that extract more with fewer resources.* The projects have developed innovative processing methods that convert pre-treated feedstocks to bio-based chemicals and materials. For example, some projects have enabled more effective thermochemical pre-treatment and downstream biochemical conversion. Other projects have developed methods for fractionalising and cleaning to enhance the purity of materials.

Viewed in a broader perspective, the BBI JU projects contribute to multiple environmental impacts such as saving energy, sustainable use of biological natural resources, reduction of the use of water, land and soil, replacement of fossil-based products, and reduction of emission of CO₂ and other GHGs. The beneficial environmental impacts have many forms.

Special attention must be paid to biodiversity as new, innovative processing of feedstock that supports and enhances biodiversity has been developed. The projects have developed processes and products that reduce the pressure on natural resources by better exploiting new feedstock and by-products as well as replacing fossil-based materials. Consequently, the innovation activities have not only industrial and commercial perspectives, but new approaches to farming that have potential for marginal lands in Europe are also presented.

Socio-economic impact

The assessment of the socio-economic impact focuses on impacts closely related to the activities that have taken place in the projects, however, some projects can typically only influence socio-economic impact indirectly.

Further, we find that almost all projects contribute to knowledge creation and to increasing academia-industry collaboration which can be interpreted as a contribution to *strengthening the research and innovation capacity*. The research and innovation capacity has mainly been strengthened by providing new insights into the development of bio-based technologies and



by establishing collaborative relationships, some of which seem to have the potential to be long lasting.

Almost all projects have contributed to the *development of value chains*. The main contribution to the development of value chains is by fostering the supply of sustainable biomass feedstock to feed new value chains and/or by optimising the use of biomass feedstock in existing value chains and, secondly, to offer innovative added-value products based on biomass feedstock that respond to market needs.

Most of the projects, of all types, indicate that the outcome of the projects has an *impact on competitiveness and job creation*, while the projects as a whole tend to assess their impact on rural development to be less strong. Typically, RIA-projects stress that the outcome of the projects will have an impact on competitiveness, indicating that the technological development will contribute to improved processes by lowering the extraction cost or increasing the efficiency, and will thereby reduce the production cost. DEMO-projects, in the same way as RIA-projects, contribute to competitiveness, but by being more specific in their estimated economic impact, by not only optimising the processes but also by the demonstration on an industrial scale. FLAG-projects are similar to the DEMO-projects in the sense that they encourage the competitiveness of the industry. Even though the DEMO- and FLAG-projects present very interesting and promising economic and environmental results which are of interest to the project partners, their impact on competitiveness is still an estimate at the pre-commercial stages. The CSA-projects have a more indirect impact on competitiveness. These projects typically have impacts on the framework conditions that can enhance innovative cooperation between stakeholders in the bio-based industry and enhance the exchange of know-how. For example, the CSA-project case BIO-Open has developed an on-line platform for the bio-materials sector that provides access to information and facilitates cooperation and innovation partnerships. Hence, CSA projects do not impact competitiveness directly and do not contribute with new experimental knowledge, but with activities or services that enhance the cooperation in the bio-based community.

Contribution to EU policy initiatives

As to the projects' contribution to EU policy initiatives, they should rather be judged by their intrinsic content than by what they explicitly say in their project documentation. Methodologically, the tricky point is that many projects have contributed to several EU policy initiatives even if the project managers do not explicitly mention the policies themselves in their general assessments.

All BBI JU projects contribute to sustainability

The projects own documentation shows that most projects find that they have contributed to the EU Bioeconomy strategy (40 of 50 projects) while fewer have contributed to The European



Green Deal (24 of 50 projects) or the renewed EU Industrial Policy Strategy (20 of 50 projects). However, practically all BBI JU projects have contributed to the EU Bio Economy Strategy and EU Policy initiatives aiming at a more sustainable, bio-based economy which is less dependent on fossil-based products, with more sustainable and efficient use of resources. When some EU policy initiatives are not mentioned in the project documentation, it may rather be because the project managers are not familiar with the policies. Hence, the project managers may be more familiar with the EU Bioeconomy Strategy than with the European Green Deal.

The assessment of the projects' environmental impact shows that almost all projects have developed innovative processes with one or several potential environmental impacts such as 1) less use of energy, 2) less carbon emission, 3) less use of water 4) less use of land 5) new raw materials 6) soil restoration and circular approaches 7) enhance biodiversity. In this regard, the assessment of the projects' environmental impact may be a more valid indicator of their contribution to EU policy initiatives, than what policy initiatives they relate to in their own documentation.

BBI JU project types contribute to EU policies in different ways

Another important question is *how* the BBI JU projects contribute to EU policy initiatives related to a more sustainable, bio-based society. The case studies exemplify, that the various types of BBI JU projects contribute to the EU Policy initiatives in different ways:

CSA projects contributes to the EU policy initiatives by impacting the market conditions and the information infrastructure of the bio-based community. For example, the BioCannDo project impacts the market conditions by providing information services that enlightens the public in order to raise awareness and acceptance of the broad public towards the bioeconomy and bio-based products. Another example is the CSA project BioOpen which enhances the cooperation and exchange of knowledge between stakeholders in the bio-based community. The project Bio-open has developed an on-line platform for the bio-materials sector that provides access to information and facilitates cooperation and innovation partnerships.

RIA projects (Research and Innovation Action) contribute to the EU policy initiatives by providing new experimental knowledge about bio-based products and innovative processes that can reduce the dependency on fossil-based products and reduce GHG-emissions. The experimental knowledge is provided in a form that can be applied for commercialisation after the end of the projects. For example, the project BIOSEA has developed new processes and value chains based on microalgae to be used in pharma, nutraceuticals, food additives and cosmetic applications. Such bio-based products can reduce the dependency on fossil-based products and have numerous environmental advantages. The output of the RIA project BIOSEA is preliminary business plans for each product created in BIOSEA addressing sectors and industries involved. In addition, the project output also includes an exploitation plan for usage of intellectual property rights and a draft for the intended route to market.



DEMO projects contribute to the EU policy initiatives by bringing new bio-based products and processes closer to the market by testing their feasibility for industrial appliance in a pre-market demonstration. Typically, the projects contribute with a pre-market demonstration of technologies or value chains. For example, the output of the DEMO-project BioForever is a demonstration of how spruce, poplar, wood wastes and other lignocellulosic feedstock can be valorised into competitive bio-based products. The bio-based products have environmental advantages compared to fossil-based products such as up to 85% reductions on CO₂-emissions compared to fossil-based products. Hence, the project contributes to the Bioeconomy Strategy as regards less CO₂ emissions and also to the EU Green Deal.

Similarly, the **FLAG projects contribute to the EU policy initiatives** by providing scientific knowledge based on full-scale demonstrations of technology or value-chains for industrial application and commercialisation. For example, the FLAG project EXILVA demonstrated an industrial symbiosis between the biomass/forest industry (Norwegian Spruce) and application industries in a wide range of market segments by developing and commercialising added value products in a sustainable way.

In summary, the BBI JU project portfolio contributes to EU policy initiatives in multiple ways: CSA-projects by impacting the market conditions and the internal information infrastructure of the bio-based community, RIA projects by providing experimental knowledge on bio-based products and processes, DEMO projects by bringing new bio-based products and processes closer to the market by testing their feasibility for industrial appliance and FLAG projects by providing scientific knowledge based on full-scale demonstrations of technology or value-chains for industrial application and commercialisation.

Validation of the completed RIA-, DEMO- and FLAG projects

The Strategic Innovation & Research Agenda³ (SIRA) sets the long term vision and objectives for the bio-based industries in Europe, and defines a set of 8 BBI JU Key Performance Indicators (KPIs) to be reached by BBI JU projects. Validation in this context is defined as how well the project empirically evidence and describe their achievements⁴. Whereas the assessment includes all projects, the validation only includes the completed projects. The validation of BBI JU projects includes a validation of how well they empirically evidence and describe their achievement of KPIs and their overall objectives as well as their environmental and socio-economic impacts.

³ https://www.bbi.europa.eu/sites/default/files/documents/BBI_SIRA_web_0.pdf

⁴ A validation score has been defined: score 1 : the achievement is empirically document or tested/demonstrated; score 2: the achievement is described but without full empirical documentation of all aspects; score 3: the achievement is not documented.



The validation exercise was performed on 23 completed RIA-, DEMO- and FLAG-projects out of a total of 143 ongoing projects. The validation shows that already these 23 completed projects have met the overall SIRA target for the BBI JU programme for some KPIs: KPI 2 (new bio-based value chains) and KPI 4 (new building blocks) while the target is almost met for KPI 1 (new cross-sector interconnections). All in all, these figures indicate that there has been significantly documented technological progress. The original target for KPI 5 (new bio-based materials) and KPI 6 (new demonstrated 'consumer' products) are, apparently, set relatively high compared to the number of KPIs with a validation score of 1, however, the majority of projects are still ongoing indicating that these two targets can be fulfilled.

KPI 8 is an indicator for technology readiness level (TRL) gain measuring whether the developed technology has gained at least one level up (the success criteria) and is thereby approaching industrial and commercial introduction. The TRL gain to be at least one TRL level for most projects and in most cases two TRL levels.

The validation of the achievements of the completed RIA-, DEMO- and FLAG-projects shows that most of the projects have empirically documented the attainment of their main objective and their environmental impacts. However, when it comes to the socio-economic impacts, most projects are challenged and only a few projects can document the socio-economic impacts. The main reason for the lacking documentation of socio-economic impacts is that most projects take place in a pre-market context.

BBI JU - a comprehensive public-private partnership which has enhanced the bio-based community.

In conclusion, the BBI JU program and project portfolio represents a comprehensive public-private partnership in research and innovation involving multiple partners that represent numerous fields of expertise and competences across different countries. The great diversity of partners shows that the innovations of BBI JU projects are based on intense cooperation between academic institutions, consultancy companies/experts, technology providers, manufacturing companies, biorefineries, environmental specialists -and many other organisations. The joint forces of the partners have provided a wealth of new experimental knowledge of bio-based products and processes and moved them closer to the market by demonstrating their feasibility for industrial application in full scale production. At the same time, many projects have shown that the market for bio-based products is still in its development and that there are still challenges ahead on the road to full scale commercialisation and market take up. However, the supported projects have outlined well-documented potential new value chains and development paths for a European bio-based economy. The timing of the BBI JU results is good as there is currently an increasing political focus as well as industry and consumer willingness to use bio-based materials or products. Looking to the future, further support towards bio-



based research and innovation may be needed to ensure a proper utilisation of the experiences gained from the DEMO- and FLAG-projects.

For informative purposes, the following graphs have been elaborated by BBI JU using as data source the information reported in the tables and figures included in the final report, and are presented here to complement with quantitative data the conclusions on the validation exercise included in the executive summary.

Graphs illustrating the validation results of BBI JU KPIs and expected environmental and socio-economic impacts

Validation of BBI JU KPIs

Figure 1: Validation scores (1,2,3) of the validated KPIs of the 23 finalized RIA and IA projects vs BBI JU KPIs targets set in the SIRA for the whole BBI JU programme. Total: 23 finalized projects (17 RIAs, 4 DEMOS, 2 FLAGs). KPI 6 refers only to DEMOs and FLAGs.

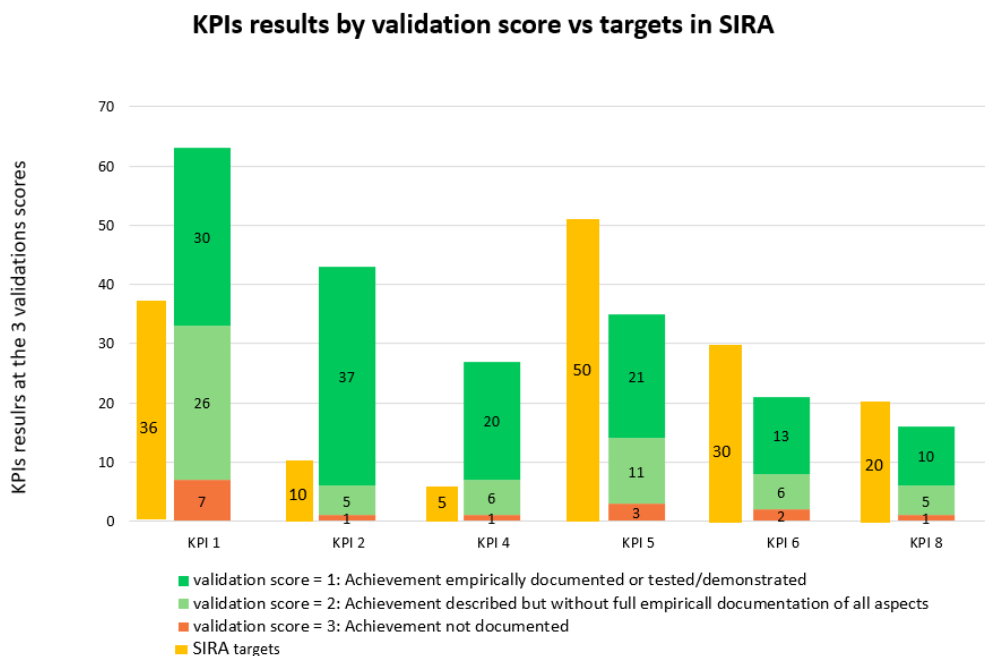
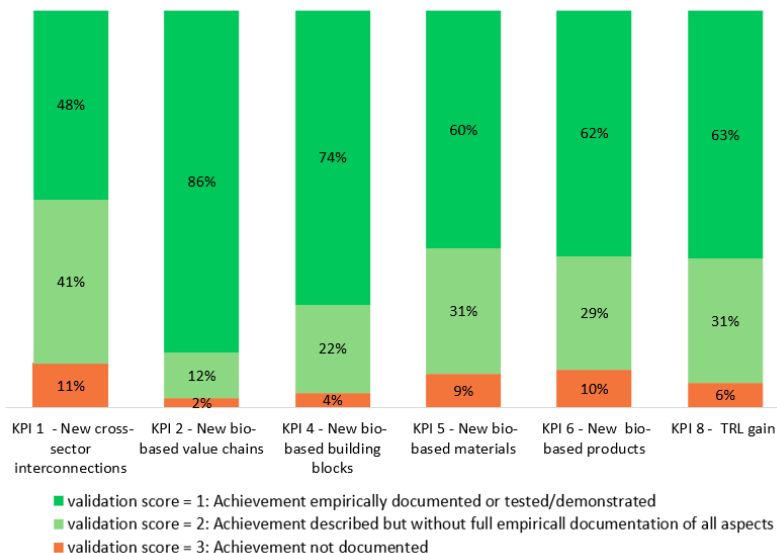


Figure 2: Percentage of validation scores reached (1, 2 or 3) for the reported KPIs results for each KPI. Total: 23 finalized projects (17 RIAs, 4 DEMOS, 2 FLAGs). KPI 6 refers only to DEMOs and FLAGs.

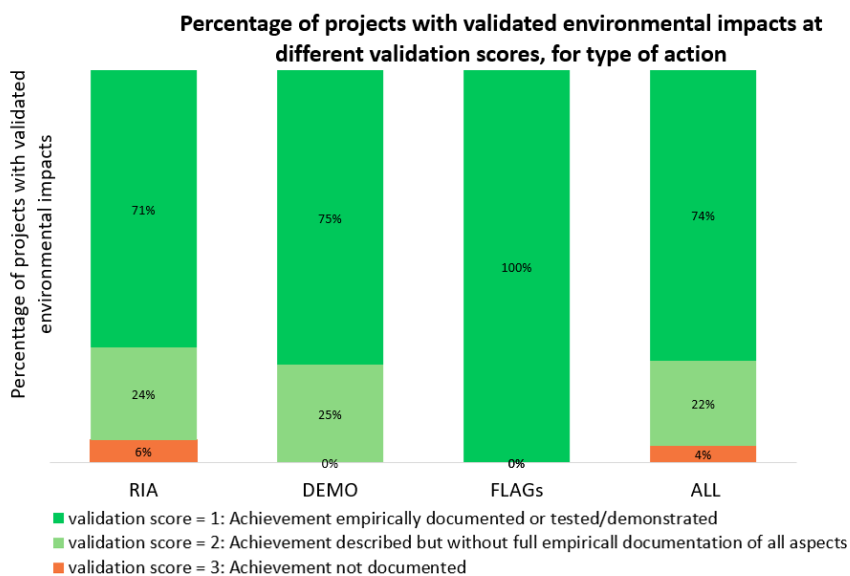


Percentage of KPIs at the 3 validation scores



Validation of environmental impacts

Figure 4: Percentage of projects with validated environmental impacts at different validation scores (1,2 3) for each type of action. Total: 23 finalized projects (17 RIAs, 4 DEMOS, 2 FLAGs).



Validation of socio-economic impacts

Figure 4: Percentage of projects with validated socio-economic impacts at different validation scores for each type of action. Total: 32 finalized projects (17 RIAs, 4 DEMOS, 2 FLAGs, 9 CSAs).

