Business cases for further investment

Backed by clear articulation of market need and estimates of cost of provision

15/08/2019

Andrea Muñoz García[1], Douglas Phillips[1], David Turley[1]

Other contributions: Katrien Molders[2], Mika Härkönen[3], Pauliina Tukiainen[3], Alla Silkina[4], Erik Meers[5], Ryan Titley[6] and Heidi Johansson[6].

[1] NNFCC Ltd, Biocentre, York Science Park, Innovation Way, York, YO10 5DG
[2] BBEU, Rodenhuizekaai 1, 9042 Desteldonk, Belgium
[3] VTT, Biologinkuja 7, Espoo, Finland, 02150
[4] Swansea University, Singleton Park, Swansea, United Kingdom, SA2 8PP
[5] University of Ghent, Coupure Links 653, Ghent, Belgium,9000
[6] ERRIN, Rue du Luxembourg 3, Brussels, Belgium, 1000

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

About Pilots4U

Pilots4U aims to setup one very visible, easily accessible network of open access pilot and multipurpose demo-infrastructures for the European bioeconomy with Europe-wide coverage and protecting IP rights of users. Since pilot- and demo equipment is very expensive and requires specific expertise, open access infrastructures are the most cost-effective manner to support the deployment of industry-driven innovations in the market.

Partners

Networks

Table of Contents

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

1 Executive Summary

1.1 Background

Pilots4U aims to setup one highly visible, easily accessible database and network of open-access pilot and multipurpose demo-infrastructures for the European bioeconomy. Additionally, Pilots4U carried out a gap analysis exercise to understand under- and overcapacities within the European landscape of pilot and demonstration facilities. The conclusions drawn from this gap analysis were discussed in a series of workshops and webinars that gathered bioeconomy experts from across Europe. The outcome of this discussion with experts were analysed and it was observed that most gaps in provision could be tackled by three generic types of intervention: 1) investment in new equipment assets to strengthen existing centres, 2) investment in coordination actions that help pilot plants to maximise the exploitation of existing equipment and expertise, and 3) investment in knowledge generation to increase the expertise and tools of the European pilot centres.

These three types of intervention were converted into business cases for investment in pilot/demo infrastructure and associated expertise that help maintaining the current momentum of key bio-based technologies as well as driving new developments.

1.2 Business cases – key messages

This report describes the three business cases based on the above-mentioned types of intervention and assesses the means by which ideal outcomes could be supported. The key messages drawn from each business case are:

- **Business case 1: investment in new equipment**. The proposed intervention suggests adding new pilot/demo equipment assets to existing open-access facilities to fill in the identified gaps while strengthening the position of the selected centre. This will, among other benefits, help maximising the past investment made in the selected centre and contributing to keeping the facility active and relevant. Furthermore, this approach intends to avoid the dilution of infrastructure and associated expertise which could lead to sub-optimal results. In this case the overall investment has been estimated at between 0.5 to 10 million € or more and will very much depend on the type of asset, its capacity and operational characteristics. To achieve its aims, the project will require of a strong team drawn from a wide range of professionals capable of effectively designing, installing and promoting the new equipment.

- **Business case 2: investment in coordination actions.** The proposed intervention suggests setting up a network of pilot plants to reduce the existing disconnection between some open-access facilities that own complementary equipment. This disconnection makes the scale up process more difficult for users/clients and could result in duplication of resources across several pilot plants. The estimated cost of the network over 4 years is expected to be 0.8 - 1.5 million €, with a significant part of the budget being dedicated to the creation of an expert group capable of providing innovative solutions to client's problems by taking into account all the steps of the process. In addition, the budget will cover joint communication efforts and coordination activities to increase the visibility and dialogue between facilities respectively.

- **Investment in knowledge generation.** The proposed intervention aims at increasing collaboration between open-access pilot plants and research centres to generate targeted scientific results for the resolution of knowledge-based scale-up challenges, to ensure that the commercialisation of new products and process is not hindered. This intervention will fund research collaboration actions between a pilot plant and a university about particular challenges affecting process technologies in the renewables sector. The overall investment has been estimated at 0.5 to 1 million € but this figure could be significantly higher as it depends on the depth a width of the project and the geographical location of researchers (salary variation per country).

The business cases were presented to a series of bioeconomy funding experts in a roundtable that took place in Brussels on the 24th June 2019. During this roundtable, experts were given the option to provide feedback about the ideas presented and to propose the best possible routes to secure funding to finance these interventions and the possible issues and barriers that would need to be addressed.

Finally, the business cases were passed to BBI JU, the funders of the Pilots4U project, along with recommendations for where the agency could take future actions.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

2 INTRODUCTION

2.1 Purpose and target group

The purpose of this report is to describe three business cases that describe different opportunities to address the gap in provision identified throughout the Pilots4U project in regard to pilot/demo infrastructure and associated expertise. This document also assesses the means by which ideal outcomes could be supported.

These business cases described in this report were presented to a series of key stakeholders with expertise in public and private funding options in order to discuss the best possible sources of funding to finance the ideas described by the business cases.

2.2 Background and previous work

Pilots4U aims to setup one highly visible, easily accessible database and network of open-access pilot and multipurpose demo-infrastructure for the European bioeconomy. Additionally, Pilots4U carried out a gap analysis exercise to understand under- and overcapacities within the European landscape of pilot and demonstration facilities. The study considered existing capabilities, industry needs and articulation of market needs. The conclusions drawn from this gap analysis were discussed in a series of workshops and webinars that gathered bioeconomy experts from across Europe.

The outcome of this discussion with experts were analysed and it was observed that most gaps in provision could be tackled by three generic types of intervention: 1) investment in new equipment assets to strengthen existing centres, 2) investment in coordination actions that help pilot plants to maximise the exploitation of existing equipment and expertise, and 3) investment in knowledge generation to increase the expertise and tools of the European pilot centres.

These three types of intervention were converted into business cases for investment in pilot/demo infrastructure and associated expertise that help maintaining the current momentum of key bio-based technologies as well as driving new developments.

3 METHODOLOGY

Following the work described in Section 2.2, the outcomes of the gap analysis and the horizon scan workshops were used to develop a scoring/assessment system of the identified gaps to gain an understanding of the most urgent/high priority gaps. Although all the identified gaps were considered relevant, the scope of the project and resource limitations only allows up to 6 of those gaps to be brought forward to the next stage of the process. Thus, a systematic methodology that allowed selection of a few key gaps, was developed.

For those key gaps, a set of options/opportunities to address these deficiencies in provision were suggested. After reviewing the suggested options to address gaps in provision, and it was observed that most gaps in provision could be tackled by three generic types of intervention that were converted into standalone business cases:

1) Investment in new equipment assets to strengthen existing centres,

2) Investment in coordination actions that help pilot plants to maximise the exploitation of existing equipment and expertise, and

3) Investment in knowledge generation to increase the expertise and tools of the European pilot centres.

It is believed that more value is gained from the generation of three generic business cases that can be applied to many of the opportunities identified during the project, rather than just describing a few very specific business cases that would only address a small number of the identified gaps. Nevertheless, some of the gaps identified as urgent/high priority are discussed in more detail within those business cases.

Each business case includes a detailed explanation of the issue to be solved, the different options available to solve the issue and the benefits of the recommended solution. The analysis also estimated the cost of each proposed intervention. Additionally, and as mentioned above, some of the gaps identified as urgent/high priority are discussed in more detail within each business case.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

4 BUSINESS CASES

Over the last few years, the European Union has set up ambitious targets to fight global challenges such as climate change, plastic pollution and reducing dependency on fossil fuels. Exploiting well-known and new emerging technologies based on the utilisation of bioderived resources will help meeting these targets and contribute to the development of sustainable growth that does not compromise future generation's resources.

However, one of the main challenges in the rapidly evolving bioeconomy is bringing newly developed molecules and techniques from lab to market. At the moment, innovation progresses along the stages of the 'innovation chain': discovery (research) - technology development (piloting) – first production (demo) – market introduction (deployment). An identified bottleneck in the innovation chain of the bio-based economy is the step from technology development to deployment. This step has to be performed first at pilot scale and later in a demonstration plant where the production process can be tested and optimised at scale in an industrial production setting. Pilot- and demo-plants are expensive industrial installations that require specific expertise, and most SMEs and also a lot of large companies have no direct access to such facilities. As a result, promising innovation processes may grind to a halt.

A solution to this problem are 'open-access pilot- and multipurpose demo-infrastructures', initially established in North and West Europe during the last decades, and that offer pilot/demo equipment to any customer in exchange for a fee. They have proven to be successful in helping innovators, especially SMEs, to bridge the so called 'Valley of Death' – this is the above-mentioned innovation phase between laboratory and successful market introduction that comes with a high technological and financial risk. As open-access infrastructure is accessible to all companies and research institutes, it can be seen as shared investments in research infrastructure.

At an EU level, support to shared access facilities will contribute to the development of the European bioeconomy by the creation of new jobs and the development of new bio-based products and processes that help fight global challenges such as climate change or plastic pollution. Additionally, working with an independent entity such as an open-access centre during the scale up process could be beneficial for innovators as this will help boosting investors' confidence in the outcomes. Support for these types of facilities agrees with current policies such as the updated European Bioeconomy Strategy in which one of the three objectives is to strengthen and scale-up the European bio-based sector; this includes the mobilisation of public and private stakeholders for the research, demonstration and deployment of bio-based solutions.

Pilots4U carried out a gap analysis to gain an understanding of potential gaps in provision (equipment and expertise) in the open-access pilot/demo facilities across Europe. The project team suggested a set of options to address some of these gaps, most of which could be tackled by three generic types of intervention that were converted into business cases: 1) investment in equipment, 2) investment in coordination actions, and 3) investment in knowledge generation and training.[1] These business cases are described in the following sub-sections in terms of proposal, benefits, financial aspects and risks associated to implementation.

4.1 Type of intervention 1: investment in equipment for existing facilities

Strategic case

What is the gap in provision? And the proposed intervention to address it?

The gap analysis performed by Pilots4U highlighted a lack of specific equipment assets in open-access pilot and demonstration facilities. A detailed list of all the identified gaps can be found in Appendix 1.

The proposed intervention aims to tackle this lack of assets and strengthen the European landscape of open-access infrastructure by the investment in new, state-of-the-art equipment to be located in existing open-access centres. During the last decades, open-access centres have contributed to de-risking the scale-up process of bio-based innovations thanks to its strategical position between fundamental research and technology commercialisation, playing a key role in helping SMEs and innovators to bring their ideas closer to commercialisation. Further investment is now required to keep existing open-access infrastructure running and up to date, so more bio-based innovations can reach the market sooner which will help tackling key global challenges.

According to the proposed intervention, the investment will go towards existing open-access centres in need of specific infrastructure and to support existing knowledge and expertise, and not towards the construction of brand-new open-access centres as this would generally cause duplication of resources. It should be noted that this is applicable to most areas of Europe with the exception of Eastern Europe where a very small number of open-access pilot/demo facilities were identified and therefore, new centres may be required in the future.

The proposed intervention includes two key aspects:

- WP1: infrastructure investment – dedicated to delivering the necessary infrastructure. Depending on the gap to be tackled, infrastructure investment could involve the upgrading of existing capabilities to enable them to process larger capacities or different types of feedstock, or the construction of new assets within an existing centre to complete its current provision. Similarly, investment could be placed towards small scale assets (semi pilot and pilot) or large assets (large pilot and demonstration) and could cover a single asset or a processing unit. Additionally, specific staff training may be required to provide the team with the necessary skills to operate the new equipment.

- WP2: communication efforts – focused on promoting the new infrastructure to maximise its visibility and attract new customers/innovators. Several communication activities are advised including attending conferences and trade fairs, and the design of bespoke social media campaigns among others.

What are the specific aims for investment?

The overarching aim of the proposed intervention is to strengthen the existing open-access infrastructure in Europe to keep it relevant, useful and to represent state-of-the-art technologies. The underlying aims are:

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

- Economically, the proposed intervention should generate economic growth by enabling more bio-based innovations reaching the market, by de-risking and reducing the cost of access to scale-up processes. The expected increase of innovations reaching the market as a result should reflect current sector activity for centres selected for investment.

- Environmentally, the new commercial bio-based innovations should contribute towards meeting targets to minimise the impact of climate change, plastic pollution or energy shortage among other policy concerns.

- Socially, creation of new businesses will create new jobs, and reinforce Europe's position in the field of research and innovation by generating high value jobs. The number of new jobs expected should reflect the number of projects reaching commercialisation.

For each pilot plant involved, the proposed intervention should increase the number of projects attracted to the facility and utilisation of the sites facilities as well as increase the volume of research funding obtained (where relevant) in comparison to the current baseline delivery per year. Expected targets for these indicators would be defined based on the present activity of the selected facility.

What are the key milestones of the project?

The key milestones/stages of the proposed intervention are:

- Design stage: new asset(s) will be designed, and the team will liaise with engineers, equipment manufacturers, contractors, etc. to obtain a robust design that accounts for all the different aspects that will play a role during the building phase.

- Building stage: this stage will involve the construction and installation of the equipment all the way up to the commissioning stage. During this time the key focus will be keeping the project on time and within budget. Towards the end of this phase, active communication will start to attract new clients that can make use of the new equipment.

- Operational stage: this phase will begin after commissioning, once the equipment becomes operational. Its main focus will be the promotion of the new infrastructure to attract new clients and maximise impact of investment.

How do such investment propositions fit with EU vision and actions?

Europe has funded, through a variety of funding mechanisms, several actions and projects to develop open-access infrastructure and encourage its use. Examples are described below:

- The EU Biobased Industries (BBI) Joint Undertaking is a €3.7 billion public/private partnership between the EU and BBI to fund research and development. The BBI JU has already invested over €110 million in flagship pilots around Europe.

- Additionally, several consortium-based projects, such as SuperBio or BioBase4SME have offered businesses discount vouchers to access open-access infrastructure.

- Other initiatives such as SmartPilots received funding to improve regional policies in support of open-access centres; Pilots4U itself received European funding to increase the visibility and coordinate the activities of the European open-access infrastructure.

The continued support for open-access infrastructure over the past few years and the positive outcomes observed suggest that government support will continue. In fact, the updated European Bioeconomy Strategy includes a key call to action: *'strengthening and scaling up the bio-based sectors, unlock investments and markets'* to be delivered through mobilisation of public and private stakeholders to support research, demonstration and deployment of bio-based solutions.

Economic case

Possible options to address gaps in equipment provision

Table 1 Options to address deficiencies in open-access pilot and demo equipment.

Options	Description
1	**Investment in new equipment assets to strengthen existing open-access centres (recommended)** Provide investment to build new equipment to address specific gaps in provision, identified through a technical and financial business case. Additionally, support communication efforts to promote the new infrastructure to increase awareness. This intervention will increase visibility of the selected facility. The new equipment will allow the open-access centre to offer a broader portfolio of services to clients, and therefore it is expected that the number of clients and projects will increase. In addition, investment in new equipment ensures the facilities remain relevant and build on past investment in the facility. Strengthening existing facilities would deliver at significantly lower cost than building an entirely new open-access centre, and importantly provides access to existing expertise. In some cases, the required assets exist but are separated from other complementary assets required to demonstrate the full value chain. In such cases, establishing shared-access, or an equipment sharing agreement between organisations would be more cost-effective.
2	**Construction of new open-access site to host the new equipment** Support could be provided for construction of a whole new site in a key location to host a range of pilot and demo infrastructure and expertise, including the assets identified as gaps by the gap analysis exercise. This approach would increase the geographical availability of open-access centres. Cost and time required will in most cases be much higher than investing in an existing facility (assuming space and capacity is available). This could lead to duplication of resources as some of the necessary equipment and expertise required for the new site will be already available in one or more existing facilities.
3	**Establish shared-access models with industry assets owners** In some cases, the equipment assets under study exist but not as open-access infrastructure (equipment is owned by industry but may not be fully utilised).

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

	Establishing a collaboration agreement between private asset owner and a pilot plant could be the most effective solution.
	This approach incurs lower cost compared to other options, as no new infrastructure is required.
	Dealing with Intellectual Property can be an issue for potential clients using the equipment. Gaining access at preferred times of operation may also be challenging.
4	**Do nothing**
	No new infrastructure is added. No cost.
	Existing facilities will only offer a reduced portfolio of equipment that may become out-dated; the initial investment made in those centres will be 'lost'. Reducing client interest may result in some of the existing facilities ceasing operation, reducing jobs and expertise.

So, what are the benefits & projections of placing new complementary equipment in existing open-access centres?

Open-access centres reduce the cost and time required for proofing scale-up and reduce the associated investment risk. In addition, investment in open-access infrastructure ensures that facilities are available to a wide range of innovators.

Existing facilities have a recognised presence in the sector which will ease attraction of projects and clients to maximise the return on investment. Furthermore, placing new equipment in exiting pilot and demo open-access infrastructure is not only beneficial for the pilot plant but also for the many innovators that will be able to use the installations as well as for the development of the European bioeconomy:

- <u>Benefits for existing open-access centres.</u> Placing new equipment in existing centres allows most effective use of existing resources, including analytical equipment, and staff expertise. This ensures that exploitation of existing infrastructure and expertise is maximised, much of which may have already been publicly funded. This contributes to keep the facility active and up to date. Furthermore, the increased portfolio of services offered should lead to a stronger position of the facility within its sector. Finally, this approach avoids dilution of infrastructure and associated expertise due to proliferation of too many open-access centres working in the same field. Although it is difficult to monetise projections, it is expected that new jobs will be generated, and additional R&D funding will be leveraged by the plant. More accurate projections can be made for specific cases and selected centres.

- <u>Benefits for innovators.</u> New and up to date assets will be available; a larger number of innovators will benefit from this low risk and fast pathway towards commercialisation. Previous discussions by the project team with existing open-access facilities indicated an 11% success rate of commercialisation of a new product and the creation of 3-5 jobs within each SME and 5-10 jobs in larger companies after the successful commercialisation of new product or process. It should be noted that projections are very difficult to standardise as they depend on what the product is and its market potential. Also, an improvement in the success rate is expected with the allocation of funds towards the preparation phase of the work.

- Benefits for the European bioeconomy. Strengthening the landscape of open-access infrastructure in Europe will translate into more bio-based innovation reaching the market, contributing to maintain European competitiveness in the global bioeconomy. Investment will generate direct and indirect jobs both at the pilot plant and at the client's company when an innovation is successfully commercialised which will in turn generate additional turnover in the sector.

Financial case

What are the likely financial requirements?

The overall investment required to add new equipment asset(s) to an existing facility has been estimated at 0.5 to 10 million € and will very much depend on the type of asset, its capacity and operational characteristics. For example, whereas updating currently available assets (i.e. digitalisation of an asset) would be at the lower end of the range (~0.5 million €), investing in new small-pilot assets would be more costly (0.5-2 million €); if new flooring space is required, the project cost could increase up to 10 million € or above. Case studies 1 and 2 in Appendix 2 show two very different examples in terms of asset type and capacity that consequently require significantly different investment. Further details about financial estimations can be found in Table 2 below and Appendix 3.

Table 2 Cost per work package associated to the implementation of the proposed intervention.

Cost description	Cost (€)
WP1: infrastructure investment Cost of new equipment, installation and flooring space (if required)	0.5-10 mill €
WP2: Communication activities Includes the cost of the communication team, communication material and promotional activities (i.e. event participation).	40000 – 60000 € (for 1 year of activity)
TOTAL	**0.5-10 mill €**

At a European level, funding for new equipment can be mainly obtained from a few different sources, including the European Innovation Partnership through its funding mechanism the European Structural and Investment Funds (ESIF), grant-funded projects, and/or equity or loan base systems. At a national level the type of funding available is similar, as new equipment can be funded through grants, equity or loan-based systems. Additionally, it should be noted that ESIF funding is granted by each Member State. A detailed relation of the possible funding sources to finance this business case can be found in Appendix 4.

What resources beyond capital investment are required?

Beyond capital investment, a series of human resources will be required to coordinate the design, development, installation and promotion of the new infrastructure (Table 3).

Table 3 Human resources required to implement the proposed intervention.

Other resources	Description

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

Installation team	The installation team covers a wide range of professionals from process designers, to engineering competences, and personnel dedicated to performing safety evaluations and deal with environmental and other regulatory permits.
Communication team	The team will coordinate communication activities to promote the new equipment, develop the necessary communication material and attend events/conferences.

What are the associated risks? How can risks be reduced?

The risks are summarised in Table 4.

Table 4 Risks associated with implementation.

Risk	Mitigation actions
Low levels of client engagement The number of clients accessing the new assets is below expectations	Continuous monitoring and increase promotional efforts and business development (including dedicated staff). Development of a comprehensive communication plan at the beginning of the project
Technical issues with equipment The equipment is not working as expected (i.e. in terms of processing capacity)	Contingency budget available Strong team of designers, engineers, etc. to develop a realistic plan at the beginning of the process.

Co-location in existing open-access centres with existing expertise will reduce risks associated with poor planning or management. Furthermore, recognised existing open-access centres are likely to be successful in attracting new users for the equipment, reducing risks associated to low levels of customer engagement.

Monitoring and evaluating

Evidence of success from similar actions?

Pilot plants across Europe have consistently delivered positive outcomes for the European bioeconomy and an increasing number of innovators have made requests to collaborate with these centres. In addition, significant public investment has been made in the last few years to fund the running and expansion of key open-access facilities.

Previous investment in open-access infrastructure has proven to be successful with regard to the return on investment. For example, the investments VTT has made to the Bioruukki Pilot Centre and to the thermochemical conversions pilot equipment have substantially increased the competitiveness of thermochemical conversions research and innovation in Horizon 2020 project calls and increased VTT's EU funding in the research area.

How can success be measured?

Several performance indicators can be used to assess the success of the investment made, following the commissioning of any new plant addition, including: the turnover of the pilot plant from point of commissioning, the number of clients and projects that accessed the facilities, additional research funding generated thanks to the new equipment, and direct and indirect jobs created as a result of the investment.

Conclusions

Past public investment in pilot/demo infrastructure has proven the potential of these facilities. Now, efforts should focus on keeping existing facilities up to date to match technology evolution and the arrival of new processes, for which further public funding is required (this is applicable to most areas of Europe with the exception of Eastern Europe where a very small number of open-access pilot/demo facilities were identified and therefore, new centres may be required in the future). Through the proposed intervention Pilots4U seeks to strengthen and update the European landscape of open-access infrastructure by investing in new, state-of-the-art equipment to be located in existing open-access centres which will allow to deliver greater synergy through linkage to existing equipment and expertise. The investment will range from 0.5 to 10 million € depending on the characteristics of the new equipment or the need for new flooring space among others and will require of a strong team formed by a wide range of professionals capable of effectively designing, installing and promoting the new equipment.

Several funding mechanisms at both European and national level, including ERDF funds, can be suitable for financing this type of infrastructure. Investment made in open-access centres is expected to revert back into the European bioeconomy, which is kept competitive within the global bio-based markets, thanks to the creation of new jobs, economic growth and minimisation of key environmental challenges.

4.2 Type of intervention 2: investment in coordination actions

Strategic case

What is the gap in provision? And the proposed intervention to address it?

The gap analysis highlighted that different equipment assets required for scaling up of a complete process (i.e. pre-treatment, main processing, downstream, further conversion of intermediates) are not generally located at the same site and are instead, distributed among different facilities.[2] This separation of unique capabilities may be the result of cross-sectoral collaboration only being recently exploited, and can have negative consequences for both pilot equipment owners and users/clients of the open-access pilot plants:

- For the pilot facilities: lack of dialogue and cooperation with peer pilot plants owning complementary capabilities, which could lead to duplication of resources and efforts (i.e. overlapping investment in infrastructure).

- For the users: hindering the scale-up of new ideas or innovations, or development of non-optimal solutions that lack an overall consideration of the process.

The proposed intervention aims to maximise investment made in open-access infrastructure and expertise over the last few years by the creation of collaborative networks of open-access centres that own complementary infrastructure within a specific value chain. The value of open-access centres has been identified by the previous case for intervention (Section 4.1).

Investment will go towards pilot plants involved in the network, supporting the establishment of the network, development of governances and sharing arrangements and to implement key

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

network activities. It is anticipated that such support would be required for a minimum period of at least 4 years.[3] The proposed intervention includes the following key aspects:

- WP1: network support – to cover the cost of creating a management group which will include members from all the open-access facilities with interest in being involved in the network, with expertise in relevant stages of the value chain.

- WP2: coordination actions – undertaking a range of activities designed to allow staff from different centres to learn from each other. Coordination actions could include knowledge exchange activities between members of each pilot plant, and possible secondments; development of tools (web-based or otherwise) that allows centres to have visibility of each other capabilities to encourage further exchange of expertise; and development of agreements to underpin equipment sharing and management of IP etc.

- WP3: communication efforts – to: 1) raise awareness of the bioeconomy opportunities to tackle societal, economic and environmental issues 2) to promote the services offered by the network and its partners. It is expected that the joint communication campaigns would enable a broader audience than could be achieved by individual entities. Communication efforts could include attendance at events in which to promote the network, the creation of communication materials (i.e. leaflets, case studies, annual reports, etc.), and the establishment of a common access point in the form of a network website.

What are the specific aims to be achieved?

The aim is to maximise the exploitation of existing open-access infrastructure in Europe. This will be achieved through increasing volumes of clients and work for the pilot plants involved in the collaborative network as it is expected that the joint communication efforts reach a much broader audience than the individual entities separately. Similarly, higher visibility will increase leverage of public funding for research projects. In addition, the proposed intervention aims to increase staff expertise thanks to a learning by sharing approach. Most importantly, the proposed intervention seeks to improve customer's experience by providing clients with optimal processes that take into consideration the entirety of their process which will reduce the time required to reach commercialisation, the cost and the associated risks.

What are the key milestones of the project?

The key milestones/stages of the proposed intervention are:

- Setting up the network. Coordinated operations begin.

- Mid-point evaluation. After 2 years, the activities performed will be examined to assess success and positive impact of the network. The means used to measure success are detailed at the end of this section.

- End of project. At the end of the project, another evaluation round will be carried out. Network participants will assess the outcomes and impacts resulting from the network and if positive, they will explore possible means of continuing the collaboration beyond project limits.

How does this fit with the EU vision?

Over the last few years, Europe has funded, through a variety of funding mechanisms, several actions and projects to develop open-access infrastructure and to encourage its use as detailed in the previous case. Significant effort has also been put towards promoting cooperation and collaboration between these organisations. At a European level, key examples of investment in cooperation are the actions supported by InterregEurope, which help regional and local governments to deliver better policy; InterregEurope supports the co-operation of regional and local authorities to avoid wasting time and money targeting the same or very similar issues individually (i.e. the SmartPilots project seeks to improve policies in support to shared-access facilities). It is also possible to find several projects that have been funded to coordinate the activities of pilot/demo open-access centres. As an example, Pilots4U received funding for the development of a network and database of open-access pilot and demo infrastructure for the European bioeconomy; and BRISK2 aims to provide researchers from around the world with access to biological and thermal biomass conversion facilities across Europe by facilitating Transnational Access to improve the success of international biofuels research and implementation.

At national level, in the UK the NIBBS (Networks in Industrial Biotechnology and Bioenergy) were funded by the UK government to foster collaborations between academia, industry, policy makers and NGOs in order to find new approaches to tackle research challenges, translate research and deliver key benefits in Industrial Biotechnology and Bioenergy.

All the above-mentioned examples suggest that the proposed intervention fits well with EU and individual government vision and aims.

Economic case

Options to address this gap in provision

Table 5 Set of options to address disconnection between open-access pilot and demo equipment.

Options	Description
1	**Creation of a network of complementary open-access facilities (recommended)** Support to maximise exploitation of existing infrastructure by the creation of a network to link facilities with complementary assets. The network will increase the visibility of the centres involved and will support provision of staff training. The network will deliver the best possible customer support by considering all the steps of a process. This approach will increase the dialogue between cross-sectoral open-access centres, with the aim of delivering innovative solutions for a client’s process. In addition, this will maximise the utilisation of investment previously made existing equipment. There is a risk that the network dissolves without ongoing funding support.
2	**Investing in new infrastructure** Support the construction and installation of new equipment assets to complete the infrastructure of a specific centre so it can offer assets across an entire value chain.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

👍	This approach helps gathering all the relevant equipment for a specific value chain under one roof, which would reduce time and cost associated with transportation of raw material and intermediate compounds between centres.
👎	Investment in new equipment will increase costs compared to encouraging collaboration between centres and could result in duplication of resource and increase the risk of reducing revenues in affected competing facilities. This approach limits the number opportunities for knowledge exchange for wider benefit.
4	**Do nothing**
	The existing open-access centres continue operating in an individual manner and knowledge exchange and joint communication activities are neither encouraged nor supported.
👍	This approach incurs in no cost.
👎	Reduces the opportunity to attract new clients. Cost for clients will increase and activities will be more time consuming without the guidance and support capable of considering all aspects across the value chain from the project outset. Reduces opportunities for knowledge exchange.

The preferred option of 'creating a network of complementary open-access facilities', addresses the key issues identified by the gap analysis most effectively, especially in cases where assets are already widely available across Europe.

The work done by Pilots4U, and proposed ongoing work, will allow identification of the most appropriate centres to be involved in any new value chain-focused network. In addition, most open-access centres are used to working as part of consortium project which will help to minimise operational issues and concern between network partners.

What are the benefits of creating a value chain-focused network of open-access facilities?

The creation of a network of open-access pilot and demo open-access centres that own complementary infrastructure provides a range of benefits:

- Benefits for the open-access centre. Maximises the use of existing infrastructure and contributes to keeping facilities running. Avoids the dilution of infrastructure and associated expertise that would be created by proliferation of too many open-access centres owning the same or very similar assets. The creation of a network will also increase visibility of the centres involved. Although it is difficult to monetise the impacts, it is expected that the investment will generate additional work and will leverage additional R&D funding for the facilities involved in the network and therefore increase turnover. The creation of new jobs is also expected both at the site and at clients' businesses.

- Benefits for innovators. Gaining access to a 'one-stop-shop' for their scale-up process to obtain guidance that considers the whole process, which can be translated into a shorter and cheaper pathway towards innovation. In addition, knowledge exchange between open-access centres can lead to innovative solutions for innovators' challenges. As mentioned above, it is expected that new jobs will be created. Previous studies based on success rates for open-access centres in the UK indicate an 11% success rate of commercialisation of new product and the creation of 3-5 jobs within each SME and 5-10 jobs in larger companies after the successful commercialisation of new product or process. It should be noted that projections are very difficult to standardise as they depend on what the product is and its market potential.

- Benefits for the European bioeconomy. Strengthening the landscape of open-access infrastructure in Europe will raise awareness and visibility which should translate into more bio-based innovation reaching the market which will contribute to maintain the European competitiveness in the global bioeconomy. Investment will generate direct and indirect jobs both at the pilot plant and at the client's company if an innovation is successfully commercialised.

Financial case

What are the likely financial requirements?

The capital investment required to implement a network of the type described is estimated in approximately 0.8 – 1.5 million € (for a 4-year project).[4] This includes funds to encourage knowledge transfer between centres, to carry out joint communication activities and to establish an expert group that can provide clients with optimal advice for their processes. Estimations are based on the knowledge of Pilots4U partners that have participated in consortium-based projects in the past. More details can be found in Table 6 below and in Appendix 3.

Table 6 Cost per work package associated to the implementation of the proposed intervention. A four-year period of activity is assumed.

Cost description	Cost (€)
WP1: Expert group Provide clients with advice during the project	500000 - 800000
WP2: Coordination actions To encourage skills and knowledge transfer between facilities. Admin team to coordinate.	140000
WP3: Communication activities Cost of communication team, communication material and promotional activities	150000 - 250000
WP4: Legal advice To facilitate collaboration between facilities. Higher workload in cases similar to exemplar case 2.	50000[5]
TOTAL	**0.8 – 1.5 million €**

The best funding pathways for investing in coordination actions are most likely to be grant-based projects, as making a business case for loan options for this type of investment could prove difficult. At a European level, coordination actions such as networking, awareness-raising and dissemination can be funded as part of larger research or innovation projects. There are other pathways to fund parts of the proposed intervention; for example, as part of H2020, the Marie Sklodowska-Curie Research and Innovation Staff Exchange (RISE) programme funds short term exchanges of personnel between academic, industrial and

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | *Topic: BBI-2016-S02*

commercial organisations. At a national level, several initiatives to fund cooperation actions can be found at different members states. A detailed relation of the possible funding sources to finance this business case can be found in Appendix 4.

What resources beyond capital investment are required?

Beyond capital investment, a series of human resources will be required to coordinate the design, development, installation and promotion of the new infrastructure (Table 7).

Table 7 Human resources required to implement the proposed intervention.

Resource	Description
Communication team	Design and development of communication campaigns and materials, participation at events, set up initial contact with potential clients, evaluation of communication performance, prepare case studies and annual reports. Required throughout the project; expertise in communication, general understanding of bioeconomy, the network and services offered by all centres conforming the network.
Admin team	Coordination of exchange activities, organisation of internal workshops. Required throughout the project; financial and administrative background, in order to coordinate the exchange actions.
The expert group	Members of all the centres involved in the network. Capable of understanding client's needs and offer cross-sectoral advice. Also, internal meetings to discuss policy support.
Legal advice	Provide advice regarding collaboration agreements, IP, etc.

What are the associated risks? How can I risks be reduced?

The risks associated to this business case include technical and commercial risks and are summarised in Table 8.

Table 8 Risks associated with implementation.

Risk	Mitigation actions
Low levels of client engagement The number of clients accessing the facilities is below expectations	Joint communication campaigns from project outset to help increase visibility. Continuous monitoring and evaluation, to address low levels of engagement right away.
Dissolution of network The networking actions cease when funding runs out	Continuous monitoring and evaluation to try and maximise success and provide positive case studies that can be used in future funding applications to support ongoing co-ordination activities.
Low levels of collaboration	Funding for legal advice to draft working agreements to gain consensus and address fears over control of IP or ideas and to

The facilities involved do not engage in as much collaboration as expected	address issues encountered in day-today working that may affect the appetite for collaboration. Agreement signed before project starts.

The network will gather existing open-access centres, most of which have past experience of working in consortium or network-like projects. This will contribute to the effective promotion of the network and will reduce the financial risk of the investment not being 'recovered' in the form of new bio-based innovations. The past collaborative experience of the centres involved will help to facilitate the dialogue between members of the expert group to increase the chances of generating innovative ideas to address client problems. This will also reduce the financial risk of not recovering the investment made in the network in the form of new bio-based innovations.

Monitoring and evaluating

What is the evidence on why this solution could be effective?

Pilot plants across Europe has consistently delivered positive outcomes for the European bioeconomy and an increasing number of innovators request collaboration with these centres. In addition, previous collaborative projects have shown positive outcomes. A network formed by keen partners can outlive preliminary project funding if it presents promising outcomes for the parts involved. For example, the project Pilots4U received funding to set up a network and database of European open-access centres. The potential of the project's results has encouraged partners to make arrangements for the establishment of a self-sustaining network that stays active once the initial funding runs out.

How will success be measured?

Several performance indicators could be used to assess the success of any investment made, including, the turnover of the pilot plants involved in the network, the increase in the number of customers and projects observed by pilot plants involved in the network, the ability of the centres involved in the network to attract additional funding for research & development and direct and indirect jobs created as a result of the network.

Additionally, website visits, social media impact and attendance to events will be assessed to measure the success of the communication campaigns. The effectiveness of coordination actions can be measured by questionnaires to employees to understand whether knowledge exchange activities were seen as positive and helped delivering better results for clients, and questionnaires for clients to understand how the network help on their way to commercialisation of their new product or idea.

Conclusions

Although pilot scale assets are available, complementary assets are not always well linked, which can make the scale up process more difficult for users/clients. Setting up a network of pilot plants with complementary assets within a specific value chain will reduce disconnection between facilities and collaboratively will deliver much more than the sum of its parts.

Relatively small amounts of public funding can come a long way when invested effectively. In this case, the suggested network would help maximising the impact of past public investment as well as encouraging knowledge exchange to deliver optimal solutions to clients' scale up

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

process at much lower cost than investing in new infrastructure. In addition, it would avoid dilution of infrastructure and expertise and the competition between existing centres. The approximate cost of running a network of these characteristics over a period of 4 years is expected to be 0.8 – 1.5 million €, with a significant part of the budget dedicated to the creation of a group of experts, capable of providing innovative solutions to client's problems.

4.3 Type of intervention 3: knowledge generation

Strategic case

What is the gap in provision? And the proposed intervention to address it?

In a scale-up process, large-scale equipment only represents half of the problem, the other half being expertise, key to find the optimal conditions at which to operate the equipment.

In some cases, the previous gap analysis exercise highlighted lack of knowledge as a key factor affecting progress for development of certain processes and/or the steps in development of a specific process. These gaps in knowledge and expertise may be due to the novelty of a technology (i.e. gas fermentation) or to the existence of specific technical issues that have not yet been optimised (i.e. gas cleaning for gasification or gas fermentation technologies, or syngas upgrading to products). This lack of knowledge can be related to both early stage development and unforeseen issues found when scaling up and have an impact on:

- Open-access centres. Gaps in knowledge and expertise are likely to increase the amount of time that pilot plants and their staff dedicate to a client's project and fail to deliver optimum outcomes.

- Innovators. Gaps in expertise can lead to the development and commercialisation of non-optimal processes in which larger amounts of energy and/or resources are needed, resulting in higher production costs hindering commercialisation.

- Bioeconomy development. Failures in the development chain means less bio-based innovations reaching the market, so the development of the bioeconomy in Europe will be hindered, affecting the competitiveness of the European industrial base.

Investment in knowledge generation is key to optimise the use of open-access facilities, help new innovations reach the market and support the maintenance of the competitiveness of Europe in the global bioeconomy. Thus, the proposed intervention suggests investing in research projects focused on addressing gaps hindering the development of bio-based technologies, with particular attention to the scale-up aspects of these challenges. The suggested investment would go towards universities, to carry out research activities, and open-access pilot and demo facilities, to test key exploitable results at larger scales. Additionally, a small part of the budget would be dedicated to the creation of an online technology hub: a collaborative space to promote dialogue between the research facility and the pilot plant that allows for the knowledge to remain within the hub even in the event of a key researcher leaving the project.

The proposed intervention includes the following key aspects:

- WP1: basic/initial research – dedicated to cover the cost of the research project, which includes researchers' salaries, consumables required and other direct and indirect costs such us travelling to conference or admin personnel respectively. This WP also includes the supporting role of open-access facility experts who will help designing the research project and will provide advice to researchers through periodic meetings.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

- WP2: scale up testing – key results will be tested at larger scales in an open-access centre in order to validate the applicability of the new method/process developed. This work package is dedicated to cover the cost of these pilot testing for which it is anticipated a duration of 1-2 weeks of work at the pilot plant.

- WP3: the online hub – this will cover setting up and maintaining an online platform. The online platform would have a discussion board where members from both centres will be able to ask questions or post challenges that there are facing in their work to find support from professionals working in different environments and backgrounds. In addition, a yearly event will be organised (i.e. a workshop) to encourage further knowledge exchange and knowledge generation between researchers and the pilot plant.

- WP4: communication efforts – focused on the promotion of the open-access centre and university involved, including their research efforts and success stories, to potential new clients. Several communication activities will be undertaken including attendance to conferences and trade fairs, and the design of bespoke social media campaigns among others.

What are the specific aims for investment?

The overarching aim is to tackle current knowledge challenges affecting the development of bio-based technologies. This will be achieved through a series of underlying objectives:

- Funding the work of several researchers to complete a research project. The number of researchers funded would vary depending on the breath of the project, but it is expected to include 1 PhD position, 1 post-doctoral researcher and the assistance of a technician and a professor. Improvements regarding the challenge under study will be measured in terms of improvements in product yield, production rate, cost or energy demand of the process (this will depend on the challenge being addressed).

- Establishing online platforms to allow communication between centres involved in the project. The effectiveness of the hub could be assessed periodically by the number of posts and through interviews with users of the platform.

What are the key milestones?

Key milestones/stages within the project would be:

- Periodic meetings to inform the pilot plant of the progress of research and a chance for discussion and future work planning.

- Establishing the online hub.

- Midterm review. When the collaboration reaches its middle point (2 years), assess the achievements so far and address needs of future work for the second part of the project.

- End of project. Evaluation to understand whether the initial aims were met, and to assess the outcomes of the research and collaboration efforts.

How does this fit with EU's vision?

The new research and innovation framework, Horizon Europe, has a proposed budget of 100 billion €, a considerable increase from the 77 billion € assigned to the previous Horizon2020 framework. This means that in just 7 years Europe will invest 50% of its total investment in science and innovation delivered over the last 30 years. Horizon Europe will directly support research relating to global challenges such as tackling greenhouse gases emissions and reducing plastic pollution. This highlights the importance placed by governmental authorities in the generation of knowledge that helps shape a new, more sustainable future.

In addition, recent policies acknowledge the importance in supporting both basic research and scaling-up stages. Over the last few years, Europe has funded, through a variety of funding mechanisms, several actions and projects to develop open-access infrastructure and to encourage its use (specific examples are listed in Type of intervention 1); and the recently updated European Bioeconomy Strategy define three main action areas one of them being *'strengthening and scaling up the bio-based sectors, unlock investments and markets'* which includes the mobilisation of public and private stakeholders for the research, demonstration and deployment of bio-based solutions.

Economic case

Options to address this gap in provision

Table 9 Set of options to address knowledge gaps affecting open-access pilot and demo infrastructure.

Options	Description
1	**Fund a research collaborative project between universities and pilot plant (recommended)** Invest in research and development to fill in knowledge gaps that currently hinder the development of bio-based technologies, create knowledge hubs and provide a collaborative space for researchers and pilot staff members. Increase the dialogue between cross-sectoral open-access centres which should lead to identification of innovative solutions to address client's problems. Cheaper option than building a technology hub (with building and maintenance costs). In some cases, the university where key research is performed may not be ideally located in relation to relevant open-access centres which may hinder collaboration efforts.
2	**Funding individual PhD/post-doctoral projects (no knowledge hub)** Invest in research to fill in knowledge gaps that currently hinder the development of bio-based technology through the funding of individual researchers. Lower cost than the creation of stronger links between both organisations. There is a risk of the knowledge generated being lost if the key researcher moves on, as no close connection is established between the open-access centre and the university. In addition, the reduced contact between professionals from the pilot plant and the university minimise the chances of developing innovative solutions.
3	**Investment in the construction of a technology hub in close proximity to the pilot plant**

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

	Invest in research and a physical collaboration space to fill knowledge gaps that currently hinder the development of bio-based technology and encourage collaboration between centres.
	The technology hub would host several research centres and technology companies, there would be more potential for interaction between a broad range of experts. In addition, the proximity to a pilot plant would help the latter to maximise contact with organisations in the hub.
	High cost option. The creation of a 'large' hub containing many institutions of different backgrounds and different interests would be difficult to draw together without a significant competitive advantage being on offer. Issues around IP sharing and confidentiality issues could hinder collaboration.
4	**Do nothing**
	The existing open-access centre continue operating without further investment in knowledge generation.
	This approach incurs in no cost.
	Fails to address knowledge gaps currently hindering sector development.

The proposed intervention, "invest in research and development to fill in knowledge gaps that currently hinder the development of bio-based technologies", is the option that targets the issue in the most effective manner allowing researchers to tap into existing expertise and promoting dialogue between experts with different backgrounds.

Furthermore, the addition of an online hub not only encourages dialogue among professionals but also as an online resource this minimises costs.

So, what are the benefits of investing in research and development to fill in knowledge gaps?

Increase collaboration between open-access pilot plants and research centres to generate targeted scientific results for the resolution of scale-up challenges will be beneficial for both the pilot plant and the research centre:

- For pilot plants. This will allow pilot plants to obtain new knowledge to solve technical challenges associated with the scale-up of new technologies through bespoke research projects which will ensure that the knowledge generated is focused on and/or considers scale-up aspects and therefore can be subsequently applied by pilot plants in addressing client projects. In addition, this approach will allow the pilot plant to access academic expertise and stay up to date with the latest scientific developments.

- For universities. The collaboration will provide funding for a series of researchers, which in addition will have access to large-scale pilot equipment to test their research ideas at scale. In addition, researchers will have the chance to expand their skills by discussing and networking with members of the pilot plant through the online technology hub. Furthermore, the publications and patents based on research results can help increase the reputation of the university.

Both institutions benefit from the innovative and synergistic ideas that can occur as a result of the dialogue between staff with different backgrounds and expertise. In addition, this approach will contribute to the formation of new experts in the sector, which will lead further developments of this (or similar) technologies in the future. In a broader sense, it is expected that this approach would incur in similar benefits of job generation as those described in 'Type of intervention 2'. Moreover, this should increase the number of innovative ideas that can be successfully scaled-up thanks to the new knowledge, generating revenue for the European bioeconomy as a result of successfully commercialised innovation.

Financial case

What are the financial requirements to implement this idea?

An overall investment of 0.5 –1 million € is foreseen to establish and maintain common one collaborative research project between a university and a pilot plant. It should be noted that the cost could significantly increase depending on the depth and width of the project research, as more researchers will be required. The funding would be split between the research centre and the pilot plant. Further details can be found in Table 10 below and in Appendix 3.

Table 10 Cost per work package associated with implementation of the proposed intervention.

Cost description	Cost (€)
WP1: Basic/initial research Salary of researchers for the stipulated timeframe (3-year project assumed), direct and indirect costs and support by personnel of the pilot plant.	300000 - 630000
WP2: testing at pilot plant This includes the cost of using pilot-scale equipment at the pilot plant to test most promising research results, for a period of 1-2 weeks.	100000- 300000
WP3: setting up hub Cost of research time required in the large-scale processing units of the pilot plants	10000 - 15000
WP4: communication efforts Salary of staff providing advice to researchers	20000
TOTAL	**0.5 – 1 million €**

As for the investment in coordination actions, the most relevant funding mechanism for the proposed intervention would be a grant-based projects. Other funding mechanisms, both at European and national levels, exist to cover the cost of specific activities included in the prosed intervention (i.e. staff training, knowledge sharing). A detailed assessment of the possible funding sources to finance this business case can be found in Appendix 4.

What resources beyond capital investment are required?

Beyond the capital investment specified above, a series of human resources will be required to organise, coordinate the above-mentioned activities (see Table 11).

Table 11 Human resources required to implement the proposed intervention.

Resource	Description
Researchers	To carry out the research necessary to solve the above-mentioned challenges.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

Pilot plant staff	To contribute to the design of the research projects, provide advice to researchers when needed and to carry out the large-scale experimentation.
Communication team	To be in charge of the set up and maintenance of the online technology hub as well as the communication activities to promote the activities of the pilot plant and the university involved in the project.

What are the associated risks? How can risks be reduced?

A series of risks have been identified regarding the suggested approach. Those risks, and the relevant mitigation measures are described in Table 12:

Table 12 Risks associated to the implementation of the recommended idea.

Risk	Mitigation actions
Research does not bring light to a problem Research does not solve the scale-up challenge targeted	Periodic meetings between researchers and pilot plant experts will be held to assess progress and come up with innovative solutions to challenges encountered as a result of the research projects
IP ownership issues No clear guidance about IP generated during research	Agreement will be signed by both parts before the start of the project
Poor availability of pilot equipment Researchers cannot access pilot equipment as it is booked for clients use	Periodic meetings will include description of future work, which will allow the pilot plant to reserve the equipment in advance.

Being able to access existing expertise at both pilot plants and universities that maximise the potential for collaboration would therefore reduce the risk of sub-optimal research delivery. In addition, it offers potential to examine impacts to help validating results and accelerate the applicability of the new results, reducing the risk of technology stalling.

Monitoring and evaluating

What is the evidence that this solution could be effective?

In 2009, the Doctoral Training Centre in Low Carbon Technologies in Leeds received funding for 5 years to train at least 50 researchers, covering a broad range of areas such as energy engineering, climate economics, transport studies and future fuels. The UK's Doctoral Training Centre programmes – funded by the national research funding agency (UKRI) – were designed to bring the best graduates and young researchers together, within defined research areas that meet the needs and goals of both industry and government. This allows the development of subject-specific research projects and the establishment of new research groups, linking academia and industry to achieve longevity and progress in joint knowledge generation. In this case, a significant number of the funded 'Low Carbon Technologies' researchers were retained within their trained research areas; this helped safeguard the knowledge generated, both within academia and industry, with several taking industrial employment following the completion of their PhD courses.

The Green Chemistry Centre of Excellence (GCCE) at The University of York is a pioneering centre in pure and applied green and sustainable chemical research and can work at scales from mg to kgs. The centre maintains close ties with a nearby open-access pilot facility, the Biorenewables Development Centre (BDC). This results in the addressing of common research efforts and goals to bring new technologies to the market. For example, the Microwave Commercialisation Club, where both GCCE and BDC are members, has the overall aim of supporting the transition of microwave technology into industry as a novel processing technology for biomass resources.

Based on the above, it is expected that investing in bringing universities and open-access pilot plants closer together will contribute to the development and commercialisation of optimal processes and products that minimise the use of energy and resources.

How will success be measured?

The effectiveness of the collaborative research project will be measured in different ways. For example, publications and patents based on research results can help increase the reputation of the university which can be measured by the position in university rankings, the number of citations and by the amount of funding gathered for further research activities in the collaborating sector. Additionally, success can be measured by the improvements achieved in challenges under study. Finally, the effectiveness of the online hub can be assessed using questionnaires that can be completed before the project commence and after the project ends. Questions including degree of confidence to deliver the most optimal solution to a client's problem can be included in the questionnaire and answers can be compared as part of the end of project evaluation exercise.

Conclusions

Expertise and knowledge about a specific process could be as important as finding the right equipment for the scale-up process. The gap analysis conducted by Pilots4U showed knowledge gaps affecting specific technologies and process, which could lead to the development and commercialisation of non-optimal processes for which larger amounts of energy and/or resources were needed, resulting in higher production costs hindering commercialisation. The proposed intervention suggests investing in knowledge generation by establishing collaborative research projects between open-access pilot plants and research centres to generate targeted scientific results for the resolution of knowledge gaps, and in particular those related to large scale issues. This approach will benefit both parties by encouraging the development of innovative ideas, bespoke research and coordination actions.

Placing public investment towards research projects to attempt filling those knowledge gaps is key to maximise the public investment made in relevant open-access infrastructure help the development of bio-based innovations. The overall investment required to generate new knowledge in universities closely connected to pilot plants has been estimated in 0.5 to 1 million € though this figure could be significantly higher as it will very much depend on the depth and width of the project and the location of the university/research centre (and therefore salary of researchers).

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

5 VALIDATION OF BUSINESS CASES

The business cases described above were presented to a range of experts in a Strategic Finance Roundtable (STR) to validate the proposed interventions, and in particular their financial aspects (e.g. funding mechanisms available, advantages/bottlenecks of this options).

The event was designed as a half-day roundtable and it was held at the Greater Birmingham and West Midlands Brussels Office in Brussels on the afternoon of the 24th of June 2019. The roundtable was hosted in connection to the Pilots4U Final event (which was held on the 25th of June), as a combined event was expected to attract a larger number of participants to both events.

The aim of the FSR was threefold:

- **Validate the business cases** developed by the project team, to understand whether the proposed interventions are the most effective way of targeting the identified gaps in provision.

- **Gain an understanding of the most relevant funding mechanisms available to support the presented business cases.** A series of funding opportunities were suggested by the Pilots4U team for each of the proposed interventions, which helped initiating discussion among participants.

- **Learn about bottlenecks of key funding opportunities.** For the most relevant funding sources, discussion was taken a step further, to understand the main issues associated to such funding sources.

The roundtable gathered a selection of stakeholders with expertise in public and private funding and financing mechanisms. Participants could take part in the event in person or via Skype for Business. Overall, 40 experts attended the FSR (16 in person and 24 via Skype).

Upon registration, participants were asked to give a brief explanation about their interest on the event, which helped the project team to gain a better understanding of the audience present at the meeting. Among participants it was possible to find different groups of stakeholders, including pilot and demo equipment owners, researchers and industry; their interest on the event varied from gaining a better understanding of the project to networking, learning about obstacles for European pilot infrastructure or finding out new ways of financing pilot and demo plants.

The project coordinator provided an overview of the Pilots4U project for the benefits of participants that were not familiarised with the project and its aims. Subsequently, the project team provided an overview of each business case, followed by some discussion time, led by a moderator to keep the dialogue's topic relevant. Main discussion points for each business case are summarised below.

Business case 1: investment in equipment for existing facilities

There was a general agreement among participants about the proposed intervention: investment in equipment is required but locating it in existing facilities seems to be more cost effective than building entirely new facilities in areas where open-access facilities are already in place. Furthermore, key issues regarding funding sources for equipment seemed to be found at large scales, which is in good agreement with the lower number of assets found through the gap analysis exercise at these scales for most technologies.

In regard to potential funding sources to finance the proposed intervention, ERDF funds have helped building many of the existing open-access centres, and therefore this funding option was discussed in detail. One of the key issues raised about ERDF is the fact that it only covers part of the cost of the project, which could be a problem for many facilities, and in particular for independent organisation that have no industry backing, making more difficult for them to achieve co-financing.

Procurement regulations associated to the purchase of equipment through public funding were also discussed, as in some cases the restrictions posed could unnecessarily increase the cost of the required equipment. As an example, procurement regulations tend to require that the equipment to be purchased should be brand new. Whereas participants agreed that in some cases brand new equipment is absolutely necessary (i.e. very specialised or state-of-the-art assets), in some other cases (i.e. equipment to perform generic processes such as pelletisers, mills or centrifuges) the purchase of second-hand kits could really help reduce cost and investment. Participants agreed that the status of the apparatus as well as the potential maintenance cost should be considered if second-hand gear is considered. As an alternative to second-hand purchasing, the option of 'plug-and-play' was also discussed. This refers to the sharing of equipment between facilities. As mentioned by one of the participants, this practice is already being implemented successfully by some facilities. A key aspect/issue associated to the 'plug-and-play' approach is equipment insurance; the borrowing/receiving institutions needs to guarantee insurance coverage of the equipment while hosting it at its facility.

Binding open-access pilot plants to commercial players was mentioned as an alternative approach to finance very large-scale infrastructure (demonstration and pre-commercial stages). On one hand, it was suggested that innovations at pre-commercialisation stages could 'fund' or partially fund the new equipment for the open-access centre as a pre-payment for the outcomes of the testing (i.e. validation, product produced). On the other hand, some open-access centres present at the roundtable stated that it was their preference to stay away from involving industry in the development of the facility as this could raise issues in relation to confidentiality and IP.

Participants also stated that statistics, metrics and success cases would significantly contribute to strengthening funding applications. Some interesting metrics such as the number of projects that move up 1, 2 or 3 TRLs thanks to accessing the facilities or the percentage of innovations that reached commercialisation were discussed. In this respect, representatives of open-access centres highlighted that these metrics are generally difficult to obtain as in some cases customers don't like to share their data due to potential IP issues. It was also added that open-access centres tend to encounter two very differentiated types of customers/innovators: those that do not want to share any information about their process, and those willing to share information and results and even co-sign press releases about their results.

Validation of business case 2: investment in coordination actions

There was generally good agreement about the need for establishing collaborative actions between different open-access facilities. Nevertheless, it was highlighted that this approach could be challenging in some cases, especially in relation to trans-regional collaboration; many regions offer support to SMEs for the scale-up of a new process or product, however this support only covers the work carried out at open-access pilot plants located within the region.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

At the moment, only a few regions (i.e. Flanders) offer support for trans-regional access to scale-up facilities which indicated that EU-wide interregional coordination is required.

In regard to funding sources for the proposed intervention, the option of financing coordination actions as part of a larger research grant-based projects was suggested by the project team and discussed with participants. Some issues associated to confidentiality and IP of project results resulting from the use of this type of funding sources (i.e. H2020 projects) were raised and discussed.

Participants also highlighted the need to generate more trusts between open-access centres, as at the moment these type of facilities are competing with each other for funding. Project partners stated that this ties very well with Pilots4U primary aim: the creation of a pan European network of open-access pilot and demonstration centres, and with the proposed intervention highlighted in business case 2.

Validation of business case 3: investment in knowledge generation

In regard to funding opportunities for the proposed intervention, H2020 and similar national calls were discussed. These funding sources were highlighted as the obvious funding opportunities, as its use already represents the current trend. However, several issues associated to funding calls were raised during the discussion.

First of all, participants pointed out the low success rate of these type of calls (some 1 in 70 for research projects, the rate could be even lower for coordination actions). In this regard, it was pointed out that cluster organisations can help boost the success rate of applications for these thematic calls, not necessarily by proposal writing but by leading organisations towards the right consortiums. Additionally, participants stressed how time consuming the application process tend to be.

Secondly, discussion also focused on the thematic character of this type of funding which could be an issue, in particular for emerging technologies, as it takes some time for these technologies to be included in thematic calls. Thematic call could also lead to researchers bidding for research projects outside their area of expertise which could hinder innovation development.

6 CONCLUSIONS

Past public investment in pilot/demo infrastructure has proven the potential of these facilities. Now, efforts should focus on keeping existing facilities up to date to match technology evolution and the arrival of new processes, for which further public funding is required. The three business cases discussed in this report represent different solutions to address gaps in provision affecting open-access pilot and demonstration centres.

In all cases the investment was expected to deliver benefits beyond the mere technology gap filling. For example, investment in equipment will contribute towards keeping open-access centres up to date and running, coordination actions will encourage innovative solutions thanks to the dialogue between cross-sectoral experts, and investment in knowledge generation will contribute to the formation of the experts of the future.

The investment required in all cases ranged from 0.5 – 10 million € and this was very dependent on a variety of factors, including the type of intervention, geographical location, length of the actions, etc. Funding was not only required to cover equipment, specific activities or research, but also support to ensure that a broad range of expertise could be accessed to help shape and inform communication, organisation, and coordination, etc.

Beyond financial requirements, other key aspects of the business cases, include risks affecting ability to implement actions or the ability to assess the degree of success that could be achieved. Risks ranged from poor levels of client engagement after investment in new equipment (i.e. low utilisation rates), to failure of networks or co-ordination actions to continue beyond initial funding rounds. Regarding assessment of success, a series of factors could be monitored such as the subsequent turnover of pilot plants to assess the impact of adding new equipment, the public visibility of facilities to measure the impact of coordination actions.

The business cases were presented to a series of bioeconomy funding experts in a roundtable that took place in Brussels on the 24th June 2019. During this roundtable, experts were given the option to provide feedback about the ideas presented and to propose the best possible funding opportunities to finance these interventions.

The proposed interventions suggested by these business cases are expected to strengthen the European landscape of open-access pilot/demo infrastructure, which should in turn contribute to a higher number of bio-based innovations reaching the market, strengthening the European bioeconomy as well. These business cases have been passed to BBI JU, the funders of the Pilots4U project, along with recommendations for the agency to take future action.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

7 APPENDICES

7.1 Appendix 1: Gaps identified and type of intervention that could be applied to address them

Table 13 Gaps identified and type of intervention that could be applied to address them

Gaps	Sector	Intervent. 1	Intervent. 2	Intervent. 3
Disconnection between cultivation assets upgrading units.	Algae	x	x	
Insufficient education at under- and post-graduate levels.	Algae			x
Knowledge is not efficiently shared among researchers.	AD		x	
Insufficient downstream processing for digestate for nutrient recovery.	AD	x		
Equipment for bioCH4 upgrading in connection to small-scale units.	AD	x		
Better selection of mechanical grinders (tons of kg).	Pre-t.	x	x	
Large-scale drying and dewatering units (1 ton).	Pre-t.	x		
Large-scale steam explosion units with possibility for higher P.	Pre-t.			
Large scale sieving/size classification equipment	Pre-t.	x		
Selection of small-scale pre-t. equip. for screening of suitable tech.	Pre-t.	x	x	
Larger pilots for pulp cooking and bleaching	Pulp.	x		
Disconnection between different parts of the pulping value chain.	Pulp.		x	
Lack of pilot and demo equipment to scale-up new processes.	Pulp.	x		
Additional capabilities for pulp drying may be required.	Pulp.	x		
Equipment assets for large-scale chemical recovery.	Pulp.	x		
Larger facilities needed (capable of processing between 10-100 tpd).	Thermo.	x		
Missing links to downstream (upgrading products).	Thermo.	x	x	

Lack of knowledge about upgrading technologies.	Thermo.			x
Type of biomass	Thermo.			x
Different fermenter types are missing.	Gas ferm.	x	x	
More micro-organism development required.	Gas ferm.			x
More process development required.	Gas ferm.			x
Gas clean-up development required.	Gas ferm.			x
Gasification and fermentation in one place needed.	Gas ferm.	x	x	
Mobile fermenters needed.	Gas ferm.	x		
More research needed on reactor design.	Solid ferm.			x
More research needed on downstream processing.	Solid ferm.			x
Lack of knowledge on available reactors at open access pilots.	Chem.			x
Larger pilot scale reactors with high P&T ratings for flammable chemicals.	Chem.	x		
Larger pilot reactors for polymerisat. of bio-based monomers.	Chem.	x		
Pilot reactors & downstream units resistant to highly corrosive chem.	Chem.	x		
Pilot scale equipment for new industrially feasible process concepts.	Chem.	x		
Larger demo scale fibre spinning lines for wet and dry spinning technologies.	New mat.	x		
Pilot-scale facilities for cellulose textile yarn and fabric production.	New mat.	x		
Larger pilot facilities for the production of nano cellulose.	New mat.	x		
Pilot-scale roll-to-roll equipment for new packaging material production.	New mat.	x		
Pilot-scale equipment for the production of foamed materials.	New mat.	x		

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

7.2 Appendix 2: Examplar case studies

Exemplar case 1: Investment to strengthen the selection of pre-treatment equipment within a selected pilot plant for the screening of suitable pre-treatment technologies.

Biomass pre-treatment is a key step for any bio-based process to optimise the form, size, component separation and composition of the biomass to meet the required standards for the main processing activity. Moreover, biomass pre-treatment influences the outcomes of the main processing and downstream phases. The importance of the pre-treatment step is reflected by its cost, which can take up to 40% of the total processing cost.

The Pilots4U database shows good availability of different semi-pilot and pilot pre-treatment assets across Europe. However, a single facility does not typically gather a wide range of specialised pre-treatment assets under one roof which can complicate the performance of screening studies for the determination of the most optimal pre-treatment method for a specific process.[6] Therefore, the proposed intervention suggests increasing the availability of pre-treatment capabilities at key centres by providing those facilities with specialised pre-treatment assets that complement their current provision. In this case, it is foreseen that the investment will go towards one or more semi-pilot or pilot scale assets (e.g. steam explosion reactor). It is expected that this intervention facilitates the performance of screening processes, increases the volume of work and funding attracted by the selected facilities, which should, in turn, contribute to increase the number of innovations reaching the market and the creation of new jobs.

The milestones and options discussed in Section 4.1, apply to this particular case, being the recommended option: investment in new equipment assets to strengthen existing open-access infrastructure.

The importance of biomass pre-treatment for any bio-based process linked to benefits and projections discussed in Section 4.1, suggest that the availability of pre-treatment screening tools can contribute to the optimisation of many bio-based process at development stages, helping to deliver new cost effective and market ready ideas.

The financial requirements range from 0.3 to 1 million € assuming that the required asset is for example, a semi pilot steam explosion device. The resources required, monitoring methods, risks and means to reduce financial risks discussed in Section 4.1 are also applicable to this case study.

Exemplar case 2: Investment in large pilot reactors with high pressure and temperature ratings for working with flammable chemicals

Reducing the energy and hazardous chemical inputs to renewable material processing typically makes use of high pressures. Working at high pressures and temperatures or in the presence of organic solvents requires specific equipment assets capable of safely sustaining these conditions. However, most of the existing infrastructure capable of functioning at these conditions is relatively small (semi pilot or pilot), and larger reactors capable of demonstrating pre-commercial production scales of operation are relatively scarce. Therefore, the proposed intervention involves investing in a large pilot or demonstration reactor capable of working under these conditions. The new assets will be located in a key open-access centre to better exploit existing expertise in working with these types of reactors. The aim of the investment is to strengthen the existing provision of open-access infrastructure, as well as increasing the volume of work and funding of the selected facilities, which will, in turn, contribute to increase the number of innovations reaching the market and the creation of new jobs.

The milestones and options discussed in Section 4.1 apply to this particular case, being the recommended option: investment in new equipment assets to strengthen existing open-access infrastructure.

Beyond the benefits listed in Section 4.1, investing in large scale assets will allow innovators to move innovations several TRLs up within the same testing and scale-up facility, accelerating the pathway and reducing the timescale towards commercialisation.

The financial requirements range from 1 to 2 million € assuming that the required assets are large pilot reactors capable of operating at high pressure and temperature, and in the presence of flammable chemicals (the cost could be much higher if new flooring space is required). The resources required, monitoring methods, risks and means to reduce financial risks described in Section 4.1 are also applicable to this case study.

Exemplar case 3: Network to connect complementary facilities and equipment related to the wood fibre materials value chain

The increasing prices of energy and raw material for pulp and paper production plus the competition for raw material with other industries (such as the energy sector), and the reduction of the traditional pulp and paper markets are driving the pulp and paper industry to expand its product portfolio. Examples being examined include use in biocomposite materials, or in the preparation of textile fibres.

The work in Pilots4U highlighted the existence of infrastructure for different processing stages of wood fibre across Europe. However, equipment tends to be divided into different locations which complicates the coordination of the different steps of the scale-up process for the innovator. Therefore, the proposed intervention suggests the creation of a collaborative network of open-access centres with complementary infrastructure within the wood fibre materials value chain, with the aim of maximising the exploitation of existing assets, as well as increasing the volume of work and funding attracted by the selected facilities.

The milestones and options discussed in Section 4.2 apply to this particular case, being the recommended option: create a network of complementary open-access facilities.

This approach is expected to deliver the benefits discussed in Section 4.2 as well as contributing to tackle key issues such as reducing plastic pollution and greenhouse gases emissions from processing operation and/or in product use by helping the commercialisation of new bio-based innovations.

The investment required to implement the proposed intervention is estimated between 0.8 – 1.5 million € (for a four year project), including the budget to encourage knowledge transfer between centres, to carry out joint communication activities and to establish an expert group that can provide clients with optimal advice for their processes. The resources required, monitoring methods, risks and means to reduce financial risks discussed in Section 4.2 are also applicable to this case study.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

Exemplar case 4: Establish shared-access models between open-access pilot plants and industry owners of large pilot and demo pyrolysis equipment.

The technology to produce bio-oil through pyrolysis of lignocellulosic biomass is well known. Currently, non-catalytic fast pyrolysis processes are at demonstration stage; past experience shows that failure to address issues that would have been detected during process scale up stages risks possible future failure when significant investment capital is at risk.[7]

The lack of demonstration scale assets for biomass pyrolysis was identified as a gap in provision. Although a lack of provision could be tackled by investment in new infrastructure (business case 1) demo units are costly to build and operate and therefore the proposed intervention suggests establishing a shared access model between an open-access centre and industry infrastructure owners. This shared access model would aim to maximise the usage of privately-owned testing facilities currently in idle status, and it would allow the open-access centre to offer a broader range of open-access equipment to innovators. Altogether, this would contribute to the faster commercialisation of biomass pyrolysis technologies, with the associated benefits for the European bioeconomy and some of the key environmental challenges (i.e. climate change).

Although this example is based on a slightly different model than the one described in Section 4.2, the intervention would require the same work packages with minor adjustments: industry owners would oversee control over the use of infrastructure (as individuals or as a consortium, based on investment made); the open-access centre would 'subcontract' the equipment for clients tests; a larger budget would be allocated to the 4th work package, focused on establishing the best working agreement between interested parties wishing to use the facility (addressing issues with IP or confidentiality, liability, use and damages).

The milestones and options discussed in Section 4.2 apply to this particular case, being the recommended option: create a network of complementary open-access facilities. It should be noted that in this case, duplication of resources would be an additional disadvantage in regard to the construction of new assets, as public funding has been widely used to help the construction of flagship and demonstration units around Europe (BBI JU).

In addition to the above-mentioned benefits, establishing shared access models with industry infrastructure owners will help to connect innovators with industry and may help secure investors for new innovation.

The capital investment required to implement a network of the type described is estimated in approximately 0.8 – 1.5 million € (for a four year project), including the budget to encourage knowledge transfer between centres, to carry out joint communication activities and to establish an expert group that can provide clients with optimal advice for their processes. It is noteworthy that in this case the development of coordination actions will depend on confidentiality agreement with the private industry owner. The resources required, monitoring methods, risks and means to reduce financial risks discussed in Section 4.2 are also applicable to this case study.

Exemplar case 5: Investment in research to solve challenges associated with gas impurities in feedstocks for gas fermentation processes.

Gas fermentation is a relatively new technology that involves the conversion of C1 gases into valuable chemicals. The feedstock gas can come from a range of sources of differing purity. The presence of impurities in the feeding gas can hinder the fermentation process as some of these impurities are toxic for the micro-organisms. However, efficient gas cleaning techniques that guarantee the quality of the incoming gas are relatively underdeveloped. The proposed intervention suggests funding collaborative research into this topic along with the creation of an online research hub where the university and open-access centre involved in the project can discuss key challenges associated with gas cleaning for gas fermentation applications.

In this case, the research project will be looking into current gas cleaning techniques and associated problems. Subsequently, the project will assess the different techniques, select those with the greatest potential and try to find solutions for the associated challenges. Finally, the most promising results would be tested at large scale in the pilot plant to validate the results at higher TRLs and therefore accelerate the applicability of the new technology/process.

The milestones and options discussed in Section 4.3 apply to this particular case, being the recommended option: Fund a research collaborative project between universities and pilot plant.

Gas fermentation is an important technology as it can contribute to significantly reduce the greenhouse gas emissions of some of the most contaminating industries (i.e. steel). Therefore, beyond the above-mentioned benefits and projections, it is expected that the development of the gas fermentation technology plays a key role in the reduction of greenhouse gases.

An overall investment of 0.5-1 million € is foreseen to establish and maintain common research efforts for each specific research project, although the cost could significantly increase depending on the depth and width of the project. The resources required, monitoring methods, risks and means to reduce financial risks discussed in Section 4.3 are also applicable to this case study.

Exemplar case 6: Investment in training activities for the staff of open-access facilities

Although activities to train staff working at open-access centres were not identified as a gap during the prior analysis exercise, the importance assigned to this aspect by potential users of facilities (identified though online survey) suggests that this should be included as an exemplar case.

The proposed intervention suggests the development of training programmes that ensure personnel in open-access centres maintain professional development and gain knowledge and training in new technologies. This should help increase the percentage of successful commercialisation rates. The work involved varies slightly from the WPs described above; WP1 would be dedicated to cover the cost of training activities, including courses, boot camps, workshops or seminars. WP2 will cover the creation of an online technology hub as the one described above that will connect the pilot plant with relevant research groups in order to favour knowledge exchange and contribute to keeping the staff of the open-access facility up to date of the latest scientific developments; and WP3 would be dedicated to communication and promotion, to highlight the constant efforts for improvement carried out in the pilot plant.

It is expected that training activities and the creation of the online hub will translate into improvements in client project results and therefore helps delivering new bio-based innovations to the market faster and quicker.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

The milestones discussed in Section 4.3 apply to this particular case. It should be noted that in this case periodic meetings would not be required. In addition, the midterm and end of project reviews will focus on assess the impact of the training activities. Regarding the options to address the gap in provision, only options 1 and 4 are applicable here, and it should be noted that options 1 would not include research activities; instead it will include the training activities described above.

Beyond the above-mentioned benefits to pilot plants and innovators, providing periodic training for the staff at the open-access centres will keep workers up to date about the latest technologies and developments within the bioeconomy and therefore, staff will be prepared to provide the best possible solutions to clients. In addition, training will contribute to make the staff feel valued and challenged.

In this case, the cost of the suggested approach (training activities for pilot plant staff, setting up an online hub and communication activities) will strongly depends on the training activities carried out and the number of staff involved. The human resources required, monitoring methods, risks and means to reduce financial risks discussed in Section 4.3 are also applicable to this case study with some minor modifications: in this case the activity of researchers will not be required, and the time dedicated by the pilot plant staff will be used to attend the training activities organised; regarding risks, there could be a risk of staff leaving after training, and therefore the investment being 'lost'. To minimise this risk, training could initially be provided to staff members with longer-term contracts. If the subsequent evaluation of training activities is positive, training could be extended to personnel with shorter-term contracts; finally, in regard to monitoring the effectiveness of training activities will be assessed in a similar fashion as the online technology hub.

7.3 Appendix 3: Detailed financial estimations

Type of intervention 1: investment in equipment for existing facilities

As mentioned in the main body of the report, this intervention required funding for two key aspects: design, development and installation of the new infrastructure, and communication activities to promote the new equipment.

The cost associated to the design, development and installation of the new equipment can be range between 0.5 – 10 million €. These estimations are based on the following assumptions:[8]

- The investment covers only the setting up phase of the new equipment and does not include budget allocation for running or maintaining the equipment once it is active. The cost for running and maintaining the equipment is generally charged as an overhead in projects that facilities carry out for clients. Similarly, the cost of an admin team that coordinates the operation has not been included in the cost of the project, as this role is generally represented by a long-term position, and therefore funding for it is obtained elsewhere.

- The range provided above (0.5 – 10 million €) is quite broad as it accounts for several scenarios. Whereas updating currently available assets (i.e. digitalisation of an asset) would be at the lower end of the range (~0.5 million €), investing in new assets would be more costly (0.5-2 million €); if new flooring space is required, the project cost could increase up to 10 million € or above.

The cost associated to communication efforts has been estimated in 40000 - 60000 € for 1 year of activity. Calculations have been made based on the following assumptions:

- The communication activities would include online marketing campaigns, preparation of communication material, participation at events and business development. As the new infrastructure will be integrated in an operational open-access centre, it is foreseen that most communication channels will be in place. Regarding the cost of the communication material, it was estimated to range between 5000 – 10000 €. If the facilities have in house expertise for the design of communication material, the cost would be closer to the lower end of the range. However, if this expertise needs to be subcontracted to an external agency, the cost could easily increase up to 10000 €.

- Between 0.3-0.5 person/month would be required to carry out the work. Assuming and average salary of 6000 €, this would incur in a cost of 20000-30000 € for 1 year of activity.[9] Communication activities are foreseen during the construction phase and the first few months of activity of the new plant.

- Some budget would be required to cover the participation of the communication team at events. A budget of 12000 € was foreseen assuming that one person would travel to each event; the average cost of travelling to an event for one person has been estimated in around 1000 €; it is foreseen that the communication team would participate in one trip a month over the period of one year. It should be noted that the cost of event participation can significantly increase if events have a registration fee or if an exhibition booth is required. Registration fees and the cost of exhibition booth

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

space in high-profile events could reach 1500 €, therefore the travelling budget could be 5000 -10000 € higher if some of the events require registration fees or booth space.

Type of intervention 2: investment in coordination actions

As mentioned in the main body of the report, this intervention required funding for four key aspects: the creation of an expert group to provide efficient advice to clients, the application of a series of coordination actions between facilities, communication aspects and legal advice.

The cost associated to the formation of the expert group has been estimated in around 0.5 – 0.8 million €. This estimation is based on the following assumptions:

- It is expected that 0.3 person/month per facility will be required for this task on average, and a salary of 6000€ is assumed. The network will receive funding for a 4-year period. This results in approximately 150000 € over per facility involved in the network over a 4-year period.

- It is expected that the expert group would travel for internal and client's meetings. Around 4 trips a year are foreseen. The average cost per person of travelling to a meeting has been estimated in around 1000 €. The travelling budget per facility involved in the network can be estimated in 15000 €.

- From the above assumptions it is expected that the cost of the expert group raises up to 160000 € per facility involved in the network. As it is foreseen that the network would be integrated by 3-5 facilities, the overall cost of the expert group would range between 0.5 - 0.8 mill €.

The cost associated to the application of some coordination actions between the facilities involved in the network has been estimated in approximately 150000 €. This estimation is based on the following assumptions:

- Part of the budget would go towards an admin team and to cover the coordination activities. The admin team will be in charge of coordinating the exchange activities between the different organisations. It is foreseen that the admin team will require up to 0.3 person/month which would incur in a cost of 90000 € over 4 years, assuming an average salary of 6000 € person/month.

- One of the key foreseen coordination activities is short staff exchanges. The travelling and accommodation costs will be covered for at least one member of staff of each pilot plant to visit the other facilities. It is foreseen that this would incur in a cost of up to 5000 € per exchange and therefore an overall cost of 30000 – 60000 € over 4 years, depending on the number of facilities involved in the network (between 3 and 5). In addition, funding will also cover the organisation of at least one internal workshop to encourage further knowledge exchange. Depending on venue, number of participants and duration of event, the cost could be between 500 – 2000 €.

The yearly cost associated to communication efforts has been estimated in 40000 - 60000 € and therefore for a 4-year period the cost would raise up to 150000 to 250000 €. The estimations made for the communication activities in 'type of intervention 1' can be applied to this case too (times 4 to account for the foreseen duration of this intervention).

The cost associated to legal advice has been estimated in approximately 50000 € for 4 year of activity based on the following assumptions:

- Drafting a H2020 agreement can take between 1 week and 1-month work.

- Legal advice would also be required to advice the different network members regarding IP generated as part of the collaboration, and other similar situations.

Type of intervention 3: investment in knowledge generation

As mentioned in the main body of the report, this intervention required funding for four key aspects: a research project, accessing pilot scale infrastructure, the setting up of an online hub for university and open-access facility to share knowledge and communication efforts.

The cost associated to support the research project has been estimated in in approximately 0.3 – 0.6 million €. This estimation is based on the following assumptions:

- The research team would include 1 Phd, 1 post-doctoral research, and 20% of the time of a professor leading the project and a technician. PhD students' yearly salaries range from 15000 to 50000 € depending on the EU country. Similarly, post-doctoral salaries can vary between 36000 and 72000 € based on location. Finally, the cost of 20% of the time of a technician and a professor would add up to 13000-35000 € per year. In addition, it is foreseen that 1day/month of key staff from the pilot plant would be required to provide assistance to researchers. Assuming an average salary of 6000 €, the cost per year would go up to approximately 12000 €. it should be noted that larger research teams would incur in larger personnel costs.

- Indirect costs such us admin personnel, bills, etc. have been estimated in 20000 € per year. Similarly, some budget has been reserved to cover the cost of consumables necessary for the research as well as travelling cost to attend to conferences, meetings, etc. This has been estimated in 20000 € per year.

- The funding would cover the work for 3 years. Based on the above-mentioned estimations, the yearly cost of supporting the research project has been estimated in 0.1 – 0.2 million €. Therefore, to cover the cost of the research project for 3 years would require 0.3 – 0.6 million €.

The cost associated to accessing pilot equipment to test key results obtained during the research project has been estimated in in approximately 0.1 – 0.3 million €.[10] Setting up the online hub would require an approximate budget of 10000 – 15000 €. Finally, the cost of communication actions would only include the cost of publishing in open-access scientific journals and the creation of some communication material (i.e. posters). This could incur in an overall cost of 20000 €. The cost of attending to events has been accounted for as part of the research project budget.

7.4 Appendix 4: Potential sources of funding to finance the case studies

Type of intervention 1: investment in equipment

Since 2014, the funding mechanism of the European Innovation Partnership (EIP) has been the **European Structural and Investment Funds (ESIF)**, which itself contains five separate funds; these include the European Regional Development Fund (ERDF), the European Social

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

Fund (ESF) and the European Agricultural Fund for Rural Development (EAFRD). Managed by the individual member states – via partnership agreements – the funding is channelled into a series of investment programmes aligned with specific policy areas. In the context of accessing ESIF investment for equipment purchase within the EU, projects falling within the broad themes of 'Research and Innovation' and 'Competitiveness of SMEs' have been funded predominantly through the ERDF and EAFRD. Generally, within each member nation, ESIF funding is devolved to different regions – these are then tasked with allocating the funding to projects. In the UK this has been conducted by Local Enterprise Partnership (LEP) areas, while other EU nations employ alternative regional funding frameworks; for example, the Belgian region of Flanders distributes ERDF funding via the Flanders Innovation & entrepreneurship agency (VLAIO). Access to ESIF funding is therefore dependent upon a multitude of factors such as location, the existing national and regional funding frameworks and their consequent research activities. Importantly, ESIF financing – particularly that sourced from the ERDF – will only cover part of the total eligible costs, with match funding required for the remainder.

One of the main funding avenues are **grants**, which are assigned to the successful applicant as a capital sum that is not required to be paid back. Supporting innovation is an important aim of the European Commission, as evidenced by the establishment of their European Innovation Council (EIC) pilot. Within this is the EIC SME Instrument, which – although highly competitive – is a potential funding pathway intended to help SMEs and start-ups from different sectors. The instrument is composed of three individual phases, with the second the most appropriate for funding investment into equipment. Representing an investment amount between €500k and €2.6million (as a 70% co-financing rate of the total costs), Phase 2 of the EIC SME Instrument is specifically intended for innovation development and demonstration purposes. Research based competition grants – such as Horizon 2020 – and Pre-Commercial Procurement (PCP), are public sector funding calls that help direct and prompt innovation. Funding competitions, either those that are government- or research-led, are often defined by existing national and global challenges, in addition to the innovative solutions required to meet them. Although the competitions represent large investment sums, they are dictated by the specific challenges and desired final outputs. A recent example of research competition grant is Bioeconomy in the North (BiN) – a collaborative transnational R&D initiative – which is funded by BMBF, the Research Council of Norway (RCN) and the Ministry for Agriculture and Forestry, Finland (MMM). Falling within a specific well-defined scope, the annual call for proposals has a 5.5 million total funding pot available for successful applicants. Individual nations may also have their own PCP initiatives; in the UK there are funding competition programmes such as the Small Business Research Initiative (SBRI) delivered by Innovate UK – which allows SMEs and other private enterprises to find potential solutions for national issues, utilising public funds.

Throughout the EU there are a range of national-level grants, often encouraging collaboration between academic research groups and industrial partners – in addition to securing the necessary investment for bridging the 'Valley of Death'. In France, the National Research Agency (ANR) have a joint laboratory initiative, called LabCom, which encourages structured partnerships between a research laboratory and SME/intermediate-sized enterprises. There are three calls a year (resulting in ~15 annual funding awards), with each successful research organisation receiving up to €300k. In the UK, the public-funded investment into academic research is conducted by its seven research councils, which fall within the remit of the national funding agency (UKRI). Responsive mode research grants – such as the Industrial Partnership Awards (IPA) and the Link scheme – are offered by the Biotechnology and Biological Science Research Council (BBSRC), which support part-funded collaborative 'pre-competitive' projects between research institutes and industrial partners. The Energy Technology Development and Demonstration Programme (EUDP), administered by the Danish Energy Agency, supports the advancement of green and sustainable energy projects – including bioenergy and biofuel production. With a total funding pot of ~€33million per funding call – which is distributed between successful applicants – the EUDP grant funds demonstration level projects instead of early-stage research. Alternatively, the InnoBooster scheme offers grants of up to €650k to Danish SMEs and entrepreneurs; applications can be made at any time, with the funding intended for projects with commercial potential and well-prepared business plans. Germany have several national grant schemes that are aimed at supporting the commercial development of academic technology-based research. The Federal Ministry of Education and Research of Germany (BMBF) have a scheme called GO-Bio which offers grants (up to €350k) to young scientists and researchers, advancing the technology transfer of 'high risk, high potential' research.

In the absence of available grants there are a number of alternative **equity- and loan-based financing options**; these are often used in combination with other funding sources, instead of being the sole source of investment. The European Fund for Strategic Investment (EFSI) is a mechanism aimed at overcoming current market failures, helping to finance strategic investments. As a funding programme, EFSI is managed by the European Investment Bank (EIB) – however, the loan-based financing of SMEs within the mechanism is administered by the European Investment Fund (EIF), which is owned by the EIB and European Commission. Access to EIF funding – through equity, debt and microfinance products – is available for EU member states, which is delivered by recognised national intermediaries and counterparts. EFSI is set to be replaced by the InvestEU programme at the start of 2021, which will continue to function in the same manner by backing investment projects. One of the main products offered by the EIF is InnovFin Equity, which provides equity investments and co-investments for innovative projects. Within this scheme, the InnovFin Technology Transfer offers partial financing – for combination with other sources, such as ERDF funding – to enterprises and SMEs with products and technologies that are at TRL 3 to 6. This can be an investment of up to €50 million, repayable over a 20+ year period. As an alternative source of finance, there are private equity and venture capital funds that are supported by the EIF – these are usually equity investments, offered by funds that specialise in a specific sector or certain stages of technology development and deployment.

As with the existing grant schemes, individual EU member states offer a range of different loan and microfinance products. In Finland, the public funding agency – Business Finland – provides funding for SMEs in the form of a loan for development and piloting. The granted loan can cover either 50% or 70% of the projects total costs, with an associated interest rate currently set at 1% over a loan period of 7 or 10 years, depending upon the amount borrowed. Other Finnish alternatives for loan funding include the Investment and Working Capital loan, offered by the state-owned Finnvera – this can be used for purchasing equipment, with a minimum loan amount of €30k and a loan period ranging from 3 to 15 years.

Type of intervention 2: investment in coordination actions

The best funding pathways for investing in coordination actions are most likely to be grant-based, as making a business case for loan options for this type of investment could prove difficult. Indeed, across Europe, the known examples of funding are predominantly part- or

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

complete-funded grants, of which there are several different international and national level programmes.

Within the Horizon 2020 - Work Programme 2018-2020, coordination and support actions – which include measures such as networking, awareness-raising and dissemination – are specifically promoted and, more importantly, funded as part of larger research or innovation projects. Therefore, costs attributed to travel, subsistence and additional remuneration – occurring as a result of the stated measures – can receive 100% of the total associated costs. Investment for coordination actions can therefore be accessed via this pathway, however these must be complementary to a larger funding proposal. It is expected that these actions will continue to be funded within Horizon Europe – the successor to H2020 – however, at this time, the details have yet to be confirmed. There are other avenues of innovation funding that embrace collaborative research and development. As part of Horizon 2020, the Marie Skłodowska Curie Research and Innovation Staff Exchange (RISE) programme funds short-term exchanges of personnel between academic, industrial and commercial organisations. Intended for building knowledge and skills – in addition to links between organisations – the RISE grant can support secondments for up to 12 months.

At a national level, here are other well-established funding routes for coordination action investments. In the UK, there are several schemes that support coordination actions, which are often offered by the different research councils. The EPSRC have Network Grants which support interaction development between the research community and other appropriate industrial and commercial organisations. The funding covers the full costs of the coordination action project, including salaries – for the time spent on setting up and managing the network – travel and subsistence, workshops and additional administrative support. The EPSRC also offer funds to academic employees via the Overseas Travel Grant; this covers travel and subsidence costs, in addition to funding the principal investigators salary and other indirect costs. The BBSRC provides a similar programme called the International Travel Award Scheme – this offers funding to BBSRC-supported researchers, covering travel costs for initiating collaborations or to visit specific facilities outside of the UK. The Worldwide Universities Network have a research development fund (RDF), providing grants of up to £10k to help plan workshops, explore research initiatives and form collaborative networks. Impact Acceleration Accounts (IAA) for example, are offered by several of the UK's research councils in support of knowledge exchange and the potential activities to achieve this. IAA funding supports secondments, user engagement events and other outreach activities. Additionally, the BBSRC provides an Exploring Innovation Seminars programme, which is aimed at improving knowledge exchange. The grant contributes up to 2 k to cover the costs of holding a seminar or networking and panel discussion to help educate and disseminate knowledge. France's National Research Agency (ANR) also offer an instrument called, Setting up European or International Scientific Networks (MRSEI). This scheme aims to create networks of European and International collaborators stemming from an initial French applicant, based at either a public or private research organisation. There are three calls a year, resulting in the successful funding of around 60 projects annually; aimed at French nationals, the successful applicant receives ~€30k towards establishing a coordinated network that should have strategic importance and a major impact in a scientific field. In 2015, the Ministry of Environment and Food of Denmark established a Danish Eco-Innovation scheme, called the Environmental Technology Development and Demonstration Program (MUDP). As part of the programme, its remit is to boost and strengthen cooperation between organisations; this includes innovation partnerships – aimed at promoting cooperation and dialogue – and international environmental cooperation, which is intended to aid the demonstration of solutions to foreign partners. Business Finland also offer a Research and Knowledge Creation grant which is intended to fund new and innovative research and development, helping the collaboration of universities and research organisations. The grant covers up to 50% of the total costs, or 65% if the project is an international collaboration – this is paid in arrears, dependent upon the reported actual costs.

Type of intervention 3: investment in knowledge generation

The best funding pathways for investing in knowledge generation through research are most likely to be grant-based, as making a business case for loan options for this type of investment could prove difficult.

At a European level, Horizon2020 is the biggest European programme to date, with 77 billion € over a period of 7 years for research and innovation. One of the key pillars of Horizon2020 is to help tackling societal challenges, most of which are closely related to the bioeconomy (i.e. climate action, resource efficiency and raw materials; greener transport; secure, clean and efficient technology). H2020 is going to be followed by Horizon Europe, with an even larger funding pot for research and innovation – 100 billion €. Similarly, the Bio-Based Industries Joint Undertaking (BBI JU) is a public-private partnership between the European Union and the Bio-based Industries Consortium aiming to increase the investment in the development of a sustainable bio-based industry sector. With a funding of 3.7 bill over a period of 7 years, BBI JU organises calls for proposals to support research, demonstration and deployment activities.

There are other avenues of innovation funding that embrace collaborative research and development; as mentioned above, as part of Horizon 2020 the Marie Skłodowska Curie Research and Innovation Staff Exchange (RISE) programme funds short-term exchanges of personnel between academic, industrial and commercial organisations.

Each Member State has their own institutions and agencies in charge of giving funding for research and innovation projects. For example, in the UK, the UKRI is the national agency providing funding for research and innovation; it brings together 7 Councils, Innovate UK and Research England, with a combined budget of £ 6 bn. In France is the National Research Agency the one in charge of administrating the funding for Research and Innovation. In Sweden, are the Central government and 4 research funding agencies the ones in charge of providing funds for research and innovation.

To fund the collaborative aspects of the proposed intervention, there are similar programmes to the RISE funds that are supported at a national level. The UK government offer a Knowledge Transfer Partnership (KTP) scheme, linking SMEs with an academic or research organisation and a graduate - this requires the business to contribute around a third of the project's costs, allowing a business to access academic expertise and new graduates. Education and knowledge transfer funding is not specific to UK-based research councils; for example, the Deutsche Forschungsgemeinschaft (DFG) – Germany's central, self-governing research funding organisation – deliver a programme called Scientific Networks which supports the exchange ideas, research approaches and staff. Business Finland also offer a Research and Knowledge Creation grant which is intended to fund new and innovative research and development, helping the collaboration of universities and research organisations. The grant

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745667 | ***Topic: BBI-2016-S02***

covers up to 50% of the total costs, or 65% if the project is an international collaboration – this is paid in arrears, dependent upon the reported actual costs.

Across Europe there are also different Innovation Voucher schemes (which have been mentioned previously) that can also be used to invest in education and knowledge transfer, rather than equipment purchase. For example, UK universities are offering vouchers as an aid for improving ties between SMEs and research institutions, helping to promote innovation and business growth.

In regard to staff training, at a European level ESIF has been – and continues to be – an important funding mechanism. Unlike the investment into equipment, when considering ESIF in the context of education and knowledge transfer, the key finance source is the European Social Fund (ESF). Again, as with the other ESIF instruments, the dissemination of ESF money is completed by individual, devolved regions and distributed in-line with national or regional policy programmes. Although ESF investments tend to be weighted towards programmes that help combat inequality and deprivation, it can also support schemes that promote education and growth. For example, some of the UK's Local Enterprise Partnerships (LEPs) and councils offer funding that helps strengthen employer commitments to education or that are aimed at increasing the retention of STEM skilled people within an area. In Belgium, there have been several different policy measures which offer educational funding and financial support that are, at least in part, funded by the ESF. This includes the eco-climate Training voucher – which gives financial support towards training workers at companies based within the environmental sector – and KMO-portefuille (SME portfolio); this gives €10k funding support to SMEs and free-lancers, based in Flanders, intended for support in training, advice or coaching.

---

[1] A specific gap could be address by two different interventions. Appendix 4 cross-references the identified gaps and the type of interventions that could be applied.

[2] It is noteworthy that in some cases, the equipment is actually not available in the European landscape of open-access facilities, but it is owned by industrial stakeholders. This can also lead to overlapping in infrastructure investment.

[3] A timeframe of 4 years was chosen as this is the typical duration of an EU funded project, which, as mentioned below, would be one of the most likely sources of funding for the network.

[4] It should be noted that cost could go up to 5 million € based on the experience of project partners in previous similar projects, especially if the consortium includes a large number of partners.

[5] It should be noted that, if the network wants to be set as a legal entity the cost of legal advice could be significantly higher.

[6] It should be noted that non-specialised pre-treatment equipment (i.e. grinders, chippers, etc.) tend to be subcontracted by the open-access centres.

[7] Koks, Z. *Technological development of Fast Pyrolysis and Hydrothermal Liquefaction: A combined approach of innovation systems and technological learning to assess future development*. MS thesis. 2016.

[8] These assumptions have been based on discussion with project partner organisations that have experience in the expansion of infrastructure of these characteristics.

[9] These assumptions have been made based on ERRIN's current activities.

[10] These assumptions have been based on discussion with project partner organisations that have own open-access pilot equipment.