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# ERIFORE

European Research Infrastructure  
for Circular Forest Bioeconomy

## D7.5 Final infrastructure development plan

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## **Executive summary**

ERIFORE – European Research Infrastructure for Circular Forest Bioeconomy – has been an Infradev-1 project (GA No 654371, 1.1.2016 – 31.1.2018) under Horizon 2020 Framework Programme. The future mission of the ERIFORE consortium is to establish an open access distributed research and innovation infrastructure for circular forest bioeconomy in Europe. ERIFORE focuses on the science and innovation bridge needed to develop and commercialise novel biorefinery process concepts for production of value added chemicals and materials from forest-based raw materials. The ERIFORE vision is to be a key contributor for European forest-based sector and to enable Europe to take the lead in the development and commercialisation of novel bio-based products.

European Strategy Forum on Research Infrastructures (ESFRI) has been successful in identifying research infrastructures (RIs) of pan-European interest to conduct top-level research activities meeting the long-term needs of European research communities and other stakeholders. Next generation RIs drive technological progress that depends on both transformative research and innovation. Implementing ESFRI infrastructures is critical for the European Union to remain at the forefront of science and technology and to stay competitive in the global knowledge-based economy. Furthermore, the coherent and strategy-led approach to policy-making on research infrastructure development has been seen to generate clear advantages on European level, such as avoiding duplication of efforts, pooling resources, rationalizing RI use, standardising processes and procedures and consolidating the global leadership of European RIs.

The main result of the ERIFORE project as an ESFRI design study is the action plan to become a distributed research infrastructure on the ESFRI roadmap in 2020. The design study work was based on extensive mapping of research needs and drivers, availability and development needs of existing research infrastructure and collaboration in the field of circular forest bioeconomy. The design study covered outlines for initial business models, financing plans and governance structures. All public deliverable reports are accessible on the ERIFORE web page ([www.erifore.eu](http://www.erifore.eu)).

Research infrastructure collaboration under the ESFRI concept would bring notable benefits for the ERIFORE partners as well as for the whole European research and innovation system in circular forest bioeconomy. The legal framework of European Research Infrastructure Consortium (ERIC) will assure scientific impactful collaboration and long-term commitments from research infrastructure owners, national ministries and funding organisations. The establishment of an ERIFORE ESFRI project would ensure that the voice of the forest-based bioeconomy is heard in policy-making bodies at national and EU level.

Work continues after the ERIFORE design study project in order to be ready for the next ESFRI Roadmap call for applications, presumably in 2019. Next phase of ESFRI planning will more carefully address the preconditions for the RI long-term sustainability and secure formal commitments from both Members and Partners.

## **Preparation for ESFRI Roadmap submission (2018-2019):**

The lead-up to submission has to be used to mature the business plan and in particular to ensure adequate commitments from the main stakeholders being national governments and other policy makers, partner organisations and related scientific and industrial interest groups. Scientific Partners need to sign a Memorandum of Understanding for the ESFRI project proposal. In addition, signatures in Expressions of Interest (EoI) and Expressions of Support (EoS) are needed from prospective Members by 2019.

## **ESFRI project: preparation phase (2020-2022):**

Having achieved ESFRI project status, it will be a continuous task to build awareness through informing and engaging stakeholders. In the preparation phase, the human resource policy will be completed and put into use as setting up the Central Office and recruiting staff becomes topical. Preparations for establishing governance in the chosen legal form will proceed towards applying for European Research Infrastructure Consortium (ERIC) status. Preparation phase completes financing and investment plans.

## **From ESFRI project to landmark: implementation and operational phases (from 2023 on):**

Eventually all legal and contractual arrangements are ready for the distributed RI to become operational. Open access and education and training activities as well as e-infrastructure are in action. Governance structure is fully in place, and funding for all operations is secured. Design and building of new infrastructure is also possible under the ESFRI collaboration.

The aim is to ensure that the distributed RI remains at the forefront of science and technology to offer the European research community and industry best opportunities to stay competitive in transferring scientific discoveries into novel concepts, products and services.

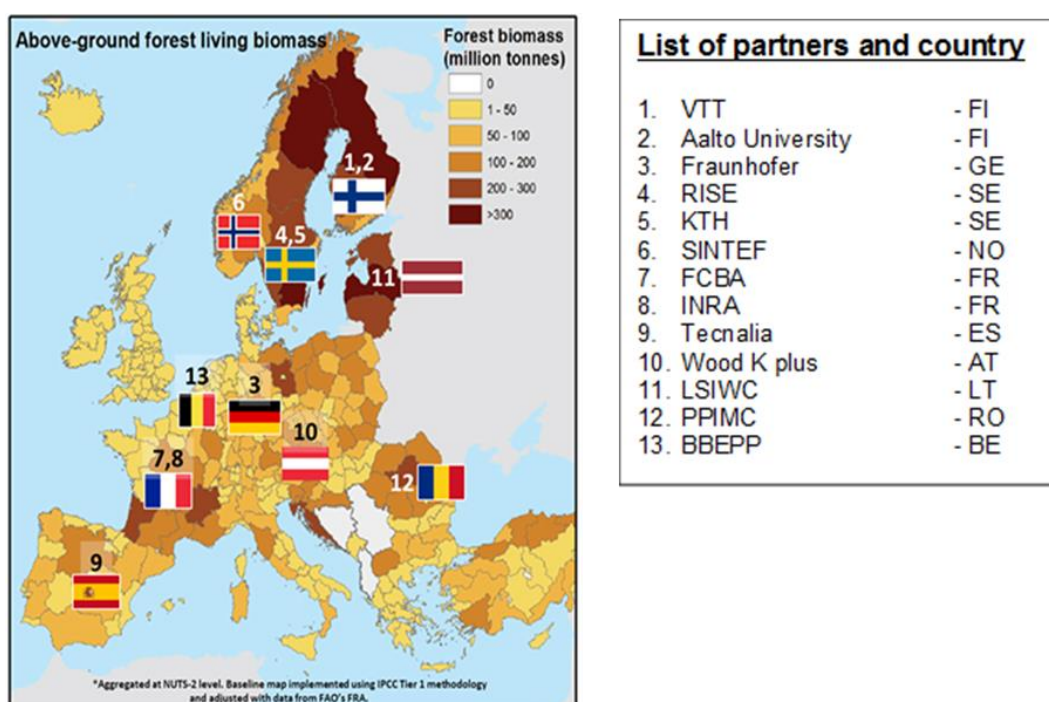
## List of Abbreviations of ERIFORE project partners

AALTO	Aalto University
BBEPP	Bio Base Europe Pilot Plant
FCBA	Institut Technologique Foret Cellulose Bois-construction Ameublement
FhG CBP	Fraunhofer Center for Chemical-Biotechnological Processes
FhG ICT	Fraunhofer Institute for Chemical Technology
INRA	Institut National de la Recherche Agronomique
KTH	KTH Royal Institute of Technology
LSIWC	Latvian State Institute of Wood Chemistry
PPIMC	“Petru Poni” Institute of Macromolecular Chemistry
RISE	RISE Research Institutes of Sweden
SINTEF	Stiftelsen SINTEF
TECNALIA	Tecnalia Research and Innovation
VTT	VTT Technical Research Centre of Finland Ltd
Wood K plus	Wood K plus Kompetenzzentrum Holz GmbH

## 1 Introduction

The aim of the ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project is to establish an open access distributed research infrastructure for circular forest bioeconomy in Europe. The objective of the ERIFORE project consortium is to submit a proposal for the next update of the European Strategy Forum on Research Infrastructures (ESFRI) roadmap.

The design study project has been carried out by 13 research infrastructure owners (see Figure 1) having a significant set of complementary capabilities in the form of knowledge, skills and infrastructure to cover the value chains from the forest biomass supply, processing, separation and purification up to conversion into products.



**Figure 1. ERIFORE-project partners.**

Figure modified from a European map of aboveground forest living biomass<sup>1</sup>

This report outlines the final development plan of the ERIFORE project. It is based on knowledge gathered during the evaluation, roadmapping and planning work in the ERIFORE project. In this report, we first outline the motivation and targets for establishing a distributed research infrastructure and an ESFRI project. Then, we present briefly excellence and facilities of the current project consortium, and thereafter describe planned activities, governance model and financing. Finally, the implementation plan summarises the necessary actions to establish ERIFORE as an ESFRI project and to develop it further into a fully functioning ESFRI landmark.

<sup>1</sup> Barredo J.I., San Miguel J., Caudullo G., Busetto L., A European map of living forest biomass and carbon stock –executive report (2012). JRC Scientific and Policy Report. EUR 25730 EN, doi:10.2788/780

## 1.1 Mission and Vision

*The mission is to establish an open access distributed research and innovation infrastructure for circular forest bioeconomy in Europe.*

The future ERIFORE distributed research infrastructure will focus on forest-based chemicals, materials and novel production processes, leaving out the research infrastructures serving primarily research for forestry or bioenergy technologies.

The science and service concept is based on the following three principles:

- 1) Enable the development of new bio-products by piloting throughout the whole value chain
- 2) Facilitate the transition of technologies from ideas to innovations
- 3) Operate as a distributed and open access European infrastructure.

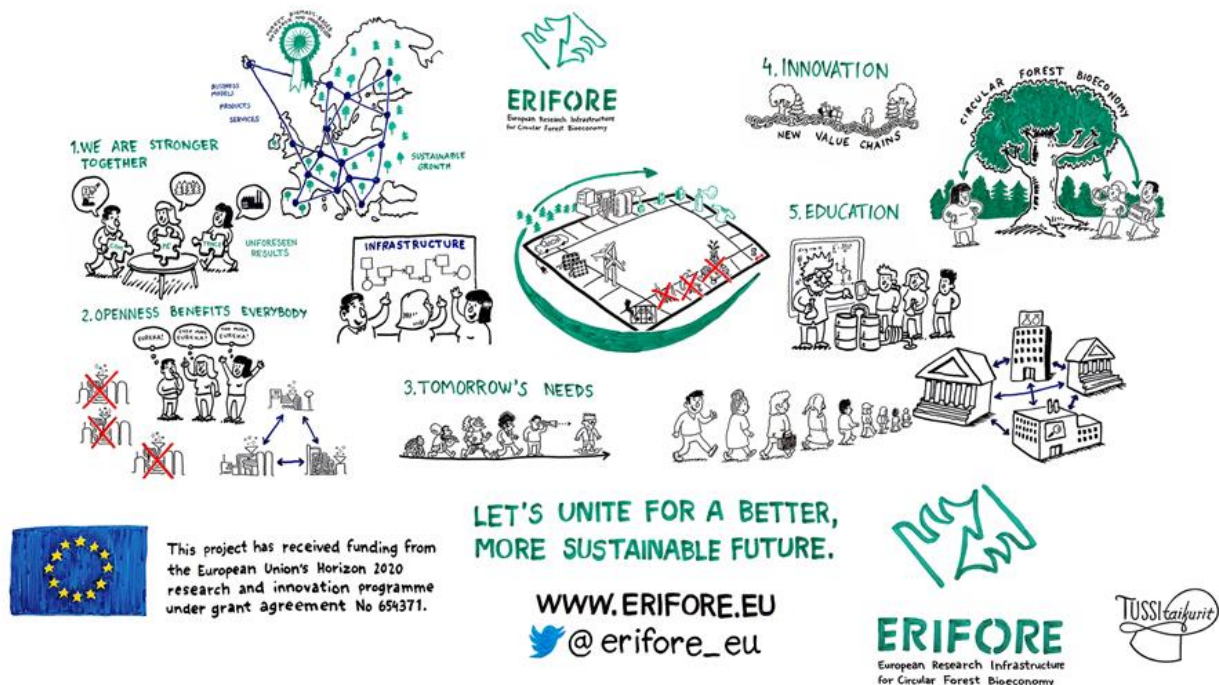


Figure 2. ERIFORE distributed research infrastructure will work towards realising Europe's potential as a world leader in forest-based bioeconomy research and innovations. Learn more about the five things we believe in by watching the [ERIFORE whiteboard video](#) accessible on ERIFORE website: [www.erifore.eu](http://www.erifore.eu)

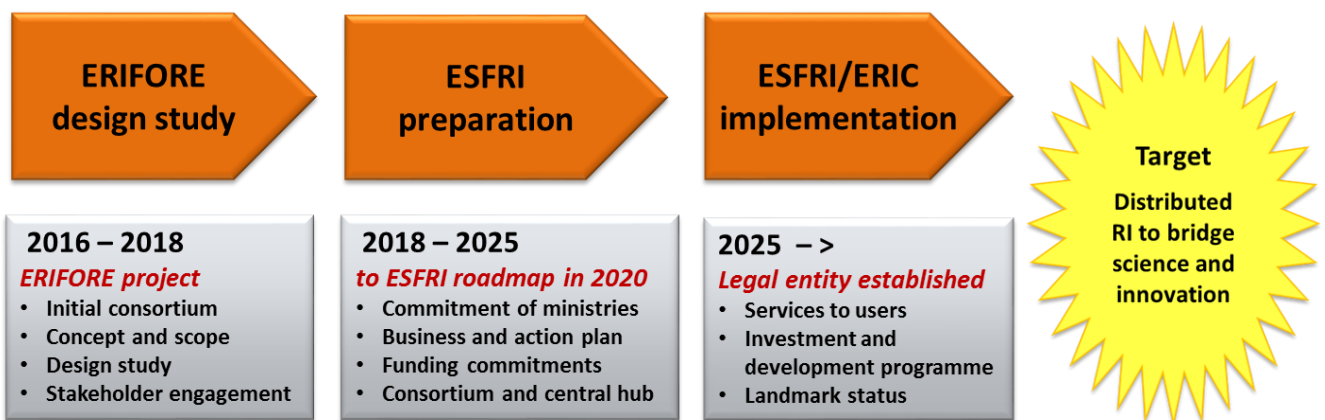
The ERIFORE aims to form a well-functioning consortium combining groundbreaking science, applied research and piloting infrastructures. The scope in respect of technology readiness levels (TRLs) will cover TRLs 2-6. This would enable scientific discoveries to be effectively transferred to new business models, products and services asserting sustainable growth and supporting the European ambition of global leadership in circular forest bioeconomy.

The distributed RI will be open for the scientific community, research organisations, small and medium sized enterprises, and industry. It will be committed to provide scientific excellence, new knowledge and up-to-date facilities with user services for the efficient execution of top-level European research under one roof.

*The vision is to be a key contributor for European forest-based sector and to enable Europe to take the lead in the development and commercialisation of novel bio-based products.*

## 1.2 Towards ESFRI

The plan is to submit an ESFRI project application for the next update of the European Strategy Forum on Research Infrastructures Roadmap, presumably in mid-2019. The lead-up to submission shall be used to mature the business plan and to ensure the adequate commitments from the main stakeholders being national governments, partner organisations and related scientific and industrial interest groups. This work will be continued after the ERIFORE design study project. The implementation plan is in detail described in Chapter 7.



**Figure 3. ERIFORE action plan towards a distributed open access research infrastructure**

Collaboration after the ERIFORE INFRADEV-1 project will continue in a non-ESFRI format via other RI development projects, such as Pilots4U, SmartPilots, Interregional innovation partnership.



## 2 Motivation and targets

The ERIFORE distributed research infrastructure aims to support the European Commission's goals of the green economy and sustainable growth. The ERIFORE distributed RI will take a leading role in coordinating investments and promoting research activities between European countries. Its Central Office will act as a single contact point for scientists, industry and policymakers seeking access to talent, ideas and facilities. The ERIFORE RI will focus on topics supporting forest-based bioeconomy concepts, from fundamental teaching and knowledge sharing to operating high-level research laboratories and large scale piloting facilities.

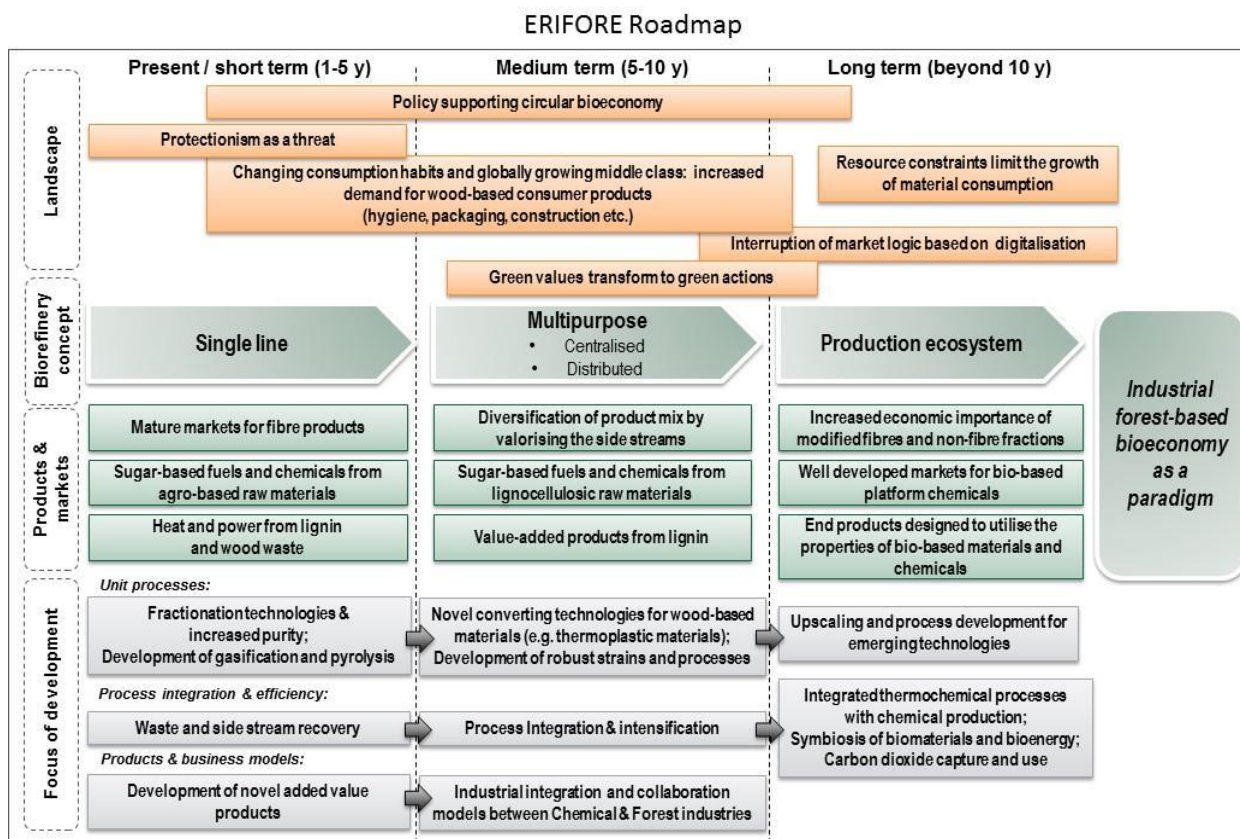
### 2.1 Demand

**Research.** The demand for research stems from highly diverse product streams, with different positions in the value chain and at varying TRL levels. Utilisation of forest biomass to new value added products requires combined understanding of the whole value chain. There is a need for research on the different value chain structures, sector specific technical research and scale-up.

Moreover, the future biorefinery concept is seen to evolve from single line production to cross-technology and multidisciplinary operation and finally towards industrial symbiosis of production ecosystems (Figure 4). Several techno-economic challenges need to be solved to realise the development pathway from one stage to another. The development needs are classified into three different themes: 1) the development of unit processes, 2) process integration and the improvement of efficiency, and finally 3) the development of products and business models. Examples of specific development needs of the first two categories are given in Chapter 3.3. The third category highlights the importance of developing novel value added products and finding bases for industrial integration and collaboration models for the new bio-based business.<sup>2</sup>

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<sup>2</sup> Leinonen Anna *et al.* (2017). D5.2 List of significant emerging concepts and evaluation of infrastructure capabilities to meet forthcoming plans. The ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project.



**Figure 4. ERIFORE roadmap exploring emerging technology concepts.** The top layer highlights some landscape conditions that can be interpreted as drivers or barriers for the development. The middle layer identifies three development steps for the biorefinery evolution and characterises the product and markets in each stage. The bottom layer contains critical development needs to realize the biorefinery evolution.<sup>2</sup>

The ERIFORE design study project carried out three case studies<sup>3</sup>, which aimed to describe how the forest-based value chains currently under development could be brought closer to realisation via coordinated RI collaboration. The selected case studies were:

1. Production of sugars from wood and their conversion into valuable commodities
2. Forest derived Wood Plastic Composite (WPC) with increased outdoor durability and fibre resistance containing lignin
3. Ioncell-F process upscaling and application for cellulose nanospinning

It was concluded that the considered projects could hardly be realised without collaboration between several partners. A key strength of the proposed distributed RI is to be able to evaluate different routes to products (any raw material, any products, any combination of technologies, quality/cost perspective) and to test and verify the products and applications together with a

<sup>3</sup> Joelson Jonas *et al.* (2017). D5.3 Case studies. The ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project.

range of geographically scattered stakeholders, thereby advancing the TRL of developing technologies. Based on the case studies, an adequate portfolio of infrastructure could be a large number of small-scale infrastructure spread over Europe, several flexible bench/small pilot units for testing the research ideas at more realistic conditions and a few pilot plants able to mimic industrial operation.

**Research infrastructure cooperation and coordination.** Europe is funding research and innovation infrastructures mainly based on organisational or regional interests (bottom-up). This bottom-up approach leads to multiplication of similar equipment in Europe, as the players not always communicate effectively or offer convenient access to their facilities.

There is a need for better top-down coordination (such as ESFRI) of research infrastructure, which could:

- Enhance cross-border access to RI
- Increase awareness of available capabilities and facilities
- Improve capacity utilisation rates of existing equipment
- Channel investments to unique equipment
- Enhance integration of relevant research fields and technology areas for the development of new bioeconomy concepts
- Effectively support implementation of European research and innovation strategies

## 2.2 Objectives

The main objectives of the ERIFORE ESFRI project are two-fold:

- A) To plan, fund, consolidate and administrate a world class distributed research and innovation infrastructure on forest-based bioeconomy across value chains.
- To consolidate existing research infrastructure into a distributed research and innovation infrastructure that covers entire value chains in a new joint legal entity to support and promote research, applied research and piloting.
  - To identify and fulfil development needs in the research infrastructure network on European and global level.
  - To ensure long-span coordination in the funding of large investments based on actual needs, and, therefore, to avoid duplicate investments in costly research infrastructures, facilities and equipment.
  - To increase utilisation rate of the research infrastructure through harmonized policies for transnational access and data management.
- B) To facilitate excellent scientific research and act as a science and innovation bridge in the field of forest-based bioeconomy.
- To offer transnational access to a Pan-European distributed research infrastructure for science and innovation.

- To increase mobility of researchers and ideas through education and training programs.
- To align organizational and national research priorities with industry needs and European strategies.

### 2.3 Pan-European relevance

ERIFORE aims at **reinforcing European policy and research infrastructure cooperation** to enhance the transition to a circular forest bioeconomy. The transition to a circular economy is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive bioeconomy. The circular economy aims to strengthen the resource-efficiency of processes and the use of recycled materials to reduce the use of additional fossil carbon, while bioeconomy aims to substitute fossil carbon by renewable carbon from biomass (including by-products and wastes). The bioeconomy uses renewable resources, such as wood, crops or fibers, instead of fossil ones to make greener products. The circular bioeconomy is in the intersection of these complementary approaches. The research field of ERIFORE focuses on developing novel biorefinery process concepts for production of value added chemicals and materials from forest-based raw materials. This is well in line with the EU Bioeconomy Strategy<sup>4</sup> with links to Circular Economy Action Plan<sup>5</sup>. ERIFORE helps to structure the research and innovation landscape by enhancing the awareness, utilisation and open access of the top-level complementary research infrastructures. In this way, ERIFORE also contributes to the development in the field at regional, national, and European level.

The open access principle and geographical distribution of the ERIFORE DRI will **encourage knowledge diffusion across Europe, and actively support the bioeconomy development of all European countries and regions**. Even though the bioeconomy is a priority for most of the European countries and regions, the level of maturity is varying. Networking and interregional cooperation between European countries and regions can facilitate learning and knowledge transfer, fostering the development of bioeconomy ecosystems in low maturity regions and unlocking the full potential of innovation in Europe. ERIFORE will contribute significantly to European cohesion and integrate less-developed regions into the development of the circular forest bioeconomy.

ERIFORE will work towards **realising Europe's potential as a world leader in forest-based bioeconomy research and innovations**. Forest-based industry has great potential to become the main player in the European bioeconomy in the coming years. Currently the national and EU statistics only monitor traditional forest sector economic activities (pulp, paper and wood products, and forestry related to these) and leave out bioenergy, chemicals, textiles, etc. that are based on forest biomass. Thus, the economic value-added and employment statistics lag behind the actual development in the forest-based bioeconomy. The turnover value of the traditional forest industry (not including forestry and furniture industry) was around 302 billion

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<sup>4</sup> European Commission, Innovation for Sustainable Growth, A Bioeconomy for Europe, European Union 2012, COM (2012)60, doi:10.2777/6462

<sup>5</sup> Closing the loop – AN EU action plan for the Circular Economy, COM(2015) 0614.

euros and 1.45 million jobs in 2014 and in 2013, respectively.<sup>6</sup> The bioeconomy as a whole is already a reality with an annual turnover of 2.2 trillion euros and 18.6 million jobs in 2014 in Europe, representing 9% of the total employment in the EU<sup>7</sup>. The ERIFORE will provide RI access needed to develop and commercialise novel biorefinery process concepts for production of value added chemicals and materials from forest-based raw materials.

In other words, ERIFORE **accelerates the transfer of the research findings** to industry. ERIFORE will build capabilities and make available research and pilot infrastructure, to enable and execute the strategic research and innovation agendas (SRIA / SIRA) for example of the following stakeholder and sector organizations:

- FTP (Forest-based Sector Technology Platform) – ‘VISION 2030’ and SRIA 2020
- CEPI (Confederation on European Paper Industries) – Roadmap 2050 to a low carbon bioeconomy
- BIC (Bio-based Industries Consortium) – SIRA 2020 and 2030 – forest-based biomass as envisioned feedstock
- EIC - (European Innovation Council) improving the innovation eco-system for scaling up, reducing barriers and enabling access to funding, talent, market opportunities and regulatory environment for innovation.

ERIFORE aims to **ensure coherence and complementarity with relevant research programs conducted at European level**. The European Union has been investing heavily in research and innovation programs to increase Europe’s global competitiveness. An analysis<sup>8</sup> of the three last published calls of the major research programmes covering the entire forest-based value chain at the European level<sup>9</sup> shows a clear tendency to increase the innovation output of the research activities. Bio-Based Industries Joint Undertaking (BBI JU) has 272 million EUR budget in H2020 for developing value chain demonstration projects for forest-based feedstock and WoodWisdom-Net Research Programme had 85 million EUR budget between 2006 and 2013. Large research programs in Europe show clear need for development and coordination of European forest-based research infrastructures. At policy level, the cross-sector networking is essential, fostering scientific advancements along the value chain and accelerating the transfer of research findings to new business models and novel products. Thus, the efficiency of research and development is ought to be increased along the value chain as well as within a research field or technology area. ERIFORE will take a leading role in promoting research activities between European countries and sectors and in coordinating investments.

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<sup>6</sup> Marc Palahi, Presentation: Insights for updating the EU Bioeconomy Strategy, Think Forest Event “Leading the way to a new European Bioeconomy Strategy”, 10.5.2017, Berlin. Accessible at European Forest Institute web site: [http://www.efi.int/portal/policy\\_advice/thinkforest/past\\_events/leading/programme/](http://www.efi.int/portal/policy_advice/thinkforest/past_events/leading/programme/) (15.5.2017)

<sup>7</sup> Ronzon T., Lusser M., Klinkenberg M. (ed.), Landa L., Sanchez Lopez J. (ed.), M'Barek R., Hadjamu G.(ed.), Belward A. (ed.), Camia A. (ed.), Giuntoli J., Cristobal J., Parisi C., Ferrari E., Marelli L., Torres de Matos C., Gomez Barbero M., Rodriguez Cerezo E. (2017). Bioeconomy Report 2016. JRC Scientific and Policy Report. EUR 28468 EN

<sup>8</sup> Hedeler Barbara *et al.* (2017) D5.4 Analysis and report on industry mapping and stakeholder interviews. The ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project.

<sup>9</sup> These are: 7<sup>th</sup> Framework Programme, Horizon2020, Bio-Based Industries Joint Undertaking and WoodWisdom-Net Research Programme.

## 2.4 Socio-economic impact

The scientific achievements made possible by the ERIFORE distributed RI will impact society through several channels:

**Increased mobility** through transnational access to infrastructure will improve training of researchers and enable scientific breakthroughs that would not be possible otherwise. The state-of-the-art equipment attracts scientific talent from all over Europe, as well as globally, increasing the number of people educated in advanced forest-based technologies. This will facilitate knowledge sharing centered on the needs and capabilities of the European scientific community and industry.

**The integration of research facilities into a distributed RI across and between different value chains** will allow proof of concept and validation of new technologies and business models. The time required to bring new ideas and innovations to the market will decrease. As a result, the competitiveness of European forest-based industry will improve, fostering **job creation and preservation**.

**Public financing for investments** in new equipment and pilot scale facilities is a de facto risk sharing mechanism, helping to generate investments that would be difficult to finance otherwise. Financial risk is further reduced through the increased likelihood that the equipment will attract users that will help burden the operational costs, and duplication is also avoided.

**The development of higher value added products** and value adding side streams will increase the returns on European forest industry. This implies increased wealth generation in areas away from major European cities. Such a development would be welcome, as it would support rural settlements that are under pressure from urbanization.

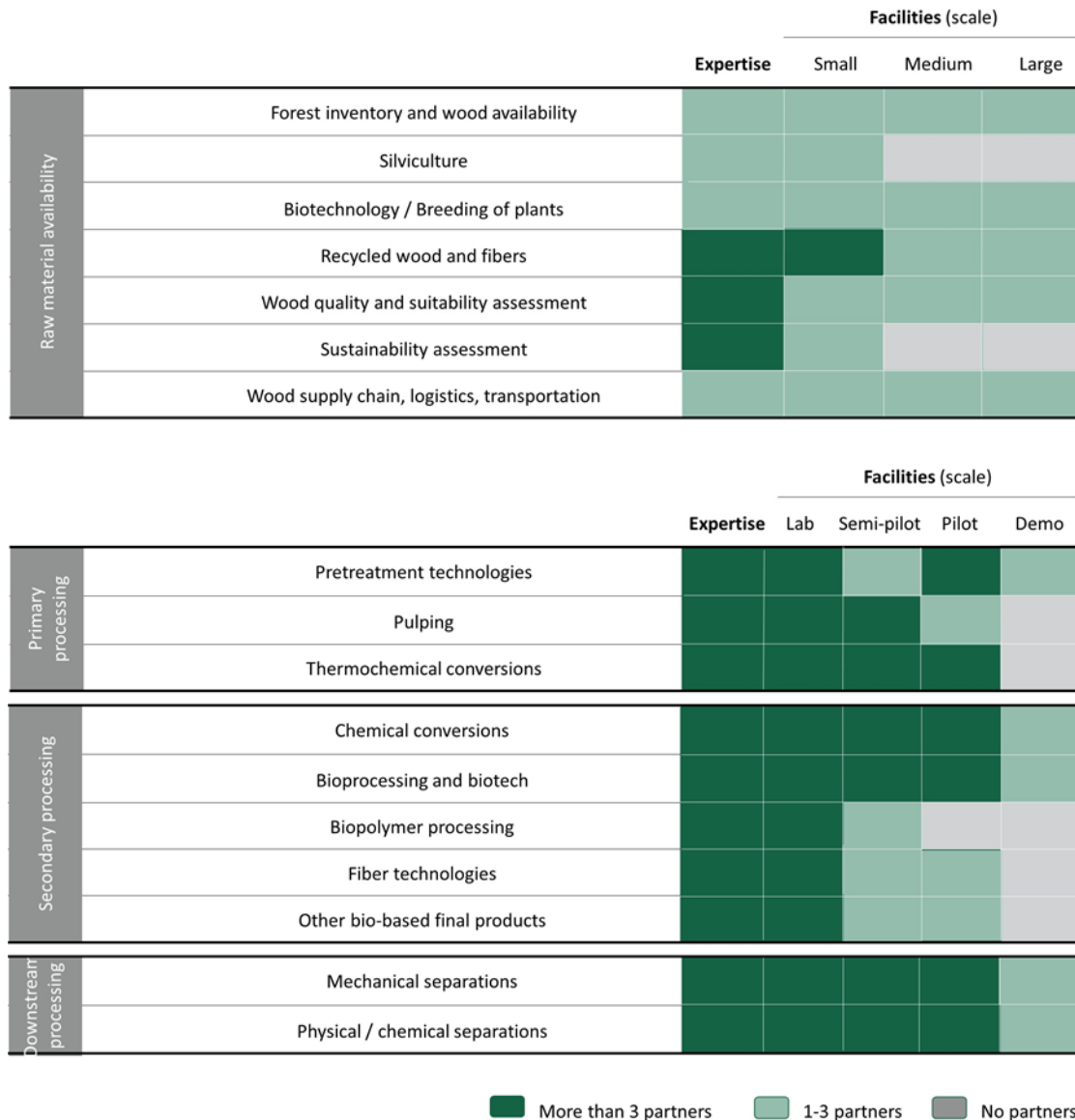
**Better coordination of research efforts** is required to achieve the ambitious goals of the 2015 Paris Agreement<sup>10</sup> on climate change. The transition to a more sustainable growth and greener economy can only happen through increased use of renewable resources, such as forest-based raw materials. While the idea is simple, it is proving difficult to achieve in practice in a market driven economy with low energy prices. The establishment of an ERIFORE ESFRI project would be a watershed moment, ensuring that the voice of the forest-based bioeconomy will be heard in policymaking bodies at national and EU level.

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<sup>10</sup> see for instance: [https://ec.europa.eu/clima/policies/international/negotiations/paris\\_en](https://ec.europa.eu/clima/policies/international/negotiations/paris_en)

### 3 ERIFORE excellence and facilities

The ERIFORE project consortium is well positioned on the way to a distributed research infrastructure. The consortium has capabilities to enable process development along the entire biorefinery value chains. The project partners are complementary in terms of knowledge, skills and infrastructure.



**Figure 5. Generic overview on the capabilities in the consortium**

Future biorefinery concepts will go beyond the current biomass uses. This is directly reflected in the infrastructure needs to realise the most up-to-date education, excellent research and innovations that are required for industrial renewal.

## 3.1 Scientific excellence

The ERIFORE consortium consists of experienced organisations with a high professional level of specialists having proven scientific record in the forest bioeconomy field. Some examples are given in Table 1.

**Table 1. Scientific excellence of key specialists from different ERIFORE research fields (limited examples). Publication figures are based on SCOPUS data from November-December 2017.**

	Name	Research field	Publications	Citations	H-Index	Patents
VTT	Prof. Merja Penttilä	Industrial Biotechnology	266	13211	66	149
	Prof. Ali Harlin	Fibre Materials and Technical Textiles, Packaging and Polymeric Materials	129	1350	21	67
	Prof. Pentti Koukkari	Chemical Reaction Engineering	63	399	11	13
	Prof. Kristiina Kruus	Biochemistry, Applied Enzymology	98	3278	33	22
	Dr. Anja Oasmaa	Thermal Conversion Processes, Renewable Energy Technology	56	3765	30	7
Aalto University	Prof. Jukka Seppälä	Polymer Technology	349	8800	52	50
	Prof. Orlando Rojas	Bio-based Colloids and Materials	261	7081	41	3
	Dean Janne Laine	Forest Products Chemistry	176	5183	38	14
	Prof. Herbert Sixta	Biorefineries	220	3604	32	18
	Prof. Tapani Vuorinen	Wood Chemistry	187	2925	28	13
KTH	Prof. Lars Berglung	Wood Nanotechnology and Material Science	225	12834	55	-
	Prof. Lars Wågberg	Fibre and Wood Nanotechnology	254	6750	46	-
	Prof. Gunnar Henriksson	Wood Chemistry	137	4319	37	-
RISE	Dr. Kent O. Davidsson	Thermochemical processes	31	832	16	-
	Adj. Prof. Henrik Wiinikka	Energy Engineering	49	558	15	-
	Adj. Prof. Olov Öhrman	Chemical Technology	34	407	13	-
SINTEF	Dr. Richard Blom	Separation Technology, catalysis	108	4368	32	-
	Dr. Carlos A. Grande	Separation Technology	91	3485	32	-
	Dr. Duncan Akporiaye	Catalysis	71	2224	28	-
	Prof. Arne Karlsson	Catalysis, Raman spectroscopy	41	969	16	46
LSIWC	Dr. Gaļina Teliševa	Biopolymer processing	72	1032	14	15
	Dr. Tatjana Dižbite	Lignin Chemistry and Applications	47	882	14	13
	Dr. Jānis Grāvītis	Wood and Biomass Primary Processing	50	418	11	1
PPIMC	Dr. Vasile Cornelia	Biocomposites	269	3519	30	-
	Dr. Iuliana Spiridon	Bio-based Materials	73	844	17	1
	Dr. Ioan Silvia	Polysaccharides chemistry and rheology	123	994	15	-



The ERIFORE project organisations have been chosen based on certain specific knowledge areas:

- FCBA, INRA, VTT and Wood K Plus have special competence area in biomass raw material sourcing and availability.<sup>11</sup>
- VTT, FhG, LSIWC, SINTEF, Tecalia and RISE have extensive competence and facilities in area of primary or secondary processing of the raw material to intermediate of final products.
- Aalto, KTH, LSIWC, PPIMC, SINTEF have profound knowledge and tools on research and development of fundamentally new products.
- BBEPP, FhG, VTT, RISE, Tecalia and SINTEF have special facilities and knowledge for piloting and scale-up of the new technologies to the level enabling start of commercialisation efforts by industry and SMEs.

**Biomass primary processing.** Due to long history and wide experience in wood materials, Aalto University and VTT have excellent competence in the area of biomass pretreatment and refining. KTH has also solid competence in the area of traditional pulping processes including pretreatments and bleaching. Furthermore, there is a strong research effort on primary processing for new materials performed within the framework of the Wallenberg Wood Science Center. Latvian State Institute of Wood Chemistry (LSIWC) has special knowledge on steam explosion, whereas Fraunhofer ICT has the best expertise in solvolysis and organosolv pulping. What comes to thermochemical conversions, VTT is one of the world's leading research institutes on biomass gasification and in the development of fast pyrolysis processes. SINTEF has worked on catalytic and non-catalytic pyrolysis for more than 25 years, but focuses also on process routes related to torrefaction and gasification. Tecalia contributes in processes to obtain second-generation biofuels of lignocellulosic biomass and forest by-products, accomplished with conversion processes based on biochemical and thermochemical technologies. RISE (SP) has a wide array of competencies and pilot facilities on hydrothermal and enzymatic conversions.<sup>12</sup>

**Secondary processing.** All partners have expertise in secondary processing where major process technologies, such as biotechnical, chemical, catalytic, thermochemical and material conversion processes, are included. Next, we mention some examples of the expertise in the field.<sup>13</sup>

Bio Base Europe Pilot Plant (BBEPP) has built up a significant expertise on syngas fermentation and cultivation of acetonic bacteria, which enables the production of both high-end and bulk chemicals with engineering strains. In respect to fermentation products, SINTEF has strong

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<sup>11</sup> Da Silva Perez Denilson *et al.* (2016) Deliverable 1.1 Report on the capabilities, research tools, networking and funding sources of the consortium partners in the field of forest biomass raw material sourcing and availability. The ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project.

<sup>12</sup> Ubele Darta *et al.* (2016) Deliverable 2.1 Report on the capabilities, research tools, networking and funding sources of the consortium partners in the field of forest biomass primary processing. The ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project.

<sup>13</sup> Nikkanen Ville *et al.* (2016) Deliverable 3.1 Report on the capabilities, research tools, networking and funding sources of the consortium partners in the field of forest biomass secondary processing. The ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project.

expertise in production of new enzymes, fuels, food additives, biopolymers, and biopharmaceuticals. Wood K plus is specialized in biotechnological conversions of lignocellulosic waste streams into platform chemicals or biopolymers as well as composites from renewable resources. Petru Poni Institute of Macromolecular Chemistry (PPIMC) works in the field of polymer processing to obtain new added value materials from cellulose, hemicellulose or lignin based raw materials. Also INRA has strong competence in biochemical processing, strain screening, polymer engineering and fibre-based materials.<sup>12</sup>

Core competences at Fraunhofer CBP cover processes such as dehydration of alcohol to olefins, hydrogenation of glucose to sorbitol and derivatisation of lignin, whereas Fraunhofer ICT works with topics related to lignin and lignin derivative conversions and biopolymer processing. VTT is strong e.g. in industrial biotechnology, foam formed fibre web materials, cellulose based textile fibres, biopolymers and polymer composites. AALTO University is well-known in the development of high-quality fibre products from lignocellulose and cellulose, and the expertise in the synthesis of novel biopolymers and polymer composites. Furthermore, AALTO has outstanding scientific experience in utilizing biomimetic approaches and supramolecular interactions to construct totally new kind of materials from nanocelluloses. Future packaging materials are under the research topics of KTH and VTT. RISE is specialized in chemical conversions of materials to chemicals and monomers, subsequently to polymers and additives and finally to physical products. Design and production of high value niche chemicals, e.g. pharmaceuticals, can be listed as one core-competence of this ERIFORE project partner.<sup>12</sup>

**Downstream processing.** The key competencies of VTT are in liquid-solid separations, membrane filtrations, drying, evaporations and distillations. Fraunhofer ICT has experience to simulate separation of different materials of biorefineries including lignin and its derivatives, cellulose based intermediate products, tall oil and biorefinery wastewaters. RISE has long experience in demonstration scale separations on for example lignin, ethanol and protein. In addition, RISE has special expertise to design optimum crystallisation processes, including characterisation of particle sizes. SINTEF in has a long track record in purification and separation of bio-derived compounds both in the field of biotechnology and chemical industry. Examples are separation of sugars from forest biomass, separation of lignin monomers from pyrolysis oils and purification of gases after gasification and bio-methane production. BBEPP has specific competence in the area of crystallisation, but also vast expertise in product recovery and purification processes including other unit operations such as centrifugation, filtration, ion exchange/adsorption, and evaporation and drying.<sup>14</sup>

**Academic and industry networks.** The ERIFORE project partners are involved in an extensive range of educational and training activities, and have wide co-operation networks between research organisations and academia. According to the network analysis based on ongoing EU-funded research projects, the ERIFORE consortium had forest-based bioeconomy

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<sup>14</sup> Johnson Karin *et al.* (2016) Deliverable 4.1 Report on Report on the capabilities, research tools, networking and funding sources of the consortium partners in the field of separation and downstream processing. The ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project.

related research collaboration with 42 universities in January 2017<sup>15</sup>. In addition, the partners have frequent contacts and projects with the leading industrial players and emerging SMEs. This forms an excellent basis to strengthen the links between academia, industry and the future open access distributed research infrastructure.

### 3.2 Existing facilities

The ERIFORE project partners have complementary research infrastructure for the development of processes for production of chemicals, fuels, fibre products and materials from renewable biomass utilizing biotechnological, chemical and thermal processing technologies. The scope and technical content of research areas and infrastructures in circular forest biorefinery field can be described in many ways. In the ERIFORE project, the dividing is based on steps in the development chain: raw material sourcing and availability, primary processing of the forest biomass, secondary processing of the biomass components and separation and downstream processing technologies.

The fields of **raw materials sourcing** and availability covers tools and expertise for topics such as forest inventory and wood availability; silviculture, wood supply chain, logistics, transportation; biotechnology / breeding; recycled wood and fibres; wood quality assessment and suitability between biomass and processing and sustainability assessment tools. However, these research facilities differ quite much from the other more process focused infrastructures of ERIFORE consortium, and therefore raw material sourcing facilities are not included into the final scope of ERIFORE-ESFRI plans.

For **primary processing**, e.g. steam explosion, pulping, and hydrolysis, many consortium partners have today a very good level of expertise and laboratory scale equipment. Some partners have also pilot scale capacities.

For **secondary processing** the consortium has a good selection of laboratory and pilot scale facilities in the research fields of chemical conversion, bioprocessing and industrial biotechnology, biopolymer processing, fibre technologies and other bio-based final products. The partners have a very extensive knowledge and equipment basis for producing intermediate products via chemical or biochemical processes, where ERIFORE is well equipped with pilot scale facilities. Somewhat less expertise and facilities could be found to be in final product and materials development, which aims to produce high-value end products.

**Downstream processing** equipment inventory was divided in two sections: mechanical separation and chemical/physical separation. Within the consortium, there is a wide range of downstream processing facilities at laboratory and pilot scale, such as continuous and batch distillation setups, preparative chromatography, crystallisation and mechanical separations such as filtration, micro-, ultra-, nano-filtration and osmosis.

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<sup>15</sup> Malin Minna *et al.* (2017) Deliverable 7.4 Report on the educational and training use of the infrastructure network. The ERIFORE (European Research Infrastructure for Circular Forest Bioeconomy) project.

The available research infrastructures of the consortium partners have certain similarities, but there is clearly also complementary facilities and expertise, which enables research on scientific and technological developments. The main part of ERIFORE facilities are for applied research and scale-up, but there is also access to more scientific research tools at the partners and by complementing through networks. Only minor infrastructure gaps were identified within the case studies<sup>3</sup>. Missing equipment were mainly within larger-scale equipment within specific applications and within the field of highly demanding reaction conditions.

The yearly operational budget of ERIFORE partners' current research infrastructure is around 80 MEUR. At least 10% of this is funded by European sources. The total capital value (CV) is reported to be around 170 MEUR. Around 30% to 50% of the invested capital has been invested in piloting facilities. These piloting facilities (TRL5-7) aim to take the technologies from laboratories (TRL1-4) closer to demonstration (TRL7-8) and final commercialization (TRL9).

### 3.3 Major upgrades of existing or construction of new research facilities

The future development needs and investment plans of research infrastructure reflect the predicted and foreseeable development of research and customer needs to develop new products.

In the short and medium term, it is essential to strengthen the prerequisites for the multi- and cross-technological capabilities. It is also important to develop the economic feasibility of the production units, for example by process intensification and integration. The development of feedstock and product fractionation, separation and purification technologies and waste and side stream recovery are important, because these issues are often the major hinders for techno-economic commercialisation of new technology concepts in this field.<sup>2</sup>

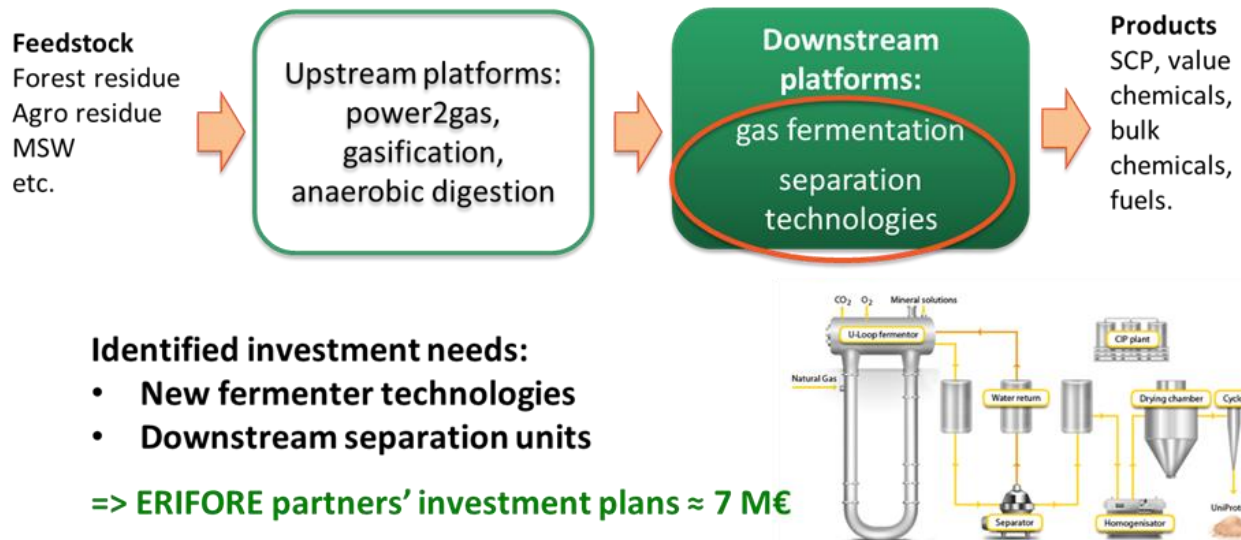
Another highly important area of new research and pilot equipment is the development of novel value added products for the future market. Examples of such new products are bio-based value chemicals and polymers for cosmetics, ingredients and pharma, single cell proteins for food and feed, biocomposites, high performance packaging materials and textile fibres. These products often require new special production technologies or unit operations differing from current industrial processes.<sup>2</sup>

In the long-term comes increasingly important to develop new techno-economically effective bio-based production ecosystems. Examples can be integrated thermochemical processes with chemical production and symbiosis between biomaterials and bioenergy.<sup>2</sup>

The volume of planned investments is about 60 M€. The development needs for ERIFORE research facilities can be classified into three main categories:

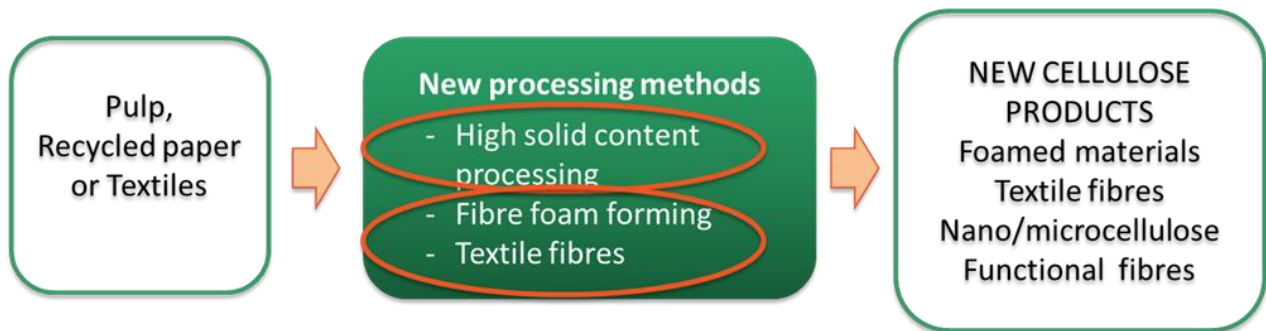
1. Special process technologies for novel value added products.
2. Pre-processing and separation technologies for techno-economical feasibility of the new processes.
3. Pilot plants for scale-up and demonstration.

An example of the special process technologies can be seen in Figure 6 below showing the value chain and related investment plans for bench and pilot scale tools for gas fermentation technology and related separation units needed to convert C1 gases to valuable products.



**Figure 6. Identified research equipment investment needs for fermentation and valorisation of C1 gases.**

Another example from material technology area is investments for laboratory and pilot scale foam forming technologies for the production of new cellulose pulp based hybrid materials used mainly for packaging, hygienic and construction materials (Figure 7). A potential and relatively short-term need is to develop new environmentally friendly methods for cellulose-based textile fibers. These material technologies can be supported by new reaction efficient high solid content process methods for chemical modification of cellulose or lignin.



### Identified RI investment needs

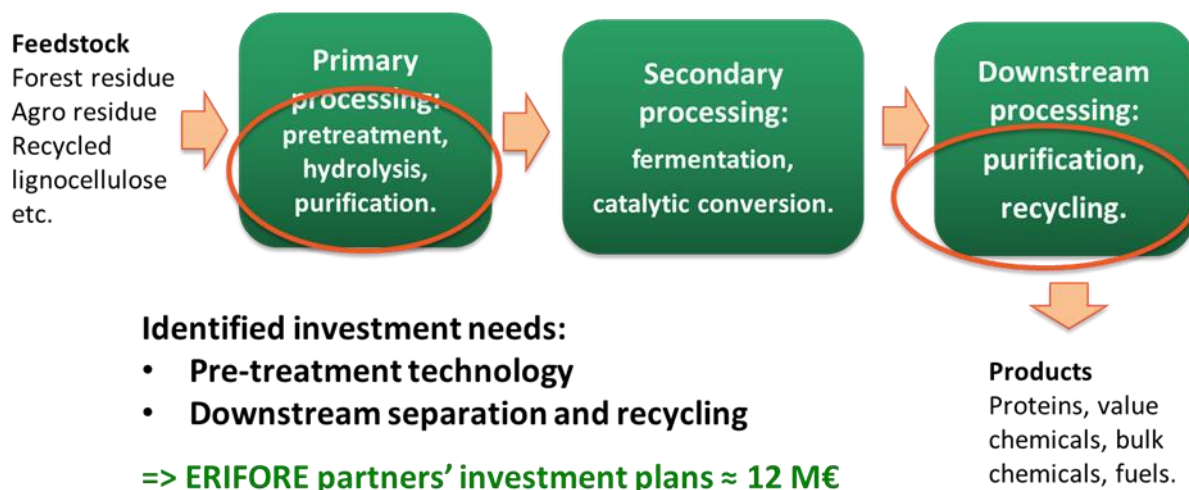
- New processes for cellulose modification
- Processes for advanced pulp based materials
- New processes for textile fibres

=> ERIFORE partners' investment plans ≈ 15 M€



Figure 7. Identified research and pilot equipment investment needs for new production technologies of lignocellulose-based materials.

Third example on investment needs is new tools for industrial biotechnology utilising 2<sup>nd</sup> generation sugars as feed for the microbes (Figure 8). The fermentation technologies are more mature, but there is evident need for techno-economically improved biomass pre-processing methods to separate pure enough raw material components. Other important investment targets are separation technologies for product recovery and purification, which are often bottlenecks for commercialisation of new industrial biotechnology processes.



### Identified investment needs:

- Pre-treatment technology
- Downstream separation and recycling

=> ERIFORE partners' investment plans ≈ 12 M€

Figure 8. Identified research and pilot equipment investment need for pre-processing and separation technologies related to industrial biotechnology processes.

## 4 ERIFORE distributed research infrastructure

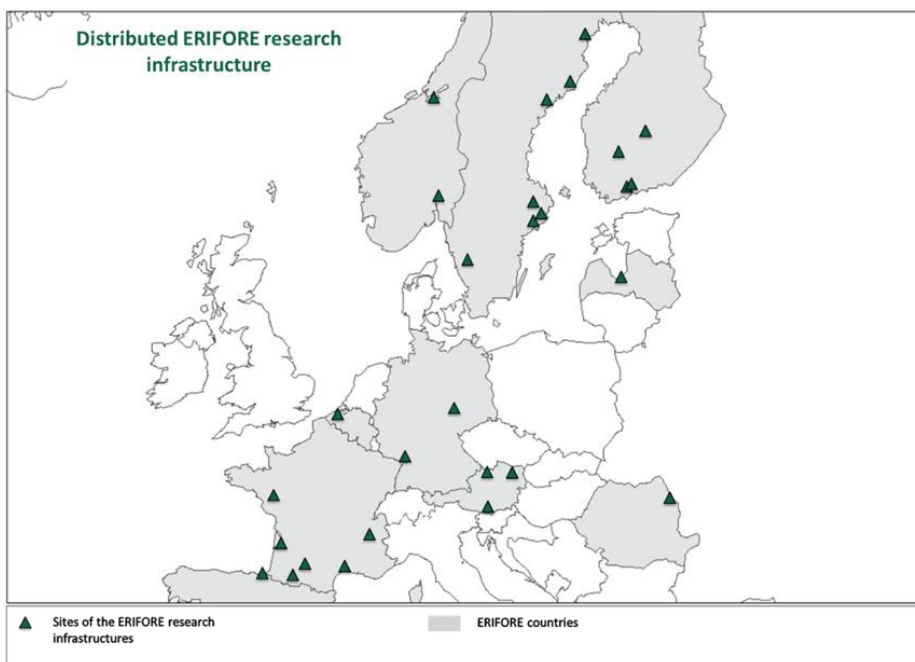
ERIFORE will be organized as a network of distributed research infrastructure with a single access point (Central Office). The Central Office's main responsibility is to manage and coordinate cooperation between the individual partners and users.

### 4.1 Organisation

#### 4.1.1 Partners

ERIFORE aims to attract the leading research organizations in Europe within the field of the forest-based bioeconomy. The initial partners will be selected among the participants in the Horizon 2020 ERIFORE project (2016-2018), but are not limited to those. Organizations from both the public and the private sector are welcome, provided that they are willing to allocate access time to their publicly funded research infrastructure to ERIFORE.<sup>16</sup>

Together, the partners' research facilities will form a network of national nodes that spans the geography of Europe. Research infrastructures represent effective innovation hubs, thus their optimal distribution across Europe and in close relationship between universities and industry is important for the innovation-based bioeconomy. Location of research infrastructures owned by the ERIFORE project partners is shown in Figure 9.



**Figure 9. Distribution of the ERIFORE research infrastructure.**

<sup>16</sup> Privately funded infrastructure is usually not assigned to ESFRI projects, except for rare cases where the infrastructure is unique and owned by a company committed to scientific excellence. In these cases, the access time allotted to the ESFRI is typically much lower than that of publicly funded infrastructure.

The benefits offered to partners include, but are not limited to:

- Increased visibility through networking activities and joint promotion
- Stamp of approval that their research and RI is classified as scientifically excellent
- Cost sharing through increased utilisation at operational cost prices
- Influence on setting national and Pan-European research priorities

#### **4.1.2 Members and host**

The ERIFORE Members will be nation states with a strategic interest and long-term commitment to the circular forest bioeconomy. Each Member will be represented by one individual in the Assembly of Members of the ERIFORE ESFRI project (see section 5 about the governance model). The representative could be, for example, a senior official from a relevant ministry or a national research council. It is required that one Member will host the Central Office that is tasked with the daily operations of the network. Non-member countries may be given Observer status, which grants access to the General Assembly without voting rights.

The main benefits to Members includes, but are not limited to:

- Increased cross-country cooperation within forest-based bioeconomy
- Job creation and preservation through quicker industrial uptake of new technology
- International recognition as an important contributor to a sustainable society
- New investments in pilot-scale equipment and upgraded research facilities
- Improved scientific return on investment from research funds

## **4.2 Users**

The ERIFORE ESFRI project has a commitment to scientific excellence, most importantly through activities for transnational access and education and training. Its main user groups include universities and research institutions. In addition, users include industries involved in forest-based bioeconomy. Special focus will be on SMEs and the aim to lower the threshold to exploit new ideas and shorten time to market entry.

The primary users from Europe and internationally will be:

- 1) Students, individual researchers, research groups, doing cutting edge research on forest-based chemical technology, from universities and research and technology organisations
- 2) Technology intensive SMEs and large companies doing research on forest-based technology; maximum 20% of time of transnational access will be devoted to industrial users.



The ERIFORE ESFRI project will provide RI access needed to develop and commercialise novel biorefinery process concepts for the production of value added chemicals and materials from forest-based raw materials.

The benefits offered to users include, but are not limited to:

- Improved awareness of available RI to implement research and innovation projects (TRL2-6) in the whole forest-based bioeconomy development chain.
- Enhanced access with dynamic management and defined access policy to cross-national and -regional infrastructures.
- One stop-shop and integrated approach to supply excellence-driven access to forest-based bioeconomy RI, resulting easier use of open access infra.
- Education and training program to support development of scientific excellence of users.

### 4.3 Activities

The activities of the ERIFORE distributed RI include most importantly (1) transnational access to RI (2) education and training and (3) e-infrastructure, each of which will be described in the following sections. These are services not only for the scientific partners of ERIFORE but also for the Pan-European and global user community. The activities will be jointly coordinated and accessible through a single-entry point.

More internally driven activities include coordinated RI management (planning, funding and maintaining the distributed RI), networking between the members and partners and dissemination. Additional activities may include techno-economic analyses, market analyses, modelling, concept building, life-cycle analysis (LCA), technology screening, benchmarking, knowledge transfer and identifying best available technologies. Activities and services outside the ESFRI framework may include contract research, business support and spin-offs.

#### 4.3.1 Transnational access to research infrastructure

Opening the access to the entire distributed RI of the ESFRI project's scientific community is one core activity. Transnational access would be granted through a common call for proposals, and applications would be approved according to common criteria. Access policy and practical implementation of access calls would be planned in the Work Programme.

The guiding principle of opening access to RI is to attract scientifically ambitious research and fully realise the potential for results and impact as well as maximise utilisation rate of RI facilities. The call for proposals could be continuous or for example arranged twice a year. The call would indicate the RI availability (facilities and timing), rules and procedures for applying. The assessment process should also be transparent, building on scientific evaluation if competing proposals fitting the threshold criteria are submitted for the same facility and same use period.

If appropriate, different priorities and stages in the access call could be defined for different user groups. For example, scientific partners in the ESFRI consortium, external European users and users from outside of Europe could be differentiated, and different priorities could be

granted or different percentages of access capacity could be reserved for given user groups. Processes and criteria should nevertheless be justified and transparently defined in advance.

The evaluation of proposals for accessing RI could have two steps. Firstly, the scientific qualities and feasibility of proposals should be checked to ensure suitability to the scope in terms of technological, scientific, ethical and other relevant aspects. The second step would apply if two or more viable proposals were submitted to compete on same facility and time period. The highest scoring proposal should then be approved. The preliminary topics for criteria for evaluating each of the two steps include:

- Scientific merits and ambitions
- Competence of researchers
- Feasibility and technical viability of plans
- Geographical and networking aspects
- Plans for dissemination and communication of results
- Ethical perspectives
- Environmental impacts
- Economic impacts

### **4.3.2 Education and training**

The education and training efforts will be further strengthened for the ESFRI project. ERIFORE would welcome more academic partners to the next phase in order to ensure top-level scientific excellence in all technology fields and to foster higher university education in forest bioeconomy across Europe.

ERIFORE ESFRI will provide a training field for new generations of scientists capable to transfer the new knowledge to innovations. Furthermore, close relationship between universities and research infrastructures contributes to an effective educational and scientific ecosystem, which attracts and supports the industry.

ERIFORE ESFRI will promote international, intersectoral and multidisciplinary collaboration in doctoral training in Europe related to forest bioeconomy. In specific, the consortium will analyse relevant topics and cooperation possibilities for Marie Skłodowska-Curie actions (MSCA). These actions will not only enhance researcher mobility, but also help the early-stage researchers to develop skills that respond to the needs of public and private sector.

Open access policy highlights a high-level of research ethics that is needed to guarantee the scientific quality of research carried out under ERIFORE ESFRI. One of the first tasks is to define a shared training strategy for staff of the distributed research infrastructure in order to make the best use of equipment and obtained research results. This will cover details of best operational practices, standards, knowledge sharing, documentation and recommended or required training activities. ERIFORE ESFRI will pledge to support the up-to-date training of its technicians and researchers e.g. through summer schools, workshops, exchange courses or

tailor-made classes. The RI owners will furthermore provide the needed training to prospective users.

### **4.3.3 e-Infrastructure**

In order to ensure working operations between the ESFRI partners as well as other users a working e-infrastructure is needed. This consists of many elements including web page, common information systems, data bank, online booking system and data management plan. This work will begin with forming a common understanding of data content, data formats and schedules of the web page, common information systems, data bank and online booking system. The first working part of the e-infra will be the ERIFORE ESFRI project's web page. In the beginning, there are mainly information of the ESFRI project and its status. More functionalities will follow as this process develops. In addition, a data management plan and a security policy need to be defined and commonly agreed on before the final decisions and implementation of the e-infra. The e-infra also needs to be maintained and updated regularly in order to guarantee a working platform for all users.

## **4.4 Human resources policy**

The RI owners of the ERIFORE project implement their own human resources policies. Thus, the first step towards ESFRI roadmap preparatory phase covers a cooperation contract between partners. Harmonized human resources policy for the preparatory phase of the ERIFORE ESFRI project shall deal with plans for staffing, reporting and monitoring of the activities. Later, the human resources policy will be fine-tuned for implementation and operation phases.

Access policies and practical implementation of access calls are described in chapter 4.3.1. Binding access agreements will be set up for partner organisations and for other RI users. The Central Office will act as a one stop-shop for the RI users.

The human resources and employment policies of the Central Office, including ERIFORE ESFRI Director, will follow the legislation of the host country. The Assembly of Members formulates the definition for the job description, appoints the Director and approves other personnel needed to manage day-to-day work at the Central Office (please see descriptions of the aforementioned governance bodies under Chapter 5.2). The recruitment processes will preferably be open, efficient, transparent, and internationally comparable. In addition, each National Node will have to define the necessary staff to support and implement the planned activities. They can either dedicate persons from their own organizations to the posts or hire new personnel to take the lead. Main selection criteria will be expertise.

Training policies will be based on ERIFORE's unique position in forest bioeconomy scene. Needed skills and competences for the operation of the distributed RI shall cover cutting-edge knowhow on technologies for the whole value chain from primary processing to end products. State-of-the-art research laboratories and analytical tools together with exceptionally broad scale-up and pilot plant facilities all need specific expertise. Engagement in training of highly qualified students, researchers and engineers will be of key importance for speeding up new

scientific discoveries and innovations. The human resources policy shall furthermore cover aspects related e.g. to equal career opportunities, principles for secondments and exchange programmes.

#### **4.5 Key performance indicators**

Key performance indicators (KPIs) are needed in order to monitor and evaluate the operations of the ESFRI project as well as to set targets for it. KPIs are mainly aimed for annual use, but could also be measured, for example, monthly or quarterly. A target value or range can be defined for each indicator in order to steer performance and alert for taking corrective actions when needed. In the next we present the preliminary list of KPIs for the future distributed RI, arranged by topic. Indicators for pan-European and international relevance will be applicable and measurable from the start of the ESFRI project. The other indicators will, on the other hand, first serve target setting and become measurable only at later stages when activities are gradually launched.

Pan-European and international relevance:

- Number of member and observer countries
- Number of scientific partners
- Impact through visibility: scientific recognition, media interest, etc.

Excellence in science and innovation (within the ESFRI project and from its activities):

- Number of peer-reviewed, scientific publications
- Number of projects; per TRL and user group
- Number of patents and licences
- Number of concepts and spin-offs

Education and training:

- Number of PhD theses and Master's theses; European and international
- Number researcher exchanges; European and international
- Number of training and knowledge sharing events organized; number of participants

Research infrastructure access and use:

- Number of users from research; partners, externals, by country, etc.
- Number of users from companies
- Research infrastructure usage rate

## 5 Governance model

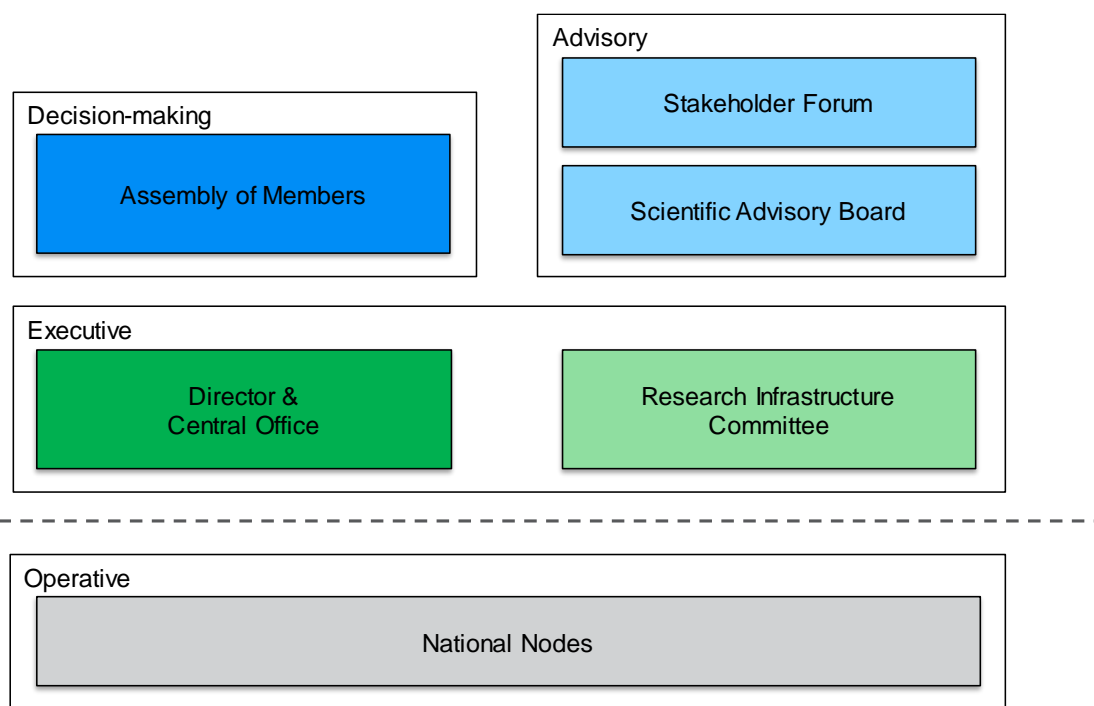
This chapter summarises the planned governance model, i.e. the decision-making and management structure, for the distributed RI that ERIFORE project pursues to develop into. The legal status, organisational structure as well as composition and roles of governance bodies are described.

### 5.1 Legal status

The distributed RI will be established under a dedicated legal status that enables the involved Members (Member States) and Partners (RI owners, such as RTOs and universities) to collaborate under secured rights and responsibilities<sup>17</sup>. Based on a thorough analysis during the ERIFORE project, the European Research Infrastructure Consortium (ERIC) framework is perceived as the most suitable choice. This legal instrument defines the position of the distributed RI under national and European laws, and an ERIC has legal personality and full legal capacity recognised in all EU Member States. The minimum governing bodies required of an ERIC are (1) an Assembly of Members and (2) a Director or a Board of Directors, of which the latter is the legal representative of the ERIC.

### 5.2 Governance bodies

The planned organisational structure suitable for ERIFORE as a distributed RI is shown in Figure 10. The composition and main tasks of the governance bodies are summarised in Table 2.



**Figure 10. Organisation chart.**

<sup>17</sup> European Commission, 2013. Assessing the projects on the ESFRI roadmap: A high-level expert group report.

**Table 2. Composition and main tasks of governance bodies.**

<b>Governance body</b>	<b>Composition</b>	<b>Main tasks</b>
<b>Assembly of Members</b>	Members: one or two representatives of each involved European Union Member State.	Highest decision-making body that takes collective decisions on the ERIC. Adopts the annual Work Programme and budget. Adopts all relevant rules, procedures and regulations. Amends the statutes. Admits new Members. Approves annual reports and accounts.
<b>Director</b>	An individual employed by the ERIC; the legal representative and contract signatory of the ERIC.	Implements decisions by and is responsible to the Assembly of Members. Is in charge of preparing and executing the Work Programme and budget as well as compiling annual reports and accounts. Takes care of internal and external communications.
<b>Central Office</b>	Up to five employees.	Supports the Director in all tasks: scientific, technical, administrative, secretarial and other duties.
<b>Research Infrastructure Committee</b>	One or two representatives from each National Node.	Supports the Director in drafting and executing the Work Programme and budget.
<b>Stakeholder Forum</b>	Externals from industry, civil society, associations, etc.	Support and advice for and collaboration with the ERIC.
<b>Scientific Advisory Board</b>	Internal and external experts from science, technology and ethics.	Support and advice for the ERIC.
<b>National Nodes</b>	National networks of Partners, i.e. RI owners.	Executes on operational level and in the national context the Work Programme and budget.

## 6 Financing

The design study phase of ERIFORE consortium was organised as a project organisation of RTOs and universities. A similar project organisation will be sufficient at beginning of preparatory phase (2020), before a selected legal status and final governance structure is established. Director and staff will gradually be appointed.

The financing of the ERIFORE ESFRI project and distributed research infrastructure consists of the funding of (1) Central Office responsible for coordination scientific, technical, administrative, secretarial issues and executing the activities in the Work Programme and (2) Required investments in research facilities within the RI owning organizations (such as RTOs and universities).

### 6.1 Financing of Central Office

Smooth implementation of the ERIFORE ESFRI project implies that Central Office and governance have a lean structure and expenses are covered by national nodes. Costs of the Central Office within transition phase from preparation phase to implementation phase will be kept as low as possible. Various funding options (membership fees, market driven private access, public support) will be considered to guarantee the necessary financial support. Central Office cost contributions may partially be covered by in-kind contributions.

In terms of the financing plan, preliminary estimations are made:

- The cost calculation is based on the assumption that the network will start with eight Member Countries.
  - 1/3 costs is covered by host country
  - 2/3 costs is covered by contributions of ERIFORE Members
- Annual costs of start-up phase are (Table 3):
  - Salary for director & 2-3 employees, responsible for management of day-to-day management (scientific, technical, administrative, secretarial and other duties). 350 k€.
  - Diverse running costs (travel costs, communication, e-infra, IPR management) are estimated to at 200 k€ per annum
  - Building charges are estimated to be 50 k€ per annum

**Table 3. Estimate of ERIFORE ESFRI Central Office budget for start-up phase.**

<b>Expenditure</b>	<b>k€ per annum</b>
Personnel costs	350
Diverse running costs	200
Building charges	50
<b>Total Expenditure</b>	<b>600</b>
<b>Income</b>	<b>k€ per annum</b>
Host country participation fee	200
Member country participation fees	400
<b>Total Income</b>	<b>600</b>

## **6.2 Financing of research facilities**

Currently Research Infrastructure investments are funded mainly by regional, such as European Regional Development Fund (ERDF), or national funding bodies. The ERIFORE ESFRI label is expected to open new funding sources and bring long-term commitments from the governments. Investments will be guided by regional, national and European bioeconomy strategies. Total funding for the distributed RI is to be provided by regional and national agencies, Member States, and European Union. The ERIFORE ESFRI project will also evaluate possibly for infra funding through public-private partnerships.

The operational costs of the ERIFORE ESFRI project will be paid by users of the facilities (not for profit basis) via research projects, grants or own ground funding. EU framework programmes (H2020 and FP9) are seen main source for project funding.

## **6.3 Financing of networking activities**

The EU has several funding instruments available for building research infrastructure collaborations. Infradev 2-4 calls are devoted to bring ESFRI projects to the level of legal, financial and technical maturity required for implementing them. Infradev funding will be applied to cover coordination cost of ERIFORE ESFRI preparatory phase.

In addition, H2020 coordination and support actions (CSA) have specific calls for building RI collaboration networks and providing funding for RI access (INFRAIA, INFRAINNOV, INFRASUPP). INTERREG funding supports regional and local governments across Europe to develop and deliver better policy. Project funding from these sources will be applied to support ERIFORE ESFRI activities.



## 7 Implementation plan

In this chapter, we combine the implementation plans for activities, governance and financing of the distributed RI ERIFORE aims to become on the ESFRI roadmap. Figure 11 summarises the actions on an indicative timeline for the design, preparation and implementation phases and the beginning of full operation. In the following subsections we explain in more detail the implementation plan (1) for short-term, i.e. until the intended entry on ESFRI roadmap in 2020 and (2) for long-term, i.e. the path from ESFRI project towards becoming a fully operational ESFRI landmark.

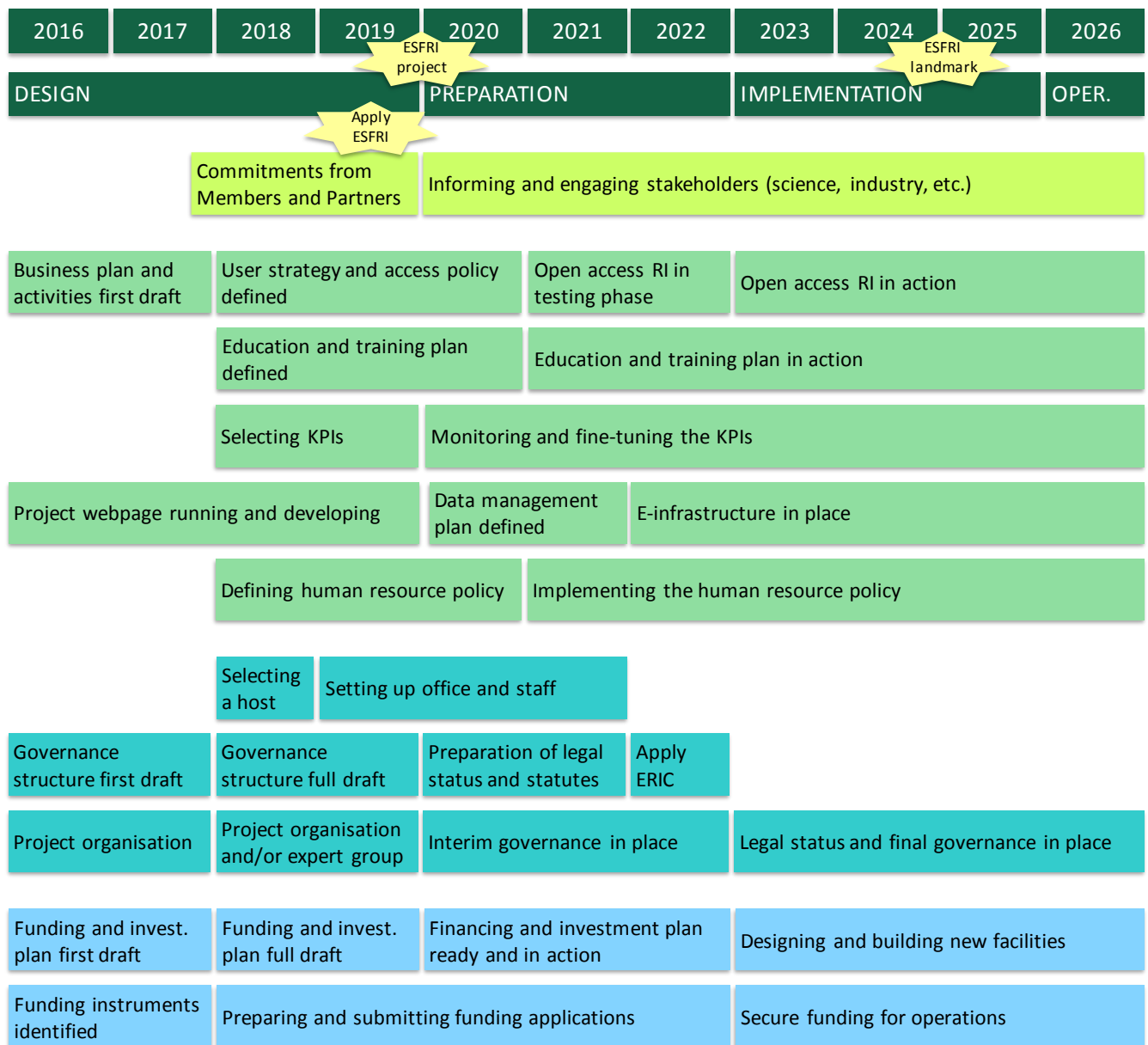


Figure 11. Indicative timeline of implementation for ERIFORE distributed research infrastructure.

## 7.1 First steps forward

**Status quo: design phase (2016-2017):** So far, the ERIFORE Infradev-1 project has produced the first drafts for (1) business plan and activities, (2) governance model and structure and (3) financing and investment plans. ERIFORE has a project website and project organisation running, and funding for further collaboration beyond Infradev-1 as well as RI investments are identified. A preliminary list of Members (countries) and Partners (RI owning RTOs and universities) has been put together, and the list will be further populated.

**“In-between phase” and preparation for ESFRI Roadmap submission (2018-2019):** The task of utmost importance is securing formal commitments from both Members and Partners so that an ESFRI application can be submitted in 2019 (presuming that there will be a call for submissions for the ESFRI Roadmap 2020). This means signatures in Memorandum of Understanding (MoU) from prospective scientific Partners and signatures in Expressions of Interest (EoI) and Expressions of Support (EoS) signed by prospective Members by 2019.

The in-between phase also allows further elaboration of user strategy and access policy, education and training plan, KPI and human policy development, governance structure drafting and planning of funding and investments. The project organisation and website should be maintained and extended as appropriate. Host selection and first staffing decisions may be topical.

## 7.2 Long-term plan

**ESFRI project: preparation phase (2020-2022):** Having achieved ESFRI project status, it will be a continuous task to build awareness through informing and engaging stakeholders. Besides Members and Partners, the stakeholder network grows to include science, industry, etc. widely. The first activities in opening access to RI as well as in education and training will be tested and launched. Monitoring of KPIs begins, and data management plan and e-infrastructure are developed.

In the preparation phase, the human resource policy will be completed and put into use as setting up the Central Office and recruiting staff becomes topical. Preparations for establishing governance in the chosen legal form will proceed towards applying for ERIC status (contracts committing the Members and Partners are signed). Before achieving it, project organisation develops into an interim governance. Preparation phase completes financing and investment plans, and new funding applications are prepared (e.g. Infradev).

**From ESFRI project to landmark: implementation and operational phases (from 2023 on):** Eventually all legal and contractual arrangements are ready for the distributed RI to become fully operational. Open access and education and training activities as well as e-infrastructure are in action. KPI framework is fine-tuned and running, and human resource policy is in use. Governance structure is fully in place, and funding for all operations is secured. Design and building of new infrastructure is also possible under the ESFRI collaboration.

## 7.3 Risks

The currently established ESFRI projects and landmarks focus on highly scientific research infrastructures, whereas the ERIFORE consortium's RI leans heavily towards applied research and scale-up. In addition, the scientific and technological scope of the ERIFORE consortium is exceptionally broad compared to existing ESFRI projects. Table 4 summarises the identified scientific, technological, political and financial risks as well as provides counter measures to avoid or remedy them.

**Table 4. Identified risks and counter measures.**

Type of risk	Risk	Counter measure
Scientific	Multidisciplinary research field and wide TRL scope.	Involve scientific community at all levels and especially Scientific Advisory board to identify RI development needs.
	Insufficient commitments from RI owners. E.g. insufficient geographical or value chains coverage of scientific leaders.	Starting the process early enough and clearly communicating the benefits to RI owners.
	Low involvement and demand from users.	The focus is chosen based on SRIA and therefore in line with actual needs/demands and will be adjusted if there is significant changes in needs/demands.
	Insufficient collaboration with sectoral organisation and the industries.	Early interaction with sectoral and industrial stakeholders for their active involvement.
Technological	Problems related to e-infrastructure, such as non-working e-infra or significant delays.	Careful planning before actual development and back-up systems for the most critical parts of the e-infra.
	Unbalanced usage rates of facilities and over-occupancy of facilities.	Careful planning, well-defined user terms, and utilisation contracts between RIs and ESFRI project organisation.
Political	Changes in political/funding programs related to forest-based bioeconomy.	Promoting long-term political commitment and actively communicating the importance of this field.
	Insufficient commitments from ministries. E.g. small number of countries or poor Pan-European coverage.	Early start of the process and actively involving the RI owners in this process.
Financial	Lack of financial commitment from ministries.	Starting the process early, actively involving the RI owners in this process and pointing out the financial benefits/impacts.
	Lack of financial support for infrastructure investments from national and regional funding sources.	Well defined investment strategy with detailed description of funding options.

## 7.4 Benefits

The ERIFORE ESFRI project will improve RI access needed to develop and commercialise novel biorefinery process concepts for production of value added chemicals and materials from forest-based raw materials. Main benefits to partners and European innovation system are summarised below.

### Benefits to ERIFORE ESFRI project partners

- Develop own excellence by attracting top scientists, partners and leading industry.
- Better business and funding plans for infrastructure investments based on long-term funding commitments by member states.
- Improved awareness and agreed access rules resulting new users and enhanced utilisation rates.
- Enhanced possibilities to attract joint funding of research projects utilising top class facilities for the cross-technological development chain of novel forest-based products and processes.

### Benefits to European innovation system

- Develop European excellence by attracting top-level scientists and leading industry.
- Improved Pan-European knowledge on investment needs enabling more effective use of long-term funding commitments. Mobilisation of private investments.
- More effective collaborative research projects through improved awareness of available research infrastructures and agreed access rules resulting easier use of open access infrastructures.
- Smart Specialisation and cross-sector research and innovation infrastructures support implementation of European bioeconomy strategies and Strategic Research and Innovation Agendas.