European Commission

Towards a European Policy for Technology Infrastructures

Building Bridges to Competitiveness

Independent
Expert
Report

Research and Innovation

Towards a European Policy for Technology infrastructures: Building Bridges to Competitiveness

European Commission
Directorate-General for Research and Innovation
Directorate E - Prosperity
Unit E1 – Industrial Research, Innovation & Investment Agendas

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Towards a European Policy for Technology Infrastructures

Building Bridges to Competitiveness

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List of abbreviations and acronyms

4D	Four Dimensional
5G	Fifth Generation
6G	Sixth Generation
AEL	Alkaline Electrolysis
AI	Artificial Intelligence
AR	Augmented Reality
BIM	Building Information Modelling
CAP	Common Agricultural Policy
CAPEX	Capital Expenditure
CCAM	European Partnership for Connected, Cooperative, and Automated Mobility
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CCUS	Carbon Capture, Utilisation, and Storage
CDA	Carbon Direct Avoidance
CETP	Clean Energy Transition Partnership
CHP	Clean Hydrogen Partnership
CO/ CO_2	Carbon Monoxide/Carbon Dioxide
CSA	Coordination and Support Action
CSP	Concentrated Solar Power
DG	Directorate General
EEA	European Economic Area
EGTI	European Commission Expert Group on Technology Infrastructures
EIC	European Innovation Council
EII	Energy-Intensive Industry
EIT	European Institute of Innovation
ELI	European Legislation Identifier
ERA	European Research Area
ERIC	European Research Infrastructure Consortium
ETP	European Technology Platform
ESRFI	European Strategy Forum on Research Infrastructures.
EU	European Union
EU-27	Abbreviation of European Union (EU) which consists of 27 countries (Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain,

	France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden)
EOSC	European Open Science Cloud
FDSOI	Fully Depleted Silicon on Insulator
FP10	Framework Programme 10
FOAK	First-of-a-kind
FoF	Factories of the Future
GBER	General Block Exemption Regulation
GDP	Gross Domestic Product
H2020	Horizon 2020
HCT	Human-Centric Technology
ICT	Information and Communication Technology
IP	Intellectual Property
IPR	Intellectual Property Rights
IoT	Internet of Things
JEF-IPCEI	Joint European Forum on Important Projects of Common European Interest
KET	Key Enabling Technology
KIC	Technology Knowledge and Innovation Community
KPI	Key Performance Indicator
MLE	Mutual Learning Exercise
MS	Member State
NSF	National Science Foundation, United States
OITB	Open Innovation Test Bed
OPEX	Operating Expenses
P4P	Process4Planet Partnership
PAWR	Platforms for Advanced Wireless Research Programme
PEMEL	Proton Exchange Membrane Electrolysis
PI	Process Integration
PV	Photovoltaic
R&D	Research and Development
R&D&I	Research & Development & Innovation
R&I	Research and Innovation
RI	Research Infrastructure
RITIFI	Research Infrastructure Technology Infrastructure for Impact (Horizon Europe project)
RTO	Research and Technology Organisation
RTD	Directorate-General for Research and Innovation, European Commission
SCAR	Standing Committee for Agricultural Research
SCU	Smart Carbon Usage
SME	Small and Medium-sized Enterprises
SOEL	Solid Oxide Electrolysis
SOI	Silicon on Insulator
SRIA	Strategic Research and Innovation Agenda
SWD	Staff Working Document

TEI	Testing and Experimentation Infrastructure
TRL	Technology Readiness Level
TI	Technology Infrastructure
US	United States
VR	Virtual Reality
XR	Extended Reality

1. A European policy for Technology Infrastructures: key recommendations

The European Union (EU) faces a pressing challenge to keep our economy and society on track of the green and digital transitions towards climate neutrality, faced by strong competition from other leading global players. The Commission Communication on 'A Competitiveness Compass for the EU' from January 2025 establishes competitiveness as one the EU's overarching principles for action. The focus is to increase productivity by closing the innovation gap to EU's main global competitors, so that tomorrow's technologies, services and clean products are invented, manufactured and marketed in the EU. The availability of support and investment for research and innovation (R&I) is a key issue holding back the growth of tech start-ups and particularly for early-stage technologies that have game-changing potential. In this context, access of innovative companies to research and technology infrastructures is one of the key elements.

To support this vision, Europe needs to develop a robust ecosystem of infrastructures supporting research, innovation and technology development that enable businesses to develop, scale and commercialise their innovations efficiently. Research infrastructures (RIs) and technology infrastructures (TIs) are essential in this ecosystem, offering advanced facilities and expertise. While RIs primarily advance knowledge and fundamental research, TIs focus on developing technological concepts towards market-ready solutions, helping businesses navigate regulatory requirements and reduce the risks associated with innovation. They are needed by companies to develop, test and validate new technologies and innovations. As they can shorten the time from lab to market and reduce the risks related to technology development and innovation activities, an increased offer of TI facilities and services has a significant potential to foster the private sector investments in research and innovation, supporting the goal of reaching the EU's target of spending 3% of gross domestic product (GDP) on R&D.

However, a stronger and more coordinated effort is needed for TIs at the EU level to ensure they can effectively support industries, especially small and medium-sized enterprises (SMEs) and start-ups, in their pursuit of sustainable growth and technological leadership. In order to achieve this, Commissioner Zaharieva, in her confirmation hearing at the European Parliament, considered proposing a new strategy for research and technology infrastructures as one of the priorities for her mandate.

The first section of this report by the Expert Group on Technology Infrastructures (EGTI) sets out five strategic recommendations, which are based on the work of the group, recent studies, consultations with industry, R&I stakeholders including host organisations of TIs and a survey of users of TI services (enterprises). The following chapters set out the arguments and evidence for each recommendation in more detail.

Recommendation 1: Formalise the definition of Techology Infrastructures

The definition of Technology Infrastructures (TIs) provided in the 2019 Commission Staff Working Document (SWD) has served as a basis for the European Research Area (ERA) Policy Agenda 2022-2024, but it has not been broadly recognised in research and innovation (R&I) policy at EU and national levels. The Expert Group on Technology Infrastructures (EGTI) identified a number of drawbacks and missing elements in the definition and proposes to update it as follows:

Technology Infrastructures are facilities, equipment, capabilities and resources required to develop, test, upscale and validate technology. They enable and accelerate technological innovations towards societal/market adoption, fostering industrial competitiveness. They provide a wide range of capacities and services from pre-competitive applied research

services, through demonstration and validation of technology, up to small-scale production. They include, amongst others, test beds, demonstration and testing facilities, pilot lines or living labs, usually embedded within non-profit research and technology organisations, universities active in technology fields or technology centres, which are open to private and public users. They can be public, semi-public or privately owned, physical or digital.

The EGTI recommends that, building on this concept, an updated definition of TIs, once agreed with the Member States, should be systematically used and included in all relevant European and national legal acts and policy documents, among others the future ERA Act and the Framework Programme 10 (FP10) Regulation, the planned European strategy for research and technology infrastructures as well as the corresponding national strategies and funding programmes.

Recommendation 2: Improve access to Technology Infrastructures

Over three quarters of the enterprises that responded to a survey conducted to inform this report underlined that access to TIs is important for developing a new technology, method or process. However, industrial users, particularly SMEs and start-ups, often face substantial barriers in accessing TIs. Many enterprises report that they do not have sufficient financial resources and/or lack the in-house expertise needed to collaborate effectively with TIs. Furthermore, a significant number of companies identify challenges on the side of the TIs themselves, such as concerns over the potential loss of control of research and development (R&D) results and industrial secrets, inadequate support staff or overly complex access procedures. Enterprises face additional hurdles to access TIs on a cross-regional or transnational level, including limited awareness of available facilities in other regions, insufficient information on services offered, restrictive import/export regulations for test samples, cost and language barriers.

The Expert Group recommends developing, in collaboration with TI hosts and industrial stakeholders, a European Charter for Access to TIs, tailored to all types of users, that provides guidelines on streamlined access procedures, and simple and transparent access conditions. The group also considers it important to develop support measures to improve the visibility of TIs and the services they can offer across the EU and to increase the opportunities and support for companies to access the infrastructures, including those located in other regions or countries.

Recommendation 3: Develop an effective investment prioritisation mechanism for European Technology Infrastructures

To support effectively the development of TIs as part of the future EU research and technology infrastructures strategy, there is a need for an investment prioritisation mechanism that currently does not exist at EU level and which is also rare at national levels. Such a prioritisation mechanism should foster collaboration among users, TI operators and funders, and between RIs and TIs. The aim is to improve the TI capacities in the EU and build interconnected networks of research and technology infrastructures that span sectors and regions, enhancing synergies and creating more integrated and efficient innovation ecosystems across the EU.

The Expert Group recommends setting up an EU level investment prioritisation mechanism for TIs that should address the needs of technologies of strategic importance for the EU's competitiveness and align strategies for their availability and access with the current and future needs of users and existing TI operators. This should support also research and innovation agendas of strategic initiatives such as European Partnerships. Identifying priorities for EU level actions should be guided by a robust set of criteria including strategic relevance, feasibility and impact, industrial ecosystem development, addressing service and facility gaps, and financial viability.

The prioritisation of investments in TIs should be based on a sound assessment of their business plans, reflect market needs, the range of potential funding sources for TIs, and capital (CAPEX) and operational (OPEX) expenditure required during the TI lifecycle. In addition to prioritising investments, EU level TI road-mapping processes should be organised, with the involvement of European partnerships and other strategic initiatives, for specific technology areas or industrial ecosystems to identify future investment options and to anticipate the skills needed to operate any new or upgraded TIs.

The Expert Group recommends implementing a limited set of pilot actions designed to test a European approach to TIs, such as those identified as examples in this report. The pilots should focus on the next steps needed to ensure the availability of and access to adequate TIs. These could include: the identification of needs, different options to address the needs, the choice of instruments to address the identified needs and their implementation, including planned actions, expected results and impact, a timeline and a budget and respective funding sources. The implementation of a pilot should be accompanied and followed by an analysis of impact and lessons learnt. The EU should consider supporting the implementation of such pilots under Horizon Europe, as well as other relevant programmes.

Recommendation 4: Establish at EU level a robust governance framework for Technology Infrastructures

A European TI coordination framework should encompass actions at EU level (such as creating a TI-dedicated funding programme, standardising access modalities and supporting capacity-building and best-practice sharing), actions at Member States level (developing national TI strategies and funding programmes), as well as actions at regional level and actions involving industry, academia and civil society.

The Expert Group considers that establishing and coordinating an ambitious European policy for TIs requires setting up a dedicated governance structure that can assume all of the functions outlined in this report. The EGTI recommends establishing a multi-actor governance framework for TIs that would consist of two layers: horizontal coordination and thematic coordination, each with distinct yet complementary roles. In the short term, this should take the form of a light advisory structure that would allow for a reflection on the ultimate model for TI governance in the EU. The governance should include all Member States, the European Commission, a broad array of industry stakeholders and TI host organisations.

The horizontal layer would be responsible, among others, for defining investment priorities using a shared framework with agreed criteria, providing a platform for strategic reflection, mutual learning and developing common approaches e.g. on access or on tailored business modelling methods. The thematic coordination layer would develop and implement schemes tailored to specific priority areas, build networks of TIs in targeted technology sectors or ecosystems and coordinate funding for agreed TI investments.

Recommendation 5: Establish funding programmes dedicated to Technology Infrastructures at European and national levels

With the rapid advancement of technology, TIs face significant funding challenges, including high investment costs in new technologies, services, and upgrades. The funding opportunities for TIs are currently fragmented and uncoordinated, undermining the development of state-of-the-art facilities and their accessibility across the EU.

The Expert Group recommends that the EU institutions should make available dedicated funding for TIs at European level from programmes supporting R&I and competitiveness and that the Member States consider setting up complementary national and/or regional

programmes (including by allocating funding from the European Structural and Investment Funds) to support, among other objectives:

- pooling of public and private funding resources available at EU, national and regional level to support large-scale investments in TIs agreed at the EU level,
- access to TIs for users where funding is an important barrier, such as SMEs, start-ups and scale-ups,
- the development of TI services and upskilling of staff, to strengthen delivery and uptake,
- the collaboration and networking among TIs, and between TIs and RIs.

2. Context and framing of the work of the Expert Group

This report summaries the work carried out by the Commission Expert Group on Technology Infrastructures (EGTI). The EGTI was established in November 2023 with the following main tasks:

1. to advise and support the Commission in the analysis of the landscape of technology infrastructures, including:
   - Reviewing the concept of technology Infrastructures;
   - Developing selection criteria for prioritisation of strategic EU pilot actions for TIs;
   - Collecting and mapping the needs of industry (including SMEs and start-ups) as users of TI services;
   - Identifying obstacles that could hamper creation of TIs, including the impact of the EU State aid rules on investments in TIs;
2. to provide recommendations for an EU level investment prioritisation and coordination mechanism for TIs.
3. to support the Commission in the analysis of access conditions and barriers to TIs and their services for different users, i.e. large enterprises, SMEs and start-ups across the EU.

The composition of the group, as well as the minutes of its meetings and further details on its work are publicly available on the Register of Commission Expert Groups and Other Similar Entities.[1]

This final report summarises the work of the Expert Group. Beyond the first section that set out five strategic recommendations, this second section frames the background and rationale of the Expert Group and its recommendations for coordinating investment in and improving accessibility to TIs to foster the transformation of European strategic value chains and to enhance industrial competitiveness. Secondly, it places the policy agenda for TIs in the broader context of other European R&I policies initiatives such as the ERA, the Green Deal, etc.

The third section discusses the different types of infrastructures (research, technology and industrial) and their role in in providing services to users. This section briefly presents:

- Firstly, the difference and complementarities between the three main types of infrastructures (research, technology and industrial) in terms of their primary purpose, accessibility conditions, types of services, etc.
- Secondly, building on this framing the Expert Group proposes a revised definition of TIs to be applied at EU, Member State and regional levels.

The fourth section discusses the needs of users for the types of services provided by TIs, summarising the findings of the analytical report on user needs[2] accompanying this report.

[1] Register of Commission Expert Groups and Other Similar Entities.
[2] Technology Infrastructures - European Commission

The fifth section discusses the main barriers and challenges faced by enterprises in accessing TIs and proposes concrete measures to facilitate and encourage the take-up of available services.

The sixth section explores the needs for funding instruments for TIs and proposes measures to increase the awareness of State aid framework applicable to TI investments.

The seventh section proposes an EU level coordination and governance mechanism for TI, presenting its main objectives and features.

The Annex to the report presents 18 examples of potential pilot actions for TIs collected by the EGTI, which could help test and implement a European approach to Technology Infrastructures.

2.1. Technology Infrastructures – a mechanism to reinforce European competitiveness

The European Union's share of global R&D is shrinking, as the EU spends consistently less on R&D as a share of gross domestic product (GDP) than our main global partners and competitors, such as US, Japan, Korea and, increasingly, China. This particularly applies to business R&D expenditure.[3] The number of EU companies among the top investors in R&D is also shrinking.[4] Reversing this trend is at the heart of the EU's ambition to pursue the green and digital transitions and to improve its competitiveness and strategic autonomy. To achieve this, it is essential to accelerate industrial R&D and innovation, its scale-up and deployment and commercialisation within a wider context of the EU's agenda to restore competitiveness, for instance by simplification of the EU regulatory environment and strengthening the EU Single Market.

With rising technological complexity, industry's innovation capacity, productivity and competitiveness increasingly depend on their internal R&D and innovation capacities as well as access to services in the field of (key) technologies. The 2024 Letta Report underlined that "Europe faces an urgent imperative to prioritise the establishment of technological foundations that foster knowledge and innovation, by equipping individuals, businesses, and Member States with the necessary skills, infrastructures, and investments, to enable widespread prosperity and industrial leadership.[5]"

The technological foundations and services to foster enhanced competitiveness can be provided by a range of research infrastructures[6] (RIs) and technology infrastructures (TIs), that together form an ecosystem of advanced infrastructures providing specialised R&D and innovation support, know-how, facilities and services. The best way to assist companies depends on the research domain, technology area, the maturity of the technology, and the intended purpose of the infrastructure. RIs and TIs complement each other with RIs focusing, but not exclusively so, on fundamental and applied research and TIs on technology development, testing, scale-up and deployment. Additionally, companies can invest in and build industrial infrastructures[7] as part of their operations.

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[3] See: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=R%26D_expenditure

[4] European Commission: Joint Research Centre, 2024 EU industrial R&D investment scoreboard, Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2760/0775231

[5] Letta, E. (2024). Much more than a Market. Speed, security, solidarity – Empowering the Single Market to deliver a sustainable future and prosperity for all EU Citizens. European Council, Brussels.

[6] Research Infrastructures means facilities that provide resources and services for the research communities to conduct research and foster innovation in their fields, including the associated human resources, major equipment or sets of instruments; knowledge-related facilities such as collections, archives or scientific data infrastructures; computing systems, communication networks and any other infrastructure of a unique nature and open to external users, essential to achieve excellence in R&I; they may, where relevant, be used beyond research, for example for education or public services and they may be 'single sited', 'virtual' or 'distributed. (Horizon Europe Regulation, 2021)

[7] Industrial infrastructures are understood as facilities developed typically with a focus on a specific product, technology or production process within an individual company, such as industrial demonstrators. Industrial

However, while the concept of RIs is well established and recognised in research and innovation (R&I) policy and amongst R&I stakeholders across Europe, this is less the case for the concept of TIs. The latter covers a wide nomenclature of terms and definitions used at European, national and regional levels, sometimes overlapping or not aligned. At EU level, TIs were defined in the European Commission's 2019 Staff Working Document (SWD) on Technology Infrastructures:

Technology infrastructures are understood as facilities, equipment, capabilities and support services required to develop, test and upscale technology to advance from validation in a laboratory up to higher TRLs prior to competitive market entry. They can have public, semi-public or private status. Their users are mainly industrial players, including SMEs, which seek support to develop and integrate innovative technologies towards commercialisation of new products, processes and services, whilst ensuring feasibility and regulatory compliance[8]*.*

The key **public added value of TIs** consists of allowing companies to derisk their R&D&I investments before market introduction and to have ideas and concepts tested and validated for faster uptake at commercial scale, while enhancing their knowledge and skills. TIs are typically operated by RTOs and universities active in technology fields, or technology centres. Through collaboration with enterprises and the provision of technological and non-technological services, they support specific industrial and innovation ecosystems, in partnership with the public sector (including regional) authorities. The role of TIs and the complementarities between the various types of infrastructures supporting research, innovation and technology development is discussed further in section 3.1 below. The table below illustrates examples of the types of TIs and the services they provide to companies to support R&I to provide context for the reader of this report.

Table 1: Examples of TIs and their services

Type of technology infrastructures	Key services
Testbeds – physical or virtual environments.	Supporting the development, testing and introduction of new products, services, processes or organisational solutions and evaluate the performance of the new technologies. The environments in which testbeds operate are generally divided into three levels: laboratory environment, simulated environment, real environment or closer to real-life conditions.
Pilot lines / plants and demonstration facilities	Pilot lines/plants and demonstration facilities: Facilities that are designed to replicate operational systems at small-scale or and simulate key aspects of a larger industrial process. Their primary purpose is to gather valuable data, assess the feasibility and efficiency of a process, and identify potential challenges before committing to large-scale implementation. Pilot lines develop new technology building blocks, new technology-based products, or employs new production technology, as a step towards the commercialisation of the new technology. Some pilot lines can offer small volume test production.
Cleanrooms	A cleanroom provides an engineered space which maintains a very low concentration of airborne particulates. It is designed to keep everything from dust to airborne organisms or vaporised

infrastructures are owned by (large) industry or high tech/deep tech start-ups/ scale-ups for their own use, sometimes embedded in production lines. They are not open to external users, though in fulfilling the needs of the owner company, they can be used for collaboration with a network of partners, including other companies, research organisations, etc.

[8] European Commission: Directorate-General for Research and Innovation, Technology infrastructures – Commission staff working document, Publications Office, 2019, https://data.europa.eu/doi/10.2777/83750

	particles outside and thus from whatever material is being handled inside. Depending on their primary purpose and design characteristics, cleanrooms can be set up both as RIs and as TIs. Cleanrooms serve experimental development of various industrial technologies, e.g. microelectronics, photonics, health and space.
Living labs	Experimentation spaces that serve to co-create, prototype, test and upscale innovative solutions in real-life settings. They ensure the direct involvement of citizens and end-users as co-creators during the experimentation process to assess user uptake and acceptance as well as social adaptation of the new technologies.

Examples of selected operational TIs are available in the recent EARTO TIs Case Studies report.[9] The cases exemplify the type and scope of existing TIs and their services.

2.2. Technology Infrastructures in the European R&I policy agenda

As noted above, the essential role of TIs in fostering innovation and driving the transition to a competitive, green and digital economy has been recognised in EU policy for some years. The concept and approach to TIs at EU level has been developed in three phases, with the aim to position TIs as key facilitators for advancing and developing technologies from laboratory validation towards market-ready solutions, serving as a bridge between research and commercialisation. The three phases in the development of the TI concept are:

First phase: Foundation of the TI Concept (2015-2019)

The EU began formally promoting TIs with a 2015 action plan aimed at enhancing SME access to Key Enabling Technologies (KETs). In 2019, the European Commission defined TIs as facilities, equipment and services supporting the development, testing and scaling of technologies to higher Technology Readiness Levels (TRLs). TIs were distinguished from RIs by their direct focus on commercial and regulatory pathways. The Commission's 2019 SWD included:

- A characterisation of the TI concept, purpose and role;
- Examples of regional, national and EU initiatives;
- The identification of key challenges:
    - *Visibility* – limited awareness of existing services, difficulties to understand the needs and how TIs can support them, lack of skills, knowledge and resources (in particular, in SMEs),
    - *Prioritisation* – lack of strategic oversight and coordination at EU level, lack of proper gap analysis and prioritisation mechanism supported by investments,
    - *Accessibility* – limited understanding by companies of access conditions, insufficient understanding of main barriers and challenges, lack of standardised definitions and a common access framework, difficulties to access TIs across regional and national borders,
    - *Networks* – limited collaboration of TIs, underexploited synergies in service provision, fragmented landscape with a high risk of duplication and inefficiencies.

[9] See: https://www.earto.eu/wp-content/uploads/EARTO-Case-Studies-on-Technology-Infrastructures-Final.pdf

Second phase: ERA Policy Agenda and developing synergies with other policies (2020-2024)

In 2020, the new European Research Area (ERA), implementing the December 2020 Council Conclusions on the ERA[10] put TIs on the agenda and emphasised their synergy with RIs in addressing regional and industrial sectoral needs. The Council conclusions on RIs in 2022 underscored the importance of mapping user needs for TIs to ensure effective resource allocation, public-private partnerships and their contribution to societal and industrial challenges. The ERA Policy Agenda (Action 12) gave a mandate to the European Commission (DG RTD), together with Member States and stakeholders, to develop TI policy, and to explore and develop a European coordination mechanism for TIs and to agree at EU level on the main components and a governance model.

With the 2020 "New Industrial Strategy for Europe" and an SME-focused strategy, TIs were acknowledged as central to supporting sustainable and digital transformations. These policies linked TIs to industrial ecosystems, through such initiatives as digital innovation hubs, open innovation testbeds (OITB) or the Chips Act, reinforcing their strategic relevance across sectors such as robotics, high-performance computing and quantum technologies.

Hence, TIs are embedded in the EU's broader policy framework as key enablers of innovation, sustainability and competitiveness, notably:

- **Knowledge Valorisation and Innovation:** TIs play a vital role in transforming research into marketable innovations, particularly for SMEs. EU-wide collaboration among innovation hubs, universities and industries fosters efficient knowledge dissemination and addresses disparities in innovation access.
- **Green and Digital Transitions:** Through their alignment with industrial ecosystems, TIs can contribute to advancing the EU's twin transitions, ensuring technological advancements address climate goals and digital capabilities.
- **Economic Resilience and Strategic Autonomy:** TIs can enhance the EU's ability to lead in critical technologies and reduce dependence on external players, fostering an environment conducive to private investment and global competitiveness.

The May **2024 Council Conclusions on Knowledge Valorisation and on the European Industrial Policy** called for a structured approach to further integrate TIs into European innovation and industrial ecosystems and requested the Commission to:

- Map User Needs: to deliver a mapping, by mid-2025, of user needs for TIs and suggesting a definition for TIs.
- Develop EU Strategy for TIs: Building on this mapping, a dedicated EU strategy should support interconnectivity among infrastructures, avoiding duplication of investments, developing complementary assets, de-risking innovation processes and encourage private sector participation.
- Support for SMEs and start-ups: Enhancing access to TIs, notably for SMEs, and developing support services related to intellectual assets management, training, regulatory or standardisation aspects, including regulatory sandboxes and real-world testing environments, to ensure innovative firms can scale up effectively.

In short, **TIs lie at the heart of the EU's efforts to bridge research, industry, and societal needs. By strategically investing in and coordinating TIs, the EU aims to not only maintain its leadership in innovation but also ensure a sustainable and inclusive future for its economy and society.** The 2024 Draghi Report underlined that TIs are "*essential for ground-breaking R&I and often serve as a focal point of R&I ecosystems. They connect academia and RTOs with the industry, enable the business valorisation of breakthrough research and are a*

[10] See: https://data.consilium.europa.eu/doc/document/ST-13567-2020-INIT/en/pdf

magnet for talent". Hence, the increased availability of TIs is likely to foster R&I investments in the EU, particularly by the private sector, and thus support European competitiveness. Increasing private sector investments in R&I is also essential for reaching the target of investing 3% of GDP in R&D, towards which limited progress has been made over the last decade. This is why the Draghi Report also calls in the medium term for an increase in investments in world-leading research and technology infrastructures, as sufficient funding for these infrastructures is one of the characteristics of competitive research and innovation systems[11]. Similarly, the Heitor Report (Interim evaluation of Horizon Europe) recommends "*Implementing a strategy to secure long-term investment in world class research and technology infrastructures that serve the needs of researchers, industry and the public sectors, including in the digital area*".

Third phase: 2025 and beyond – development and implementation of a European policy for Technology Infrastructures.

This EGTI report is a contribution to the debate on the place and role of TIs in future EU (and Member State) policy frameworks. It notably provides a source of reflection for a European policy on TIs under the ERA Policy Agenda 2025-27. According to the recommendations included in this report, specific actions could include:

- **Setting up a governance structure for TIs** at EU level in consultation with Member States and industrial stakeholders.
- **Implementation of a first wave of strategic TI pilots** based, among other considerations, on the results of the proposed pilots and the mapping of focus areas, and
- **Development of a new funding instrument at EU level** under the next Framework Programme, as recommended in this report.

[11] The Future of European Competitiveness, Pat B, pg. 245 and 247. See: https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en

3. Technology Infrastructures – defining their role in the European innovation ecosystem

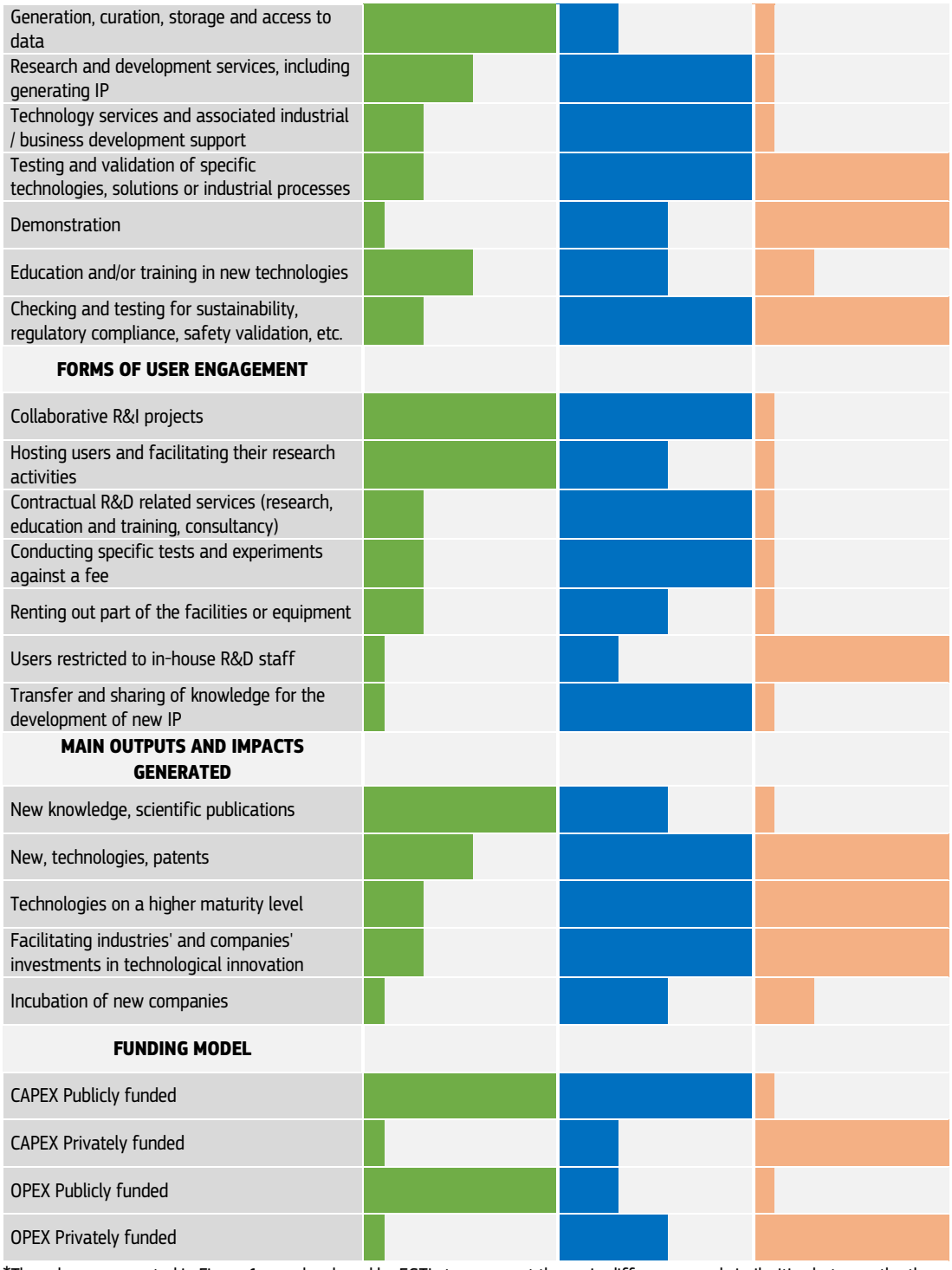
3.1. The ecosystem of infrastructures supporting research, innovation and technology development

The infrastructures supporting research, innovation and technology development activities includes facilities, major equipment or sets of instruments, capabilities, resources and support services, including digital infrastructure and the associated human resources. Such infrastructures are generally (very) costly to create, operate and maintain. As explained in Chapter 2.1, EGTI considers there are three basic types of infrastructures: research infrastructures, technology infrastructures and industrial infrastructures. These infrastructures form a complementary ecosystem of capacities, facilities and services supporting scientific discovery, innovation and technological development from laboratory to deployment at commercial scale. The main features of these infrastructures can be characterised along seven main dimensions[12] (See Figure 1). As the three types of infrastructures are complementary, several features can be equally applicable to more than one type. However, each of them has also a set of distinctive characteristics defining their uniqueness.

Figure 1. Characterisation of infrastructures

DIMENSIONS	Research Infrastructures	Technology Infrastructures	Industrial Infrastructures
PRIMARY PURPOSE			
Enable the advancement of scientific and applied research			
Support industry in technology development, upscaling, testing and validation			
Support the development of a specific product, service or industrial process			
PRIMARY USERS			
Scientists / researchers			
Companies, from large to small including research intensive SMEs and start-ups			
Public sector (hospitals, museums, public authorities and agencies, universities, etc.)			
ACCESSIBILITY CONDITIONS			
Open access based on the excellence of the envisaged scientific/technological research			
Open access to specific technological expertise with transparent access conditions			
Restricted access to selected users			
TYPES OF SERVICES			
Access to scientific instrumentation and research and testing facilities			

[12] Length of the bars in the graph are indicative to illustrate the extent to which a given statement applies to a specific type of the infrastructure.



*The scheme presented in Figure 1 was developed by EGTIs to represent the main differences and similarities between the three types of infrastructures. The length of bars illustrates the degree of relevance of each feature included in the model and should not be understood as percentages.

3.1.1. Differences and complementarity of technology infrastructures and research Infrastructures

As recognised in the Council conclusions on Research Infrastructures (2 December 2022), TIs and RIs are part of the same infrastructure ecosystem, complementing each other with the services they provide. Overall, **the main purpose, functions and the use made** of these infrastructures are the most important aspects to distinguish between RIs and TIs:

- **The primary purpose and functions of the infrastructure**: while RIs primarily serve the needs of the broad scientific community to conduct research and achieve progress in science, and offer access to research data for users from academia and industry, TIs mainly serve the needs of the private sector related to derisking the development, testing and upscaling of technology in pre-commercial phase through demonstration and deployment of innovative or improved products, services and industrial processes to support competitiveness needs of companies.
- **The types of services provided by the infrastructure**: RIs and TIs both provide access to a range of facilities, equipment, and also (skilled) human resources and support services. For RIs, those services mainly entail the facilitation and conduct of (pre-competitive) research activities in various scientific fields, whereby those facilities are also essential to achieve scientific progress. TIs provide pre-competitive applied research services and technology-related services, which can range from feasibility study to integration and scaling-up of the technology into applications, products and services, small-scale production and demonstration of technology, product testing and validation in real-world environment (or close to real-life conditions), and the accompanying business development support. Even though the provision of testing services by RIs is increasing, they mostly offer experimental conditions needed to create a purposefully controlled environment, often quite different from the “real-life” conditions, to demonstrate the scientific concepts. TIs on the other hand aim at testing the technological concept against the real or close-to-real environment, and the choice of equipment and test conditions should be as representative as possible of production lines or real conditions of use. The seamless RI-TI service offerings are needed for example, when lab scale proof-of-concept studies are further upscaled at pilot facilities of TIs, or when advanced analytical or lab scale capabilities are needed to support piloting or high-throughput advanced characterisation, since both phases are typical in scale-up and commercialisation of new ideas and concepts[13].
- **The main type of users of the infrastructure**: both RIs and TIs are open to different users under transparent conditions that might differ depending on the type of user. The primary users of RIs are scientists but, as mentioned above, increasing number of RIs also provide some specific services to industry. The main users of TIs are private for-profit companies (incl. SMEs) and researchers working on technology development. The combination of services of RIs and TIs can also be used for more demanding needs, to address complex challenges linked to developing new technologies that require multiple infrastructure services (e.g. in fields of microelectronics or advanced materials)[14]. This combination is a rich field to explore and exploit further, potentially within the scope of the proposed TI pilots.
- **Funding model**: Most capital investments (CAPEX) and funding for operation (OPEX) in RIs come from the public sector. Funding for capital investments in TIs come largely from the public sector as well, but private funding is also often involved to a greater extent. A significant share of the funding for operational costs of TIs, on the other hand, comes from R&D collaborations with the private sector.

[13] RITIFI: Research Infrastructures Technology Infrastructures for Impact https://ritifi.eu/
[14] https://ritifi.eu/

3.1.2. Technology Infrastructures and Industrial infrastructures: understanding the boundaries

Technology infrastructures and industrial infrastructures have a different purpose, operate under different conditions and address different needs.

- **The purpose, functions and use of the infrastructure**: TI use and lifespan goes beyond the development of a single product or industrial process, beyond a single company, and while they need to be maintained up-to date following the pace of technology advancement, they usually cover several technologies and application areas. TIs help industrial companies to develop the maturity of the devices, technology and high-tech components. Developed solutions and technology applications can be used in other domains and sectors as well. Industrial infrastructures (owned by private enterprises) are typically developed with a focus on a specific product, technology or production process within an individual company.
- **Ownership of the infrastructure:** TIs are usually embedded within larger applied research and technology organisations (RTOs), universities active in technology fields or other technology centres[15]. They combine sets of equipment and capabilities that serve a common purpose addressing specific technology fields, application areas, and/or sectors/value chains. Industrial infrastructures are typically owned by (large) industry or high tech/deep tech start-ups/ scale-ups for their own use, sometimes embedded in production lines.
- **Funding model**: Contrary to TIs, most of the funding for industrial infrastructures, both capital investments and for operation, is ensured by the private sector, notably the company or companies owning the infrastructure. Partial public funding for such infrastructures is rare and comes only in specific, well-defined cases.
- **Services and users of the infrastructure**: TIs provide services open to many users with transparent access conditions. They are capable of adapting the equipment or facility to support the needs of different users. Moving from higher TRL to industry applications requires alignment of infrastructures to industry norms and procedures. The companies have their own infrastructures to carry out the final demonstrations and validation prior to full-scale commercial application and market launch[16]. Industrial infrastructures typically do not provide services to many users. They are built by an industrial company to address their own specific needs to gain a competitive edge (which may also include its utilisation by the respective network of partners, including research organisations, technology providers, customers, etc.).

3.1.3. RIs, TIs and industrial infrastructures in the innovation ecosystem

The capacities and services provided by RIs and TIs and industrial infrastructures and demonstrators are complementary to each other covering different steps needed for scale up technologies towards industrial processes and manufacturing. To understand how this works in practice, it is helpful to refer to specific examples.

[15] Technology centres are public or private organisations carrying out applied research and close-to-market innovation (typically in TRL 3 to 8), see: https://monitor-industrial-ecosystems.ec.europa.eu/technology-centre/mappingThey can also be set up as collaboration hubs between companies and R&I actors.
[16] See for example 'Scaling up innovative technologies for climate neutrality - Mapping of EU demonstration projects in energy intensive industries', European Commission 2023, Publications Office of the EU (europa.eu).

Box 1. Examples of innovation ecosystem including RIs, TIs and industrial infrastructures providing a technology development process up to industrial demonstration and deployment

How a full infrastructures ecosystem is built in Grenoble (France) around Edge AI and energy consumption:

One of the main challenges of Edge AI is to reduce energy consumption. One very efficient way to address this challenge is to use silicon-on-insulator substrates, and especially fully depleted SOI (FDSOI). This technology was invented and industrialised in the Grenoble ecosystem. **CEA Leti[17] operates a world-class TI for semiconductors featuring 300mm cleanrooms for upscaling technologies from research to industry**. Industrial partners (e.g. Soitec) may access the infrastructure to develop new semiconductor related products, such as advanced substrates and devices for FDSOI. A key challenge with advanced substrates is to understand the behaviour of the novel materials at the nanoscale, which in turn accelerates the development cycle. **Research staff of the TI regularly access the European Synchrotron Radiation Facility (ESRF[18]), a research infrastructure located nearby to perform materials characterization** using the unique capabilities of the RI. The results provide the fundamental scientific knowledge needed to optimise the material performance in the CEA Leti cleanrooms, ultimately providing the industrial partners with the most advanced SOI technologies necessary for a competitive industry. **These novel technologies are transferred to industrial infrastructures such as the pilot lines of partner semiconductor companies**, both locally and in other regions of Europe, and eventually around the world.

How a Portuguese RTO operates 16 RIs and TIs in a complementary way in support of researchers and SMEs:

Within INESC[19], **RIs target scientific areas of specialization**, such as Optical and Electronic Technologies (namely for 5/6G Communications), Bio-Instrumentation, Flexible and Autonomous Robotics, **and are design to support mainly scientific research and advanced education** (PhD and MSc). The main users are researchers from the organization and the associated higher education Institutions, students, and also researchers from industry, particularly from large companies and high-tech start-ups. They are equipped to support fundamental and applied research activities and develop and produce prototypes. One example is the Laboratory of Industrial Robotics and Automation[20], where new concepts and technologies are developed for smart, mobile and flexible robotics and automation, mainly funded by fundamental and applied research projects. **TIs are more oriented to application areas or sectors like manufacturing industry or e**nergy, integrating a variety of technologies and commercially available solutions to simulate near-to-real operational conditions. They are used to support mainly SMEs, both technology providers and users, with applied research, technology development, test, validation, demonstration and dissemination of new technologies and innovative products and systems. An illustrative example is the iiLab – Industry and Innovation Lab[21], targeting the manufacturing industry and bringing together technologies and solutions, including the prototypes developed in the RIs, whose TRLs will be increased in partnership with companies, in areas like robotics and automation, modelling and simulation, virtual/augmented reality, Internet of Things (IoT), fifth-generation (5G) networks, Artificial Intelligence (AI), etc. This laboratory also includes rooms for specialised education and training services, that combine conventional classes with hands-on experience, particularly relevant for SMEs.

[17] https://www.leti-cea.fr/cea-tech/leti/Pages/Accueil.aspx
[18] https://www.esrf.fr/
[19] https://inesc.pt/en/
[20] https://www.inesctec.pt/en/laboratories/laboratory-of-industrial-robotics-and-automation#intro
[21] https://www.inesctec.pt/en/laboratories/iilab-industry-and-innovation-lab#intro

How all infrastructures dimensions can be combined in the same facilities to cover the whole value chain of bio and circular economy process technologies in Finland:

The VTT Bioruukki Pilot Centre[22] for bio-based products and circular economy (Espoo, Finland) **combines RI, TI (and partly Industrial Infrastructures) facilities and services for material and chemical technologies.** Bioruukki pilot Centre is part of the Bioeconomy RI which has been at the Finnish roadmap of research infrastructures since 2014. In this collaboration VTT is focusing on applied research and scale-up, and Aalto as university has more emphasis on lower TRL scientific research. It consists of open access pilot and laboratory facilities for research, education and innovation (RI dimensions) hosted by Aalto University and VTT. It provides development, scale-up and demonstration of new bio and circular economy process technologies and products piloting centre (TI dimensions) hosted and managed by VTT. The Pilot Centre can rent spaces and facilities to third parties, such as companies or other RTOs. For instance, a start-up company has units in Bioruukki, where they have their own additional equipment installed in VTT's pilot line to demonstrate the technology (industrial infrastructures dimension) in TRL 6-7. Other industrial companies have scaled up the technology and production process developed in Bioruukki based on VTT's innovation to set up their own demonstration plant for production (another industrial infrastructure) in TRL 7-9. This unique Pilot Centre covers the whole value chain of bio and circular economy process technologies from basic research to innovation, technology and development of industrial processes from lab to pilot case scale. It benefits from support services provided by other VTT premises and experimental piloting at four pilot platforms, providing users with the necessary experimental process data to realise their next steps: process design and product samples for material testing and pre-marketing. The Pilot Centre facilities are typically used in **the early phase of industrial process technology scale-up** by generating information for investment decisions of larger industrial pilot or demonstration units.

The collaboration between the different types of infrastructures can also be beneficial for the development of technologies needed for upgrading the infrastructures. For example, the collaboration of TIs in open access pilots with process equipment manufacturers test centres proved effective to define and design new pilot scale equipment. This type of collaboration increases the knowledge level on both sides, provides the necessary learnings for the TIs, accelerates the development cycles and allows companies to focus their resources and efforts on investing into facilities that are needed for their own purposes in R&D and demonstration[23].

3.2. An updated definition of technology infrastructures

The European Commission's 2019 definition of TIs describes them as facilities, equipment and services enabling technologies to progress from lab validation to market readiness, supporting business in commercialisation. This definition is gaining traction, with interest and engagement from various actors, but requires broader acceptance across EU and national policies. A unified EU definition would streamline policy, align investments and highlight the unique role of TIs alongside RIs, bolstering Europe's industrial resilience and efficiency, climate neutrality and digital transformation.

Key elements of the current definition of TIs include their substance (facilities and capabilities), purpose (advancing technologies to higher TRLs), ownership (public, semi-public or private), and

[22] More information available at: Technology infrastructures | VTT. The Bioruukki Pilot Centre is referenced in multiple European and Finnish inventories, such as Home | Pilots4U; https://monitor-industrial-ecosystems.ec.europa.eu/
; https://monitor-industrial-ecosystems.ec.europa.eu/technology-centre/mapping
; https://www.bioeconomyinfra.fi/facilities; https://research.fi/en/results/infrastructures
[23] RITIFI CSA project https://ritifi.eu/

users (primarily industrial players, especially SMEs). However, the Expert Group identified drawbacks and missing elements of this definition, such as:

- Insufficient recognition of researchers and start-ups as users,
- The need to highlight the primary purpose of TIs in boosting technology readiness levels (TRLs) and supporting competitiveness,
- A lack of emphasis on openness, non-discriminatory access, and their adaptability for multiple and diverse uses and users,
- The absence of examples that are useful to illustrate the types of TIs, in a similar manner to the examples provided in the RI definition.

Addressing these gaps would ensure broader acceptance and help enhance the effectiveness of TIs across Europe. Accordingly, the EGTI proposes the following updated definition:

Technology Infrastructures are facilities, equipment, capabilities and resources required to develop, test, upscale and validate technology. They enable and accelerate technological innovations towards societal/market adoption, fostering industrial competitiveness. They provide a wide range of capacities and services from pre-competitive applied research services, through demonstration and validation of technology, up to small-scale production. They include, amongst others, test beds, demonstration and testing facilities, pilot lines or living labs, usually embedded within non-profit research and technology organisations, universities active in technology fields or technology centres, which are open to private and public users. They can be public, semi-public or privately owned, physical or digital.

TIs are therefore used typically either for technology and industrial development activities at intermediate TRLs and/or for testing and demonstration activities at higher TRLs, or for both activities. They can also provide non-technological services such as business development and human resources support, including training and skills development in new technologies.

Technology development activities at intermediate TRLs, include:

- Own technology development projects carried out by host organisations,
- Collaborative R&D projects (consortium-based projects) between host organisations and other research organisations and universities, often together with industry and other end users,
- Contract research or research services funded by industry.

Activities at higher TRL include activities to test, demonstrate and upscale technologies in industrially relevant environment, including the first industrial deployment prior to mass production: test beds, pilot lines, etc.

Access to these infrastructures is open to a variety of users, such as:

- Private sector companies ranging from large enterprises to SMEs and start-ups.
- Public organisations, i.e. research and technology organisations (RTOs), universities, public authorities and publicly owned companies.

The distinctive characteristics of TIs described above are key elements in creating a sound and sustainable business model. When financial components such as cost structure and revenue streams are included, all nine elements of the business model canvas are addressed[24]. Developing sound business models is crucial for the sustainability of infrastructures. Therefore, it is recommended to create a customised business model canvas for TI investment projects, tailored to the unique characteristics outlined in the seven dimensions (described in Chapter 3.1). This

[24] See e.g. https://www.strategyzer.com/library/the-business-model-canvas - Business Model Canvas

approach can help project initiators prepare clearer proposals and enable funders to better and more quickly understand the proposed infrastructure project. To achieve this, a workshop involving key stakeholders could be organised to collaboratively develop such a model.

4. What are the needs of (users) industry for TIs?

Understanding the current and the future needs of users is crucial for the relevance of any actions strengthening the TIs capacities, including maximising the impact of investments in TIs. Due to this, in response to the request of the Council[25], the EGTI received a mandate to carry out an in-depth analysis of such needs.

In order to get a broad understanding of the user needs, EGTI engaged in comprehensive fact finding and evidence gathering that included the analysis of existing documents and external inputs as well as direct engagement with enterprises across the EU. The outcomes of this analysis are included in a dedicated Analytical Report on TI user needs[26], which accompanies this EGTI Final Report.

The Analytical Report builds on the following sources of information used in the report include:

- A public survey addressed to individual enterprises,
- Strategic research and innovation agendas of selected European Partnerships,
- European technology platforms and industrial technology roadmaps,
- National initiatives aimed at mapping TI user needs,
- Findings of the Horizon Europe funded project RITIFI[27], and
- Reports of the European Strategy Forum on Research Infrastructures (ESFRI).

This chapter summarises the main findings of this analysis, while significantly more information is included in the Analytical report.

4.1. Results of the survey addressed to enterprises

The public consultation through an online survey was launched by the European Commission on 19 August 2024 and was open until 30 November 2024. It was accompanied by a promotion campaign involving industry umbrella organisations, Member States contact points for ERA action 12, EGTI Members and social media channels. In total, 328 responses were received, with the majority (77%) coming from EU-based enterprises.

The respondents represented diverse enterprise types and industrial ecosystems. SMEs accounted for the largest group (45%), followed by very small enterprises and very large companies. The surveyed enterprises spanned key sectors, including mainly mobility, health, aerospace and defence, digital, energy, electronics, agri-food, construction and with less representation in textile and tourism, cultural and creative industries, social economy and civil security, retail and proximity. The majority (88%) of the respondents target markets beyond their national borders, from a regional EU market to the global market.

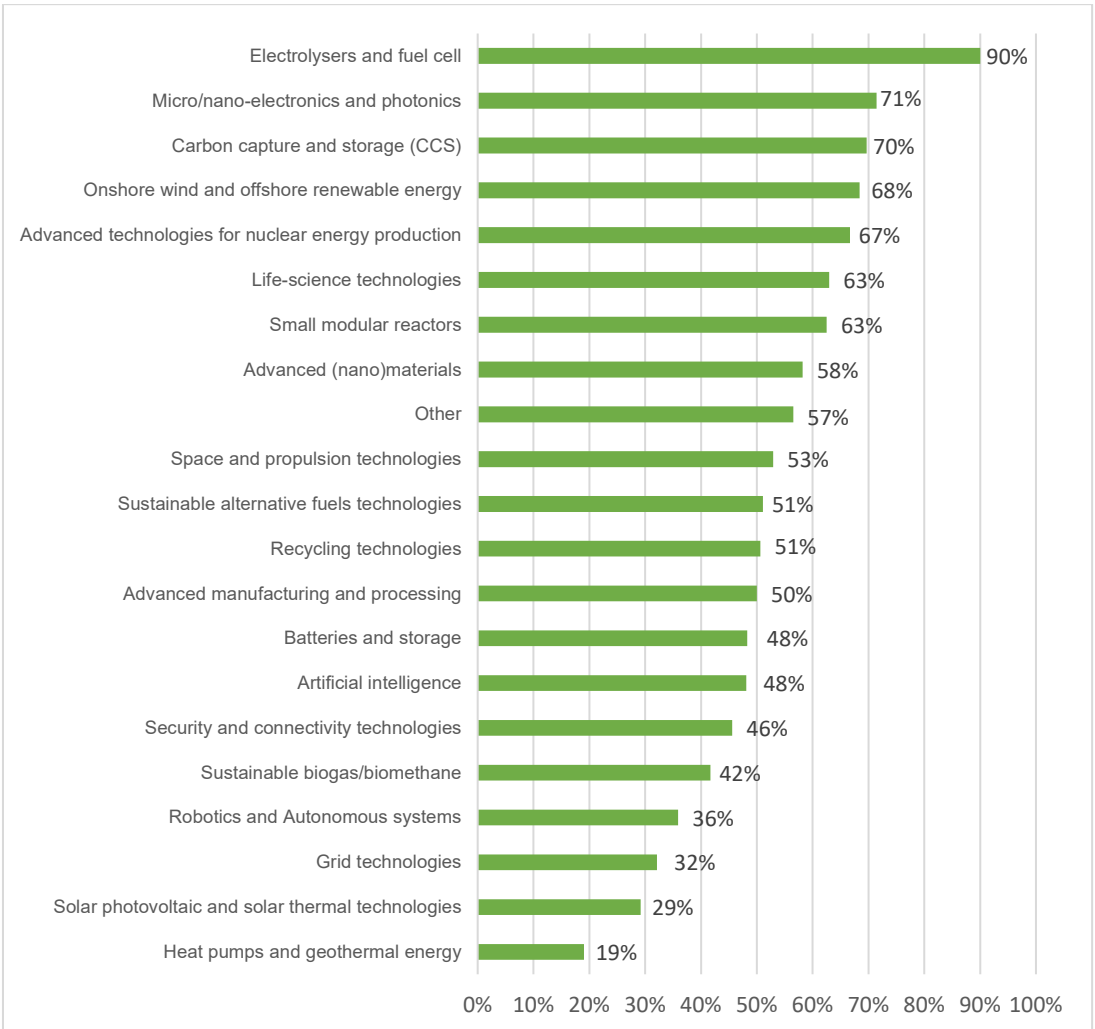
The Commission has identified 14 industrial ecosystems while working on the financial liquidity and investment needs of the EU27 in response to the COVID-19 crisis.[28] These ecosystems play a crucial role in shaping Europe's economic landscape and driving innovation. The survey respondents operate notably in mobility/transport, health, aerospace and defence, digital, energy & renewables as well as energy intensive industries, electronics and agri-food. The less

[25] Council conclusions on Research Infrastructures of 2 December 2022.
[26] Technology Infrastructures - European Commission
[27] Home - RITIFI
[28] They are described in the Annual Single Market Report 2021, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52021SC0351

represented industrial ecosystems were construction, textile and tourism, cultural and creative industries, social economy and civil security, retail and proximity.

The survey revealed a high degree of utilisation of TIs by the respondents. The majority of enterprises participating in the survey (264 or 80%) declared that they use TIs. TIs are important either because an enterprise wants to develop a new technology, method or process (253 responses, or 77%), test their product and processes in real life conditions (239 responses or 65%), to perform tests on their manufacturing processes (232 responses or 60%), or to increase their skills-base (233 responses or 61%). Among these users, 32% engaged extensively with TIs, while 49% used them to a moderate extent. Only 16% of respondents indicated that they do not use TIs at all for the development of a new product, service or process, technologies or methods. Half of them reported having insufficient knowledge / information about TIs in general and about the availability of specific TIs. Other reasons were a too big geographic distance to a TI, a difficulty to access TIs, not meeting the specific needs of the enterprise, regulatory approval constraints or a lack of financial resources.

Figure 2. Proportion of TIs missing in technology areas seen by enterprises as an investment priority in the next two years.

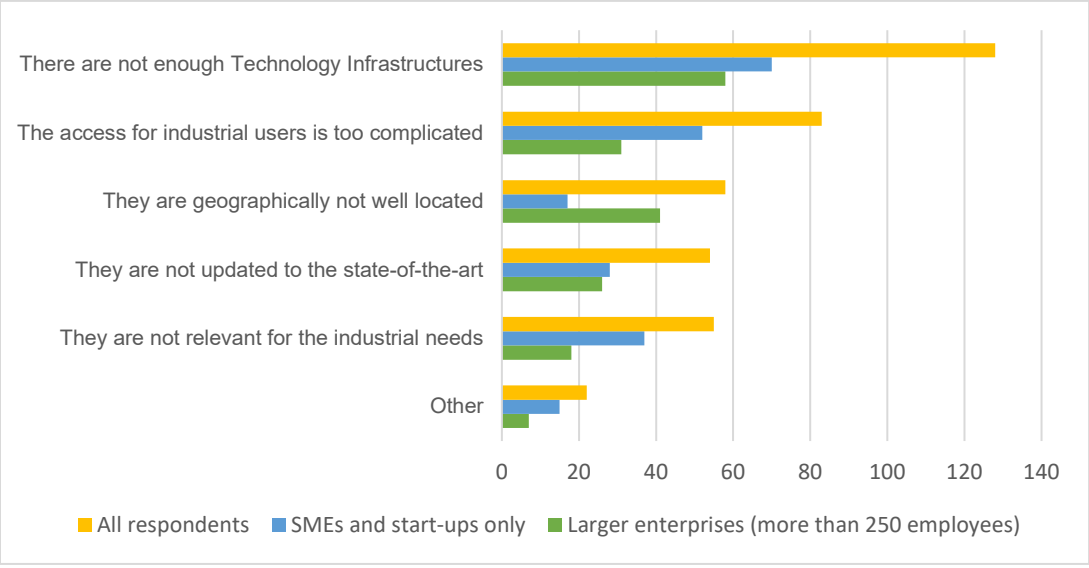


Respondents were asked to position themselves with respect to technologies used in their current production processes and future investment priorities and to consider if there are adequate TIs available to them to support their innovation efforts. The survey showed that a perceived lack of available TIs differs significantly across technology areas. The share of enterprises considering that they do not have adequate TIs to support their technology development plans is particularly high in electrolysers and fuel cells, micro/nano electronics and photonics, as well as carbon capture and storage, being the top three. At the same time, in areas like solar energy technologies, heat pumps and geothermal energy only a small fraction of enterprises reported such deficiency. (See Figure 2)

The mentioned reasons for why the offer of TI services is not sufficient include a perception that there are simply not enough TIs, that access to the TI is too complicated for industrial users, that TIs are not relevant for the industrial needs, that they are inconveniently located, or that facilities are not state-of-the-art (see Figure 3).

Taking a closer look at the answers given by SMEs and start-ups and comparing them with the answers given by larger enterprises to this question the perceived reasons for lacking access to TIs differ depending on the size of the enterprise replying. For instance, even if for both categories the fact that there are not enough TIs arrives in 1st position among the answers, we can notice that this is a much more important reason for larger enterprises (64% of answers) than for SMEs and start-ups (46%). Larger enterprises also more often consider that TIs are not conveniently located (45%) than smaller enterprises (11%).

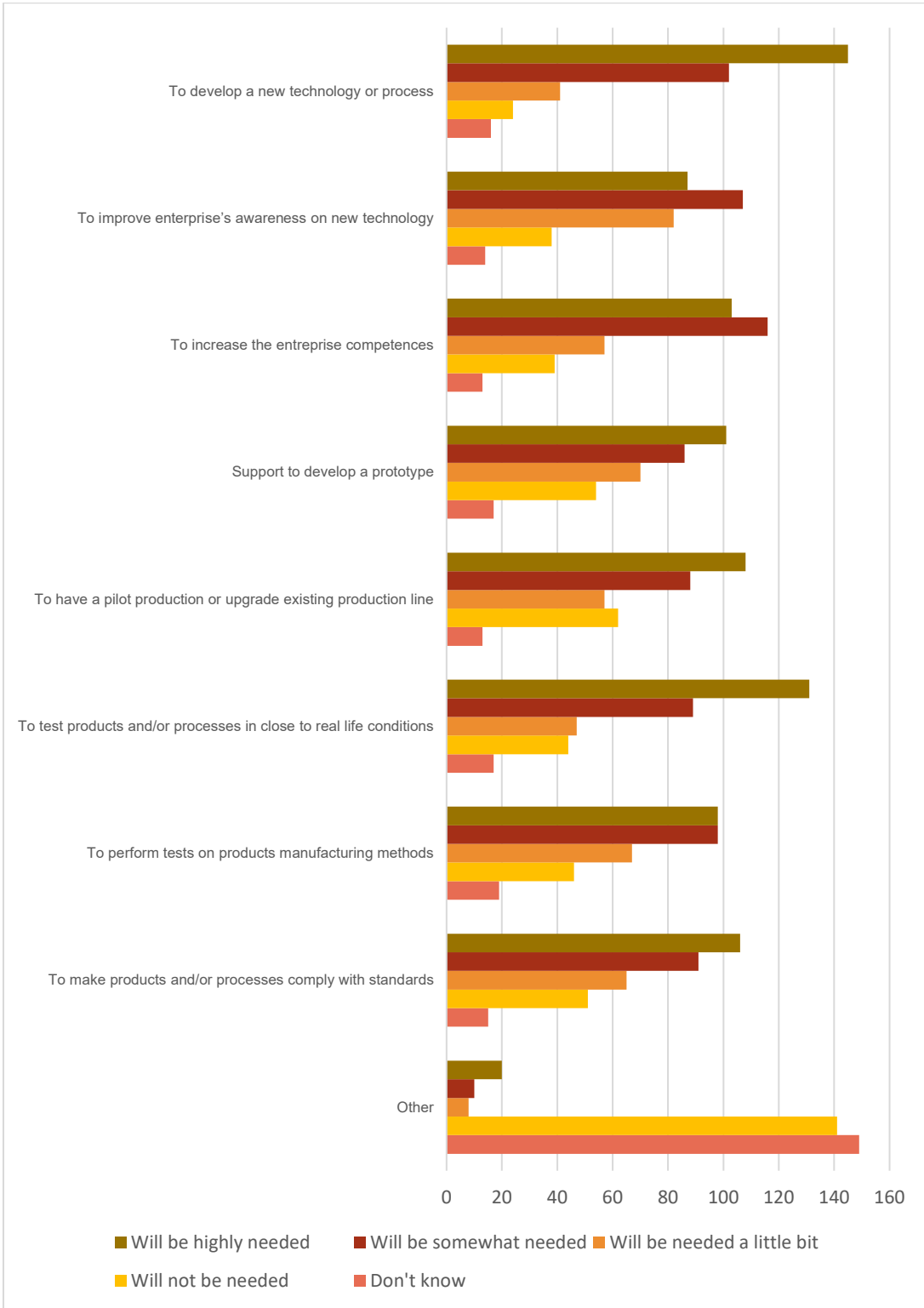
Figure 3. Perceived reasons for lacking TIs in specific technology areas



Regarding specific TIs services, enterprises expressed strong interest in most types of services that could enhance their capacity for innovation listed in the survey, with the highest demand for support to develop new technologies, methods, and processes, and to test products in near-real-life conditions. (See Figure 4)

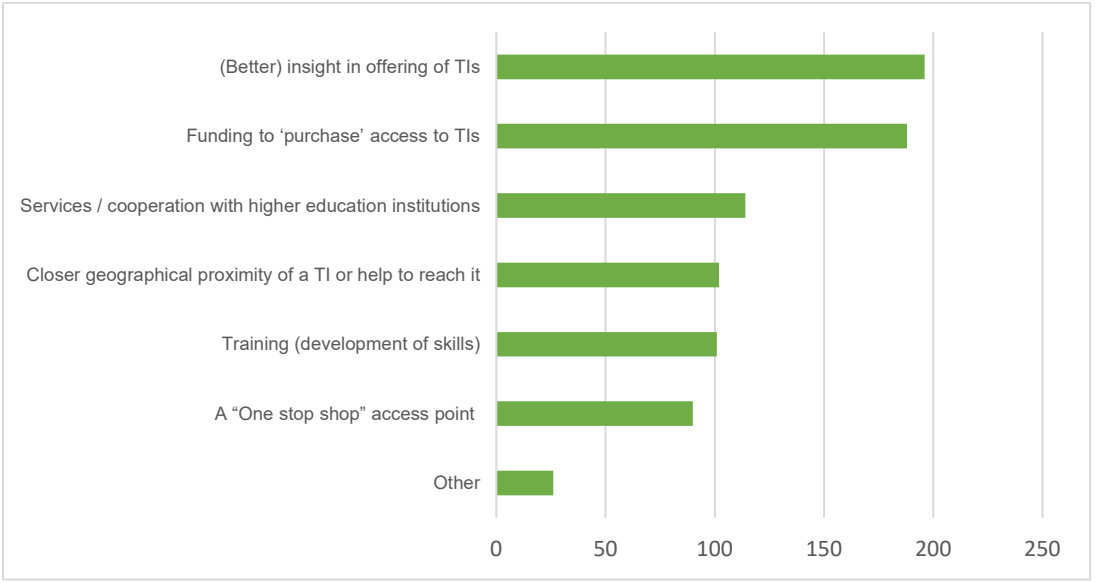
Over half of the respondents also indicated additional service needs such as bioprocessing, virtual testing, training, capacity building, and scientific communication. Some noted the importance of specialised support for intellectual property management, funding access, and partnerships for commercial development. These findings emphasise the need for targeted investments and service diversification to better align TIs with industry demands and drive innovation across sectors.

Figure 4. Support or services needed by enterprises to enhance their capabilities to innovate and develop innovation(s) and technologies further



The survey also explored the different options to help enterprises increase their usage of TIs (See Figure 5) The two that resonated the most with the surveyed enterprises are (1) making existing TIs more visible by offering (better) insights into their services (196 respondents – 60%); and (2) availability of funding to 'purchase' access to TIs (188 respondents – 57%). All other ideas for increasing the use of TIs were also found relevant by many enterprises.

Figure 5. Help needed to increase usage of TIs



The survey suggests that while SMEs and start-ups would benefit from better information about the services of TIs and from funding to purchase access to them, larger enterprises' first preference is for the establishment of a 'one stop shop' access point. These results are coherent with the fact that larger enterprises have a better insight on what TIs can offer them and are more able to invest into accessing them.

4.2. Further insights into user needs

Beyond the survey of enterprises, the user needs analysis done by this Expert Group benefited from inputs provided by other initiatives on this topic, such as the RITIFI project and the European technology platforms as well as the analysis of existing documents performed by the European Commission including selected reports of ESFRI, strategic research and innovation agendas of European Partnerships as well as industrial technology roadmaps.

4.2.1. RITIFI insights on User needs for Technology Infrastructures

The project, among its activities, looked into the user needs for TIs based on a user experience and expectations survey, as well as interviews with industry representatives from five specific technology areas: biomedical, clean hydrogen, circular materials, particle accelerators and superconducting magnets, and microelectronics and semiconductors.

The user expectations survey focused on the identification of services needs and customer value proposition, especially when linking lower-TRL activities at RIs with higher-TRL activities at TIs, impact of services, funding of services and barriers for using RI/TI services. The survey and interviews revealed that users value the complementary application of RIs and TIs, which broadens their effectiveness and output for application-related questions. However, users also highlighted several barriers to using integrated RI/TI services, including funding and pricing issues, long

delivery times, and lack of knowledge about available services. The boundary between RIs and TIs is often fuzzy, with many service providers offering both types of services. The respondents also highlighted the importance of having knowledge about the RIs and TIs, as well as their capabilities, in addition to purely infrastructure-related information. The respondents also emphasised the need for clear and transparent pricing, as well as simplified access procedures.

The case studies conducted in the five technology areas identified specific user needs and challenges. For example, in the biomedical area, users highlighted the need for streamlined processes, simplified customs regulations, and clearer points of contact for industry engagement. The biomedical industry also emphasised the importance of trust and long-term partnerships with RIs and TIs, as well as the need for specialized technologies and expertise. In the clean hydrogen area, users emphasised the importance of trust, proximity, and flexibility in collaborations with RIs and TIs. The clean hydrogen industry also highlighted the need for specialized testing infrastructure and efficient routine measurements for qualification.

For the circular materials area the need for seamless collaboration between RIs and TIs has been highlighted, as well as access to supporting services such as techno-economic and environmental assessments. The circular materials industry also emphasised the importance of having access to R&D services across the entire technology readiness level (TRL) range, from fundamental research to commercial deployment. The particle accelerators and superconducting magnets area had a unique relationship between RIs and TIs, with TIs providing major components for RIs and industry using these components for various applications. The microelectronics area highlighted the need for access to highly sophisticated infrastructures, as well as the importance of expertise and knowledge in microelectronics.

4.2.2. Addressing technology development needs of Horizon Europe Partnerships

The Horizon Europe Partnerships identify sectoral and cross-sectoral technological development needs in the areas they cover. In some cases, they also explicitly refer to the needs of TIs in supporting them. In order to illustrate the relevance of the strategic research and innovation agendas, eight European Partnerships were analysed.

The battery sector, driven by the ongoing clean energy transition and the uptake of zero-emission mobility, has risen to be of strategic importance on a global level. The **BATT4EU Partnership**, aims at establishing the world's best battery innovation ecosystem by 2030, by building a competitive, sustainable, and circular European battery value chain to support the shift toward a carbon-neutral society. Key areas for further development identified by the partnership include advanced materials, battery cell design and manufacturing, as well as circular economy initiatives, for which coordinated efforts are needed to develop cutting-edge technologies. Additionally, digitalisation tools and safe-by-design frameworks need to be integrated into pilot lines to optimise manufacturing and recycling systems, improving efficiency and safety.

Another important sector, where the development and upscaling of innovative solutions is pivotal to secure Europe's competitiveness, is that of mobility. The **European Partnership for Connected, Cooperative, and Automated Mobility (CCAM)** is dedicated to advancing key technologies in the sector for safe, sustainable, and automated road transport. To drive this innovation, CCAM stresses the importance of large-scale demonstrations, and the use of pilot lines and living labs as essential platforms for testing and validating these technologies in real-world conditions. These solutions include on-board decision-making systems, vehicle perception systems, and high-resolution mapping and localisation tools that ensure accurate positioning in dynamic environments. Developing and deploying CCAM systems requires rigorous testing and validation. However, high development costs and regulatory uncertainty hinder progress. TIs can address these challenges by providing controlled testing environments, reducing costs and ensuring compliance with existing safety standards and certification requirements.

The **Clean Hydrogen Partnership (CHP)** aims to advance a variety of hydrogen technologies essential for achieving the EU's carbon neutrality by 2050, with a focus on scaling up low-carbon hydrogen production, storage, and distribution. At higher TRLs, the main focus in on water electrolysis using renewable electricity, with a particular emphasis on upscaling electrolysers such as Alkaline Electrolysis (AEL), Proton Exchange Membrane Electrolysis (PEMEL), and Solid Oxide Electrolysis (SOEL). Beyond water electrolysis, other renewable hydrogen production methods, including solar-driven processes, biological methods (e.g., algae and microbes), and biomass gasification, need to move beyond pilot projects to larger-scale demonstrations, integrating these technologies into broader energy systems. Many technologies are still at lower TRLs requiring substantial R&I efforts to achieve commercial readiness. Scaling up production capacity, improving cost competitiveness, and establishing robust distribution infrastructure are key areas requiring coordinated efforts.

The **Clean Steel Partnership (CSP)** aims to achieve the decarbonisation of the European steel sector and transform it into a vital, sustainable, and circular industry by developing technologies at a high readiness level (TRL 8). To achieve this, the partnership focuses on two main technology areas: Carbon Direct Avoidance (CDA) and Smart Carbon Usage (SCU). CDA emphasises green hydrogen and electricity to avoid emissions, while SCU incorporates carbon capture, utilisation, and storage (CCUS) and process integration (PI) to repurpose or minimise emissions. The steel sector also faces competitive pressures from global markets, a lack of zero-carbon electricity and hydrogen availability, and the need for carbon capture and storage (CCS) infrastructure. Demonstrators, repeatedly highlighted throughout the Strategic Research and Innovation Agenda (SRIA), are essential for scaling steel technologies to industrial levels. They can help to address critical barriers, optimise processes, and integrate innovations into steelmaking, paving the way for large-scale implementation.

In the process industries, a wide range of technologies require further development to achieve climate neutrality, resource circularity, and EU's global competitiveness by 2050. The **Process4Planet Partnership (P4P)** explores a wide range of key technologies needing further advancement including: renewable energy integration, like the use of large-scale solar and wind power combined with industrial energy storage systems; hydrogen integration, exemplified by green hydrogen production through electrolysis and its use as a feedstock or energy carrier in steel manufacturing; CO_2 capture and utilisation, including innovations like CO_2-based concrete production and catalytic conversion of CO_2 into synthetic fuels; and digitalisation of processes, such as the deployment of digital twins for process optimisation and intelligent monitoring systems to improve energy efficiency. While these technologies are at varying stages of development, many are at pilot or demonstration stages, with the need to upscale towards first-of-a-kind plants (TRL 8-9) for commercial deployment. TIs in conjunction with cross-sectoral collaboration, investment in infrastructure, and fostering innovation hubs can play an important enabling role to achieve this.

The **Clean Energy Transition Partnership (CETP)** supports achieving climate neutrality through advancements in clean energy technologies. The partnership's SRIA identifies key areas requiring progress: zero-emission power, energy storage, heating and cooling systems, CCUS, and cross-cutting digital technologies. For zero-emission power technologies like photovoltaics (PV), offshore wind, and concentrated solar power (CSP), priorities include improving efficiency (30-40%), cutting costs (35-50%), and enhancing integration through pilot lines, hybrid solutions, and circular materials. Similarly, energy storage technologies need advancements in materials, integration, and digital monitoring to address short-to-seasonal storage demands. Meanwhile, CCUS technologies are vital for decarbonising hard-to-abate sectors, with a focus on cost reduction, scaling infrastructure, and public acceptance. Lastly, cross-cutting digital technologies (e.g., AI, IoT, advanced modelling) enable automation and interoperability but face barriers like regulatory misalignment, resource shortages, and funding gaps.

The **Made in Europe SRIA** outlines essential technology developments for advancing the European manufacturing sector. Innovations are critical for improving production efficiency, enabling circular economy practices, and driving digital transformation. Key focus areas include advanced manufacturing technologies, such as additive manufacturing, smart mechatronic systems, and recycling technologies. Technologies like simulation, digital twins, and AI are also

emerging but require further development for full-scale industrial application. To bridge the gap between innovation and real-world application, the SRIA stresses the importance of demonstrators, as part of the main key-performance indicators (KPIs), as well as pilot lines. These facilities will enable validation, optimisation, and scaling of processes, such as zero-defect manufacturing and predictive maintenance, in line with sustainability and resource efficiency goals.

The **Photonics21** SRIA outlines the strategic research needs for advancing photonics technologies in Europe, which are vital for numerous sectors, including high-performance computing, quantum technologies, augmented reality, virtual reality (AR/VR), space, defence, and agriculture. To maintain Europe's technological leadership in this area, the SRIA focuses on advancing photonics technologies, including silicon photonics, optical components, and energy-efficient displays. Addressing the technological gaps in materials, fabrication processes, and integration challenges remains crucial for realising the full potential of photonics. As many technologies are at TRL 6 or 7, and their scalability must be demonstrated in real-world environments, TIs can enable this process through pilot lines and demonstrators, where pilot manufacturing and real-world testing can accelerate their commercialisation.

As showcased by this selection of Horizon Europe Partnerships, many groundbreaking solutions need dedicated support to scale up and progress beyond experimental development in order to achieve full industrial application. This is due to various common barriers across the sectors and industries, including high capital costs, technological and regulatory hurdles, material resource constraints, as well as infrastructure bottlenecks. Addressing these challenges through coordinated innovation ecosystems, underpinned by state-of-the-art TIs, comprehensive policy support, and continued cross-border collaboration will be essential to realising the full potential of these transformative technologies.

4.2.3. Identifying Needs in Industrial Sectors through Industrial Technology Roadmaps

The current and future needs for TIs in specific industrial sectors are closely linked with the key trends and future directions in technology development. There are different sources of information providing such outlook, for example industrial technology roadmaps or European Technology Platforms (ETPs). This section highlights two types of such roadmaps: industrial technology roadmaps developed by the Commission in the framework of the ERA and selected sectoral roadmaps developed by industrial associations. In addition, the section analyses inputs gathered from five ETPs.

4.2.3.1. ERA Industrial Technology Roadmaps

The "ERA industrial technology roadmap for low-carbon technologies in energy-intensive industries" highlights key pathways for decarbonisation, focusing on steel, chemicals, cement, and other EII sectors. These pathways include electrification, green hydrogen usage, CCS, CCU, alternative feedstocks, renewable energy integration, energy/materials efficiency and circular economy principles. These technologies show varying maturity levels. Pilot lines, demonstrators, and industrial symbiosis hubs are essential for first-of-a-kind (FOAK) projects to mitigate risks and accelerate uptake. Challenges like long investment cycles, regulatory uncertainties, and cross-sectoral collaboration require innovation hubs, better regulation, and knowledge-sharing to drive progress.

The **"ERA industrial technology roadmap for circular technologies in the textile, construction and energy-intensive industries"** evaluates key technologies across three industrial ecosystems: textiles, construction, and energy-intensive industries (EII). In textiles, technologies like recycled materials and near-infrared automated fibre sorting exhibit high TRLs (7-9), indicating advanced development. Secondary bio-based raw materials fall within medium TRLs (4-6), while material blend separation technologies are in the low TRL range, reflecting early-stage testing. For the construction ecosystem, the focus is on building information modelling (BIM) and advanced manufacturing technologies. BIM-compatible plug-ins and four-dimensional (4D)

BIM applications reach high TRLs (6-9), while modular design and additive manufacturing technologies are in the mid-range (4-6), transitioning from piloting to wider application. In the EII ecosystem, technologies for waste treatment, carbon dioxide/carbon monoxide (CO2/CO) utilisation in polymers, and improved recycling processes fall between TRLs 3-8, with some in pilot phases. The roadmap stresses the role of TIs (that are at the moment available mostly in textile and construction industrial ecosystems), which serve as platforms/facilitators for the industries, especially for SMEs and start-ups and are a key element in the development of local and regional innovation ecosystems.

The **"ERA Industrial Technologies Roadmap on Human-Centric Research and Innovation**" highlights human-centric technologies (HCTs) as essential to Industry 5.0, focusing on innovations that enhance collaboration between humans and technology, prioritising safety, productivity, and user-centric design. These include AI, robotics, extended reality (XR), digital twins, and wearable technologies. Technologies still in early stages or being tested include advanced systems for human intention recognition, exoskeletons for physical augmentation, and some applications of AI-driven personalisation systems. The roadmap stresses the importance of TIs like living labs, as they can accelerate the development and deployment of these technologies by providing real-world testing environments where stakeholders can collaborate. By integrating stakeholder input and iterative testing, such infrastructures bridge innovation and adoption effectively.

4.2.3.2. Sectoral Industrial Technology Roadmaps

Technology roadmaps developed within the industrial sectors highlight the directions in which industrial research and innovation efforts need to progress in order to strengthen the competitiveness of a given sector and its transition to climate neutrality. As an example, demonstrating the relevance of such roadmaps as a source of information on current and future needs of TI services, a short analysis is presented of the Ceramic Roadmap 2050[29] prepared by the European Ceramic Industry Association, and an Action Plan for the European Chemical Industry's Innovation Leadership[30].

The **Ceramic Roadmap** identifies four broad areas of new technology development needs:

1) Switching to more sustainable energy sources for production plants: increasing availability of green hydrogen and of related infrastructure, enhancing the electrification of ceramic manufacturing processes to reduce reliance on fossil fuels, and developing technologies for using alternative fuels like biofuels, biogas, and synthetic gases;
2) Developing and implementing CCS and CCU technologies to manage process emissions;
3) Recycling and Reuse: new technologies for increased use of recycled materials and improving methods for the reuse of ceramic products;
4) Energy efficiency Innovative technologies: microwave-assisted drying to enhance drying efficiency and heat pumps to improve energy efficiency for heating and cooling processes.

These are the areas where support of Technology Infrastructures could accelerate the decarbonisation of the ceramic industries.

The **Action Plan for the European Chemical Industry's Innovation Leadership** outlines what needs to be done to position the chemical industry in Europe as a leader in innovation in line with the overall objectives set in the "Antwerp Declaration"31 published in February 2024. Out of nine points, two actions express the chemical industry's need for collaboration with TIs.

Action 2 calls for prioritising pilot plant facilities with flexible infrastructures to also support smaller enterprises across industries. It also proposes the establishment of a European network of technology parks with flexible, multipurpose infrastructure supporting the validation of new sustainable process technologies. The chemical industry considers that this is needed in order to

[29] ceramic-roadmap-to-2050.pdf
[30] Nine actions to boost the EU chemical industry's innovation leadership - cefic.org
[31] The Antwerp Declaration for a European Industrial Deal

maximise synergies and scale up breakthrough technologies, which are very capital intensive. In the pilot plant stage, development costs increase substantially compared to lab costs. Moreover, Action 3 calls for fostering EU-wide collaboration across industries and academia, supporting cross value chain initiatives and sufficient joint centres of excellence for IP development and sharing.

4.2.3.3. European Technology Platforms (ETPs)

The Commission also reached out to the ETPs to gather information on needs for TIs in specific sectors, as seen from the perspective of public-private multi-actor fora focused on key technology and innovation areas. 5 ETPs provided inputs:

- Aquaculture (active in the production of aquatic foods)
- SusChem (sustainable chemistry)
- Photonics21 (photonics[32])
- FABRE TP (animal breeding and reproduction)
- Textile (textile and clothing industries)

These ETPs members are active in a wide range of industrial ecosystems. All these ETPs members need advanced manufacturing and processing technologies with a large amount also needed life-science technologies, advanced (nano)materials, AI, and robotics and autonomous systems.

The contributions show that improving information on TIs is needed for ETPs members. All ETPs also declared that their members need TIs for their development to a certain extent. The enterprises get access to TIs mainly through the use of the services of an intermediary, collaborations with research organisations or participation in collaborative projects. The main barriers to use TIs concern the lack of financial resources, the lack of required expertise or support for area of technology needing to be addressed, an insufficient geographical proximity of TIs, and the lack of resources within TI to support industry needs. All respondents declared that funding to purchase access to TIs would help their members, 80% added that a better knowledge in offering of TIs and better geographical proximity of TIs would help too.

All ETPs consider that there are not enough TIs. Some also say that they may be irrelevant for industrial needs, for example because they were mostly developed for other sectors (with the example of materials, advanced manufacturing & robotics). In general, they call for a more transparent information on TIs and related services offered by RTO's & universities, allowing also an access to them as easy as possible, especially for SME's. The benefits of European funded transnational access programmes are also noted.

They state that their members would need some specific services often not available at TIs. In addition, they identified area where TI could improve, such as the administrative and financial support offered by TIs, a better promotion of the relevance and potential of TIs, an engagement from TIs towards other industrial ecosystems and technology fields.

There are some specificities depending on the field concerned. For instance, the FABRE TP highlights particularly the need for developing TIs in the field of high-performance computing and data analysis. The Textile ETP also regrets the absence of TIs in textile-specific digital (automation/robotics) or circular (recycling) innovation domains, which also leads to a shortage of support and services such as demonstration/testing, consulting, and training that could be offered to SMEs.

4.2.4. Industrial user needs of Research Infrastructures

When analysing user needs for TIs, it is relevant to consider the needs of industrial users for Research Infrastructures. From the ESFRI reports published since 2023, four contain relevant

[32] Photonics is a technology encompassing all of the products and processes around the emission, manipulation and detection of light.

messages: Landscape Analysis (2024), Report on Access to RIs (2024) and two Reports on Cooperation of ESFRI Landmarks with Industry (2023). In this context, the relevance of the ESFRI reports for TIs lies in the indication of existing gaps in services that are relevant for industry, degree of cooperation between RIs and industrial partners indicating to what extent the RI services are used by enterprises, as well as the challenges that RIs face when cooperating with industry.

According to the ESFRI Landscape Analysis[33], services that are mostly relevant for industry are found in RIs in physics (mostly analytical facilities), health and food, energy as well as digital research infrastructures (high-performance computers). In particular, in the field of energy, the document notes high relevance of the services for industry of ESFRI RIs, and thus their potential significant synergies with TIs. The ESFRI Landscape Analysis also identifies the existing trends and gaps in services. Some of these gaps are also relevant for industrial users. In particular, in the field of energy a lower number of ESFRI RIs is noted, pointing to a lower level of integration of RIs at EU level in this field. The specific areas where RI and TI gaps were identified include electrification, energy production and storage (including hydrogen production) and synthetic fuels. ESFRI advocates that this gap needs to be addressed with a 'vigorous' programme for RIs and TIs to address existing needs.

In the Health and Food domain, multiple RIs are of potential relevance for industry, in particular in industrial biotechnology, plant genetics and phenotyping, RIs supporting clinical research and therapeutic development. With currently little support of governments for use of these RIs by enterprises, the ESFRI report suggests that they develop a business model dedicated to services to the private sector. In the Health and Food domain, a number of specific infrastructure gaps were identified, including in animal farming or enabling multinational clinical trials.

RIs in physical sciences, in particular different types of analytical facilities, offer services of high relevance for industry, for example for new materials development, testing and analysis of their properties, or for medical instrumentation and development of treatments and therapies (e.g. cancer). However, for the moment, collaboration with industry constitutes a small but growing fraction of activities of these infrastructures.

Taken into account the specificities of the three domains, and the relevance of RIs in this area for the private sector, there is a strong potential for synergies and collaboration with TIs.

ESFRI published two reports on cooperation of the ESFRI Landmarks with industry. The first report, based on a survey of ESFRI Landmarks[34] conducted in 2022 found that for all but one European Research Infrastructure Consortium (ERIC) (96%) and for over 80% of national entities, collaboration with industry constitutes less than 10% of total revenue. However, 73% of them declared that their 'equipment, services or data are accessible through test beds, pilot lines, demonstrators and testing facilities', which arguably could be seen as more akin to TIs. Specific barriers to cooperation with industry that were found include different goals and expectations, administrative and legal burdens, access rules and IPR issues.

The second report, based on the survey of enterprises[35] reached through a network of Industry Contact Officers/Industry Liaison Officers based at RIs, established through the ENRIITC project[36], gives significant insights into the type of RI services used by enterprises and the barriers experienced. Overall, 92% of survey respondents (145 out of 157) confirmed they collaborate with RIs. Approximately one third of users indicated that cooperation was required to accelerate their business and deliver on their strategy, whereas a quarter stated that cooperation with RIs was not strategically planned and was ad hoc when the need for specific services required the RI use.

53% of the respondents indicated that they cooperate with RIs several times per year, while only 4% reported a one-off cooperation. Access to facilities was the most frequently identified type of

[33] landscape2024.esfri.eu
[34] Cooperation of ESFRI Research Infrastructures (Landmarks) with Industry | www.esfri.eu
[35] Survey Report on Cooperation of ESFRI Research Infrastructures (Landmarks) with Industry | www.esfri.eu
[36] European Network of Research Infrastructures & IndusTry for Collaboration | ENRIITC | Project | News & Multimedia | H2020 | CORDIS | European Commission

service at RIs that enterprises mentioned (55%). Full service (e.g. support in sample preparation, data analyses, interpretation, etc.) were indicated by 35% and nearly a quarter of respondents identified access to data or collection as an offered service.

4.3. Conclusion

The analysis presented in this report draws upon a number of different sources of information, resulting both from direct engagements with enterprises on their needs for TIs and the barriers they experience, as well as the examination of strategic documents outlining the technology development directions in selected industrial ecosystems. The main conclusions across all the inputs are highly consistent.

First, an important role of TI in supporting innovation and technology development activities is broadly recognised and enterprises across different sectors and technology areas are interested to engage in collaboration with TIs.

Second, while the need for support from TIs is expressed by enterprises of all sizes, from start-ups to very large corporations, the barriers to such collaboration significantly differ. For smaller enterprises they are mostly related to lack of resources and insufficient awareness of how TI can support them, while for larger enterprises they lie more in the location and adequacy of TI facilities and services. Moreover, the barriers to access to TIs are very similar to those reported to RIs, hence it would be optimal that any activities aimed at mitigating these barriers, cover both RIs and TIs.

Third, the perceived availability of TIs varies significantly across sectors and technology areas. For example, in the area of heat pumps, geothermal energy and solar energy technologies, less than 30% of enterprises which plan to use these technologies reported a lack of available TIs (though barriers to access them still persist). At the same time, a very substantial share of enterprises reported insufficient availability of TIs for their future development needs for electrolysers (90%), micro/nano electronics and photonics (71%) and carbon capture and storage technologies (70%).

Fourth, this report confirms the relevance of the broad approach to the identification of user needs that allows to combine direct insights from enterprises with the broader perspective on the needs of technology development. It also demonstrates the interest of enterprises to engage with policy makers on their specific needs in relation to TI services in their sector or technology area. It also shows the potential of engagement with organised industrial communities, such as European partnerships, technology platforms or industrial associations to design policy actions best suited to the needs of the users.

Finally, this analysis points already in some specific directions where sectoral initiatives on TIs could have the most significant impact and could be used for designing first policy actions in areas strategic for the EU, especially if these findings are corroborated by additional sources of information. At horizontal level it clearly demonstrates the need for policy action to improve the accessibility of TIs, as such action promise to have high impact that could be quickly achieved.

5. Improving access to technology infrastructures

Quick and straightforward access to TIs is essential to reduce the substantial capital investment needed by SMEs for innovation, from research to commercialisation. Companies can use TIs to gain access to, testing, and validation facilities, as well as technological expertise in order to lower costs of first rounds of maturing the innovation, accelerate technology development and mitigate risks.

Access conditions significantly influence how users, particularly SMEs and start-ups, engage with TIs for testing, experimentation, and scale-up. However, cross-regional and transnational EU-wide

access remains challenging due to factors such as limited awareness of available facilities, little information on service offerings, complex import/export regulations for test samples, and language barriers.

It is critical to examine all aspects of TI access, including legal, financial, and administrative frameworks, collaboration models, networking opportunities, and capacity-building measures. Best practices should be identified and widely shared to improve accessibility and foster industrial transformation across the EU.

The analysis presented in this chapter builds on multiple stakeholder inputs gathered through the discussions at the workshops on Access conditions to Technology Infrastructures held on 27 February 2024 and on Enhancing SME access to Research and Technology Infrastructures held on 7 June 2024, and through the enterprise survey on user needs. It also benefits from the conclusions of the study on the 'Policy landscape supporting technology infrastructures in Europe' done by the Technopolis Group[37].

5.1. Success Factors for Efficient Access to Technology Infrastructures

Key to the success of TIs is their ability to meet the specific needs of enterprises, notably smaller firms, which often lack clarity on their technological challenges. Hosts, including research and technology organisations (RTOs), universities, and technology centres, must offer tailored, agile, and flexible services while fostering collaboration to share expertise, resources and accelerate investments.

Transparent access conditions, clear user rules, and effective communication build trust and engagement. Open calls can serve to generate an initial contact and longer-term frameworks facilitate access and commitment for use. Matchmaking mechanisms align SMEs with appropriate TIs, ensuring productive collaborations. Comprehensive access policies should detail physical and virtual access, and remote options, service descriptions, support measures, rights and obligations as well as user fees, and available support processes like business idea assessments, testing, funding advice, and IPR management.

Financial support schemes such as vouchers further enable SME access. Beyond technical services, successful TIs integrate training, consultancy, and access to innovation networks to maximise user benefits. Cross-border and cross-sector collaboration enhance impact, involving academia, governmental bodies, industry, and society to attract possible new users and encourage collaboration.

TIs operate within the European frameworks and support companies in regulatory compliance, quality assurance, and leveraging public resources like data repositories and cloud tools. By offering technological and non-technological services, TIs provide comprehensive solutions that enhance their value and effectiveness.

5.2. Barriers and challenges for enterprises to access TIs

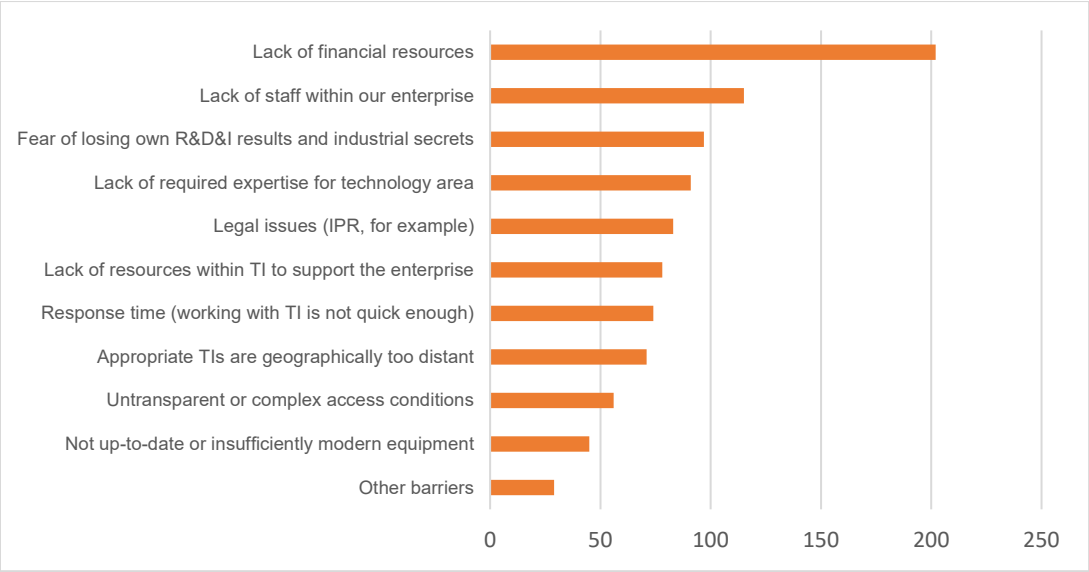
5.2.1. The barriers faced by TI users

Industrial users, particularly SMEs and startups, can face significant barriers when accessing TIs (and indeed RIs). These barriers include a lack of understanding of the practicalities of accessing TIs, such as funding requirements, technical knowledge, IPR considerations or even simply relate more to a lack of information and a misunderstanding on the services provided by TIs.

[37] Technology Infrastructures - European Commission

The TI user needs survey results highlight that a significant number of companies face **barriers to accessing TIs**. (see Figure 6). The most significant barriers concern the enterprises themselves, in particular the lack of financial resources to access TIs (62% of respondents), which notably concerns more smaller enterprises, and the lack of in-house expertise (35%). However, a significant number of companies reported also barriers concerning TIs, including worries about losing control over R&D results and industrial secrets (30%), lack of support staff or complex access conditions.

Figure 6. Barriers to access to TIs



Other barriers include e.g. the need for universities to adopt a more entrepreneurial mindset and improve scientific communication to enhance collaboration and facilitate technology transfer; the importance of stronger security measures for data generated/used and legally binding agreements to protect business data; and the administrative burden.

Cost Barriers: Potential high access costs, including training, maintenance and regulatory compliance, can be prohibitive, especially for SMEs and startups. Absence of differentiated pricing models and financial misconceptions about TIs amplify these challenges, highlighting the need for dedicated SME and start-up support schemes (vouchers, etc.).

Barriers also differ between SMEs, start-ups and large companies, with established medium-sized industrial companies being the hardest to engage (see he Analytical report on TI user needs for a more detailed analysis). Large enterprises navigate generally the RI and TI landscape more easily, as they have e.g. more financial and human resources that can be dedicated to collaboration with TIs, and more advanced ideas of the technology development and services they need, while SMEs and start-ups often struggle to define their needs.

Scepticism and Cultural Gaps: Companies often doubt the value of working with TIs until they experience the benefits. Many prioritise other investments over working with TIs, indicating that a cultural shift and trust-building are needed to overcome the barriers mentioned.

The reports of ESFRI also identified barriers for cooperation of industry with RIs, where only 11% of the respondents to ESFRI survey stated that there were no barriers. Nearly half of the respondents highlighted a lack of financial resources (53%) and a lack of staff on the company

side (49%) as the main barriers. Other barriers include legal issues (e.g. IPR), response time, and lack of available technical personnel at the RI.

It is noticeable that the barriers to accessing RIs identified in the ESFRI report are consistent with the barriers reported by enterprises with regard to access to TIs, therefore lessons from RI operations can guide strategies for TIs, and vice versa. Hence, coordinated efforts, potentially tested in the pilots being proposed, to address these challenges would benefit both infrastructure types.

5.2.2. The challenges faced by TIs

As reported by a variety of stakeholders and users consulted by the Expert Group, TIs face several challenges that limit their accessibility and effectiveness, particularly for SMEs. These challenges may not be equally applicable to all TIs, especially the most advanced ones that have already put in place effective collaboration models with enterprises.

- **Visibility and Awareness**: Many SMEs lack awareness of the TI landscape and its benefits, resulting in underutilisation of the TIs and their services. TIs sometimes struggle to engage industry partners due to insufficient funding for the extra support required by SMEs, business intelligence and tailored offerings.
- **Business models** not aligned with market needs: TIs may lack clear, industry-aligned business models, resulting in inefficiencies, fragmented efforts and inadequate services for SMEs. Pricing models often fail to address SME financial constraints, creating further access barriers, that may be addressed by subsidies for SMEs to access TIs.
- **Market Alignment**: Some TIs service offerings may not fully align with end-user needs, leading to a gap with market demand, particularly in fast evolving technology fields. A shortage of skilled personnel and specialised support may also hamper effective usage.
- **Fragmentation and Coordination**: The TI ecosystem is fragmented, with limited coordination among infrastructures, leading to inefficiencies and missed synergies. Geographical disparities and remote locations exacerbate accessibility issues, especially for stakeholders in less developed regions.
- **Regulatory and Funding Issues**: Outdated and stringent regulations in high-tech sectors, coupled with fragmented and uncoordinated funding systems, hinder innovation and transnational access.
- **Access and IPR Concerns**: Ambiguous and diverse access rules discourage engagement with TIs. Concerns about intellectual property (IPR) protection and data security further deter users, especially those worried about the risk of misappropriation. Although, it should be acknowledged that the different collaboration models have different contractual and legal aspects (collaborative research vs. contract research).
- **Technological Change and Delays**: Rapid technological advancements require adaptable infrastructures and well-trained staff. Slow decision-making and deployment processes hinder innovation, while delays in upscaling, testing and market deployment often result in missed opportunities.

5.3. Measures to improve accessibility of TIs

Addressing access barriers and aligning TI services with SME needs and requires action at both EU and national policymaking levels and the TI level. Together, these efforts can create a supportive ecosystem that enhances the visibility, accessibility, and effectiveness of TIs. Building on the available evidence, the following actions are endorsed by the Expert Group.

5.3.1. EU and National Policy Levels

Recognising TIs Strategically: TIs must be fully integrated into EU, national, and regional R&D&I policies with a focus on fostering pan-European and inter-regional collaboration and industrial R&I to bridge innovation gaps and boost EU-wide capacity.

Building Capacity, Networks and Collaboration:

- Facilitate transnational and multisite collaboration among TIs with structured communication, resource alignment, and robust agreements addressing legal complexities.
- Strengthen collaboration between TIs and RIs through dedicated funding, joint service pipelines, and thematic networks to streamline operations and enhance synergy.
- Promote a value-chain approach to create structured, business-oriented ecosystems near SME clusters, and fostering regional innovation.

Improve Visibility, Facilitate Trust and Collaboration:

- Each TI should have a 'single-entry point' (a form of one stop shop or industrial contact/outreach service) providing clear and transparent information on the infrastructure, its standardised services and support that can be provided. This would enable enterprises, and particularly SMEs, to learn about TI's outside of their field of expertise as well as about available funding opportunities. The aim being to engage industrial partners, SMEs and start-ups in identifying priorities for strategic collaboration and investments.
- Provide training for SMEs on innovation management, technology transfer, intellectual property and data management.

Public and Private Funding Synergies:

- Align public and private investments in TIs to cover the entire innovation lifecycle, including RIs, targeting to enhance the national strategies and collaborations as well as rapid pace of technology development in certain areas/sectors.
- Introduce funding mechanisms for SMEs and start-ups, such as dedicated access programmes, vouchers and access subsidies, and better integrate TI services into existing EU funding initiatives such as the European Innovation Council (EIC).

Guidelines for Streamlined and Transparent Access:

- Develop best-practice guidelines in the form of a European charter of access for TIs with streamlined access procedures, and simple and transparent access conditions, tailored to industry needs. Ensure flexibility to accommodate different user cases and TI models.
- Create sector-specific guidelines with input from SMEs to align access processes with industry needs.
- Promote digital access and virtual platforms to enhance connectivity and reduce geographical constraints for the use and access of TIs at the national level with outreach to pan-European networks (when applicable).

5.3.2. Technology infrastructure level

Based on extensive stakeholders' inputs, including from RI communities during workshops organised on the theme of access to TIs and RIs, there are a number of areas where TIs could consider improvements that would facilitate their collaboration with users:

User-Focused Services and Capabilities:

- Simplify access procedures and adapt engagement models to industrial needs.

- Provide clear information on access, including confidentiality, liabilities, rights and obligations, costs, data management, IP protection, security, health and safety issues, insurance and modalities to solve potential disagreements and disputes.
- Appoint dedicated staff (e.g. industry contact officers) to guide SME engagement with TIs.
- Train users to operate TI equipment with reduced host support in areas of with lower technical protocols and/or safety and security requirements, fostering expertise through collaborations with education and research institutions.
- Offer specialised certifications and skill-building opportunities to ecosystem actors, tailored to market needs.

Strengthening Business Models and Access Opportunities:

- Develop go-to-market strategies and promote industry engagement to drive commercialisation and innovation. Adopt a business-oriented approach to R&D development that is agile and respond to changing market demands.
- Introduce remote testing and simulation platforms to overcome physical barriers and expand access to distributed facilities.
- Leverage intermediaries to bridge gaps between technology providers and end-users, facilitating seamless collaboration. Such an approach is also relevant for improving the pathways of RIs towards industry.

Many of these practices have already been put in place in the most advanced European TIs, however they need a broader uptake. By implementing these strategies, the TIs operating at levels across the different innovation ecosystems can increase their role as accessible, efficient and industry-aligned resources, fostering innovation and sustainable industrial development.

6. Improving framework conditions for development of TIs in Europe

6.1. Mobilising funding for investments in TIs

All potential funding sources should be looked at when considering allocating funding to TIs. **The funding allocation should be based on a combination of top-down and bottom-up approaches**, involving both the allocation of funding to priority areas identified through the needs assessment and policy objectives (top-down approach), and the allocation of funding to specific projects and initiatives proposed by TI operators and users (bottom-up approach).

A gap analysis is necessary to identify the funding gaps and needs for TIs and their services. This involves analysing the current funding landscape and identifying the gaps in funding for different needs of TIs, such as capital expenditures, operational costs and maintenance.

Investment prioritisation mechanisms implemented at EU, national and regional levels should consider all available funding sources, such as:

- relevant EU funding programmes and instruments,
- public-private partnerships that allow for a combination of public and private funding sources.
- national and regional funding programmes, including government grants,
- funding mechanisms available through the European Investment Bank,
- private funding sources, including grants from charitable foundations, venture capital and private equity as well as user fees.

In order to improve the use of different potential funding sources for TI investments, funding authorities and TI operators would benefit from organised exchange of experience and practices and from guidance developed at EU level on the available funding sources for TI investments, as well as support to operation and access, including the legal conditions such as State aid rules and practical implementation modalities.

Box 2. Examples of public-private partnership funding TIs

The US National Science Foundation's (NSF) PAWR programme: This programme is a public-private partnership that supports the development of wireless testbeds for research and development in wireless communication and networking technologies. The programme is funded by the NSF through grants, as well as by contributions from a wireless industry consortium of 30 companies and associations, including Juniper, Ericsson, Nokia-Bell Labs, Interdigital, Samsung, Intel, Qualcomm, AT&T, Sprint, T-Mobile, and Verizon.

The H2020 programme has supported several public-private partnerships in providing funding for TIs, including the "Factories of the Future" (FoF) partnership, which aimed to support the development of new technologies and innovations in the manufacturing sector. The partnership was funded by the European Commission and industry partners, including companies such as Siemens, Bosch, and Philips.

The German government's “Future Research and Innovation Strategy”: With the "Future Research and Innovation Strategy", Germany strengthens its innovative powers and secures Europe's technological sovereignty.

The French government's "Investments for the Future" programme: This programme includes a public-private partnership which is funded by the French government and industry partners, including companies such as Total, Sanofi and Orange.

The EU should enhance actions to provide funding and support for the development of TIs in technology areas and sectors, where EU level intervention is needed. In particular, the EU should **make available dedicated funding for TIs at European level from programmes supporting R&I and competitiveness to support pooling of resources available at EU, national and regional level to support large-scale investments in TIs agreed at the EU level**. Such instruments would provide support for TIs in areas of strategic interest for the EU and where gaps have been assessed by TI road-mapping exercises. The Expert Group proposes that the funding mechanisms cover two key dimensions:

1. A Top-Up (or co-funding) investment component:

Designed to incentivise the mobilisation of national and regional funds by offering additional EU contributions when countries or regions allocate their budgets to strategically aligned projects. This should also cover the funding for upgrade and modernisation of existing TIs, to support their continued operation and effectiveness.

This approach could mirror successful models like EUROSTARS, ERA-NET+ and Chips pilot lines effectively encouraging co-investment at multiple levels. Thanks to coordination of investment priorities at EU level, the national and regional governments should be encouraged to develop adequate co-funding mechanisms on their side to match the EU support.

2. A European dimension component:

Dedicated to funding activities that enhance European networking and (inter-national and inter-regional) collaboration. This includes fostering connections between TIs across borders, between regions and between TIs and RIs, building integrated value chains and strengthening the European innovation ecosystem.

Such a funding instrument, rooted in the EU R&I policy, should include measures supporting the development and structuring of the TI landscape across the EU and promote their use by industry, SMEs and start-ups such as:

- Supporting access to TIs for the users where funding is an important barrier, such as SMEs, start-ups and scale-ups;
- Supporting the collaboration and networking among TIs, and between TIs and RIs;
- Providing support for the development of TI services and upskilling of their staff, to support service delivery and uptake;
- Providing funding for the development of new technologies and innovation that can help TIs keeping up with the state of the art;
- Providing funding for the development of new TIs at EU level, to support the creation of new infrastructure and services addressing user needs across the EU.

6.2. EU State aid rules and investments in TIs

The Expert Group discussed the impact of the EU State aid rules on investments in TIs and their operation based on feedback gathered from a broad range of stakeholders, including Member State authorities and funding bodies, universities and RTOs hosting TIs, regional authorities, and others.

They noted that current State aid frameworks (notably the General Block Exemption Regulation - GBER - of 2023[38] and the State aid Framework for RDI) do not define TIs but link them with testing and experimentation infrastructures (TEIs). Considering the diverse business-models and broad understanding of TIs in national R&I policies and in organisations hosting such infrastructures, as reflected in the updated definition proposed in this report, the fact that currently TIs are implied to be in certain cases legally equalled to TEIs is causing concerns and needs to be clarified. In result this creates uncertainties for Member States and stakeholders, under which State aid provisions public support to their investments in TIs should be covered. This legal uncertainty hinders the development of public funding programmes for such infrastructures.

In this context, the Expert Group considers it important to **improve the clarity and legal certainty around the State aid rules applicable to TIs and to increase awareness of these rules** among national authorities and stakeholders. The Group considers that the following actions would improve the knowledge and understanding of the State aid provisions applicable to investments in and operation of TIs:

1) Remind national authorities to use and consult the available platform eState aid WIKI, a platform where the Member States can pose their questions for interpretation of novel issues on principle in case of uncertainty on interpretation. Make known to all other stakeholders the availability of this platform and the necessity to ask their State aid authorities for guidance and if not available to pose an interpretation question. The benefit of promoting the use of this platform is that the interpretation and guidance is available to all, which ensures the uniform application of the State aid rules throughout the EEA.
2) Establish a Community of Practice on State aid as part of TI governance at EU level as a platform for exchange of experience on setting up funding programmes for TIs that are conform with the State aid rules, identifying novel State aid related questions, and developing guidance on setting up TIs that are in line with State aid legislation.
3) Set up and implement in this context a mutual learning exercise (MLE) among Member States addressing the approach to State aid issues at national level.
    - This would provide the opportunity to identify the different national approaches in the implementation of State aid rules by the Member States and create conditions for greater alignment of the implementation of State aid rules with respect to TIs across the EU, which is essential in view of co-funding of potential commonly agreed TI investments in the future.
    - The MLE could for example help to standardise checklists how Member States should deal with State aid rules to evaluate investments in TI, which would facilitate the alignment of investments and reduce the time needed to take a decision.
4) Updating the 'Decision tree for State aid rules' by the Commission to cover the new provisions for TEIs of the revised GBER and the RDI framework, as well as recent case law of the European Court of Justice.
    - This could include guidance on the specific questions on the State aid framework provisions for TEIs and their application identified by the Expert Group:
        - Conditions applicable specifically to publicly supported investments in TEIs;
        - Supporting access to TEIs by SMEs and start-ups (e.g. vouchers)- this should include an analysis of the conditions under which a specific category of stakeholders could be offered privileged access in line with State aid rules;
        - Supporting operation of TEIs (e.g. coverage of maintenance, etc.);
        - Handling a change of the business model of an infrastructure (e.g. what happens from the State aid perspective if an infrastructure, during operation, goes over a certain

[38] Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty Text with EEA relevance. ELI: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02014R0651-20230701

percentage of economic activity included in the business model under which the original investment was made);

- Guidance from the EC with respect to TIs and State aid rules could specify under what conditions a TI needs to be considered a TEI and when it can be considered a RI, under the current RDI State aid framework. It could also identify factors that may lead to the public funding for TIs to be considered State aid (or the absence of State aid).

As an alternative, such guidance could be developed under the proposed future Community of Practice, if it is not feasible to include it in the revision of the 'Decision Tree'.

It would also be beneficial to explore lessons from the existing TI funding and operation models set up in compliance with EU State aid rules, such as Norwegian Catapult Centres (see box).

Box 3. Example of the Norwegian Catapult Centres model on approaching State aid

The Norwegian Catapult initiative strengthens technological infrastructure to accelerate and enhance industrial innovations, particularly for SMEs facing barriers to accessing or establishing test facilities. The scheme features five technology areas—Manufacturing Technology, Future Materials, Digital, Sustainable Energy, and Ocean Technologies—supported by five catapult centres and eight nodes. These centres foster innovation and collaboration by providing shared facilities, expertise, and industrial partnerships.

Each centre operates as a cluster comprising a facilitator and leading industrial partners, who optimise test and verification infrastructures. Over 40 major Norwegian enterprises are contractually committed to sharing their test facilities with third parties, promoting accessible innovation ecosystems.

State aid is provided to these centres under the EU's R&D&I Framework, facilitating investments in open, shared infrastructures to address market failures and coordination inefficiencies. Aid is channelled through the Industrial Development Corporation of Norway (SIVA)[39] to ensure compliance, with a notification process underway to sustain the scheme within funding limits.

The Norwegian Catapult scheme exemplifies a strategic approach to overcoming innovation barriers and promoting collaborative industrial growth across key technology areas.

[39] See: https://siva.no/virkemidler/norsk-katapult/

7. Coordination and prioritisation of investment in TIs

The future TI landscape must be structured to reflect users' needs to remain relevant, efficient and sustainable, supported by effective governance models that enhance European competitiveness and address strategic priorities. Currently, the EU lacks mechanisms to identify common investment priorities for TIs, and the fragmented infrastructure landscape limits collaboration. This hinders the EU's ability to develop large-scale, state-of-the-art (or networked) facilities requiring pooled expertise and funding. Successful initiatives like the Chips Pilot Lines demonstrate the potential of coordinated efforts, though they often require substantial legal frameworks, such as the Chips Act, to proceed.

To support the development of TIs, there is a need for effective investment prioritisation and funding allocation mechanisms. There are examples of successful prioritisation mechanisms that support the development of TIs at national level or, in specific cases, at EU level. However, there is a lack of a broader EU coordination mechanism for TIs. This section proposes options for:

- Coordination and governance mechanism for TIs,
- Investment prioritisation for TIs, and
- Developing TI pilot actions.

7.1. Models for a coordination and governance mechanism for TIs at EU level

The Expert Group compared different existing governance models (see the box below) that serve to identify EU priorities for R&I investments as regards their components relevant for a European TI governance. Several of these models are described in the report on the TI policy landscape prepared by Technopolis Group[40] and in the report from the RITIFI project[41]. Box 4 presents models selected by EGTIs to demonstrate the diversity of existing governance structures.

Box 4. Main governance frameworks relevant to TIs

1. European Strategy Forum on Research Infrastructures (ESFRI). ESFRI is a strategic forum involving national governments, the scientific community and the European Commission, shaping RI policy in Europe.

- Relevance for TIs:
  - ESFRI Roadmap identifies European RI investment priorities; a similar but more flexible approach is needed for TIs.
  - ESFRI facilitates and influences funding decisions at EU and national levels.
  - ESFRI Strategy Working Groups could inspire governance models for TIs.

2. Standing Committee for Agricultural Research (SCAR). SCAR is a Member State-led forum addressing R&I challenges in the agri-food sector, organised into Strategic and Coordination Working Groups.

- Relevance for TIs:
  - SCAR discussions shape CAP innovation pillars and Horizon Europe's Cluster 6 topics.

[40] Technology Infrastructures - European Commission
[41] Home - RITIFI. A full draft report on governance options for TIs is annexed to this paper. It shortly analyses different governance mechanisms existing at EU level and identifies elements relevant for TIs.

- Flexible group creation and dissolution respond to strategic shifts.
- Involvement of sector-specific ministries strengthens industrial strategy links.

3. Institutionalised Partnerships. These long-term R&I partnerships (e.g. Art. 185 - Metrology, Art. 187 - Joint Undertakings, EIT KICs) are based on robust legal frameworks to integrate EU, Member States, and industry efforts.

- Relevance for TIs:
  - Mandates cover strategic planning and funding coordination.
  - Partnerships could house a TI pilot, integrating a TI pillar into existing strategies under current governance.

4. Co-programmed EU Partnerships (e.g. EOSC) The European Open Science Cloud (EOSC) exemplifies a partnership approach uniting public and private stakeholders to fund and implement a common shared vision in a specific technology field.

- Relevance for TIs:
  - Multi-stakeholder governance, including national governments and research organisations through a formalised legal entity structure (the EOSC Association) , fosters collaboration.
  - Roadmaps and strategic agendas support coordination with national/regional initiatives and Horizon Europe funding.

5. Joint European Forum on Important Projects of Common European Interest (JEF-IPCEI[42]). The JEF-IPCEI identifies areas of strategic EU interest for potential future IPCEIs and works to increase the effectiveness of the design, assessment and implementation of IPCEIs.

- Relevance for TIs:
  - A partnership composed of Member State authorities and European Commission representatives. The JEF-IPCEI may also invite representatives from candidate countries, industry, academia and other stakeholders.
  - The forum is organised around two levels: High level: senior Member State officials responsible for economic and industrial policy and senior Commission officials. Technical level: Member State authorities responsible for IPCEI matters and officials from the European Commission.
  - The JEF-IPCEI aims to develop methodologies covering the entire lifecycle of the IPCEI process and work via four workstreams: (1) identification, (2) design, (3) assessment and (4) implementation and evaluation.

There are existing examples of successful coordination mechanisms supporting the development of TIs. They provide a tested approach to bringing together relevant TI services under one organisational umbrella in a technology area, facilitating access for companies. They demonstrate the potential to coordinate efforts, investments and R&I agendas of TIs in priority areas.

Box 5. Examples of approaches to building shared platforms of TIs

The Nordics Testbed Network: This is a many-to-many platform that supports networks of TIs in the Nordic and Baltic regions. The platform facilitates the exchange of knowledge and

[42] IPCEI are governed through a framework under EU State Aid rules. This framework allows Member States to provide significant support to collaborative and cross-border projects of strategic importance while ensuring compatibility with the EU's internal market principles. See https://competition-policy.ec.europa.eu/state-aid/ipcei_en

technology transfer among R&D stakeholders and enables them to contribute to the development of testbeds tailored to their needs, regardless of their geographical location.

The Open Innovation Testbeds (OITB) instrument under Horizon Europe: This instrument supports the development of many-to-many platforms that provide common access to physical facilities, capabilities, and services established in at least three Member States and Associated Countries. The OITB instrument requires the establishment of a legal entity that should be operational within the first six months of the project and organises yearly workshops that serve as a platform for sharing best practices and discussing topics ranging from acquiring clients to transitioning from research projects to business.

The Testing and Experimentation Facilities (TEFs) funded through the Digital Europe programme: These are centralised platforms for testing and experimenting with AI-based solutions in real-world environments. The TEFs are specialized large-scale testing and experimentation facilities open to all technology providers across Europe to test and experiment at scale state-of-the-art AI solutions. One large TEF is funded per sector (Agrifood, Healthcare, Manufacturing, Smart Cities and Communities), composed of a network of around 4-6 nodes in at least three countries (possibly including smaller facilities, so-called “satellites” that are connected to one or more nodes).

Improved EU coordination of TIs could harmonise standards, enhance networking, and avoid duplication, benefiting the broader EU market. Establishing TI networks in strategic technology areas would boost service accessibility and operational coherence.

7.2. Proposed features of an EU level coordination and governance features for TIs

A multi-actor **framework for cooperation and coordination** should include:

- A common definition of TIs and their services, to ensure a shared understanding among Member States and key stakeholders. This definition should encompass a wide range of services and remain adaptable to the specific subset of services provided by each TI.
- A comprehensive set of common objectives and priorities for TIs, to guide investment decisions and ensure alignment with EU policy objectives.
- A platform for sharing information and best practices among Member States authorities and key stakeholders (e.g. industry, RTOs), to support the development of TIs and their services. This could include: workshops and conferences, to bring together experts and stakeholders from across the EU, a knowledge-sharing platform, to provide access to information and best practices on TIs and their services, the development of case studies and other, to provide insights and lessons learned from the development and operation of TIs.
- A mechanism for sharing information and best practices among TIs and between TIs and RIs, including key performance indicators, to foster cross-sectoral and cross-border synergies, as well as facilitate learning from successes and challenges within the broader infrastructure landscape. This could include the drafting of common technical and operational standards and guidelines for TIs to ensure that they are developed, managed and operated in a consistent, interoperable, safe and effective manner.
- Advisory service for business modelling and/or business plans to provide TIs with tools and resources to ensure their long-term sustainability and alignment with market and societal needs.

- A mechanism to facilitate mapping of TIs and joint investment decisions and avoid duplication of efforts to maximise the efficient use of resources and foster collaborative investment strategies.

A coordinated European road-mapping exercise and gap analysis would improve policymaking, reduce fragmentation, and prevent duplication. This should include a cross-border market analysis of supply and demand to align Technology Infrastructures (TIs) with user needs. The EU could lead such efforts, integrating national and institutional initiatives while focusing on the development and testing of critical technologies through existing structures.

This coordinated framework would enhance the efficiency and impact of TI investments. By involving all relevant stakeholders - industry, academia, TI hosts and civil society - the EU can ensure inclusive policy development and investment prioritisation. Stakeholder engagement is crucial for shaping effective TI strategies.

While some Member States prioritise specific technology areas, such as ICT, biotechnology, and nanotechnology, preferences vary widely. The EU should identify common strategic technology sectors for TI support that align with the EU policy goals while respecting the subsidiarity principle.

The Expert Group considers that a **governance framework for TIs** should consist of two layers: horizontal coordination and thematic coordination, each with distinct yet complementary roles.

1. Horizontal Coordination

Functions:

- Define priorities using a shared framework with agreed criteria.
- Provide a platform for strategic reflection, mutual learning, and developing common approaches.
- Offer funding for cross-cutting activities.

Structure:

An informal advisory forum with high-level representatives from all Member States, the European Commission, broad representation of industry umbrella organisations, and TI-hosting entities. This group ensures technological foresight and expertise in TIs' functions and operations, integrating them into broader strategies.

There are three basic implementation options in which a horizontal coordination mechanism for TIs could be established:

1) integrated into an already existing governance structure with relevant scope and competences,
2) embedded into a new governance that could be set up to foster EU's competitiveness and oversee the related priority setting and investments, or
3) established as a completely new body dedicated exclusively to Technology Infrastructures.

TIs are distinct from RIs and should be governed in line with their unique characteristics (see Chapter 3), emphasising industrial policy as much as R&I policy. Hence, the option recommended by EGTIs is the creation of a new, dedicated TI governance body based on the specificity of TIs. National representatives in such a forum, beyond ministries responsible for research and innovation, could also be connected to ministries of industry or economic development to align TI governance with industrial and technological competitiveness goals.

2. Thematic Coordination

Responsibilities:

- Implement actions tailored to specific priority areas.

- Facilitate networking of TIs in targeted technology sectors or ecosystems, also with users and stakeholders.
- Coordinate funding for TI investments.

Implementation:

Utilise, as much as possible, existing structures such as European Partnerships to engage key stakeholders and regional authorities, ensuring alignment with EU and regional strategies (e.g. smart specialisation). Public-private partnerships should play a central role in pooling funding and expertise. For example, the Strategic Research and Innovation Agendas of Partnerships, and other relevant EU initiatives, should integrate the assessment of the landscape and needs for TIs as well as the existing gaps.

Participation of regional and local authorities would also be important as many regions may have their own TIs strategies and funding programmes, developed as part of their smart specialisation strategies, that align with EU policy objectives and priorities.

Key Tools:

- Taking account of the existing mappings of TIs[43], map and develop directories of TIs and their services to make visible to all stakeholders and users the capabilities available across the EU.
- Establishing networks of TIs in specific technology areas, to facilitate cooperation and coordination among TI operators
- Platforms to connect TIs with potential users.
- Information-sharing mechanisms for best practices.
- Frameworks for joint investment decisions to avoid duplication.

Interplay Between Horizontal and Thematic Mechanisms

The Horizontal Coordination layer provides the overarching strategic framework, aligning thematic efforts with EU-wide objectives like competitiveness and technological sovereignty. It fosters strategic dialogue, supports mutual learning and TI visibility, and ensures cohesion across efforts.

The Thematic Coordination layer operates within specific priority areas, addressing targeted needs. By leveraging tailored networks, flexible schemes, and granular coordination, it ensures practical, effective advancements.

Thematic mechanisms feed insights and progress into the horizontal framework, enabling monitoring, experience-sharing, and addressing implementation challenges. This interplay maximises alignment, avoids duplication, and enhances the overall impact of the EU's TI strategy.

A governance mechanism covering both the horizontal level and the thematic level, could be implemented in the form of a light advisory structure or a fully-fledged governance with a strong coordination, agenda setting and monitoring role.

- **An advisory model**: This option, inspired by SCAR and Joint European Forum on IPCEIs, is the lightest model which does not necessitate a legal form. It allows to set priorities for TIs and shape its landscape with a directionality based on needs from industry and set priorities from Member States. It would consist of both a high-level platform and a light coordination of thematic actions, completed by a secretariat.

[43] See for instance: European Commission: Directorate-General for Research and Innovation, Van de Velde, E., Braito, N., Van Roy, V., Pereira, T. et al., Mapping of technology infrastructures supporting clean and renewable energy industries in Europe, Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2777/028028

- **Fully-fledged governance model**: This is a policy driven model with industry, operators and funders inspired by ESFRI's modus operandi, but with a lighter structure and a more flexible approach to the coordination of funding and to its thematic coverage. This option reflects the high ambition level, and the highest level of commitment, that creates a stand-alone governance set-up that includes a high-level representation board, completed by a TI coordination board and a secretariat. In addition, TI thematic circles would, in its different thematic configurations, represent active TI operators in Europe, industry representatives as well as representatives from national administrations in the relevant departments.

The Expert Group considers that establishing and coordinating an ambitious European policy for TIs requires setting up a dedicated governance structure that can assume all the functions outlined above. In the short term, this should take the form of a light advisory structure that would allow for a reflection on the ultimate model for TI governance in the EU. The governance should include all Member States, the European Commission, a broad array of industry stakeholders and TI host organisations.

In addition, to ensure the expected impact of a TI policy, an EU coordination mechanism for TIs must be underpinned by European, national and regional strategies for TIs as well as the associated funding programmes supporting a set of commonly agreed activities and investments.

7.3. How should investments in TIs be prioritised?

Effective prioritisation should follow a clear process and agreed criteria such as: needs assessments, investment scale, alignment with policy objectives, technology relevance, and market demand. The identification and prioritisation of EU level TI pilot actions should consider the following:

- **Policy objectives**: The investment prioritisation mechanisms should be aligned with EU policy objectives, such as fostering Europe's competitiveness and strategic autonomy, increasing the resilience of European value-chains, and addressing societal challenges.
- **Critical technology areas of strategic interest to the EU, its Member States and regions** where the need to source and retain qualified experts and adequate infrastructures is even greater.
- A thorough **assessment of the current needs, coming from users and TI operators,** is necessary to identify the gaps and demands for TIs and their services. This involves analysing the current landscape of TIs, including their availability, accessibility, and utilisation rates. The needs assessment should also take into account the specific requirements of different industries, sectors, and regions.
- **Scale of investment needed** as combined or sequential funding covering different needs throughout the TI lifecycle is often the norm and reflecting the core task of public funding to close relevant gaps.
- Adopting a long-term perspective (e.g. using foresight or horizon scanning) on technology developments, likely future user needs and strategic positioning of the EU is required to ensure an adequate evolution of the TI capacities across the EU. Such an analysis should identify gaps in the current TI landscape and provide insights into the potential demand for new or upgraded TIs.

Prioritisation should foster collaboration among users and stakeholders but also between RIs and TIs, aiming at building interconnected value chains that span across sectors and regions, enhancing synergies and creating a more integrated and efficient innovation ecosystem. The analysis must consider localisation specificities for building complete ecosystems and fostering interaction among them and identify diverse funding sources to ensure long-term sustainability and equitable access to these infrastructures.

Identification of priorities requires a comprehensive horizon scanning, involving the TI hosting organisations as well as an in-depth analysis of user needs. To test how such a scan and identification process could work the Expert Group carried out an initial collection of ideas for potential pilot actions, listing a non-exhaustive set of examples with respective needed EU-level actions on TIs (see Annex).

The prioritisation of investments in TIs should be based on a sound assessment of the business plans, reflecting market needs, and including the funding sources made available for that TI investment, including CAPEX and OPEX. Next to prioritising investments, TI road-mapping processes may be required at EU level for specific technology areas or industrial ecosystems to identify future possibilities and to anticipate skills needs to operate any new or upgraded TIs.

A non-exhaustive set of examples where EU action on TIs would be needed, which may also involve additional investments, if such a need is confirmed by an in-depth analysis, has been identified by the Expert Group (see Chapter 8 - Annex). However, as argued above, an appropriate governance mechanism needs to be established to perform a broader horizon scanning of the needs for EU action on TIs in specific areas, and to prioritise them based on an agreed set of criteria.

The following criteria are proposed to guide the selection of priorities for EU actions on TIs:

1. **Achievability and Impact:**
    - Pilots should demonstrate tangible results, offering valuable lessons and achieving a mix of outcomes to maximize learning and flexibility.
    - Incorporate "quick wins" with sectors and technologies where groundwork or partnerships already exist (e.g., batteries, aviation, hydrogen, clean energy, semiconductors).
2. **Strategic Relevance:**
    - Address urgent and critical challenges with significant implications, stimulating immediate industry action without waiting for policy maturation.
    - Target emerging and disruptive technologies with high breakthrough potential, such as quantum computing and biotechnology.
    - Addressing gaps in R&D&I capacities in strategic value chains.
3. **Gap Closing:**
    - Identify and address existing gaps in facilities, services, accessibility, or technology readiness.
    - Focus on bridging significant gaps in critical areas to ensure competitiveness and technological sovereignty (e.g., accessibility, emerging markets, geographical reach).
4. **Ecosystem Development:**
    - Foster collaboration among large industries, SMEs, and start-ups, promoting scale, innovation, and cross-sector synergies.
    - Leverage TIs to build connections between high-tech sectors and traditional industries (e.g., advanced manufacturing and renewable energy).
5. **Training and Skills Development:**
    - Clearly address identified industry needs for workforce development, emphasising training and upskilling opportunities.
    - The potential for TIs to recruit staff with the required STEM qualifications and expertise to operate TIs and provide services.

6. **Accessibility:**

   - Consider geographical accessibility to ensure TI availability aligns with user needs, while reducing barriers to entry for companies across Europe.

7. **Implementation Feasibility:**

   - Evaluate governance readiness, stakeholder involvement, and availability of resources to support pilot rollouts effectively.

8. **Financial Viability:**

   - Target financial support towards:
     - First-of-a-kind TIs or significant upgrades of existing ones.
     - Technologies benefiting multiple sectors or improving EU industrial competitiveness.
     - Innovations aligning with EU climate and sustainability goals.

By applying these criteria, EU actions can balance learning opportunities, address critical industry needs, and contribute to Europe's strategic technology and innovation goals. The application of these criteria should also allow for a 'mix' of pilot types to a) maximise the learning experience, b) remain flexible to evolving industry needs and c) to accommodate different budget scenarios.

7.4. Pilot actions to test a European approach to TIs

The Expert Group consider that the added value of an effective European approach to TIs lies in achieving tangible and measurable impact in specific strategic areas by identifying pilot actions. Hence, the Expert Group proposes a set of criteria for the selection of pilots that would test different strategies and instruments, and their feasibility, as well as learn from the implementation experience of a European approach in a given area and with a given objective.

The overarching goal of a pilot is to test a European approach to TIs with a limited set of selected actions to improve the availability of infrastructure facilities and services in key technology areas for the future and their accessibility for companies across the entire EU, in or across industrial ecosystems.

A pilot should therefore include at least: the identification of needs, different options to address the needs, the choice of actual instruments to address the identified needs, and their implementation, including planned actions, expected results and impact, a timeline and a budget and respective funding sources. The implementation of a pilot should be accompanied and followed by an analysis of impact and lessons learnt. Pilots are a way of learning through 'first of a kind' endeavours – they are meant to pave the way for a wider application of the measures provided by the EU policy and to close urgent capacity or access gaps. The EU should consider supporting the implementation of such pilots under Horizon Europe.

A pilot action should examine, assess and respond to identified needs, existing expertise and the approach taken to address specific ecosystems (e.g. regarding technologies as compared to industrial ecosystems or geographically defined ecosystems). For each selected pilot action, the decision on the goal(s) of pilot action would be based on a mapping of existing barriers, gaps and shortcomings, and an evidence-based analysis of the most suitable means to address them.

A TI pilot would focus on measures to enhance innovation and address industry needs and technological trends, identification of potential gaps and mismatch between supply and demand or instances where existing regulation unintentionally imposes obstacles to accessing TIs. This includes defining key areas of analysis, fostering networks between TIs for seamless cooperation, and conducting comprehensive mapping and gap analysis of existing (and planned) RI and TI facilities and services. The pilot would identify relevant stakeholders, and financial resources, while proposing strategies to overcome obstacles through operational measures and investment plans.

Implementation could involve technical planning, facility upgrades, new service deployment, training for industry professionals, and developing access mechanisms like remote access and regulatory sandboxes. It could also promote innovation ecosystems across regions and address regulatory barriers.

Finally, an impact assessment would draw lessons that would guide future initiatives. The selection and analysis of pilot actions and the definition of related European investment strategies would have the objective to achieve, through the provision of adequate infrastructures, services and cooperation options, an evident and traceable impact on the volumes, priorities and speed of industrial R&I investments, and developing and exploiting new technologies in Europe, their scale-up and deployment and competitive market positioning.

The completion of an initial, limited set of EU pilots should lead to designing fully-fledged, comprehensive EU actions on TIs in selected priority areas.

8. Annex: Pilot Actions for Technology Infrastructures

8.1. Introduction

As part of the effort to strengthen the provision of services by technology infrastructures (TIs) to European industry, a collection of ideas for pilot actions was launched by the EGTI to identify and test different strategies and instruments for improving the availability and accessibility of TIs. This annex presents the collected examples and provides an analysis and classification, according to a typology, of the actions they aim to test, such as for example TI mapping, the creation of one stop shop, the integration of TI with Research Infrastructure, etc. In general, these pilots would address common issues such as fragmentation, capability gaps and SME access to TIs and aim to improve scalability, time-to-market, and TI funding while streamlining access. The aim is helping policy makers to select and launch a number of pilot actions to test and implement the European approach to Technology Infrastructures.

8.2. Pilots to test a European strategy for TIs

As explained in Chapter 7.3 of this report, the rationale for this exercise is rooted in the need to address several critical challenges facing Europe's technological and industrial ecosystems:

- Fragmentation of existing TIs: many existing infrastructures operate in isolation, often limited to regional or national boundaries. This fragmentation hampers collaboration and prevents the pooling of resources to address shared challenges effectively.
- Gaps in technological capabilities: emerging sectors such as hydrogen technologies, circular economy, and edge AI demand specialised facilities that are currently either inadequate or non-existent in Europe.
- Accessibility for small and medium-sized enterprises (SMEs): SMEs often lack the financial or logistical means to access state-of-the-art TIs, limiting their ability to innovate and compete on a global scale.
- Regulatory and funding barriers: complex regulatory frameworks and insufficient funding mechanisms create obstacles for cross-border collaboration and the development of new infrastructure.
- Alignment with EU Strategic Goals: the European Green Deal, the digital transformation agenda, and the push for technological sovereignty all require robust TIs to succeed. These infrastructures must support sustainability, competitiveness, and resilience across industrial sectors.

By implementing targeted actions in key areas, the pilots would seek to:

- Test innovative approaches for improving the accessibility, functionality, and integration of TIs.
- Develop new governance and funding models to enhance the sustainability of these infrastructures.
- Foster cross-border collaboration and create a cohesive European TI ecosystem.

The overarching goal of such pilots is to be more than technical trials; they should constitute strategic investments in Europe's future, aiming to secure its position as a global leader in technology and innovation. The lessons to be learned from these pilot actions should provide invaluable insights for scaling successful models across the continent, ensuring that European industries remain at the forefront of global technological advances.

8.3. Collected examples of potential Pilots

The Expert Group and the European Commission collected a total of 18 ideas for pilot actions, covering a wide range of thematic areas. The goals of the proposed pilots vary, but most aim to improve the availability and accessibility of TIs, develop synergies with RIs, enhance innovation and competitiveness, and address specific industrial and R&I needs in the EU. This chapter provides a brief summary of each of the 18 pilots.

- **Pilot 1: 6G Campus Europe:**

The 6G Campus Europe pilot aims to develop and deploy a 6G network infrastructure, transforming existing 5G environments into cutting-edge 6G platforms. It includes the development of new 6G technologies and the creation of a 6G testbed. The goal is to improve the competitiveness and innovation capacity of European industry, and to address complex societal challenges. This would involve the development of new 6G technologies, the creation of a 6G testbed, and the establishment of a community of 6G practitioners. Located in Aachen, Germany, the pilot would also focus on the development of 6G applications for various industries, such as manufacturing, healthcare, and transportation and will involve telecommunications companies.

- **Pilot 2: AI Algorithms:**

The AI Algorithms pilot would focus on the development and deployment of artificial intelligence algorithms, including machine learning and deep learning. The goal is to improve the efficiency and effectiveness of industrial processes, and to reduce costs and improve product quality. By establishing foundational technology infrastructures for deploying AI on edge devices, it seeks to enable real-time data processing with minimal latency. This is particularly relevant for sectors such as manufacturing, healthcare, and automotive. While Europe has a strong regulatory framework for AI, reliance on non-European platforms is a vulnerability. This pilot, with the involvement of already identified industrial players, would map existing infrastructures, integrate services, and develop accessible frameworks to empower SMEs and support technological sovereignty.

- **Pilot 3: Automotive**:

The Automotive pilot aims to develop and deploy new automotive technologies, including electric vehicles, autonomous vehicles, and connected cars. The goal is to improve the competitiveness and sustainability of the European automotive industry, and to reduce environmental impact. The pilot would focus on the development of automotive applications for various industries, such as transportation, logistics, and tourism. This initiative would focus on mapping existing resources, integrating TIs, and enhancing collaboration across the automotive ecosystem. Partners such as Fraunhofer, CEA, and VTT are expected to contribute. By addressing gaps in infrastructure, the pilot aims to accelerate the transition to greener and smarter mobility solutions.

- **Pilot 4: Aviation**:

The Aviation pilot focuses on the development and deployment of new aviation technologies, including aircraft design, manufacturing, and maintenance. The goal is to improve the competitiveness and sustainability of the European aviation industry, and to reduce environmental impact. Strategic wind-tunnels for aviation are particularly essential for testing low-emission technologies in realistic conditions. This pilot aims to adapt and revamp wind-tunnel capabilities, creating a reference network accessible to both large corporations and SMEs. Despite a robust aviation research ecosystem in the EU, access is often limited to well-resourced actors. ONERA, DLR, and the Clean Aviation Partnership are expected to lead this effort. The pilot's focus would include ensuring wider access, enhancing testing capabilities, and integrating these infrastructures into broader EU strategies for sustainable transport.

- **Pilot 5: Batteries:**

The Batteries pilot aims to develop and deploy new battery technologies, including lithium-ion batteries, solid-state batteries, and fuel cells. The goal is to improve the competitiveness and

sustainability of European industry, and to reduce environmental impact. The European Battery Incubator would seek to create a shared battery technology database and establish digitalised TIs to enhance SME access. Potential partners include BEPA, Battery2030+, and members of the RITIFI project, so as to build upon lessons from existing European collaborations. Despite growing demand, gaps in infrastructure and uneven geographical distribution hinder progress. The pilot would address these issues by developing a strategic roadmap, integrating TIs, and prioritising funding mechanisms. The pilot would also focus on the development of battery applications for various industries, such as energy, transportation, and construction.

- **Pilot 6: Carbon Technologies:**

The Carbon Technologies pilot focuses on the development and deployment of new carbon technologies, including carbon capture, utilisation, and storage. The goal is to reduce greenhouse gas emissions and improve the sustainability of European industry. It aims to develop mobile, containerised infrastructures for carbon capture, utilisation, and storage (CCUS). By enabling on-site testing of industrial CO2 emissions, the pilot seeks to accelerate technology adoption and optimise scalability for diverse sectors. Proposed partners include the CAPTURE and Smart Delta Resources platforms. Current challenges include high costs and fragmented research efforts. This pilot would establish a roadmap to standardise testing protocols and enhance collaboration across sectors. The pilot would also focus on the development of carbon applications for various industries, such as energy, chemicals, and construction.

- **Pilot 7: Chemical Industry:**

The Chemical Industry pilot aims to develop and deploy new chemical industry technologies, including process optimisation, safety, and sustainability. The goal is to improve the competitiveness and sustainability of the European chemical industry, and to reduce environmental impact. It would focus on scaling up sustainable chemical processes, including material recycling and bio-based production. The pilot aims also to overcome regulatory and logistical barriers, streamline access to pilot facilities, and accelerate commercialisation. Partners such as BASF, Fraunhofer, and leading universities are expected to collaborate. The pilot would also focus on the development of chemical industry applications for various industries, such as pharmaceuticals, agrochemicals, and materials.

- **Pilot 8: Circular Materials**:

The Circular Materials pilot focuses on the development and deployment of new circular materials, including recycling, reuse, and waste reduction. The goal is to reduce waste and improve the sustainability of European industry. By enabling pan-European circular material flows, the intention is to enhance industrial resilience and reduce resource dependencies. By targeting critical sectors such as plastics, textiles, and construction, the pilot aims to harmonise regulatory frameworks and implement EU-wide quality guidelines for material reuse and recycling. Key partners include DTI, VTT and Fraunhofer. Current efforts in circular economy are hindered by fragmented infrastructures and inconsistent regulations. This pilot would establish a coordinated network of TIs, streamline access for industrial users, and promote sustainable practices across multiple ecosystems. The pilot would also focus on the development of circular materials applications for various industries, such as manufacturing, construction, and packaging.

- **Pilot 9: Hydrogen Technologies:**

The Hydrogen Technologies pilot aims to develop and deploy new hydrogen technologies, including hydrogen production, storage, and utilisation. The goal is to improve the competitiveness and sustainability of European industry, and to reduce environmental impact. This pilot is designed to validate and characterise hydrogen systems at scale, addressing critical gaps in Europe's energy transition strategy. By leveraging existing infrastructures and creating new ones where necessary, the pilot aims to improve scalability and de-risk hydrogen technologies for industrial deployment. Hydrogen Europe and EERA are considered as key stakeholders. Current facilities are sparse and lack the capacity to meet the demands of large-scale validation. The pilot would integrate supply chains, prioritise infrastructure upgrades, and foster collaboration to accelerate

the adoption of hydrogen technologies. The pilot would also focus on the development of hydrogen applications for various industries, such as energy, transportation, and chemicals.

- **Pilot 10: Biotech and Biomanufacturing**:

The Industrial Biotechnology and Biomanufacturing pilot focuses on the development, scaling up and deployment of new biotechnology and biomanufacturing technologies, including biomedicine, bioenergy, and bioproducts. The goal is to enhance the competitiveness and innovation capacity of European industry, while addressing complex societal challenges. Industrial biotechnology and biomanufacturing hold transformative potential for the bioeconomy and health sectors. This pilot would generate a roadmap for scaling biomanufacturing solutions and industrial processes, identifying technological bottlenecks, and fostering collaboration between research organisations, universities of applied research and industry. IBISBA network and EuropaBio are likely partners in this endeavour. While Europe has made strides in biotech, gaps in scaling facilities remain a barrier to commercialisation. The pilot's actions include mapping existing TIs, addressing regulatory challenges, and creating frameworks for translational research that bridge the lab-to-market gap. The pilot would also focus on the development of biotechnology and biomanufacturing applications for various industries, such as pharmaceuticals, agriculture, and energy-renewables.

- **Pilot 11: Materials Characterisation**:

The Materials Characterisation pilot aims to develop and deploy new materials characterisation technologies, including materials testing, analysis, and simulation. The goal is to improve the efficiency and effectiveness of industrial processes, and to reduce costs and improve product quality. It seeks to establish state-of-the-art facilities for evaluating novel materials. Key objectives include improving time-to-market, integrating TIs, and enhancing SME access. Partners include Fraunhofer, CEA, and leading material science institutes. The pilot addresses gaps in testing and validation capabilities, ensuring Europe remains competitive in advanced materials innovation. The pilot would also focus on the development of materials characterisation applications for various industries, such as aerospace, automotive, and energy.

- **Pilot 12: Photonics and Health**:

The Photonics and Medical Devices pilot focuses on the development and deployment of new photonics and health technologies, including medical imaging, diagnostics, and therapeutics. The goal is to improve the competitiveness and innovation capacity of European industry, while addressing complex societal challenges. The pilot aims to create a TI network for the development and validation of photonics-based medical technologies. Key objectives include integrating R&D facilities for marked driven prototyping, enhancing SME access and supply chains, and harmonising regulatory standards. Partners may include RTOs, the supplier industry, medical device manufacturers, and EU regulatory bodies. The pilot addresses critical gaps in device validation and aims to improve time-to-market for cutting-edge medical technologies. Additionally, the pilot would also focus on the development of photonics and health applications for various industries, such as healthcare, biotechnology, and promoting the uptake of these technologies in heavily regulated medical device domains.

- **Pilot 13: Remote Operations in Safety and Security Critical Domains:**

The Remote Operations in Safety and Security pilot aims to develop and deploy new remote operation technologies for safety and security critical domains, including energy industry, mining, healthcare, transportation, aerospace and industrial maintenance in demanding operating environments. The goal is to improve the efficiency and effectiveness of remote operations, and to reduce costs and improve safety and security. The pilot aims to establish framework and roadmap for shared TIs that support real-time monitoring, maintenance, and training. Partners such as research and technology organisations (RTOs), SMEs and midcaps, and industry leaders in robotics and advanced user interfaces, XR, AI, connectivity, machine learning and automation are expected to play key roles. By addressing gaps in interoperability and accessibility, the pilot would enhance Europe's capabilities in remote operation technologies. Additionally, the pilot would also focus on the development of remote operation applications for various safety and security critical

domains, such as high security operations solutions for robotics, nuclear safety, fusion reactor maintenance systems, and other demanding safety critical industrial domains.

- **Pilot 14: Self-Driving Labs:**

The Self-Driving Labs pilot focuses on the development and deployment of new self-driving lab technologies, including autonomous systems, robotics, and artificial intelligence. The goal is to improve the efficiency and effectiveness of industrial processes, and to reduce costs and improve product quality. Self-Driving Labs leverage artificial intelligence and automation to revolutionise materials discovery and R&D processes. These autonomous laboratories will optimise experiments, reducing time and cost while increasing efficiency. The pilot aims to build and integrate new TIs capable of supporting the seamless operation of self-driving labs across Europe. Academic consortia, AI developers, and material science companies are expected to play a key role. Although Europe leads in AI research, interoperability among labs remains a challenge. This initiative would address gaps by creating state-of-the-art facilities, ensuring SMEs have equitable access, and fostering collaboration across borders. The pilot would also focus on the development of self-driving lab applications for various industries, such as manufacturing, logistics, and healthcare.

- **Pilot 15: Smart Construction:**

The Smart Construction pilot aims to develop and deploy new smart construction technologies, including building information modelling, construction automation, and sustainable building. The goal is to improve the competitiveness and sustainability of the European construction industry, and to reduce environmental impact. It aims to develop advanced TIs for sustainable construction materials and methods. By integrating digital twins and circular design principles, the pilot seeks to enhance Europe's competitiveness in construction innovation. Partners include leading RTOs and construction firms. Current challenges include limited access to cutting-edge testing facilities and inconsistent standards. The pilot would establish a unified framework for testing, certification, and scaling innovative construction technologies. The pilot would also focus on the development of smart construction applications for various industries, such as building, infrastructure, and urban planning.

- **Pilot 16: SMRs Supply Chain:**

The SMRs Supply Chain pilot focuses on the development and deployment of new supply chain technologies for Small and Advanced Modular Reactors (SMRs/AMRs), including design, manufacturing, and construction. The goal is to improve the competitiveness and sustainability of the European nuclear industry, and to reduce environmental impact. It aims to address gaps in infrastructure, regulatory alignment, and industrial capabilities to enhance Europe's competitiveness in next-generation nuclear technologies. It can build upon the newly created European Industrial Alliance on Small Modular Reactors and the existing SNETP platform. The pilot would also focus on the development of supply chain applications for various industries, such as energy, construction, and manufacturing.

- **Pilot 17: Test at Sea:**

The Test at Sea pilot aims to develop and deploy new testing and validation technologies for offshore wind energy, including testing, inspection, and maintenance. The goal is to improve the competitiveness and sustainability of the European offshore wind energy industry, and to reduce environmental impact. The goal is to strengthen European TIs in the blue economy, particularly in offshore renewable energy and clean technology, by focusing on integrating and expanding existing TIs rather than creating entirely new facilities, ensuring a stronger and more connected European network for offshore technology testing and validation. It would build upon an array of previous European projects such as EU-Scores or HOPE and sectorial organisations, such as InterWaters, OEE and WindEurope. The pilot would also focus on the development of testing and validation applications for various industries, such as energy, transportation, and construction.

- **Pilot 18: Wind Energy:**

The Wind Energy pilot focuses on the development and deployment of new wind energy technologies, including wind turbine design, manufacturing, and maintenance. The goal is to improve the competitiveness and sustainability of the European wind energy industry, and to reduce environmental impact. It aims to advance the testing and validation of wind turbine components under real-life conditions. This thematic focus aligns with Europe's goals for renewable energy and climate resilience. By addressing the fragmentation in current testing facilities, the pilot seeks to establish a unified platform that enables companies, particularly SMEs, to accelerate innovation and deployment. Potential partners include the European Wind Energy Association, Fraunhofer IWES, and VTT Finland. Despite the presence of world-class infrastructures, access is uneven across regions. Actions would focus on mapping existing TIs, creating a centralised access point for testing, and ensuring faster time-to-market for cutting-edge turbine technologies. The pilot would also focus on the development of wind energy applications for various industries, such as energy, transportation, and construction.

The 18 pilot actions proposed can also be organised[44] into several categories addressing the technology fields and industrial ecosystems they would contribute to improve:

- **Energy and Environment:** 6G Campus Europe, Automotive, Aviation, Batteries, Carbon technologies, Hydrogen technologies, SMRs supply chain, Test at Sea, and Wind energy.
- **Materials and Manufacturing:** Materials Characterisation, and Smart construction.
- **Digitalisation and Automation**: AI algorithms, Remote operations in safety and security, and Self-driving labs.
- **Biotechnology and Healthcare**: Biotech and biomanufacturing, Photonics and Health.
- **Circular Economy**: Circular materials, Chemical industry

Moreover, many pilots align with the EU's Green Deal by promoting sustainable practices and decarbonisation. Sustainability-focused actions drive the transition to a green economy, reinforcing Europe's leadership in climate action and environmentally conscious innovation.

8.4. Typology of Actions

The 18 pilot actions cover a broad spectrum of activities but can be grouped into key typologies based on their objectives, operational focus, and strategic outcomes. This typology provides insights into the systemic improvements these pilots aim to achieve for European TIs.

- **Mapping Available TIs and Services**

Several pilots emphasise the importance of creating a comprehensive map of existing TIs, highlighting capabilities, gaps, and opportunities for optimisation. Mapping enables a coordinated approach to resource allocation, ensures transparency in capabilities, and highlights regional disparities. This action is foundational for creating a cohesive TI ecosystem that aligns with EU strategic goals. *Some examples[45]: SMR supply chain, Industrial Biotech, and Automotive.*

- **Elaborating Strategic Roadmaps**

Strategic roadmaps provide frameworks for long-term development and integration of TIs. Roadmaps facilitate alignment across stakeholders, define clear milestones, and guide investments. By addressing regulatory bottlenecks and technical gaps, they ensure consistent

[44] It should be noted that many of these above pilots could fit in two or more categories. The categorisation only mentions their main technology fields and industrial ecosystems.

[45] All the examples mentioned in this chapter are non-exhaustive.

progress towards innovation and sustainability. *Some examples: Batteries, Carbon technologies, and Test at Sea.*

- **Integrating TIs and relevant supply chains**

Some pilots focus on creating synergies between TIs and industrial supply chains as integration ensures that innovations transition smoothly from research to deployment. It fosters cross-sectoral collaboration and strengthens Europe's position in critical industrial domains. *Some examples: Hydrogen Technologies, Aviation, and Photonics and Health.*

- **Integrating RIs and TIs together**

Some pilots will help ensure that research findings transition smoothly into industrial applications by fostering closer collaboration between research institutions and TIs. Indeed, integrating RIs and TIs is crucial for ensuring that technological advancements do not remain confined to the research phase but are effectively scaled and tested in real-world conditions. Several systemic challenges must be overcome such as the fragmentation of resources, regulatory barriers and a need for cross-sectoral collaboration. *Some examples: SMR supply chain, Materials characterisation, Aviation.*

- **Scalability and improving time to market**

Pilots can support the rapid scaling of innovative solutions by ensuring that TIs provide the necessary industrial validation, certification, and standardisation processes as scaling and reducing time-to-market are critical factors in maintaining Europe's competitive edge in high-tech industries. The pilots in this category could contribute to develop standardised testing frameworks, fill a gap in high-TRL support and limit the financial risks for industry as companies may hesitate to invest in scaling without reliable validation and certification processes. *Some examples: Smart construction, Photonics and Health, Test at Sea.*

- **Create one stop shops**

Such pilots will look to streamline access to TIs by offering centralised platforms that provide integrated services, including technical support, funding guidance, and market access. One-stop shops simplify access to TIs for businesses, especially SMEs that often lack the resources to navigate complex infrastructures, bringing key benefits such as reducing administrative burdens, allowing faster innovation cycles and enhancing cross-sector collaboration. *Some examples: Wind Energy, SMR supply chain, self-driving labs.*

- **Identification, implementation and pooling of funding**

Pilots will focus on finding ways to address the underfunding of TIs by optimising the coordination of public and private financial resources as funding remains one of the most significant bottlenecks. Many pilots highlight the following challenges: short-term funding cycles (with project-based financing models which often do not align with the long-term needs of TIs); difficulty to consistently implement State Aid rules in pooling of funding from several Member States; a fragmentation of resources (multiple funding mechanisms exist but lack coordination, leading to inefficiencies). Some examples: *Carbon technologies, Industrial Biotech, Remote operations in safety and security.*

- **Revamping or Creating New TIs**

Some pilots target the establishment of entirely new infrastructures or significant upgrades to existing ones. These initiatives address gaps in capacity and functionality, supporting emerging technologies that require specialised facilities. By investing in cutting-edge infrastructures, Europe can maintain its competitiveness in global markets. *Some examples: Self-Driving Labs, Wind Energy, and 6G Campus Europe.*

- **Providing wider access and developing services for SMEs**

Several pilots emphasise democratising access to TIs, especially for SMEs. Expanding access levels the playing field, enabling SMEs to innovate and contribute to industrial growth. This action also ensures equitable distribution of technological benefits across regions and sectors. *Some examples: AI Algorithms, Aviation, and Photonics and Health.*

- **Regulation and IPR Management**

Some pilots focus on harmonising regulations and improving intellectual property rights (IPR) management. Regulatory clarity and streamlined IPR management reduce barriers to innovation. These actions ensure that European TIs remain attractive for global partnerships while fostering local industrial growth. *Some examples: Chemical Industry, Circular Materials, and Batteries.*

8.5. Conclusion

The proposed pilots demonstrate how improvements to the availability and accessibility of TIs, enhancing innovation and competitiveness in the EU, can be made. The typology of actions reveals a range of approaches, from mapping and strategic roadmapping to integration and scalability. These pilots intend to collectively address critical gaps in Europe's TIs deployment and accessibility, while aligning with strategic EU priorities such as sustainability, digital transformation, and competitiveness.

The pilots span a wide array of sectors and technologies, showcasing the adaptability of TIs to meet various industrial and societal needs, at the condition of ensuring an improved access to TIs for SMEs and start-ups. The emphasis on integrating TIs with relevant supply chains and RIs demonstrates the recognition of the importance of collaboration and coordination in accelerating innovation and competitiveness.

The short format requested for the proposal also led to some gaps and areas for improvement, including the need for more precisions on how to improve IPR management and regulations hampering development. Additionally, some proposals could benefit from a more detailed analysis of the potential impact and scalability of the proposed actions.

Overall, the identified examples of pilot actions have the potential to make a significant impact on the development and deployment of TIs in the EU, as they will provide essential insights for shaping EU policies, governance frameworks, and funding mechanisms for TIs. However, it is essential to ensure that the pilots are well-coordinated, and that the results are disseminated and exploited effectively to maximise their impact. The governance and coordination structure proposed for the implementation of a European approach to TIs should ensure the achievement of those objectives as well as fostering new pilot action proposals in addition to this non exhaustive list of examples.

In conclusion, the proposed pilots offer a promising starting point for improving the availability and accessibility of TIs in the EU, and for enhancing innovation and competitiveness in European industry, but they should be seen as part of a broader effort to develop a comprehensive approach to TI development and deployment.

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This report presents the findings of the Commission Expert Group on Technology Infrastructures (EGTI), established in November 2023 to analyse, support, and provide recommendations for improving technology infrastructures (TIs) in Europe. The group explored critical topics such as the definition of TIs, assessing industrial needs, and addressing barriers to access for industry, SMEs and start-ups. With a focus on enhancing European strategic value chains and industrial competitiveness, this report offers actionable recommendations for TI governance and investment prioritisation at the EU and national levels.
The report also addresses the need for developing funding instruments for building-up TI capacities to align with evolving industrial requirements.

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