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Introduction

The deliverable describes how to perform the socio-economic assessment of the EIRENE RI. Given the complexity of the socio-economic impact assessment of research organizations and research infrastructures, and the development phase the EIRENE RI is being in, the documents provides a framework and the guidance to be followed in the implementation and operation phase.

The deliverable describes the approaches and ways, hoe the socio-economic assessment is being realized and proposes the framework for the EIRENE RI, which would be valid and valuable for both the EIRENE management and stakeholders.

Definitions

Impact is the extent to which the intervention has generated or is expected to generate positive or negative, intended or unintended, higher-level effects.

(*OECD*)

The term impact describes all the changes which are expected to happen due to the implementation and application of a given policy option/intervention [such as investment in a Research Infrastructure and its activities]. Such impacts may occur over different timescales, affect different actors and be relevant at different scales (local, regional, national and EU).

(*European Commission*)

Socio-economic impact assessment

Socioeconomic impacts refer to the effects that projects, policies or developments have on both social and economic aspects of human communities and societies. In other words, socioeconomic impacts are typically assessed through socioeconomic impact assessments, which analyze how interventions might change the economic and social conditions of affected communities, regions or countries. These impacts encompass the intersection between social conditions and economic factors.

Economic Impacts	**Social Impacts**	**Cross-cutting Impacts**
• Employment generation or job loss • Income and wealth distribution changes • Economic growth and productivity • Market development and competitiveness • Innovation and technological advancement • Public and private investment patterns • Regional economic development	• Health and well-being outcomes, effect on public health • Education and skills development • Social inclusion and cohesion • Quality of life improvements • Cultural preservation or change • Demographic shifts • Housing availability and quality • Access to services and infrastructure	• Poverty reduction or exacerbation • Gender equality effects • Intergenerational equity • Environmental justice • Community resilience and adaptation capacity • Governance and institutional changes • Policy and regulatory implications

The table above present several direct impacts, which may be considered when assessing the Socio-Economic Impacts of the public spending programme, project or even the research infrastructure.

There are several definitions and ways how to approach the SEI assessment for research infrastructures. Below we provide the basic ones, which are usually considered as relevant and as the background for any analysis or discussion about the SEI assessment tools.

OECD

According to the OECD (Organisation for Economic Co-operation and Development), socio-economic impact analysis is a systematic assessment of how a policy, program, project, or intervention affects various social and economic aspects of communities and individuals. The OECD defines it as an approach that evaluates both the direct and indirect consequences of policies or projects, analyzing how they influence:

1. Economic factors (employment, income, productivity, market dynamics)
2. Social dimensions (quality of life, health, education, social cohesion)
3. Distribution effects (across different population groups, regions, or sectors)

The OECD emphasizes that comprehensive socio-economic impact analyses should consider both quantitative measures (such as costs, benefits, and statistical indicators) and qualitative dimensions (like social well-being and community resilience). They're intended to inform evidence-based decision-making and improve policy outcomes by understanding the full range of effects beyond purely financial considerations.

ESFRI

According to ESFRI (European Strategy Forum on Research Infrastructures), socio-economic impact analysis is defined as the assessment of the wider benefits that research infrastructures bring to society and the economy beyond their direct scientific outputs.

ESFRI's approach to socio-economic impact analysis emphasizes:

1. The evaluation of both direct and indirect impacts of research infrastructures on the economy, society, and environment
2. The importance of measuring both quantitative indicators (such as job creation, innovation outputs, regional development) and qualitative dimensions (knowledge transfer, human capital development, social cohesion)
3. The need for long-term assessment, as many impacts of research infrastructures materialize over extended periods

ESFRI particularly focuses on how research infrastructures contribute to addressing societal challenges, generating innovation, enhancing regional development, and creating value through knowledge transfer and human capital formation. ESFRI recommends using a variety of methodologies including cost-benefit analysis, input-output models, case studies, and narrative approaches to capture the full spectrum of impacts across different stakeholder groups and timeframes.

ERIC Forum

According to the ERIC (European Research Infrastructure Consortium) Forum, socio-economic impact analysis is defined as a systematic evaluation framework that assesses how research infrastructures contribute value to society and the economy beyond their primary scientific objectives.

The ERIC Forum's approach to socio-economic impact analysis emphasizes:

1. A comprehensive assessment of both tangible and intangible benefits generated by research infrastructures
2. The measurement of direct, indirect, and induced effects across multiple dimensions (economic, social, environmental, and cultural)
3. The importance of capturing impacts at different geographical scales (local, regional, national, and European)

4. The need to evaluate both short-term outcomes and long-term structural changes

The ERIC Forum particularly focuses on how research infrastructures contribute to innovation ecosystems, skills development, regional competitiveness, and addressing societal challenges. Their framework typically incorporates both quantitative metrics (economic returns, job creation, patents) and qualitative indicators (knowledge spillovers, capacity building, policy influence). The ERIC Forum's definition recognizes that impact pathways are complex and non-linear, requiring diverse methodological approaches and stakeholder perspectives to capture the full spectrum of socio-economic benefits generated by research infrastructures.

RI-PATH

According to RI-PATHS (Research Infrastructure Impact Assessment Pathways), socio-economic impact analysis is defined as a structured methodology for understanding and measuring the diverse ways research infrastructures create value for society, the economy, and scientific advancement.

The RI-PATHS framework conceptualizes socio-economic impact analysis as:

1. A multi-dimensional assessment that captures both the direct scientific outcomes and the broader societal and economic benefits of research infrastructures
2. A pathway-based approach that traces how research infrastructure investments generate impacts through various transmission channels and impact pathways
3. A stakeholder-oriented evaluation that considers different impact dimensions relevant to various beneficiary groups (scientific community, industry, policymakers, civil society)
4. A methodologically diverse process combining quantitative indicators with qualitative narratives to capture the full spectrum of impacts

RI-PATHS emphasizes that socio-economic impact analysis should be tailored to the specific characteristics and objectives of each research infrastructure, while enabling some degree of standardization and comparability. Their approach particularly focuses on understanding the mechanisms through which impacts are generated rather than just measuring end outcomes.

With the respect to above mentioned, we consider the SEI analysis as the **structured framework to assess, describe and communicate the value (added value) the research infrastructure is providing or contributing to the society and research community**. It includes both the research results and their direct impact on the research community, innovation and policymakers, but also the wider and indirect economic and social impacts. The use of quantitative and qualitative indicators, including the narratives for better understanding and communication is expected. It should be also clear, that the SEI assessment and evaluation is different from the performance assessment, therefore the SEI could not be performed only based on relatively simple KPIs, which, on the other hand, serve as the complementary and background data for the evaluation.

Socioeconomic Impacts of Research Organizations and Research infrastructures

Research organizations/infrastructures generate significant socioeconomic impacts through multiple channels. As mentioned above, the key channels are economic impacts, broader social impacts. The impacts may be both direct and relatively easily to identify, formulate and quantify, but also indirect which only contribute to some value creation. This what makes the complex SEI Assessment complicated and what prevents the development of one-size/type-fits-all methodology creation and implementation.

In the table below we provide the example as common impacts relevant for research infrastructures, research organizations, but even for large-scale research projects.

Economic Impacts	Social Impacts	Broader Social Impacts
Direct Economic Contributions: • Job creation for researchers, administrative staff, and support personnel • Local spending on goods, services, and infrastructure • Tax revenue generation for local and national governments • Development of commercial research parks and innovation districts **Knowledge Economy Development:** • Commercialization of research via patents, licenses, and spinoff companies • Attraction of venture capital and research investment to regions • Industry collaboration leading to new products, services, and markets • Workforce development through specialized skills training	**Educational/Human Resources Enhancement:** • Training of highly skilled graduates who enter the workforce • Life-long learning opportunities • Professional development opportunities for existing workers • Knowledge dissemination through publications and open-access initiatives • Public education and science literacy programs **Health, Wellbeing, Quality of life:** • Medical research leading to improved treatments and healthcare outcomes • Public health research informing policy and prevention strategies • Life expectancy and healthy life years • Personalized medicine approach • Social science research addressing community challenges • Environmental research supporting sustainability and quality of life	**Policy Influence:** • Evidence-based policymaking informed by research findings • Development of standards, regulations, and best practices • Expert consultation for government and industry decision-making • International collaboration addressing global challenges • Science diplomacy **Community Engagement:** • Public-private partnerships addressing local needs • Citizen science initiatives involving community members • Cultural enrichment through research-based exhibitions and programs • Enhanced civic pride and identity in "knowledge cities" • Access to Data and knowledge • Public awareness a environmental impact

The extent and distribution of above presented groups of impacts vary significantly based on the research organization's size, focus, location, funding models, and efforts to maximize societal benefits beyond pure academic metrics.

One of the key problems discussed in several academic papers is also the definition of the causality of the research results or services and the impact attributed to it. For this case, Reed et al. (2021) provide two types of causation – necessary and sufficient causation. Building on these and other considerations, Reed et al. (2021) define research impact as demonstrable and/or perceptible benefits to individuals, groups, organizations and society (including human and non-human entities in the present and future) that are causally linked (necessarily or sufficiently) to research.

The key issue is how to choose the methodology, which would provide this information in an understandable way, would be robust enough to describe all major impacts and would be cost-effective and applicable internally with no need of major annual consultancy costs.

The ESFRI Policy brief (2023) defines several recommendations and key points for SEI assessment and its methodology:

- Acknowledging the **differences between RIs** and avoiding direct comparisons in impact assessments.
- No one-size-fits-all methodology for impact assessments; a **customized approach** should be taken.
- Recognizing the **primacy of scientific impact** while also considering other socio-economic impacts.
- Considering the **longitudinal nature of impact assessments** and the need for data collection over time.
- Ensuring **adequate resources for impact assessments** and the development of internal expertise.
- **Integrating** impact analysis frameworks **into RI governance systems**.

There are several publications, studies and outcomes of the projects, which attempt to introduce viable and effective model, guideline or framework for SEI assessment. Considering the studies describing these models, it is hardly possible to create one-size-fits-all methodology, which would map and quantify all the economic and social impacts of the investment and the operational activity of the Research Infrastructure. The reasons for it are namely:

- The **impacts occur after several years** from the time when the investment is being made or the scientific outcome is produced,
- The impacts may be **indirect** and the **contribution** of the RI may not be the only one causing the impact itself, in other words, there are many external factors to be included,
- There is necessity for the **credible and longitudinal data** from various resources – not only dependent on the RI itself (but also from users, industry, universities, policy makers), which makes the exercise challenging,
- There are impacts and pathways, which may **not** be relevant **for all the RI types**,
- The SEI assessment is **not the same as the performance assessment**, which, however, provides important inputs and information for the impact assessment (namely specific KPIs).

Based on that, we assume that the methodology or approach for the SEI assessment for individual RIs may be specific (at least in the given area of research and state of development), build on the scientific impacts and outcomes, use the systematically collected data as the background, and should provide enough information for both internal and external stakeholders in both quantitative and qualitative manners.

Main SEI Assessment methods

The RI-PATHS project, currently widely used resource for both the EC and RIs themselves, realized a complex review of different methods and approaches for assessing the socio-economic impact of research infrastructures and identified six main methods or approaches:

1. Socio-economic assessment based on impact multipliers;
2. Methods applying the knowledge production function;
3. Cost-benefit analysis;
4. Approaches based on multi-method, multiple partial indicators;
5. Theory-based approaches;
6. Case studies.

Socio-economic assessment based on impact multipliers

The goal of this assessments is to quantify the economic effects of investments of large investments project and is of the advantage for the policymakers and macroeconomic effects of investment actions. There are basically two main approaches – using already existing multipliers (e.g. the fiscal multiplier for given fields, markets and areas) or existing input-output analysis, or calculating the specific input-output analysis for the specific project. Input-Output Analysis is an economic modeling technique that examines the interdependencies between different sectors of an economy which was invented in 70s. This approach requires lot of data, statistical modelling and understanding of the economy, models and relationships within the given sector. This makes it appropriate mor for externally performer evaluation for the purpose of policy-makers and funders, and less appropriate for the RIs themselves and their management.

Methods applying the knowledge production function

The Knowledge Production Function (KPF) is a conceptual and empirical framework that models how inputs to research and innovation processes translate into knowledge outputs. It can be extended beyond measuring research outputs to evaluate broader socioeconomic impacts. This approach provides a structured framework for understanding how research inputs translate not just into knowledge but ultimately into societal benefits. Similarly with the previous, it requires specific expertise and experiences and data to develop such a evaluation. These models use several stages identifying knowledge outcomes (patents or publications), their diffusion into the environment (licensing, transfer of knowledge or technology, citations of publications), their implementation (improvement of technology, development of new technologies and products), their effect on the economy (increase of the productivity, job creation etc.).

Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) is a systematic economic evaluation methodology that quantifies and compares the total costs and total benefits of a project or investment, assessing whether the benefits outweigh the costs. For research infrastructures, CBA provides a structured framework to determine if investments create positive net social value, weighing immediate expenditures against often uncertain and long-term benefits. The CBA is required in many projects (ESIF) and is also expected for Research Infrastructures and recommended by the ESFRI. To conduct a comprehensive Cost-Benefit Analysis for research infrastructures, it is needed to collect robust data on the costs (capital costs, opetational costs, opportunity costs – in the whole life-cycle of the RI), data on benefits (scientific benefits, expected revenues and economic effects of all relevant impacts – environmental, health, societal) and other contextual data allowing proper discounting and calculation. The CBA is very robust methodology, which is widely used of large investments project and have the potential to be used for both the RI managers and policymakers and funders. As in the previous case and considering the complexity, it is very time-consuming and costly to provide the CBA correctly.

Approaches Based on Multi-Method, Multiple Partial Indicators

Multi-method, multiple partial indicators (MMPI) approaches recognize that no single methodology or metric can fully capture the complex socioeconomic impacts of research infrastructure. Instead, these approaches triangulate evidence using diverse methods and complementary indicators to build a comprehensive impact narrative. There are predefined sets of indicators for Research infrastructures, which well fit to their needs and have the potential to credibly describe the impact of the defined infrastructure. As every set of indictors, there is the challenge in its interpretation and the logic should be clearly described to present the whole picture of the RI.

Theory-based approaches

Theory-based approaches provide a structured framework for understanding how research activities lead to socioeconomic impacts by explicitly mapping out the underlying mechanisms and causal pathways. As such require extensive knowledge of the environment and the way how the RI or any other systems work. These approaches move beyond simple input-output measurements to explore why, how, and under what conditions research creates value for society. Instead of providing "simple" number, it provides the reasoning and also the narratives, which are of a great benefit for the broader audience. There are several theory-based frameworks, such as theory of changes, providing comprehensive description of how and why desired change is expected to happen in a particular context, contribution analysis, Contribution Analysis, providing a structured approach for examining causal claims when attribution is difficult, Realist evaluation, seeking for understanding what works, how, under which conditions and for whom, or the success case methods using narratives.

Case-studies

Case studies serve as a powerful methodology for evaluating the socioeconomic impacts of research by providing rich, contextualized insights into complex impact pathways. They offer depth and narrative coherence that quantitative approaches alone cannot achieve. There are two main approaches - Within-Case Studies and Cross-Case Studies. They represent two distinct but complementary analytical approaches in case study research methodology, each with different purposes, strengths, and limitations. Within-case studies are focused on examining causal processes, mechanisms, and relationships within a single case. They provide rich, detailed analysis that helps explain how and why particular outcomes occurred in specific contexts. Cross-case studies are systematic comparative analyses that examine patterns, similarities, and differences across multiple cases to develop more generalizable insights and identify causal conditions that lead to particular outcomes. This approach is particularly valuable for socioeconomic impact evaluation because it allows for testing theories across different contexts.

Impact Pathway Analysis in the Context of Evaluation Approaches

Impact Pathway Analysis (IPA) is a versatile approach that integrates with and complements the previously described methodologies for socioeconomic impact evaluation. It serves as both a conceptual framework and a practical tool that can be embedded within multiple evaluation approaches. Impact Pathway Analysis thus serves as an integrative element across evaluation approaches, providing a structured way to visualize, analyze, and communicate the complex processes through which research generates socioeconomic impacts. Its flexibility allows it to be embedded within various methodological frameworks while maintaining focus on the critical question of how research translates into societal benefits. Below we provide several illustrations and schemes of Impact Pathway or logic models.

OECD introduces simple logic model, where inputs are the resources mobilised by the RI to perform its activities, Activities enable science and technology, may include targeted economic and social activities and may develop the skills and competencies of human resources, outputs are the results of activities and impacts are intended or unintended effects of RI services and activities and outputs during RI's whole lifecycle.

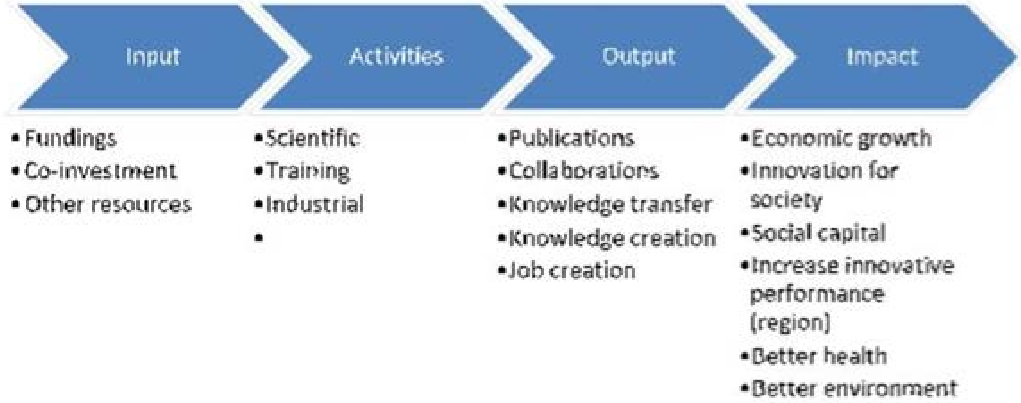


Figure 1 The logic model – how to measure impacts (OECD)

The Road to impact presented in the ResInfra@DR publication provides very similar logic with slightly more specific stages of impact creation. The logic and scheme, however, remains the same.

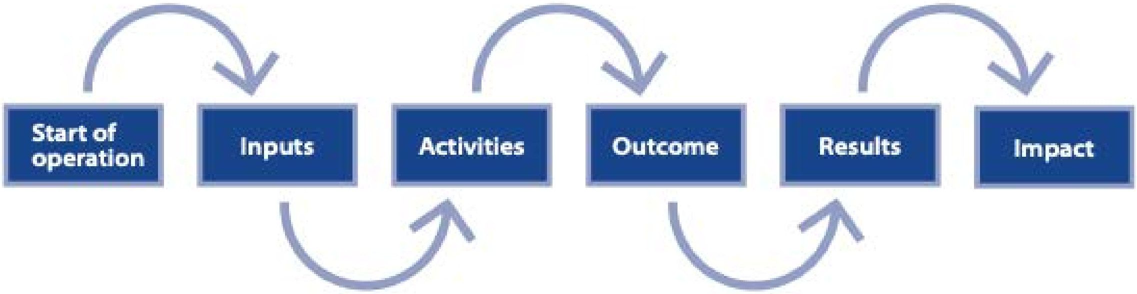


Figure 2 Road to impact (ResInfra@DR)

Currently most cited and used concept, as already discussed, is the impact pathway developed within the RI-PATH project, which present simple, but not simplistic logic: "The resources you invest or use allow for (or prompt) an activity to happen. This activity generates some direct results (so-called outputs) that can lead to certain short- or long-term effects (so-called outcomes). Finally, certain impacts emerge.„

Figure 3 Impact pathway - communication - RI PATH

Research Infrastructure management operates across a spectrum of control and influence regarding socioeconomic impacts. RI managers directly control internal operational elements such as strategic priorities, resource allocation, technical capabilities, and access policies. They maintain indirect influence over intermediate factors including user research directions, methodological adoption, community formation, and knowledge transfer activities. However, ultimate socioeconomic impacts—scientific breakthroughs, commercial applications, policy changes, economic growth, and societal benefits—fall far beyond both their direct control and influence. Despite this limited control over final outcomes, these impacts remain critically important to funders, policymakers, and RI managers themselves, as they justify investments, demonstrate value, and inform strategic decisions about research infrastructure development and sustainability.

Accordingly, RI PATH defines three spheres in connection to the logic model:

- **Sphere of control,** which covers everything that the Research Infrastructure's team can control and for which it is fully responsible. It includes activities and the direct outputs from these activities.
- **Sphere of influence,** which covers effects outside the direct control of the Research Infrastructure's team which depend on how RI users or stakeholders react to the results produced. However, they remain at arm's length as the Research Infrastructure interacts directly with the user and stakeholder groups in question and can seek to influence their behavior.
- **Sphere of interest,** which covers the lasting impacts and structural changes manifesting in the economy and society. Socio-economic impacts are highly context-driven and hence outside the direct control of the Research Infrastructure, yet this sphere is exactly the focus of an impact assessment.

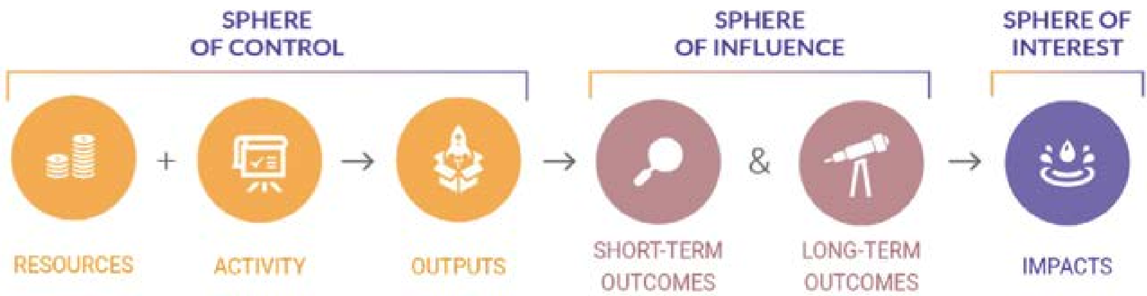
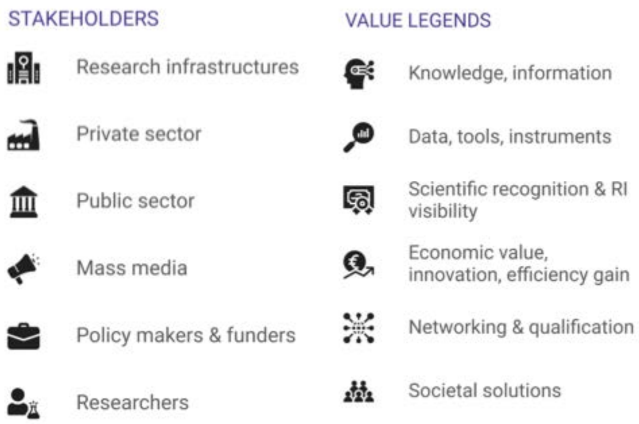


Figure 4 Impact pathway logic (RI PATH project)

The RI Path project guideline presents consolidated list of identified pathways, including visualisations depicting the schematic logic of the causal chains in a simplified form



P1 – Publication-citation-recognition

P2 – Employment, operations and standardised procurement:

P3 – Technology transfer and licensing

P4 – Learning and training through joint development of instruments and tools

P5 – Learning and training by using RI facilities and services

P6 – Training and higher education cooperation

P7 – Interactive problem-solving for the private sector (industry)

P8 – Addressing societal and public-sector challenges

P9 – Provision of specifically curated/edited data

P10 – Changing fundamentals of research practice

P11 – Creating and shaping scientific networks and communities

P12 – Promoting engagement between science, society and policy

P13 – Communication and outreach

Not all the impact pathways presented above should be relevant for ever RI. According to the character of the RI, it should be decided, which pathways are most relevant and these should be further analyzed. Taking this into account, together with the current preparatory state of the EIRENE RI, we propose for the implementation phase to:

1. Introduce systematic monitoring of the inputs, activities and outcomes on both the "central" and "national" level,
2. Implement the monitoring of the KPIs, which have already been introduced in specific deliverable, and based on the KPIs,
3. Define relevant impact pathways, and
4. Provide the case-studies describing the added value and impacts of EIRENE RI.

The preliminary set of KPIs is following.

Preliminary set of KPIs

EIRENE RI Objective	**Proposed preliminary KPIs**
Enabling scientific excellence	Number of user requests for access
	Number of users served
	Number of user requests
	Number of publications
	Number of citations
	Percentage of top (10%) cited publications
	Ratio of number of services delivered and total number of services available in the network
	Average ratio of number of services on number of infrastructures
Delivery of education and training and enable knowledge transfer	Number of master and PhD students using the RI
	Total number of trained non-RI staff
	Number of scientific conferences, seminars, webinars, … organised by the RI
	Number of educational and outreach activities
	Number of participants in educational and outreach activities
Enhancing collaboration in Europe	Number of members of the RI from ESFRI countries
	Share of users and publication per ESFRI member country
Facilitating economic activities	Income from commercial activities and the number of entities paying for service
	Number of regional firms using the RI (can be categorized by size/turnover)
	Number of suppliers (local/regional) (may also add turnover data)
Outreach to the public	Engagement achieved by direct contact
	Outreach through media
	Outreach via the RIs own web and social media
Providing scientific data and associated services	Number of publicly available curated data sets used externally
	Number of data requests
	Facilities connected to IT services
Providing scientific support/advice (to policy)	Participation by RIs in policy related activities
	Citations in policy related publications
	Number of resources (data, specimen, informatics) dedicated to support policy

Facilitating international cooperation	Share of users and publications per non-ESFRI member country
	International trainees
	Number of members of the RI from non-ESFRI countries
Fostering innovation	Number of patents and licensing
	Number of innovations/patents co-developed with industry

Every node or central hub will be regularly asked for delivering the values for KPIs and the examples of most notable outcomes and their impacts (the temporal aspect should be considered), namely in the form of case studied and narratives, which may be also communicated widely and to the general public.
Since the delivery of real case studies may be delayed because of the delayed effects of outcomes and activities, we EIRENE RI will deliver the narratives and examples of added value of EIRENE services, existence and role within the EU and globally. The examples of are provided below.

The Importance of Case Studies and Narratives in Socioeconomic Analysis of Research Infrastructures

Case studies and narratives serve as essential methodological tools in the socioeconomic analysis of research infrastructures. They provide contextual depth and qualitative insights that complement quantitative metrics, creating a more comprehensive evaluation framework. These narrative approaches are particularly valuable for capturing the multifaceted impacts of research facilities that often extend beyond traditional economic indicators.

The case-studies allow to transform abstract data into compelling stories that resonate with diverse audiences, including policymakers seeking evidence of return on public investment, industry partners evaluating potential collaborative opportunities, local communities concerned about regional development implications, scientific communities assessing strategic research priorities and seeking for research partnerships and capacities, and international funding bodies comparing investment options. These stakeholders often require different types of evidence for their decision-making processes, and narratives can be tailored accordingly while maintaining factual integrity. Obviously, very important is its potential for communication with general public and awareness raising.

The case-studies excel in documenting complex socioeconomic impacts that defy simple quantification. As such, the case studies may:

1. Illustrate how scientific advancements translate into broader societal benefits across different stakeholder groups,
2. Document the evolution of impacts over extended timeframes (as the impacts in the research environment manifest in long-run) , including unexpected outcomes,
3. Contextualizing quantitative data within the specific institutional, regional, and disciplinary environments (the relevance to RIS or specific strategies and documents may be presented),
4. Revealing causal mechanisms and interrelationships between technical capabilities and socioeconomic outcomes.

From a methodological perspective, case studies offer significant analytical benefits.

Capturing Complex Causal Relationships	Case studies excel at illuminating the complex causal pathways through which research infrastructures generate socioeconomic impacts. While statistical correlations can identify patterns, case studies reveal how specific capabilities lead to particular outcomes through detailed examination of decision sequences, resource allocations, and interaction processes. This level of detail enables analysts to understand not just that impacts occurred, but precisely how they materialized and what is the role and value added in this process.
Incorporating Multiple Data Sources	The case studies permit the integration of diverse data types that would be difficult to combine in purely quantitative approaches. Researchers can triangulate evidence from institutional records, stakeholder interviews, financial data, publication records, and external evaluations. This improves validity through the convergence of multiple evidence streams and may potentially lead to producing more robust (data-driven) findings.
Addressing Temporal Dimensions	Research infrastructure impacts often develop over extended timeframes with distinct phases of development, maturation, and transformation. Case studies can implement longitudinal designs that track these dynamic processes over time, documenting how initial outputs evolve into intermediate outcomes and eventually generate broader socioeconomic impacts. This temporal sensitivity is particularly valuable for understanding how infrastructure investments produce returns over different time horizons.
Contextual Sensitivity	Research infrastructures operate within specific institutional, disciplinary, and regional contexts that significantly influence their performance and impact. Case studies are valuable at documenting how these contextual factors shape outcomes through detailed examination of governance structures, funding mechanisms, access policies, and stakeholder relationships. This contextual intelligence helps explain variation in outcomes across different infrastructure investments.
Counterfactual Analysis	Well-designed case studies can approximate counterfactual analysis by examining comparable research endeavors conducted with and without access to specific infrastructure capabilities. This comparative approach helps isolate the added value of the infrastructure investment from other factors contributing to research outcomes. Through structured comparisons across carefully selected cases, researchers can strengthen causal inferences even without experimental designs.
Integration of Stakeholder Perspectives	Research infrastructures serve diverse stakeholder communities with different values, priorities, and evaluation criteria. Case studies can systematically incorporate these multiple perspectives, documenting how different stakeholders experience and value the infrastructure's contributions. This approach reveals the differential distribution of benefits across stakeholder groups and helps identify potential tensions or synergies between competing objectives.
Capturing Unintended Consequences	Research infrastructures frequently generate significant impacts that were not anticipated in their original planning. Case study methods are particularly effective at identifying and documenting these unintended outcomes, both positive and negative. Through open-ended inquiry and systematic observation, researchers can detect emergent phenomena that might be missed in more narrowly defined quantitative studies focused on predetermined metrics.

The methodological advantages of case studies and narratives in research infrastructure analysis derive from their capacity to capture complexity, incorporate diverse evidence, address temporal dynamics, and reveal causal mechanisms. When implemented with appropriate rigor and transparency, these approaches yield insights that complement and deepen quantitative analyses, providing a more comprehensive foundation for evidence-based decision making.

A persistent challenge in research infrastructure evaluation is the attribution of observed socioeconomic outcomes to specific investments, universities and facilities, including research infrastructures. It becomes much complicated in case of cooperation of RIs and joint provision of services, which is now becoming a trend both in projects (INFRASERV) but also in terms of RI clustering. Case studies may address this challenge by documenting the specific pathways through which infrastructure capabilities enable research outcomes (or to which it contributed to documented impacts), capturing testimonials from key actors (researchers, RI operator) who can verify causal connections, providing detailed chronologies that establish temporal relationships between infrastructure services (its extent) and subsequent impacts and illustrating counterfactual scenarios by comparing similar research questions pursued with different or no infrastructural support.

The most robust and actually the most relevant socioeconomic analyses combine narrative approaches with quantitative metrics in a complementary and complex framework. Case studies can inform the development of more relevant quantitative indicators while also providing explanatory context for observed statistical patterns. This integrated approach yields more policy-relevant insights than either method alone.

For research infrastructure managers, partners and also for the policymakers, well-constructed case studies have the potential to provide strategic intelligence that informs critical decisions regarding investment priorities for facility upgrades or expansions (both within the RI – e.g. prioritizing specific services or nodes, and the funders), optimization of access policies and user support services to maximize the number of users, their user experience and maximize the impacts, development of collaboration models with industry and other stakeholders (e.g. within crises or needs, incl. COVID), design of outreach and educational programs (including specific training, study programs or even life-long learning), and formulation of long-term sustainability strategies.

Case studies and narratives represent vital components of comprehensive socioeconomic analysis for research infrastructures. They illuminate the human dimensions of scientific enterprise, document complex impact pathways, and translate technical achievements into accessible frameworks. When integrated with appropriate quantitative methodologies, they provide a powerful foundation for evidence-based policy and management decisions that maximize the societal return on infrastructure investments.

EIRENE Case-studies and narratives

Here we provide selected case studies and narratives of potential or already proven impact of EIRENE Research infrastructure. We provide more types and styles of mostly ex-ante case studies to provide the level of detail and way of argumentation, which may be and usually is provided. The examples are:

- PestiRiv : a French study of Santé publique France (SPF) and Anses on residential contamination using an EIRENE national hub.
- Understanding What Makes Us Sick — and Preventing It (Pioneering Health Protection through Environmental Research)

PestiRiv : a French study of Santé publique France (SPF) and Anses on residential contamination using an EIRENE national hub.

The problem : Citizens living near farms or vineyards, which are using pesticides are highly concerned by possible residential exposure. In the absence of robust data, this is leading to anxiety, depreciation of property and tension between communities. Also there are different procedures to deliver/spray pesticides and their impacts on neighbors are unknown. A French study by SPF and Anses aimed at addressing this issue at large scale (> 3000 participants).

What Eirene can do: Eirene is developing harmonized assays (in blood, urine, hair, etc.) for a large variety of chemicals, including pesticides. These can be quantitatively assayed in humans through targeted analysis. Furthermore, other methods are also available in EIRENE facilities allowing "suspect screening" or non targeted assays. The latter are extremely useful because they are not hypothesis driven and in particular they can detect metabolites of pesticides as well as other unsuspected contaminants which are rarely assayed. The study is underway and results will be published during 2025.

Conclusion: Eirene can provide actual exposure data, not only on what is happening in environmental samples but also in humans which is what people living near pesticide-using farms do expect. This may lead to changes in the way pesticides are delivered and decrease anxiety of neighbors.

Understanding What Makes Us Sick — and Preventing It (Pioneering Health Protection through Environmental Research)

Every day, people are exposed to countless environmental factors—chemical pollutants, poor air quality, stress, diet, and lifestyle—that affect their long-term health. While our genes contribute to disease risk, up to 70% of chronic diseases are driven by modifiable, non-genetic factors. These are part of the human exposome. Launched in 2022 and coordinated by the University of Vienna, Exposome Austria focuses on high-throughput exposomics, especially the study of how early-life exposures impact health across the lifespan. The key societal and economic benefits are:

Better health outcomes: By identifying environmental triggers of diseases early, EIRENE helps shift from reactive to preventive healthcare, reducing the burden of chronic conditions like cancer, diabetes, and cardiovascular disease.

Smarter regulation: The data and tools developed by EIRENE support safer chemical regulation and risk assessment, protecting citizens and ecosystems. Exposome Austria is closely aligned with the Austrian Human Biomonitoring Platform which is an official body, informing the Austrian Parliament on a biannual basis with a written report. On the global scale, EIRENE members participate on the implementation of PARC partnership, which results will help launch European and national strategies to reduce risks posed by hazardous chemicals to health and the environment, and with WHO, UNEP and other intergovernmental agencies.

Innovation and industry impact: EIRENE fosters the development of cutting-edge technologies for exposure detection, data integration, and risk modelling—opening new markets and jobs in biotech, health tech, and environmental monitoring.

Global positioning: With Austria as a founding member, national investment ensures that Austrian science, health policy, and industry remain at the forefront of this critical international field.

EIRENE and its Austrian hub represent a once-in-a-generation opportunity to modernize health research and policy by understanding the environmental roots of disease. Continued support and funding will ensure the Europe´s leadership in building a healthier, safer, and more sustainable future for all.

Funded by the European

Climate change and mycotoxins: the role of European research infrastructure in human biomonitoring and exposome research

"Climate change leads to increased exposure to harmful toxins", according to a recent report of the European Environment Agency. Indeed, climate change is causing more toxic fungi to contaminate our food supply. These fungi grow on crops and subsequently enter our food, producing tens of mycotoxins that can be carcinogenic, retard growth, or suppress the immune system. The socio-economic impact of mycotoxin contamination is significant. Mycotoxins are a threat to food safety and security, leading to economic losses in agriculture due to reduced crop yields and increased costs for food safety measures. In addition to growing in the field, these fungi can also develop during food storage. Fungi require specific amounts of heat and moisture; some need lower temperatures, while others need higher ones. Due to climate change, we are witnessing a shift in fungi that were previously confined to tropical regions. For instance, *Aspergillus flavus* and its aflatoxins are now already more prevalent in Italy and the Balkan region. These mycotoxins are invisible in our food, necessitating analysis. Food is monitored by food safety agencies, but not all food can be analyzed. Moreover, legal limits allow concentrations below the maximum limits to enter our food. Consequently, we are continuously exposed to lower concentrations of various mycotoxins simultaneously. The impact of chronic multi-mycotoxin exposure on carcinogenic processes and immune suppression is not well understood.

Therefore, it is crucial to measure mycotoxins and their biomarkers/metabolites in human fluids such as urine and blood. This requires highly specialized equipment like liquid chromatography-mass spectrometry. To conduct this on a European scale, faster processing of blood and urine samples is essential. This can be achieved by investing in shared European research infrastructure for faster and more accurate detection of mycotoxins making use of automated sample handling and linkage with analytical equipment. Consequently, trends due to climate change can be detected more timely, allowing for quicker implementation of policy measures to better prevent disease burden. Early detection and intervention can prevent large-scale health crises, reduce healthcare costs, and ensure a safer food supply, ultimately contributing to the overall well-being and economic stability of European societies.

The impact of EIRENE Hub in Sweden

As soon as EIRENE RI started to be discussed in Sweden three authorities were informed, The Swedish Environment Protection Agency, the Swedish Chemical Agency and the Swedish Food Agency, and all three came in with support letters for EIRENE RI. They are not handling the political support for infrastructures in Sweden which is managed by the Swedish Research Council (VR). The authority support is important and has been up for discussions in the national "Toxicology Council" several times. The council is reporting to nine director generals at their corresponding authorities, an organisation named SamTox (collaboration in toxicology matters on a national level). The deputy coordinator of the Swedish EIRENE RI hub is a member of this council. EIRENE RI has been instrumental in the discussions at the highest university levels from all the six universities forming the Swedish EIRENE hub. The work with this infrastructure has increased the knowledge also among other Swedish universities and organisations. For example, the Swedish hub coordinator has been approached by the Swedish Chemical Society magazine for an article presenting the exposome for their readers. The article is scheduled for the summer 2025.

The extreme complexity of exposure to anthropogenic chemicals, their abiotic transformation products and metabolites require expertise in so many different fields showing the necessity of a European infrastructure. This is also motivated in relation to the number of different instruments and expertise in managing the instruments. The Swedish authorities are well aware of this and with the long history of environmental monitoring for human and environmental health it is evident for them to support the full concept of EIRENE RI. What is commonly mentioned in these discussions is e.g. the need of highest quality in the analysis and the need of comparability.

What is further discussed among the Swedish stakeholders is the need of toxicity testing of discharges of pollutants and for human exposure. Here EIRENE RI will play an important role. It is noted that results from wildlife, chemical exposure to workers and accidents are important observation in linking health effects to exposure. In this context it is worth to mention that the Nordic countries have undertaken and just completed a survey on the competence needs in risk analysis (toxicology and related science as well as risk communication) and identified significant competence provision needs. The report from the stakeholder group is specifically mentioning EIRENE RI and the exposome.

Reference
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Resources:

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Annex I: Ex-ante Socio-Economic Impact Assessment of EIRENE RI

Valuing the socio-economic impact of the publicly funded project (incl. Research Infrastructure) should give the policy makers, citizens and specifically funding bodies the answer to the simple question, "What is the benefit of the project and what will be delivered for the taxpayers' money?" To be able to answer this question, one should determine the costs and benefits of such an investment. The costs usually consist of the actual investments made, opportunity costs and, in case of infrastructures, by the environmental and the actual investment generated costs (e.g. the noise in the case of a highway). On the contrary, the benefits of the public spending programmes, specifically research and development related programmes, are generated through new knowledge, technology and innovations, increased qualification of the human resources and the improved quality of the environment and human health. Apart from the relatively simply valuable benefits, such as the creation of new jobs, new patents and spin-offs, the valuation of the other benefits is relatively complicated and is usually arbitrary.

Therefore, the presented cost-benefit analysis (CBA) is designed as a very simple ex-ante CBA, which presents the principles and assumptions to be taken into account when elaborating the robust CBA during the preparatory phase.

MID- AND LONG-TERM SOCIO-ECONOMIC BENEFITS OF EIRENE RI

The mid- and long-term benefits will result from the strengthened collaboration of research infrastructures which will decrease the level of fragmentation of European research activities and will, among others, increase the effectiveness of European research.

The EIRENE RI will benefit from the ongoing strategic European projects, such as HBM4EU, ERA-PLANET or the exposome-related projects. The collaboration of the individual research infrastructures in the field of monitoring networks, for instance, and especially related data storage and management capacities will contribute to more effective data handling procedures, the interoperability of data systems and the availability of robust datasets to relevant users (policy makers, researchers etc.). From the economic point of view, these benefits may be understood as economies of scale (to some extent, the unit price decreases with the increasing level of output) and economies of scope (the cost of production decreases as a result of the increasing number of different goods/services produced). Moreover, the quality of services will be definitely higher.

The EIRENE RI will contribute to improved understanding of the environmental exposure and the potential health risks to both EU citizens and policymakers, which will result in sound policy making at EU and national levels. In general, EIRENE RI will contribute to better protection of the health of EU citizens, innovative health policies, and better healthcare provision and, at the same time, to industrial competitiveness by developing new exposure, effect, and susceptibility biomarkers, and improved analytical and risk assessment methods. Last, but not least, EIRENE RI will strengthen the focus on education, training, capacity building and knowledge sharing in the respective area.

Effective utilization of European research capacities will also capitalize previously realised ESIF investments and support their long-term sustainability.

ECONOMIC AND INNOVATION IMPACTS OF EIRENE RI

The impact on the innovation generated by the EIRENE infrastructure will be different in two different phases of its development:

- implementation phase (mainly construction) and
- operational phase.

Implementation phase
One of the capital-intensive phases of establishing the research infrastructures is the construction phase. The reasons for this are as follows:

- new premises are built, reconstructed, or upgraded,
- new technologies are purchased, technologies replaced or upgraded and
- in specific cases, new technologies are developed (tailor-made).

In this particular case, we call the impact "innovation induced though public procurement".
The direct economic impact can be measured in:

- turnover of companies realizing the innovation, which could be done in collaboration with scientists and technicians from the side of RI, which implies the increase of
- technical and professional skills of employees of the contractor – which may be valued by the possible increase of costs of work, broadening expertise and/or offering new services/goods to other clients,
- the goodwill of the companies,
- the regional potential in terms of innovation (the region hosting the RI will present itself as pro-innovative and worthwhile to invest in), which could be analysed both ex-ante and ex-post,
- this may also lead to a market spill-over effect.

The valuation would be possible once the final list of RIs participating is made and the final Technical Development Plan is elaborated (which is expected during the preparatory phase).
The direct innovation impact can be measured in:

- innovation or development activities realized in the collaboration between the contractor and the scientists, which may significantly shift the current state of the art of technologies,
- human capital: know-how acquired – either through hiring highly-skilled researchers, technicians, lab-managers, technical or even project managers able to manage complex technological projects or through the training of current employees, who will become highly-skilled and able to realize more advanced projects in the future.

Operational phase
This phase is not as capital intensive as the other phase but lasts for decades and both the economic and innovation impact may be significantly higher. Moreover, the impact on the development of local human capital and the local innovation environment becomes very important.

The economic impact can be relatively easily estimated or determined by the structure and volume of service provided to the user community, expenditures to be spent within the infrastructure (consumables, services, maintenance), jobs to be created, revenues to be generated and multiplied (such as the spending of researchers using the research infrastructure) and the value to be provided to non-academic users (e.g. the industry). In this respect, the direct economic impact may be measured in:

- value of the service/access provided to the public sector (e.g. researchers) – measured by its actual costs,
- volume of collaborative research (research realised in collaboration with the application sector),

- volume of research grants to be approved and spent due to the activity of RI,
- volume of the external services and consultancy provided by the RI,
- volume of funds spent on maintenance, renewal, service, and consumables (incl. gases, media, glass, chemical substances etc.),
- volume of expenditures on human capital – both scientific and management (slightly higher in the case of distributed infrastructures),
- number of jobs to be created (number of jobs multiplied by the annual average wage),
- volume of general multiplied spending (researcher staying at a local hotel etc. can be easily calculated by using a fiscal multiplier),
- volume of service provided (to the industry),
- value of outcomes (publications, patents, knowledge),
- value of trainings etc.

Elaboration of such a complex system would require sophisticated methods used e.g. in public spending programme evaluation or GDP calculation, such as input-output analysis, which require the availability of detailed data, models analysing transactions between sectors or models using fiscal multipliers. The ex-ante analysis will be made during the preparatory phase once the final form of EIRENE RI is decided. Nevertheless, based on the previously presented studies we can expect that the multiplication effect of spending in R&D is not lower than 4, which means, that every 1 EUR invested will bring 4 EUR into the national spending, which is a very effective way of investing public resources.

The innovation impact is driven by the research outputs of the RI activities, which are usually the following:

- research publications and new findings – where the valuation is in general not simple and entirely exact but is possible. On the contrary, the innovation value and societal value of these outputs are evident.
- application results, such as patents, utility models and others, mainly those utilized and capitalized e.g. in licenses (in general, the technology transfer),
- start-ups or spin-offs originating from the research done at RI or from the corresponding technology development,
- joint undertakings/ventures of RI and industrial partners, new collaborations and networks,
- volume of capitalized innovations realized by companies that used the research infrastructure service.

The innovation activity also significantly affects the human resources in the area, where the innovation is realized and utilised, in our case in the location of the infrastructure Nodes. The basic impact on human resources is as follows:

- new skills (scientific, technical, technological, managerial, interpersonal etc.),
- new knowledge of employees,
- fostering of an international environment, which, together with the two above-mentioned impacts results in the increased attractiveness of the region and research institute/infrastructure and may attract highly skilled and motivated (also international) talents.

The overall effect of innovation and scientific results and knowledge is definitely broader and requires a robust analysis, which will be elaborated within the preparatory phase of the project.

ESTIMATED ECONOMIC BENEFITS OF EIRENE RI

To determine the direct economic impact of EIRENE RI is relatively difficult due to:

- the current state of the project (the project is entering its preparatory phase and not all the potential Nodes are confirmed, therefore the total investments and other costs are not fixed),
- such a project generates a number of externalities (the outputs / impacts of research project funded from the public budgets may be perceived as public goods),
- the investment and operation costs paid by the public resources (the evaluation of public spending is complicated in general),
- such a project usually does not generate direct incomes and is "non-profit" by definition (the actual economic analysis based on cash-in / cash out principles will provide negative value of the investment).

Therefore, we decided to substitute the Cost Benefit Analysis with an analysis based on the capital investments and overall turnover of the research infrastructure and evaluate the impact of the investment on the economy by the so-called fiscal multiplier. This approach helps to avoid common mistakes in valuation and provides a raw, but credible estimate of the impact of such infrastructure on the economy. In addition, economic literature proves a strong and significant relationship between R&D expenditure and economic growth.
The instrument of fiscal multiplier plays an important role in macroeconomic theory. At the simplest level, the fiscal multiplier stands for the change in the output (or turnover) of the economy for a change in a fiscal policy instrument – e.g. change in government investments, change in tax policy, change in the transfers. In the macroeconomic theory, the multiplier is used to assess the effects of the fiscal policy. For our purpose, we will use it to assess the effect of investments to the very specific sector of economy, which is the R&D and science. The values of the multiplier vary between 0.5 for traditional investments and increase when moving to services or high-tech investments. For investments into R&D and education, the fiscal multipliers are quite high. In the study published in the Global Health[1] the authors examined the value of the multiplier being highest in the case of investments in the sectors of Health (mean 4.32, min. 2.51, max. 6.14), Education (mean 8.24, min. 3.94, max. 12.54). Even the area of investments to the environment demonstrates relatively high, but also volatile value of the multiplier (mean 8.39, min -3.84, max. 20.62)[2]. For our case, we will use the value of 5 (considering the three beforementioned values) to estimate the economic impact of investments. Therefore, we will sum-up the overall investment (including the operation costs) and multiply it by the value of the multiplier. This will give us the value of economic effect of the investment. The following table presents the investment made/to be made in EIRENE RI countries according to our economic model and cost book and the expected effect. The value of investments is provided in the real values and considers the expected inflation rate.

Table 1 Multiplication effect of investments into EIRENE

Country	Investment	Effect
Austria	24 343 424 €	121 717 120 €
Belgium	34 089 432 €	170 447 160 €
Czech Republic	72 125 304 €	360 626 520 €
Finland	14 764 902 €	73 824 510 €
France	34 447 862 €	172 239 310 €
Germany	23 903 588 €	119 517 940 €
Greece	9 700 397 €	48 501 985 €
Iceland	8 667 909 €	43 339 545 €
Italy	28 335 881 €	141 679 405 €
Netherlands	50 443 695 €	252 218 475 €
Norway	13 544 897 €	67 724 485 €

[1] Reeves A, Basu S, McKee M, Meissner C, Stuckler D. Does investment in the health sector promote or inhibit economic growth?. *Global Health*. 2013;9:43. Published 2013 Sep 23. doi:10.1186/1744-8603-9-43

[2] The values are pre-recession fiscal multipliers, 1995-2007 in US.

Slovakia	10 316 521 €	51 582 605 €
Slovenia	33 516 252 €	167 581 260 €
Spain	50 032 627 €	250 163 135 €
Sweden	32 947 411 €	164 737 055 €
UK	12 881 023 €	64 405 115 €
US	10 708 624 €	53 543 120 €
TOTAL	**464 769 749 €**	**2 323 848 745 €**

According to above-mentioned foundations, the direct economic effect of the EIRENE in the long run counts for **2 323 848 745 EUR.**

The effect of investments could also be presented by the creation of new jobs. There is one specific study published in 2018 dealing with the impact of R&D and Science Spending on job creation, namely in the case of the American Recovery and Reinvestment Act. The authors of the study found that over the program's five-year disbursement period, each one million USD in R&D and science spending was associated with twenty-seven additional jobs. The estimated job-year cost is about $15,000. In EUR, that would correspond to 31 jobs associated with invested million EUR.

Table 2 Number of associated jobs with EIRENE RI investments

Country	Investment	Associated jobs
Austria	24 343 424 €	755
Belgium	34 089 432 €	1057
Czech Republic	72 125 304 €	2236
Finland	14 764 902 €	458
France	34 447 862 €	1068
Germany	23 903 588 €	741
Greece	9 700 397 €	301
Iceland	8 667 909 €	269
Italy	28 335 881 €	878
Netherlands	50 443 695 €	1564
Norway	13 544 897 €	420
Slovakia	10 316 521 €	320
Slovenia	33 516 252 €	1039
Spain	50 032 627 €	1551
Sweden	32 947 411 €	1021
UK	12 881 023 €	399
US	10 708 624 €	332
TOTAL	**464 769 749 €**	**14408**

FROM SCIENCE TO INNOVATIONS

As mentioned in the previous section, EIRENE RI will have positive effect on innovation in the respective regions in both phases of its development (implementation and operation). Moreover, specific impacts could be defined even at this stage, when the Nodes (local infrastructures) work independently.

Technological innovation

Technological innovations will follow the research and development of methods and instrumentation in the areas of EIRENE infrastructure's operation. We expect development and innovation at least in following areas:

- analytical laboratories employing new methods and sampling techniques,
- developing of analytical equipment and methods for non-target screening and target monitoring in the biological and environmental matrices,

- development of unified SOP for screening analyses and newly identified chemicals (e.g. PFAS, metabolites etc), standardized methods and workflows,
- establishment of human sentinel platform: a human biomonitoring (HBM) health system with opt-in follow-up possibilities for participation in specific HBM studies,
- developing new sensor technologies for environmental monitoring – remote sensing, near-real time monitoring,
- performing human biomonitoring through non-invasive sampling and analytical techniques,
- developing DB and information systems – interoperability of data, large data handling tools,
- developing dedicated protocols, specific for different types of large-scale and high time-resolution external exposome data will be developer,
- using advanced environment performing temporal and multi-scale data integration of exposure and health data with land use and air/water/soil quality geographical layers
- developing new hazard testing methods (in vivo/in silico).

The innovations mentioned above are intended to create business opportunities and be adopted by local industries, including the SMEs (or even start-ups and spin-offs), and could be brought to national and/or international level. This will increase the competitiveness of those companies, and also the respective regions, and consequently, the EU as a whole.
But the innovations will not only lead to the business opportunities or creation of new start-ups. From the scientific point of view, it will allow to realize new studies, which have not been possible before. The effect of standardization and harmonization has been discussed before and may play important role in comparative studies realized within the EU, allow to comparison of outcomes of funded European projects etc.

Social innovation
Social innovation is usually seen as the process of developing and using effective solutions to be challenging, and often systemic social and environmental issues in support of social progress. The EU has launched the initiative of Innovation Union, which constitutes the following key initiatives (blocks of actions):

- Strengthening Europe's knowledge base – EIRENE RI will bring specific knowledge and expertise together to foster and strengthen common research activities, which will result in strengthening the knowledge base and reducing research fragmentation in the EU,
- Getting ideas to market – the technical innovations will be brought to the market via industrial partners (as mentioned above),
- Maximizing regional and social benefits – EIRENE RI will play an important role in increasing the competitiveness of specific EU regions where the Nodes will be located. Moreover, the research areas of the EIRENE RI are in line with European and relevant National and Regional Smart Specialization Strategies,
- Innovation partnerships - Five European Innovation Partnerships have been launched in key areas of active and healthy ageing, water, agriculture, raw materials, and smart cities. EIRENE RI refers at least to four of these EIPs and may bring new results to be implemented in this area,
- International collaboration – EIRENE RI represents numerous international partners from the EU and already collaborates with excellent non-EU research infrastructures and institutions, which increases EU competitiveness even more.

EIRENE RI will contribute to social innovation through, e.g.,

- supporting decision-makers in the assessment of the effectiveness of measures by co-designing different policy scenarios at national or regional levels and link health effects with pollution,

- providing a valuable and up to date support to national institutions (i.e. ministries, regional governments, industries) involved in the protection of human health and implementation of European and international legislations on toxic chemicals and anthropogenic contaminants,
- Innovation partnerships – EIRENE RI refers to the following innovation partnerships formulated by the EU: active and healthy ageing, water, agriculture, and smart cities.

Attracting innovation-oriented resources

The EIRENE infrastructure will serve as a pan-European platform for assessment of environmental and human exposures and their potential health impacts, through which harmonised and validated data will be collected, analysed, and presented. These acquired outputs of the ERIENE RI will contribute to better health protection of EU citizens, innovative health policies and better healthcare provision. We expect that EIRENE RI will attract complementary innovation-oriented resources from both public bodies and the application sector. The basic motivations of both sectors are the following:

Public sector:

- informed decision making in the relevant areas, which will result in relevant and justified decision-making both on a national and European level,
- high-quality public service provided to society,
- contribution to the sustainability of public health services and public budgets,
- contribution to social innovation a population welfare.

The resources from the public services will be acquired mainly in the form of research grants, public procurements, and in-kind contributions, which will support the actual operations and outreach activities of the EIRENE RI.

The application sector will use the actual outputs, services, and knowledge, e.g. in the form of user access to research infrastructure, new methodologies, techniques, and standards. To our knowledge, the relevant market for health-related products and services is increasing rapidly (e.g. the analysis and interpretation of human microbiome, which is frequently demanded from end-users – citizens, human relevant toxicological models for the pharmaceutical industry, or human health risk assessment models for the consumer products industry); therefore, the business development potential of EIRENE RI is very high.

The resources from the application sector, both public (e.g. hospitals) and private, will be acquired mainly in the form of collaborative research, various forms of joint undertakings, contractual research, in-kind contributions, and if possible, from donations.

Societal impacts of EIRENE RI

EIRENE RI is designed to answer a need for the RI linking environmental exposures with health identified in the latest ESFRI Roadmap. While the chemical exposures are in the centre of attention of multiple strategies there is currently no infrastructure addressing the chemical exposures, technologies for their characterization, or longitudinal population cohorts enabling the long-term assessment of health impacts.

Horizon Europe is focused on five missions and the impact of environmental exposures on population health is most relevant for *cancer & smart cities*. However, the tools and services developed within EIRENE RI are widely applicable also in the others: *adaptation to climate change* (population cohorts), *healthy oceans, seas, coastal & inland waters* (Non-Target-Screening analytical approaches for assessment of toxic exposures), *and soil health & food* (NTS, population cohorts).

The Green Deal consists of the policy objectives incl. climate neutrality, circular economy, clean energy, smart mobility, sustainable food strategy but especially the overarching ambition of zero pollution. This challenge cannot be addressed without capacities for assessment of chemical pollution, characterization of toxic mixtures, their sources, and environmental and health impacts.

EIRENE RI will provide a sustainable solution to these needs by bringing together complementary capacities existing in the EU and upgrade them into the pan-European infrastructure.

Knowledge impacts of EIRENE RI

In this chapter we estimate the knowledge impacts of the research infrastructure over the following 10 years, i.e. until the beginning of the operation phase. To estimate the impacts for the operation phase would not be responsible due to the level of uncertainty related to possible progress and development in the research area and final shape of the EIRENE RI. Up to now, we have estimated the number of research results in the form of publications, the applicable results in a form of patents, utility models and possible spin-offs, policy documents to be formulated, business opportunities in the form of business contracts and educational and training outcomes. The knowledge impacts of EIRENE RI were identified with the help of the realized 2017 survey responded to by more than 130 relevant participants.

Table 3 Expected knowledge impacts

Impact	Value/No. (estimated)
Scientific results and publications	
- research publications	850
- presentations	180
- proceedings	240
Knowledge and innovation	
- patents and utility samples	4
- licenses	1
- spin-offs / start-ups	2
Policy documents	
- policy documents	50
Industrial collaboration (incl. application sector from public side)	
- number of contracts	190
- number of users from the industry	30
Educational and training programs	
- number of workshops/trainings	260
- number of students using RI	600