FCC Socio-economic benefits

Context

This work has been carried out in the frame of the EU co-funded H2020 project "Future Circular Collider Innovation Study" (FCCIS). The goal is to plan for a sustainable Future Circular Collider scenario by identifying and analysing the socio-economic impact potentials and developing strategies and plans to incorporate them in the FCC scenario development from the onset. The socio-economic impact estimates rely on a working hypothesis of the resources engaged for the FCC project. Therefore, the work includes total project cost estimates. The FCCIS project is an integral part of the overall international FCC Feasibility Study hosted by CERN.

Benefits in figures

Benefit	Total undiscounted (Million CHF)	Total discounted (Million CHF)	Share of the benefit
The value of scientific production	7 885	4 768	14%
Training benefits	10 817	4 106	12%
Industry benefits	10 474	6 907	20%
… for suppliers	9 806	6 497	
… for ICT spin-offs	668	410	
Data and ICT benefits	16 085	10 441	30%
… from the development of a digital information platform	4 434	2 808	
…from the development of a web collaborative service	5 274	3 129	
… from the development of a detector simulation software	6 378	4 504	
Cultural benefits	4 981	3 224	9%
…for onsite visitors	4 206	2 760	
… for online visitors	774	464	
Environmental benefits	3 601	2 204	6%
…from the reuse of excavated materials	517	393	
… from renewable energy production	2 628	1 545	
… from the reuse of waste heat	455	266	
Value of residual assets	6 938	3 401	10%
Total quantified benefits	-	**35 050**	100%
Total costs (CAPEX + OPEX)	32 425	**21 169**	
Net present value (total benefits - total costs)	-	**13 881**	
Benefit / cost ratio	-	**1.66**	

Summary

This report details the data, assumptions, methodologies and outcomes of the socio-economic impact analysis for the initial phase of the FCC research infrastructure - the FCC-ee lepton collider. The analysis spans the entire lifecycle of FCC-ee, encompassing its design, construction, operation, and gradual energy upgrade phases, with an assumed duration of 37 years. The methodological approach is based on the latest literature and empirical research on the economic quantification of impacts associated with research infrastructures, and on the ESFRI recommendations for the long-term sustainability of research infrastructures.

In evaluating the FCC-ee project, both costs and benefits are expressed incrementally in comparison to a scenario where the project is not implemented. In this counterfactual scenario, the LHC would continue its operation until its anticipated end of life, and no new particle-collider would be constructed. CERN would continue its operation, exploiting the existing particle accelerator and experimental infrastructures. This approach is designed to capture the "net" change, focusing on causally related effects that can be specifically attributed to the FCC-ee project.

This socio-economic impact analysis assumes an FCC-ee project with two large experiments, collectively involving approximately about 176 000 individuals over the project's lifespan. This diverse group comprises scientists, engineers, technicians, administrative staff, doctoral and post-doctoral researchers, and undergraduate students. Of the total participants, approximately 10% is assumed to be active on the particle accelerators and technical infrastructures, while the remaining 90% will be engaged in the detectors and experimental physics. It is known that the current baseline of the FCC-ee foresees four experiments and this change would have to be taken into consideration at a later update of the study.

The FCC-ee project is conceived as a design-to-cost project, with a total investment projected at approximately 12 billion CHF in the scenario that is assumed for this study. This figure encompasses civil engineering, technical infrastructures, particle accelerators and investment costs related to the detectors and experiments. Operation costs encompass all human resources involved in the project, irrespective of the organisation employing them, as well as all expenses (both in-kind and outflows) that are needed for operating, maintaining, and repairing the FCC-ee research infrastructure throughout the entire project duration (e.g. electricity, water, spares and human resources for maintenance and repair). These operational costs amount to a total of 20 billion CHF, equivalent to approximately 600 million CHF annually over the project's lifespan.

The cost figures used in this study, along with the projected number of project participants must be regarded as a working hypothesis that serves estimating the socio-economic impacts and that help identifying key impact pathways and pathways that underperform and require further attention. They are formulated based on the understanding of the project at the time of the analysis and are expected to undergo further revisions and refinements as the design progresses.

It is not possible to comprehensively identify and therefore analyse all potential benefits that a large research infrastructure like the FCC-ee could generate. The materialisation of the actual benefits depends largely on the design of an impact creation framework. For instance, the economic benefits of visitors rely on the existence of a well organised visitor programme and dedicated visit points. Some benefits are intangible in nature, such as advancements in scientific knowledge, impacts related to science diplomacy, ethical considerations, and the trust in science. Additionally, certain impacts are challenging to predict at this early stage. Therefore, the analysis concentrated on the direct benefits currently known and foreseeable based on past factual evidence, for instance from the LHC and the European XFEL project.

The analysis was concluded as soon as a high level of confidence was achieved in demonstrating a break-even point between benefits and total costs. For all estimates, conservative assumptions were made. Future research will be carried out to estimate the probability distribution function of the impacts and to identify the factors that most critically affect the impacts. A Monte Carlo simulation will be applied to this end.

The first impact pathway assessed is the value derived from **scientific content production**. It stems from the knowledge flow generated by scientists and engineers engaged in the collider and its experiments, resulting in diverse scientific products, ranging from journal articles and working papers to conference proceedings and presentations. These products can have a lasting impact, extending beyond the High-Energy Physics community, potentially influencing other knowledge domains and addressing broader societal challenges. Scientometric techniques were employed to estimate scientific production and its propagation from the FCC-ee project. The methodology involved analysing historical patterns observed in comparable high-energy physics research programs like Tevatron, LEP, and LHC. The economic concepts of "opportunity cost" and "value of time" were employed to determine the social value of scientific products. This approach considered the time spent by individuals in producing these outputs and valued it based on their average hourly salaries. This method was applied to estimate the social value of scientific products produced by researchers directly involved in the research program (tier 0 products), those citing the initial tier 0 knowledge (tier 1 products), and products citing tier 1 outputs (tier 2 products). Over 22 thousand scientific products are expected to be directly produced by researchers within the FCC-ee project, with an additional 300 thousand products likely to be generated through citations until the year 2080. By factoring in the assumption that a portion of the time spent by authors is dedicated to research activities and the production of scientific outputs (55%), the estimated benefit from scientific production is around 7.86 billion CHF (± 4% in the more pessimistic and more optimistic scenarios). This valuation accounts for the diminishing value of tier 1 and tier 2 products compared to tier 0 products, as knowledge propagates through subsequent waves of production and the initial input from FCC-ee progressively diminishes.

The second impact pathway under consideration is the **value of training**, which reflects FCC-ee's role in imparting knowledge, fostering skills development, and building capacities for individuals actively engaged in the research infrastructure program throughout its lifecycle. This analysis specifically evaluated the benefits accrued by apprentices, trainees, technical students, doctoral students, post-doctoral researchers, and associated personnel up to a cut-off age of 30. The analysis did not include the training value for other highly qualified personnel, temporary labour and contracted works as well as for professionals that move from the project into other industrial domains. The benefit has been quantified by estimating the lifelong career development improvements for participants upon entering the labour market after gaining a working experience within the research program. Previous studies, further validated through a survey involving approximately 2 600 individuals, indicate that the lifetime salary benefit for an early-stage researcher works at FCC-ee ranges from a minimum of 2% to a maximum of 10% for the average period of stay within the research infrastructure (3.78 years). The total socio-economic benefit is assessed at around 10.8 billion CHF (± 66%).

The third impact pathway explores the benefits generated by the project for the **industry**. This encompasses advantages for supplier companies engaged in the design, construction, and operation of the new research infrastructure, as well as the creation of spinoff companies, particularly those in the ICT sector. The benefit stems from increased financial performance of the suppliers resulting from the knowledge gained through close collaboration with the research infrastructure. This knowledge, in turn, contributes to the creation and improvement of new processes, products, and services that suppliers can leverage in other markets and domains. A profit multiplier has been determined, standing at 1.96 for procurement with low or moderate technology intensity levels and 3.09 for procurement with high technology intensity levels. Applying this multiplier to the capital expenditure, the benefits are estimated at 9.8 billion CHF (± 3%). Regarding spinoff companies, based on historical data, it is assumed that FCC-ee would generate approximately two new spin-off companies in the information and computing technologies sector alone each year from the design and preparation phase until the end of the observation period. Considering the probability of company survival each year and the annual market value of companies in the ICT sector, the socio-economic benefit is estimated at 667.5 million CHF (-10 % in the pessimistic scenario and +43 % in the optimistic scenario). In total, the direct benefits for industry arising from FCC-ee are estimated at 10.5 billion CHF.

The fourth impact pathway encompasses **free and open-source software, systems, and platforms** causally linked to the research program, coupled with the provision of open data by the research infrastructure. This study focused on the quantification of the socio-economic impacts of a selected set of ICT tools and software essential for the FCC-ee project, for which measurable historic data of sufficient quality for relevant periods could be identified for model development. An econometric model was constructed to estimate the socio-economic impact of a new virtual information repository, designed to fulfil the collaborative data storage and usage requirements of FCC-ee. The estimated value is derived from measurable benefits associated with comparable repositories, encompassing data storage, online usage, and downloads, net of the present value of its development, operation and maintenance costs. This benefit is calculated at 4.4 billion CHF. Additionally, the value generated from developing a new service to facilitate the worldwide collaboration involved in the FCC-ee project in terms of meetings, calls, and event management was assessed by considering the hypothetical willingness to pay (WTP) of private users for such a tool, totalling 5.3 billion CHF. Lastly, the socio-economic impacts arising from a new or significantly upgraded detector simulation software, with potential applicability beyond high-energy physics, were estimated as the cost that external users would save by adopting the software made freely available by CERN and other contributors. The estimated value stands at 6.4 billion CHF. The total socio-economic value derived from ICT and data amounts to around 16 billion CHF.

The fifth impact pathway pertains to engagement of laypeople. Such kind of activities are directly linked to scientific research, the technologies employed for this research, and the operations involved in designing and running particle accelerators and experiments. For the purposes of this study, the focus was put on on-site visitors and online/social media users. The impact of these activities was estimated based on actual observations of the LHC programme, measured in terms of increased awareness, interest, and understanding of science by members of society, collectively referred to as "**cultural benefit**". It is estimated that FCC-ee will host well over 10 million visitors over its projected time horizon, representing an increase of 4.25 million compared to the counterfactual scenario. Of these visitors, 55% are expected to explore CERN visit points, including the new Science Gateway, the no longer operational LHC and two of its experiments (CMS and ATLAS). 45% would visit FCC-ee experiment and tunnel infrastructures, including the construction sites. The benefit for on-site visitors was estimated using the travel cost method, which incorporates the costs borne by visitors to travel to CERN and FCC, the economic value of time spent traveling, along with any local expenditure connected to their visit based on an actual survey curried out over one year at CERN. This benefit is estimated at 4.2 billion CHF (± 15%), with 44 to 49 % of the economic benefits relating to the local expenditures of visitors. For virtual visitors engaged through CERN-managed webpages and social media, the benefit was estimated based on the "opportunity cost of time". After estimating the volume of online visits directly associated to the FCC project and valuing the time spent during these visits, the benefit is estimated at 774 million CHF. In total, the cultural benefits quantified in this analysis amount to 4.98 billion CHF.

Some of the **environmental benefits** that the FCC-ee project could generate were also assessed. They include the voluntary goal to supply the FCC-ee with electricity from renewable energy sources, the reuse of excavated materials deriving from the construction works, and the supply of recovered waste heat during the operation phase. Securing the electricity of the FCC-ee via the creation of renewable energy sources would generate benefits by making available the residual overcapacity to society at a competitive cost and low carbon footprint. This benefit is estimated at 2.6 billion CHF. The benefit from using waste heat for heating and cooling in the region nearby the collider amounts to 455 million CHF, consisting in the avoided cost for the consumers, who would benefit from heat at a significant lower cost than the current heat energy mix, and in the associated lower carbon footprint. The benefit from the reuse of excavated materials has been estimated as the avoided costs of off-site treatment, transport and conventional disposal. The economic value beyond the avoidance of the disposal is not included in this estimation given the uncertainty about the actual use options that depend on the one side on the excavated materials composition and, on the other side, on the technological readiness levels of the re-use pathways by the time the FCC construction starts. The wide adoption of the excavated materials re-use technologies developed for the project is also not included in this estimate. It is included in the pathway of industrial spillovers, representing an increase of the benefits generated by high technological intensity developments. The conservatively estimated benefit is expected to be around 517 million CHF, thus bringing the total environmental benefit at 3.6 billion CHF.

In addition to the so far mentioned impacts, a portion of the investments, involving assets such as radiofrequency systems, electricity infrastructure, and civil structures, will endure for future use in a subsequent hadron collider project. This **residual value** of FCC-ee assets is significant and contributes to the sustainability of the integrated FCC programme. The estimated value stands at approximately 6.9 billion CHF, equivalent to 56% of the total FCC-ee investment.

To aggregate the value of measured benefits and compare them with costs, a **social discount rate** (SDR) was established specifically for the FCC-ee project. Instead of relying on existing SDRs suggested by international organisations, this project-specific rate accounts for the level of development and preferences for consumption and investments in countries contributing to the CERN budget and the very long duration of the project. The assumed SDR value is 2 %.

Applying the SDR to the benefits, a **total present value of benefits of 35.1 billion CHF** has been determined. Comparing this value to the 21.2 billion CHF present value of all costs (capital and operating costs) yields a **positive net present value of 13.9 billion CHF**. The benefit/cost ratio is 1.66, indicating that the so far quantified socio-economic benefits exceed costs by 66%. Considering a more pessimistic scenario (higher costs and lower benefits) and a more optimistic scenario (lower cost and higher benefits) shows that the NPV ranges between 9.5 billion CHF (B/C ratio = 1.44) and 17.9 billion CHF (B/C ratio = 1.87). These findings strongly suggest a positive net contribution of the FCC-ee project to societal well-being. It serves to demonstrate the long-term sustainability of the proposed new scientific research infrastructure.

The reported findings must be considered as a baseline only. Concerning costs, the estimates are provisional. The environmental repercussions of the construction have not yet been integrated into the analysis. A more comprehensive socio-economic analysis, given additional time and resources, might uncover additional positive impacts. The analysis so far permitted identifying the key impact pathways and can help to design the research infrastructure for sustained impact creation, by integrating the analysis of impacts for the environment, economy and society at large, in line with the current EU practice in policy and infrastructure impact assessment.

To gauge the volume of the societal benefits, a comprehensive survey was conducted among nearly 10 500 individuals across nine countries, including both CERN member and non-member states potentially contributing to the FCC project. The survey aimed to assess public awareness of CERN and its research activities, to evaluate the perceived value of a new research infrastructure, like FCC, to the public, and to compare this monetised value with the per-capita annual contributions made by CERN member states. Results indicate that 41% of the respondents are aware of CERN and its mission, which, although lower than some other international organizations like NASA, remains generally positive. Over 80% of respondents believe that scientific research at CERN advances our understanding of the universe and contributes to improving quality of life. The hypothetical "willingness to financially participate" in the development of the new research infrastructure project was assessed, revealing varying distributions by country. Median values range from 2 CHF per person per year in France to 20 CHF in Switzerland, both CERN member states. For non-member states, the median willingness to pay (WTP) varies from zero in Japan to 24 in the USA (although the mean value for Japan is 10 CHF, meaning that a significant fraction of the Japanese adult population values that type of scientific research). The benefit was estimated by multiplying the estimated per capita yearly WTP by a total adult population of about 380 million persons over 30 years in the CERN Member States, starting with the first relevant FCC-ee investments. It has a discounted present value of 319 billion CHF in the CERN Member States alone. In all observed cases, the perceived public value in CERN's member states is higher than CERN's annual operational budget of 1.4 billion CHF. The average per capita contribution in these states is approximately 2.5 Euro per year or about 5 Euro per income taxpayer per year - less than the average price of a cup of coffee or tea in these countries. The total estimated WTP surpasses the estimated costs by a factor of 20 and exceeds the quantifiable benefits by over 11 times. These findings robustly support the conclusion that the decision to invest in an FCC program can be considered justified from a societal perspective, since the people who potentially fund the endeavour assign more value to it than it costs in total.

Finally, this report presents a set of recommendations that have been derived from the work presented in this analysis. Their purpose is to assure that the benefits can be monitored and regularly reported so that the updated findings can be integrated into the infrastructure's design, construction and operation phases.

Conclusions

The socio-economic impact analysis conducted on the Future Circular Collider - electron-positron (FCC-ee) project has revealed numerous benefit potentials across various domains. The total present value of quantified socio-economic benefits associated with the FCC-ee research infrastructures has been conservatively estimated at 35.1 billion CHF with a range from 31.1 billion CHF to 38.5 billion CHF in pessimistic and optimistic scenarios. The benefits quantified so far are based on the analysis of the following impact pathways:

- The value of scientific products produced by scientists, engineers, and researchers, generating additional knowledge through citations;
- Positive impacts on supplier companies and the creation of information and communication technology (ICT) spin-off companies;
- Development of openly accessible software packages, platforms, and online services, with potential applications beyond high-energy physics;
- Training opportunities and salary increases for early-career researchers involved in the FCC-ee project;
- Impacts generated by on-site and online visitors;
- Environmental benefits from the reuse of excavated material and waste heat, as well as the production of electricity from newly created renewable energy sources.
- The residual value of fixed assets built for FCC-ee that will be used by the subsequent FCC-hh.

These benefits have been appraised through a conservative methodology, drawing on the current understanding of the project, insights garnered from analogous past research infrastructures, and socio-economic impact analyses - exemplified by studies such as Florio et al.'s examination of the LHC and HL-LHC in 2016, as well as Bastianin and Florio's work in 2018. Additionally, recent data collected between 2020 and 2023 has played a crucial role in shaping these estimations. To ensure a comprehensive perspective, data gathering efforts included over 16 000 individuals through online surveys. This diverse group included members of the public, visitors to CERN, users or users of platforms like Zenodo and Indico, as well as former researchers.

The quantified benefits exceed the total costs associated with the design, construction, and operation of FCC-ee by a factor of 1.66, resulting in a net positive socio-economic impact for the project.

These findings should still be regarded as preliminary, since the project cost estimates are still evolving and the benefits are not always fully analysed and only a subset of impact pathways could be quantified so far. Furthermore, negative environmental impacts stemming from the project's construction (e.g. the consumption of agricultural land, the greenhouse gas footprint) have not been factored into the analysis yet. Conversely, in terms of benefits, a more thorough socio-economic analysis, with increased time and resources, could unveil additional positive impacts.

The approach used in this analysis intentionally excludes estimating the unforeseeable impacts of knowledge increase generated by the science mission on the society, because of their inherent unpredictability. The assessment of the public good value of the research infrastructure for the public offers an insight into the overall benefits of FCC-ee for society, gauged through the public's perspective and willingness to financially contribute to the project's implementation. This value is remarkable, 20 times larger than the estimated costs and more than 11 times larger than the benefits quantified so far.

While recognising the need for refinement, this analysis serves as a tool to inform decision-making, optimize user engagement, identify and mitigate risks, and enhance social acceptability for the FCC-ee project. The findings emphasize that the FCC-ee project holds the promise of positive impacts not only for the scientific community but for the entire society, thereby contributing to the project's long-term sustainability.

Recommendations

This study showed that a break-even of costs and benefits can be achieved with the presented FCC-ee research infrastructure with the impact pathways documented so far. However, the potential can only be fully exploited if a continuous tracking of socio-economic impacts is integrated into the infrastructure's design, construction and operation phases. To achieve this objective, nine recommendations have been formulated.

1) **The FCC programme should allocate personnel and material resources for the impact identification, design, planning, implementation, monitoring and assessment process to help fully leveraging the impact potentials and making FCC a socio-economically sustainable endeavour.**

This personnel needs to be empowered to be able that the results of the impact assessment and the impact generation recommendations are indeed considered in the design where appropriate, that they are implemented and that the continuous, systematic monitoring and analysis is carried out with the help of all participating project members. This requires that socio-economic impact assessment is implemented as a cross-cutting activity across the entire organisation, with the direct involvement of the highest possible managerial level and reporting directly to CERN's key stakeholder, the Council. This approach is expected to secure the sustainability and effectiveness of the process, as well as help enhance project acceptance among financially contributing countries.

2) Concerning the impacts generated by scientific products, the FCC programme should encourage that scientific and engineering works are published via "gold open access" channels (as opposed to "self-publishing") and reputable outlets (as opposed to depositing information in preprint servers only). This ensures proper identification of works for tracking purposes and increases their likelihood of uptake.

This socio-economic impact assessment study has revealed challenges in identifying all scientific outputs associated with the research infrastructure activities. It is essential to track the scientific production of researchers involved in experiments and monitor citations across papers and other scientific products. However, scientific outputs lacking proper unique digital identifiers and citation references, as it is often the case with workshop proceedings and presentations available in platforms like Indico cannot be adequately identified and considered for socio-economic valuation. These types of outputs should, whenever possible, be replaced or supplemented by citable reports or papers. Establishing strategic partnerships with leading publishers, as exemplified by the SCOAP3 project, is a suitable approach to assure the presence of citable publications. Open access platforms used for dissemination could integrate download, citation and reference tracking, if they do not already offer those functions (e.g. Zenodo and ArXiv currently lack these functions). Furthermore, additional research is necessary to expand monitoring and tracking of scientific content beyond scientific and engineering articles and presentations to include books to better understand the societal uptake of knowledge acquisition within the FCC programme.

3) Concerning the value of training, the FCC programme should foresee a framework to monitor the movement of people after they leave CERN, to facilitate the analysis of future career developments.

Every individual contributing to the FCC project for a minimum duration should be encouraged, on a voluntary basis, to engage in a comprehensive monitoring programme. Thanks to mechanisms to reconnect with them periodically, this initiative would entail long-term follow-up and periodic collection of a set of basis information on their current work position.

4) To ensure the effective analysis of industrial spillovers generated during project implementation, the FCC program should incorporate systematic monitoring of the economic impacts on suppliers resulting from procurement actions over multi-year periods.

Given that these effects may not manifest immediately and can extend beyond the duration of the procurement contract, it is crucial to obtain feedback from the involved companies. This necessitates the establishment of a comprehensive procurement monitoring framework that facilitates ongoing engagement. Such a framework should include provisions for storing information on the individuals initially involved in the contract, enabling periodic follow-up after the contract's conclusion. Additionally, it should facilitate the collection of essential information regarding the spillover effects generated by the procurement experience with CERN on the company.

This can be achieved through mechanisms such as short online surveys designed to gather pertinent data. By implementing this approach, the FCC program can gain valuable insights into the long-term economic impacts of its procurement activities, fostering continuous improvement and enhancing collaboration with industry partners.

5) Information and Communication Technologies (ICT) have been identified as a key impact pathway that should be better leveraged through targeted transition actions to society, accompanied by systematic monitoring of uptake.

CERN and the FCC represent a globally unparalleled environment for the development of software and platforms to serve the needs of global collaborations, which is in high demand across societal and industrial sectors, too. By identifying the specific requirements of such collaborations and initiating dedicated development projects, the potential for widespread adoption beyond the FCC project can be created. Examples include collaborative event management, document creation, communication (both one-to-one and one-to-many), file sharing, information management, social networks, remote operation, cybersecurity, distributed computing and data processing. CERN and the member states should ensure that the developed technologies are accessible to users outside the high-energy and particle physics community, free of charge, while also guaranteeing long-term maintenance and improvement. This requires making software and tools available on platforms that support download and installation tracking. The lack of such data has been identified as one of the limiting factors hindering accurate estimation of ICT impacts.

6) With respect to the impact of spin-off companies, there is a need to establish a systematic method for tracking companies founded by former participants in the FCC programme, monitoring their evolution over time, and assessing their economic value.

The establishment of new companies leveraging knowledge acquired through the FCC programme represents an important societal benefit. Notably, spin-offs often emerge from participants' amalgamation of different skills and experiences, rather than the direct exploitation of a single licensed technology. In particular, the technologies developed in collaborative R&D projects cannot be attributed to CERN alone and CERN does not track the technologies of collaboration partners. However, to accurately gauge the economic and societal benefits generated, a voluntary, systematic tracking mechanism is essential. This tracking framework should facilitate a comprehensive assessment of the impact of spin-off companies. It could include the establishment of a centralised database to record information about spin-off companies (such as their founders, country, industry sector, products/services offered), and the possibility to periodically contact them to provide updates on their companies' progress.

7) Concerning the cultural impacts, the study revealed the relevance of economic benefits due to on site visitors. To ensure a sustainable monitoring of this impact pathway, **CERN and the FCC collaboration should establish a unified framework to continuously collect essential data on visitor to CERN's exhibition centres, the experiments and any other relevant visit site.**

A systematic tracking mechanism for visitors is indeed necessary to accurately report on the effects of on-site visitors. Visitors should be requested to provide a small set of basic information, including their country of origin, mode of transport to Geneva, main purpose of the visit, duration of stay, visitor spending, and feedback on the exhibitions and the visit sites (e.g. their level of satisfaction). By implementing this monitoring framework, it will be possible to effectively track and evaluate the cultural impact of on-site visitors, as well as enabling continual enhancement of visitor experiences.

8) The identification of environmental benefits and their analysis should be intensified.

The identification and analysis of environmental benefits is important to the social acceptability and for achieving a net-zero balance of the scientific research activity for the society. This requires the establishment and empowerment of economics and environmental experts in the coming project preparatory phase and intensified cooperation with industrial partners and host-state services, for a reliable identification of potential environmental benefits and costs associated with the project. In addition to the creation of renewable energy sources, the re-use of waste heat and the re-use of excavated materials, further opportunities may be uncovered through additional research and extended discussions with project stakeholders. For instance, impact pathways related to water usage, land management, biodiversity conservation, and transportation infrastructure need thorough investigation. Assessing potential negative environmental impacts is equally important. Understanding and mitigating adverse effects such as pollution are critical for achieving sustainable outcomes and ensuring responsible use of natural resources.

9) Continuous monitoring of the so called "common good value" has been identified as a suitable approach to validate the investments against the expectations of funders, ultimately the taxpayers. This approach should be further intensified through surveys conducted in all potential funding countries and regularly repeated to enhance our understanding of how social acceptance can not only be maintained but also be improved.

A framework for streamlining this process has been developed within this project, enabling the activity to continue with only marginal additional resources. Expanding data collection to additional countries, beyond those already surveyed, can provide insights into the factors influencing the people's perception on the FCC programme. The findings should be regularly shared with CERN management and the Council and summarised for broader dissemination to all stakeholders, including the public, through channels such as CERN's social media platforms and its main websites.