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Results of the socio-economic impact study

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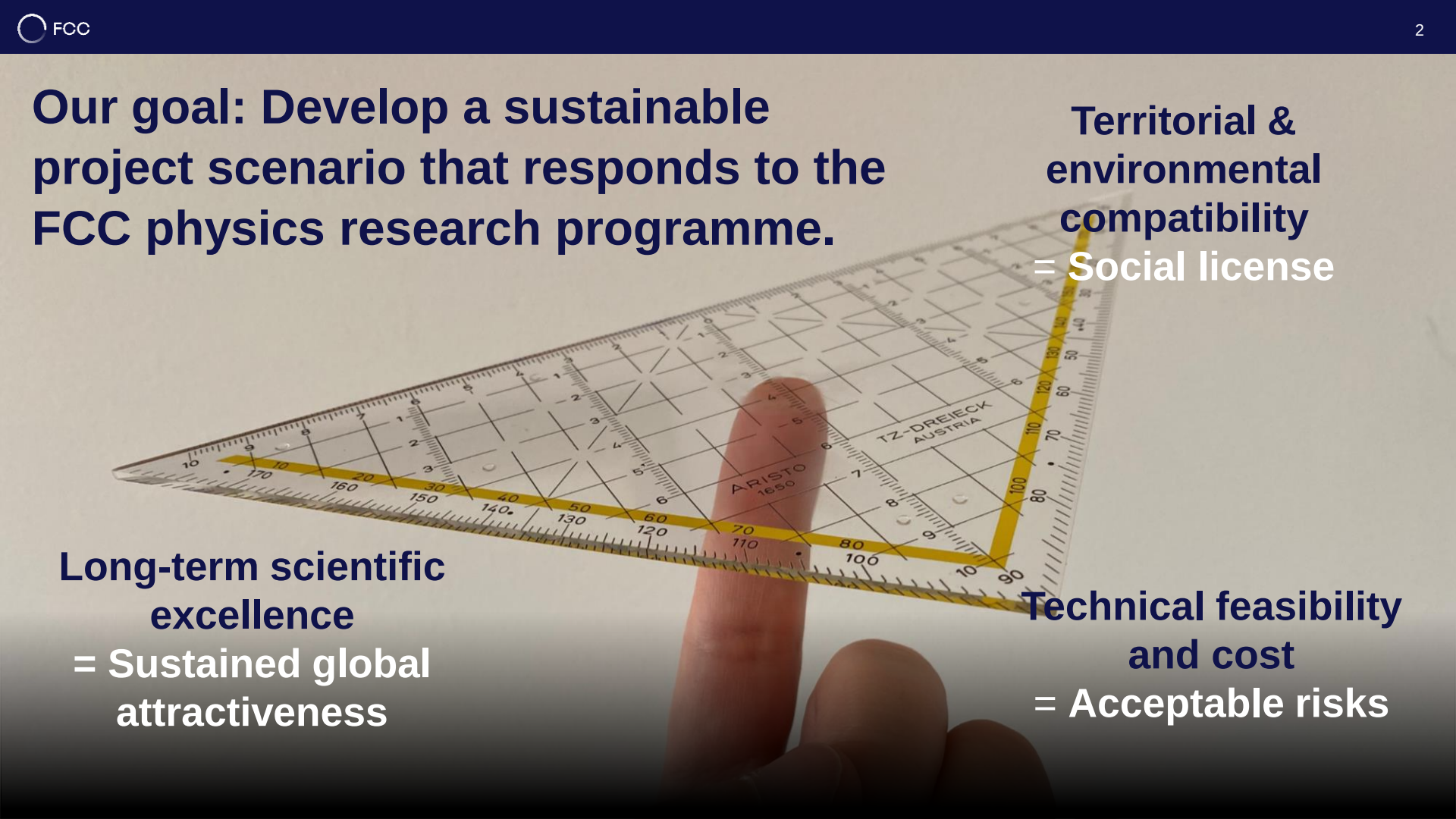
FCC Week 2024, San Francisco, June 2024

Our goal: Develop a sustainable project scenario that responds to the FCC physics research programme.

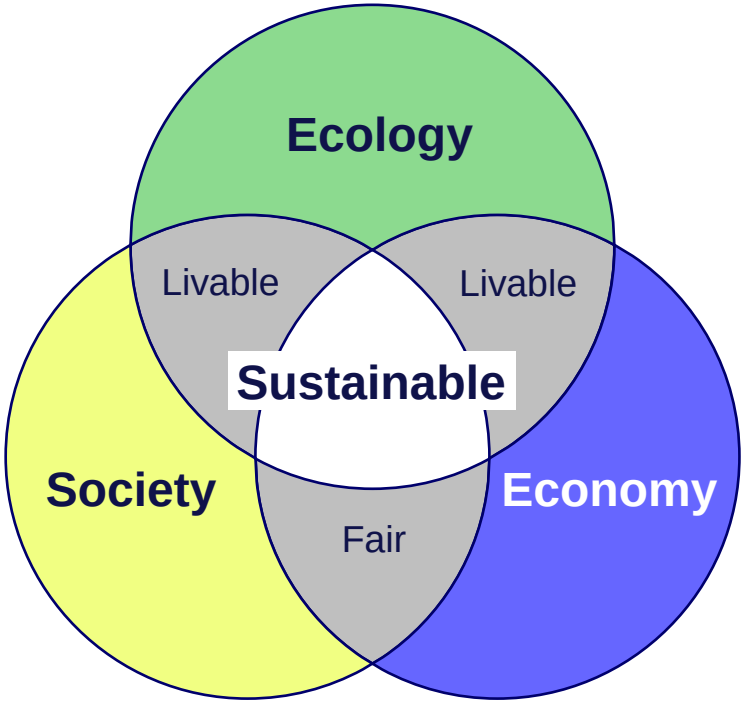


Territorial & environmental compatibility
= Social license

Long-term scientific excellence
= Sustained global attractiveness

Technical feasibility and cost
= Acceptable risks

Sustainability – an equilibrium of aspects



Economy : science, technology and economy

- Goal of the mission – the **scientific excellence**
- Total **costs** (CAPEX + OPEX)
- **Risks**
- Direct, indirect and induced **economic benefits**

Society

- **Socio-economic** benefit potentials
- **Common good value**
  (the value as perceived by people)
- **Social license** - territorial feasibility

Ecology

- Negative **externalities**
- **Ecological benefit** potentials

GOUVERNEMENT
Liberté
Égalité
Fraternité

Socio-economic evaluation according to French law

L'article 17 de la Loi du 31 décembre 2012 de programmation des finances publiques oblige tout porteur de projet d'investissement financé par l'Etat ou par l'un de ses établissements à réaliser préalablement une évaluation socioéconomique. Son décret d'application du 23 décembre 2013 confie deux missions au SGPI :

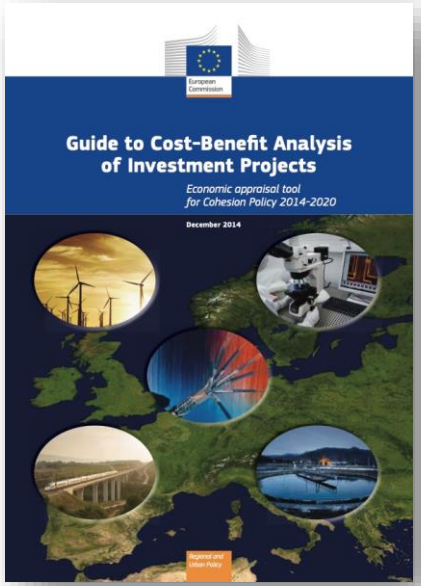
Financial analysis

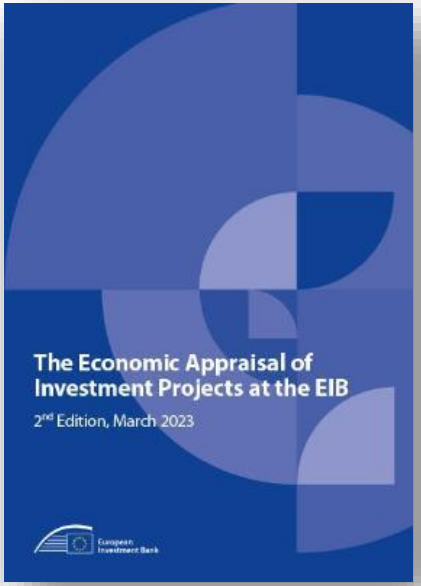
- Capital expenditures
- Operation expenditures
- Revenues (voluntary payments)
- In-kind contributions

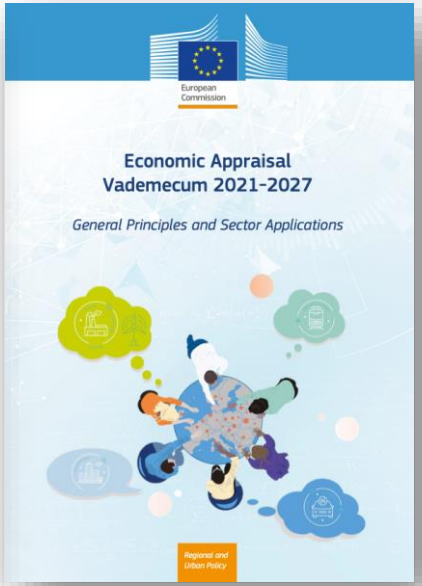
Socio-economic analysis

- Benefit potentials
- Positive externalities (avoidance)
- Negative externalities
- Compensations

EU/EC requirements for sustainability analysis

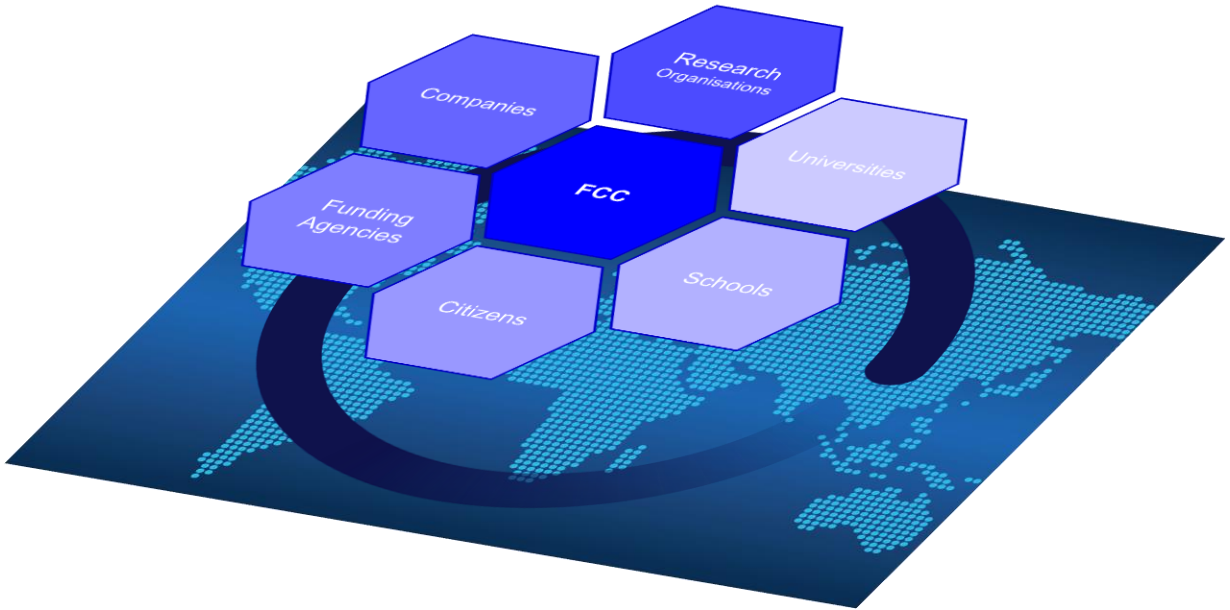






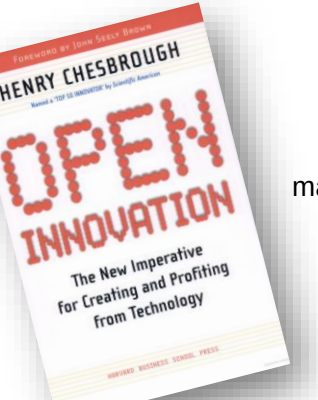
- **All guides** relevant for Research Infrastructure investment projects **foresee an integrated social cost-benefit approach**.
- **Required** for loans (e.g. **EIB**).
- **Required** for inclusion in the **European Strategy for Research Infrastructures (ESFRI)**.

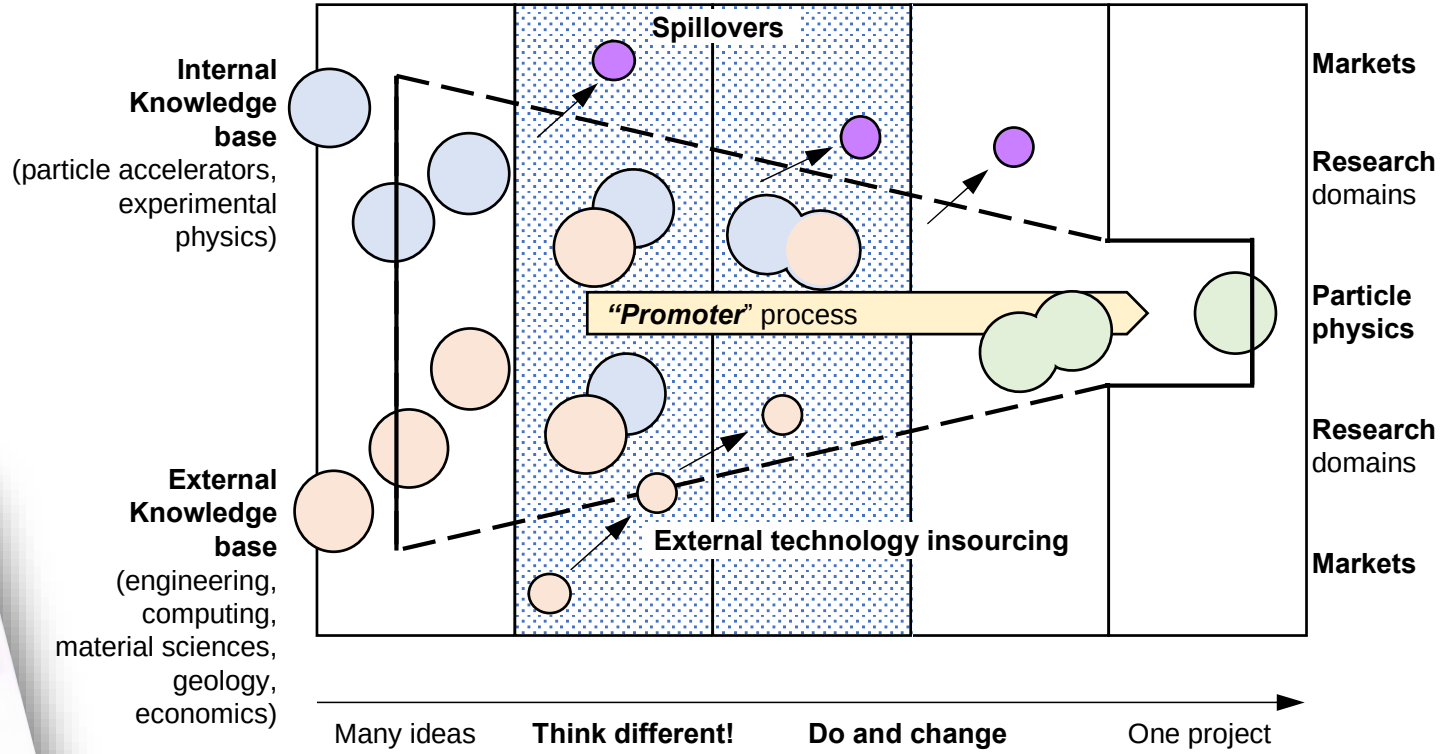
A Research Infrastructure can be **a platform transforming the environments** into which it is embedded…



…at different levels…

…through **Open Innovation**

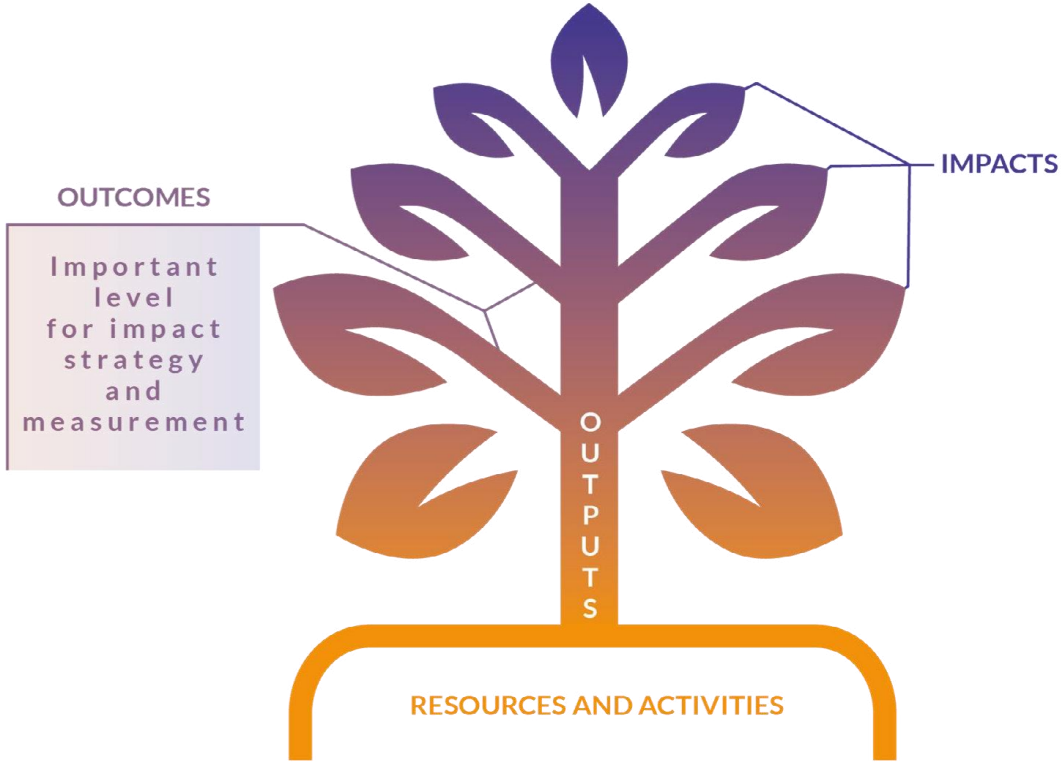




Socio-economic design: a way to attain sustainability

Required steps:

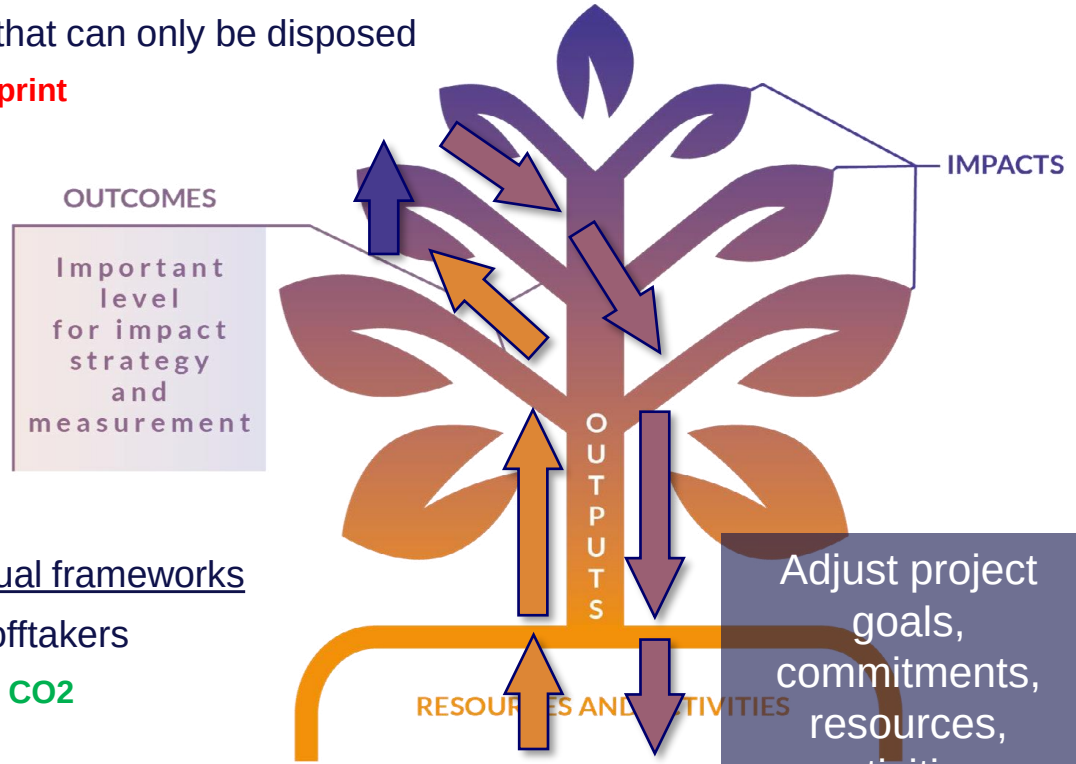
- **Which pathways exist**
- **Which pathways are relevant**
- **How to quantify each pathway**
- **Estimate each pathway value**
- **Prioritise impactful pathways**
- **Design for impact optimisation**



RI-Paths impact tool: https://ri-paths-tool.eu

Iterative approach: analyse then adjust

- **Example: Excavation produces spoil** that can only be disposed
  - **WASTE! Costly and implies CO2 footprint**
- Who has a relevant solution?
- Will it work?
- Is it economically viable?
- Who else has the same need?
- Establish a business plan
- Quantify and estimate!
- Develop the process
- Leverage or adapt regulatory & contractual frameworks
- Enter agreements with contractors and offtakers
  - **NO LONGER WASTE! Less cost, less CO2**



Comprehensive Cost-Benefit analysis

Estimated **Net Present Value** of the project as **discounted value of all estimated benefits net of discounted costs at the end of the observation period:**

$$NPV = \sum_{B=1}^{n} PV_B - (PV_C + PV_O + PV_E)$$

- PV_B is the present value of **benefit *B***
- PV_C is the present value of the sum of all **capital expenditures** and PV_O of all **operation expenditures**
- PV_E is the present value of the sum of all **negative externalities**

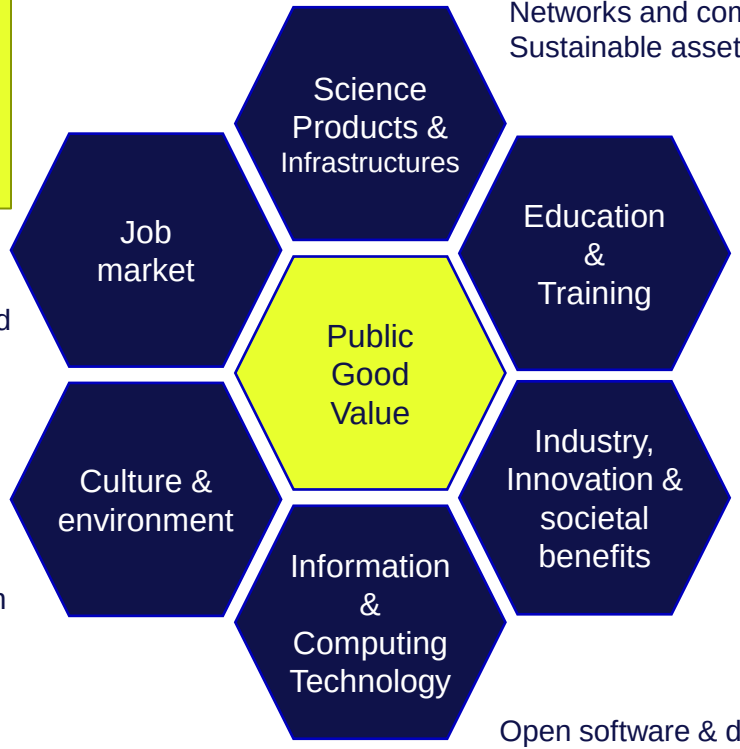
$$Present\ Value\ of\ Benefit\ B = \sum_{t=1}^{n} \frac{B_t}{(1+SDR)^t} \quad Present\ Value\ of\ a\ cost\ C = \sum_{t=1}^{n} \frac{C_t}{(1+SDR)^t}$$

- *t* is one year of the observation period, running from *1* to *n*, from the first year of the analysis to the end of the observation period
- B_t is the value of benefit *B* at time *t*
- *SDR* is the social discount rate value established for the analysis.

Note: a project is sustainable if NPV > 0, B/C > 1.05 (typically with $p < 0.05$) and the economic rate of return is higher than the applied Social Discount Rate (2%).

Impact pathway analysis model

Not all benefits can be merged into a single Cost-Benefit model. For instance, the public good value and the job market are analysed separately.



Papers, books, articles, presentations, conferences, lectures
School books, university training materials
New and improved methodologies, practices
Networks and communities
Sustainable assets built up for future research opportunities

Salary premium
Life standard increase

GDP growth impact
Industrial spillovers
Waste heat supply
Excess energy creation
Company spinoffs
Innovation impacts (products & services)

Open software & data
Open platforms & systems

On site visitors
Virtual visitors
Exhibitions, events
Books, films, music
Species, biodiversity and habitat protection

Jobs sustained
New jobs created

In line with the economic appraisal of R&I infrastructures, EC Vademecum 2021-2027, page 36, Figure 1.

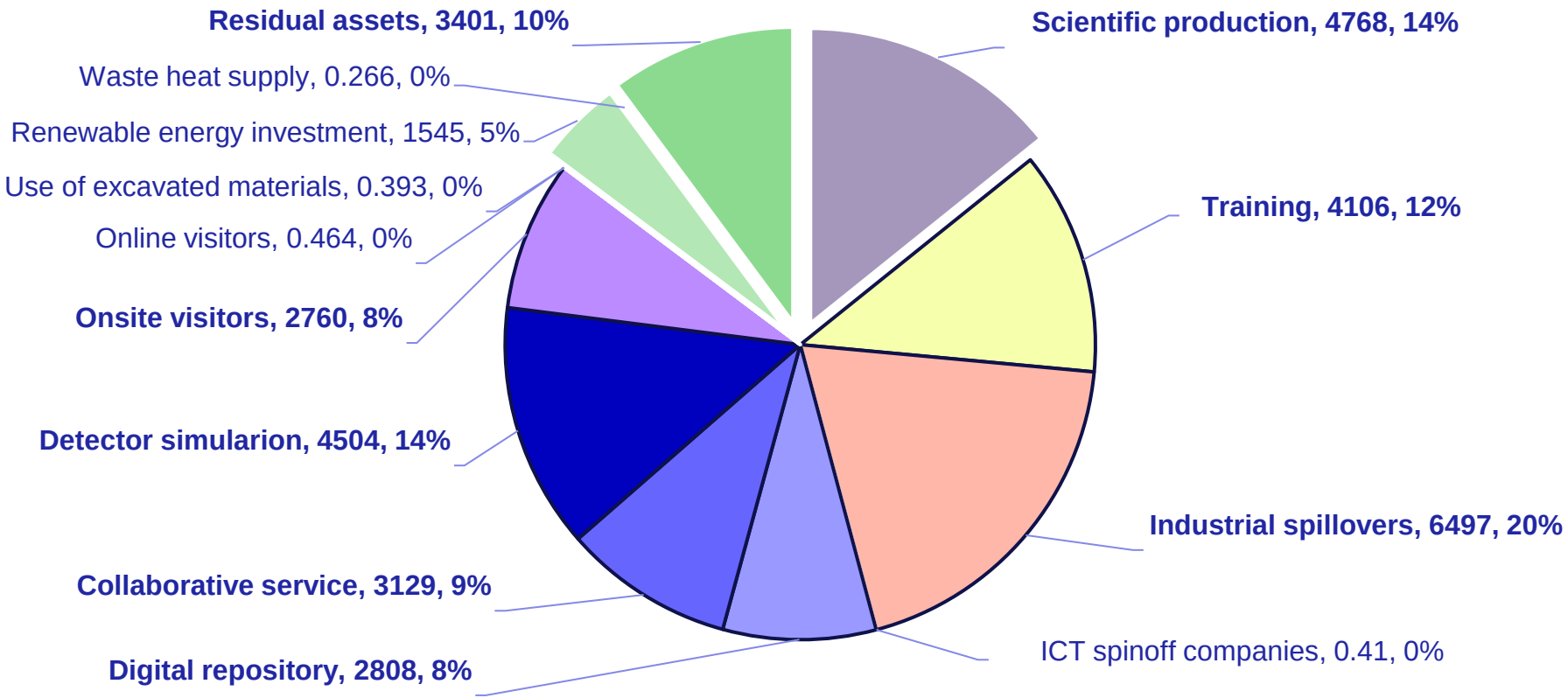
Results of the Cost/Benefit Analysis

Benefit	Total undiscounted [MChf]	Total discounted [MChf]
Value of scientific production	7 885	**4 768**
Training benefits	10 817	4 106
Industry benefits	10 474	6 907
… for suppliers	9 806	6 497
… for ICT spin-offs	668	410
Value of data and ICT benefits	16 085	**10 441**
… 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
Value of cultural benefits	4 981	**3 224**
… for onsite visitors	4 206	2 760
… for online visitors	774	464
Value of environmental benefits	3 601	**2 204**
… 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**
Total quantified benefit estimates	-	**35 050**
Total costs (CAPEX + OPEX)	32 425	**21 169**
Net present value (total benefits - total costs)	-	**13 881**

https://zenodo.org/doi/10.5281/zenodo.10653395

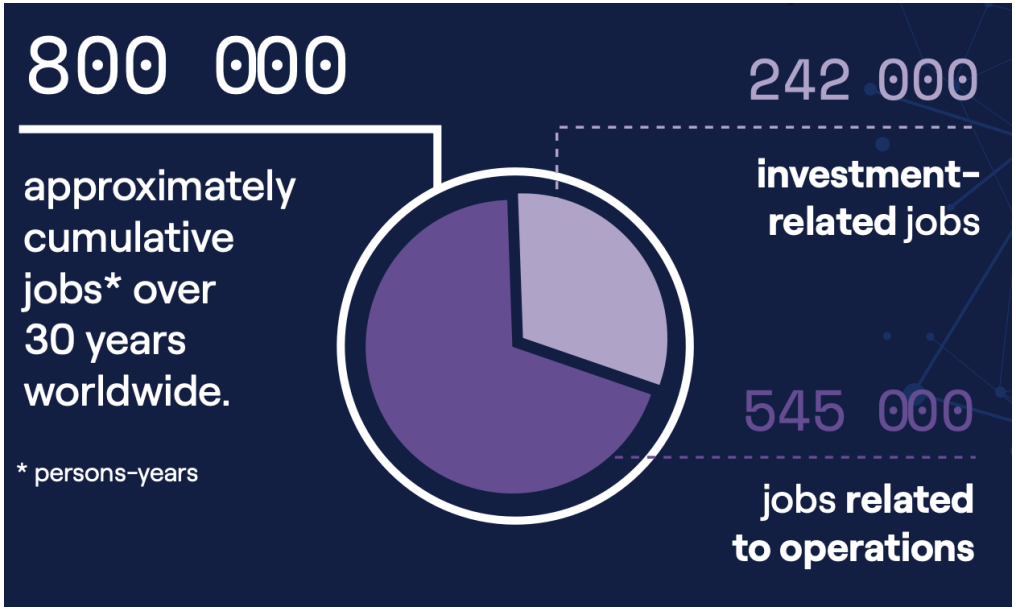
NOTE: figures are mid-point estimates

Benefits: 75% = ICT+visitors+training+industrial spillovers

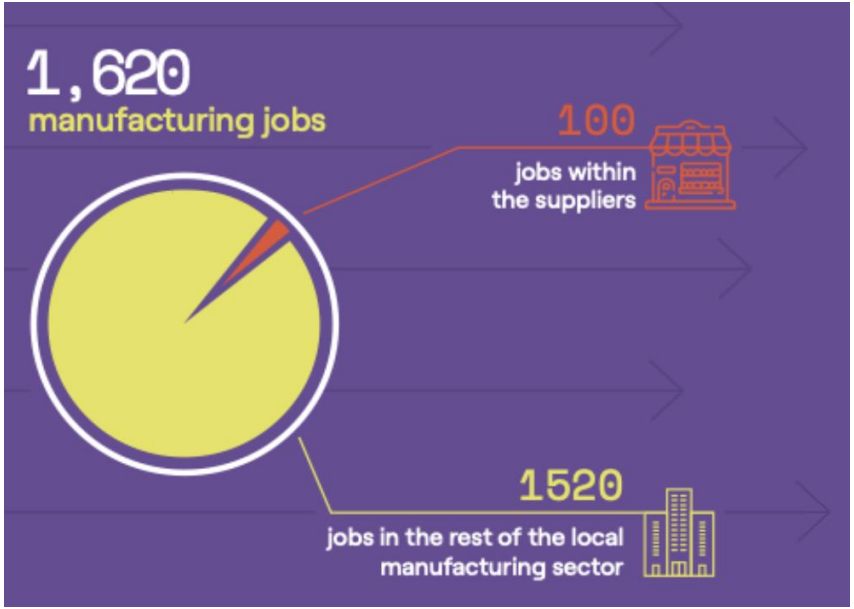


The creation of jobs

WIFO value-added analysis and person-years job creation at a global scale.



Regional job creation analysis by LSE: Superconducting RF manufacturing leads to sustained high-tech job creation. **Each 1 direct employee sustains 15 more regional jobs.**



https://doi.org/10.5281/zenodo.7986138

https://doi.org/10.5281/zenodo.7553423

Public Good Value

Value of the RI perceived by the public = a gauge for the justification of the investment.

10 500 individuals surveyed in 9 countries.
Significant parameters identified:

- Awareness of CERN and the FCC
- GDP per capita (Purchasing power Parity against USD)

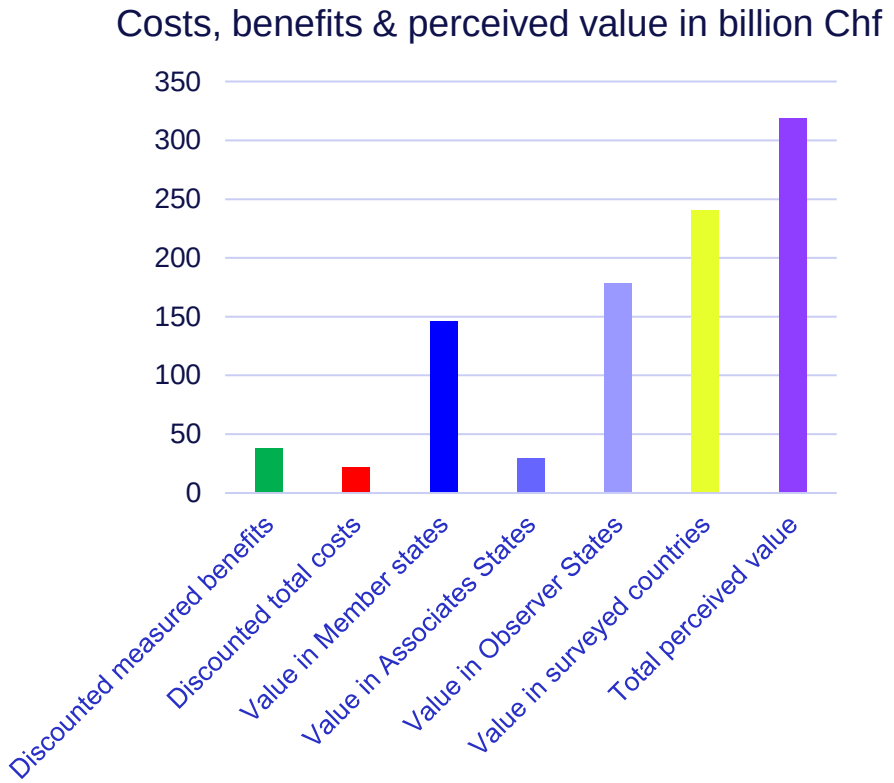
Model built and time horizon chosen: 30 years

- Average is 2.5 euro per taxpayer or 5 euro per capita in all CERN member states.
- Average is 0 in Japan and 24 in USA.
- Median between 2 CHF in France and 20 CHF in CH.

Total value estimated only for a population of 380 million persons in the CERN member states over 30 years is 110 billion CHF. With associated and observer strates it is 320 billion CHF.

In all observed cases the **perceived public value in CERN's member state is higher than CERN's annual budget.**

Supports the conclusion that a decision to invest in an FCC programme can be considered justified from a societal perspective, since the people who potentially fund assign more value to the infrastructure that it costs in total.



Further elements to be included

- Revised total cost
- Revised schedule
- Cost of carbon (GWP)
- Loss of land
- Loss of forest
- Loss of agricultural income
- Loss of biodiversity
- Increased scientific collaborations
- Value of creation of new habitats and preservation of wetland zones
- Revised waste heat capacities
- Potential water re-use benefits
- Benefits from commonly carried emergency services
- Revised gains from excavated materials use
- Wider societal and economic gains from the application of developments carried out for FCC only (e.g. MATEX, low carbon concrete plant)
- Revised cultural benefits
- Complementary ICT benefits
- Benefits from increased regional economic activities

A major challenge: coverage

Known Knowns

We measure
the impact pathways,
plan and forecast them.

Known Unknowns

We know the **impact pathways exist**,
but we do not know
how to measure them.

Unknown Knowns

We have **insufficient time, people, money to measure**,
analyse and plan
for the impacts.

Unknown Unknowns*

Impact pathways thatwe are **not aware of and that we cannot measure.**

We do not know the size of **the "impact universe"**

- What are the 100% ?
- Do 100% exist at all?

*D. Rumsfeld, 12 Feb. 2002

A major challenge: coverage

Known Knowns

We measure
the impact pathways,
plan and forecast them.

Known Unknowns

We know the **impact pathways exist**,
but we do not know
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Unknown Knowns

We have **insufficient time, people, money to measure**,
analyse and plan
for the impacts.

Unknown Unknowns

We do not know the size of the "impact universe"

- What are th
-

RI core mission is not assessed.
We cannot use
Benefit / Cost assessment
to directly compare fundamental
scientific research Infrastructure
scenarios

*D. Rumsfeld, 12 Feb. 2002

Another challenge: consistency

Common good value:
Quantified by WTP
“How much is it worth to you
to fund research
with an FCC per year?”

Value-added and job creation:
Quantified by
Input-Output Tables
Indirect – direct – induced jobs

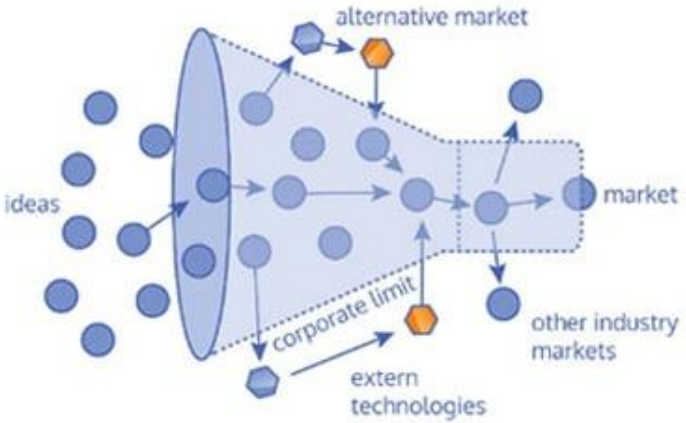
Incremental benefit estimates:
Measured by
tourist spending +
leasure time value

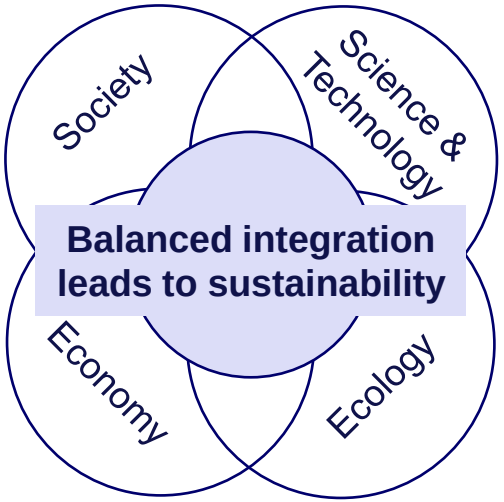
- Double counting
- Tripple counting
- Missing counting
- Base year
- Currency
- Value assumptions
- Methods
- Observation period
- Geographical extent
- … and much more

Takehome messages

Research Infrastructures such as the FCC are ideal platforms for Open Innovation if a proper platform around the science mission is established early.

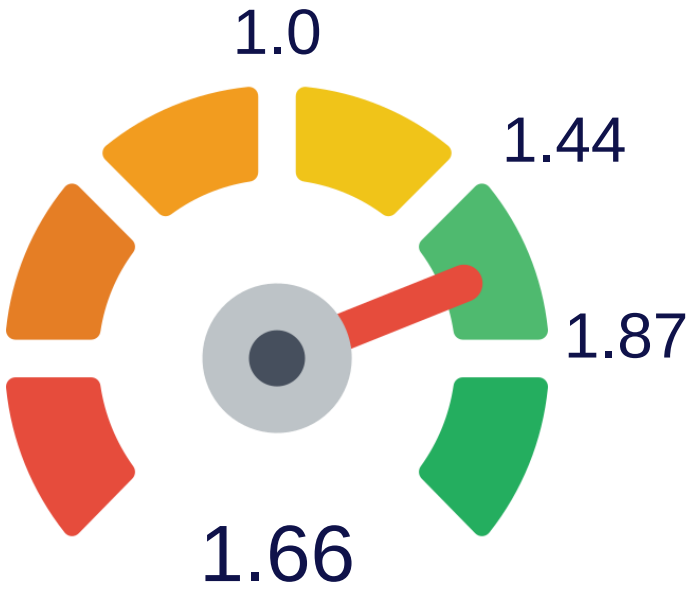
Sustainability is analysed using well established economics methodologies and integrates several dimensions. Different indicators are reported. Full benefit coverage is not achievable.





Performance so far

- **Results are robust** and do not significantly change with minor adjustments of cost and benefit hypothesis.
- **Sensitivity to different and variable social discount rates** (SDR) turns out to be insignificant due to the very long time duration of the project.
- **Negative externalities remain to be included**, e.g. the shadow price of carbon, the loss of land and agricultural income.
- **Futher benefits can be added**, subject to time and resource availabilities. ICT and cultural goods exhibit strong potentials.



Mid-point Cost/Benefit ratio:	1.66
Pessimistic estimate:	1.44
Optimistic estimate:	1.87