GUIDELINES ON COST ESTIMATION OF RESEARCH INFRASTRUCTURES

StRESFRI
STUDY

StR-ESFRI Study

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FOREWORD

The ESFRI Roadmap contains indicative figures on the set-up and operating costs of the Research Infrastructures, based on estimates provided by the ESFRI Projects and Landmarks. The previous methodology for collecting estimated cost data presented two significant challenges with results: cost categories were not uniformly represented by the RIs, and quoted values fluctuated inconsistently over time.

A discussion developed in the ESFRI Executive Board and in the ESFRI Forum on the need to elaborate a cost analysis for RIs that would be referenced to standard economic methods – e.g. adopting the discount cash-flow analysis for the full lifecycle of the RI, but with RI-specific figures that could be appropriate for the different kind of RIs and their funding schemes. The objective of the cost analysis is to give full transparent evidence of the required investment for the set-up and running resources for operation of the RIs, using state of the art financial units that are easily interpreted and communicated to the political and funding authorities. Adoption and use of the cost analysis will strengthen the reliability of the cost information reported in the ESFRI Roadmap updates, and will provide solid reference values for the monitoring activities of ESFRI on the Projects and on the periodic update of the Landmarks status of the operational RIs.

StR-ESFRI opened a public competition of professional consultants to commission a cost analysis study on RIs and the proposition of a user-guide for applying it to the specific case of ESFRI RIs. The contract was awarded to CSIL – the Centre for Industrial Studies – an independent research and consulting company, specialised in applied economic research, evaluation of public investment projects, infrastructure project appraisal, that already worked in the past on cost-benefit analysis of some Research Infrastructures like CERN and CNAO.

The results of this research are summarized in a CSIL document that was presented during the 68th ESFRI Forum Meeting on 27th-28th March 2019 in Liblice (CZ) and well received by the Forum. ESFRI will take note of the results of the CSIL report in developing its Roadmap methodology and guide for the next updates.

Here we present an extended version of the *Guidelines on Cost Estimation of Research Infrastructures* as a StR-ESFRI Study downloadable from the esfri.eu website. It is offered for reference to all RI managers and financial officers informing on an advanced cost analysis methodology.

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Abbreviation list

BAU	Business as usual
EOSC	European Open Science Cloud
ESFRI	European Strategy Forum on Research Infrastructures
FAIR	Findable, accessible, interoperable and re-usable (data)
IPRs	Intellectual Property Rights
NPV	Net Present Value
RI	Research Infrastructure
VAT	Value Added Tax

1. Introduction

These guidelines are developed in the framework of the StR-ESFRI project (Support to Reinforce the European Strategy Forum for Research Infrastructures), to provide a conceptual and methodological tool for cost estimation of Research Infrastructures (RIs) included (or willing to be) in the ESFRI Roadmap. The report provides a unified framework to gather data concerning costs along life cycle of RIs in a harmonized way. It illustrates general principles and suggests technical solutions when data seem not immediately available or difficult to estimate. It also takes into account the specificities of different typologies of RIs, which are active in different research domains and adopt different accounting systems.

The main audience of these guidelines is RI senior managers who are responsible for financial planning and long-term sustainability of the RI; however, some technical expertise may be needed to implement the methodology (e.g. head of finance).

The common cost accounting methodology presented in these guidelines is based on the best international practice in the field of infrastructure project appraisal, allowing comparability across different types of RIs, countries and scientific fields and it is inspired by solid principles leading to univocally interpretable results.

The main purpose of this document is to support ESFRI and the ESFRI-related Research Infrastructures ('projects' and 'landmarks') in providing evidence-based financial perspectives for their lifecycle phases and maintaining regularly updated information for the Forum.

Adopting a common framework is essential not only for gathering data and supporting funding decisions, but also to allow update and verification of the information. It can also be used by RI managers for more far reaching exercises such as assessing the socio-economic impact of the RIs[1] (particularly with the use of cost-benefit analysis) or ensuring long-term financial sustainability and, ultimately, facilitating the dialogue with funding agencies.

It has to be noted however that, in offering a pan-European methodology to evaluate costs of design, preparation, implementation and decommissioning of RIs across different legal frameworks, and regulatory and accounting standards, these guidelines do **not** aim at substituting the standard accounting rules in place in the different countries and under the different legal statuses.

The methodology has been discussed and tested with four existing RIs and their comments and reactions are reflected in the final version of the guidelines.

The guide is structured as follows: the first chapter describes in a nutshell the steps and easy-to-use rules to be followed for cost estimation; the following chapters instead provide a more comprehensive description and explanations of the basic principles and the different cost items to be considered. The Annex includes a set of exemplary tables showing the possible structure and level of disaggregation of data and financial information. The guide is complemented by an Excel file providing a template for the cost data collection and computation of present values.

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[1] The methodology presented here is in line with the 'Guide to Cost Benefit Analysis of Investment Projects' (last release 2014) adopted by the European Commission, DG Regional and Urban Policies, for major infrastructure projects, including RIs. This is a reference also adopted by the European Investment Bank and accepted by the European Court of Auditors and by other international development banks.

2. The method in a nutshell

Costs of Research Infrastructures (RIs) include amounts that have to be paid (cash outflows) or resources that have to be employed (in-kind contribution) for the design, preparation, construction or set up, operation, maintenance, upgrade and decommissioning of a RI. The standard rules to be followed for cost estimation, which are presented in more details in the next chapters, are the following:

1. **Define the unit of analysis.** A careful delimitation of the unit of analysis may require apportionment and aggregations of cost items, for example when the infrastructure works with a complex of facilities managed by different legal entities or when they are distributed. RIs do not always coincide with the costs of the hosting organisation(s).

2. **Adopt a long time horizon.** The timespan for cost estimation must reflect the entire lifecycle of the RI. Costs must be reported for each year of the time horizon.

3. **Fix the start date.** The time horizon starts the year when the first resources are deployed (cash or in-kind) for the design and preparation phase of the RI. Re-use of components of existing facilities are 'sunk' costs and should not be included.

4. **Fix the base year.** The base year is the point-in-time when the cost estimation is made and it does not necessarily coincide with the start date. Past and future costs should be intended with respect to the base year.

5. **Costs should be expressed in real terms.** Prices must be constant at the base year: future costs must be forecasted according to realistic assumptions and should be net of inflation while past costs, usually reported in financial statements, must be converted into base year value by applying the inflation index.

6. **Only cash outflows are reported.** The cost accounting must follow a cash flow method. Depreciation, reserves and other accounting items that are usually reported in balance sheets must not be included. Sources of financing can be used to identify cost items but shall not be mixed or added to them.

7. **In-kind contribution must be included** by calculating their corresponding market price or actual production costs.

8. **Costs must be expressed in Euro.** The official exchange rate of the base year must be used to convert foreign currencies in Euro.

9. **Costs must distinguish between investment costs and operating costs**. Investment costs include: design and preparation; construction and start-up; replacement costs; major upgrades; decommissioning. Operating costs include: rent of building or equipment; personnel; ordinary maintenance and repair; utilities and consumables; management and administration, etc.

10. **Total costs must be calculated at present value.** Future costs must be discounted while past costs must be capitalised (in addition to inflated, as explained at point 5) with an appropriate discount factor.

The steps are illustrated in the following diagram, while more comprehensive explanations and discussions of the rules to be followed are provided in the following sections.

3. General principles

Before illustrating the specific rules for cost accounting, this chapter illustrates some general principles that should guide the costing exercise. They are meant to clarify the overall rationale and approach of the cost estimates.

3.1 Identification of the unit of analysis

The cost estimation must include all the material and immaterial components which are functionally connected to the attainment of the RIs mission. The elements so identified should consist of a self-sufficient unit of analysis.

Project identification consists of the definition of the unit of analysis and of its precise borders in geographical, legal, functional and timing terms. It is the first step for a sound cost estimate. Such exercise is not always as straightforward as it may appear at a first glance. The unit of analysis must indeed include all cost components that are necessary to achieve the scientific mission of the RI; this means that it can include a complex of different facilities located in different places and managed by different organisations.

RIs are often managed **through international collaborations involving many legal entities**. An individual scientific project can require a complex of facilities and experiments. For example, an accelerator without a detector cannot deliver any experimental data and the same if only the detector is considered. Such facilities can be run by different legal bodies with separate juridical (and accounting) arrangements. In this case, the definition of the unit of analysis requires the careful aggregation and apportionment of several items which may be under different contractual arrangements. This entails gathering data from the financial statements of all the entities involved so that some harmonisation may be needed before aggregating cost items.

For distributed RIs, consisting of a network of hub(s) (e.g. coordinating secretariat) and nodes located in different locations/countries and in different (often already existing) infrastructures, the relevant cost items include those incurred by the hub together with those incurred by national nodes, as long as all those components and/or projects are necessary to make the RI achieving its mission. The costs of the RI are the sum of the costs of each component, disregarding its geographical location. As nodes and/or hubs may be located within existing facilities that also perform research activities unrelated to the distributed RI, only cost items attributable to the distributed one, including shares of time machine or personnel costs, must be included in the cost estimation.

DETERMINING THE TOTAL COSTS OF DISTRIBUTED RIs

A distributed RI is «a network of distributed resources»[2] and consists of a Central Hub (i.e. coordination secretariat) and interlinked National Nodes, which can be further coordinating local nodes. A first important distinction is between distributed RIs (which, according to the ESFRI roadmap, need – among other requirements – to be identified by a unique name, legal status[3], and governance structure) and a coordinated research network, which is instead the collaboration of fully independent research performing organizations.

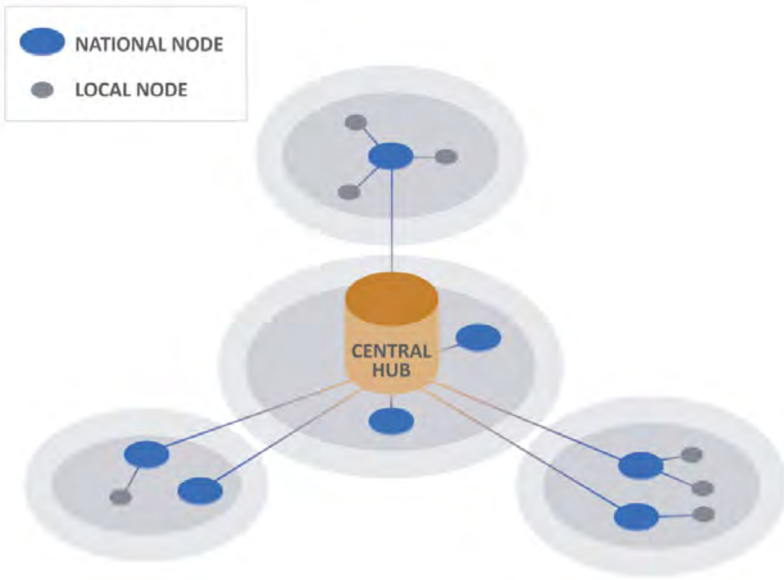

Figure 1 Distributed RI

Whereas the problems of apportionment and aggregation arise for both distributed RIs and coordinated research networks, the specificity of the former is that resources (in full or in part) are coordinated and managed by the Central Hub. This adds a layer of complexity, which requires distinguishing:

- The costs of central hub for research activities and/or service provision (if any);
- The costs of central hub for coordination;
- The cost of national nodes for the coordination of local entities;
- The costs of national/local nodes for research activities and/or service provision.

The lack of mandatory requirements for the nodes to share financial data with the hub requires willingness, resources and strong coordination to perform a reliable costing exercise. In some cases, when the number of sub-entities is too high and the exercise to gather all the data would be too time-consuming, approximation should be made at more aggregate level, based on the available sources. When only the costs of the central hub are available, this should be made clear.

[2] Source: https://ec.europa.eu/research/infrastructures/index.cfm?pg=about

[3] It is worth noting that the requirement of the legal status is not universally required, see for example OECD (2014), *International Distributed Research Infrastructure: Issues and Options*, available here https://ec.europa.eu/research/infrastructures/index.cfm?pg=about

An individual RI can manage a portfolio of different facilities and research projects, each of them with its own objective(s). If the cost estimation relates to a single experimental facility being part of a larger complex, the costs that are shared with other experiments are not entirely within the scope of the cost estimation and therefore should be carefully apportioned to the infrastructure under examination. In other words, if different facilities are hosted in the same site, with some functional interrelations – e.g., energy costs, administrative costs, data centres – costs that are common to all the facilities must be apportioned to the different entities according to the rate of their actual use and following transparent criteria.

APPORTIONMENT AND AGGREGATION

Apportionment and aggregation usually go hand in hand. In RIs involving several legal entities and collaborations, for instance, actual costs from the different legal entities' accounts must first be apportioned and then aggregated in a unique account. This is a common situation for distributed RIs, but it also applies to single-sited RIs where it may happen that a major institution includes different facilities and experiments with several legal entities as part of the related international collaborations. Hence, in defining the unit of analysis, it is important:

- for the institution hosting the facility/experiment, to distinguish the costs pertaining to the facility which has to be costed from those pertaining to the more general functioning (e.g., institutional activities, outreach, etc.) of the hosting RI (apportionment).
- for the international collaborations, to distinguish the costs relevant to the activities off-site from the costs that instead pertain to the general functioning of the legal entity (apportionment).
- to aggregate only the costs of the facility/experiments pertaining both to the hosting RI and the international collaborations duly apportioned.

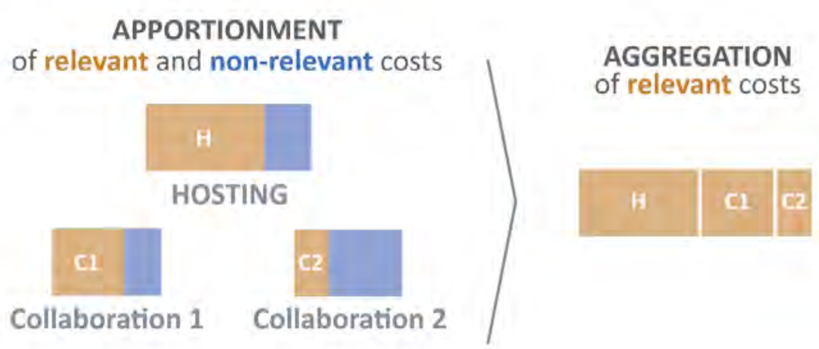

Figure 2 Aggregation and apportionment

Differentiating between "blue" and "brown" costs is the act of apportionment

The sum of "brown" costs is the act of aggregation

Some RIs take advantage of **facilities, land, or equipment owned by existing infrastructures.** For the purpose of the costing exercise it is important to distinguish whether the new facility constitutes an additional, self-standing unit or whether it is instead an upgrade or an additional component still part of the same facility. More precisely, considering the components owned by an existing facility:

- if they are simply a re-use of a spare component of a previous facility that could not have alternative use, their cost should be considered as “sunk”[4] and should not be included in the cost computation of the new RI.
- If they are a re-use of a spare component but some investments are required for minor improvements of the inherited facilities/equipment, such additional costs should be considered as part of the cost-estimation of the new RI.
- If the facility, land or equipment is provided as in-kind contribution, then their cost is part of the cost-estimation of the RI and their appropriate value shall be computed (see below on this).

3.2 Setting the time horizon

Cost estimates must be related to the entire lifecycle of the infrastructure, which means considering the costs spanning the entire period of time during which the facility remains useful. Total costs include both investment and operating costs.

The financial resources needed to set-up and run a RI may span a long period of time. In addition, the typical spending profile and cost distribution, for different categories of the RI, often show spikes over time (see figure below).

[4] A sunk cost is a cost that has already been incurred and thus cannot be retrieved. For this reason they are irrelevant for future decision-making.

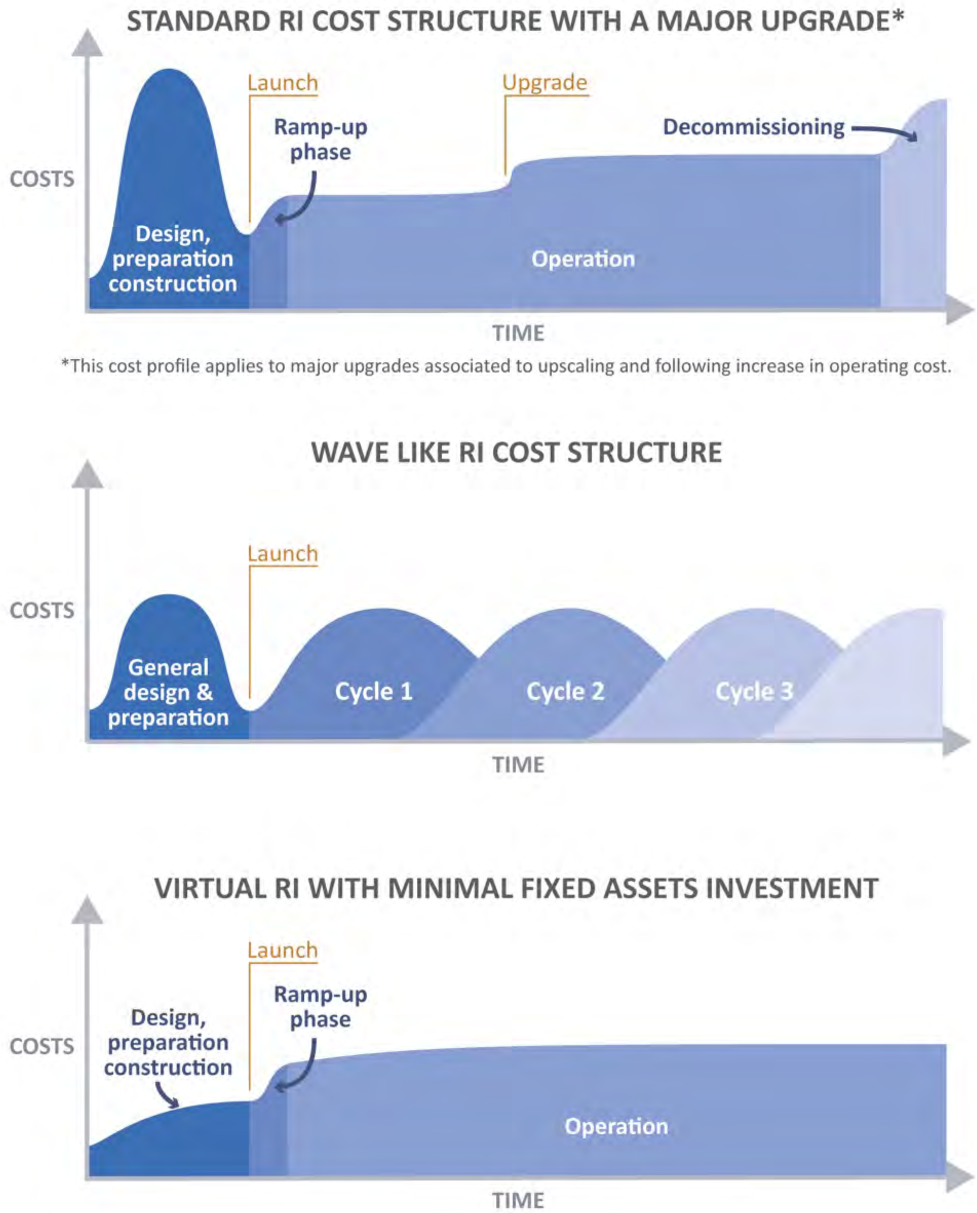

Figure 3 Cost structures of RIs

A standard spending pattern shows a relatively large investment peak during design, preparation and construction, a ramp-up phase after launch and until the full capacity is reached, then a quasi-flat spending period during operation; spending peaks again if major upgrades are planned and during decommissioning[5]. There are however exceptions to this cost-structure. For example, RIs involved in tasks which are performed cyclically (e.g., surveys) display a wave-like cost structure, where preparation and implementation costs are incurred at every cycle. Another example is provided by those RIs, typically distributed facilities and/or RIs which rely on existing

[5] The impact of major upgrades on the level of operating costs may be different: in case of significant upscaling (e.g. increase in the scale or complexity of performed activities), operating costs may increase while in case of technological improvements leading to efficiency gains they may remain equal or even decrease after the upgrade.

infrastructures, whose set-up phase includes only minor investment costs as compared to the operational costs.

The costs of a RI should be considered through its entire life cycle. It is thus important to take into consideration a reasonably **long time horizon** (the EC Guide, 2014 suggests 15-25 years but for some RIs a longer time horizon can also be justified). This is irrespective of the point in time when the cost-analysis is conducted (be it *ex ante*, *in itinere*, or *ex post*). For the purpose of the costing exercise a long-term perspective, looking at the entire lifecycle of a RI, will allow to describe and assess all the expected/generated costs, including those spreading far into the future. This will enable not to miss costs that may be important even if less immediately observable (e.g. replacement costs) and to plan in advance the means to secure long-term financial sustainability. RIs may produce effects (and financial consequences) over long periods of time even beyond its life cycles – e.g., in presence of nuclear wastes requiring expensive decommissioning costs for their disposal and long-lasting liability, or air/soil/water pollution bringing remediation costs.

In order to fix an appropriate time horizon two elements are necessary: a) **identification of the 'start date'** and b) estimation of the **overall realistic duration** of the RI. As per the former, it should coincide with the year in which the first outflow related to the RI materializes or the first in-kind contribution is received. This is not always straightforward to identify because the conceptual phase of a RI can be long and may include an initial period when the scientific mission is still open to different options defined in a very broad way. As a general rule, the start date should be fixed when the first financial or in-kind allocation is made for activities of the preparatory phase of the already well-defined RI. There should be evidence of a detailed, technical identification of the scope and nature of research activities for considering the time horizon to have started. To this end, the discussion with the scientific staff can be key to identify the proper starting point.

Once the start date is set, the entire life-cycle of the infrastructure must be defined. This includes the design, preparation, set-up and a sufficiently long operational phase, including upgrades, if any, and final decommissioning. The technical and scientific staff can advise about how long is the period in which the facility remains reasonably useful. In some cases, since not all design or feasibility studies lead to the implementation of a RI, some of these costs may be considered as sunk costs (more details on this in 3.5).

The base year is the point-in-time when the cost estimation is performed, i.e. the year of the ESFRI Roadmap application. Depending on whether it is *ex-ante* (before or approximately coinciding with the start year), *in itinere* (just after the set up and launch), *mid-term* (after some years of operations) or *ex-post* (after most of the operations have already been performed), **costs can be forecasts/projections, actual/observed data or a mix of them**. They shall be accounted for each year of the time horizon, according to the discounted cash flow approach, as described in the next section.

3.3 Discounted cash flow method

To allow consistency and comparability in cost estimates, a harmonized system of accounts and prices shall be adopted for the entire time horizon.

The recommended cost accounting rule is the **cash flow method,** which requires considering **only actual cash inflows and outflows** reported in the moment in which they materialise. This system differs from the standard company accounting conventions and requires some adjustments if balance sheets and financial statements are used as sources of data. In particular, accounting items that do not correspond to actual flows, such as for example depreciation or reserves, are disregarded. As a general rule, all prices should be considered net of Value Added Tax, unless it is not recoverable and thus represents an actual cash outflow. Differences may arise from one country to the other. For cost estimations, outflows represent the only relevant source of data (see box below).

SOURCES OF FINANCING

RI facilities are largely dependent on a wide range of public financing sources. While sources of financing (such as grants, loans, or member fees) provide essential insights for assessing the financial sustainability of investment (which requires the matching between financial in-flows and outflows year-by-year), it should be kept in mind that they are inflows and hence should not be taken into consideration for the cost estimation. They are however a proxy of the costs covered trough cash contributions.

Many RIs may rely on some forms of **in-kind support.** This can be related to the use of donated scientific equipment or the exploitation of time machine or personnel costs (this is particularly true for pan-European RIs, which rely heavily on in-kind contributions from national members). They can also refer to technical components or equipment supplied by one of the partners (e.g. one Member State as a share of its contribution) and made available in-kind to the RI. Such arrangements correspond to the use of real resources not appearing in the budgetary cost as a cash flow of the RI (but can appear in the budget of the donating/participating partner institution). They are however relevant indication of costs and, as a general rule, **should be taken into account at their current market price,** if available. When dealing with innovative products for which no market price is available, it may be possible to determine likely prices by looking at the price of competing, perhaps less innovative, products, or to calculate the marginal cost of production as a proxy for market price.

APPORTIONMENT OF IN-KIND CONTRIBUTIONS

In-kind contributions may happen in many forms and for a variety of items. It is worth distinguishing the case of **variable** in-kind costs (e.g., contribution of personnel, access to equipment of services) from **fixed** in-kind costs (e.g., hosting, building, overhead costs). For the latter case, where the “burden” of the in-kind contribution can be considered uniformly distributed, it is possible to calculate a fixed rate of apportionment as a share of the variable costs of the RI.

Care must be paid when aggregating costs occurring in different years. Costs occurring in one year cannot simply be added to costs occurring in another year, with the exception perhaps a very distant year in the lifespan of the RI. This is because 1€ today has more value than 1 € tomorrow, for a variety of reasons including inflation, risk aversion and opportunity cost of capital. For this reason, **total costs must be expressed in present value**[6]. Past/future costs must be translated into present values by means of an appropriate capitalisation/discount rate: each future cash flow should be discounted by an appropriate financial discount factor and each past cash flow should be capitalised[7]. In principle the two discount/capitalisation rates may differ as they represent two different opportunity costs (prospective and retrospective). The adopted rates must be in real terms (see next section on the price system).

CAPITALISATION AND DISCOUNTING

In order to translate future costs into present values they should be discounted by an appropriate rate (actualization). The opposite applies to past costs which are capitalized. To this and, an appropriate discount factor would be:

$$\mathrm{a_t} = \frac{1}{(1+i)^t}$$

where t is the time; i is the discount rate; $\mathrm{a_t}$ is the discount factor.

The actualization of future costs can be done by multiplying the total costs in a given year by the identified discount factor:

$$\mathrm{PV} = \frac{\mathrm{FV}_t}{(1+\mathrm{i})^{\mathrm{t}}}$$

Where PV is the present value (at the base year) of the future estimated amount FV_t. The higher is the discount rate i, the lower the present value of the future amount. The PV of a stream of cash flows is thus calculated as the sum of all the present values:

$$\sum_{t=0}^{N} \mathrm{PV} = \frac{\mathrm{FV}_t}{(1+\mathrm{i})^{\mathrm{t}}}$$

The capitalisation of past costs is done in the opposite way, considering the following coefficient:

$$\mathrm{a_t} = (1+\mathrm{i})^{\mathrm{t}}$$

which determines the following formula for determining the present value PV of past costs PC:

$$\mathrm{PV} = \mathrm{PC}_t(1+\mathrm{i})^{\mathrm{t}}$$

If we consider the case of a RI infrastructure over a short time horizon of 5 years (2016-2020) with the total spending per year being € 100, the point-in-time of the analysis being 2018 (i.e. the project is in the middle of its life cycle and the analysis is *in itinere*), then the capitalisation of past costs and discounting of future ones is depicted in the table below.

[6] Present value (PV) is the current value of a future sum of money or stream of cash flows given a specified discount factor.

[7] The suggested value by the European Commission for major infrastructural projects co-funded with European Structural and Investment Funds is 4% in real terms, see Article 19 (Discounting of cash flows) of Commission Delegated Regulation (EU) No 480/2014). The adoption of a different discount rate should be justified.

Year of disbursement	Amount (€)	Discounting/actualization	Present value (€; in 2018)
2016	100	$\mathrm{PV} = 100(1+0.04)^2$	108.16
2017	100	$\mathrm{PV} = 100(1+0.04)^1$	104.00
2018	100	$\mathrm{PV} = 100(1+0.04)^0$	100.00
2019	100	$\mathrm{PV} = \frac{100}{(1+0.04)^1}$	96.15
2020	100	$\mathrm{PV} = \frac{100}{(1+0.04)^2}$	92.46
Total	**500**		**500.77**

As it is evident from the table above, the actualization of past cost results in a present value which is higher of the actual disbursement; the discounting of future costs results in a present value which is lower of the foreseen costs. This relationship is described by the figure below.

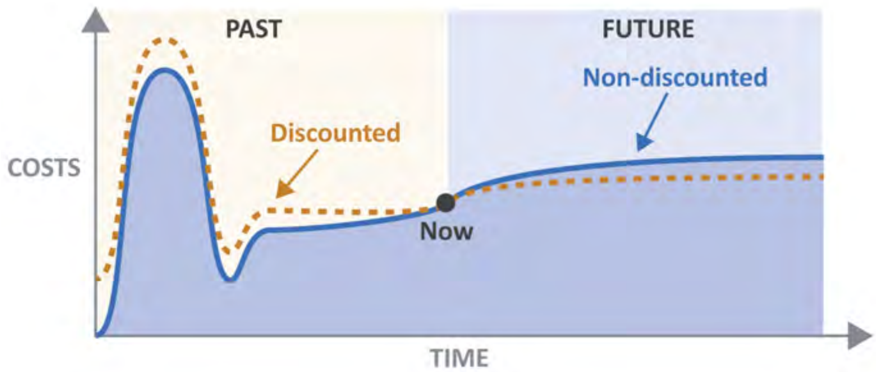

Figure 4 Actualization and discounting

3.4 Currency and prices

To allow comparability alongside different time horizons and countries it is essential to adopt a unique price system. **All costs shall be expressed in a unique currency**. For the ESFRI framework Euro is the relevant currency. Costs expressed in different currencies shall be translated into Euro through the official exchange rate of the base year. This is particularly relevant for RIs which have collaborations or procurement activities with different countries or even facilities located in countries which adopt different currencies.

Prices must be constant (or 'real', i.e. prices fixed at a base-year). The use of current prices (or 'nominal', i.e. prices adjusted projecting inflation in the future at a constant rate) must be avoided. The use of prices fixed at the base year must be consistent throughout the whole time horizon. Forecasted costs must include only real price variations, i.e. net of inflation variations[8] if proper analysis and supporting evidence of price changes is available. Past current costs must be translated into base year values by means of an inflation index. In order to aggregate historical current values with present ones they must be both inflated and then capitalised.

[8] When the prices of some items are expected to change significantly, above or below the average inflation rate, this differential should be taken into account in the corresponding cash flow forecasts.

INFLATION

The table below shows the inflation rates and factors for costs considering the time series of inflation rate for the United Kingdom (Source: IMF):

	2	3	4	5	6	7	8	9	10	11	12	13
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Inflation rate, average consumer prices	2.68	2.46	1.83	1.56	1.33	0.80	1.23	1.26	1.36	1.34	2.06	2.33
Inflation factor	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
Inflation adjustment factor	1.58	1.54	1.50	1.48	1.45	1.43	1.42	1.40	1.39	1.37	1.35	1.32

	14	15	16	17	18	19	20	21	22	23	24
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Inflation rate, average consumer prices	2.32	3.60	2.17	3.30	4.46	2.83	2.57	1.46	0.04	0.66	2.68
Inflation factor	0.02	0.04	0.02	0.03	0.04	0.03	0.03	0.01	0.00	0.01	0.03
Inflation adjustment factor	1.29	1.26	1.22	1.19	1.16	1.11	1.08	1.05	1.03	1.03	1.03

The inflation factor is calculated by dividing by 100 the inflation rate; for the calculation of the inflation adjustment factor, one should set at 1 the inflation adjustment of the point-in-time year and calculate the adjustment factor backward according to the formula

$$\mathrm{IAF}_{t-1} = \mathrm{IAF}_{t}(1 + \mathrm{IF}_{t-1})$$

where IAF is the Inflation Adjustment Factor and IF is the Inflation factor.

This inflation factor concurs then to the estimation of the present value. For example, if a cost of € 100 is incurred in 1995, the computation of the present value of this cost will require adjusting this value for inflation by multiplying it by a factor of 1.58 (see table above).

3.5 Incremental approach and counterfactual

Costs must always be accounted for according to an incremental approach, which requires to consider the costs occurring for the set-up and implementation of the RI net of those that would occur in any case in absence of the RI (the 'without the RI', or counterfactual, scenario).

Costs estimation need to consider an **appropriate counterfactual**, i.e. what would have been the costs in the absence of the project. The computation of the incremental costs is thus performed by subtracting the costs of the counterfactual scenario from the costs of the RI.

In the case of a newly established RI, i.e. with no pre-existing scientific service or infrastructure, the without-the-project scenario is one with no operations and the incremental scenario is relatively easy to calculate since it coincides with the costs of the RI itself. However, in case of investments aimed at improving or expanding an already existing RI, the counterfactual is represented by the costs of maintaining the service or infrastructure at a level that it is still operable (Business As Usual – BAU) or even small adaptation investments that were programmed to take place anyway (do-minimum). Incremental costs are then the difference between the scenario with and that without the project. This implies that cost savings translates into positive cash flows.

As mentioned, not all the feasibility, design and preparation studies lead to the implementation of the potential RI considered. Hence, in some cases the BAU scenario shall include also the design and preparation phase of the aborted RI, at least partially, as "sunk costs".

The choice between BAU or do-minimum as counterfactual should be made on a case by case basis. In case of uncertainties, the BAU scenario shall be adopted as a rule of thumb. If do-minimum is used as counterfactual, this scenario should be both feasible and credible, and not cause undue and unrealistic additional benefits or costs. For some distributed infrastructures the establishment of the RI may include only the setting up of the network. In this case the BAU scenario would coincide with the project(s) continuing to operate in an uncoordinated way.

4. Total investment costs and residual value

4.1 Definition

Investment costs are related to the acquisition of durable tangible and intangible assets. They are incurred in view of effects that materialize in a financial year(s) different from that in which they took place.

Total investment costs include **initial investment costs** (those occurring at the beginning of the lifecycle for the design, set-up and start of the infrastructure) and **replacement costs** (occurring during the reference period to replace short-life machinery and/or equipment). In some cases they can also include costs for **major upgrading** (a substantial change of technical approach which cannot be considered routine maintenance) and **decommissioning costs** (when there are dangerous materials or waste to be disposed of after the shutdown of the facility).

Information on investment costs are usually contained in the feasibility study (if the analysis is performed from an *ex-ante* perspective) or in the financial statement (*ex-post*) and the data to consider are the cash or in-kind deployment encountered in the single accounting periods (years) in order to make available the various types of assets or the equivalent market value for in-kind contributions not reported as financial flows.

A residual value of the fixed investments must be included within the investment costs account for the end-year. The residual value reflects the capacity of the remaining service potential of fixed assets whose economic life is not yet completely exhausted.

4.2 Main items

Even if the cost types are project-specific, the data can be usually aggregated into some macro-items, which will be analysed in the following sections:

- Design and preparation (as part of initial investment costs, including testing and start-up)
- Construction and start-up, including:
    - Physical (e.g., land acquisition, installations, constructions) and non-physical (e.g., IPRs, cloud, other information technologies) assets, usually the major component of initial investment costs;
    - Personnel;
    - Start-up costs (e.g. training, licences, etc.);
- Replacement costs;
- Major upgrades;
- Decommissioning and end-of-life costs.

4.2.1 Design and preparation

Design and preparation costs are all the in-kind and cash expenditures needed for the **conceptual design and feasibility study** of the infrastructure. They also include the costs for the preparatory phase of a RI, including possible interim-phase after the preparatory project.

The main items included in this cost category are scientific, technical and managerial personnel costs; networking activities; joint-research activities and trans-national cooperation. In-kind contributions in this phase can be mainly in the form of in-kinds contribution of personnel costs.

Since not all design and preparation studies lead to the implementation of the project, in some cases these can be considered as sunk costs – at least partially. Moreover, in the case of new facilities developed in the same location of previous infrastructures and experiments, which to some extent take advantage of the existing assets, it is important not to include the costs incurred before the start of the design period, such as costs for feasibility studies undertaken when the mission of the RI had not been clearly defined yet, or construction costs already sustained for a previous project. These, as mentioned, are often sunk costs and must be excluded from the investment costs.

4.2.2 Construction and start-up costs

Constructions costs relate to the **set up and launch** from a physical, institutional, legal, organisational and managerial point of view of the infrastructure. The main items are presented in the following sections.

4.2.2.1 Physical and non-physical assets

Assets can be **physical or non-physical**. The former usually include all assets such as land acquisition, buildings, civil works, machineries and equipment. Physical assets usually represent a significant share of investment costs of non-virtual major infrastructures. Non-physical assets include virtual assets (such as IT platforms, clouds, virtual information technologies and data banks) and other intangibles (such as intellectual property, patents and licences).

Assets can be provided also in the form of in-kind contributions, when they do not correspond to any cash outflow corresponded directly by the RI. In-kind contributions may refer to both physical assets (such as a magnet, machinery, etc.) and non-physical assets (such as virtual components). In the case of multi-sited or distributed RIs, which have more than one physical site, it is key to properly aggregate the cost items. In particular, the costs related to the national hubs or nodes must be calculated as per quota of participation in the distributed RI.

4.2.2.2 Personnel

Cost of the personnel involved in all the construction and set-up phase not related to the routine operations of the RI – should be included in the investment costs. They can include scientific, technical, administrative and managerial personnel costs.

Personnel may be provided also as in-kind contributions: they should be included in the analysis at the **equivalent labour cost** covered by the partner institution and including salaries, fringe benefits, and social security contributions of personnel engaged. In the case of distributed RIs, when the personnel may be involved in different activities also not related to the distributed RI, it is important to include only the share of his/her work-time actually dedicated to the considered RI as documented in timesheets or similar internal records. The same may apply for the administrative personnel in the hosting organisation which do not fully coincide with the facility under assessment but hosts a portfolio of different facilities. In this case, the time should thus be duly apportioned distinguishing the amount that should be charged to the RI.

4.2.2.3 Consumables, utilities and other costs

They include all the costs incurred during the initial phase to set-up the facility which are not included in the previous categories. They can include the use of energy, water or waste disposal, travel and other cost for networking and join research activities and so on.

4.2.2.4 Start-up costs

They include all costs related to the launch of operations, including training costs and acquisition of licences and patents.

4.2.3 Replacement costs

Replacement costs correspond to the capital expenditure required to replace those assets whose economic lifetime is shorter than the reference period. The economic lifetime is different for various investment assets (buildings, machinery and equipment, etc.). In order to keep a facility in operation, each asset must be replaced at the appropriate time and the replacement costs, when foreseen since the start, must be included in the investment costs.

4.2.4 Major upgrades

Extraordinary maintenance and major upgrades are investments cost which occur during the operational phase and are related to the modernization and expansion of the facility. They are interventions which modify the performance in a structural way and produce effects beyond the financial year(s) in which they take place.

As a general rule, they should be included in the analysis in the year they are planned to occur only (i) if they are **pertinent** to the initial investment project and (ii) if they were already **scheduled** in the ex-ante phase. If one or both conditions are not met, these investments should be analysed in separate studies.

The timing profile of major upgrades may vary depending on the specific RI. Such upgrades are often planned well in advance, in anticipation of new technologies which were not available at the time of the initial design but were available at the start-up of the project.

It is important to decide since the beginning whether an upgrade is part of the life-cycle of the RI or whether instead it constitutes a self-standing project.

4.2.5 Decommissioning and end-of-life costs

End-of-life costs relate to any decommissioning costs and/or environmental mitigation costs that may be necessary at the end of the time horizon to dismantle the whole or individual components of the fixed assets. Major items are usually the costs of dismantling, disposal and land reclamation. In case of nuclear wastes, these costs can be particularly high (up to absorbing completely the residual value) and produce long-standing financial responsibility.

4.3 Residual value

The residual value reflects the capacity of the remaining service potential of fixed assets whose economic life is not yet completely exhausted. It must be included for the end-year and with a negative sign, since it is an inflow. It will be zero or negligible if a time horizon equal to the economic lifetime of the asset has been selected or if decommission costs are particularly high. It is the only inflow item of the total investment costs.

4.4 Present value of total investment costs

Total investment costs must be calculated along the entire time horizon as the discounted sum of the financial flows of all the investment cost items for the entire time horizon, regardless the sources of financing. In an *ex-ante* perspective, the present value of total investment costs is thus as follows:

$$PV = \sum_{t=0}^{N} \frac{D_t}{(1+i)^t} + \frac{C_t}{(1+i)^t} + \frac{RC_t}{(1+i)^t} + \frac{MU_t}{(1+i)^t} + \frac{DC_t}{(1+i)^t} - \frac{RV_t}{(1+i)^t}$$

where N is the number of years of the time horizon, D_t is the design and preparation costs at time *t*, C_t is the construction and start-up costs at time *t*, RC_t are the replacement costs at the time *t*, MU_t are the major upgrades costs at time *t*, DC_t is the decommissioning costs at time *t*, RV_t is the residual value at time *t* and *i* is the selected discount rate.

Similarly, in an *ex-post* perspective, the present value of total investment costs is:

$$PV = \sum_{t=0}^{N} D_t (1+i)^t + C_t(1+i)^t + RC_t(1+i)^t + MU_t(1+i)^t + DC_t(1+i)^t - RV_t(1+i)^t$$

where *i* is the selected capitalisation rate.

In an *in itinere* perspective, both discounted future costs and capitalised past costs should be summed.

5. Operating costs

5.1 Definition

Operating costs include all disbursements (both in-kind or outflows) needed to operate and maintain the new or upgraded facility.

In an ex-ante perspective, cost forecasts can be based on historic unit costs. In an ex-post perspective they can be retrieved from financial statements and balance sheets provided the necessary adjustments to adhere to the cash flow method.

Operating costs can be distinguished between **fixed** (for a given capacity, they do not vary with the volume of good/service provided) and **variable** (they depend on the volume). Cost of financing (i.e. interest payments) follow a different course and must not be included within the operating costs (but they should be accounted for in an analysis of financial sustainability).

Although it is always possible to compute the average annual operating costs, it should be noted that operating costs tend to be relatively constant when the RI is running at full capacity, but in the start-up and launch phase, before arriving at full capacity, there is a ramp up phase which can last some years (see Figure 3). Hence, assuming costs to be constant across the entire lifetime of RI is not accurate and can fail to provide useful information. Measures such as the net present value provide much more insights, compared to the annual average, for the aims of cost estimation.

5.2 Main items

Although the actual composition is project-specific, **typical operating costs include**: rent of buildings or sheds, rental of machinery; personnel; ordinary maintenance and repair of assets; utilities (consumption of raw materials, fuel, energy) and consumables; users support, services purchased from third parties. Other operating costs may include: environmental protection measures, general management, administration and quality control costs, royalties paid for the use of patented products or processes, promotional campaigns and other outreach expenditures. Obviously, the weight of these cost items is different across various scientific domains and type of infrastructures. As already mentioned, in line with the cash flow method items such as depreciation, customarily used in standard accounting, shall not be included for the purpose of cost estimations.

A **cost book** is a list of unit costs for the main cost items of the RI (e.g., cost of the access for one day, unit cost of administrative/scientific/managerial personnel, etc.). It is usually produced during the preparatory phase of infrastructure and can be used to forecast the operating costs.

Personnel costs are usually distinguished by functions (research, administration, technical operation, etc.) and by category. As mentioned, if personnel contribution is provided in-kind contributions they should be included in the analysis at the equivalent labour cost, including the value of salaries, fringe benefit, and social security contributions. Apportionment is needed in case of distributed facilities, as already discussed for investment costs.

Training expenses should also be taken into account, as those related to the development of scientific, technical and management skills and capabilities which are essential also for the sustainability of the RI.

Equipment, materials and labour costs necessary for cleaning and maintaining the buildings and the facilities in good condition, including expenditure to fix broken parts and replacement of spare parts are included as **repair and ordinary maintenance costs**. As mentioned above, they include replacement costs of fixed asset if self-financed by the project revenues.

Utilities and support services include: fuel/diesel, electricity, gas, water and recycled waste, as well as other specific services. An estimate of utilities consumption is essential for identifying the existing sources of supply and any existing or potential bottlenecks or shortages if requesting either internal or external additional supplies.

Consumables include raw materials, base metals, (semi)processed materials and components, packaging materials, containers, lab materials, etc. The transport costs from source of supply to the facility shall also be considered.

Users support refers to the cost-per-user related to the assistance to the users when accessing the facility (either physically or virtually). It has implications on the technical and scientific infrastructure, the time of the administrative, technical and scientific personnel that is dedicated to each user (users office, referees, technical assessment of feasibility, specific user-demanded consumables). It may also include costs related to the use of guesthouse and canteen for the users (to be operated also on week-ends and holidays) and possible contributions towards travel of users in case of lack of external funds. These items can vary significantly across different types of RIs but, in any case, they represent actual costs to be reported.

Data Management, FAIR compliance, EOSC compliance result in significant costs for the implementation of metadata and maintenance of repositories open to the reference users and/or to the wider public which might exploit the interoperability. Such costs may include: disk space, computing power, networks, electric energy, specialised personnel (e.g., data stewards or data scientists); these costs are usually heavily dependent upon the number of users.

5.3 Present value of operating costs

Similar to investment costs, operating costs must be calculated along the entire time horizon by reporting the total value of disbursement or in-kind contribution for each year of the time horizon and for each of the main cost items. Values will be equal to zero during the design and construction costs, then ramping up after the opening and start of operation and finally almost constant during the full capacity phase. The present value of total operating costs is calculated as the sum of the discounted and capitalised financial flows of all the cost items for the entire time horizon.

6. Annex: Case studies

The cases included in this annex are examples of different typologies of RIs and cost structures. They are meant to provide suggestions on how to present the costs and overcoming some of the most common challenges. The case studies are inspired by real RIs but, for obvious confidentiality reasons, do not reflect their actual costs. They are however realistic examples reflecting – in proportion, evolution, apportionment and aggregation – reasonable estimates for the typology and cost structure considered.

The cases follow the structure of the excel template annexed to the present Guide.

All cases start with setting the key-parameters of a RI:

- Country: for the proper computation of the appropriate inflation rate.
- Base year, start date and time horizon: for the subsequent computation of discount and/or actualization.
- Capitalisation and discount rates: set always, in these case studies, at the rates of 5% and 4%. Deviations from these parameters should be justified.
- Scale and currency should also be made explicit.

After setting the key-parameters, both investment and operating costs are presented. In these cases, the excerpts of the tables always refer to *total* as *discounted total*. Finally, a cost overview is presented.

6.1 A single-sited RI in operation

The case presented here can be thought as a standard case with low level of complexity. It is the case of a single-sited RI in operation. The key parameters are set as follows:

Country	Greece
Time horizon (n of years in the reference period)	20
Start date of time horizon	2006
Base year (point-in-time of the analysis)	2018
Last year of time horizon	2026
Scale (unit, thousands,million, etc.)	Million
Currency	EUR
Capitalisation Rate (%, backward)	5.0%
Discount Rate (%, forward)	4.0%

The investment costs include all the relevant costs along the entire life-cycle: from design and construction, the foreseen update and decommissioning. The operating costs follow a standard structure, with a ramp-up phase followed by a stabilisation of prices and a little increase at the time of the foreseen major upgrade.

Table 1 Investment and operating costs of a single-sited RI - *EUR million, nominal not discounted*

	Tot. (*discounted, EUR 2018)*	2006	2007	2008	2009	2010	2011	2012	2013-2016	2017	2018	2019-2025	2026
Design and preparation	**17.92**	1.30	1.50	2.15	3.00	2.00							
Physical assets	**13.01**	1.00	1.20	1.50	2.00	1.50							
Non-physical assets	**6.50**	0.50	0.60	0.75	1.00	0.75							
Personnel	**14.97**	0.80	1.20	1.40	2.00	1.70				1.00	1.20		
Major upgrade	**4.62**									2.00	2.50		
Decommissioning	**2.19**												3.00
Initial investment costs	**59.22**	**3.60**	**4.50**	**5.80**	**8.00**	**5.95**				**3.00**	**3.70**		**3.00**
Replacement costs	1.53							0.3		0.5		0.1	
Total investment costs	**60.75**	**3.60**	**4.50**	**5.80**	**8.00**	**5.95**		**0.3**		**3.50**	**3.70**	**0.1**	**3.00**
Residual value	4.38												-6
Personnel	**27.11**						1.20	1.40	1.60	1.90	1.90	1.90	0.90
Training	**6.75**						0.20	0.30	0.40	0.50	0.50	0.50	0.20
Utilities	**5.41**						0.20	0.25	0.30	0.40	0.40	0.40	0.20
Consumables	**5.41**						0.20	0.25	0.30	0.40	0.40	0.40	0.20
User support	**8.77**						0.10	0.30	0.50	0.70	0.70	0.70	0.30
Data management	**0.81**						0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total operating costs	**54.25**						**1.95**	**2.55**	**3.15**	**3.95**	**3.95**	**3.95**	**1.85**

An overview of total costs is provided below:

	EUR	Million at base year (2018)
Total investment costs, not discounted		42.32
Total investment costs, discounted		60.75
Residual value, not discounted		6.00
Residual value, discounted		4.38
Total operating costs, not discounted		54.48
Total operating costs, discounted		54.25
Yearly operating costs in the last year of time horizon		1.85

6.2 A distributed RI in operation

This is the case of a distributed RI, including both national nodes and local sub-nodes. The key parameters are set as follows:

Country	United Kingdom
Time horizon (n of years in the reference period)	40
Start date of time horizon	2007
Base year (point-in-time of the analysis)	2018
Last year of time horizon	2047
Scale (unit, thousands,million, etc.)	thousand
Currency	EUR
Capitalisation Rate (%, backward)	5.0%
Discount Rate (%, forward)	4.0%

Investment and operating costs can be presented aggregated per central hub and national node(s). Investment costs are incurred up to 2013; from 2014 there are only operating costs. Operating costs increase until they stabilize after the ramp-up phase.

Table 2 Investment and operating costs of a distributed RI - *EUR thousand, nominal not discounted*

	Tot. (*discounted, EUR 2018*)	2007	2008-2011	2012	2013	2014	2015	2016	2017	2018	2019	…	2047
Central hub	**18,455**	**128**	**1,782**	**1,782**	**1,782**								
Non-physical asset	5,684	80	540	540	540								
Design	1,705	24	162	162	162								
In-kind	11,066	24	1,080	1,080	1,080								
….													
Node Country 1	**1,724**	**62**	**120**	**120**	**240**								
Node country 2	**743**	**33**	**55**	**55**	**90**								
Total investment costs	**20,923**	**223**	**1,957**	**2,112**	**2,134**								
Residual value													-1,500
Central hub	**186,235**					1,001	2,009	2,922	4,461	9,553	9,707	9,707	9,707
Node Country 1	**144,332**					775	1,557	2,264	3,457	7,403	7,522	7,522	7,522
Node country 2	**59’537**					320	642	934	1,426	3,054	3,103	3,103	3,103
Total operating costs	**390,103**					2,097	4,208	6,121	9,344	20,011	20,333	20,333	20,333

An overview of the total costs is provided below:

	EUR thousand at base year (2018)
Total investment costs, not discounted	14,381
Total investment costs, discounted	20,923
Residual value, not discounted	1,500
Residual value, discounted	481
Total operating costs, not discounted	632,144
Total operating costs, discounted	390,103
Yearly operating costs in the last year of time horizon	20,333

6.3 An upgrade of an existing single-sited facility

This is the case of a single-sited RI; the case considered here concerns a major upgrade of a RI existing for over 50 years. This means that the scope of the costing exercise is not the RI as a whole but the incremental scenario of the upgrade as compared to a business as usual (BAU) scenario. The main challenges here concern the identification of a proper unit of analysis and the related time horizon. In determining the proper unit of analysis apportionment exercises should be possibly made: for estimating the cost of upgrade it will be necessary to identify and apportion the related costs from balance sheets which are related to the entire RI. It is instead essential to consider only those costs which correspond to the incremental scenario with respect to the counterfactual, i.e., the business as usual. The main challenge is thus to “isolate” the incremental, as showed in the figure below.

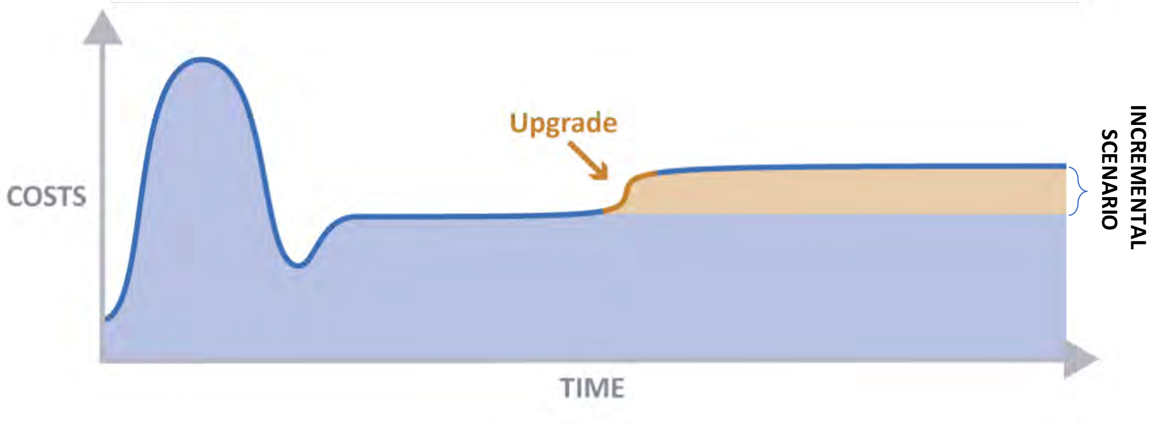

Figure 5 Upgrade scenario vs. BAU scenario

Of course this has also an influence on the time horizon; for instance, in the case considered, even if the RI was founded in the 1960s the base year should relate to the upgrade – hence, it is set at year 2000. It is not always straightforward to identify the correct base year as it is likely that different upgrading options were taken into considerations at different moments. Design costs should be considered sunk costs if they are borne also for those upgrades which are finally not implemented.

The following table contains the key-parameters as identified per the case considered.

Country	France
Time horizon (n of years in the reference period)	33
Start date of time horizon	2000
Base year (point-in-time of the analysis)	2018
Last year of time horizon	2033
Scale (unit, thousands,million, etc.)	thousand
Currency	EUR
Capitalisation Rate (%, backward)	5.0%
Discount Rate (%, forward)	4.0%

The table below shows the investment costs of a major upgrade of a single-sited RI. It is worth noting that it is very likely that in the first years the operating costs would be rather stable, before the upgrade is fully implemented, following by a rump-up phase and thus a stabilization.

Table 3 Investment and operating cost of a single-sited RI with a major upgrade- *EUR thousand, nominal not discounted*

	Tot. (*discounted, EUR 2018*)	2000	2001	2002-2021	2022	2023	2024	2025	2026	2027	2028-2032	2033
Design and preparation	**2,319**	172	237									
Fixed assets	**19,183**	172	237	…	900	800						
IT assets	**17,630**	86	119	…	2,700	2,400						
Equipment	**51,726**	172	237	…	3,600	3,200						
Personnel	**69,357**	258	356	…	900	800						
IPRs	**17,630**	86	119	…	900	800						
Decommissioning	**22,211**											40,000
Total investment costs	**200,057**	**946**	**946**	**…**	**9,000**	**8,000**						**40,000**
Consumables	**992**				100.0	100.0	100.0	100.0	115.5	127.1	139.8	97.9
Training expenses	**496**				50.0	50.0	50.0	50.0	57.8	63.5	69.9	48.9
Maintenance	**1,983**				200.0	200.0	200.0	200.0	231.0	254.1	279.5	195.7
Administration	**694**				70.0	70.0	70.0	70.0	80.9	88.9	97.8	68.5
Location rent	**2,975**				300.0	300.0	300.0	300.0	346.5	381.2	419.3	293.5
Personnel	**992**				100.0	100.0	100.0	100.0	115.5	127.1	139.8	97.9
Total operating costs	**8,131**				**820**	**820**	**820**	**861**	**947**	**1,042**	**1,146**	**802**

A summary table with overview of investment and operating costs is provided below:

	EUR thousand at base year (2018)
Total investment costs, not discounted	170,919
Total investment costs, discounted	200,057
Residual value, not discounted	0
Residual value, discounted	0
Total operating costs, not discounted	11,843
Total operating costs, discounted	8,131
Yearly operating costs in the last year of time horizon	802

6.4 A distributed RI in operation

This is the case of a distributed RI infrastructure, whose central hub is based in Germany.

Country	Germany
Time horizon (n of years in the reference period)	21
Start date of time horizon	2002
Base year (point-in-time of the analysis)	2019
Last year of time horizon	2023
Scale (unit, thousands,million, etc.)	Million
Currency	EUR
Capitalisation Rate (%, backward)	5.0%
Discount Rate (%, forward)	4.0%

The particularity of this RI is that it does not follow a standard cost-structure but a wave-like cost structure (see Figure 3). One main challenge of this approach is to identify which are the investment costs and which are the operating costs. Indeed, differently from what happens with RIs with a standard cost-structure, the investment costs are incurred for each of the waves – hence, during the entire life-cycle of the RI. In this particular case investment and operating costs span over the same time horizon. In particular, for the case considered here, the phases of design, preparation, and construction are considered to be part of the investment costs as reported in the table below. Another challenge is the allocation of the costs between the costs related to the core operations of the RI (the survey, in our case), typically carried out by the national nodes, and the costs related to the international coordination (borne by the central hub).

Table 4 Investment and operating costs - Distributed RI with wave-like cost structure - *EUR million, nominal not discounted*

	Tot. (*discounted, EUR 2018)*	2002	2003	2004	2005	2006	2007	2008	2009-2021	2022	2023
Int. Coordination	**77.8**	**1.299**	**1.299**	**1.299**	**2.635**	**1.459**	**2.961**	**1.842**	**…**	**2.065**	**4.194**
Design	65.6	1.061	1.061	1.061	2.153	1.155	2.345	1.530	…	1.816	3.687
Preparation	5.3	0.119	0.119	0.119	0.241	0.152	0.308	0.156	…	0.082	0.167
Construction	6.8	0.119	0.119	0.119	0.241	0.152	0.308	0.156	…	0.167	0.340
Waves	**130.0**	**0.855**	**0.855**	**0.855**	**1.736**	**0.618**	**1.255**	**0.646**	**…**	**6.220**	**12.629**
Design	14.0	0.214	0.214	0.214	0.435	0.284	0.577	0.288	…	0.406	0.825
Preparation	0.6	0.013	0.013	0.013	0.027	0.017	0.034	0.017	…	0.009	0.019
Construction	115.5	0.628	0.628	0.628	1.274	0.317	0.644	0.341	…	5.805	11.785
Total investment costs	**208.80**	**2.15**	**2.15**	**2.15**	**4.37**	**2.08**	**4.22**	**2.49**	**…**	**8.29**	**16.82**
Residual value	1.03										1.2
Int. Coordination	12.3	**0.169**	**0.344**	**0.169**	**0.344**	**0.217**	**0.440**	**0.223**	**…**	**0.361**	**0.732**
Waves	4.4	**0.062**	**0.062**	**0.062**	**0.127**	**0.084**	**0.170**	**0.084**	**…**	**0.135**	**0.275**
Total operating costs	**16.6**	**0.232**	**0.406**	**0.232**	**0.470**	**0.300**	**0.610**	**0.307**	**…**	**0.496**	**1.007**

The final table shows the most relevant summary information of the analysis.

EUR	Million at base year (2018)
Total investment costs, not discounted	166.8
Total investment costs, discounted	207.8
Residual value, not discounted	1.2
Residual value, discounted	1.0
Total operating costs, not discounted	12.2
Total operating costs, discounted	16.6
Yearly operating costs in the last year of time horizon	1.0

Glossary

Apportionment	The division or split of resources (costs and/or person or machine-time) among different legal entities or projects according to their proportion of actual use.
Base year	The point-in-time of the analysis, which serves as a base for financial computations. It is the reference year for the analysis, i.e. ex-ante, mid-term, ex-post.
Business as usual	An inertial scenario assuming no change in the operation.
Capitalisation	The process of determining the present value of past flows (backward perspective), adjusting for a proper financial capitalisation rate.
Cash flow	The amount of money transferred in- or out.
Current price	The current price, also known as the nominal value, is the price at which goods and services are sold in the market. Differently from real prices, nominal prices include inflation.
Constant price	Constant prices are a way of measuring the real value of a good and/or service. A year is chosen as the base year. For any subsequent or different year, the value of the good/service is measured using the price level of the base year, regardless of variations in the inflation index.
Counterfactual	The scenario that describes what would happen in the absence of the project/RI.
Deflating	The action of changing current (nominal) prices into real (constant) prices by removing the effect of price change.
Discount rate	The interest rate used to discount future cash values to determine their present value
Discounting	The process of determining the present value of future cash flows (forward perspective), adjusting for a proper discount rate
Do-minimum	A scenario assuming only planned or committed minor future investments needed to keep unchanged the current performance or to perform small improvement of the project/RI.
In-kind contribution	Non-cash contribution provided by a legal entity (e.g. in terms of personnel or machine time, supply of equipment, services, buildings, etc.)
Inflation	The rate at which the average price level of a basket of selected goods and services in an economy increases over a period of time. It is a proxy of the increase of the general level of prices. Real prices are converted into current ones by adding inflation to the former, and vice versa.
Net Present Value	The difference between the present value of inflows and the present values of outflows in a given period of time.
Present value	The capitalised or discounted value of a past or future cash flow at a given capitalisation or discount rate.