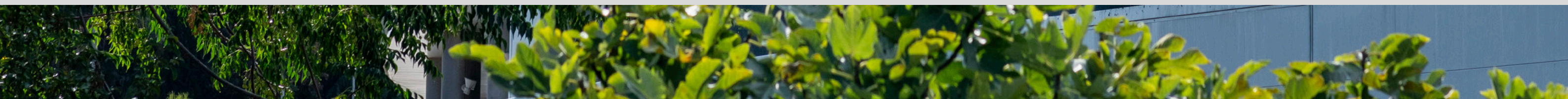
Economic and Social Impact of ALBA II

José García Montalvo (Pompeu Fabra University)

Josep Maria Raya (Tecnocampus, Pompeu Fabra University)

upf. Universitat Pompeu Fabra Barcelona

October 2023



Contents

Executive summary 3

1. Introduction 4

2. Economic impact 5

    2.1. Methodology 5

    2.2. Data for analysis: Investment and technical coefficients 5

    2.3. Demand vector 5

    2.4. Social accounting matrix 6

    2.5. Results 6

3. Socio-economic impact 7

    3.1. Methodology 7

    3.2. Basic assumptions 7

    3.3. Financial analysis: Results 7

    3.4. Economic analysis 8

        3.4.1. Benefit through development of new products 8

        3.4.2. Benefit through network of knowledge and contacts 8

        3.4.3. Benefit through research 8

        3.4.4. Benefit through human capital development 9

        3.4.5. Benefit through social capital development 9

        3.4.6. Benefit for visitors 9

        3.4.7. Benefit for the destination's image 9

        3.4.8. Social costs 9

        3.4.9. Results of economic analysis 9

4. Conclusion 12

5. Bibliography 13

Executive summary

General aspects

This report presents an analysis of the economic and social impact of the construction and commissioning of the ALBA II Synchrotron, the project to upgrade the ALBA Synchrotron and make it a fourth-generation facility.

The project consists of modernising the ALBA Synchrotron light source to improve the current performance of the accelerator and of the synchrotron light emitted, particularly its resolution and coherence. In addition, the equipment will be updated in 14 beamlines and three additional beamlines will be built, two of which measuring almost 200 metres long. This length allows for the use of new synchrotron light techniques that will put ALBA II at the forefront of the state of the art.

These analyses apply to the period 2024–2056 and are based on the 2024–2038 expenses and investments budget, which implies a differential investment of 162.7 million euros compared to the scenario where ALBA is not upgraded.

Objectives

- To strengthen Spain's and the European Union's competitive position in terms of big research infrastructures.
- To facilitate access for scientists and companies to a synchrotron light source in the southern European Union.
- To harness more of Catalonia's and Spain's scientific and technological potential.
- To improve the capacity of the Spanish science and technology system and its collaboration with other big European research infrastructures.
- To help to make Spanish companies more competitive.
- To improve citizens' well-being through the application of synchrotron light to the development of advanced materials for energy, for the semiconductor industry and for new solutions for health, climate change, environment protection, etc.

Assumptions underlying the social impact analysis

The methodology of this cost-benefit analysis consists of quantifying the benefits and costs (including externalities) of a certain investment for the whole society in monetary terms. This way, the results can be directly compared with the costs, based on the net value of the investment.

The facility is assumed to have an operational life of 25 years, once construction is completed.

The baseline scenario assumes an inflation rate of 3%, a discount rate of 3%, 188 operational days per year for the facility and a period of 2 years from when an experimental beamline is commissioned to when saturation occurs.

Main social impact analysis results

- The economic analysis in the baseline scenario signals a net present value of 544 million euros, a benefit-cost ratio of 1.37 and an annual internal rate of return of 20.3%. In other words, **every euro invested in ALBA II has an annual social return on investment of 1.20 euros**. This figure is more than twice the rate obtained from ALBA, which was already high, as rates of return rarely reach double digits. This is down to the fact that the new investment into ALBA II leverages a large proportion of the investment into ALBA, thus increasing its profitability.
- The **cumulative monetised social benefit will reach 2.112 billion euros during the 2024–2056 period**: a figure that compares very favourably with the cost of the infrastructure.

Assumptions underlying the economic impact analysis

The methodology used is the input-output model, which calculates the direct, indirect and induced impacts by gathering intersectoral or intermediate transaction flows in a certain region or country for a specific year, as well as the different final demand vectors and primary inputs.

The economic impact is calculated in three areas: production, value added and employment.

Three phases are analysed: the operation of the current facility and supply period of ALBA II (2024–2029), the construction period (2030–2031) and the operation of ALBA II (2032–2056).

Main economic impact analysis results

Across the three phases (operation and supply, construction and operation) an **impact of 1.123 billion euros** (which implies a **multiplier of 1.9 for every euro** of direct production in ALBA II) will be generated, the **value added will reach 346 million euros** (**multiplier of 1.94 for every euro** of direct added value in ALBA II) and **361 full-time jobs will be created** (**multiplier of 4.36 for each direct job** in ALBA II).

1. Introduction

In 2003 and 2010, two studies were conducted on the economic and social impact of ALBA: one before the start of the investment, or an ex-ante evaluation, and another before its commissioning, or an ex-post evaluation (García-Montalvo and Raya Vilchez, 2005; Raya Vilchez and García-Montalvo, 2016). These economic impact studies and cost-benefit analyses (Raya Vilchez and Moreno-Torres, 2013) allow the economic and social effects of the construction/improvement of a certain infrastructure to be quantified and communicated to society.

The 2010 study, carried out after the initial construction phase, assumed 25 years of operation with 7 beamlines from 2011. The financial analysis concluded that the internal rate of return was 6.4% and the benefit-cost ratio was 1.18. The economic analysis in the baseline scenario signalled a net present value of 147.7 million euros, an internal rate of return of 7.9% and a benefit-cost ratio of 1.35. In 2023, with 10 operational beamlines and four more under construction with similar but slightly increased public investment, there is no doubt that these conservative baseline scenario forecasts have been exceeded. This confirms both the logic and the validity of the methodology applied to the socio-economic impact study in the context of ALBA as an instrument for assessing the investment to be made.

Developments in synchrotron light source technology are driving evolution towards the fourth generation across the world, which opens new doors to explore the details of matter thanks to a much brighter beam. The ALBA Synchrotron team has recently started work on designing the ALBA II project, which involves updating the accelerator that acts as a light source, building new experimental beamlines and updating current beamlines, data infrastructures and other services. ALBA II will offer greater resolution, better data analysis capacity and quicker experimentation capabilities, in order to ensure the scientific and industrial community's continued access to the best internationally competitive instruments. The upgrade optimises reusing already developed infrastructure.

The design and construction of ALBA II is planned to take place in parallel to ALBA's continued operations until 2029. Then, 2030 and 2031 will be dedicated to dismantling the current accelerator and installing and commissioning the new accelerator and beamlines. ALBA II is expected to become operational in 2032, 20 years after ALBA was commissioned.

The original economic impact study and cost-benefit analysis were carried out by the same core of researchers who conducted the study on the impact of this change to a fourth-generation synchrotron.

The aim is to carry out an analysis of the economic impact (in terms of production, gross value added, or GVA, and employment) and social impact (assessing aspects such as the effects of ALBA II on research and education) of the investment to turn ALBA into ALBA II, a fourth-generation synchrotron. This is therefore another ex-ante evaluation. All analyses apply to the 2024–2056 period, which covers the investment into and the commissioning of ALBA II and its new beamlines. The period used is the minimum horizon observed in literature on technological infrastructure investment projects (25 years) counting from the commissioning of ALBA II (planned for 2032). Given the distribution of income and costs, broadening this time horizon entails increased return on investment.

This study is structured as follows. Section 2 presents the economic impact analysis, which includes a description of the methodology, the data analysed, the demand vector, a results matrix and an explanation of the results. Section 3 presents the social impact, using the cost-benefit analysis methodology, and the results obtained. In the final part, some brief conclusions are drawn.

2. Economic impact

The analysis of the economic impact of the ALBA II Synchrotron light source takes into account both the initial investment and operating costs up to the end of its service life. The methodology used is a calculation based on input-output tables, which is the standard for this type of study and was used for the 2003 and 2010 estimates.

2.1. Methodology

The evaluation of the economic impact of an infrastructure is conducted using information from input-output tables (IOTs), which gather intersectoral or intermediate transaction flows in a certain region or country for a specific year, as well as the final demand vectors and primary inputs. Input-output tables show disaggregated information on:

- Intermediate transactions involving goods and services between the productive sectors of an economy.
- Final purchases of goods and services made by consumers, businesses, the public sector and the foreign sector (in the form of exports).
- Businesses' payments to primary factors, to the public sector (in the form of taxes) and to the foreign sector (in the form of imports).

With this statistical information, an input-output model of the economy can be developed. In this model, variations in the productive sectors' global level of economic activity are explained by variations in final demand, with one notable particularity: sectoral interdependencies allow for a calculation of the cross effect of a change in final demand for a product or service offered by a sector on the global activity index of the other sectors. The specific effect on a sector will depend on the structure of its production technology in relation to the goods and services needed in its production activity that are produced by and come from other sectors.

The main advantage of the input-output analysis is its potential for measuring the effect of productive interdependency between sectors and distinguishing between direct and indirect impact. The direct impact measures the effect on a sector's activity of having to adjust its production to satisfy new final demand levels. Meanwhile, indirect impact measures adjustments in production levels in all sectors in response to new demand for inputs that are needed to meet the level of production required in the sector in which the new final demand originally occurs. Given that each sector that provides inputs also requires inputs from other sectors, the indirect impact captures the sequential adjustment in all sectors to fulfil each other's input needs in response to changes in final demand.

The calculation of direct and indirect effects cuts off the sequence of economic influences on the generation of factor income. However, the circular flow of income does not stop at this point in the real world; instead, the generation of new income helps to increase the purchasing power of the consumers who receive this new income. It therefore has an additional effect on final demand. For example, higher salaries for employees can lead to growth in household consumption of products from several sectors of the economy. The effects caused by households' increased final demand are known as induced effects.

At this point, information on work-related technical coefficients (which measure employment requirements per unit produced) is used to calculate the effect of a change in final demand on employment. Similarly, information on unit value added (salaries and other income, mainly capital income) is used to calculate the effect on the value added.

2.2. Data for analysis: Investment and technical coefficients

The economic impact analysis requires two basic inputs: the project investment and the technical coefficients from the social accounting matrix (SAM). The first step is to calculate the investment in the construction phase and break it down according to the sector from which it came.

2.3. Demand vector

The demand vector indicates the increase in demand brought about by the construction and operation of the ALBA II Synchrotron light source. To calculate the economic impact of ALBA II, the information on the planned vectors of investment and operating costs provided by ALBA for the analysed period displayed in Figure 1 has been used. The total cost – which includes the construction of the new accelerator, three experimental beamlines, new data infrastructures and extra investments for continuous development, operations, maintenance and staff – for the 15 years from 2024 to 2038 is 1 billion euros.

The ALBA II construction phase is from 2024 to 2031, with a total investment of 162.7 million euros, represented annually in yellow in Figure 1. ALBA operating costs and investment coexist alongside this construction phase and will extend beyond 2031 to allow ALBA II to operate, as represented annually in blue, orange and grey in Figure 1. ALBA II operating costs and investment have been extrapolated to the 2039–2056 period exclusively for the purposes of this economic and social impact study.

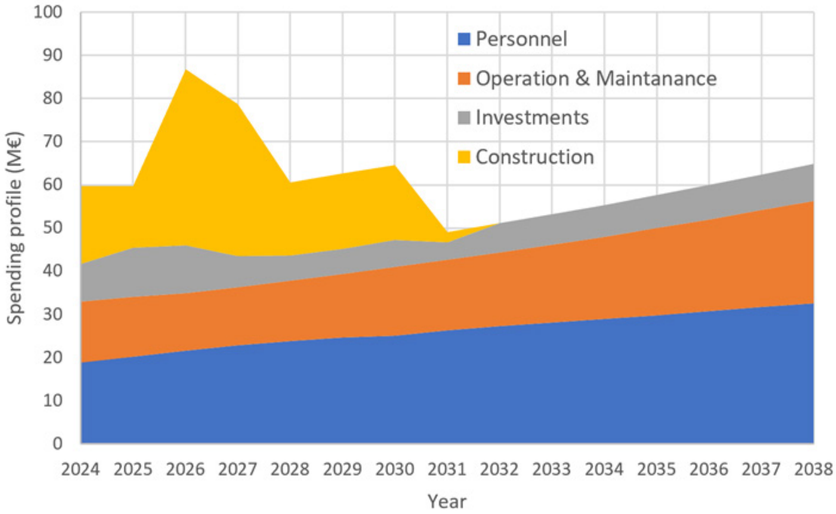


Figure 1.- Annual evolution of investments and operating costs forecast for ALBA and ALBA II

2.4. Social accounting matrix

Furthermore, the multipliers calculated in 2010 have been used with the information on the Catalan economic structure extracted from the aforementioned input-output tables, Regional Accounts and Alcaide Guindo (2010). As mentioned above, IOTs offer details of production, income and expense accounts broken down according to sector. Closing the circular flow of income requires data on income and expenses for the private, foreign and public sectors, as well as their respective deficits and surpluses (contribution to the community's aggregate saving). For this purpose, the IOTs are used to establish social accounting matrices (Llop, 2012).

2.5. Results

The economic impact is calculated in three areas: production, value added and employment. The starting point is the demand vector calculated from the assignment to different economic sectors of the expenses according to the expenses and investments estimate for 2024–2038. Staff costs and the 'users and other transfers' line item have been excluded from these expenses. The other line items (investments, current expenditure, operating costs and financing costs) make up almost 60% of the estimate. The results are included in Table 1. The analysed line items generate an impact of 1.123 billion euros (which implies a multiplier of 1.9 for every euro of direct production in ALBA II), value added of almost 346 million euros (multiplier of 1.94 for every euro of direct value added in ALBA II) and 361 full-time jobs (multiplier of 4.36 for each direct job in ALBA II).

GDP (2024–2038)	*DIRECT*	*INDIRECT*	*INDUCED*	*TOTAL*
Agriculture, livestock, fishing and extractive industries	5,000	14,880	227,246	247,127
Industry, construction and energy	533,974,229	132,248,728	345,688,892	1,011,911,849
Services	58,196,021	7,268,745	45,821,100	111,285,866
Total	**592,175,250**	**139,532,354**	**391,737,238**	**1,123,444,842**
EMPLOYMENT (2024–2038)				
Agriculture, livestock, fishing and extractive industries	0	0	0	0
Industry, construction and energy	61	81	149	290
Services	22	13	37	71
Total	**83**	**94**	**186**	**361**
VALUE ADDED (2024–2038)				
Agriculture, livestock, fishing and extractive industries	0	0	0	0
Industry, construction and energy	142,650,382	29,730,722	108,017,874	280,398,978
Services	35,707,718	4,392,110	25,972,462	66,072,147
Total	**178,358,100**	**34,122,832**	**133,990,336**	**346,471,124**

Source: compiled by author. Table 1.- Economic impact of ALBA II (euros)

3. Socio-economic impact

As it is a simplified outline of reality, the input-output analysis methodology presents certain limitations, partly because it does not take into account monetary, tax and labour factors, for example. Some of the model's main intrinsic restrictions are the hypotheses of linearity and stability underlying the technical coefficients and the static nature of the analysis (Muñoz, 2010). Furthermore, some authors (Taks et al., 2011) point out that many of the criticisms directed at economic impact studies based on an input-output analysis are linked to the use of multipliers with an excessive impact (especially in aspects relating to visitors and not excluding time-switchers or casuals), as indicated by Matheson (2009), and to a lack of consideration of positive and negative externalities, as signalled by Barget and Gouguet (2007).

3.1. Methodology

This is why a suitable solution is to accompany the economic impact study with a cost-benefit analysis methodology (Policy, 2014). A cost-benefit analysis (CBA) is an instrument that seeks to evaluate investment projects from the perspective of society's needs, so that priorities can be established when decisions are made (De Rus, 2010). The CBA consists of quantifying the benefits and costs of a certain investment for the whole society in monetary terms. This way, the results can be directly compared with the costs, based on the net value of the investment. So, when the benefits outweigh the costs (positive net value), the activity is economically justified.

The main problem lies in how difficult it is to express all the relevant effects of a public investment (like the investment for ALBA II) in monetary terms. In economics, everything that contributes towards increasing people's well-being is deemed a social benefit, while everything that damages it is a social cost. Therefore, the value of a big research infrastructure is linked not only to its profitability, but also to whether it improves or worsens people's well-being, which is gauged by individual preferences given a certain income distribution. The result of this is that the benefits and costs of a public investment must take on a social perspective, as indicated above.

3.2. Basic assumptions

To calculate the project's socio-economic impact, the methodology in this document (CBA) follows the principles set out in Florio (2019) and Florio et al. (2008). Some of the usual assumptions made are the following:

- The time horizon is 25 years, counting from when ALBA II is commissioned. This hypothesis is based on this being an investment comparable to an energy investment, the construction period lasting 8 years (2024–2031) and the median service life for this type of facility being 25 years according to international standards (2032–2056). In fact, in order to make a conservative estimate, the lower recommended limit was chosen (between 25 and 30 years).
- The residual value is deemed to be the value of the land where the facility is located, calculated at current prices. The basis is the calculation of the discounted net present value of the investment into ALBA II. The baseline scenario assumes an inflation rate of 3%[1] and a discount rate of 3%.

Two parts are usually distinguished within the cost-benefit methodology. First, there is the financial analysis, which evaluates the financial part of the investment without making corrections for prices in non-competitive conditions or incorporating positive or negative externalities. Second, there is the economic analysis, which uses the financial analysis as a starting point and takes into account both externalities and corrections of prices obtained in non-competitive conditions (if applicable).

3.3. Financial analysis: Results

The most commonly used indicators for the financial analysis are internal rate of return (IRR), net present value (NPV) and benefit-cost ratio (BCR).

The IRR is the rate of return that makes the net present value of the investment equal to zero. Therefore:

$$VAN(S) = \sum_{t=0}^{n} S_t \,(1+TIR)^t = 0$$

where *Sn* is the net flows at moment *n*. The document Guide to Cost-Benefit Analysis of Investment Projects, prepared by the Evaluation Unit of the DG for Regional and Urban Policy (European Commission), indicates that a low or even negative IRR does not invalidate a project, on the condition that it can achieve its objectives.

The NPV is the discounted present value of the net flows generated by the project.

$$VAN(S) = \sum_{t=0}^{n} a_t S_t = \frac{S_0}{(1+i)^0} + \frac{S_1}{(1+i)^1} + . + \frac{S_n}{(1+i)^n}$$

where a_t is the discount factor and *i* is the interest rate (or the opportunity cost of the funds).

The BCR is the relationship between the present value of the benefits and the present value of the costs, including investments.

1 although inflation is currently at 3.5% and core inflation is at 5.8%. In any case, the sensitivity analyses show that a rise in inflation increases the project's net present value and internal rate of return (as the income flow is greater than the cost flow).

Using the data and the assumptions detailed in the sections above, the baseline scenario results in a net present value of 217 million euros and an internal rate of return of 9.7% (Table 2). These results comfortably exceed the results obtained in 2010. This is because the income is higher (instead of 7 experimental beamlines, during the period, between 10 and 17 are active) and the costs are lower, as most of the investment was made before 2010. The income from industrial use and the investment and operating costs for ALBA II were obtained from ALBA's accounts. The financial income obtained for researchers' hours of using ALBA II was gathered in a similar way to the 2010 calculation, but now with information on ALBA's costs.[2] The income for each 'shift' is updated using the same inflation rate (3%) and reduced as the number of experimental beamlines increases, until the 17th beamline is saturated in 2033. Demand is calculated based on the assumed use of 98% (practically saturation), which is the current demand (5,227 'shifts'). This demand increases from the 10 current beamlines to 17, assuming that each new beamline is saturated in two years, which is the maximum observed thus far.

NPV	**€217,216,751**
IRR	**9.7%**
B/C	**1.14**

Source: compiled by author. Table 2.- Financial analysis results

3.4. Economic analysis

The economic analysis seeks to determine the project's overall contribution to the region's or the country's well-being. Therefore, the subject of interest in this case is all of society, not just the owner of the infrastructure. Making the transition between the financial analysis and the economic analysis requires consideration of corrections to the financial results to account for externalities and the conversion of goods and services acquired in non-competitive conditions into market prices.

The Guide to Cost-Benefit Analysis of Investment Projects prepared by the Evaluation Unit of the DG for Regional and Urban Policy (European Commission, 2014) and Florio (2019) recommend taking a series of positive externalities into account in technological infrastructures. To this end, aspects such as the following should be evaluated in monetary terms: knowledge generation (patents and publications), human capital development (doctoral and postdoctoral researchers), social capital development (conferences, visits), benefits for providers and benefits for the image of Barcelona. Meanwhile, a monetary evaluation of the environmental costs should be included in the costs section. Guides to calculating all of these cases are available.

To calculate the monetary value of the aforementioned externalities, in all cases, the social benefit is calculated for the most recent year for which information is available (usually 2021 or 2022) and this benefit is projected into the future, taking into account changes in the number of experimental beamlines, the discount rate and the inflation rate. This approach is conservative, especially in aspects where exponential growth is to be expected (as has occurred up to now), such as in the value of aspects relating to research. Below is a discussion of the main aspects and how they have been calculated.

3.4.1. Benefit through development of new products

Florio et al. (2008) recommend calculating benefit through the development of new products using the economic value of the patents. In the case of ALBA, there are currently 16 patents: an average of two per year. It is important to put this figure into context. According to data from the Spanish Patent Office, Catalan universities have applied for a total of 298 patents in the last decade. So, in 7 years (2015–2021), ALBA alone applied for more than 5% of this total. The value of these patents is linked to the number of citations they receive a posteriori. As these patents are recent, assessing this aspect through this channel is difficult. According to Ceccagnoli et al. (2005), patents should be valued at €300,000, while Sartori et al. (2014) put forward a more conservative value (€85,000) based on European Investment Bank data (2013).[3]

3.4.2. Benefit through network of knowledge and contacts

Other businesses can also benefit from the network of knowledge and contacts entailed by a commercial relationship with ALBA. To calculate this, the sectors' average multiplier according to the profitability of each sector has been used, based on information from the SABI database, which contains 1.7 million Spanish companies and all their accounting data and economic and financial ratios. The weighted average of EBITDA to sales has been used. With a turnover value of 1.43 and a 14.7% rate of return in 2019, this component contributed 1.8 million euros in 2021.

3.4.3. Benefit through research

The benefit through research is one of the main social benefits of scientific infrastructures. This benefit is measured through citations in articles by scientists who do not belong to ALBA. As is to be expected, the number of citations has grown from the creation of ALBA (40 in 2011) to the present day (around 10,500 in 2021). The usual way of calculating the value of each citation includes the cost of the researcher's time, from downloading the publication to citing it. This cost is measured based on the average salary of researchers in the field. Therefore, the value calculated for 2021 is €63,862.

2 If calculated exactly the same as in 2010 – taking into account the annual Spanish fee at the ESRF and the real number of shifts fulfilled – the result is a unit cost of 7,751 euros per shift. This is very similar to the range obtained with ALBA unit costs in the considered period.

3 Though this may be a qualitative indicator, it is worth highlighting that ALBA has been cited in 337 documents that have contributed towards creating patents (Catalano et al., 2021).

3.4.4. Benefit through human capital development

It is obvious that a scientific infrastructure like ALBA is instrumental in human capital development or, in other words, the creation of knowledge, skills and competencies needed outside the strict sphere of research. Fundamentally, research infrastructures are a talent hub. Students do not pay a fee for their training in a research infrastructure; instead, they receive training thanks to third-party resources such as grants. An externality is thus created. Education economics techniques help to measure the increase in the human capital available for society. Human capital contributes to the economy's growth and productivity. Doctoral and postdoctoral researchers access a form of learning through practice that is difficult to obtain outside these institutions. Salaries reflect the skills acquired during this time at a major scientific infrastructure. The benefit of doctoral candidates' training is calculated according to their higher future salary (educational output), duly discounted, due to the positive externalities resulting from working at ALBA. This parameter is calculated in the standard way used in literature in the field (assuming that they will retire at the age of 65). This bonus for having worked at ALBA – of around 5% – applies to all predoctoral, doctoral and postdoctoral researchers. The final total for 2021 is 2.25 million euros.

3.4.5. Benefit through social capital development

As for social capital development, over the years, researchers have organised academic seminars, workshops, courses and conferences, which attract visitors from all over Europe. For example, the year 2019 (2020 and 2021 were strongly impacted by the pandemic) saw 1,225 visitors to ALBA, either as guest speakers or as participants in seminars and workshops. Visitors' willingness to pay is calculated through the travel cost method (adding together transport, accommodation and registration costs and the opportunity cost in terms of the attendees' salary for those days). Assuming an average willingness to pay of 2,000 euros (Sartori et al., 2017), the result in this case is €1,856,000.

3.4.6. Benefit for visitors

Other additional benefits considered as part of this estimation of ALBA II's socio-economic impact are the benefits for visitors and for the image of the area.[4] Throughout the year, ALBA receives visits from schools, businesses and staff from other universities. In 2019, for example, it received around 17,000 of these visitors. They are beneficiaries of ALBA in that their willingness to pay for the visit is higher than the price they actually pay (the visit is free). As is the case with other recreational activities, the best way to estimate willingness to pay is through the travel cost analysis (Clawson and Knetsch, 2013), which assumes that each visitor's financial and economic costs can be used to estimate their willingness to pay. Following a conservative approach, we have used data from the mobility survey for the Barcelona area from 2018. This implies an assumption that journeys originate in this area and cost around €16.70 per visitor and that no additional costs are incurred. For 2021, the resulting benefit for visitors is €117,240.

3.4.7. Benefit for the destination's image

In addition, others visit ALBA virtually through the website or social media. On top of that, there is the benefit for the destination's image. ALBA's notoriety is another of the benefits for the surrounding area, particularly Cerdanyola del Vallès, Barcelona, Catalonia and Spain. A common way of measuring this notoriety is through the news generated in the media, whether traditional (press, radio and TV) or digital (social media, website, etc.). These news can be viewed as advertising impact, which implicitly increases the notoriety of the area and tends to be assessed through clipping. In 2021, this value was €342,055.

3.4.8. Social costs

Finally, turning to social costs, the environmental cost of ALBA II has been estimated by taking into account a price per ton of €86.60,[5] consumption of 48 GWh/year and the weighted average of Spanish electrical companies' CO_2 emissions per kWh (0.30 kg/kWh).[6] The environmental cost in 2021 is therefore estimated to be €524,120.

3.4.9. Results of economic analysis

All in all, the economic analysis in the baseline scenario signals a net present value of 544 million euros and an annual internal rate of return of 20.3%. In other words, every euro invested in ALBA II has a social return on investment of 1.20 euros per year.

NPV	**€544,409,863**
IRR	**20.30%**
B/C	**1.37**

Source: compiled by author. Table 3.- Results of economic analysis

Figure 2 summarises the distribution of the cumulative net present value of ALBA II's benefit by component. ALBA II will have a cumulative monetised impact of 2.112 billion euros in the 2024–2056 period, according to the data gathered in this relatively early phase of the project. Given that not all activities, products and results can be monetised accurately at this stage, this figure compares very favourably with the costs of the infrastructure. The main cumulative benefits are the financial benefit or value for users (access) and the research benefit in terms of scientific publications, which make up almost 90% of the total cumulative net social benefit of ALBA II.

4 Other possible benefits, such as the non-use value, have not been calculated, as this would require a survey to gauge people's willingness to pay to have the infrastructure (regardless of whether or not they use it). In the case of the Large Hadron Collider, Florio et al. (2016) estimate that this non-use value would pay back 24% of total costs.

5 www.sendeco2.com

6 Spanish National Markets and Competition Commission

Moreover, Figure 3 presents the distribution of the net present value over time. It shows that once ALBA II is commissioned (2032), the NPV presents a clearly upward trend, which would continue if the time horizon were extended – it could easily be extended to 2060 – and the return on investment would be much higher.

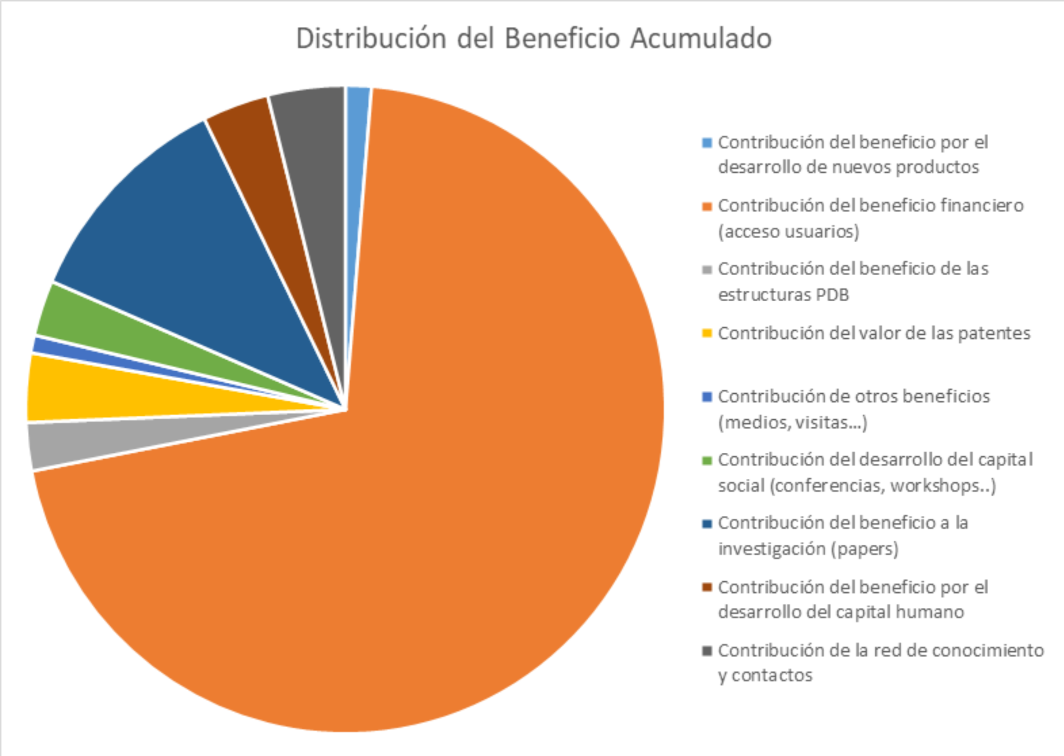


Figure 2.- Distribution of the cumulative net present value of ALBA II's benefit

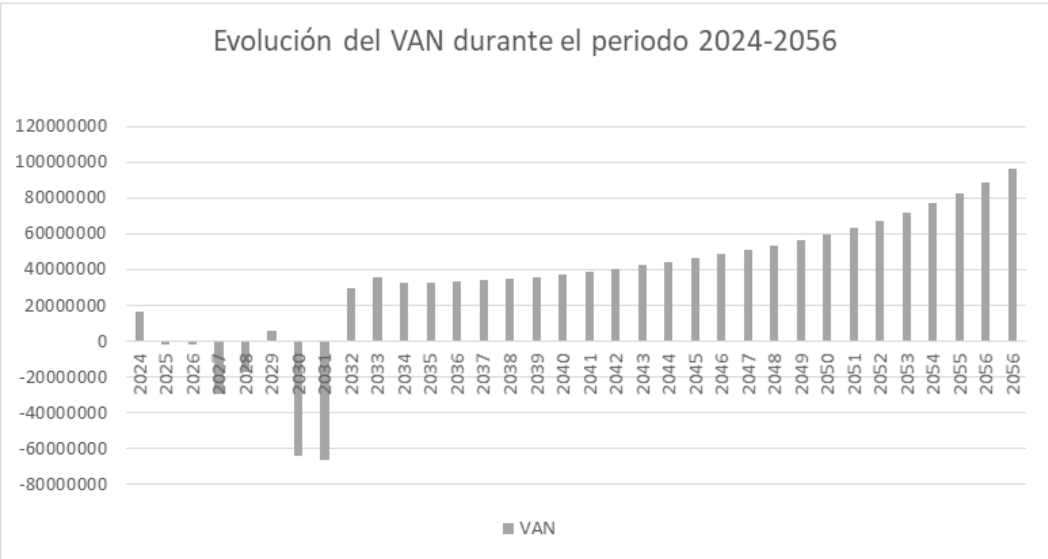


Figure 3.- Distribution of the net present value

4. Conclusion

This report has presented a current calculation of the economic and social impact of the construction and commissioning of the upgrade from ALBA to ALBA II, a fourth-generation synchrotron, as well as a cost-benefit analysis of this scientific infrastructure.

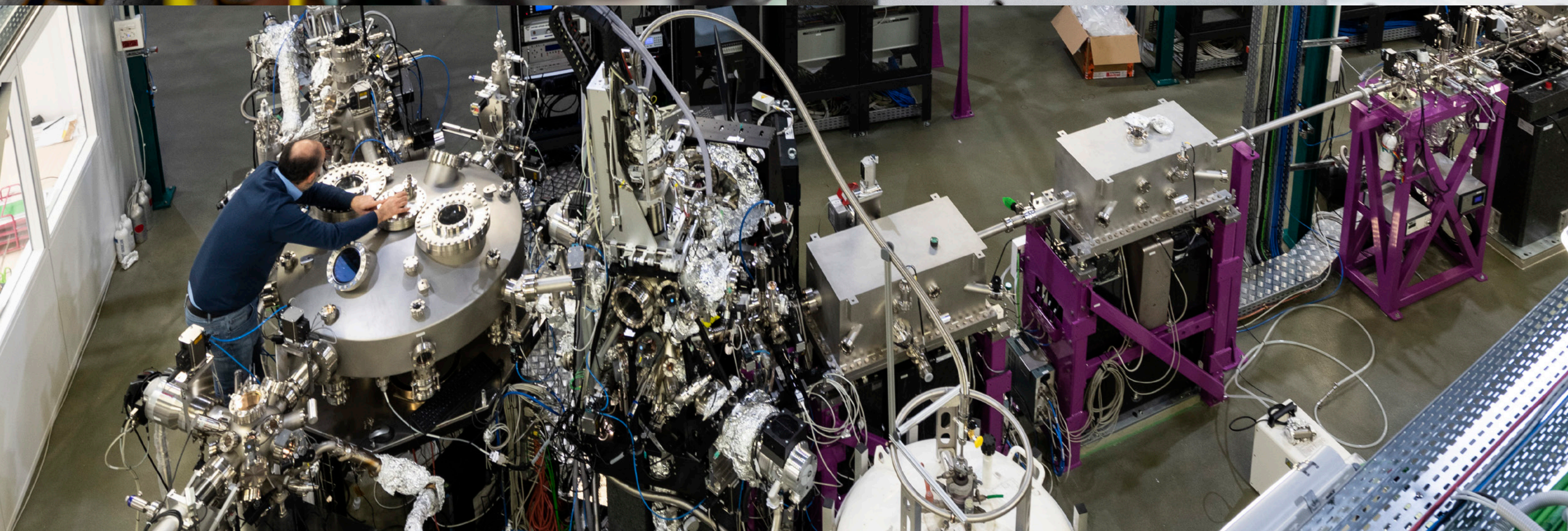
The economic impact calculation suggests that ALBA II would generate **an impact of 1.123 billion euros, add 346 million euros of value and create 361 full-time jobs**. These figures must be combined with a **cumulative monetised benefit of 2.112 billion euros and a social return on investment of 20.3%**.

The conclusion to be drawn from this is that the **rate of return for the ALBA II investment is very high**. To provide context, it is **more than twice the rate obtained from ALBA, which was already high**, as rates of return rarely reach double digits. This is down to the fact that the new investment into ALBA II leverages a large proportion of the investment into ALBA, thus increasing its profitability.

Furthermore, as mentioned, the assumptions made for this report are undoubtedly conservative. This is especially the case for the time horizon. Looking forward, this calculation of ALBA II's economic and social impact could be improved by updated data, a recalculation of economic impact multipliers, a socio-economic impact exercise that incorporates a sensitivity analysis into the initial assumptions and a simulation exercise that lends a probabilistic perspective to the possible results.

5. Bibliography

- Alcaide Guindo, P., 2010. Avance de las magnitudes económicas españolas en 2009 y serie provisional del" Balance Económico Regional": años 2000 a 2009. Cuad. Inf. económica 1–64.
- Barget, E., Gouguet, J.J., 2007. The Total Economic Value of Sporting Events Theory and Practice. J. Sports Econom. 8, 165–182. doi:10.1177/1527002505279349
- Catalano, G., López, G.G., Sánchez, A., Vignetti, S., 2021. From scientific experiments to innovation: Impact pathways of a Synchrotron Light Facility. Ann. Public Coop. Econ. 92, 447–472.
- Ceccagnoli, M., Gambardella, A., Giuri, P., Licht, G., Mariani, M., 2005. Study on evaluating the knowledge economy–What are patents actually worth? The value of patents for today's economy and society. Eur. Comm. DG Intern. Mark. Tender No. MARKT/2004/09/E, Final Rep. Lot 1.
- Clawson, M., Knetsch, J.L., 2013. Economics of outdoor recreation. Routledge.
- De Rus, G., 2010. Introduction to cost-benefit analysis: looking for reasonable shortcuts. Edward Elgar Publishing.
- Florio, M., 2019. Investing in Science: Social Cost-Benefit Analysis of Research Infrastructures, The MIT Press. MIT Press.
- Florio, M., Finzi, U., Genco, M., Levarlet, F., Maffii, S., Tracogna, A., Vignetti, S., 2008. Guide to cost-benefit analysis of investment projects. Eval. Unit, DG Reg. Policy, Eur. Comm.
- Florio, M., Forte, S., Sirtori, E., 2016. Forecasting the socio-economic impact of the Large Hadron Collider: A cost–benefit analysis to 2025 and beyond. Technol. Forecast. Soc. Change 112, 38–53.
- García-Montalvo, J., Raya Vilchez, J.M., 2005. Potenciant la nova economia a Catalunya: una anàlisi econòmica de la font de llum de sincrotró del Vallès (ALBA). Coneix. i Soc. Rev. d'Universitats, Recer. i Soc. la Inf. 32–59.
- Llop, M., 2012. The role of saving and investment in a SAM price model. Ann. Reg. Sci. 48, 339–357.
- Matheson, V.A., 2009. Economic multipliers and mega-event analysis. Int. J. Sport Financ. 4, 63.
- Munoz, J., 2010. Evaluación del impacto sobre la ocupación total catalana de la crisis inmobiliaria a partir de una simulación con las tablas input–output de Cataluna. XVII Jornadas Estadıstica las Comunidades Auton. (Caceres, 20–23 Oct. 2010).
- Policy, EU., 2014. Guide to Cost-benefit Analysis of Investment Projects. Policy 2014, 2020.
- Raya, J.M., Garcia-Montalvo, J.G., 2016. Anàlisi cost-benefici i d'impacte econòmic del sincrotró ALBA. Nota d'Economia 115–125.
- Raya Vílchez, J., Moreno-Torres, I., 2013. Guia pràctica 9: introducció a l'avaluació econòmica. Col.lecció Ivalua de guies pràctiques.
- Sartori, D., Catalano, G., Genco, M., Pancotti, C., Sirtori, E., Vignetti, S., Bo, C., 2014. Guide to cost-benefit analysis of investment projects. Economic appraisal tool for cohesion policy 2014-2020.
- Taks, M., Kesenne, S., Chalip, L., Green, B.C., Martyn, S., 2011. Economic impact analysis versus cost benefit analysis: The case of a medium-sized sport event. Int. J. Sport Financ. 6, 187.



ALBA Synchrotron - www.cells.es

Carrer de la Llum 2-26, 08290 Cerdanyola del Vallès (Barcelona)