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Bio-FlexGen

5.5 Potential social impact report

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Technical References

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[1] PU = Public
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CO = Confidential, only for members of the consortium (including the Commission Services)

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Summary

This document constitutes Deliverable D5.5. “Potential Social Impact Report¨ of the project ¨Bio-FlexGen¨. This deliverable belongs to Task 5.2 ¨Social Assessment¨ of Work Package (WP) 5 ¨Sustainability studies¨.

The goal of T5.2 is to measure the potential social impact of the technologies developed in the Bio-FlexGen project. As the TRL targeted for the end of the project is low (TRL4), a real-life implementation of the technology beyond a controlled environment (laboratory) has not been planned. Therefore, ZABALA, together with the project coordinator and other consortium partners has built two theoretical scenarios where the technology may potentially be deployed in the future, a residential (District Heating) use case in Sweden and an industrial use case in Spain.

For each of these two scenarios, the main stakeholders to be potentially impacted in each use case were identified in deliverable 5.3 ¨Analysis of local stakeholders and engagement plan¨. To measure the social impact of the Bio-FlexGen technology, a selection of 66 social impact indicators and the methodology for measuring them were defined in deliverable 5.4 ¨Selection of Social Impact Indicators and Methodology for measurement¨. These 66 indicators were validated by the experimental community, pilot coordinators, academic partner (Comillas University) and other consortium partners in dedicated sessions. From the validation process, 32 final indicators to be measured were selected.

This deliverable describes the indicators validation process, the final selection of 32 social impact indicators to be measured, the measuring methodology and the results of the indicator´s measurement. Based on the indicators results, the deliverable presents the potential social impact of Bio-FlexGen project and provides future recommendations.

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Abbreviations

BTC	Biomass-fired Top Cycle
CAPEX	Capital expenditures
CBA	Cost-Benefit Analysis
CHP	Combined Heat and Power
DH	District Heating
GDP	Gross Domestic Product
GVA	Gross Value Added
LHV	Lower Heating Value
mFRR	Manual Frequency Restoration Reserve
OPEX	Operating Expenditures
RISE	Research Institutes of Sweden
SDGs	Sustainable Development Goal(s)
TRL	Technology Readiness Level
TvAB	Tekniska Verken AB (utility)
WP	Work Package

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1 Introduction

This deliverable presents the final output of Task 5.2 "Social Assessment" of WP5 "Sustainability studies" with the results of the social impact assessment of the Bio-FlexGen project in the two hypothetical scenarios. The main objective of the social impact assessment has been to assess the social impact of the new technologies developed (Biomass-fired Top Cycle technology, BTC) at company and local level, and the social acceptance that the implementation of such technology could have at national and at European level.

For each of these two scenarios, the main stakeholders to be potentially impacted in each use case have been identified in deliverable D5.3 ¨Analysis of local stakeholders and engagement plan¨. The identified stakeholders allowed understanding the social acceptance of the Bio-FlexGen technology, identifying the social benefits and risks, fostering the future social acceptance of the technology.

To measure the social impact of the Bio-FlexGen technology, a selection of 66 social impact indicators and the methodology for measuring them were defined in deliverable 5.4 ¨Selection of Social Impact Indicators and Methodology for measurement¨. This selection of indicators measures the following aspects 1) impact in access to energy /power (including impact in energy poverty), 2) impact in local culture, 3) impact in environmental behavior, 4) impact in local economy (including job creation), 5) impact in social cohesion, 6) impact in social empowerment (including local engagement and participation in the project). The 66 indicators were validated by the experimental community, pilot coordinators (Cemex, Sulquisa and Tekniska Verken AB-TvAB), academic partner (Comillas University) and other consortium partners in dedicated sessions.

From the validation process, 32 final indicators to be measured were selected. From the preliminary list of 66 indicators, 32 refer to aspects that can only be measured after the BTC technology is deployed and implemented in real life settings, and therefore these indicators cannot be measured in the current technological development stage (low TRL). Following this reasoning, 32 indicators were selected as measurable within the theoretical use cases, providing a baseline understanding of the technology's potential social risks and opportunities. Based on that, recommendations to be considered before technology implementation have been elaborated, favoring the social acceptance of bio-energy technologies.

Therefore, deliverable D5.5 describes the indicators selection and validation process, the final selection of 32 indicators, the how these indicators were operationalised and applied, and the main results obtained.. Based on the results, this deliverable presents the potential social impact of Bio-FlexGen project and provides future recommendations. Deliverable D5.5 is therefore structured as follows:

- Section 1 introduces the objectives and scope of the deliverable, providing the context of Task 5.2 within WP5 and outlining the methodology used to assess the social dimension of Bio-FlexGen.
- Section 2 presents the validation process of the social impact indicators initially defined in Deliverable D5.4, including the methodology applied by consortium partners and local community members, and the main results of the validation exercises.
- Section 3 describes the application and data collection process of the social impact indicators developed for the Bio-FlexGen use cases.. It includes a detailed description of the theoretical business cases in Sweden and Spain, the data sources used, and the limitations encountered, together with the mitigation strategies adopted.
- Section 4 presents the measurement results of the 32 validated indicators, structured across the four social impact categories: Impact on Employment (A), Economic Dimension (B), People and Communities (C), and Social Acceptance (D). For each category and subcategory, the

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section provides quantitative and qualitative outcomes as well as interpretative analysis of the findings.

- Section 5 discusses the potential social impact of the Bio-FlexGen project, summarising the main conclusions derived from the indicators' assessment and the implications for local stakeholders and communities in both countries.
- Section 6 provides recommendations and future engagement strategies aimed at enhancing the positive social impacts of Bio-FlexGen and improving its social acceptance in potential future deployment contexts.
- Section 7 includes the list of references used throughout the deliverable.
- Appendix A presents the indicators' database validated by project partners. Appendix B presents the material and outcomes of the validation workshop conducted with the Navitas Student Association in Sweden. Appendix C presents the results in graphs of the social acceptance survey.

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1.1 Social impact of bioenergy projects

Bioenergy (including solid biomass, biogas and liquid biofuels) continues to be the main source of renewable energy in the EU, accounting for about 59% of total renewable energy consumption across all Member States in 2021 (European Commission, 2023). (EU Commission, 2023). Biomass can be used for heating, electricity generation, and the production of transport fuels and currently, there is a balanced distribution across biogas end-users: 22% in buildings, 14% in industry, 19% in transport, and 15% in power generation. According to the European Biogas Association, Europe's biogas and biomethane sector supports over 210,000 jobs and delivers around 60 Mt CO_2-eq savings annually. In addition, in 2020, the EU-27 biogas industry generated an estimated €5.75 billion in turnover. Meanwhile, bioenergy overall accounted for ~59% of the EU's renewable energy consumption in 2021. These figures underline not only the economic relevance of bioenergy but also its role in supporting climate objectives and regional employment within the EU.

While biomass is a renewable energy source, its sustainability depends on several factors — including the type of biomass and how communities and stakeholders are affected. Biomass is generally derived from organic materials such as forestry and agricultural residues, waste streams, and the biodegradable fraction of municipal waste. According to projections for 2040 in Europe, sequential crops (≈ 42 %), agricultural residues (≈ 20 %), and animal manure (≈ 19 %) are expected to account for around 81–82 % of the biomethane feedstock mix (for anaerobic digestion) (European Biogas Association, 2024).

Despite the potential of bioenergy and technological advances, there are barriers in fulfilling its potential. Previous European projects, such as the ALFA project[1], have identified low social acceptance and awareness, insufficient technical knowledge and skills, and financial and regulatory barriers as the main challenges. This project indicates that European citizens see environmental and economic benefits in biogas from farming, but a substantial minority remain concerned about health risks, safety, and property values near plants. Acceptance improves with greater knowledge and trust in farmers and authorities, though a *NIMBY* attitude persists. These insights highlight the need for biogas projects to include early assessments of potential social and environmental impacts, tailored to local conditions, and supported by indicators that allow impacts to be measured and compared systematically.

Given the importance of awareness, technical knowledge, and regulatory barriers, biogas projects should carry out preliminary screening of possible environmental and social impacts. This includes assessing effects on areas such as natural resources, food security, community development, energy access, employment, income, and greenhouse gas emissions. The scale, timing, and magnitude of impacts are highly context-specific, depending on local conditions and the type of biomass used. For this reason, robust indicators are essential to measure and compare the impacts of biogas projects in a consistent way.

[1] EU Alfa project

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1.2 Social impact assessment of Bio-FlexGen project

Based on the need to measure potential impacts, systematic assessments are essential to properly address the challenges of sustainability and social acceptance and in bioenergy projects. Therefore, the objective of the social impact assessment in the Bio-FlexGen project is to evaluate the effects on local communities at the two pilot sites. Together with Task 5.1 on environmental assessment, WP5 seeks to ensure the social and environmental sustainability of the Bio-FlexGen value chain, identify related risks and opportunities, and provide recommendations for future real-world implementation.

Given that the project has not planned a real implementation of the technology developed, the assessment has been conducted under the two theoretical scenarios where the technology may potentially be deployed in the future: District Heating (DH) use case in Sweden and industrial use case in Spain.

To this end, Task 5.2 began by identifying the key stakeholders in each scenario, both internal and external, who are representative of future groups affected by the project. This allows for a better understanding of potential social benefits and risks, while supporting the future social acceptance of the technology developed. For each of these two scenarios, the main stakeholders to be potentially impacted in each use case were identified in deliverable D5.3 ¨Analysis of local stakeholders and engagement plan¨.

- In the case of Sweden, the main stakeholders are **local communities**, who would benefit from greater energy stability and efficiency as an existing biomass-based Combined Heat and Power (CHP) unit is replaced with the new BTC technology.
- In the case of Spain, the main stakeholders are internal ones, primarily **employees** who are directly involved in the deployment of the new BTC technology and benefit from job stability, training, and new opportunities; and secondly, investors who are strongly influenced by the company's environmental, social, and financial performance. Local communities are also indirectly affected through the companies' broader economic, environmental, and social impacts.

Based on the identification of key local stakeholders, ZABALA has elaborated a preselection of 66 social impact indicators described in deliverable D5.4 "Selection of Social Impact Indicators and Methodology for Measurement". This preselection of 66 indicators was organized under four main impact categories (employment, economic dimension, people and communities, and social acceptance) gathering the main social impacts that may arise because of the execution of a bioenergy project.

The preselection of 66 indicators has been validated by the project partners and the experimental communities in Sweden in a dedicated workshop guaranteeing that these indicators fulfil not only the interests of the consortium but also the concerns and interests of local communities. This validation has resulted in the final dashboard of 32 indicators used to measure the social impact of the Bio-FlexGen project.

It is important to note that, although the Bio-FlexGen project initially defined six scenarios in deliverable D5.4 by combining two business cases (industrial and residential) with three stages of the biomass value chain (biomass extraction, energy production, and CO_2 capture and storage), these were not fully applied in the present assessment. While this framework provides a comprehensive structure, its full application was not possible because the pilot activities are based on hypothetical use cases. Under such hypothetical conditions, some areas, particularly biomass extraction and CO_2 capture and storage, are more difficult to measure, since they require real operational data that is not available in the pilot design. Instead, the assessment focused on the two main business cases where the technology would realistically be implemented (industrial and residential), using measurable indicators directly linked to the pilot contexts. Nevertheless, elements of biomass extraction are still covered indirectly through selected indicators (e.g., those addressing supply chains, emissions, and environmental performance). This approach ensures that key dimensions of the value chain are not

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ignored, while keeping the analysis grounded in data that can be meaningfully assessed under hypothetical scenarios.

2 Social impact indicators - Validation

2.1 Methodology

This chapter presents the methodology of the validation of the social impact indicators (as defined in Deliverable D5.4). The validation was conducted by the project partners and by local community members in Sweden, as the social acceptance indicators target local communities and required testing with a representative group.. This combined approach ensured that the indicators are not only scientifically robust but also socially meaningful, context-specific, and aligned with the priorities and values of the communities directly involved.

2.1.1 Validation by consortium partners

For the validation carried out by the project partners, the Indicators' Data Sheet containing the 66 composite indicators presented in Deliverable 5.4 was shared with them and used as a validation tool. To enable this use, and in addition to the original information regarding category, subcategory, indicator number, indicator name, and the description of how to calculate them, three additional columns were added (Appendix A):

A. Included/Excluded: this column indicates whether the indicator is included (IN) or excluded (EX) after the validation process. The included (IN) indicators are those to be measured.

B. Justification field for the inclusion or exclusion of the validated indicator.

C. Sources for collecting the required data for measuring the indicator.

Deliverable 5.4				Validation columns		
Category *Subcategory*	No.	Indicator	How to calculate the indicator	EX/ IN	Justification for EX / IN	Source
Employment *Job quality*	A3.1	Skilled/unskilled jobs	% of skilled/unskilled jobs created when replacing the current CHP unit with the new CHP BTC unit	IN	This indicator can be measured as an estimation of the percentage of skilled/unskilled jobs out of the jobs that would be created with the new technology	Pilot coordinators, Phoenix

Table 1 Indicators' Data Sheet. Example of ¨Category Employment¨ > Subcategory ¨Job quality¨, indicators A3.1 ¨Skilled/unskilled jobs¨

The Indicators' Data Sheet (Appendix A) was distributed to pilot coordinators (TvAB AB, CEMEX, Sulquisa), to University of Comillas, and to project coordinator (RISE), so that each could validate it using the designated validation columns. All partners agreed on the soundness of the 66 indicators for a potential real implementation scenario. However, since the Bio-FlexGen project is not being implemented in a real context, the common validation criterion applied by all validators was *measurability*, that is, whether the indicators could be assessed in a hypothetical scenario such as Bio-FlexGen project. Once the validation results were compiled, the selection of 66 indicators was presented at the Bio-FlexGen Consortium Meeting held in Berlin in April 2024, where the remaining consortium partners had the opportunity to share their views and discuss the final selection.

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2.1.2 Validation by local community members

As a key stakeholder in the residential use case in Sweden, the validation of the social impact indicators was carried out through an online workshop with the local community of Linköping, specifically with the Navitas Student Association (Navitas, 2024), the largest student organization at Linköping University dedicated to sustainable development. The workshop brought together representatives of the association to evaluate the proposed set of social impact indicators and to share their perspectives on the dimensions of sustainability most relevant to them. The outcomes provide valuable insights into how the indicators are perceived at the community level, highlighting both the categories considered most significant and the aspects that may require further attention in future developments.

Beyond the validation exercise, the workshop was also leveraged to directly measure the indicators related to Social Acceptance, allowing for both an assessment of the methodological framework and the collection of first-hand data from community members. This dual approach ensured that the indicators were not only theoretically validated but also empirically tested within the local context.

The validation exercise was carried out through an online workshop with 7 members of Navitas. The online tool used for the validation was Microsoft Teams and to interact with participants using real – time voting, the platform Mentimeter (Mentimeter, 2024) was used. The workshop consisted of four sections in which the participants´ input was collected through exercises in the form of word cloud, voting (strongly disagree – strongly agree), and open questions:

1. Questions to identify participants´ profile & participants´ knowledge and interests in bioenergy and sustainability.
2. Bio-FlexGen project description: The technical developments of the project were explained by projecting the Bio-FlexGen video ¨ [The HyFlex Biomass-fired Top Cycle power plant: Maximum product flexibility and energy independence! (youtube.com)] ¨ available on Youtube (Bio-FlexGen, 2024). Next, the sustainability and social acceptance components of the project were explained and instructions for the validation exercise were shared with participants.
3. Validation of indicators. The validation exercise was conducted through an interactive Mentimeter session in which participants evaluated the 66 indicators grouped into categories and subcategories. To simplify the process, the assessment was performed at subcategory level rather than for each individual indicator, adapting the content to be more easily understood. Participants were asked to rate, on a scale, the relevance of each subcategory for measuring the social impact of a bioenergy project.
4. Direct measurement of Social Acceptance indicators. To conclude the workshop, the validated social acceptance indicators were directly measured through Mentimeter. This exercise allowed collecting preliminary data on community perceptions while simultaneously testing the applicability of the methodological framework within a real local context.

2.2 Results

2.2.1 Results of the Validation sessions with consortium partners

Of a total of 66 indicators, 32 indicators were selected for conducting the measurement within the Bio-FlexGen project. The indicators were selected based on the validation process by consortium partners, and the validation by community members. The results are presented in section 2.2.3 Dashboard of selected social impact indicators. Overall, all the categories (*Impact on employment, Impact on economic dimension, People and communities* and *Social acceptance*) are represented by a certain number of indicators.

Project partners exclude some indicators such as ¨Employee income – Annual average income per employment category compared to minimum or median wage¨, because indicators on working

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conditions and rights collect information at company level and are not specific to the Bio-FlexGen project and its potential impact. The same reasoning applies to other indicators of the category impact on employment, such as ¨employment benefits¨, ¨hours of work¨, ¨freedom of association¨, ¨number of work-related deaths, accidents, diseases¨, ¨average salary gap between female and male employees¨, ¨gender equality plan¨.

From the category ¨Impact on Economic Dimension¨ indicators related with macroeconomics were excluded because although scaling up of the technology at national level could potentially benefit the macroeconomics, the impact of the pilot tested in Bio-FlexGen is limited.

Regarding the potential impact on ¨People and communities¨, indicators referring to ¨Community engagement¨, ¨community investment in education and awareness¨, and those related to the ¨Development of Energy communities¨ were excluded. It was decided to exclude these indicators because as the project will not be implemented in real life, remaining at a pilot stage, no real engagement with local communities, authorities, or NGOs will occur. Therefore, evaluating community engagement mechanisms or the development of energy communities was considered not applicable for this case.

Most indicators listed in the category ¨Social Acceptance¨ were included in the final list of indicators. These were to be measured through a survey completed by community members and therefore were defined as both measurable and interesting. During the validation process, feedback was received in the phrasing of the questions to contextualize them. For example, the question ¨In the realization of a biomass/bioenergy plant the population's opinion should be asked for¨ was eliminated from the questionnaire, as giving the opportunity to citizens to express their opinion when such plants are implemented is compulsory by law in Sweden.

2.2.2 Outcomes of the Validation workshop with community members

In this section, the main outcomes of the **Local Community Validation Workshop** are presented. The section is divided following the implemented workshop structure: Exercise for initial introductions and general impressions on Bioenergy; short introduction to the Bio-FlexGen project; exercise for validating indicators; exercise for measuring the indicators.

a) Participants´ profile & participants´ knowledge and interests in bioenergy and sustainability (see Appendix B).

Participants profile. A total of 7 students between the ages of 21 to 25 participated in the workshop. The participants came from diverse backgrounds: environment management, civil engineering, environmental engineering, design and product development, and chemical analytics.

Cons and Pros of Bioenergy. The participants found bioenergy a sustainable way to generate energy while also managing waste. Still, when asked to define ¨bioenergy¨ using key words, participants reflected the benefits but also the challenges of bioenergy. The words used to define bioenergy were *conflict of interest, resource effective, sustainable, organic, difficult, complex, future, heat, compost, underrated, important, environmentally friendlier, waste, circularity,* and *waste management*.

Next, the pros and cons of bioenergy were discussed in more depth. The identified advantages include its role as an effective way of managing waste, its ease of implementation, its circularity, renewability, sustainability, its support for agriculture, and its potential for job creation. On the other hand, several disadvantages were highlighted: it requires initial implementation efforts and is difficult to launch, depends on efficient waste management, still produces carbon emissions, demands infrastructure and large volumes of input, and can be costly, complex, and potentially unsustainable. In addition, it may generate conflicts of interest.

What should a sustainable project consider? Insights from community members on what a project should consider to be sustainable validate the methods applied in WP5 to evaluate the sustainability

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of the technologies developed in the Bio-FlexGen project. The participants emphasized aspects such as public acceptance and the inclusion of diverse perspectives, waste minimization through circularity, focus on the entire value chain considering system boundaries, cooperation, reduction of transport needs and impact assessment that considers long-term effects and impacts on nature. In addition, they highlighted that the project should be carried out under reasonable standards, with attention to longevity and cost-benefit factors.

What is social sustainability for you? Input from community members on how they define social sustainability helps to complement the list of social impact indicators with the communities' perspective. The participants described social sustainability as ensuring that basic needs and more are covered; providing support to those in need; fostering respect and safe living environments; and promoting happiness, equality, commitment, well-being, and social interaction. In addition, they highlighted the importance of healthy environments, including respect for others' health, awareness of mental health, and attention to both physical and mental well-being.

b) Bio-FlexGen project description (see appendix B)

This section presented the Bio-FlexGen project after participants provided their opinions on the aspects a project should consider in order to be sustainable, although no further contributions were provided at this stage.

c) Validation of indicators

To validate the indicators, participants were asked to rate the relevance of the different subcategories in which the indicators are grouped, using a scale from 1 (very low relevance) to 5 (very high relevance). After completing the voting, they were invited to engage in an open discussion about the indicators. During this exchange, participants shared additional insights, such as explanations for their choices and reflections on the role of the indicators in their community context. When asked whether any relevant subcategories or indicators were missing, participants confirmed that the proposed framework was complete, and no additional indicators were suggested.

The following presents the outcomes of the validation exercise across categories and subcategories, underscoring the aspects that participants regarded as most and least relevant.

Employment category (on average 4/5) (see Table 2)

- The subcategories selected as most relevant are "Health & safety" (5/5), "Working conditions & rights" (4.8/5) and "Job quality" (4.3/5).
- The other subcategories are still considered relevant but ranking lower "Job stability" (3.8/5), "Employment generation" (3.2/5) and "Ratio of female to male labor force" (2.7/5).

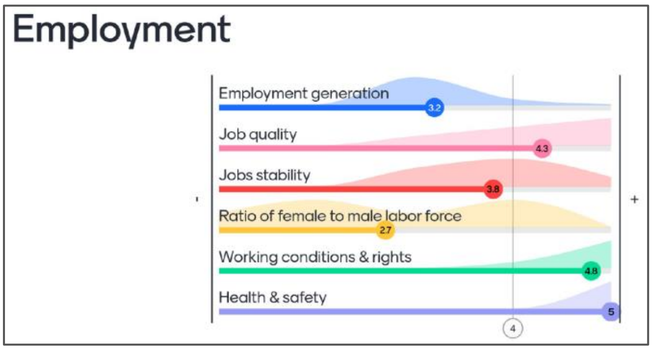

Table 2 Validation results of Employment category

Economic dimension (on average 3.8/5) (see Table 3)

- The subcategories selected as most relevant are "Dependency on fossil fuel imports" (5/5) and "Efficiency of bioenergy technology" (4.5/5).

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– The other subcategories are still considered relevant but ranking lower "Energy prices (production cost, household cost)" (3.7/5), "Local economic contribution (to local industries, taxes)" (3/5) and "Macroeconomics" (2.7/5).

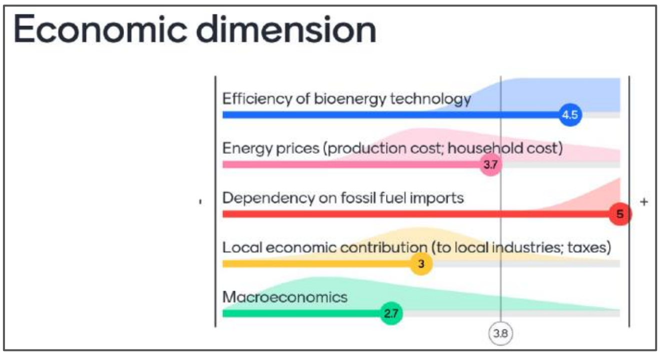

Table 3 Validation results of Economic dimension category

People and communities (on average 3.8/5) (see Table 4)

– The subcategory selected as most relevant is "Food security: edible feedstock diverted from food chain to bioenergy" (4.8/5).

– The other subcategories are still considered relevant but ranking lower "Interaction of industry with communities (invest in education)" (3.8/5), "Land conflicts" (3.8/5), "Traditional livelihoods and cultural heritage sites" (3.5/5) and "Development of energy communities" (3.3/5).

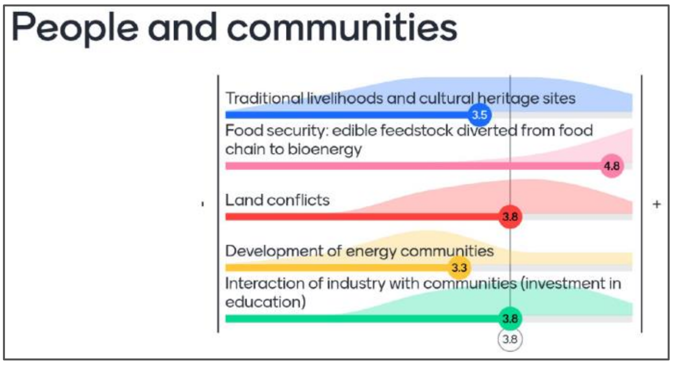

Table 4 Validation results of People and communities category

Social acceptance (on average 3.8/5) (see Table 5)

– The subcategories selected as most relevant are "Public concerns: environment, safety, culture" (4.5/5), "Trust in stakeholders (industry, municipality)" (4/5).

– The other subcategories are still considered relevant but ranking lower "Level of knowledge on bioenergy" (3.8/5) and "Participation of society" (3/5).

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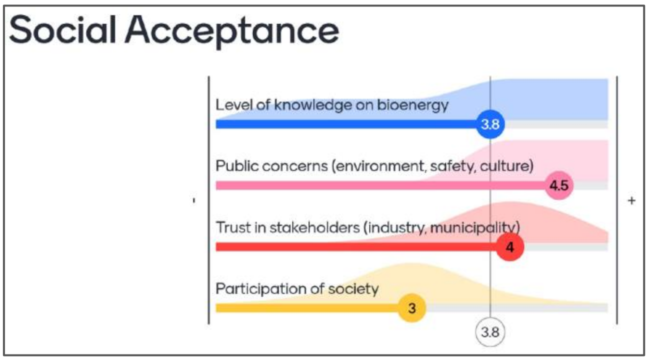

Table 5 Validation results of Social acceptance category

In summary, the validation exercise showed that all four categories—employment, economic dimension, people and communities, and social acceptance—were considered relevant by community members, with employment emerging as the most highly valued, particularly regarding health and safety, working conditions, and job quality. The remaining categories were also acknowledged as important, with emphasis placed on reducing dependence on fossil fuels, ensuring food security, and addressing public concerns and trust in stakeholders.

In conclusion, local communities regarded the current set of indicators as an adequate framework for assessing the project's sustainability, while recommending the inclusion of additional indicators to further strengthen the framework in future assessments. In particular, participants proposed adding indicators focused on health and well-being, equity and inclusion, long-term resilience, and biodiversity and ecosystem services. Regarding **health and well-being**, communities highlighted the importance of considering perceived health impacts of bioenergy deployment, such as air quality improvements or reduced stress associated with energy security. Regarding **equity and inclusion**, participants underlined the need to assess how the benefits of the project, such as employment opportunities, cost reductions, and local revenues, are distributed across different social groups, especially those in rural or vulnerable areas. Regarding **long-term resilience**, it was noted that sustainability also depends on the capacity of BTC technology to adapt to climate variability, market fluctuations, and policy shifts. Finally, regarding **biodiversity and ecosystem services**, participants suggested that the framework could include explicit measures of biodiversity, soil health, and ecosystem preservation, ensuring consistency with the broader objectives of the EU Green Deal and reinforcing the environmental credibility of bioenergy initiatives.

In summary, the validation process demonstrated strong community endorsement of the current indicators while also providing constructive feedback to refine future assessment frameworks. Integrating these additional dimensions would enhance the robustness and inclusiveness of the Bio-FlexGen social impact evaluation.

d) Direct measurement of Social Acceptance indicators by Navitas Student Association

Finally, the workshop was also used to directly measure the indicators related to Social Acceptance. This made it possible not only to assess the robustness of the methodological framework but also to gather first-hand data from community members, in this case through the active involvement of the Navitas Student Association. The outcomes of this measurement are presented in Measurement results (Section 3.4.4 Category D: Social Acceptance).

2.2.3 Dashboard of selected social impact indicators

This section presents the dashboard of the 32 validated indicators selected to be measured and the data sources. The indicators are grouped and presented in four categories: Category A - Impact on employment (Table 6), Category B – Impact on economic dimension (Table 7), Category C - People and communities (Table 8), Category D - Social acceptance (Table 9).

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Subcategory	No.	Indicator	Impact level
Job losses	A1.1	Total number of job losses	Local: TvAB, Sulquisa, CEMEX
Job creation	A2.1	Total number of jobs created	Local: TvAB, Sulquisa, CEMEX
Job quality	A3.1	% skilled/unskilled jobs	Local: TvAB, Sulquisa, CEMEX
	A3.2	% permanent/temporary	Local: TvAB, Sulquisa, CEMEX
	A3.3	Provision of worker training	Local: TvAB, Sulquisa, CEMEX

Table 6 Category A - Impact on employment

Subcategory	No.	Indicator	Impact level
Economic feasibility	B1.1	Productivity/efficiency of biomass	National (Spain, Sweden)
	B1.2	Gross value added of biomass	National (Spain, Sweden)
	B1.3	Profitability (BTC technology)	Local: TvAB, Sulquisa, CEMEX
Energy poverty	B2.1	Increase/ decrease of energy prices due to energy efficiency	National (Spain, Sweden)
	B2.2	Increase/ decrease of energy cost share in disposable households' income due to energy efficiency	National (Spain, Sweden)
Energy efficiency	B3.1	Increase/ decrease of energy efficiency (BTC technology)	Local: TvAB, Sulquisa, CEMEX
	B3.2	Increase/ decrease of energy production costs (BTC technology)	Local: TvAB, Sulquisa, CEMEX
Energy security	B4.1	Increase/ decrease of fossil fuels imports (BTC technology)	Local: TvAB, Sulquisa, CEMEX National (Spain, Sweden)
	B4.2	Energy diversity of the energy mix	National (Spain, Sweden)
Rural development	B6.1	Contribution to local industries in the local economy (BTC technology)	Local and regional: Linkoping (Sweden), Spain (Colmenar de Oreja, Madrid; Alicante; Alcanar, Tarragona)
	B6.2	Taxes/ royalties paid to the local government (BTC technology)	Local and regional: Linkoping (Sweden), Spain (Colmenar de Oreja, Madrid; Alicante; Alcanar, Tarragona)

Table 7 Category B – Impact on economic dimension

Subcategory	No.	Indicator	Impact level
Impact on traditional livelihoods and cultural heritage sites	C1.1	Limitation in access to traditional livelihoods practices (BTC technology)	Local and regional: Linkoping (Sweden), Spain (Colmenar de Oreja, Madrid; Alicante; Alcanar, Tarragona)
	C1.2	Limitation in access to areas or resources of cultural value (BTC technology)	Local and regional: Linkoping (Sweden), Spain (Colmenar de Oreja, Madrid; Alicante; Alcanar, Tarragona)

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Food security	C2.1	Edible feedstock diverted from food chain to bioenergy (BTC technology)	Local and regional: Linkoping (Sweden), Spain (Colmenar de Oreja, Madrid; Alicante; Alcanar, Tarragona)
Land use and land use change	C3.1	Total area of land for feedstock production (BTC technology)	Local and regional: Linkoping (Sweden), Spain (Colmenar de Oreja, Madrid; Alicante; Alcanar, Tarragona)
	C3.2	Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production (BTC technology)	Local and regional: Linkoping (Sweden), Spain (Colmenar de Oreja, Madrid; Alicante; Alcanar, Tarragona)
	C3.3	Area of land currently under dispute, land conflict (BTC technology)	Local and regional: Linkoping (Sweden), Spain (Colmenar de Oreja, Madrid; Alicante; Alcanar, Tarragona)

Table 8 Category C – People and communities

Subcategory	**No.**	**Indicator**	**Impact level**
Level of knowledge	D1.1	Level of knowledge on bioenergy	Local: Linkoping (Sweden)
Public concerns	D2.1	Environmental concerns	Local: Linkoping (Sweden)
	D2.2	Safety and social concerns	Local: Linkoping (Sweden)
	D2.3	Impact on traditional livelihoods and cultural concerns	Local: Linkoping (Sweden)
Local/Global advocacy for development of bioenergy industry	D3.1	Global support	Local: Linkoping (Sweden)
	D3.2	Local support and relevance of proximity	Local: Linkoping (Sweden)
Trust and credibility in stakeholders	D4.1	Trust in industry	Local: Linkoping (Sweden)
	D4.2	Trust in municipality	Local: Linkoping (Sweden)
Participation of society	D5.1	Desired information	Local: Linkoping (Sweden)
Attitudes towards funding	D6.1	Desired level of involvement of funding actors	Local: Linkoping (Sweden)

Table 9 Category D – Social acceptance

From the original list of 66 indicators, several were excluded as they could not be appropriately measured in the context of Bio-FlexGen. The main reasons for exclusion are: (i) the project is not being implemented at full industrial scale, which prevents the evaluation of indicators requiring real-world deployment data (e.g., employment of vulnerable groups, household-level affordability); and (ii) data limitations, as some indicators would require external datasets not available at the required level of detail (e.g., long-term distributional effects, detailed macroeconomic impacts). The final set of 32 social impact indicators therefore includes only those that can be robustly measured within the scope of the project and are most relevant to its sustainability assessment.

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3 Social impact indicators - Measurement

The social impact indicators are measured for the different use cases of the Bio-FleGen project: two residential use cases in Sweden and three industrial use cases in Spain. Different methods and data sources are applied to collect both quantitative and qualitative data. This chapter presents a description of the use cases, the measurement methodology, as well as the limitations and mitigation strategies applied.

3.1 Description of Bio-FlexGen use cases

The Bio-FlexGen project aims to develop and validate a flexible and highly efficient renewable energy Combined Heat and Power (CHP) technology in two theoretical scenarios, a residential District Heating (DH) scenario in Sweden and an industrial scenario in Spain. To test the technology, Swedish and Spanish use cases have been modelled with and without BTC (Biomass-fired Top Cycle) CHP technology for a reference year of 2021.

3.1.1 Use cases in Sweden

The Swedish cases explore the application of BTC CHP technology in the DH sector. TvAB, which is responsible for heat supply within the DH grid in Linköping and nearby areas, produces this heat directly from CHP units. In this context, a FLEX CHP plant using forest residue chips was studied. The Swedish use cases therefore focus on investigating whether efficient cogeneration with BTC technology can enable optimal participation in energy markets and generate additional profit. These studies provide valuable insights into the feasibility and economics of applying BTC technology in the DH sector, helping to identify the main benefits and barriers to its commercial deployment.

- **SE-TvAB-01**: analyses whether TvAB power system will benefit from the utilization of BTC technology to meet the heat demand and to generate electricity during high price hours and increase profit.
- **SE-TvAB-02:** investigates the potential of BTC technology to provide balancing power, while being introduced in the Linköping power system.

3.1.2 Use cases in Spain

The business use cases in Spain evaluate the potential of CHP BTC in comparison with existing CHPs and with other energy carriers. The Spanish use cases include applications of the BTC technology in two different industrial applications: CEMEX (cement industry) and Sulquisa (mining and chemical industry).

- ES-Sulquisa-01: Production of Sodium Sulphate
- ES-CEMEX-01: Efficient electricity use and distributed generation
- ES-CEMEX-02: Drying fuels and raw material
- ES-CEMEX-03: Flexible hydrogen used for cogeneration

All four use cases across two different energy-intensive industries provide valuable insights about the feasibility and economics of BTC technology in the industrial sector and identify the main benefits and barriers for the commercial exploration of the technology.

ES-Sulquisa-01: Production of Sodium Sulphate

The use case for Sulquisa, a leading producer of Sodium Sulphate, focuses on generating heat and electricity for the constant operation of a sodium sulfate production plant. The production process is intensive in both thermal and electrical energy, and currently is supplied through three cogeneration

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lines, formed by a gas turbine and a recovery boiler. This use case analyses how BTC technology could replace existing natural gas-fired CHP installations to meet the required steam and electricity demand. The objective is thus to study the possibility of replacing the 3 CHP units running on natural gas with the new BTC technology combined with a high-temperature heat pump.

CEMEX USE CASES

Cement production is an energy-intensive industrial process that provides a relevant example for exploring the integration of CHP technologies, particularly in auxiliary operations such as fuel and raw material drying. The three use cases explored with cement maker CEMEX aim to contrast various operational modes for BTC CHP technology for two different plant designs. The three applications for CEMEX are: onsite generation and flexibility provision, drying of fuels and raw materials and finally exploring the flexible use of hydrogen. Two cement plants are considered: Alicante and Alcanar which have different biomass availability potentials. By studying the use of the technology to meet electricity demand, heat, and as a potential source of renewable hydrogen, the three use cases allow for a holistic review of BTC adoption in the cement industry.

ES-CEMEX-01: Efficient electricity use and distributed generation (Alicante & Alcanar plants)

The first use case analyses options for increasing self-generated renewable electrical energy without any heat demand (all waste heat is cooled by cooling tower) The sub-objectives are:

- Reduce the dependency on electricity markets, price dynamics, and the network by increasing the self-generated amount of renewable energy used in the plant.
- Reduce the carbon footprint of cement production by decarbonizing electricity use.
- Reduce the carbon footprint of cement production by reducing fossil fuel use.

ES-CEMEX-02: Drying fuels and raw material (Alcanar plant)

The second use case analyses how the heat generated by the BTC CHP installation can be used to meet the drying needs of two different fuel lines within the Alcanar cement plant: a new line for alternative fuels (AF) and an existing line for petcoke. In addition to power generation, the BTC system provides heat that is used in both processes. The AF line operates with a belt dryer supplied with hot water from the flue gas condenser, while the petcoke line requires direct heating with higher-temperature flue gases, which takes place after the ECO section of the BTC heat recovery steam generator.

ES-CEMEX-03: flexible hydrogen used for fuel (Alicante & Alcantar plants)

This use case investigates the potential role of green hydrogen in cement production. Initially, the concept considered a BTC HYFLEX plant producing hydrogen from biomass. However, it was finally decided not to use the HYFLEX approach. Instead, hydrogen is imported from external electrolysers and applied only during start-up sequences of the FLEX plant, while biomass remains the main fuel during normal operation. The purpose of using hydrogen in start-up is to shorten the duration of these processes and improve operational efficiency. The scope is therefore limited and very similar to the other use cases.

3.2 Approach for measurement of the indicators

This subsection presents the approach applied for the measurement of the indicators, combining quantitative and qualitative methods. The baseline scenario is defined as the current situation in both Sweden and Spain, while the Bio-FlexGen scenario considers the inclusion of novel BTC CHP technology in the DH system in Sweden and the integration of BTC in industrial applications in Spain. In Sweden, the simulations are carried out for a baseline case that models TvAB's current portfolio, while the updated model replaces one boiler of KV1 with two BTC units. The use of two BTC units ensures that the resulting thermal capacity remains comparable between the benchmark and updated models. In Spain, the benchmark case reflects the current technology and fuel mix in each plant, whereas the

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updated model scenario considers the replacement of this technology with a BTC unit supporting either boiler or heat pump systems, depending on the specific use case.

Quantitative indicators

Quantitative data is required for the first three categories of indicators: employment, economic dimension, and people and communities. The data sources have been selected in collaboration with pilot coordinators and other consortium partners when conducting the validation exercise, where it was specified which of the required data could be extracted from company records and indicated other potential data sources.

With regard to the quantitative indicators, a considerable share was derived from the analyses carried out by Comillas within WP4 *"Integration and adaptability of Bio-FlexGen to the energy system"*. In particular, the deliverables of the first three tasks of WP4 provided essential calculations that serve as a foundation for the present work.

- *Task 4.1 Business models' analysis for the different business use cases (Leader: RISE).* In this task two types of models are developed: (1) operational/scheduling models to calculate estimated revenues to be made from participating in the potential markets as well as operational costs, and (2) investment models to calculate financial indicators corresponding to the investment cases. In this context, parameters related to productivity, profitability of BTC technology, energy efficiency, production costs, fossil fuel imports, and contribution to local development have been employed to evaluate the economic feasibility and local development indicators.
- *Task 4.2. Cost-benefit analysis (CBA) for system integration of the BTC (Leader: Comillas).* This task aims to perform the CBA of the BTC process from the system point of view involving how cost-effective the performance of the technology can be under future scenarios for different EU markets. In this context, parameters related to energy prices have been used to evaluate the potential economic performance of BTC technology.
- *Task 4.3. Scalability and replicability analysis of the proposed solutions (Leader: Comillas).* The objective of this task is to understand the effects of implementing similar solutions on a larger scale or under different contexts that may be found across Europe. In this context, parameters related to biomass consumption have been used to evaluate the contribution of the BTC technology to local economy.

Qualitative indicators

Qualitative indicators were used for the fourth category of indicators: social acceptance. These were assessed through an online survey (Appendix C) distributed to the Linköping community via the Linköping University mailing list and the Linköping municipality newsletter (Figure 1), with the support of the pilot partner TvAB.

The survey contained three profile-related questions (age, gender, profession/study programme) and 14 Likert-scale questions on knowledge, awareness, and interest in the bioenergy industry, aiming to capture the community perspective on these topics. The survey was created using Microsoft Forms (Microsoft, 2024) and translated into Swedish, with an informed consent form covering data privacy and participants' rights attached prior to completion.


Nyhetsbrev juni 2024

Klimatsmart

Linköping

Tips och aktuellt kopplat till kommunens klimatarbete

Berätta vad du tycker om biobränslebranschen

Bio-FlexGen

För att nå dagens klimatmål behöver energisektorn ställa om till mer hållbara produktionsmetoder. Tekniska verken är med i EU-projektet Bio-FlexGen som syftar till att utveckla en ny och mer effektiv kraftvärmeprocess.

Som en del i projektet utförs just nu en social studie med inriktning på linköpingsbornas uppfattning om biobränslebranschen. Om du har en stund över - besvara enkäten och bidra till utvecklingen av framtidens hållbara energisystem.

Till enkäten

Figure 1: Linköping Municipality Newsletter

3.3 Limitations and mitigation strategies

There have been some limitations in the measurement of the social impact indicators, for which mitigation strategies have been defined. First, the lack of

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universally recognized standards for social impact assessment must be acknowledged. To address this, an extensive literature review (Deliverable 5.4) was conducted to identify representative social indicators.

Next, methodological challenges arise from the fact that the indicators are assessed under hypothetical scenarios. Since the project is at a low TRL, the actual impacts of technology implementation cannot be measured and must instead be estimated. To address this limitation, from the initial set of 66 preselected indicators, only those measurable under hypothetical scenarios were retained. The final selection was carried out in collaboration with pilot coordinators, who contributed their expertise and knowledge regarding the feasibility of collecting specific data.

Regarding the collection of qualitative data, the social acceptance survey was distributed through various channels, including the mailing list of Linköping University and the newsletter of the Linköping municipality, in order to reach a broad and diverse segment of the local community. Despite these distribution efforts aimed at increasing participation, the number of responses did not reach the expected level.

Further limitations arise from the diversity of the indicators. While some indicators require data to be collected at the national or regional level (e.g. macroeconomic indicators), others depend on information specific to the pilot companies (e.g. Occupational Safety and Health) or to the project itself (e.g. biomass availability, technology efficiency). This heterogeneity complicates the establishment of a consistent baseline across all pilots. To address this challenge, different data collection methods have been applied, such as national statistics, company records, and survey data.

Another limitation is the difficulty of making direct comparisons, as the available data corresponds to different years. This temporal inconsistency may affect the coherence of the datasets and reduce the precision of the indicators and should therefore be considered when interpreting the results.

Main limitations	**Mitigation strategies**
Lack of universally recognized **social impact assessment standards.**	Extended literature review to get representative social indicators.
Methodological challenges in the measurement (hypothetical scenario, no real implementation) – Estimations because lack of real data – Challenges in collecting data through the survey.	We have selected indicators that can be measured. – Data collection in collaboration with pilot coordinators. – Working with pilots in the identification of main communities & distribution of the survey through different channels (municipality newsletter; university students´ emailing list).
Indicators provide data at **different scales** National (macroeconomics), regional Company level (occupational safety & health) Project level (biomass, technology efficiency)	Different data sources: national statistics, company records, surveys

Table 10 Main limitations and mitigation strategies

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4 Social impact indicators- Measurement results

This section presents the results for the calculation of the indicators across the four different impact categories: A) Impact on employment, B) Impact on economic dimension, C) People and communities, D) Social acceptance.

4.1 CATEGORY A: IMPACT ON EMPLOYMENT

Impact on employment examines the effects of deploying the BTC technology on the workforce in the different pilot companies. The indicators assess both potential risks and opportunities, including job losses, job creation, and the quality of the employment generated. In doing so, this category provides insights into how BTC technology may influence employment stability, skills development, and the overall contribution to local and regional labor markets.

4.1.1 Subcategory A1: Job losses and A2: job creation

This subcategory assesses the impact of BTC technology on employment levels in the pilot companies, considering both potential job losses and new job opportunities. The indicators measure whether the replacement of existing CHP units with BTC plants leads to job losses or to the creation of new positions in operation, maintenance, construction, and biomass supply. In the case of Bio-FlexGen, existing jobs are largely maintained through reskilling, while additional permanent and temporary positions are created, contributing positively to local employment and regional development.

A1.1 Total number of job losses and A2.1 Total number of annual direct jobs created

A1.1 provides information about the number of job losses resulting from replacing the current CHP units or existing power plants with the new CHP BTC unit in the different use cases, specifically in the cases where a current CHP unit is operating. On the other hand, A2.1 measures the total number of direct jobs created for the construction and installation, operation and maintenance, manufacturing, and biomass supply jobs related to the deployment of the CHP BTC unit. The operation and maintenance jobs are calculated by Phoenix along with TvAB, CEMEX, and Sulquisa in the specific use cases. Construction and installation, manufacturing, and biomass supply jobs calculations are extracted from the Institute for Sustainable Futures' (ISF) report *Calculating global energy sector jobs* which presents job creation projections for the global power sector by 2050.

RESULTS

Regarding A1.1, in both countries, Sweden and Spain, current CHP's operation employees would be able to switch from operating the current CHP unit to the BTC CHP unit by acquiring specific technical training (see indicator A3.3).

In Sweden, where the BTC unit replaces an existing CHP unit, the current 15 operation jobs would be maintained for operating the new BTC unit. In this case, where the BTC plant only will run part-time and it will substitute other boilers that will not operate simultaneously, there will be no extra staff needed in the fuel yard, and only 5 dedicated field operators. Additionally, 1.5 Engineers will be hired, summing up to 6.5 new positions created.

In the Spanish Sulquisa case, where three existing natural gas-fired CHP units will be replaced by the BTC technology combined with a large high-temperature heat pump, the existing 25 operating jobs will be maintained and will be sufficient to operate the new plant so no jobs will be destroyed, and no extra staff is foreseen. In the case of CEMEX, where there are not CHP units running in Alicante or Alcanar plants, there will be necessary 5 new operators in each plant (1 operator per each of the 5 shifts), 0.5 Engineers (1 Engineer share with other units) and 1.5 responsible for feeding each of the plants, summing up to 7 new positions in each plant.

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	BASELINE	BIO-FLEXGEN (operation and maintenance)	IMPACT RESULT
TvAB	15	15 + 6.5	**+6.5**
Sulquisa	25	25	**-**
CEMEX-Alcanar	-	7	**+7**
CEMEX-Alicante	-	7	**+7**

Table 11 A1 Job losses and A2 Job creation (direct jobs: operation and maintenance)

Furthermore, for construction and installation of the BTC plant in the three use cases, ISF estimates that a total number of 14 full-time jobs will be necessary for each power plant. It is assumed that a local workforce will undertake the installation and construction works, and these predominantly take place in the beginning phase of the power plant and last during the period in which the power plant is built until the first operation.

	BASELINE	BIO-FLEXGEN (construction)	IMPACT RESULT
TvAB	-	14	**+14**
Sulquisa	-	14	**+14**
CEMEX-Alcanar	-	14	**+14**
CEMEX-Alicante	-	14	**+14**

Table 12 A1 Job losses and A2 Job creation (other direct jobs: construction)

On the other hand, regarding indirect jobs created, ISF estimates that 2.9 full-time jobs will be necessary to manufacture a unit of power generation capacity. However, the manufacturing of equipment and components for power plants may occur outside the country where the power generation capacity is being installed. Additionally, if we consider the biomass supply chain jobs, we can sum up to 29.9 additional indirect jobs. These include all the jobs associated with crop production, construction, operation and maintenance of conversion plants, transportation of biomass, as well as jobs generated within the economy such as supporting industries, services and similar (ISF, 2015). These supply chain jobs will be created at national level (Sweden and Spain) in the regions where the biomass feedstocks are located.

	Manufacturing (job years/MW)	Biomass supply (jobs/PJ)	Total
TvAB	2.9	29.9	**+32.8**
Sulquisa	2.9	29.9	**+32.8**
CEMEX-Alcanar	2.9	29.9	**+32.8**
CEMEX-Alicante	2.9	29.9	**+32.8**

Table 13 Indirect jobs created within Bio-FlexGen project

Therefore, the integration of BTC technology would generate a positive impact on local employment since on one hand, the current jobs involved in the operation of the energy/heat systems in the pilot companies would be maintained and upskilled with technical training about the latest developments in bioenergy. Moreover, BTC technology would require the creation of additional direct jobs in TvAB and CEMEX. In addition, the construction and installation of the BTC plant requires hiring additional workers and it is assumed that a local workforce will undertake these works. However, these jobs would have less impact or effect on local employment since they would have the duration of the construction phase.

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On the other hand, the deployment of the BTC plant will create indirect jobs necessary to manufacture the equipment and components of the BTC plant. These jobs, however, would have less impact at the local level since the manufacturing of equipment and components for power plants may occur outside the country where the power generation capacity is being installed. Lastly, considering the biomass supply chain, Bio-FlexGen project will create additional 119.6 indirect jobs mainly in the regions where the biomass feedstock is located in Sweden and Spain.

Moreover, bioenergy is a decentralised energy option whose implementation presents positive impacts on rural development by creating business and employment opportunities (EUBIA). At EU level, data from the latest AVEBIOM report indicate that biomass is the renewable energy source that generates the most employment per unit of energy produced. In addition to creating more jobs than any other type of renewable energy, it does so within the EU since the entire process of biomass collection and its transformation to the final fuel is done without the need to import jobs or materials. As can be seen in the following table, biomass generates twice as many jobs as gas-based energy and is notably more efficient, in terms of job creation, than nuclear energy.

ENERGY SOURCE	JOBS/GWH
Biomass	0.22
Coal	0.18
Gas	0.12
Nuclear	0.0009

Table 14 Jobs per energy unit produced (AVEBIOM)

In Spain, the logistics associated with the supply of the facilities is one of the greatest assets that the biomass sector has. As mentioned before, biomass is the energy that generates and maintains the greatest number of jobs per MW installed, especially jobs linked to the supply of biomass fuels to the facilities. This ability to generate and maintain jobs is of great value in territories that are considered part of the emptied Spain, since investment in a biomass plant manages to socioeconomically energize and structure the territory, creating stable and long-term opportunities for the population. These opportunities are linked to the energy transition and the circular bioeconomy, both strategic policies for Spain and Europe (FEDEA), and closely linked to the Spanish Just Transition Strategy (2019) which aims to guarantee employment, justice and social and territorial cohesion, especially in the territories affected by the dismantling of nuclear and coal plants. Within this context, mining basins and other regions where conventional power plants are being dismantled will be able to benefit from new investments in the biomass sector because many of these regions are forested.

In Sweden, bioenergy plays a central role in the country's energy mix and rural economy. The sector contributes to local development by supporting forest management, promoting the use of by-products from the forestry and pulp industries, and creating stable employment opportunities in rural areas (Bioenergy International, 2025). Moreover, the well-established district heating networks in Sweden rely heavily on biomass, particularly forest residues, demonstrating the country's capacity to integrate bioenergy into efficient and sustainable energy systems. This approach not only supports national climate objectives but also strengthens Sweden's position as a benchmark for sustainable bioenergy deployment in Europe.

CONCLUSIONS

The integration of BTC technology in Sweden and Spain is expected to have a positive impact on employment. Current jobs in existing CHP plants will be maintained and upskilled through specific training, while new direct jobs will be created in the pilot companies. Additional temporary employment will be created during construction and installation phases, mostly covered by local workforce. Beyond direct employment, BTC deployment will also generate indirect jobs linked to equipment manufacturing (though often outside pilot countries) and especially through the biomass supply chain in the case of Spain, which will create over 100 additional jobs at national level. Overall,

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the Bio-FlexGen project contributes to local and regional job creation, rural development, and the EU's just transition objectives by fostering stable, long-term opportunities in the bioenergy sector.

Sources: Phoenix, Sulquisa, CEMEX, Institute for Sustainable Futures (ISF), European Biomass Industry Association (EUBIA), AVEBIOM (Spanish Biomass Association), FEDEA, Bioenergy International

4.1.2 Subcategory A3: Job quality

This subcategory evaluates the quality of employment generated by the deployment of BTC technology, considering aspects such as skill requirements, permanence of jobs, and opportunities for training. The indicators examine the balance between skilled and unskilled positions, the share of permanent versus temporary contracts, and the extent of training provided to workers. In the case of Bio-FlexGen, the majority of new positions are medium- to high-skilled, permanent roles, complemented by specific training on BTC technology and company-level programs, thereby contributing to workforce upskilling and long-term employability.

A3.1 Skilled/unskilled jobs

A3.1 provides the percentage of skilled and unskilled jobs out of the new jobs created (A2) when constructing/replacing the current CHP plants with the new CHP BTC unit in the different use cases. The categorization of high/medium/low skilled jobs is presented below (ILO, IRENA):

- High skilled: Professional/managerial
- Medium skilled: Technician/skilled crafts/supervisory
- Low skilled: Semi-skilled and unskilled

RESULTS

In Sweden, out of the 6.5 new direct jobs created within TvAB, only 1.5 are skilled (engineer, 23.1%) and 5 are medium skilled (operators, 76.9%) considering that the main skills required for operators are technician and skilled craft level skills in operating and maintaining the equipment (ILO, 2011). Similarly, in Spain, out of the 7 jobs created in each plant within CEMEX, only 0.5 jobs are high skilled (engineer, (7.1%) and 6.5 are medium skilled (operators, 92.9%) in each of the plants.

OPERATION AND MAINTENANCE	Direct jobs created	High skilled	Medium skilled	Low skilled
TvAB	6.5	**1.5 (23.1%)**	**5 (76.9%)**	0
Sulquisa	-	-	-	-
CEMEX-Alcanar	7	**0.5 (7.1%)**	**6.5 (92.9%)**	0
CEMEX-Alicante	7	**0.5 (7.1%)**	**6.5 (92.9%)**	0

Table 15 A3.1 Skilled/unskilled jobs (operation and maintenance)

Additionally, the 14 jobs required for the construction and installation of the BTC plants in each pilot site cover a range of skills in construction, at professional, skilled construction trades and general construction worker levels (ILO, 2011). According to ILO (2011), IRENA (2017) and ANUIES (2019) the following occupations and their skill level can be found in the construction and installation stage of a bioenergy plant:

Construction and installation		Skills Level		
Occupation	**Education Fields**	**High**	**Medium**	**Low**
Construction workers and technical personnel	Technicians		x	x
Civil engineers and foremen	Engineering	x	x	
Health and safety experts	Health and Safety	x		

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Electrical and mechanical engineers	Engineering	x		
Environmental Experts	Engineering & Natural Sciences	x		
Quality-control Experts	Engineering & Logistics and Quality Assurance	x		

Table 16 Skill level in the construction and installation phase (Sources: ILO, IRENA, ANUIES)

Lastly, regarding the indirect jobs created within the biomass supply chain, it is assumed that the jobs in feedstock processing (i.e. manual agricultural labour) and transport are medium and low skilled, while those associated with the processing phase are high skilled (FAO, 2014).

CONCLUSIONS

In conclusion, the integration of BTC technology will have a positive impact on employment by generating mainly medium-skilled jobs required for the operation of the pilot plants. Additionally, construction and installation activities will create 14 new local jobs per plant, offering opportunities for workers with medium and low skill levels, which are easier to source locally. The biomass supply chain will also generate further employment across different skill levels, though these jobs will mostly arise in the regions where the biomass is extracted rather than directly at the plant sites.

Sources: TvAB, Sulquisa, CEMEX, FAO, ILO, IRENA, ANUIES

A3.2 Permanent/temporary jobs

A3.2 provides the percentage of permanent and temporary jobs out of the new jobs created (A2) when constructing/replacing the current CHP plants with the new CHP BTC unit in the different use cases.

RESULTS

As previously described, the jobs created within the pilot companies will be permanent (engineers and operators) over the technical operational lifetime of the plants whereas the construction and installation jobs will take place in the beginning phase of the power plant and last until the first operation.

	Direct jobs created (operation and maintenance)	Permanent	Temporary
TvAB	6.5	**6.5 (100%)**	0
Sulquisa	0	**0**	0
CEMEX-Alcanar	7	**7 (100%)**	0
CEMEX-Alicante	7	**7 (100%)**	0

Table 17 A3.2 Permanent/temporary jobs (operation and maintenance)

	Other direct jobs created (construction)	Permanent	Temporary
TvAB	14	0	14 (100%)
Sulquisa	14	0	14 (100%)
CEMEX-Alcanar	14	0	14 (100%)
CEMEX-Alicante	14	0	14 (100%)

Table 18 A3.2 Permanent/temporary jobs (construction)

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CONCLUSIONS

The integration of BTC technology in the different use cases will have a positive impact within the pilot companies in terms of jobs quality since all the jobs created will be permanent. At local level, the local employment will also benefit from temporary construction jobs typically assumed by a local workforce.

Sources: TvAB, Sulquisa, CEMEX

A3.3 Provision of worker training

Indicator A3.3 measures the average hours of training per year per employee, with a specific focus on training related to BTC technology.

RESULTS

All pilot cases will require BTC training provided by Phoenix for approximately one and a half months, combining theoretical and practical training in each BTC plant. Assuming that a working day is 8 hours, the training will sum up to **264 hours approximately**. In Sweden, this training will be provided to the new 6.5 jobs created for the operation of the BTC plant and to the current staff operating the plant. In Spain, for the Sulquisa use case, the technical training will be also provided to the current 25 operation employees as well as to the 10 maintenance employees and the 10 staff employees (technical office, risk evaluation manager, environment manager, engineering, management, and laboratory). In the case of CEMEX, the BTC training provided by Phoenix will be offered to the new 14 employees of both plants (Alicante and Alcanar) as well as to the current departments: Maintenance (10 employees), Production (1 manager, 2 shift managers, 5 workers), Sustainability (1 manager), Quality (1 manager and 5 workers), Sales (1 biomass responsible), and Laboratory testing (1 employee).

Furthermore, all new employees will also receive the required technical training in the integration of the new BTC plant with the current installations as well as each company's own general training (onboarding) for new employees and training in specific topics such as health and safety, etc.

	Number of employees receiving BTC training	**Number of hours of training** (hrs)
TvAB	15+6.5	**264**
Sulquisa	25+10	
CEMEX-Alcanar	7+27	
CEMEX-Alicante	7+27	

Table 19 A3.3 Provision of worker training

CONCLUSIONS

In summary, the integration of BTC technology in the different use cases will have a positive impact in terms of upskilling the pilot companies' workforce, by not only providing technical training about the latest developments in bioenergy to the new BTC plant employees but also by upskilling the current employees from diverse areas within the pilot companies. Bio-FlexGen project contributes then to making companies move towards skill enhancement, worker progression, and ultimately to productivity increase.

Sources: TvAB, Sulquisa, CEMEX, Phoenix

4.2 CATEGORY B: IMPACT ON ECONOMIC DIMENSION

The Economic category addresses the economic sustainability aspects of the Bio-FlexGen project across the different use cases. It considers how the technology performs in terms of cost efficiency, competitiveness, and its broader economic implications. The subcategories analyzed under this pillar are: B1 – Economic feasibility of biomass use, B2 – Energy poverty factors, B3 – Energy efficiency

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results, B4 – Energy security, and B6 – Local development. Together, these indicators provide a comprehensive view of the economic impact of deploying Bio-FlexGen technology at local, national, and European levels.

4.2.1 Subcategory B1: Economic Feasibility

This subcategory evaluates the economic sustainability of the Bio-FlexGen technology by assessing the performance of different fuel sources, their costs, profitability, and contribution to the economy. The indicators examine aspects such as the productivity and efficiency of fuels, their net energy balance, gross value added, and overall profitability at company level. In the case of Bio-FlexGen, the substitution of fossil fuels with agricultural and forestry residues is expected to improve cost efficiency, reduce fuel price volatility, and support long-term economic competitiveness, particularly in Spain where dependence on imported fossil fuels is significant.

B1.1 Productivity/efficiency of fuel sources

B1.1 measures the increase/decrease of productivity of the main fuel source at national level in terms of resource availability to inform about the economic sustainability of each fuel industry. We measure this indicator by measuring the following: a) annual national production of main fuel source, and b) main fuel cost. Fuel costs are retrieved from deliverable D4.1.

RESULTS

In TvAB, where the main fuel currently used is biomass (recycled wood), this indicator does not apply. Regarding the main fuel sources used in the different use cases in Spain, we have considered natural gas as the main fuel source in the case of Sulquisa, and fuel oil for the applicable CEMEX use cases.

Concerning the annual production of natural gas, Spain produced in the year 2022 only 529 GWh out of the 363,287 GWh of natural gas consumed in the country (0.15%)[2]. Therefore, Spain imported 446,251 GWh of natural gas mainly from countries such as Argelia and Nigeria, as well as from Qatar and Norway. As for fuel oil, Spain only produced 1,000 tons of oil in 2022, covering only the consumption demand by 0.002%[3]. The main oil exporting countries to Spain are India, France, Italy, Poland, and Lithuania.

In terms of solid biomass, the primary energy production and gross inland consumption in Spain amounted to 5.3 million metric tons of oil equivalent in 2022 where consumption was equal to production throughout the period under consideration[4].

FUEL TYPE	PRODUCTION (GWh)	CONSUMPTION (GWh)	IMPORTS (GWh)	IMPACT RESULT (%)
Natural gas	529	363,287	446,251	**0.15%**
Fuel oil (oil)	11,630	664,994	716,800	**0.002%**
Biomass	28,938	28,938	-	**100%**

Table 20 Annual national production of main fuel source in Spain, 2022

However, according to the Engineering Institute of Spain, there was an availability of more than 17.5 million tons of biomass dry matter (73% tons of agricultural residues) in 2022.

Species/Crop	Type	Potential (t dm/year)*	Availability (t dm/year)*
Coniferous forest	residues	3,031,382	1,438,717
Broad-leaved forest	residues	3,601,615	1,594,704

[2] https://www.cores.es/sites/default/files/archivos/estadisticas/est-gas-balance-2022.pdf
[3] https://www.cores.es/sites/default/files/archivos/estadisticas/est-petroliferos-balance-2022.pdf
[4] Statista 2022

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Mixed forest	residues	893,080	549,137
Scrub species	treatment	2,080,482	937,845
Wooded grassland	environmental	941,701	252,248
Total foresty		**10,548,261**	**4,772,650** (27%)
Dry cereals	straw	16,944,193	5,420,661
Irrigated cereals	straw	4,682,592	3,746,230
Rice	straw	394,983	316,204
Olive crops	pruning	1,819,981	1,455,168
Fruit trees	pruning	1,411,563	1,129,094
Vineyards	pruning	843,949	675,000
Crop mixture	pruning	123,225	99,416
Total agriculture		**26,220,486**	**12,841,774** (73%)
TOTAL BIOMASS		**36,768,747**	**17,614,424**

Table 21 Potential and availability of biomass in Spain (Engineering Institute of Spain, 2022)

*Tons of dry matter/year

Regarding the fuel cost, the economic impact of changing the main fuel from fossil natural gas to biomass in the Sulquisa use case will be highly positive since the BTC technology allows the cost of fuel to be reduced by more than 50%. In the first CEMEX use case where the electric energy consumed in both plants is imported from the electricity grid, this indicator does not apply. In the second use case, the cost of fuel consumption associated with burning fuel oil for drying purposes is considered. Since fuel oil costs were asked to remain confidential, we obtained the data from the Engineering Institute of Spain. In this case, the use of biomass will allow to reduce the cost of the main fuel by almost 70%. It is important to note that both natural gas and biomass prices fluctuate over time due to market conditions and policy factors, so the specific percentage reduction presented here corresponds to the 2022 reference year and may vary in future scenarios. Furthermore, industries using fossil fuels such as natural gas are subject to the European Union Emissions Trading System (EU ETS), which requires them to purchase allowances for every tonne of CO_2 emitted. By replacing a fossil fuel with a renewable one, companies not only reduce their fuel costs but also avoid these additional emission-related expenses, which are expected to increase progressively over the coming years.

In the third CEMEX use case which also considers hydrogen during the start-up sequences, the baseline cost of fuel is considered while the costs of biomass and hydrogen are considered for the BTC scenario. As in the second use case, fuel oil costs are obtained from the Engineering Institute of Spain. In this case, when only biomass works as the main fuel, we obtained the same result than in the second use case, this is a reduction of the main fuel cost by almost 70%. However, when we consider hydrogen for the start-up sequences, the price of this fuel results in 33% and 13% higher than that of the fuel oil in each plant, respectively.

B1.1 PRODUCTIVITY/EFFICIENCY OF FUEL SOURCE (main fuel cost)	**BASELINE** (€/MWh)	**BIO-FLEXGEN** (€/MWh)	**IMPACT RESULT** (%)
SWEDEN			
TvAB	30.17 (350 SEK/MWh)	30.17 (350 SEK/MWh)	-
SPAIN			
ES-Sulquisa-01	47.92	23.19	**-51.61%**
ES-CEMEX-01			
Alcanar	-	-	-
Alicante	-	-	-
ES-CEMEX-02 *Alcanar*	76.8	23.19	**-69.8%**

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ES-CEMEX-03		23.19	**-69.8%**
Alcanar	76.8	102.9* (3.43 €/kgH2)	**+33.9%**
Alicante	76.8	87* (2.90 €/kgH2)	**+13.3%**

**hydrogen cost was converted into €/MWh based on the Lower Heating Value of H2 which is 33.33 kWh/kg*

Table 22 B1.1 Productivity/efficiency of fuel source (main fuel cost, 2022)

Furthermore, in addition to the lower cost per kWh of biomass—especially for residual agricultural and forest biomass—another competitive advantage of this fuel over fossil alternatives is its relative price stability. Although biomass prices fluctuate depending on feedstock type, season, and logistics, their variations are generally lower than those of fossil fuels, as reflected in the *AVEBIOM Consumer Biomass Price Index* (AVEBIOM, 2024). In addition, as a cleaner and more sustainable energy, numerous financial incentives for businesses and households are available to promote its use.

In terms of production of fossil fuels, Spain has historically been characterized by its scarcity of fossil fuels. This has translated into great external dependence. According to the latest data from Eurostat, the degree of foreign energy dependence in Spain reached 69.1% in 2021. This means that the country imported around two-thirds of the primary energy consumed, so self-sufficiency reached only 31% (Statista, 2024).

By contrast, Spain is the third European country in terms of absolute forest biomass resources (only behind Sweden and Finland) and the seventh in per capita terms. In 2021 Spain had a forest area of 27,664,674 hectares (57% of the total) and was the country in Europe with the greatest increase in forests, with an annual growth rate of 2.2%, much higher than the EU average (0.51%) (M. de Gregorio, 2020).

On the other hand, Spain leads positions in other biomass resources. Despite the latest extreme weather conditions, Spain continues to be the world's leading producer and exporter of olive oil with an annual production of 1.4 million tons of olive oil in 2021 and an area dedicated to olive groves that is around 2.5 million hectares. Spanish olive oil production represents 60% of the EU's production and 45% of the worlds. Furthermore, Spain is the country in Europe with the highest production of pigs. It is estimated that it generates about 50 million tons of slurry per year (M. de Gregorio, 2020).

However, Spain is at the bottom of the European ranking for the use of forestry and agricultural resources in the generation of electrical, thermal, biogas/biomethane energy and valorisation of the organic fraction of municipal waste (M. de Gregorio, 2020). The main causes of the low valorisation of the biomass in Spain can be found in the unequal geographic availability of biomass (the regions with the highest production rate are Castilla y León, Castilla-La Mancha and Extremadura), the climatic conditions in each region, unequal distribution of manufacturers and installers of biomass equipment throughout the territory, and the unequal availability of public incentives in region (M. de Gregorio, 2020).

Lastly, it is important to highlight that only 4% of the biomass consumed in the EU is imported. Most of the biomass consumed (92.8%) is local and is valued in the same country in which it is produced, which helps to guarantee the sustainability of the life cycle of this productive activity, by minimizing large movement of fuel from one country to another (which has an impact on emissions derived from transport).

CONCLUSIONS

In Sweden, where the main fuel currently used is biomass (recycled wood), this indicator does not apply. In Spain, however, we can conclude that the Bio-FlexGen technology contributes to foster sustainable development by promoting an economical and sustainable alternative to fossil fuels such as natural gas or fuel oil. In the Spanish use cases, biomass reduces fuel costs by over 50% and up to 70%, while also providing greater price stability compared to volatile international fossil fuel markets. Spain's significant biomass potential, particularly from agricultural residues, reinforces this advantage,

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although its energy valorization is still limited by regional and structural barriers. At the EU level, biomass is largely produced and consumed locally, strengthening both energy security and the environmental sustainability of the fuel mix.

Source: CORES, Statista, Engineering Institute of Spain, APPA Renovables, Deliverable D4.1 Business models analysis

B1.2 Gross value added of main fuel source

This indicator measures the Gross Value Added (GVA) generated by the different fuels industry involved in the baseline and BTC scenarios. However, due to the lack of data related to the specific GVA of the different fuel industries, we have measured the economic contribution of the different fuel industries to the national Gross Domestic Product (GDP).

RESULTS

Fuel industry	**Contribution to Swedish GDP** (%)	**Contribution to Spanish GDP** (%)
Oil and gas industry	0.1–0.2	1.1–1.4
Biomass industry	0.11–0.16	0.04–0.07

Table 23 B1.2 Contribution of different fuel industry to GDP in Sweden and Spain (2021)

In 2021, Sweden's energy value chains contributed only modestly to national GDP, but with a clear focus on renewables. The oil and gas chain accounted for just 0.1–0.2% of GDP, as refining capacity is small and natural gas plays an almost negligible role in power generation (Eurostat, 2021). In contrast, the biomass chain contributed around 0.11–0.16% of GDP, reflecting the strong role of biomass in CHP and DH systems, where it represented 5–7% of total electricity generation (SCB, 2021). However, the importance of biomass in Sweden extends far beyond these figures: it underpins a complete forestry-to-energy value chain, generates direct jobs in fuel supply and CHP plant operations, and induces indirect employment in areas such as machinery, transport, and engineering. Moreover, it strengthens local economies by anchoring energy production in rural areas, while also supporting Sweden's climate goals through sustainable forest management and by reducing the need for imported fossil fuels.

In contrast, Spain showed a very different pattern. The oil and gas chain represented a much larger share, around 1.1–1.4% of GDP, driven by the importance of petroleum refining and the reliance on natural gas, which accounted for roughly one fifth of electricity production in 2021 (Eurostat, 2021). Furthermore, Spanish electricity, gas and oil companies pay significant taxes each year: only the four largest companies in the energy sector contributed a total of 10,720 million euros to the Spanish tax agency in 2023 (El Periódico de la Energía, 2024). The biomass chain, by contrast, contributed only 0.04–0.07% of GDP, consistent with its relatively minor role in Spain's energy mix (REE, 2023). However, fossil fuels also generate significant indirect costs that are often ignored. Being finite, their extraction becomes increasingly expensive and deepens dependence on imports. Their combustion causes pollution that harms health, reduces productivity, and drives climate change with severe economic consequences such as crop losses and coastal erosion. Extraction and transport also damage soil and water, while import dependence exposes countries to supply risks and price volatility. If these costs are included, the net economic benefit of fossil fuels is far lower than official data suggest (M. de Gregorio, 2020). In Spain, the annual cost of fossil fuel pollution is estimated at 23,631 billion dollars (1.68% of GDP) (Greenpeace, 2020), and the economy could have grown up to 5% more between 2014 and 2020 if pollution had remained below WHO recommendations (EsadeEcPol). On the contrary, although biomass currently has a small share in Spain's energy mix, it holds great potential to generate economic, social, and environmental benefits. Its use supports industrial activity, creates jobs in rural areas, and helps retain population while promoting the bioeconomy. It also reduces dependence on fossil fuel imports, improving Spain's external balance. Environmentally, biomass mitigates CO_2 emissions, lowers the risk of forest fires, and prevents methane emissions and waste mismanagement,

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with current facilities already avoiding costs estimated at €334 million in CO_2 and €150 million in fire extinction annually (M. de Gregorio, 2020).

CONCLUSIONS

In summary, this indicator shows the clear difference between Spain and Sweden in the role of biomass in their energy economies. In Sweden, biomass is already a key resource, linked to forestry and energy, creating jobs, supporting rural areas, and helping climate goals together with hydropower and nuclear. biomass remains underutilized, despite its potential to reduce fossil fuel imports, cut emissions, and create employment in rural areas. Strengthening biomass valorization could help Spain depend less on fossil fuels and move toward the more sustainable model seen in Sweden.

Sources: Eurostat, Statistics Sweden (SCB), El Periódico de la Energía, Red Eléctrica Española (REE), M. de Gregorio, Greenpeace, EsadeEcPol

B1.3 Profitability of BTC technology

The main goal of this economic indicator is to evaluate the profit generated when the new BTC technology is integrated into the pilots' production portfolios. This indicator is calculated by RISE and Comillas in *Task 4.1 Business Model Analysis* where profitability is measured as the total dispatch revenue minus total dispatch cost (see also indicator B3.2) minus equivalent annual investment cost resulting from the replacement of the current technology with the BTC units developed under Bio-FlexGen project. For the Swedish use cases the total revenue is calculated as the sum of the product of the electricity sold at each hourly snapshot and the market price. In the Spanish use cases, the total revenue is calculated as the total sum of revenues generated by selling electricity to the market and by providing upwards and downwards secondary operating reserves.

B1.3 PROFITABILITY	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 (MSEK/year)	156.1	201.6	**29.12%**
SE-TvAB-02 (MSEK/year)	158.85	211.3	**33%**
SPAIN			
ES-Sulquisa-01 (M€/year)	-16.02	-11.98	**25.2%**
ES-CEMEX-01 (M€/year)			
Alcanar	-18.44	-12.42	**32.6%**
Alicante	-12.92	-7.07	**45.3%**
ES-CEMEX-02 (M€/year)	-20.08	-14.88	**25.9%**
ES-CEMEX-03 (M€/year)			
Alcanar	-18.44	-12.43	**32.6%**
Alicante	-12.92	-7.07	**45.3%**

Table 24 B1.3 Profitability of BTC technology at company level

RESULTS

In Sweden, comparing the baseline data with the profitability data that would be obtained by TvAB when one CHP unit is replaced with BTC units, we can see that for both use cases the project would generate higher profitability, disregarding the investment cost. In the first use case, the profit would be increased by 29.12% while for the second one, where it is assumed that TvAB is providing balancing power while trading in both day-ahead and manual Frequency Restoration Reserve (mFRR) markets, the profit generated is even higher, reaching 33%. However, the sensitivity analysis shows that the profitability highly depends on the biomass prices and when equivalent annual investment cost is compared with the annual profit generated by BTC units, the annual investment cost is at least 2.5 times higher than the annual profit.

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Results from the Spanish industrial use cases show that the inclusion of BTC technology can achieve higher total profits and reduction of CO2 emissions in all cases, even when considering the investment costs. A sensitivity analysis considering 2023 prices for electricity, secondary reserves, biomass, and fossil fuels resulted in higher profits as well, although lower than those of the baseline 2021 scenario. In the case of Sulquisa, the final total profit obtained when replacing the current technology with BTC units would be 25.2% higher, representing a difference of more than 4 M€/year.

In the first CEMEX use case, the total profit results would be 32.6% higher (6 M€/year) in Alcanar when replacing the current technology with Bio-FlexGen technology. This profit would be generated as a result of the dispatch revenues coming from selling excess electricity and providing operating reserves which sum up to 6.91 M€. In Alicante, the final profit results would be 45.3% higher (5.85 M€/year) than the current situation. In the second CEMEX use case, total profitability would be 25.9% higher (5.2 M€/year) when replacing the current technology with the BTC technology in Alcanar plant. Lastly, in the third use case, the baseline scenario remains the same as in the first use case, and as the simulations for the BTC results can be considered negligible, the same data for the BTC technology apply too (32.6% higher profit in Alcanar and 45.3% in Alicante plant).

CONCLUSIONS

In conclusion, we can say that in Sweden, replacing CHP units with BTC technology leads to higher profitability in the scenarios analyzed; however, its economic viability is limited due to the strong dependence on biomass prices and investment costs that significantly exceed the profits obtained. In Spain, by contrast, the results are more favorable: the introduction of BTC technology generates substantial increases in profitability across all cases studied and contributes to reducing CO_2 emissions, even when investment costs and energy price variations are considered.

Sources: Deliverable D4.1 Business models analysis

4.2.2 Subcategory B2: Energy Poverty

This subcategory assesses the impact of bioenergy projects on household energy affordability and access. The indicators examine how the integration of Bio-FlexGen technology may influence electricity prices, household energy costs, and the share of disposable income spent on energy. In the case of Bio-FlexGen, the use of biomass residues can contribute to reducing household energy costs, particularly in Spain, where dependence on imported fossil fuels is high, while in Sweden the impact is more related to stabilizing prices within an already biomass-integrated energy system.

B2.1 Variation in energy prices due to energy efficiency

This indicator measures the impact of BTC technology on electricity prices. The analysis has been conducted by RISE and Comillas in *Task 4.2 Cost-benefit analysis for system integration of the BTC* and the results are presented in deliverable *D4.2 Cost-benefit analysis for system integration of the BTC*. This analysis studies the impact of BTC technology on the marginal cost of electricity which ultimately impacts the expected electricity prices.

RESULTS

In Sweden, we can see that incorporating the BTC technology into the energy system negatively affects the marginal costs in most of the SEs[5] in the reference year 2035, leading to higher expected electricity prices. The opposite effect is observed for the 2045 scenario, where the marginal costs significantly fall in the 4 SEs, resulting in lower expected electricity prices.

[5] Sweden is divided into four bidding zones (SE1-SE4)

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SRMC (EUR/MWh)	2035			2045		
	BASELINE	BIO-FLEXGEN	IMPACT RESULT	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SE1	13.3	13	-2.25%	2,162	237.7	-89%
SE2	13.7	15	+9.48%	72.7	37.7	-48.14%
SE3	14	25.4	+81.4%	72.7	37.7	-48.14%
SE4	14	25.4	+81.4%	72.7	37.7	-48.14%

Table 25 B2.1 Variation in energy prices in Sweden in 2035 and 2045 with and without BTC

**Note: SRMC stands for Short-Run Marginal Cost (€/MWh), representing the cost of supplying an additional unit of electricity in the system.*

In Spain, considering that the marginal cost of electricity accounts for the cost of supplying an additional 1 MWh of electricity to the system, as shown in the graphic below, the 2030 BTC Spanish scenario presents more hours throughout the year with lower marginal cost, coinciding with greater renewable production. Therefore, we can conclude that in the 2030 scenario, incorporating BTC leads to lower electricity marginal costs which ultimately **lowers the expected electricity prices**.

However, in the 2050 scenario, in which renewable production is 100% in both scenarios, the **marginal prices are practically the same** and, on average, lower than those in the 2030 scenario.

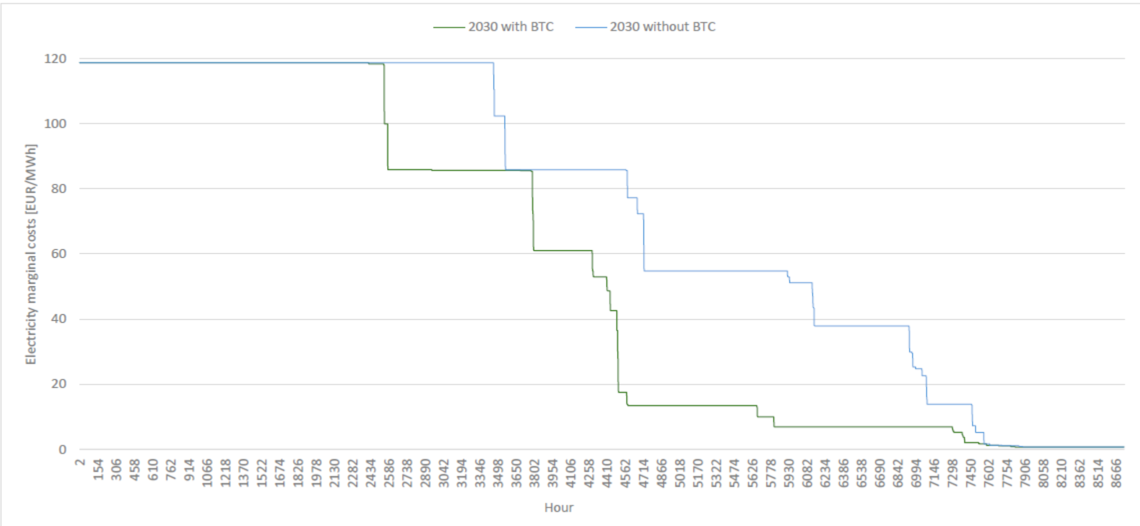

Figure 2 Electricity marginal costs in Spanish 2030 scenario

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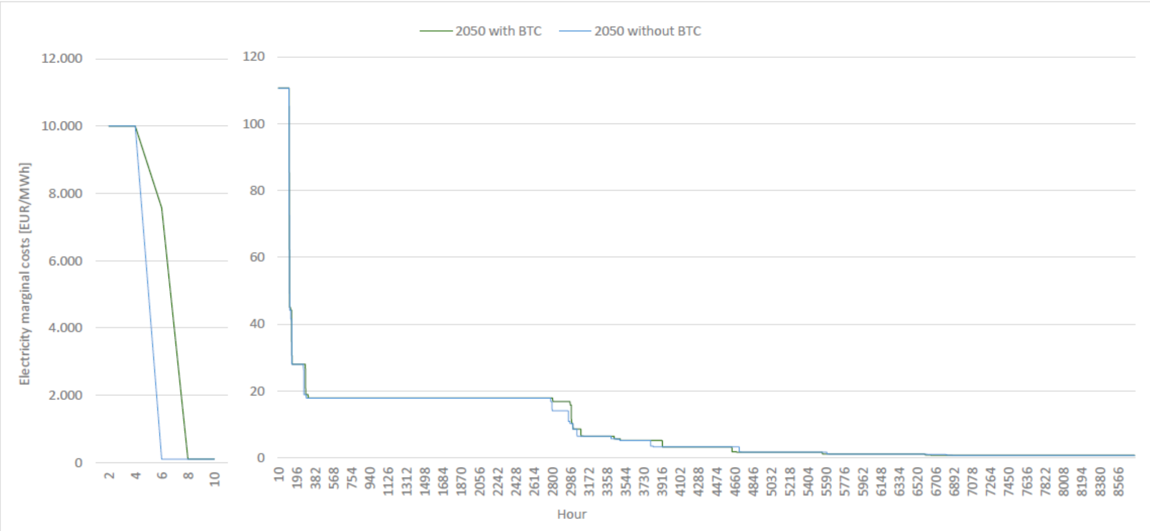

Figure 3 Electricity marginal costs in Spanish 2050 scenario

CONCLUSIONS

In conclusion, the impact of BTC technology on electricity marginal costs varies across countries and time horizons: in Sweden, it initially raises costs but later contributes to reducing them, while in Spain it helps lower costs and electricity prices when renewables expand, with differences disappearing once the system becomes fully renewable.

Source: Deliverable D4.2 Cost-benefit analysis for system integration of the BTC

B2.2 Variation in energy cost share in disposable households' income due to energy efficiency

B2.2 measures the increase/decrease in the percentage of household income spent on energy resulting from the increase/decrease of energy prices when integrating BTC technology in the energy mix in Sweden and Spain (see also indicator B2.1). However, since there is not a real implementation of the BTC technology that allows us to quantify this variation, we will just provide the current percentage of household income spent on energy and the increase/decrease percentage of this cost resulting from integrating more renewable energy into the energy mix in Sweden and Spain.

RESULTS

The context of Sweden is very different from that of Spain since biomass is already widely integrated into the Swedish energy system, mainly through DH networks that supply the majority of households, as well as in the form of wood pellets and biofuels. In fact, according to Eurostat and the Swedish Energy Agency, more than 60% of DH production comes from biomass and other bio-based fuels, making it one of the countries with the highest penetration of biomass in Europe. The widespread use of biomass in Sweden means that the potential for additional household cost savings from switching to biomass is limited. While households connected to DH powered by biomass may benefit from 10–20% lower energy costs compared to those relying exclusively on electric heating, the broader impact of biomass is systemic: it helps to keep heating costs relatively moderate and stabilizes prices across the entire energy system, providing protection against extreme price volatility rather than delivering large individual savings.

In this context, while the widespread use of biomass limits the potential for large additional household savings, it is still relevant to consider the incidence of energy vulnerability in the Swedish population. According to the EU Energy Poverty Observatory, around 3.3 % of Swedish households reported being unable to keep their homes adequately warm, and 0.7 % fell behind on utility bill payments (including electricity). These figures reveal that even in a country with high biomass penetration, a non-negligible

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share of households face energy stress. In this context, BTC or biomass-based technologies may provide social as well as systemic benefits.

In Spain, according to the 2023 Energy Poverty Report by Comillas Pontifical University, a median household spends 4.9% of its income on energy, while households in energy poverty spend over 9.8%. Energy poverty continues to rise, affecting more than 30% of households in 2022, with 11% in severe situations. Despite a moderation in energy prices in 2023 following the historic peaks of 2022, the relief in pressure on vulnerable households has been insufficient. 17% of households (over 8 million households) were unable to keep their homes warm, 9% fell behind on electricity bills, 12% under-consumed energy to the point of discomfort, and 17% spent more than twice the share of an average household to paying energy costs. Moreover, 11% (about 5 million households) suffered severe hidden energy poverty, spending less than a quarter of what is needed to cover their basic energy needs, the highest figure in the historical series.

Within this context, bioenergy generation can serve as a tool to promote social inclusion and reduce energy inequality, particularly among vulnerable groups. Solid biofuels such as wood pellets generally offer a lower average energy cost (€/kWh) than fossil fuels or electricity. Although biomass prices may fluctuate depending on feedstock type, season, and logistics, they tend to be more stable than those of fossil fuels and electricity (*AVEBIOM, 2024*). Consequently, using biomass as a household energy source can significantly reduce domestic energy costs, although the exact savings depend on several factors such as the type of biomass used, the efficiency of the heating system, and local market conditions. In Spain, it is estimated that the use of biomass can reduce household energy expenses by approximately 20–40%, depending on energy prices and system performance (*IDAE, 2023; APPA Renovables & Deloitte, 2023*).

	BASELINE (% of income)	BIO-FLEXGEN (% of income)	IMPACT RESULT (% reduction)
Sweden	-	-	-
Spain	4.9 – 9.8	3.43 – 6.86	**- (20-40%)**

Table 26 B2.2 Variation in energy cost share in disposable households' income

CONCLUSIONS

In conclusion, as a renewable and locally available energy source, the integration of BTC technology into the energy mix in Sweden and Spain can help lower household energy costs and reduce vulnerability to price fluctuations (see also indicator B2.1). In Spain, the use of biomass for residential heating can reduce household energy expenses by approximately 20–40% compared to conventional fuels, depending on local energy prices, system efficiency, and the type of biomass used (*AVEBIOM, 2024; IDAE, 2023; APPA Renovables & Deloitte, 2023*). In Sweden, where biomass is already widely integrated through District Heating networks, the effect is more systemic, contributing to long-term price stability and resilience rather than large individual savings. Overall, BTC deployment supports fairer and more inclusive energy systems by combining affordability and stability across different national contexts.

Sources: AVEBIOM (2024); IDAE (2023); APPA Renovables & Deloitte (2023); Eurostat (2024); Swedish Energy Agency (2023); EU Energy Poverty Observatory (Sweden); Comillas Pontifical University (2023).

4.2.3 Subcategory B3: Energy Efficiency

This subcategory evaluates the efficiency of bioenergy technologies in terms of energy production and resource use. The indicators examine how the Bio-FlexGen technology performs compared to baseline scenarios, focusing on electricity and heat dispatch as well as production costs. In the case of Bio-FlexGen, improvements in energy efficiency are expected through the optimized use of biomass

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residues and renewable hydrogen, enabling higher electricity generation, reduced reliance on external energy sources, and overall gains in system performance.

B3.1 Energy efficiency

Energy efficiency is measured by the increase/decrease of electric and heat volumes that BTC technology dispatches compared to the baseline scenario by using optimization models that incorporate its technical and economic parameters to properly assess the use cases. This indicator provides information on the impact of BTC technology on both economic and environmental sustainability.

This calculation has been performed by RISE and Comillas in *Task 4.1 Business models' analysis for the different business use cases,* and the comparative results are provided in deliverable *D4.1 Business models analysis.* According to these calculations, the electric power dispatch measures the total sum of technology-dispatched electric power volumes, and the heat power dispatch is calculated (if applies to the use case) as the total sum of technology-dispatched thermal power volumes.

RESULTS

In Sweden, the energy efficiency of the Bio-FlexGen technology is higher compared with that of baseline scenario since the electric power dispatch is increased by 10.3% in the first use case and by 15.6% in the second use case (the heat dispatch does not apply in the Swedish use cases).

In Spain, given the configuration of the Sulquisa plant, the final electricity dispatch of the BTC scenario is lower, delivering 31.2% less electricity than the 3 CHP units Sulquisa has currently installed. Note, however, that the total electric power dispatch accounts for electricity production covering internal demand plus the excess production which is sold to the market, and that the BTC technology delivers part of its electric output to the heat pump.

In the three baseline scenarios of CEMEX, none of the plants produce electricity and the total energy consumed is imported from the electricity grid so a comparison in energy dispatch does not apply in this use case. Nevertheless, the impact of the BTC technology in terms of energy efficiency would be positive (*) since the technology delivers between 141 and 153 GWh of electricity in all the use cases and revenues are increased by selling part of the electricity production during hours of high electricity prices and purchased from the market during hours of lower costs.

B3.1 ENERGY EFFICIENCY Electric and heat power dispatch	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 Electric power dispatch (GWh)	372	410.3	**+10.3%**
SE-TvAB-02 Electric power dispatch (GWh)	352.33	407.3	**+15.6%**
SPAIN			
ES-Sulquisa-01 Electric power dispatch (GWh) Heat power dispatch [GWh]	82.26 126.82	56.61 126.82	**-31.2%** -
ES-CEMEX-01 Electric power dispatch (GWh) *Alcanar* *Alicante*	- -	142.52 141.67	* *
ES-CEMEX-02 Electric power dispatch (GWh) Heat power dispatch (GWh)	- 28.85	153.48 28.85	* -
ES-CEMEX-03	-	142.51	* -

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Alcanar	34.67	34.67	*
Electric power dispatch (GWh)			-
Heat power dispatch (GWh)	-	141.66	
Alicante	27	27	
Electric power dispatch (GWh)			
Heat power dispatch (GWh)			

Table 27 B3.1 Energy efficiency without and with BTC technology

CONCLUSIONS

In summary, the inclusion of BTC technology in the Swedish and Spanish use cases demonstrates clear improvements in energy efficiency. By producing more electricity for participation in different markets, BTC optimizes the use of available resources and reduces reliance on external supply. This translates into higher economic benefits, greater competitiveness for companies, and at the same time a meaningful contribution to the decarbonization and overall efficiency of the energy system.

Source: Deliverable D4.1 Business models analysis

B3.2 Energy production cost

B3.2 is calculated as the increase/decrease of the total cost of dispatch of the BTC technology compared to the baseline scenario. This indicator provides us with information about the impact on the economic and environmental sustainability of BTC technology.

This calculation has been performed by RISE and Comillas in *Task 4.1 Business models' analysis for the different business use cases,* and the comparative results are provided in deliverable *D4.1 Business models analysis*. According to these calculations, the total cost of dispatch accounts for the total sum of fuel cost, start-up and shut-down costs for BTC and boiler units, CO2 emission costs, excess heat cooling costs, and grid power purchases.

RESULTS

In Sweden, the electric power dispatched by the BTC technology results in a higher dispatch cost for both use cases, producing a negative impact on the economic and environmental sustainability of the Bio-FlexGen technology compared to the baseline scenario. In the first use case, the dispatch cost is increased by 32.3% while in the second use case this increase reaches 40.5%.

In Spain however, all the use cases result in a decrease dispatch cost. In the Sulquisa use case, the reduction in CO2 emission costs and fuel costs make the BTC technology almost 60% less costly than the baseline scenario. In the case of CEMEX, where the baseline scenario cost corresponds to the cost of purchasing electric power from the grid to cover the demand in both plants, the dispatch cost decreases in the three use cases. In the first case, in Alcanar plant, even accounting for BTC's operating costs, the total dispatch cost ends up being 39.3% lower than in the baseline scenario. In Alicante plant, while BTC capacity is assumed equal in both locations, Alicante's demand is almost 30% lower, meaning that BTC can increase excess electric power volumes sold at the market, thus increase revenues. For the second CEMEX use case, the dispatch cost decreases by 48% and for the third use case this decreases 39% and 30% in Alcanar and Alicante respectively.

B3.2 ENERGY PRODUCTION COST	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 (MSEK/year)	102.5	135.6	**+32.3%**
SE-TvAB-02 (MSEK/year)	92.98	130.6	**+40.5%**
SPAIN			
ES-Sulquisa-01 (M€/year)	-18.96	-7.60	**-59.9%**
ES-CEMEX-01 (M€/year)			

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Alcanar *Alicante*	-18.44 -12.92	-11.19 -9.04	**-39.3%** **-30%**
ES-CEMEX-02 (M€/year)	-19.97	-10.31	**-48.4%**
ES-CEMEX-03 (M€/year) *Alcanar* *Alicante*	 -18.44 -12.92	 -11.20 -9.04	 **-39.3%** **-30.0%**

Table 28 B3.2 Energy production cost without and with BTC technology

CONCLUSIONS

In conclusion, the production cost of BTC technology is lower only in the Spanish use cases, enhancing the economic competitiveness of Sulquisa and CEMEX. In the Swedish use cases, by contrast, BTC technology results in higher production costs, generating a negative impact on the economic and environmental sustainability of TvAB.

Source: Deliverable D4.1 Business models analysis

4.2.4 Subcategory B4: Energy Security

This subcategory assesses the extent to which bioenergy projects contribute to reducing dependence on fossil fuel imports and to diversifying the energy mix. The indicators examine changes in fossil fuel use, renewable energy dispatch, and the balance of energy sources at national level. In the case of Bio-FlexGen, the replacement of fossil fuels with biomass residues and renewable hydrogen is expected to enhance energy security by lowering import dependence and increasing the share of domestically available renewable resources.

B4.1 Fossil fuel imports

B4.1 is calculated within WP5 as the increase/decrease of fossil fuel dispatch of the BTC technology compared to the baseline scenario. This indicator assesses the environmental and economic impact of BTC technology and specifically the general decrease in fossil fuel dispatch volumes and consequently the decrease in carbon emissions.

This calculation has been performed by RISE and Comillas in *Task 4.1 Business models' analysis for the different business use cases,* and the comparative results are provided in deliverable *D4.1 Business models analysis*. According to these calculations, the fossil fuel dispatch is calculated as the ratio between the total sum of fossil-fueled generators' dispatch volumes and the total sum of the total dispatch volumes over the full year. The remaining portion corresponds to renewable dispatch. This indicator also provides the increase/decrease of carbon emissions associated with the fossil fuel dispatch.

RESULTS

In Sweden, the first use case results in 4.2% decrease in fossil fuel dispatch and consequently in 18.8% increase in renewable energy dispatch by integrating the BTC technology. Moreover, this reduction of fossil fuel dispatch volumes produces 2.22% decrease in carbon emissions. For the second use case, the integration of the BTC technology results in 5.5% decrease in proportion of fossil fuel dispatch and 27% increase in renewable energy dispatch. This reduction of fossil fuel dispatch volumes results in 2.5% decrease in carbon emissions.

In Spain, for the Sulquisa use case, the proportion of fossil dispatch drops to 10.4% by replacing the main fuel from natural gas to biomass. Consequently, the proportion of renewable dispatch increases by 89.6%, resulting in a decrease of 81.6% in carbon emissions. In the first use case of CEMEX, the electric energy consumed in both plants is imported from the electricity, so this indicator does not apply. In the second case, as the electricity demand is covered by the power purchased from the grid, the total proportion of fossil dispatch is not informed in the baseline scenario. By integrating the BTC

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technology, the proportion of fossil dispatch is only 0.95%, and it is caused by burning fuel oil in the assisting boiler. In the third use case, for the partial replacement of fuel oil usage in the kiln in both plants, the same heat is being delivered in the baseline scenario by burning fuel oil and in the BTC scenario by burning renewable hydrogen. Therefore, the proportion renewable dispatch in both plants increased by 100% and consequently decreased in fossil fuels and carbon emissions by 100%.

B4.1 FOSSIL FUEL IMPORTS	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01			
Proportion renewable dispatch (%)	18%	21.4%	**+18.8%**
Proportion fossil fuel dispatch (%)	82%	78.6%	**-4.2%**
Carbon emissions (MTCO2)	315	307.9	**-2.22%**
SE-TvAB-02			
Proportion renewable dispatch (%)	17%	21.6%	**+27%**
Proportion fossil fuel dispatch (%)	83%	78.4%	**-5.5%**
Carbon emissions (MTCO2)	314.5	306.5	**-2.5%**
SPAIN			
ES-Sulquisa-01			
Proportion renewable dispatch (%)	0%	89.6%	**+89%**
Proportion fossil fuel dispatch (%)	100%	10.4%	**-89.6%**
CO2 emissions (MtonCO2)	0.042	0.008	**-81.6%**
ES-CEMEX-01			
Alcanar	-	-	**-**
Alicante	-	-	**-**
ES-CEMEX-02			
Proportion renewable dispatch (%)	-	99.05%	**+99.05%**
Proportion fossil fuel dispatch (%)	-	0.95%	**-**
CO2 emissions (MtonCO2)	0.008	0.006	**-21.2%**
ES-CEMEX-03			
Alcanar			
Proportion renewable dispatch [%]	0%	100%	**+100%**
Proportion fossil fuel dispatch (%)	100%	0%	**-100%**
CO2 emissions (MtonCO2)	0.009%	0%	**-100%**
Alicante			
Proportion renewable dispatch [%]	0%	100%	**+100%**
Proportion fossil fuel dispatch (%)	100%	0%	**-100%**
CO2 emissions (MtonCO2)	0.007%	0%	**-100%**

Table 29 B4.1 Fossil fuel dispatch, renewable dispatch and carbon emissions without and with BTC technology

Furthermore, it is important to note that less than 5% of the biomass and waste used for energy in the European Union is imported. The vast majority, over 95%, is produced and consumed locally within the EU, which enhances the sustainability of this activity's life cycle by reducing the need for large-scale transportation of fuels between countries and, consequently, lowering transport-related emissions (IEA Bioenergy, 2024).

CONCLUSIONS

In summary, the integration of BTC technology leads to the replacement of fossil fuels for heating and power generation across all use cases, resulting in an overall reduction in fossil fuel dispatch volumes and, consequently, a decrease in carbon emissions. Moreover, as most biomass used in the EU is locally sourced, this further supports the sustainability of the energy transition.

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Source: Deliverable D4.1 Business models analysis, IEA Bioenergy 2024

B4.2 Energy diversity/diversification of the energy mix

This indicator measures the diversification of energy sources in the energy mix which ultimately indicates the degree of vulnerability or dependence by a country on a few suppliers.

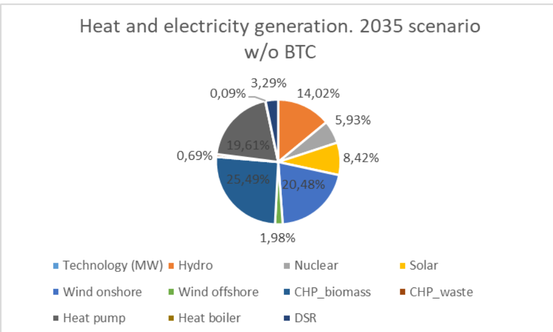
The analysis has been conducted by Comillas in Task 4.2 *Cost-benefit analysis for system integration of the BTC*, performed at national level to assess the integration and profitability of BTC technology within Sweden and Spain's electricity and heat systems using the openTEPES modelling tool (*Comillas Pontifical University, 2023*). In Spain, the analysis is performed in 2030 and 2050 scenarios, while for Sweden, it is performed for 2035 and 2045, following both countries' National Climate and Energy Plans.

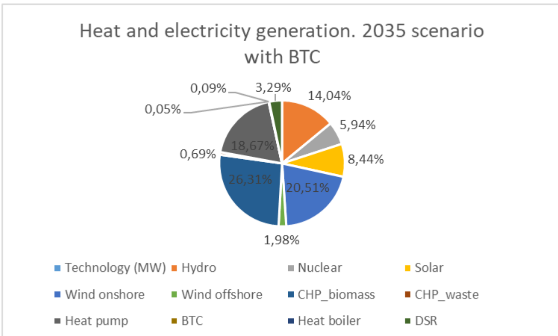
RESULTS

The analysis distinguishes three main energy sources (renewable, fossil, and electric) where the "electric" category represents electricity consumed as input in heating technologies such as heat pumps, rather than electricity used for power generation. In addition, DSR (Demand Side Response) refers to an energy management practice that provides flexibility to the system by adjusting electricity demand rather than acting as a generation technology. In the case of Sweden, electricity and heat generation are part of the same aggregated system-level mix in the *openTEPES* model, and therefore the results represent the overall energy composition of the system rather than two separate sectors.

B4.2 ENERGY DIVERSITY	ELECTRICITY GENERATION			HEAT GENERATION		
SWEDEN 2035	**BASELINE**	**BIO-FLEXGEN**	**IMPACT RESULT**	**BASELINE**	**BIO-FLEXGEN**	**IMPACT RESULT**
Renewable	99%	99%	-	39.477%	39.535%	**+0.15%**
Fossil	0.78%	0.78%	-	9.16%	9.16%	-
Electric	0.189%	0.194%	**+2.64%**	51.36%	51.3%	-
SWEDEN 2045	**BASELINE**	**BIO-FLEXGEN**	**IMPACT RESULT**	**BASELINE**	**BIO-FLEXGEN**	**IMPACT RESULT**
Renewable	99.65%	98.14%	**-1.51%**	90.6%	59.76%	**-30.84%**
Fossil	0.35%	0.61%	**+0.26%**	5.28%	9.64%	**+4.36%**
Electric	0.68%	1.24%	**+0.56%**	4%	30.6%	**+26.6%**

Table 30 B4.2 Energy diversity in Sweden without and with BTC technology





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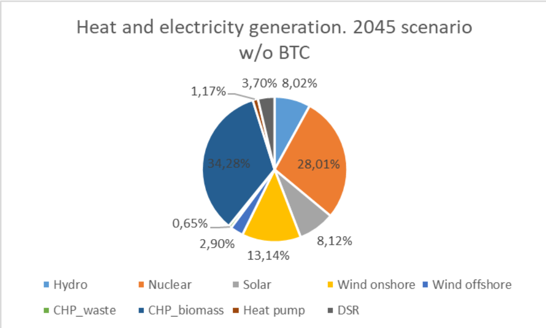

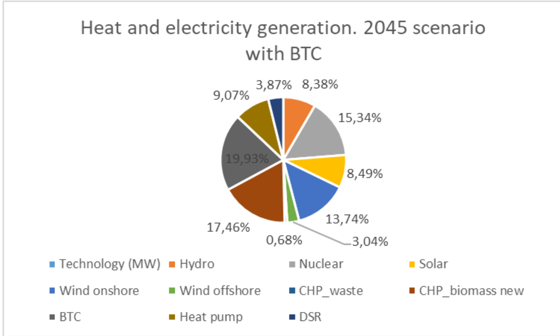

Figure 4 Swedish energy mix in 2035 and 2045 scenarios without and with BTC technology

As we can see in Table 31, we cannot see big differences in the impact of BTC within the Swedish energy mix in 2035. This is because Sweden CHP production in Sweden is highly renewable already making use of biomass and waste as main fuels. Regarding the DH sector, through the replacement of fossil fuel-based heating by biobased CHP plants connected to DH systems, Swedish heating system is almost fossil-free (only 1.5 % of the total fuel used in 2020 in DH systems are fossil-based); and currently 110 biomass and waste-fired CHP plants are connected to 72 of the DH grids in Sweden.

On the other hand, Swedish electricity production is based largely on hydropower located in the northern part of the country, nuclear power, and thermal power, but the expansion of wind power is steadily increasing. In addition, the production and use of biofuels for electricity and heat production is also increasing.

Within this context, the results obtained for the reference year of 2035 show that to satisfy the system electric demand the model prioritizes BTC over nuclear technology. However, for a situation that the need for investment in heat generating technologies is higher to meet the system heat demand than that of electricity, the model prefers to invest in CHP biomass rather than in BTC technology.

In the 2045 baseline scenario, regarding electricity generation and as indicated for 2035 scenario, we do not see big differences in the impact of BTC within the energy mix. As for heat production, the model invests mostly in heat-pumps, nuclear technology, CHP (waste) and CHP (biomass) to meet the heat and electricity demand. In the BTC scenario, this technology is getting invested in all price zones (in some zones, BTC technology is about 4 times higher than that of CHP biomass technology).

B4.2 ENERGY DIVERSITY	**ELECTRICITY GENERATION**			**HEAT GENERATION**		
SPAIN 2030	**BASELINE**	**BIO-FLEXGEN**	**IMPACT RESULT**	**BASELINE**	**BIO-FLEXGEN**	**IMPACT RESULT**
Renewable	86.3%	89.7%	**+3.4%**	71.6%	57.8%	**-13.8%**
Fossil	13.7%	10.3%	**-3.4%**	21.2%	**15.8%**	**-5.4%**
Electric	-	-	-	7.1%	**26.4%**	**+19.3%**
SPAIN 2050	**BASELINE**	**BIO-FLEXGEN**	**IMPACT RESULT**	**BASELINE**	**BIO-FLEXGEN**	**IMPACT RESULT**
Renewable	100%	100%	-	28%	19%	**-9%**
Fossil	-	-	-	-	-	**-**
Electric	-	-	-	72%	81%	**+9%**

Table 31 B4.2 Energy diversity in Spain without and with BTC technology

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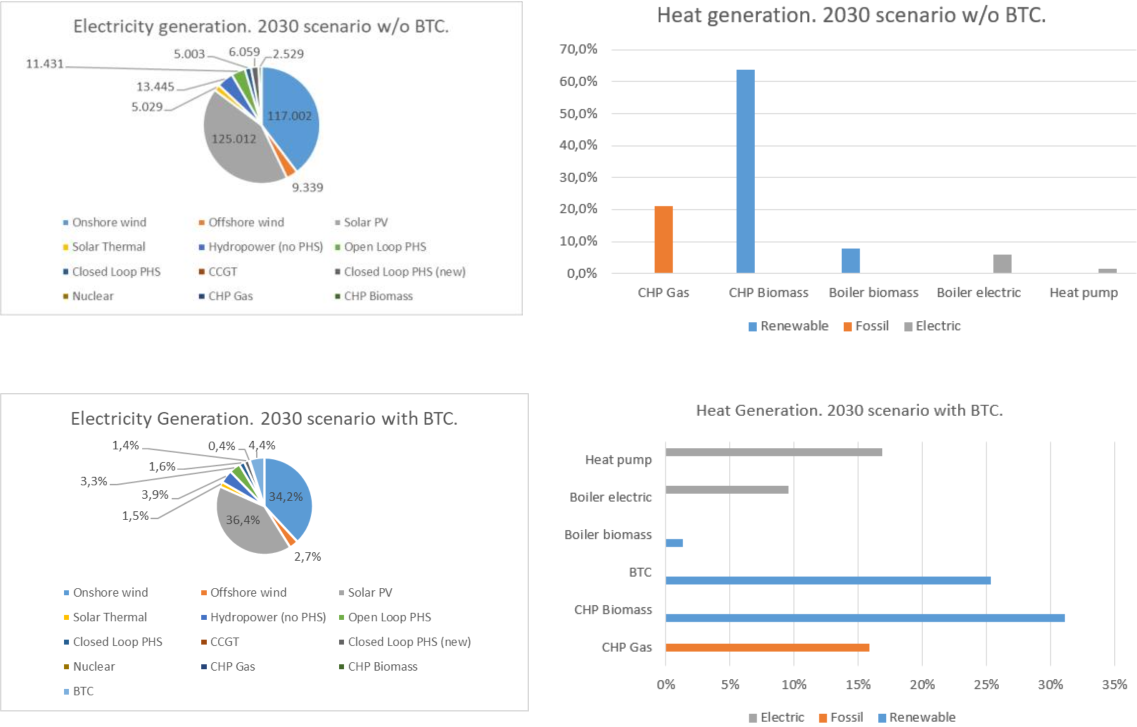
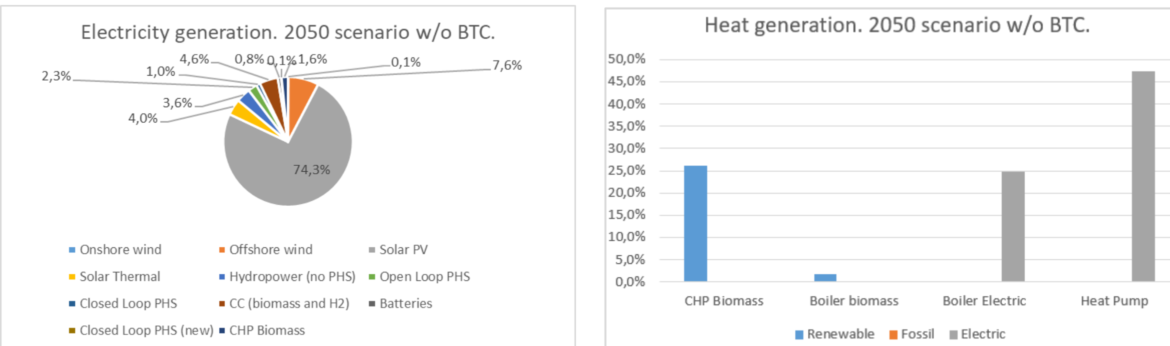


Figure 5 Spanish energy mix in 2030 scenario without and with BTC technology

In Spain, according to the Spanish Energy and Climate Plan, the Spanish electricity system is expected to achieve 81% renewable electricity generation by 2030 and 100% by 2050. Within this context, in the 2030 baseline scenario, all renewable technologies account for 86% of total generation where wind and solar are the main electricity generation technologies (Figure 5). In the case of low-temperature heat generation, the percentage of renewable generation is 72%, while fossil generation is 21% and electric generation 26%. The main heat generation sources are CHP biomass (64%) followed by CHP Gas (21%).

The integration of BTC technology into the 2030 Spanish scenario increases the renewable electricity generation from 86% to 90% and renewable heat changes from 72% to 58%, while electric heat increases from 7% to 26%. In terms of the energy mix, BTC significantly impacts the total generation mix, reducing the generation of combined cycle gas turbine (CCGT) by replacing more than 15 TWh of electric generation and reducing conventional biomass CHP technology. On the other hand, BTC decreases biomass CHP and boiler heat generation and hydrogen boilers, although they can contribute to decarbonizing heat production by using renewable fuel, are not competitive due to their high CAPEX values.



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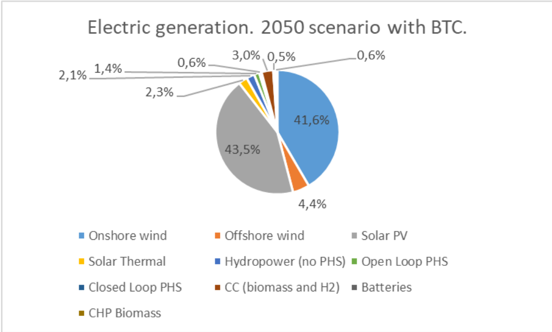

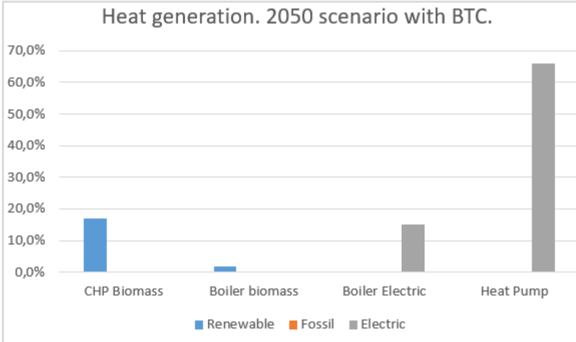

Figure 6 Spanish energy mix in 2050 scenario without and with BTC technology

In 2050, 100% of the electricity is expected to be renewable, where solar photovoltaic is the main electricity generation technology (74%). Heat production with biomass reaches 28%, and 72% comes from electric devices. The technology that produces the most heat is the heat pump, followed by traditional biomass CHP and boilers, while electric boilers produce significantly less volumes. For this reference year, initial assumptions reveal that BTC technology is not as competitive primarily due to its high CAPEX compared to conventional biomass CHP technology. However, the model indicates investments in BTC with a small 10% reduction in their investment cost. Electrification of heat production exceeds 80%, with biomass boilers and CHPs complementing the mix. Additionally, higher biomass prices make CHP and biomass boiler generation less attractive while increasing the competitiveness of BTC due to its higher efficiency.

CONCLUSIONS

In conclusion, BTC technology has not a significant impact on the Swedish energy mix since the energy system is already highly renewable and, specifically, CHP production already makes use of high proportion of biomass and waste as main fuels. In the case of Spain, BTC technology allows the system to surpass the 81% threshold of renewable electricity generation expected for 2030. On the contrary, for 2050, BTC technology is not as competitive.

Sources: *Deliverable D4.2 Cost-Benefit Analysis for System Integration of the BTC; Comillas Pontifical University (2023) openTEPES Modelling Tool.*

4.2.5 Subcategory B6: Local Development

This subcategory assesses the contribution of bioenergy projects to local and regional economic development. The indicators examine the extent to which the project generates positive impacts for nearby communities, including the use of local suppliers, the creation of business opportunities, and the payment of local taxes and fees. In the case of Bio-FlexGen, local development impacts are expected mainly through the construction phase, which relies on local engineering and civil works, and through the purchase of biomass sourced within national or regional supply chains, while also generating tax revenues for local authorities.

B6.1 Contribution to local industries in the local economy

B6.1 measures the proportion of the companies' annual spending on local suppliers (biomass suppliers, equipment, goods, services …) resulting from replacing/constructing the BTC plant in the different use cases. Local areas are defined as municipality, neighboring municipalities, state or province. Nevertheless, we will also estimate the impact on national and European suppliers.

RESULTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grand agreement N° 101037085.

To calculate the total annual spending on local suppliers, it is considered, on the one hand, the purchase of biomass necessary to feed the BTC plant and on the other, the spending on equipment, goods and services required for the construction and installation of the BTC plants.

The amount of biomass in tons/year is calculated by Comillas by dividing the annual biomass consumption by the average calorific value of the biomass, which based on deliverable D4.3, we can use an average value of 5.46 MWh/ton of biomass. Biomass prices are retrieved from D4.1, where the price for Sweden is 350 SEK/MWh and the price for the Spanish use cases is 23.19€/MWh.

Based on this, the annual spending on biomass resulting from replacing the CHP unit with the BTC unit in TvAB will be 4.78 million euros per year. However, this economic impact will mainly occur outside Linköping municipality and Östergötland county, since the biomass purchased by TvAB is largely sourced from other regions of Sweden and from Norway.

In Spain, the regions with higher biomass potential are Aragón, Castilla-La Mancha and Castilla y León, potentially enabling them to supply biomass to other constrained regions such as Comunidad Valenciana (deliverable D4.3 Scalability and replicability analysis of the proposed solutions). Given that the Spanish pilot companies are located in Comunidad de Madrid (Sulquisa) and Comunidad Valenciana and Cataluña (CEMEX) we can assume that the biomass required to run the BTC plants will not be purchased locally but outside these provinces.

In the case of Sulquisa, BTC technology will replace three existing natural gas-fired CHP units. Consequently, the switch to biomass will generate an estimated positive economic impact of **5.52 million euros per year** compared to the baseline scenario, in which the current fuel (natural gas) is imported from outside Spain. However, although this impact occurs at the national level, most of the biomass procurement will likely take place outside the Comunidad de Madrid, mainly in Aragón, Castilla-La Mancha, or Castilla y León, where suitable biomass feedstock sources are more readily available.

In the CEMEX use cases where no CHP units are being replaced, the purchase of biomass for the BTC technology will be 7.49, 7.92, and 7.84 million euros per year in Alcanar plant in each of the three use cases, and of 7.81 in the two Alicante's use cases. As in the case of Sulquisa, the economic impact will not occur locally (Alicante and Tarragona provinces and Comunidad Valenciana and Cataluña) but most probably in the three provinces mentioned before where the biomass stocks are more available.

B6.1 CONTRIBUTION TO LOCAL INDUSTRIES IN THE LOCAL ECONOMY (national impact)	**Annual biomass consumption** (GWh/year)	**Biomass annual amount** (tonnes/year)	**Biomass annual spending** (MEUR/year)
SWEDEN			
TvAB	158.6	29,048	**4.78** (55.5M SEK/year)
SPAIN			
ES-Sulquisa-01	238.1	43,577	**5.52**
ES-CEMEX-01			
Alcanar	322.8	59,079	**7.49**
Alicante	336.7	61,623	**7.81**
ES-CEMEX-02 *Alcanar*	341.7	62,538	**7.92**
ES-CEMEX-03			
Alcanar	338.3	61,916	**7.84**
Alicante	336.7	61,623	**7.81**

Table 32 Annual spending on biomass (impact at national level)

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On the other hand, regarding the spending on equipment, goods and services required for the construction and installation of the BTC plants, we have considered the BTC plants costs (CAPEX) retrieved from D4.1 (see Table 34). These costs include the following main items: main equipment purchase (fuel feeding, gasifier, gas turbine, heat recovery boiler, etc.), engineering and general facilities services, EPC[6] service fee, owner's engineering/supervision, and equipment royalties, operator training, start-up cost and working capital.

CAPEX	Unit	TvAB	Sulquisa	CEMEX PowerGen (Alicante and Alcanar)	CEMEX CHP (Alcanar)
	M€	90	58	86.9	88.1

Table 33 Total plant cost (CAPEX) breakdown for use cases (Source: deliverable D4.1)

To analyze the economic impact of the BTC plants' costs, we have broken down the engineering and general facilities services into the following items: engineering services, construction and civil works, electrical assembly, and assembly of equipment. However, since there is not a real implementation of the BTC technology, we cannot calculate the real cost of each item. Nevertheless, to have a broad estimation of the local economic impact of the project, we have estimated the impact scope of each item along with pilot partners. As we can see from Table 35 engineering services, construction and civil works, low voltage electric assembly, and equipment assembly usually carried out by local companies whereas high voltage electric assembly, and the purchase of sand for the gasifier are carried out at national level. Lastly, based on the type of equipment required for the construction and installation of the BTC plant, the purchase of this equipment is very likely to be acquired from European companies.

ENGINEERING AND GENERAL FACILITIES SERVICES	LOCAL IMPACT	NATIONAL IMPACT	EU IMPACT
Engineering services	x		
Construction and civil works (metal structure, building enclosure works, etc.)	x		
Electrical assembly: high voltage		x	
low voltage	x		
Purchase of equipment (turbines, gasifiers, heat pump, boilers, etc.)			x
Assembly of equipment	x		
Sand (gasifier)		x	

Table 34 B6.1 Contribution to local industries in the local economy. Impact scope of engineering and general facilities services.

CONCLUSIONS

In summary, the economic impact of deploying BTC technology comes both from the purchase of biomass and from the construction and installation of the plants. While biomass is often sourced from outside the immediate area, creating mainly regional or national impacts, the construction phase generates direct local benefits through services such as engineering, civil works, and assembly. Overall,

[6] EPC: Engineering, procurement, and construction company

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BTC technology supports the wider economy while also contributing to local industries during implementation.

Sources: TvAb, Sulquisa, CEMEX, Comillas, Deliverable D4.1 Business models analysis, Deliverable D4.3 Scalability and replicability analysis of the proposed solutions

B6.2 Taxes/royalties paid to the local government

B6.2 measures the breakdown of payments made to the local government resulting from replacing/constructing the BTC plant in the different use cases.

RESULTS

By quantifying the tax benefits to the local economy, we will consider the main taxes derived from the construction and installation process of the BTC plants in each municipality which should allow for increases in local public spending.

In Sweden, local governments charge fees covering the **administrative costs of issuing building permits** which depend on the project's size and complexity. For the construction of a BTC plant, the estimated administrative cost for obtaining a building permit in Linköping amounts to approximately 300,000 SEK. Additionally, industrial facilities must obtain an **environmental permit** (*miljötillstånd*), which is issued by a specialized environmental court rather than the local municipality. This permit regulates emissions, waste, and other environmental aspects of the installation. The estimated cost for obtaining such an environmental permit for a BTC plant in Sweden is **around 3 million SEK.** Regarding waste management, Sweden applies a **waste management tax** (*avfallsskatt*) of **744 SEK per tonne** for waste sent to landfill. This tax also applies to ashes or residues generated by combustion processes that are disposed of in landfills. Since the exact amount of residues generated in the BTC process is not yet quantified, we can only provide this tax rate as an indicative reference.

	Building permit (€)	**Environmental permit (€)**	**Waste management tax (€/ton)**
TvAB	**27,450** (300,000 SEK)	**274,500** (3M SEK)	**68,10** (744 SEK/ton)

Table 35 B6.2 Taxes paid to local government in Sweden

In Spain, new industrial plants must pay the tax on **Constructions, Installations and Works** (**ICIO**, by its Spanish acronym). The ICIO tax rate taxes any construction, installation or work that requires obtaining the corresponding construction or urban planning license, is determined by the city council and cannot exceed a maximum rate of 4%[7]. The ICIO tax is applied to the civil and construction works excluding the equipment and material costs, as well as the engineering services. In addition, new industrial plants in Spain must pay the **activity fee** which is fixed based on the square meters of surface area affected by the activity. The civil and construction costs, and the square meters of each use case were provided by Phoenix when calculating the CAPEX in D4.1. Furthermore, industrial plants in Spain must also pay a waste management tax on the disposal of waste in landfills, incineration and co-incineration of waste. In this case, this tax applies on the remaining residues (ashes) from the combustion when they are put on landfill. However, as we don't know the amount of ashes generated, we cannot calculate this tax for each use case and only can provide the indicative tax for each of them.

In the case of **Sulquisa**, located in Madrid, the **ICIO tax rate is 4%** of the civil and construction works cost (10 M€), resulting in **400,000 €**. The **activity license fee** has been estimated at **7,376.8 and r**egarding waste management, the **landfill fee for ashes disposal** is estimated at approximately **50–60**

[7] https://serviciostelematicosext.hacienda.gob.es/SGFAL/ConsultaTipos/aspx/descargaPDF.aspx?URLPDF=2021/REGIMEN%20COMUN/4C-ICIO.pdf

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€/t. In the case of **CEMEX Alicante,** the ICIO rate is 3.25% of the civil and construction works cost (**520,000 €** (3,25% of 16 M€), while in Alcanar (Tarragona) the local ordinance sets a lower rate of **2.52%** (**403,200 €**), locally referred to as "Cànon Urbanístic" (urban development tax). Both correspond to the same tax regulated under Spanish local finance law. The **activity license fee** is similar to the case of Sulquisa for both locations, being estimated at around **7,376.8 €.** Lastly, for the CEMEX cases, no waste management tax has been considered, since the ashes generated by the BTC process would be reused as raw material within the cement production process, pending prior characterization. Therefore, no landfill disposal or associated tax would apply initially.

Civil and construction works cost	**Unit**	**TvAB**	**Sulquisa**	**CEMEX PowerGen** (Alicante and Alcanar)	**CEMEX CHP** (Alcanar)
	M€	16	10	16	16
BTC plant square meters	m^2	20,000	15,000	20,000	20,000

Table 36 Civil and construction costs, and square meters of each use case (D4.1 Business models analysis)

	Construction license (€)	**Activity license (€)**	**Waste management tax (€/ton)**
Sulquisa	**400,000** (Madrid, 4%)	**7,376.8**	**50–60**
CEMEX Alicante	**520,000** (Alicante, 3.25%)	**7,376.8**	-
CEMEX Alcanar	**403,200** (PowerGen) + **403,200** (CHP) (Tarragona, 2.52%)	**7,376.8**	-

Table 37 B6.2 Taxes: Construction, activity and waste management taxes

CONCLUSIONS

In summary, the deployment of BTC technology will generate an important positive economic impact for the local economy through the local taxes related to the construction and activity fees as well as waste management related to the construction and operation of the BTC plant in each use case.

Sources: TvAB, Sulquisa, CEMEX, D4.1 Business models analysis

4.3 CATEGORY C: PEOPLE AND COMMUNITIES

This category assesses the social dimension of Bio-FlexGen, focusing on potential impacts on local communities and their livelihoods. The project relies exclusively on forestry and agricultural residues, explicitly excluding feed and food crops for biofuel production in order to avoid negative effects such as land use change, biodiversity loss, or water resource depletion, in line with the European Renewable Energy Directive (RED III). Therefore, indicators related to impacts on **traditional livelihoods and cultural heritage sites (C1)**, **food security (C2)**, and **land use (C3)** are not affected in the context of the Bio-FlexGen project.

4.3.1 Subcategory C1: Impact on traditional livelihoods and cultural heritage sites

This subcategory assesses whether the sourcing of bioenergy feedstock affects traditional livelihoods (such as hunting, fishing, or harvesting of traditional foods and medicines) or restricts access to areas of cultural value, including sacred or recreational sites. In the case of Bio-FlexGen, all feedstock is

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sourced from forestry and agricultural residues rather than from newly deforested land. As a result, the project does not reduce access to traditional practices or cultural heritage areas.

C1.1 Limitation in access to traditional livelihoods practices

This indicator measures the limitation in access to traditional livelihoods practices (hunting and fishing, harvesting of traditional food and medicines, …) resulting from deforestation for biomass extraction (decrease of percentage of land dedicated to these activities over the years).

RESULTS

The project does not diminish the land available for traditional livelihood practices, as the biomass in all use cases is sourced from forestry and agricultural residues rather than from deforested areas.

C1.1 LIMITATION IN ACCESS TO LIVELIHOODS	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 (% land)	-	0%	**0%**
SE-TvAB-02 (% land)	-	0%	**0%**
SPAIN			
ES-Sulquisa-01 (% land)	-	0%	**0%**
ES-CEMEX-01			
Alcanar (% land)	-	0%	**0%**
Alicante (% land)	-	0%	**0%**
ES-CEMEX-02 (% land)	-	0%	**0%**
ES-CEMEX-03			
Alcanar (% land)	-	0%	**0%**
Alicante (% land)	-	0%	**0%**

Table 38 C1.1 Limitation in access to livelihoods

C1.2 Limitation in access to areas or resources of cultural value

C1.2 measures the limitation in access to areas or resources of cultural value such as sacred and recreational sites as a consequence of deforestation for biomass extraction (decrease of percentage of land dedicated to these activities over the years).

RESULTS

The project does not affect areas or resources of cultural value, such as sacred or recreational sites, since the biomass used in all use cases is sourced from forestry and agricultural residues rather than from deforested areas.

C1.2 LIMITATION IN ACCESS TO CULTURAL AREAS	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 (% land)	-	0%	**0%**
SE-TvAB-02 (% land)	-	0%	**0%**
SPAIN			
ES-Sulquisa-01 (% land)	-	0%	**0%**
ES-CEMEX-01			
Alcanar (% land)	-	0%	**0%**
Alicante (% land)	-	0%	**0%**
ES-CEMEX-02 (% land)	-	0%	**0%**
ES-CEMEX-03	-	0%	**0%**

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Alcanar (% land) Alicante (% land)	-	0%	0%

Table 39 C1.2 Limitation in access to cultural areas

4.3.2 Subcategory C2: Food security

This subcategory evaluates the potential impact of bioenergy feedstock sourcing on food availability and the diversion of edible feedstock from the food chain. The indicator examines whether biomass used in the project competes with food production. In the case of Bio-FlexGen, all feedstock is sourced from forestry and agricultural residues, and therefore no edible crops are diverted from the food chain to bioenergy.

C2.1 Edible feedstock diverted from food chain to bioenergy

C2.1 measures the edible feedstock diverted from food chain to bioenergy (Kilograms or Tons/year).

RESULTS

The project does not divert edible feedstock from the food chain to bioenergy, as the biomass in all use cases is sourced from forestry and agricultural residues rather than from food crops.

C2.1 EDIBLE FEEDSTOCK DIVERTED FROM FOOD CHAIN	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 (Kg or T/year)	-	0	0
SE-TvAB-02 (Kg or T/year)	-	0	0
SPAIN			
ES-Sulquisa-01 (Kg or T/year)	-	0	0
ES-CEMEX-01 Alcanar (Kg or T/year) Alicante (Kg or T/year)	- -	0 0	0 0
ES-CEMEX-02 (Kg or T/year)	-	0	0
ES-CEMEX-03 Alcanar (Kg or T/year) Alicante (Kg or T/year)	- -	0 0	0 0

Table 40 C2.1 Edible feedstock diverted from food chain

4.3.3 Subcategory C3: Land Use and Land Use Change

This subcategory assesses the potential impacts of bioenergy feedstock sourcing on land availability and land-use dynamics. The indicators examine whether biomass production for the project requires additional land, drives conversion between land-use types, or involves areas under dispute. In the case of Bio-FlexGen, since all feedstock is sourced from forestry and agricultural residues, no additional land is required, no land-use conversion is triggered, and no land conflicts are involved.

C3.1 Total area of land for feedstock production

C3.1 measures the total area of land used for bioenergy feedstock production, in comparison with the national surface and the area of agricultural and managed forest land.

RESULTS

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The project does not require any additional land for bioenergy feedstock production, as the biomass in all use cases is sourced from forestry and agricultural residues rather than from dedicated cultivation. Therefore, no additional land area is allocated to biomass production within the project.

C3.1 TOTAL AREA OF LAND FOR FEEDSTOCK PRODUCTION	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 (ha)	-	0	0
SE-TvAB-02 (ha)	-	0	0
SPAIN			
ES-Sulquisa-01 (ha)	-	0	0
ES-CEMEX-01 Alcanar (ha) Alicante (ha)	- -	0 0	0 0
ES-CEMEX-02 (ha)	-	0	0
ES-CEMEX-03 Alcanar (ha) Alicante (ha)	- -	0 0	0 0

Table 41 C3.1 Total area of land for feedstock production

C3.2 Net annual rates of conversion between land-use types

C3.2 measures the net annual rates of conversion between land-use types caused directly by bioenergy feedstock production.

RESULTS

The project does not cause any conversion of land-use types, as the biomass in all use cases is sourced from forestry and agricultural residues rather than from dedicated feedstock production. Net annual rates of land-use change attributable to the project are therefore considered to be zero.

C3.2 NET ANNUAL RATES OF CONVERSION	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 (ha)	-	0	0
SE-TvAB-02 (ha)	-	0	0
SPAIN			
ES-Sulquisa-01 (ha)	-	0	0
ES-CEMEX-01 Alcanar (ha) Alicante (ha)	- -	0 0	0 0
ES-CEMEX-02 (ha)	-	0	0
ES-CEMEX-03 Alcanar (ha) Alicante (ha)	- -	0 0	0 0

Table 42 C3.2 Net annual rates of land conversion

C3.3 Area of land currently under dispute

C3.3 measures the area of land currently under dispute or subject to land conflict.

RESULTS

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The project does not involve land under dispute, as the biomass in all use cases is sourced from forestry and agricultural residues rather than from newly allocated or contested land. Therefore, the area of land under dispute attributable to the project is considered to be zero.

C3.3 LAND CONFLICTS	BASELINE	BIO-FLEXGEN	IMPACT RESULT
SWEDEN			
SE-TvAB-01 (ha)	-	0	**0**
SE-TvAB-02 (ha)	-	0	**0**
SPAIN			
ES-Sulquisa-01 (ha)	-	0	**0**
ES-CEMEX-01			
Alcanar (ha)	-	0	**0**
Alicante (ha)	-	0	**0**
ES-CEMEX-02 (ha)	-	0	**0**
ES-CEMEX-03			
Alcanar (ha)	-	0	**0**
Alicante (ha)	-	0	**0**

Table 43 C3.3 Land conflicts

4.4 CATEGORY D: SOCIAL ACCEPTANCE

This category examines the extent to which bioenergy projects are perceived and accepted by society, focusing on factors such as public concerns, trust in stakeholders, knowledge about bioenergy, and opportunities for participation. In the case of Bio-FlexGen, the indicators under this category capture how local communities perceive the environmental, social, and cultural implications of the technology, as well as the degree of confidence in project developers, authorities, and industry actors. Therefore, the social acceptance indicators provide essential insights into community perceptions and trust, which are critical for the long-term sustainability and legitimacy of the project.

Qualitative data to assess the social acceptance dimension was collected through a **workshop** organized in collaboration with the **Navitas Student Association**, as well as through an **online survey** distributed to **Linköping University students** via the university's mailing list, and to the local community of **Linköping Municipality** through the municipal newsletter in order to reach a broad and diverse segment of the local community. These contacts were established thanks to the support of the Swedish pilot partner, TvAB. However, despite these distribution efforts, the number of responses did not reach the expected level, with only **six responses** received. Respondents ranged in age from **22 to 74 years old** (average age 40) and represented **diverse backgrounds**, including computer science, energy and environmental management, home care, civil engineering, and retirement. The **majority (67%) were men**, reflecting a small but varied sample of perspectives on bioenergy acceptance.

4.4.1 Subcategory D1: Level of Knowledge

This subcategory assesses the general level of understanding and awareness that local communities have about bioenergy technologies, their feedstock sources, and their environmental and social implications. A well-informed community is more likely to make balanced judgments about the benefits and risks of bioenergy, which directly influences overall social acceptance.

The results were collected through a qualitative survey following a *Likert scale* (from 'totally disagree' to 'totally agree') in which the opinion of participants regarding knowledge, public and environmental concerns, safety, impact of traditional livelihoods and cultural concerns was collected. Data is presented in tables below, and the corresponding graphs are included in Appendix C. To weight

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qualitative values, a rating of 1 to 5 was assigned to the qualitative values ¨totally disagree¨, ¨disagree¨, ¨neutral¨, ¨agree¨, ¨totally agree¨ respectively. The results are presented per statement and as an average of the ponderation per category. Average values higher than 3 show that participants in general agree or totally agree with the statements, while values under 2 represent that participants disagree or totally disagree with the statements.

D1.1 Level of knowledge on bioenergy

D1.1 measures the community's general understanding of bioenergy concepts, technologies, and feedstock sources. It assesses how familiar local residents are with biomass and bioenergy production processes, including the types of resources used and the forms of energy generated.

RESULTS

Knowledge about biofuels and bioenergy scored 3.7, indicating that most participants have a generally positive understanding of basic bioenergy concepts and the relevance of this energy source. Knowledge about resources used for bioenergy production reached a score of 3.2, slightly above the neutral point, suggesting that participants have a moderate level of familiarity with the types of biomass and raw materials employed, although this knowledge may not be deep or widespread. Knowledge about the types of energy produced from biofuels obtained the highest value, 4.0, showing that participants clearly recognize the different energy forms derived from biofuels. The overall average score of 3.6 indicates that, in general, participants agree with the statements related to their level of knowledge about bioenergy implying that the community demonstrates a moderate to good understanding of the topic, although there is room for improvement in specific technical areas.

D1.1 LEVEL OF KNOWLEDGE	IMPACT RESULT
Biofuels and bioenergy	**3.7**
Resources used for bioenergy production	**3.2**
The types of energy that can be produced from biofuels	**4**
Average	**3.6**

Table 44 D1.1. Level of Knowledge

CONCLUSIONS

Overall, the results indicate a moderate to high level of knowledge among local communities regarding bioenergy. Participants showed a good understanding of the types and applications of energy derived from biofuels, while their familiarity with feedstock sources and production processes is somewhat lower. This suggests that, although the community has a solid foundation to participate in discussions about bioenergy, there is still a need for educational and awareness programs to strengthen technical understanding and promote more informed decision-making related to bioenergy initiatives.

4.4.2 Subcategory D2: Public concerns

This subcategory examines the extent and nature of community concerns regarding bioenergy projects. It includes perceptions of environmental, safety, and social risks, as well as potential impacts on cultural values or traditional livelihoods. Understanding these concerns is essential to anticipate resistance, address misinformation, and promote transparent communication strategies.

D2.1 Environmental Concerns

D2.1 measures public perceptions of the potential environmental impacts of bioenergy plants, such as air pollution, odor, water contamination, noise, or visual effects on the landscape. It captures concerns about how biomass operations might affect environmental quality and local ecosystems.

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RESULTS

The results showed that the highest concern relates to air pollution and odor disturbances (3.7), suggesting that these are the most visible or immediate issues for the community. Moderate concern was expressed regarding noise and dust from traffic (3.0) and road damage (2.7), while lower concern was observed for water contamination (2.3) and soil degradation (2.3). The overall average score (2.8) indicates a general tendency toward low to moderate concern about environmental risks from bioenergy projects.

D2.1 ENVIRONMENTAL CONCERNS. *Biofuels/bioenergy plants can cause…*	**IMPACT RESULT**
Air pollution and odor disturbances	**3.7**
dangers for groundwater or surface water	**2.3**
soil degradation	**2.3**
noise and dust from traffic for the delivery of raw materials	**3**
roads´ damage due to traffic for delivery of raw materials	**2.7**
a negative impact on the natural landscape	**2.7**
Average	**2.8**

Table 45 D1.2 Environmental concerns

CONCLUSIONS

Overall, the findings suggested that community members recognize some environmental risks, mainly related to air quality and local disturbances, but do not perceive bioenergy as a major environmental threat. The relatively low concern levels indicate that public opposition may be limited, although continued communication and transparency are recommended to prevent misinformation and strengthen public confidence in bioenergy development.

D2.2 Safety and social concerns

D2.2 measures perceptions of safety and social risks associated with biomass plants, including fears of accidents, fires, or explosions, as well as potential effects on property values, tourism, or food prices. This indicator reflects how perceived risks shape community attitudes toward bioenergy projects.

RESULTS

The results showed different levels of concern across topics. Regarding economic and land-use aspects, the highest concern is related to excessive monocultures (3.3) and competition with food production (3.0), while concerns about energy price increases (2.2) and food access (2.3) remain lower. For safety and local economic impacts, scores are significantly lower: respondents disagree that bioenergy plants negatively affect property values (1.8), local economies (1.8), or pose higher accident risks than coal plants (1.5), resulting in a low average of 1.9. On the contrary, positive perceptions appear in the statements related to economic improvement and compensation fairness, both rated 3.8, showing that participants recognize potential benefits and the importance of fair treatment for affected groups. Overall, the average results range between 1.9 and 3.8, indicating low concern about safety risks and moderate agreement with potential economic and environmental benefits.

D2.2 SAFETY AND SOCIAL CONCERNS *The production of biofuels…*	**IMPACT RESULT**
will increase the price of energy	**2.2**
competes with the production of food	**3**

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can reduce our access to food	2.3
will increase excessive monocultures (e.g. of individual tree species)	3.3
Average	2.7

Table 46 D2.2 Safety and Social Concerns on the Production of biofuels.

D2.2 SAFETY AND SOCIAL CONCERNS *The Biofuels/ biogas plant…*	IMPACT RESULT
Has a negative impact on property values in our community	1.8
Worsens our economy (e.g. reduced property values, fewer tourists)	1.8
Is worse for my economy than a wind farm (e.g. reduced property value, fewer tourists)	2.3
Poses a higher risk of accidents to residents than a coal-fired plant (e.g. risk of fires and explosions due to gas leakages or leakage of a container)	1.5
Average	1.9

Table 47 D2.2 Safety and Social Concerns on the biofuels/ biogas plant

D2.2 SAFETY AND SOCIAL CONCERNS	IMPACT RESULT
Improves our economy (e.g. higher value of forests)	3.8
People negatively affected by power generation projects should be compensated	3.8
Average	3.8

Table 48 D2.2 Safety and Social concerns in general

CONCLUSIONS

In general, communities express little concern about safety or negative social effects from bioenergy projects and even perceive potential economic and environmental advantages. While some hesitation remains about land-use changes and monocultures, the overall attitude is neutral to positive, suggesting a favorable context for social acceptance if transparent communication and fair compensation mechanisms are maintained.

D2.3 Impact on traditional livelihoods and cultural concerns

D2.3 measures how communities perceive the effects of biomass extraction and bioenergy operations on access to traditional livelihoods and cultural practices, such as hunting, fishing, or the use of sacred and recreational areas. It helps identify potential cultural or social tensions that could affect project legitimacy.

RESULTS

The results showed a moderate level of concern, with participants agreeing to some extent that biomass extraction could reduce access to traditional livelihoods such as hunting, fishing, or gathering forest products (3.2). Concerns about restricted access to sacred or recreational sites are slightly lower (2.8). The average score of 3.0 indicates an overall neutral to moderately concerned perception,

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suggesting that communities recognize possible cultural and livelihood impacts but do not view them as highly critical.

D2.3 IMPACT ON TRADITIONAL LIVELIHOODS AND CULTURAL CONCERNS *Biomass extraction can…*	IMPACT RESULT
Reduce our access to traditional livelihoods (hunting and fishing, mushroom and berry picking)	3.2
Disrupt our culture by reducing access to sacred and recreational sites	2.8
Average	3.0

Table 49 D2.3 Impact on Traditional Livelihoods and Cultural concerns

CONCLUSIONS

Overall, communities express a moderate awareness of potential cultural and livelihood impacts from biomass extraction, mainly related to access to traditional activities. While these concerns are not dominant, they highlight the importance of inclusive planning and dialogue with local stakeholders to ensure that bioenergy development respects cultural values and traditional resource use.

4.4.3 Subcategory D3: Local/Global Advocacy for Development of Bioenergy Industry

This subcategory evaluates public support for the development of the bioenergy sector at both global and local levels. It reflects how citizens perceive bioenergy as a solution to global challenges such as climate change and energy dependency, as well as its potential local benefits for economic and social development. The indicators measure attitudes towards the overall importance of bioenergy and its acceptance within local communities, helping to identify levels of global endorsement and local willingness to host such projects.

D3.1 Global support

D3.1 measures public attitudes toward bioenergy as a means to address global challenges, including climate protection, energy independence, and national economic development. It captures the degree to which people view bioenergy as a fair, clean, and beneficial energy source within broader sustainability goals.

RESULTS

D3.1 results showed strong positive attitudes toward bioenergy, with all statements scoring above 3.3. The highest agreement appears to be with the perception that bioenergy helps reduce dependence on imported energy (4.2) and protects the climate (4.0). Similarly, respondents believe bioenergy is an effective way to produce electricity and heat (4.0) and can contribute to national economic development (3.8). Slightly lower, but still positive, are views regarding its cleanliness (3.5) and the fair balance between costs and benefits (3.3). The overall average of 3.8 indicates a high level of global support and trust in bioenergy as a sustainable and beneficial energy source.

D3.1 GLOBAL SUPPORT *Bioenergy/ Bioenergy plants*	IMPACT RESULT
is a good way to produce electricity and heat	4
should play an important role in Sweden's future energy production	3.5
protects the climate	4
is a clean source of electricity	3.5

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the relationship between costs (e.g. odours) and benefits (e.g. economic profits) is distributed fairly	**3.3**
that burn biofuels helps reduce dependence on imported energy	**4.2**
can contribute to economic development in Sweden	**3.8**
Average	**3.8**

Table 50 D3.1 Global Support

CONCLUSIONS

In summary, the community demonstrates a strong global endorsement of bioenergy, recognizing its potential to combat climate change, enhancing energy independence, and supporting economic growth. Positive perceptions outweigh concerns, reflecting a broad social acceptance of bioenergy's global role in sustainable development. Continued communication on fairness and transparency could further reinforce this supportive attitude.

D3.2 Local support and relevance of proximity

D3.2 measures local acceptance of bioenergy plants in nearby areas, exploring attitudes toward perceived benefits for municipalities, and the acceptable distance between plants and residential areas. It helps gauge the "Not In My Backyard" (NIMBY) effect and the perceived contribution of bioenergy to local development.

RESULTS

D3.2 results showed a high level of local support, with respondents expressing agreement that they support bioenergy plants in their neighborhoods (3.7) and consider such projects contribute to the economic development of their municipality and region (3.8). The overall average (3.8) indicates a positive local perception of bioenergy's role in fostering local progress.

Regarding proximity, 83% of participants stated that the distance would not be relevant as long as the facility is not visible from their homes, while 17% reported that distance is not relevant at all. None of the respondents rejected the facility regardless of distance, and none required a specific minimum distance. When asked about acceptable proximity, 83% indicated 1–5 km, while only 17% preferred more than 50 km. These results reveal low resistance and minimal NIMBY attitudes, with aesthetic visibility being the primary concern.

D3.2 LOCAL SUPPORT AND RELEVANCE OF PROXIMITY	**IMPACT RESULT**
I support biofuels/bioenergy plants in my neighbourhood	**3.7**
Biofuels/bioenergy plants can contribute to the economic development of my municipality and region	**3.8**
Average	**3.8**

Table 51 Local Support and relevance of proximity I

D3.2 LOCAL SUPPORT AND RELEVANCE OF PROXIMITY	**IMPACT RESULT**
To what extent would the distance between your house/apartment and biofuels or bioenergy plant be important to you?	
I do not/would not accept the facility, regardless of distance	**0%**
The distance of the facility to my home is not/would not be relevant to me	**17%**

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The distance is/would not be relevant but the facility should not be visible from my home	**83%**
The facility should maintain a minimum distance from my home	**0%**
What minimum distance to a biofuel/bioenergy plant from your home would be acceptable to you?	
1-5km	**83%**
20-50km	**0%**
>50km	**17%**

Table 52 Local Support and relevance of proximity II

CONCLUSIONS

In general, communities show strong local support for bioenergy development, recognizing its economic value and limited social disruption. Acceptance is even high for nearby facilities, with concerns focused mainly on visual impact rather than distance or safety. These findings suggest favorable conditions for local bioenergy deployment, provided that landscape integration and transparent communication are ensured.

4.4.4 Subcategory D4: Trust and credibility in stakeholders

This subcategory evaluates the level of confidence that communities have in the main stakeholders involved in bioenergy projects, particularly the industry and local authorities. Trust is a key factor influencing social acceptance, as it reflects how people perceive the transparency, competence, and responsibility of those managing and regulating the technology. The indicators measure the degree of trust in the industry to operate plants safely and in municipalities to ensure fair oversight and consider public concerns.

D4.1 Trust in industry

D4.1 measures the level of trust that local communities have in industrial operators to ensure safe, transparent, and socially responsible implementation of bioenergy projects. It evaluates perceptions of competence, reliability, and willingness to consider residents' concerns.

RESULTS

Results from D4.1 showed high levels of trust in the industry. Respondents strongly agree that environmental permits guarantee safe and technically reliable facilities (4.5) and that companies operate such facilities safely (4.2). Trust is slightly lower, though still positive, regarding whether the permitting process adequately considers residents' concerns (3.8). The overall average of 4.2 reflects strong public confidence in industrial operators, particularly in their technical capability and compliance with safety and regulatory standards.

D4.1 TRUST IN INDUSTRY *I trust that...*	**IMPACT RESULT**
the facility's environmental permit means that safe technical facilities will be built, and that these are built using safe methods	**4.5**
the permit process takes into account the concerns of local residents, and that the company follows what comes out of the permit	**3.8**
the company will/would operate the facility safely	**4.2**

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Average	4.2

Table 53 Trust in industry

CONCLUSIONS

Overall, communities demonstrate a high degree of trust in the bioenergy industry, especially regarding technical safety and operational reliability. While confidence in the consideration of local concerns is somewhat lower, perceptions remain very positive, showing that clear communication and strong regulation increase public confidence.

D4.2 Trust in municipality

D4.2 measures confidence in local authorities to oversee the safe and fair deployment of bioenergy plants. It assesses whether citizens believe municipalities take public concerns into account and enforce appropriate safety and environmental regulations.

RESULTS

The results showed moderately high levels of trust in local authorities. Respondents expressed the highest confidence that supervisory authorities ensure the construction of safe technical facilities (4.0) and that the Land and Environmental Court makes responsible decisions (3.8). Trust is slightly lower, though still positive, regarding the municipality's consideration of residents' concerns (3.3) and the application of safety checks (3.7). The overall average of 3.7 indicates a generally positive perception of municipal competence and responsibility in overseeing bioenergy projects.

D4.2 TRUST IN MUNICIPALITY *I trust that*	**IMPACT RESULT**
Linköping Municipality will/would consider residents' concerns	**3.3**
The Land and Environmental Court makes a responsible decision on whether or not such a facility should be built	**3.8**
the supervisory authority ensures that secure technical facilities will be built	**4**
the regulatory authority will/would carry out safety checks to ensure safe operation of the facility	**3.7**
Average	**3.7**

Table 54 Trust in municipality

CONCLUSIONS

Overall, the community shows solid trust in local authorities, particularly in their technical oversight and regulatory responsibility. Although confidence in how well public concerns are considered is somewhat lower, perceptions remain positive, suggesting that transparent decision-making and effective communication can further strengthen institutional credibility and public confidence.

4.4.5 Subcategory D5: Participation of society

This subcategory assesses the degree of public involvement in the planning and implementation of bioenergy projects. Participation reflects how citizens are informed, consulted, and engaged in decision-making processes. The indicators evaluate community expectations regarding access to information, opportunities for consultation and cooperation, and the assumption of shared responsibility. Higher participation levels contribute to transparency, trust, and long-term social acceptance of the technology.

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D5.1 Desired information

D5.1 measures how important it is for community members to be informed in advance about planned bioenergy projects and how satisfied they are with the quality and timing of the information provided. It reflects the role of transparency in social acceptance.

RESULTS

The results showed a very high expectation for information transparency, with respondents strongly agreeing that it is important to receive information in advance about planned bioenergy projects (4.3). This highlights that communities value clear and proactive communication as a foundation for building trust and acceptance.

D5.1 DESIRED INFORMATION	IMPACT RESULT
It is important for me to receive information in advance about planned biofuel/bioenergy plants	**4.3**

Table 55 Desired information

CONCLUSIONS

In summary, the results indicate that early and transparent communication is a key public expectation in the bioenergy sector. Ensuring that communities are well-informed from the planning stage can significantly enhance participation, trust, and long-term social acceptance of bioenergy projects.

D5.2 Desired consultation, D5.3 Desired cooperation, and D5.4 Desired assumption of responsibility

Since in Sweden bioenergy projects are already subject to mandatory public consultation under the Environmental Impact Assessment (EIA) process within the national environmental permitting framework (CE Sweden, 2025), it was considered redundant to assess indicators related to “desired consultation” (D5.2), “desired cooperation” (D5.3), and “desired assumption of responsibility” (D5.4). These aspects are institutionally guaranteed and form part of Sweden’s governance system, where residents and stakeholders are formally consulted and their views must be considered before permits are granted. Therefore, measuring these indicators would not provide additional value, since they represent mandatory legal steps rather than voluntary participation.

4.4.6 Subcategory D6: Attitudes towards financial support/ funding

This subcategory analyses public perceptions of the role of financial actors, such as public authorities, banks, and investors, in supporting bioenergy projects. The indicator assesses the desired level of involvement and transparency of these actors in project financing. Positive attitudes towards funding are linked to perceptions of fairness, accountability, and alignment with community interests, which reinforce trust and overall social acceptance.

D6.1 Attitudes towards financial support and funding

D6.1 measures stakeholder opinions on the role and involvement of financial actors, such as public authorities, banks, or investors, in supporting bioenergy projects.

RESULTS

D6.1 showed a moderately positive attitude toward financial involvement, with respondents agreeing that decisions regarding local bioenergy projects should be made together with the financial actors behind them (3.5). This indicates a general expectation that funding institutions share responsibility and participate transparently in project decisions, reinforcing the importance of openness in financial governance.

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D6.1 ATTITUDES TOWARDS FINANCIAL SUPPORT AND FUNDING	IMPACT RESULT
Decisions regarding the realization of a local biomass/bioenergy plant must be made together with the financial actors behind the project	3.5

Table 56 Attitudes towards financial support and funding

CONCLUSIONS

In summary, the community shows support for collaborative decision-making involving financial stakeholders, reflecting a desire for transparency and accountability in how bioenergy projects are financed. These results suggest that visible and responsible participation from financial actors can further strengthen public trust and acceptance of bioenergy initiatives.

4.4.7 Complementary insights from the Navitas Student Association Workshop

Qualitative data to assess the social acceptance dimension was also collected through the workshop organized in collaboration with the Navitas Student Association. The session aimed to complement the quantitative indicator analysis by gathering participants' perspectives on bioenergy's perceived benefits, risks, and social implications. During the workshop, students discussed topics such as trust in industry and authorities, environmental and cultural concerns, and the role of transparency and participation in bioenergy development. The discussions provided valuable context to interpret the indicator results, revealing that social acceptance depends not only on technical performance but also on communication, fairness, and community involvement.

Most participants (strongly) agreed that bioenergy plants were a suitable form of energy generation and that bioenergy should play an important role in Sweden's future energy production. In general, participants expressed neutral opinions regarding the ratio between the costs of bioenergy plants (e.g., odours) and their benefits (e.g., financial gains). They also remained neutral on whether bioenergy was a clean energy source. Overall, most participants did not seem concerned about potential risks and impacts of bioenergy plants. They strongly disagreed with the statement *"Bioenergy plants cause negative impacts on property values in our community"* and disagreed with the statements *"Bioenergy plants cause environmental degradation"* and *"Bioenergy plants increase the risk of accidents for residents."* This perception was consistent with their high level of trust in industry, as they strongly agreed that the industry would ensure safe technological facilities.

Participants remained neutral regarding the potential increase of monocultures and competition with food production, explaining that in Sweden monocultures are uncommon and bioenergy plants mainly operate using waste-based feedstocks. While trust in the industry's ability to ensure safe technology was high, participants expressed concerns about their right to participation.

Regarding participation of society, although Swedish law requires public consultation during the planning and implementation of bioenergy projects, the workshop served as an opportunity to explore whether citizens are truly aware of these processes. Despite the legal obligation for consultation, many participants felt insufficiently informed about how these procedures take place, and their trust in the industry to consider residents' concerns was relatively low (2.7/5). When asked about the importance of being informed in advance, participants' responses ranged between neutral and agree (3.5/5), while they disagreed with the idea that they could actively contribute to decisions about installing bioenergy plants in their neighborhood (2/5). These findings reveal a gap between formal consultation requirements and public awareness, emphasizing the need for more effective communication and participatory mechanisms to strengthen social trust and transparency in future bioenergy projects.

In general, local support was high. Participants agreed with the construction of bioenergy plants in their neighbourhood (4/5) and believed that such projects could contribute to the economic

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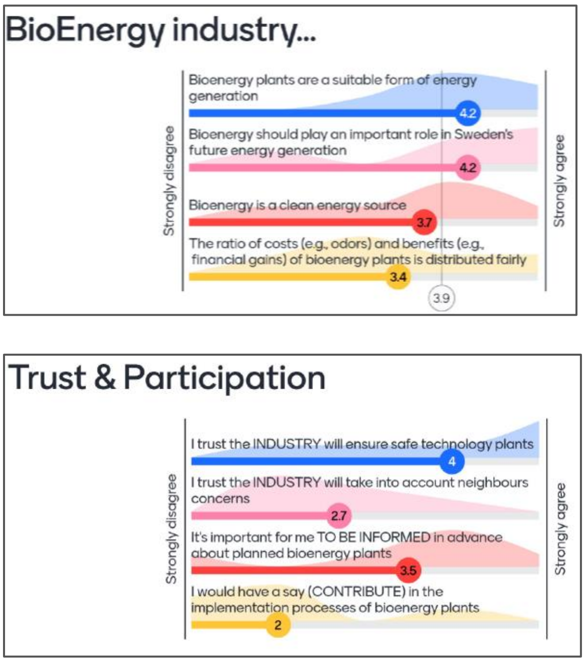
development of their municipality (4.3/5). Their main concerns related to odours and visual impacts on the landscape, leading them to prefer that bioenergy plants be located in industrial areas or near existing facilities, rather than in the countryside or traditionally agricultural land.



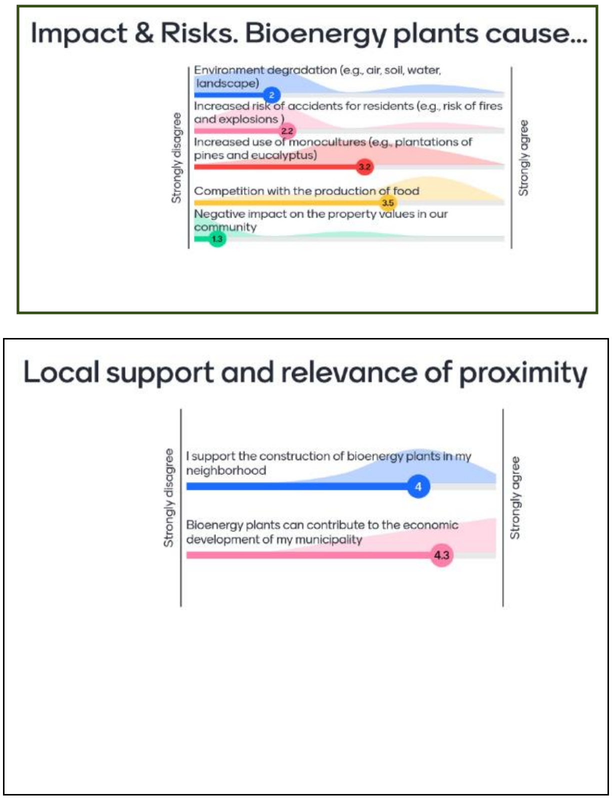


Figure 7 Social acceptance results from the workshop

5 Potential social impact of Bio-FlexGen project

The Bio-FlexGen project demonstrates a **strong positive social impact across employment, economic, and community dimensions**. The results are presented according to impact categories, geographical scale (from local to European), and key stakeholder groups for each use case.

Overall, Bio-FlexGen preserves existing jobs, creates new permanent and temporary opportunities, and supports workforce upskilling, thereby strengthening human capital. Economically, the substitution of fossil fuels with agricultural and forestry residues reduces import dependency, stabilizes energy prices, and generates value through local and national supply chains. From a community perspective, the project safeguards traditional livelihoods, cultural heritage, and food security, while fostering rural development and social cohesion. Together, these outcomes position Bio-FlexGen as a socially responsible and sustainable initiative aligned with the EU's Green Deal and Just Transition objectives.

Category A: Impact on Employment

Bio-FlexGen generates a positive effect on employment across all pilot sites. Existing jobs in CHP plants are preserved, with employees offered targeted training to operate the new BTC units. In addition, new direct jobs are created, particularly for operation, maintenance, and construction phases, with most being permanent and medium-skilled positions that match the skills of the local workforce. Beyond direct employment, indirect jobs emerge in the biomass supply chain, transport, and equipment manufacturing, adding long-term opportunities at regional and national levels. Importantly, the project contributes to upskilling current staff, improving career development and productivity

Category B: Impact on the Economic Dimension

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From an economic perspective, the project demonstrates strong sustainability potential. The replacement of fossil fuels with agricultural and forestry residues reduces fuel costs by more than 50% in the Spanish use cases and provides greater price stability compared to volatile fossil fuel markets. Beyond direct cost reductions, biomass offers additional economic advantages due to its local availability and reduced dependency on imports. In addition, by replacing fossil-based generation, BTC technology avoids the costs associated with CO_2 emissions under the EU Emissions Trading System (EU ETS), further improving its competitiveness and long-term cost efficiency. Industries using natural gas or other fossil fuels currently pay for every tonne of CO_2 emitted (a cost expected to increase in the coming years) whereas biomass-based systems are exempt from such expenses. Furthermore, Bio-FlexGen promotes local and national economic benefits: during the construction phase, local industries and service providers are engaged, while at the operational stage, the biomass supply chain stimulates regional economies, particularly in rural areas. Taxes and fees associated with new installations also support municipal revenues. Overall, BTC technology contributes to economic resilience, aligns with the circular bioeconomy, and supports the EU's Just Transition goals through both cost reduction and carbon mitigation.

Category C: People and Communities

The project avoids negative social or cultural impacts since it does not restrict access to traditional livelihood practices, nor does it affect areas of cultural or spiritual significance. Similarly, no edible feedstock is diverted from the food chain, since biomass feedstocks exclusively consist of agricultural and forestry residues rather than food crops. By ensuring that biomass sourcing does not compete with food production or traditional land uses, the project safeguards community well-being. At the same time, the decentralized bioenergy model strengthens rural development, particularly in regions at risk of depopulation, creating business opportunities and supporting local cohesion. This positions Bio-FlexGen as a socially responsible project that integrates energy innovation with community interests.

Category D: Social Acceptance

Overall, Bio-FlexGen benefits from a supportive social environment, with high trust and moderate concerns which are key conditions for long-term acceptance. Participants from the online survey and the workshop recognise its role in climate protection, energy independence, and economic development. Knowledge about bioenergy is moderate to high and public concerns are limited, mainly related to odour and visual impacts. Trust in industry and authorities are strong, showing confidence in safety and environmental oversight. However, many citizens are unaware of existing consultation processes, suggesting a need for clearer communication. Communities also value transparency and shared responsibility, expecting financial and institutional actors to be involved openly in project decisions.

GEOGRAPHICAL SCOPE OF BIO-FLEXGEN SOCIAL IMPACTS

At the **company level (pilot sites)**, Bio-FlexGen contributes directly to operational efficiency, reduced fuel costs, and employment stability. Existing workers are retained and upskilled, while new permanent and temporary jobs are created for plant operation, maintenance, and construction. These benefits enhance workforce resilience and ensure that employees gain future-oriented skills aligned with the energy transition.

At the **community level**, the project generates employment and economic opportunities without causing negative externalities such as odor, land-use conflicts, or displacement. By sourcing biomass exclusively from agricultural and forestry residues, Bio-FlexGen safeguards cultural values, traditional livelihoods, and food security, ensuring that bioenergy development is compatible with local interests and community well-being.

At the **local and regional level**, Bio-FlexGen strengthens rural economies through the creation of biomass supply chains and related industries. The use of agricultural and forestry residues not only

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provides local value creation but also helps mitigate the risk of forest fires by reducing biomass accumulation. In doing so, the project contributes to regional cohesion and supports the revitalization of depopulated rural areas—particularly in regions of Spain vulnerable to economic decline and outmigration.

At the **national level**, Bio-FlexGen demonstrates a positive social impact in both Sweden and Spain, though with different emphases. In **Sweden**, the project focuses on maintaining employment and consolidating technological leadership in the bioenergy sector. Existing CHP jobs are preserved, employees benefit from targeted upskilling, and a small number of new permanent medium-skilled positions are created to operate the BTC units. Temporary jobs during construction also generate local economic benefits. While the economic impact is more moderate, given that biomass is already well integrated into Sweden's energy system, the project reinforces national expertise in sustainable bioenergy and contributes to ongoing climate and innovation goals. In **Spain**, the project delivers an even stronger positive social and economic impact. By replacing fossil fuels such as natural gas and fuel oil with agricultural and forestry residues. Bio-FlexGen *significantly reduces energy costs and enhances price stability, while promoting greater independence from imported fuels.* The project sustains existing jobs, creates new direct positions, and generates substantial indirect employment in biomass supply chains, particularly benefiting rural regions with high biomass potential. The decentralized bioenergy model contributes to rural development, offers long-term opportunities in areas vulnerable to depopulation ("empty Spain"), and aligns with the Spanish *Just Transition Strategy* by fostering job creation and economic diversification in regions undergoing industrial restructuring.

At the **European level**, Bio-FlexGen contributes to EU-wide efforts to reduce emissions, expand renewable energy sources, and promote social sustainability. Its scalable and replicable technology demonstrates the potential for deployment across Member States, reinforcing the EU's leadership in sustainable energy and advancing the goals of the *European Green Deal* and *Just Transition* frameworks. By combining technological innovation with tangible socio-economic benefits, Bio-FlexGen exemplifies how bioenergy can support a fair, inclusive, and low-carbon energy transition across Europe.

5.1 Stakeholder-Based Social Impact

The potential social impact of the Bio-FlexGen project differs by stakeholder and national context, reflecting the priorities and social structures of each demonstration site.

Sweden (District Heating – Key stakeholder: Local communities)

In Sweden, the main stakeholder group affected by Bio-FlexGen is the local community surrounding the DH plant. The project ensures job continuity, introduces new technical roles, and enhances local energy resilience.

- **Employment and opportunities**: No job losses occur during the transition to BTC technology. Instead, new permanent technical positions are created at TvAB, most of them filled by local residents with specific BTC training. This secures local employment and builds technical capacity within the community.
- **Territorial and economic effects:** Although biomass is sourced regionally and nationally rather than within the municipality, the construction and installation phases generate local economic activity through engineering, civil works, and assembly services. These short-term contracts benefit local SMEs and contribute to community income.
- **Energy affordability and stability:** While BTC increases marginal electricity costs in the short term (2035), it helps reduce prices and enhance energy stability in the longer term (2045). This strengthens social resilience and mitigates vulnerability to energy crises.

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- **Sustainability perception:** Biomass feedstock derives exclusively from forestry and agricultural residues, avoiding competition with food production or deforestation. This strengthens public trust and community acceptance by aligning local environmental and sustainability values.

Overall, the Swedish use case demonstrates that Bio-FlexGen supports local employment, strengthens regional energy security, and reinforces public confidence in renewable energy technologies as socially beneficial and environmentally sound.

Spain (Sulquisa and CEMEX – Key stakeholders: Employees and investors)

In Spain, the key stakeholders are employees (primary) and investors (secondary), reflecting the project's strong industrial and labor dimensions.

Employees:
Bio-FlexGen ensures job stability, creates new employment, and provides extensive training opportunities in both demonstration plants.

- **Job retention and creation:** At Sulquisa, all existing jobs are maintained with no losses. In addition, at each CEMEX plant, new permanent and temporary jobs are created during construction and start-up phases.
- **Job quality and skills development:** Most new positions are medium-skilled operator roles complemented by a smaller number of engineering positions. All permanent roles are stable and locally filled. Each worker receives over 250 hours of BTC-specific training covering operation, integration, and safety procedures, directly improving professional skills, career prospects, and workplace safety.
- **Just Transition alignment:** By maintaining employment and providing re-skilling in decarbonizing industries, Bio-FlexGen supports both Spanish and EU Just Transition policies, ensuring that industrial transformation benefits workers rather than displacing them.

Investors:
For investors and industrial operators, Bio-FlexGen demonstrates clear economic and environmental advantages.

- **Fuel cost savings:** At Sulquisa, switching from natural gas to biomass reduces fuel costs by over 50%; at CEMEX, replacing fuel oil achieves nearly 70% savings.
- **Profitability and competitiveness:** This cost reductions translate into profitability increases of approximately +25% for Sulquisa and +32–45% for CEMEX, strengthening the financial viability of sustainable energy models.
- **Environmental performance:** CO_2 emissions are reduced by 80% at Sulquisa and nearly 100% at CEMEX, enhancing companies' ESG ratings and public reputation.
- **Challenges and balance:** Although biomass presents lower calorific efficiency compared to fossil fuels, the overall balance remains positive due to significant cost, employment, and environmental benefits.

Overall, the Spanish demonstrations show that Bio-FlexGen delivers tangible benefits for workers and companies alike, driving economic performance, employment stability, and sustainability. These outcomes reinforce social support for renewable bioenergy and highlight the project's contribution to fair industrial decarbonization.

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6 Future recommendations and engagement strategies

Although Bio-FlexGen has demonstrated positive social outcomes, future actions should focus on addressing challenges to fully realize its long-term potential and maximize its social, economic, and environmental benefits.

In Sweden, production costs of BTC technology remain higher than in the baseline scenario, highlighting the need for cost-reduction measures, scaling up production, and securing supportive policy instruments to enhance competitiveness. Similarly, the profitability of BTC technology is still sensitive to biomass prices and investment costs, underlining the importance of establishing long-term supply contracts and financial support schemes.

At the community level, while the project contributes positively at regional and national level, local economic impacts could be further strengthened by incentivizing local biomass collection and fostering cooperation with farmers, forest owners, and SMEs. Finally, although the project safeguards food security and cultural values, maintaining and enhancing social acceptance requires continuous stakeholder engagement, and transparent communication on sustainability and community benefits.

At the country level, while Sweden should prioritise improvements in economic performance and competitiveness, Spain should focus on local value creation and rural revitalisation. In both contexts, strengthening workforce training, innovation, and technology integration will be key to sustaining long-term economic and environmental performance of the Bio-FlexGen project.

Beyond these technical and economic priorities, maintaining and enhancing social acceptance will also be crucial. In Sweden, engagement should prioritise clear communication and community participation around DH systems, ensuring that citizens understand the technology's safety and environmental benefits. In Spain, emphasis should be placed on internal communication, worker training, and alignment with the Just Transition objectives to secure employee trust and motivation. Together, these actions can maximise the project's overall social, economic, and environmental value.

6.1 Future Engagement Strategies for Bio-FlexGen Use Cases

The assessment of social, economic, and environmental indicators in the Swedish and Spanish use cases suggests potential impacts of the Bio-FlexGen technology, such as job creation, cost reductions, and sustainability gains. However, the true value of these outcomes would depend on how they are perceived and understood by the stakeholders most directly affected. In a real implementation scenario, communication and engagement actions could be designed to ensure that stakeholders not only receive transparent information but also feel actively involved in the transition. Based on this, an external engagement strategy targeting local communities is proposed for Sweden, while an internal strategy focusing on employees is proposed for the Spanish industrial cases.

Sweden – District Heating (Key Stakeholders: Local Communities)

- **Communication channels**: Disseminate information through municipal and regional websites, local media, and social networks. Collaborate with local authorities to include BTC technology within broader sustainability communications.
- **Community events:** Present BTC technology at local fairs, energy days, and town-hall meetings. Organise open days at DH facilities to allow citizens to experience the technology first-hand.
- **Workshops and citizen meetings**: Run accessible, non-technical workshops explaining community benefits (stable energy prices, job security, emission reductions). Highlight temporary construction jobs and medium-term energy security gains.

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- **Key messages**: BTC creates new local jobs without job losses, helps stabilise energy prices, reduces dependence on fossil fuels, and uses sustainable biomass that does not compete with food or forests.

Spain – Sulquisa & CEMEX (Key Stakeholders: Employees)

- **Internal communication:** Use existing channels such as intranet updates, newsletters, and management briefings to ensure regular visibility of project progress. Departmental meetings should provide employees with opportunities to ask questions, share concerns, and understand how BTC technology affects their work and the company's sustainability goals.
- **Training as engagement:** Present the BTC technical training (≈250+ hours) not just as a technical requirement but as a professional development opportunity. Focusing on bioenergy, digital monitoring, and safety skills will support workers' adaptation to a changing energy sector. Linking training to certification and long-term employability will boost motivation and reinforce employee ownership of the transition.
- **Dialogue spaces:** Establish focus groups or Q&A sessions to allow staff to share expectations and feedback. These spaces build trust, improve transparency, and make employees feel actively included in the process.
- **Key messages:** Emphasise that BTC deployment will not cause job losses; instead, it creates stable skilled positions and aligns with Spain's Just Transition Strategy and EU climate goals making the technology both secure and socially responsible.

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7 Conclusions

Task 5.2 "Social Assessment" of WP5 aimed to evaluate the potential social impact of the Bio-FlexGen technologies through a structured framework of indicators applied to **two theoretical deployment scenarios**: a **District Heating use case in Sweden** and **two industrial use cases in Spain**. These scenarios were designed to anticipate the potential social implications of future deployment and to assess how the *Biomass-fired Top Cycle (BTC)* technology could influence employment, economic performance, community well-being, and social acceptance across different contexts.

A total of **66 indicators** were initially defined and validated by consortium partners and community representatives, resulting in **32 final measurable indicators** organized under four categories: employment, economic dimension, people and communities, and social acceptance. The validation confirmed that all categories were relevant, with employment ranked as the most significant, particularly in relation to health, safety, and job quality. Participants also stressed the importance of food security, energy affordability, and trust in stakeholders, and proposed future inclusion of indicators on health and well-being, equity, resilience, and biodiversity.

The **measurement results** reveal that Bio-FlexGen performs positively across all social dimensions. The technology preserves existing jobs, creates new permanent and temporary positions, and fosters workforce upskilling. Economically, it lowers fuel costs by more than 50% in Spain, increases profitability, and supports local and regional economies through biomass supply chains. Socially, it safeguards food security, cultural heritage, and traditional livelihoods, while contributing to rural revitalization and community cohesion. Although social acceptance was only evaluated in Sweden, the results indicate broad community support and trust in renewable bioenergy solutions.

In conclusion, Bio-FlexGen demonstrates a **high potential for positive social impact**, especially in job creation, economic resilience, and community well-being. Despite the data limitations inherent to its current development stage, the results provide preliminary but robust evidence that BTC technology can support a fair, inclusive, and sustainable energy transition in Europe.

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Appendix A. Validation by project partners

This project has received funding from the European Union's Horizon 2020
research and innovation programme under grand agreement N° 101037085.

Categories	Subcategory	No	Indicators	How to calculate the indicator	Validation by partners	Justification for the inclusion (IN)/ exclusion (EX) of the indicators
CATEGORY A: IMPACT ON EMPLOYMENT	A1: JOB LOSSES	**A1.1**	total number of job losses	total number of job losses as a consequence of replacing: - the current biomass extraction technology - current fossil fuel energy plants - or adapting the current BTC technology as well as job lossess for other existing livelihood activities (due to the expansion of biomass extraction)	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
	A2: JOB CREATION	**A2.1**	total number of annual direct jobs created	total number of annual direct jobs created to operate (sum of the three situations): - the new biomass extraction technology - the new bioenergy plant/technology - the new CO_2 capture and storage technology Breakdown should be given for categories of employment (management, technician…) and desagregated by sex, skilled/unskilled, indefinite/temporary	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
	A3: JOB QUALITY	**A3.1**	% skilled/unskilled jobs	Annual percentage of skilled/unskilled jobs per category of employment (management, technician…).	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		A3.2	% permanent/temporary	Annual percentage of permanent/temporary jobs created. Percentage of workers that have a fixed contract employment per category of employment (management, technician…).	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		A3.3	Provision of worker training	Average hours of training per year per employee and type of training (excluding OHS training)	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
CATEGORY B: IMPACT ON ECONOMIC DIMENSION	B1: ECONOMIC FEASIBILITY	**B1.1**	Productivity/efficiency	Indicator broken down into: - Productivity of bioenergy feedstocks by feedstock or by farm/plantation - Processing efficiencies by technology and feedstock - Amount of bioenergy end product by mass, volume or energy content per hectare per year - Production cost per unit of bioenergy	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		B1.2	Net energy balance	Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of feedstock production,, processing of feedstock into bioenergy, bioenergy use; and/or lifecycle analysis	**EX**	The indicator was finally removed as it is technical rather than social, already covered by B3.1 (Energy efficiency) and B3.2 (Production cost), and its inclusion would create redundancy and confusion.
		B1.3	Gross value added	Gross value added per unit of bioenergy produced and as a percentage of gross domestic product	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		B1.4	Profitability	Indicator broken down into: - Annual net present value - Annual return on investment - Payback period - Internal rate of return	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
	B2: ENERGY POVERTY	**B2.1**	Increase/decrease of energy prices due to energy efficiency	Increase/decrease of energy prices due to energy efficiency	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		B2.2	Increase/decrease of energy cost share in disposable households income due to energy efficiency	Annual percentage expenditure for energy	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.

	B3: ENERGY EFFICIENCY	**B3.1**	Increase/decrease of energy efficiency	Annual increase/decrease of energy efficiency from: - biomass extraction technology - biopower production - CO2 capture technology	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		B3.2	Increase/decrease of energy production cost	Increase/decrease of energy production cost	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
	B4: ENERGY SECURITY	**B4.1**	Increase/decrease of fossil fuel imports	Increase/decrease of fossil fuel imports	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		B4.2	Energy diversity/diversification of the energy mix	Increase/decrease of fossil fuel imports	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
	B6: RURAL DEVELOPMENT	**B6.1**	Contribution to local industries in the local economy	Percentage of total production cost paid annually to local contractors and suppliers: - biomass suppliers - other raw materials and goods	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		B6.2	Taxes/royalties paid to the local government	Breakdown of payments made to the local government per year	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
CATEGORY C: PEOPLE AND COMMUNITIES	C1: IMPACT ON TRADITIONAL LIVELIHOODS AND CULTURAL HERITAGE SITES	**C1.1**	Limitation in access to traditional livelihoods practices (hunting and fishing, harvesting of traditional food and medicines, …) as a consequence of deforestation for biomass extraction	Percentage of lands, territories and natural resources used traditionally by Indigenous Peoples for subsistance and food production (farming, fishing, hunting, gathering, herding) which are now damaged, diminished, contaminated, etc. due to the expansion of biomass extraction compared to benchmarks established in the past (5, 10, or 20 years etc.).	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		C1.2	Limitation in access to areas or resources of cultural value such as sacred and recreational sites as a consequence of deforestation for biomass extraction	Percentage of lands, territories and resources of cultural value such as sacred and recreational sites which are now damaged, diminished, contaminated, etc. due to the expansion of biomass extraction compared to benchmarks established in the past (5, 10, or 20 years etc.).	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
	C2: FOOD SECURITY	**C2.1**	Edible feedstock diverted from food chain to bioenergy	Annual amount of edible raw material diverted into bioenergy production. This can be checked with the operation and cross checked with local or national authorities or environmental NGOs.	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
	C3: LAND USE AND LAND USE CHANGE	**C3.1**	Total area of land for feedstock production	Total area of land for bioenergy feedstock production, and as compared to national surface and agricultural and managed foest land area. This can be checked with the operation and cross checked with local or national authorities or environmental NGOs.	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		C3.2	Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production	Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production, including the following: - arable land and permanent crops, permanent meadoows and pastures, and managed forest - natural forest and grasslands, peatlands, and wetlands This can be checked with the operation and cross checked with local or national authorities or environmental NGOs.	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.
		C3.3	Land conflicts	Area of land currently under dispute, land conflict. Quantitative number (ha) and qualitative description of any current or previous land use conflicts.	**IN**	Relevant data and measurable within the scope of the project. This indicator is calculated in collaboration with project partners.

CATEGORY D: SOCIAL ACCEPTANCE	D1: LEVEL OF KNOWLEDGE	D1.1	Level of knowledge on bioenergy	**Survey items (Likert scale: 1-5):** *How would you rate your general knowledge on:* *- Biomasss and bioenergy* *- Resources used for bioenergy production* *- The types of energy that can be produced from biofuels*	**IN**	It can be collected with the survey. Interesting information on the level of knowledge on bioenergy.
	D2: PUBLIC CONCERNS	D2.1	Environmental concerns	**Survey items (Likert scale: 1-5):** *Biomass/bioenergy plants cause :* *- Air pollution and odor disturbances* *- dangers for groundwater or surface water* *- soil degradation* *- noise and dust from traffic for the delivery of raw materials* *- roads´ damage due to traffic for delivery of raw materials*	**IN**	It can be collected with the survey. Interesting information on environmental concerns.
		D2.2	Safety and social concerns	**Survey items (Likert scale: 1-5):** *The production of biofuels…* *- will increase the price of energy* *- competes with the production of food* *- can reduce our access to food* *- will increase excessive monocultures (e.g. of individual tree species)* *The Biofuels/ biogas plant…* *- Has a negative impact on property values in our community* *- Worsens our economy (e.g. reduced property values, fewer tourists)* *- Is worse for my economy than a wind farm (e.g. reduced property value, fewer tourists)* *- Poses a higher risk of accidents to residents than a coal-fired plant (e.g. risk of fires and explosions due to gas leakages or leakage of a container)* *- Improves our economy (e.g. higher value of forests)* *- People negatively affected by power generation projects should be compensated*	**IN**	It can be collected with the survey. Interesting information on safety and social concerns.
		D2.3	Impact on traditional livelihoods and cultural concerns	**Survey items (Likert scale: 1-5):** Biomass extraction can… *- Reduce our access to traditional livelihoods (hunting and fishing, mushroom and berry picking)* *- Disrupt our culture by reducing access to sacred and recreational sites*	**IN**	It can be collected with the survey. Interesting information on perspectives on traditional livelihoods impact.
		D3.1	Global support: - Climate protection - Environmental protection - Distributive justice - Import dependancy - Contribution to national economic development	**Survey items (Likert scale: 1-5):** Bioenergy/ Bioenergy plants *- is a good way to produce electricity and heat* *- should play an important role in Sweden's future energy production* *- protects the climate* *- is a clean source of electricity* *- the relationship between costs (e.g. odours) and benefits (e.g. economic profits) is distributed fairly* *- that burn biofuels helps reduce dependence on imported energy*	**IN**	It can be collected with the survey. Interesting information on social perspectives.

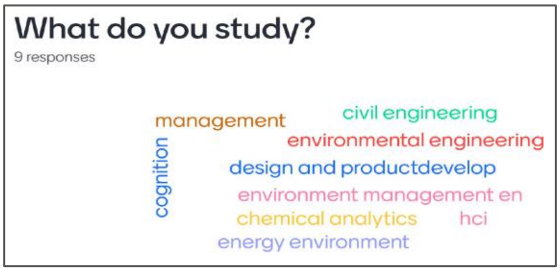
SOCIAL ACCEPTANCE	D3: LOCAL/GLOBAL ADVOCACY FOR DEVELOPMENT OF BIOENERGY INDUSTRY	D3.2	Local support and relevance of proximity	**Survey items (Likert scale: 1-5):** *-I support biofuels/bioenergy plants in my neighbourhood* *-Biofuels/bioenergy plants can contribute to the economic development of my municipality and region.* *To what extent would the distance between your house/apartment and biofuels or bioenergy plant be important to you?* *- I do not/would not accept the facility, regardless of distance* *- The distance of the facility to my home is not/would not be relevant to me* *- The distance is/would not be relevant but the facility should not be visible from my home*☐ *- The facility should maintain a minimum distance from my home* *What minimum distance to a biofuel/bioenergy plant from your home would be acceptable to you?* *1-5km* *20-50km* *>50km*	**IN**	It can be collected with the survey. Interesting information on social perspectives.
	D4: TRUST AND CREDIBILITY IN STAKEHOLDERS	D4.1	Trust in industry	**Survey items (Likert scale: 1-5):** I trust that… *- the facility's environmental permit means that safe technical facilities will be built, and that these are built using safe methods* *- the permit process takes into account the concerns of local residents, and that the company follows what comes out of the permit* *- the company will/would operate the facility safely*	**IN**	It can be collected with the survey. Interesting information on social perspectives.
		D4.2	Trust in municipality	**Survey items (Likert scale: 1-5):** *I trust that* *- Linköping Municipality will/would consider residents' concerns* *- The Land and Environmental Court makes a responsible decision on whether or not such a facility should be built* *- the supervisory authority ensures that secure technical facilities will be built* *- the regulatory authority will/would carry out safety checks to ensure safe*	**IN**	It can be collected with the survey. Interesting information on social perspectives.
	D5: PARTICIPATION OF SOCIETY	D5.1	Desired information	**Survey item (Likert scale: 1-5):** *It is important for me to receive information in advance about planned biofuel/bioenergy plants*	**IN**	It can be collected with the survey. Interesting information on social perspectives.
	D6: ATTITUDES TOWARDS FINANCIAL SUPPORT/ FUNDING	D6.1	Desired level of involvement of funding actors	**Survey item (Likert scale: 1-5):** *Decisions regarding the realization of a local biomass/bioenergy plant must be made together with the financial actors behind the project*	**IN**	It can be collected with the survey. Interesting information on social perspectives.

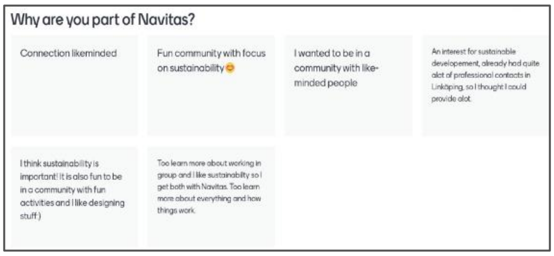
Appendix B. Validation workshop with community members

Introduction and inform consent

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grand agreement N° 101037085.

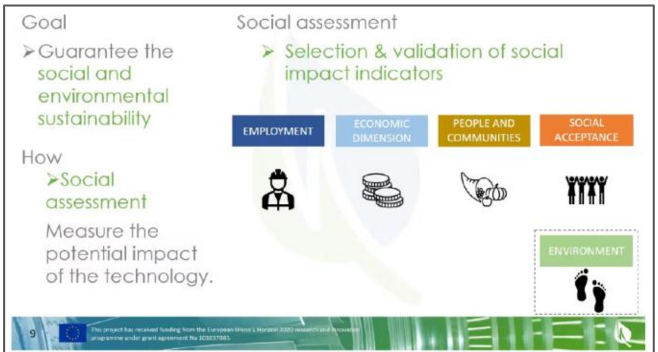
Profile questions & biogas knowledge.





Project description

Introduction to BioFlexGen Technology

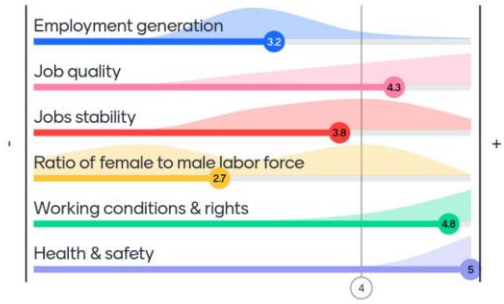


Introduction to Sustainability & Social Acceptance

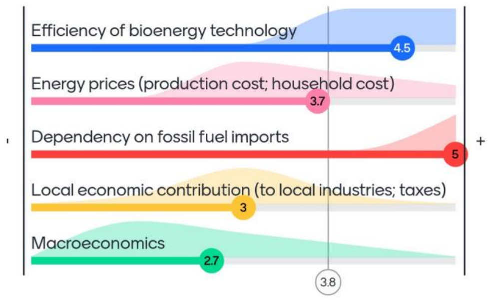
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grand agreement N° 101037085.

Validation of the indicators

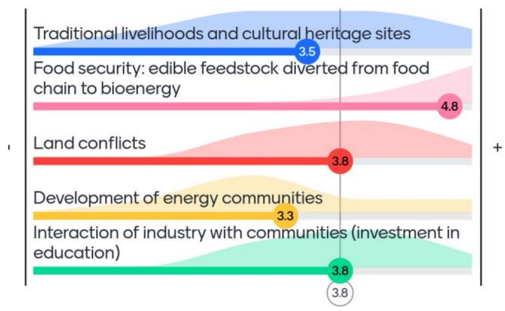
Employment



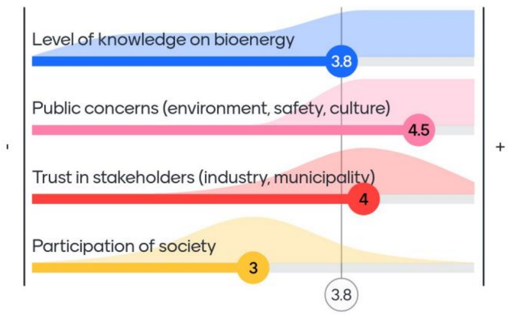
Economic dimension



People and communities



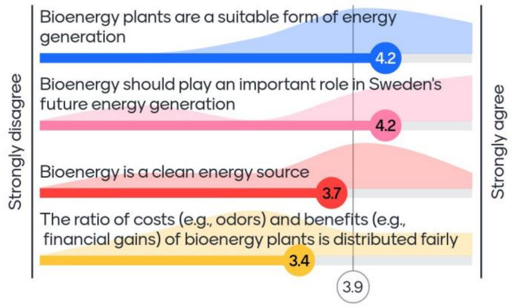
Social Acceptance



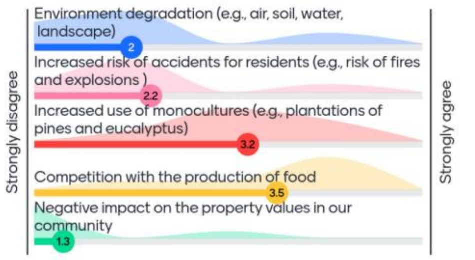
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grand agreement N° 101037085.

Measurement of indicators

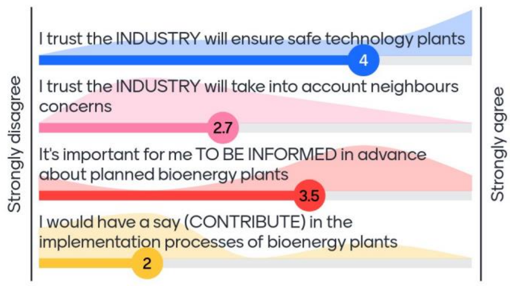
BioEnergy industry...



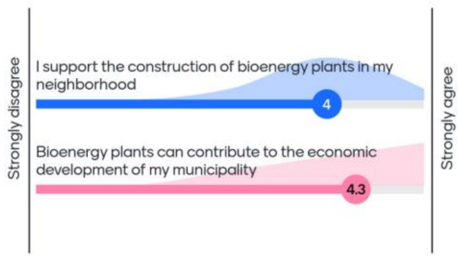
Impact & Risks. Bioenergy plants cause...



Trust & Participation



Local support and relevance of proximity



Appendix C. Results of the survey

The graphs of the survey results created with Microsoft Forms are presented in the following pages.

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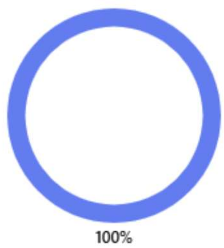
Información general sobre respuestas

Activo

Respuestas	Tiempo promedio	Duración
6	07:20	548 Días

1. **By clicking "I agree" you agree with the following statements:**
   1. I agree to take part in this survey as part of the research of the Project BioFlexGen.
   2. I understand that my opinions, views, data and experiences shared within this survey will be used only for the Project BioFlexGen.
   3. I understand that my participation is voluntary and I can withdraw at any moment during the course without giving a reason, and that my input will be deleted from the research.

- I agree 6
- I disagree 0



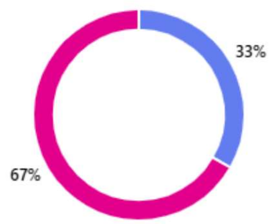
2. Ålder

6
Respuestas

Respuestas más recientes
"74"
"47"
"50"
...

3. Kön

- Kvinna 2
- Man 4
- Icke binär 0
- Jag föredrar att inte säga 0

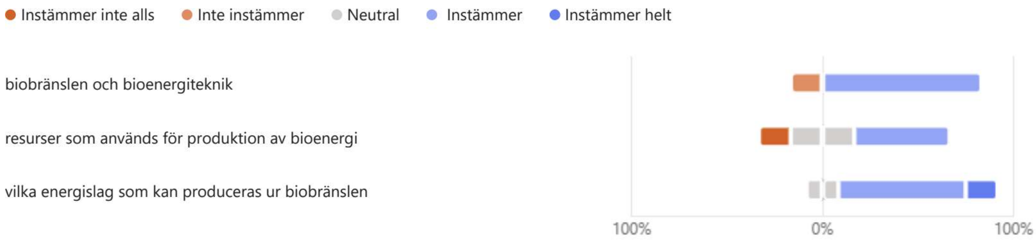


4. Yrke och/eller studieprogram

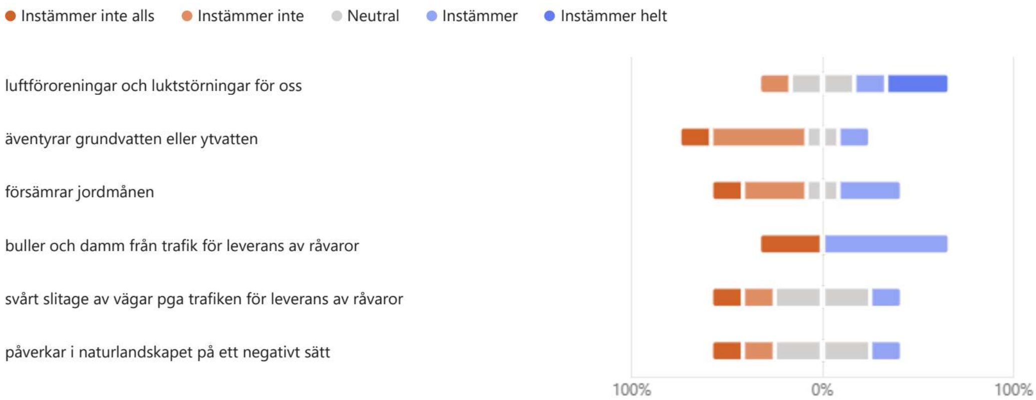
6
Respuestas

Respuestas más recientes
"senior"
"miljöansvarig"
"Civilingenjör"
...

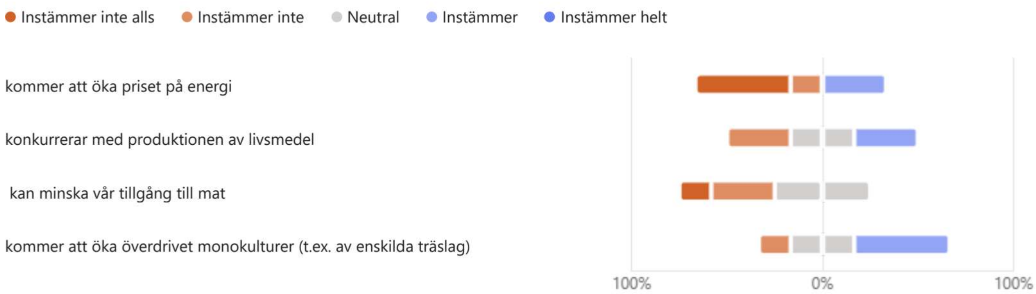
5. Vi har kunskap om



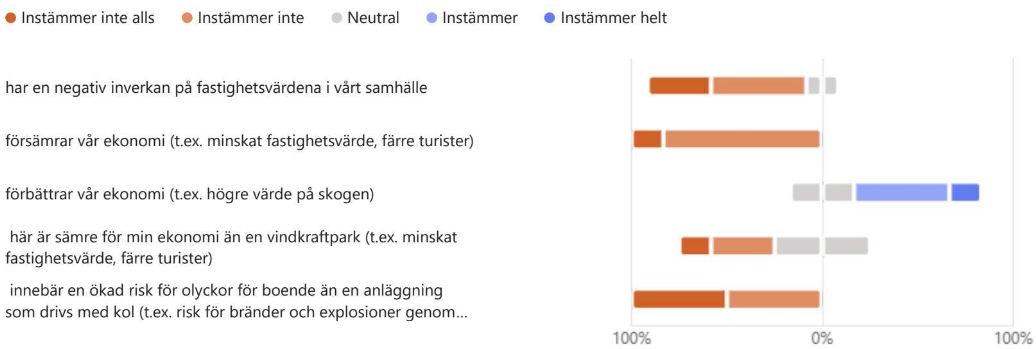
6. Biobränslen/bioenergianläggningar kan orsaka



7. Produktionen av biobränslen

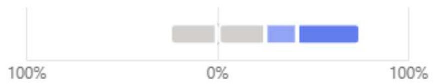


8. Biobränslen/bioenergianläggningen



9. Människor som påverkas negativt av kraftproduktionsprojekt bör kompenseras

- Instämmer inte alls
- Instämmer inte
- Neutral
- Instämmer
- Instämmer helt



10. Uttag av biobränslen kan

- Instämmer inte alls
- Instämmer inte
- Neutral
- Instämmer
- Instämmer helt

minska vår tillgång till traditionella försörjningsmetoder (jakt och fiske, svamp och bärplockning)

störa vår kultur genom minskad tillgång till heliga platser och platser för rekreation

11. Bioenergi/ Bioenergianläggningar

- Instämmer inte alls
- Instämmer inte
- Neutral
- Instämmer
- Instämmer helt

är ett bra sätt att producera el och värme

bör spela en viktig roll i Sveriges framtida energiproduktion

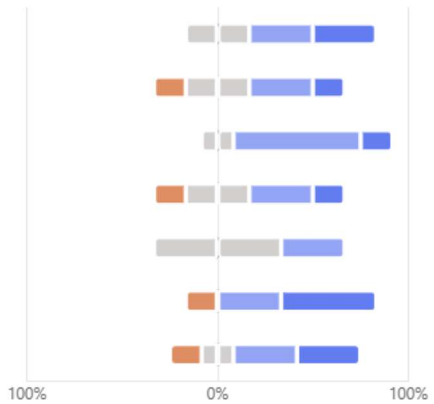
skyddar klimatet

är en ren elkälla

förhållandet mellan kostnader (t.ex. lukter) och fördelar (t.ex. ekonomiska vinster) fördelas rättvist

som eldar biobränslen bidrar till att minska beroendet av importerad energi

kan bidra till den ekonomiska utvecklingen i Sverige



12. Lokalt stöd

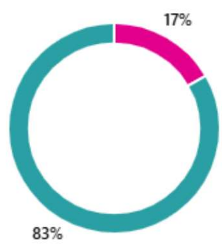
- Instämmer inte alls
- Instämmer inte
- Neutral
- Instämmer
- Instämmer helt

Jag stödjer biobränslen/bioenergianläggningar i mitt grannskap

Biobränslen/bioenergianläggningar kan bidra till den ekonomiska utvecklingen i min kommun och region

13. I vilken utsträckning skulle avståndet mellan ditt hus/lägenhet och biobränslen eller bioenergianläggning vara viktigt för dig?

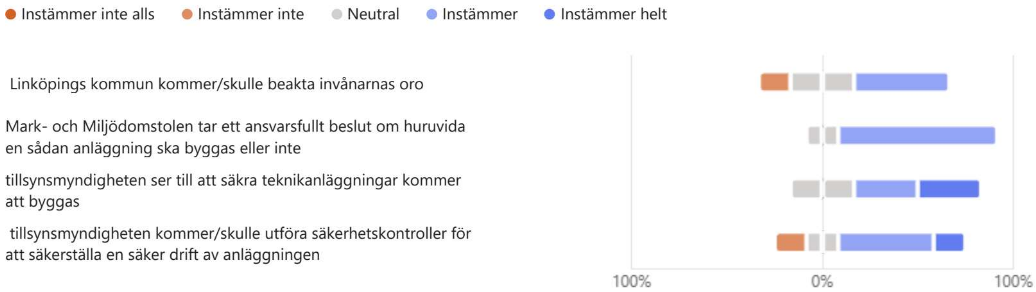
Jag accepterar/skulle inte acceptera anläggningen, oberoende av avståndet	0
Anläggningens avstånd till mitt hem är inte/skulle inte vara relevant för mig	1
Avståndet är/skulle inte vara relevant men anläggningen ska inte synas från mitt hem	5
Anläggningen ska hålla ett minimalt avstånd till mitt hem	0



14. Vilket minsta avstånd till en biobränsle/bioenergianläggning från ditt hem skulle vara acceptablet för dig?

15. Jag litar på at

16. Jag litar på att



17. Det är viktigt för mig att få information i förväg om planerade biobränsle/bioenergianläggningar

18. Besluten när det gäller förverkligandet av en lokal biomassa/bioenergianläggning måste fattas tillsammans med de finansiella aktörer so m står bakom projektet

19. Tack för att du har fyllt i enkäten! Du kan lägga till kommentarer i texten nedan om du vill dela med dig av ytterligare input!

1

Respuestas

Respuestas más recientes

...