Designing a Sustainability Plan for La Salve Brewery

D. Ferreira-Martínez[1(✉)], M. Zacarias[1], K. Gonzalez[2], J. Ruiz-Ibinarriaga[2], and A. Lopez-Aguera[1]

[1] Departament of Physics, Santiago de Compostela University, Rúa Xosé MaríaSuárez Núñez, S/N. (Campus Vida), 15782 Santiago de Compostela, Spain
dario.ferreira@rai.usc.es

[2] La Salve Company, Telleria Kalea, 31A, 48004 Bilbo, Bizkaia, Spain

Abstract. In this paper the design of a Sustainability Plan for the Salve brewery is modelled. To support transition for decarbonization of the company ensuring a triple zero production (energy, waste, and transport), the critical points during the production process have been identified from a SWOT analysis. Using the CLEWs tools (through the OSeMOSYS software), five scenarios are designed and evaluated according to the company energetic needs. Both historical set of real consumption data of the company, as well as the growth expectations raised by the owners have served as the basis for the work. To simplify the decision making to the company, both investment and total associated costs as well as the corresponding CO2 emissions has been estimated in the period 2023–2030. As main results, an energetic scenario including the use of bagasse waste, the implementation of photovoltaic solar energy and avoiding the fossil fuels, allows to achieve the planned objective with an economic contribution assumable by the company. In addition, several potential business niches associated with the circular economy have been identified.

Keywords: Sustainable energetic transition · CLEWs · Circular economy · Brewery

1 Introduction

La Salve is a traditional historical brewery, created in 1886 in Bilbao (Euskadi Region, Spain). The brewery, maintaining the philosophy from its origins, is committed to generating local value and wealth in the environment. For this reason, it is currently a company that is constantly searching for innovation and sustainable development. In this paper the design of a Sustainability Plan for the company to reach the expectations of a complete production's decarbonization (Triple Zero Philosophy Beer) across a sustainable transition is presented.

To identify the main sources of unsustainability, a SWOT matrix, in terms of Lifetime Analysis (LCA), has been performed [1]. The extended LCA indicators are considered as the adequate unbiased estimators to evaluate the economic, energetic, and environmental

P. S. Duque de Brito et al. (Eds.): ICoWEFS 2022, *Proceedings of the 2nd International Conference on Water Energy Food and Sustainability (ICoWEFS 2022)*, pp. 185–194, 2023.
https://doi.org/10.1007/978-3-031-26849-6_20

sustainability of any product/process/initiative. Following a "cradle to cradle" scheme, the raw materials, the production beer process, the packaging, the associated waste, and the distribution process as well as their environmental impact contribution are clarified.

One of the processes identified as a threat is the energy consumption associated with both production and transport for distribution. However, it can also be considered as an opportunity, if an environmentally friendly energetic system is designed. Because La Salve is mostly a local company, distribution constitutes a small percentage of the overall energetic needs being the most consuming both electric and heating components. The heating demand is linked to the production, fermentation and washing processes.

Given the economic implications and logistics that have arisen, the task of modeling suitable scenarios towards *Zero Energy Production* is not easy, particularly for a highly productive and constantly developing company like La Salve. The company's expectations are to have enough information to make informed decisions having knowledge of the effects of any initiative in the medium to long term previously to its implementation.

These concerns are common to the entire business fabric. In the current nexus frameworks for sustainable development, tools are being developed to fulfill the explained request. Among them, OSeMOSYS [2, 3], an open-source tool that allows predictive modeling of economic optimization of any energy scenario. OSeMOSYS can be freely applied according to the user's needs and allows to evaluate a set of scenarios of its MoManI interface [4].

This work is focused on the feasibility study and economic optimization of a series of possible energy transition initiatives that allow decarbonizing (*Triple Zero*) the production processes of the La Salve brewery using the OSeMOSYS tool.

2 La Salve Brewery

The Brewery of La Salve is in Bilbao (42.5º N latitude), with a moderate Atlantic climate. It occupies 628.61 m^2 in surface. In the subsoil is located a tank of homogenization of wastewater.

Figure 1 shows an outline of the processes associated with the beer production process. The company has provided data on raw materials, process and energies used during the production of beer, as well as modes of transport and distances along the supply chain.

Raw Materials. The raw materials mainly used are malt, hops, yeast, water, and some additives. The company purchases within the nearby markets the malt, which is the main beer component [5]. In addition, the brewery is involved in an innovative project that promotes the local hops production [5]. As for the yeast, up to 80% is reused.

With respect to the water needs, the plant is supplied with water from the network, since the quality is adequate for the beer production [1].

Packaging. The most common packaging are barrels and glass bottles. Currently, the brewery is evaluating various options for reducing the footprint associated with this process, which is undoubtedly one of the most demanding in economic, energetic, and environmental terms [1]. In particular, the barrels with less impact of the market are used [6]. Bottles with 48% recycled glass [7] are being used nowadays.

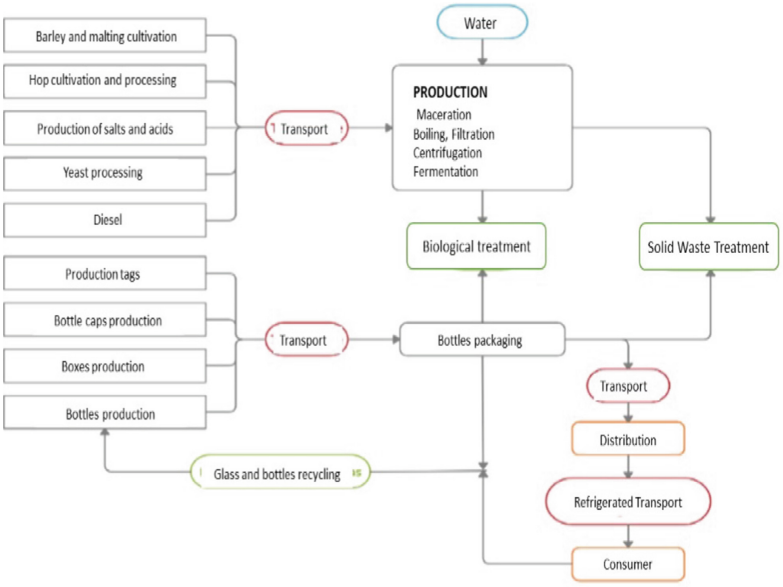

Fig. 1. Beer production scheme in La Salve

Energetic Consumption. The brewery is supplied by the national electricity grid, with a contracted consumption of 70 kW and an average annual consumption of 90 MWh. Concerning the thermal demand, the factory is supplied by 200 kg/h generated by a steam boiler powered by diesel as natural gas is not available in the region.

3 Methodology

The economic viability of different scenarios is evaluated using OSeMOSYS [2, 3] (Open-source Energy Modeling System) and its MoManI interface [4].

The brewery total decarbonization is performed through a linear optimization considering the energetic mix. As results are discussed: i) the new installed energetic capacities per technology; ii) the economic global cost and iii) associated emissions. Several scenarios, attending to the SWOT matrix internally developed by the company [1, 8] are defined and evaluated. The time interval defined for the study goes from 2022 to 2030. Data prior to 2022 are considered for validation. As working hypothesis, following the actual Spanish regulations no taxes associated to the pollutant emissions are included.

4 Evaluation of Scenarios for Sustainable Transition

As explained before, the energy requirements to be met are twofold: electricity and hot water (2095 kl/year). Among the possible initiatives towards sustainability, different scenarios are proposed: those dedicated to the search for biofuels to replace fossil

fuel, the ones obtaining of electricity from renewable energy sources and finally mixed solutions that encompass the problem in a global way. Finally, scenarios focused on full decarbonization will be evaluated. To model the scenarios, all the parameters, including technical and economical, are identified. la salve power system has been modeled using OSeMOSYS. To validate the model, the available data prior to 2020 have been considered. consequently, the improvement actions will be applied from 2023.

4.1 La SAlve's Current Situation: Business as Usual (BAU))

The BAU scenario is defined as a frozen version of the energetic system. The long-term evaluation of BAU allows the evaluation of the non-insertion of new initiatives into the nexus energetic mix. Table 1 shows the overall energetics needs. To adapt the system during the study period, an annual increasing rate of 3% is considered to the electric cost.

Table 1. Current energetic (thermal and electric) La Salve´s consumption. Types, demands, and costs. [8, 9]

Electricity		Gasoil		Water	
Contracted power	50 kW	Calorific value	43100 kJ/kg	Consumption	2095 kL/year
Cost increase	3% per year	Consumption	14440 kg/year	Fuel cost	5.4 €/kL
Fuel cost	164.17 €/MWh	Fuel cost	0.8235 €/kg	Boiler	
Emissions	0.18 tCO_2/MWh	Emissions	0.0033 tCO2/kg	Capacity	0.056 kg/s

4.2 Evaluation of Sustainable Thermal Scenario (SUSTHE)

To face an agenda towards decarbonization, the challenge is to reduce and/or avoid the use of polluting fuels. In that sense, scenarios based on the replacement of the gasoil used as fuel by La Salve to heat water, with more sustainable ones indeed, exist several options: from green electricity, geothermal, or wood combustion (chips or pellets). Considering the wood combustible solution, exists an oil boiler that can be adapted for wood-pellet burning with the same operational useful lifetime.

In addition, this solution is favored by allowing the reuse of the company's main waste: The bagasse produced during the malt cooking process, which can be pelletized. A dedicated study shows a promising calorific potential [1].

Table 2. Types, demands, and costs of the technologies included in the scenario. [1, 8, 10–12]

	Bagasse	Pellet	Pelletizer		Boiler Adapter
Fuel cost	0	0.0052 €/kg	Capacity	0.28 kg/s	
Calorific value	12131 kJ/kg	1882.8 kJ/kg	Inversion Cost	22,000 €	20,000 €
Disponibility	55360 kg/year	Neccesary	Fuel Cost	0.018 €/kg	

A first rough calculation shows that the current production of bagasse will be insufficient to cover the total calorific needs. However, since this type of waste can be pelletized, unmet needs can be covered by standard pellets, from the local production when possible.

Resuming, the proposed scenario will be allowing the replacement of the fossil fuel (BAU) with pellets, both own and nearby purchased. For this, two investments are envisaged: the adaptation of the boiler and, for the reuse of bagasse, a pelletizer machine. The specific database used is included on Table 2.

The SUSTHE scenario has been evaluated using OSeMOSYS modeling tool. As can be seen in Fig. 2 (a), the elimination of gasoil as a fuel in favor of the pellet constitutes the economically optimal solution despite the costs associated with the adaptation of the boiler and the pelletizer.

Figure 2. (b) shows the total costs, including initial investments, the price of fuels (gasoil, the electrical cost of the pelletizer bagasse or external pellets), as well as maintenance. The important initial investment associated to this scenario during the first two years is recovered with the lower price of the pellet respect to gasoil.

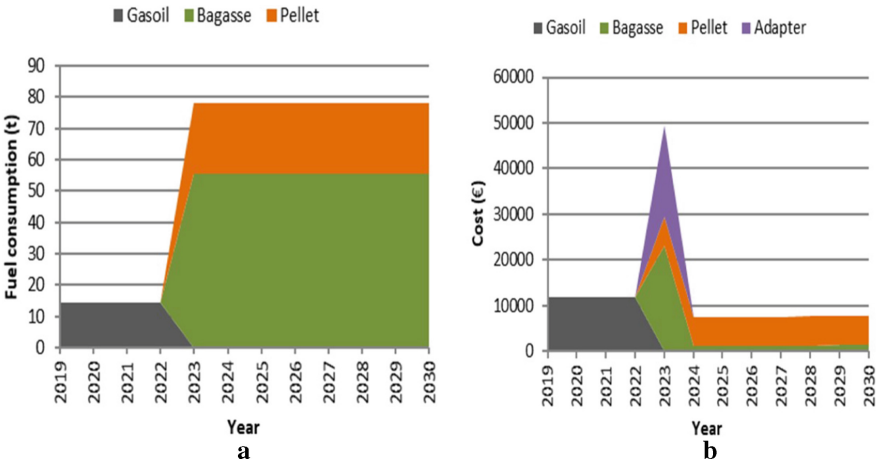

Fig. 2. On the left (a) Annual fuel consumption. On the right (b) Expected total cost along the evaluation period. The slight cost after 2024 in bagasse corresponds with associated electric variable costs of the pelletizer.

As a final remark, the associated CO_2 emissions strongly decreases with respect to the BAU. This is because the pelletized material coming either forest residues or the bagasse residues themselves, have zero emission associated.

4.3 Evaluation of Sustainable Electric Scenarios (SUSELE)

Within the framework of the sustainable transition process, the need to advance in a process of energy independence, the so-called *"Zero energy"* is imposed. The current configuration of the Spanish electricity system favors the implementation of local electricity production systems grid-connected working in *"Net Balance"* regime.

In addition, the so-called "after counter" accumulation systems are currently beginning to be popularized. This type of system favors a stable and controlled injection to the electric grid while economically benefiting the producer.

Table 3. Types, demands, and costs of the Solar Photovoltaic and accumulation technologies. [3, 8, 14–16]

	SOLAR (panels)	Batteries (storage)
Maintenance cost	100.72 €/MWh	–
Inversion cost	3284.17 €/MWh disminution 2% per year	53960–99920 €/MWh
Operational life	12 years	6 years

To study the economic viability of the proposal, a specific scenario has been designed and evaluated using the OSeMOSYS tool. Technically, the simplest solution is the implementation of a photovoltaic solar energy roof-plant, eventually associated to an accumulation system. Moreover, to favor circular economy processes, second-life ion-lithium batteries (coming from electric cars) are proposed as storage system. So, as working hypothesis, to the BAU scenario constrains, the opportunity of including both PV systems and/or storage system is included. The specific database used is included on Table 3.

As shown in Fig. 3, a gradual implementation of PV technology grid connected constitutes the most competitive option at economical level. In fact, because of the modularity of PV installations, the high associated initial investment can also be gradual which facilitates the economic logistics of a small company such as Salve. The proposed installed capacity from 50.2 kWp in 2023 to 74.5 kWp in 3030, being able to satisfy 73% of the total electric demand.

The actual price of the second-life ion-Lithium batteries inhibit its contribution to an optimal electric mix of La Salve. A future price drop [16] would induce a reconsideration of the scenario.

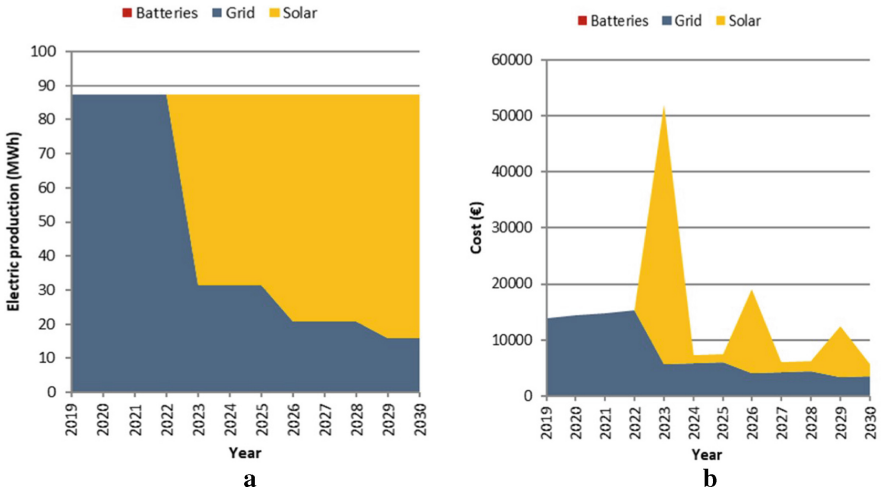

Fig. 3. On the left (a) Yearly electric production by technology. On the right (b) Total cost.

4.4 Global Zero Energy Scenario (ZERO)

In accordance with La Salve's medium-term expectations, the objective is to achieve a zero global energy system (both thermal and electric). To assess both economic viability and estimated investment, a new scenario has been constructed that combines the above scenarios (BAU, SUSTHE, SUSELE).

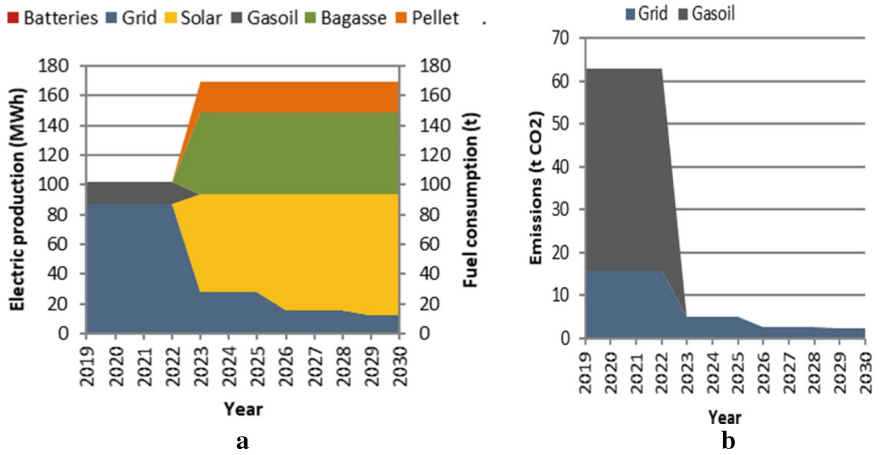

Fig. 4. On the left (a) Annual energetic production by technology. On the right (b) the CO_2 associated emissions.

As a conclusion, while external dependence has sharply decreased, a complete ZERO energy scenario is not economically competitive, being necessary a small dependence on external electrical grid. This is due to both the seasonal instability of the solar resource

and the still high price of accumulation systems. The emissions associated with this scenario (Fig. 4 (b)), show a remarkable decrease, associated with the elimination of fossil fuels in the heating processes, being the remaining emissions legated to the one associated to the electrical network (8% from the BAU scenario).

4.5 Triple ZERO Scenario (ZERO_TRP)

Based on the previous scenarios, a last alternative is proposed, undoubtedly much more ambitious: to convert La Salve´s beer into a product of the so-called *Triple Zero*, that is zero energy, zero waste, zero emissions. It has been seen how the SUSTHE scenario promotes zero waste by using organic waste as biofuel. From the ZERO energy scenario, it has managed to strongly reduce external energetic dependence, even if a small dependence on the electrical grid and its corresponding associated CO_2 emissions remains.

To fulfill the Triple Zero expectative, a new scenario is defined. As new constrain, a linear decrease of the emissions fulfilling the objective of zero emissions for 2030 is applied as work hypothesis. In addition, there is in Spain several electrical companies that offer the possibility of consuming exclusively "green energies" from the network.

This possibility has been contemplated as an added component. This type of energy tariff is around 20% more expensive, although the entry into the market of CO_2 carbon credits can be contemplated. The possibility of including "second life" batteries as energetic source is always open.

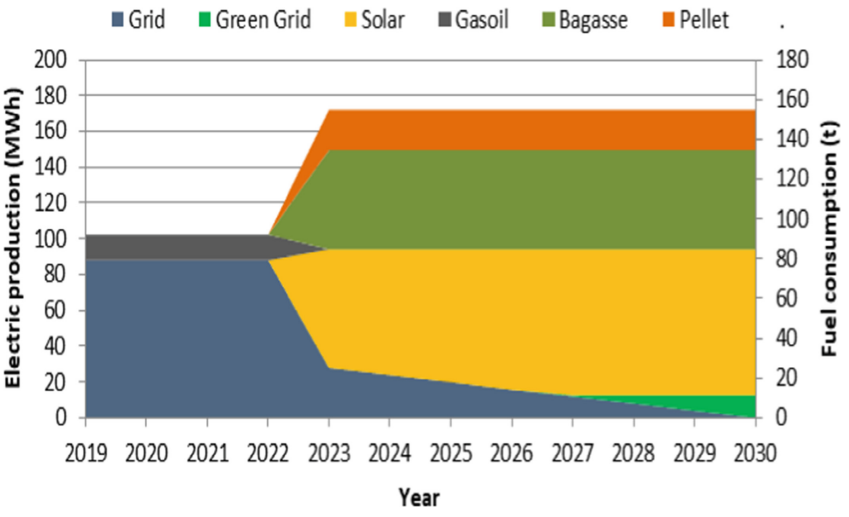

Fig. 5. Annual electric production by technology as well as the thermal fuel consumption.

As main remark, Fig. 5 shows how the "green energy" electric network appears, whereas the current second-life batteries inhibit their use. The implementation costs are like the ZERO scenario.

4.6 Scenarios Comparison for Decision Making

Once the different scenarios have been evaluated, in this section a comparative study is proposed, in both economic and environmental terms to facilitate the company´s decision making,

Figure 6 (a) shows the total costs associated with each scenario in the interval under study (2023–2030). New Investment, fuel (either electric or thermal), and maintenance costs are separately evaluated. As can be seen, the ZERO and ZERO_TRP scenarios appear as the most promising. Although they entail heavy initial investments, (close to 100.000 euros) both maintenance and fuel costs make them hardly competitive. The estimated overall saving with respect to BAU is near to 12%.

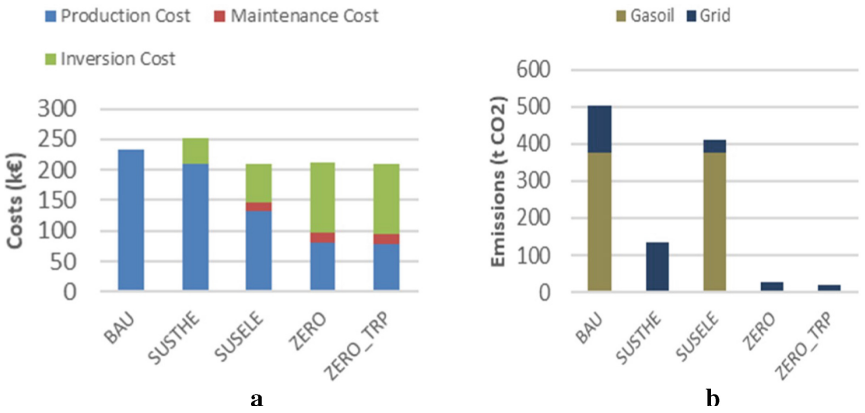

Fig. 6. On the left (a) Total costs, in k€. On the right (b) Total emissions for each scenario between 2023 and 2030.

Finally, in Fig. 6 (b) the emissions associated with the different scenarios are characterized. As can be seen, the SUSTHE scenario appears as the one with the greatest impact facing the decarbonization goal. The ZERO scenario is even stricter since, the implementation of solar panels, decreases the emissions associated to actual electrical grid. As expected, ZERO_TRP scenario, fully achieve expectations of quasi-ZERO energy dependence and ZERO emissions.

5 Conclusions

The design of a roadmap towards the decarbonization of the brewery La Salve is presented. The final objective is an economic feasibility study of different action scenarios that allows the manufacture of *Triple Zero Beer* (energy, waste, emissions). For this, both the detailed data of the company and the corresponding SWOT analysis have been analyzed. From there, the design of a roadmap for sustainable energy transition is identified as a crucial point of the process. Through the OSeMOSYS software, five scenarios are designed and evaluated according to the company energetic needs. To simplify the

decision making to the company, both investment and total associated costs as well as the corresponding CO_2 emissions has been estimated in the period 2023–2030.

As main results, the Triple Zero Beer Scenario (ZERO_TRP) appears as not only possible but the most promising: the zero CO_2 emission can be achieved by 2030, mainly because the use of fossil fuels is avoided.

Although they entail heavy initial investments, (close to 100.000 euros) both maintenance and fuel costs make them hardly competitive. The quasi-ZERO external energetic dependence is accomplished. The 5% of grid-energy production remaining is associated to energetic green sources. The estimated overall saving with respect to the actual working regime is near to 12%.

References

1. Gonzalez del Rey, K.: Diseño de un Plan de Sostenibilidad para la empresacervecera La Salve. Universidad de Santiago de Compostela. Departamento de Física (2021)
2. Introduction to OSeMOSYS—OSeMOSYS 0.0.1 documentation. https://osemosys.readthedocs.io/en/latest/manual/Introduction.html. Cited 14 Mar 2022
3. Howells, M., et al.: OSeMOSYS: The Open Source Energy Modeling System. An Introduction to Its Ethos, Structure and Development, vol. 39, pp. 5850–70. Energy Policy (2011)
4. Almulla, Y., et al.: Model Management Infrastructure (MoManI) Training Manual. KTH-dESA, pp. 1–61 (2017)
5. "La Salve". LA SALVE Bilbao - Cerveza:: Beer :: Garagardoa. Accessed 10 Mar 2022
6. "Enfoqueen la sostenibilidad - KeyKeg." https://www.keykeg.com/es/duurzaamheid. Accessed 31 Mar 2022
7. "Fabricación y venta de envases, botellas y tarros de vidrio | Vidrala." https://www.vidrala.com/es/. Accessed 31 Mar 2022
8. Confidential internal communication with La Salve
9. Poderes Calóricos de algunos Combustibles – RECOPE. Accessed 15 Mar 2022
10. Precio del pellet en España 2021. https://www.caloryfrio.com/energias-renovables/biomasa/precios-especiales-en-sacos-de-pellets.html. Accessed 20 Mar 2022
11. Palet de 70 sacos de pellet NATURPELLET · LEROY MERLIN. Accessed 05 Mar 2022
12. China High Efficiency 1-1.5 T/H Wood Pellets Making Machine Ring Die Sawdust Wood Pellet Mill - China Biomass Pellet Machine, Straw Pellet Machine. Accesed 15 Feb 2022
13. García-Gusano, D., Martín-Gamboa, M., Iribarren, D., Dufour, J.: Prospective analysis of life-cycle indicators through endogenous integration into a national power generation model. Resources **5** (2016)
14. Míguez Fariña, A.: Estudio de diferentes escenarios para la transición energética de Galicia mediante el uso de herramientas CLEWs. Universidad de Santiago de Compostela. Departamento de Física (2020)
15. Martinez-Lasernaa, E., et al.: Battery second life: hype, hope or reality? A critical review of the state of the art. Renew. Sustain. Energy Rev. **93**, 701–718 (2018). Accessed 25 Feb 2022
16. Baterías de segunda vida: Febrero 2021, Informe de la Comunidad Tecnológica de Almacenamiento. PowerPoint Presentation (globalelectricity.org). Accessed 07 Apr 2022