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Blue Economy Circular Value Chains

Business case: Resource efficiency in Morocco's fish processing industry for canning, fish meal, and fish oil

Company overview

Sector: Fish canning, Fish meal, Fish oil

Name: Complex Industriel Belhassan (CIBEL)

Number of employees:

Fishmeal: 80 Staff full-time

Fish canning: 300 Staff full-time and 700 part-time

Key products: Canned fish, Fish meal, Fish oil

Main markets:

Canned fish export (Africa, Asia, Europe, North America), Fish meal and Fish oil (Europe, China, North America)

Standards & certifications before MED TEST III: IFS - BRC-Kosher-Friend of the sea- MSC- BIO- Gluten Free- Halal - Amfori BSCI - SMETA GMP+ , Friend of the sea, Marin Trust

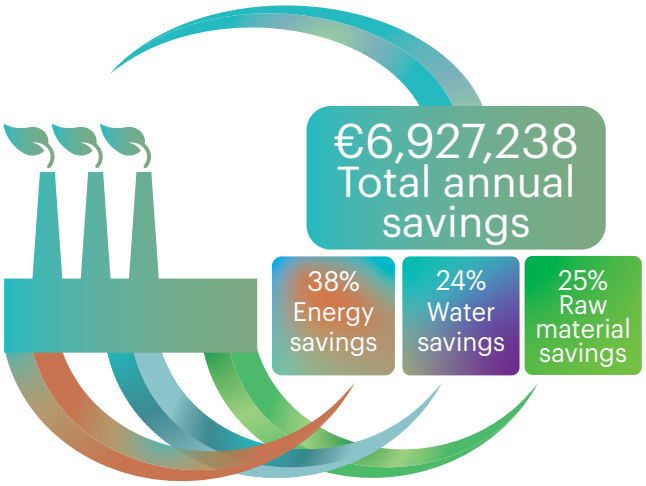
Complex Industriel Belhassan (CIBEL) is a leading fish processing company in Agadir, a coastal city in Morocco. The company plays a significant role in the seafood and fish sector of the region and is vertically integrated, comprising fish canning, fish meal/fish oil, and fish freezing factories. These factories are located in the industrial zone of Anza of Agadir.

The CIBEL group has always been committed to maintaining quality and sustainability in its operations. The company practices eco-friendly methods, with genuine social consideration towards its staff and works closely with local fishermen to preserve marine life and support the economy in the Agadir community.

This case study focuses on the fish canning and fish meal/fish oil factories of CIBEL, with respective annual input capacities of 20,000 tons and 40,000 tons and explores the industrial symbiosis between these two factories.

Overall benefits

Overall, the MED TEST III project identified in the fish can and fish meal factories 39 measures that have the potential to provide a total economic benefit of nearly €7 million annually. These measures comprise energy, water and raw materials savings and the development of new high-value end-products. The identified measures require an estimated investment of about €13.7 million and have an average payback period (PBP) of two years. Of the identified measures, 80% were accepted by the CIBEL management, including 20% currently under implementation, 20% planned and 38% retained for study. The measures retained for study raised interest from the CIBEL management regarding the relocation to "Haliopolis", a dedicated industrial area for the fish processing industry northeast of Agadir. The company is planning to integrate the identified Resource Efficient and Cleaner Production (RECP) practices into the design of this greenfield project, which is the optimal scenario for realizing the factory's highest economic and environmental benefits.



Data based on the production year 2022

Implementing all the identified measures would enable CIBEL to reduce 5,000 tons of CO_2 emissions annually and save almost 210,000 m³ of water and more than 15,000 MWh of energy annually.

In addition to the identified resource efficiency measures, the project investigated that the canning factory is currently discarding a significant amount of fish waste into the sewage system. This wasted material can be used as raw material in producing fish meal and fish oil. The recovery of this material is a good example of industrial symbiosis across the fish canning and fish meal/oil factories, resulting in economic gains and a total reduction of Chemical Oxygen Demand (COD) by 1,820 tons and Biological Oxygen Demand (BOD) by 1,328 tons. It would, therefore, contribute to environmental sustainability and increase economic profitability for the CIBEL Group.

> "During the pilot tests carried out with the technical team, the exploration of new markets for high added value and the results of the development of potential new products were very positive. Measures to improve the management of energy, water, raw materials and co-products have been put in place within the CIBEL group, with promising results"
>
> Sara El-Baissi
> CEO, CIBEL

Saving opportunities: Fish canning**

Actions	Economic key figures			Resource savings and environmental impacts		
	Investment Euro*	Economic benefits Euro* per year	Payback period years	Water and Materials per year	Energy MWh per year	Environmental impact per year
Heat conservation and recovery	228,617	141,581	1.6	5,000 m³	2,558	Total:
Renewable energy and energy management	1,054,473	223,772	4.7	-	3,724	2,122 tons CO_2 emissions
Process water optimization	49,297	9,849	5.0	125,833 m³	-	300 tons COD
Material recovery for food applications	518,428	806,941	0.6	500 tons raw materials *****	***	200 tons BOD
Fish skin and scale recovery for collagen production	1,645,811	486,717	3.4	386 tons raw materials *****	****	
TOTAL	**3,496,627**	**1,668,860**	**2.1**	**130,833 m³ 886 tons**	**6,283**	

*Exchange rate as 10.95 Dirham = 1 Euro
** Numbers based on production value from 2022

*** The installation of this new process line will increase the annual energy consumption by 618 MWh
**** The installation of this new process line will increase the annual energy consumption by 478 MWh
***** These materials are transferred from conventional fishmeal and fish oil into high-value end-products

Heat conservation and recovery

Several measures were identified to enhance the efficient use of thermal energy and recover wasted heat from exhaust gases, purges, and condensates. Automatic regulation of boiler purges helps minimize energy losses from purged water. Implementing automation to control valves and sensors optimizes water and energy consumption by coordinating the operation of multiple sterilizers and their respective cycles. This automation efficiently directs the flow of water or steam from one sterilizer in operation to another in a distinct phase of the sterilization process. Recovered energy from boiler purges, using a flash evaporator to capture steam, can be utilized to preheat secondary fuel tanks in the boiler room.

Installing a water-to-air heat exchanger on boiler flue gases enables the recovery of some of the heat contained in the flue gases. This recovered heat can preheat the boiler feed water, enhancing overall energy efficiency. As a result, 120 tons of heavy fuel per year can be saved, and this investment would have a PBP of one year.

Renewable energy and energy management

This set of measures encompasses a spectrum of energy-saving strategies, ranging from cost-effective initiatives like optimizing subscribed power and lighting systems, resulting in €4,000 in savings with a PBP of less than one year. It extends to medium-scale investments, such as improving machine efficiency by implementing variable speed drives. Furthermore, high-impact investments are oriented towards the generation of renewable energy, encompassing both thermal and photovoltaic solar energy solutions. The deployment of photovoltaic panels is expected to yield 634 MWh per year in electricity, reducing grid consumption for an annual saving of more than €55,000. Meanwhile, thermal solar energy can be used for pre-heating of 20,000 m³ of boiler make-up water, leading to substantial savings of 200 tons of heavy fuel for an associated cost reduction of € 114,000 per year.

Additionally, implementing an energy management system could deliver a 5% reduction in energy consumption, equivalent to 129 MWh per year.

Process water optimization

Specific water efficiency measures can lead to an annual savings of 125,000 m³. The current unique water supply profile of the company, with 80% input from seawater at no cost (except energy cost for the reverse osmosis unit), did not provide any motivation to look for water saving opportunities, despite the high volumes of wastewater discharged. Implementing cost-effective measures such as water metering systems, solenoid valve installations controlled by production operations, the addition of nozzles on watering and rinsing ramps for fish conveyor belts, and the introduction of new washing lines for fish trays can significantly reduce water consumption. Furthermore, this approach can decrease the discharge of 300 tons of COD and 200 tons of BOD. While a total PBP of five years for the water conservation measures calculated at the current CIBEL site, may appear relatively high, the investments for those measures will be repaid within less than a year when the factory will be relocated to another site that has no access to seawater supply.

Fish by product recovery for food applications

During the initial phase of the fish canning processing, each sardine is cut to fit the can. This cutting process generates a residual part known as 'collars,' constituting on average 8% of the total fish weight and that can reach up to 50% during favourable seasonal peaks. An estimated 500 tons of collars can be systematically collected yearly under the fish heading machine. The available meat from these collars can be subsequently extracted and processed using belt or screw separators to create various food products, such as terrines, pâtés or fish balls.

The collars as raw material value is €0.4 per kilogram. If CIBEL extends the production line for food applications, the annual gross margin can be estimated at more than €800,000, assuming a sales volume of 750 tons of finished products priced at approximately €3 per kilogram. CIBEL is currently evaluating various recipes with the objective of formulating a product line.

Fish skin and fish scale recovery for collagen production

The recovery of scales through the fish heading machine and various stages of the production chain offers a valuable opportunity for collagen extraction. With a yield ranging from 15% to 22% and a raw material content of 0.5% in recoverable scales and 5% in recoverable skin, derived from the total raw material weight of sardines, CIBEL has the potential to produce between 40 to 45 tons of pure collagen annually.

Establishing a collagen production unit involves the implementation of a specialized process line, encompassing separators, bioreactors, ultrafiltration skids, evaporators, dryers, centrifuge separator, and a packaging system. These measures require an initial investment of €1,600,000 in an additional gross revenue of over €486,000 per year for the company with a PBP of 3.4 years.

Saving opportunities: Fish meal and Fish oil**

Actions	Economic key figures			Resource savings and environmental impacts		
	Investment Euro*	Economic benefits Euro* per year	Payback period years	Water and Materials per year	Energy MWh per year	Environmental impact per year
Heat conservation	667,332	298,364	2.2	19,000 m³	6,202	Total:
Technological upgrade of the separation process	492,680	109,318	4.5	4,500 m³	1,211	2,872 tons CO_2 emissions
Renewable energy and energy management	199,204	109,070	1.8	-	1,815	85 tons COD
Development of a new unit for the production of fish hydrolysates	8,276,712	3,235,564	2.6	***	***	56 tons BOD
TOTAL	**9,635,928**	**3,752,317**	**2.6**	**23,500 m³**	**9,227**	

*Exchange rate as 10.95 Dirham = 1 Euro
** Numbers based on production value from 2022
**** Implementing this measure, as a new production line, requires an annual water consumption of 24,000 m³ water and an energy consumption of 10 292 MWh.

Heat conservation

Opportunities for energy conservation can be achieved through a group of measures that include the implementation of automated regulation for boiler blowdown and its associated energy recovery, the incorporation of water/air heat exchangers at boiler flue outlets, the deployment of an air/air heat exchanger at the boiler flue outlet, and the utilization of solar thermal technology for preheating boiler water. These measures yield annual energy savings of 6,202 MWh and a concurrent reduction of 1,741 tons of CO_2 equivalent.

Particularly, adopting thermal solar energy solutions enables the preheating of water entering boilers, a critical requirement for steam production in the fish meal and fish oil processing line. This specific measure alone accounts for more than 25% of the total annual energy savings of 1,510 MWh. Likewise, improving the evaporator's performance by increasing juice concentration using enzymatic treatment accounts for 2,257 MWh (36% of the total energy costs) and 2,000 m³ of water savings for a PBP of less than three months.

Technological upgrade of the separation process

Implementing advanced technologies gives a better separation of fish meal (solid fraction) and fish oil (liquid oily fraction), concentrating and removing excess water to enhance protein content, all within a single operational stage. By replacing outdated decanters with tricanters and streamlining the conventional process, energy consumption is significantly reduced while enhancing the final products' quality (higher protein content). The investment in the technological upgrade has a PBP of 4.5 years and would result in annual savings of 1,211 MWh and 4,500 m³ of water while reducing pollution by 85 tons of COD, 56 tons of BOD, and 450 tons of CO_2 emissions.

Renewable energy and energy management

In line with the approach taken in the fish canning facilities, two significant energy-saving initiatives have been proposed. The first measure suggests enhancing the factory's energy self-sufficiency by integrating photovoltaic panels, generating over 400 MWh annually. The second measure foresees implementing an energy management system to optimize energy consumption, achieving a 5% reduction. The investment for these measures has a PBP below two years and would reduce CO_2 emissions by 687 tons annually and save 1,815 MWh of grid energy every year.

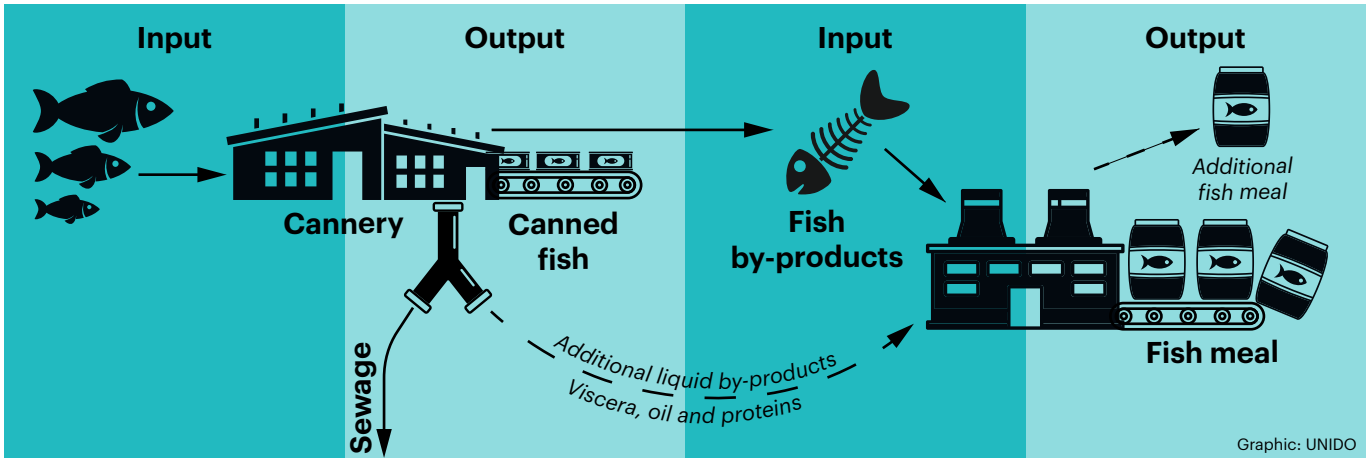
Development of a new unit for the production of fish hydrolysates

One promising avenue for utilizing by-products involves the production of sardine hydrolysates. Fish hydrolysates are valuable products derived from the enzymatic breakdown of fish proteins into smaller peptides and amino acids. Driven by the demand for high-quality protein sources, organic fertilizers, nutritional supplements and sustainable solutions, fish hydrolysates are rich in essential nutrients, benefiting versatile applications across various industries, including aquaculture, agriculture, pet food, and dietary supplements.

Considering the vertically integrated position of CIBEL in the fish value chain, a scenario for establishing a unit for producing fish hydrolysates is proposed. The unit would use 10,000 tons of sardine co-products, including heads and viscera, and an additional 2,000 tons of whole sardines that do not meet the quality standards for canning, obtained from 'CIBEL's canning unit, as a feedstock. This strategic development would also require diverting some raw materials from the fishmeal production.

An alternative approach involves procuring high-quality by-products from other canned fish producers to create a large hydrolysate production unit alongside the existing fishmeal facility. Fish hydrolysates have a market value of 2,500 to 3,000 € per ton, which is higher than the market value of fish meal, ranging from 1,200 to 1,700 € per ton. By establishing a new production unit for fish hydrolysates with an annual capacity of 12,000 tons, CIBEL can generate an additional revenue of €3.2 million per year for an initial investment of €8.2 million. The PBP for this investment is estimated at 2.6 years.

> "The project uncovered significant resource-saving opportunities and demonstrated the rapid return on investment of technological upgrades. The measures identified can be applied to most fish processing companies in Morocco, safeguarding our environment and strengthening the competitiveness of the industries by reducing energy and water costs, which are significant factors in production costs."
>
> Mohamed Belhaj Soulami
> General Director Cleantech and Senior Environment Expert



Fish waste recovery for additional fishmeal and fish oil production

The industrial symbiosis between fish canning and fish meal factories is pivotal for the operational efficiency of a vertically integrated company such as CIBEL. The fish can factory serves as the primary supplier of raw materials for the fish meal factory. Despite diverting 8,000 tons of by-products from fish canning to produce fish meal and fish oil, RECP audits have identified an untapped source of material in the sewage that, if collected, would yield substantial economic and environmental benefits.

Introducing a dry transport of fish solid waste at the canning factory, facilitated by air-powered pneumatic conveyors, would reduce the consumption of 50,000 m³ of water annually and over 50% of pollution in the sewage. Dry transport also preserves the quality of by-products, significantly enhancing their market value and valorization capacity.

Moreover, liquid effluents, conventionally discharged into the sewage system at the canning plant, present an opportunity to re-integrate the by-products to produce fishmeal. By implementing this measure, RECP audits indicate that more than 1,610 m3 of juice can be reclaimed, producing 330 tons of fish meal and 77 tons of fish oil annually. Due to the high levels of protein and lipids found in these juices, adding them to the fish meal production process can increase the protein content of the final product by 5%. This will bring the protein content of the fishmeal up to 65%, which meets international standards. As a result, the quality and market value of the fishmeal will be enhanced by at least €100 per ton.

Additionally, the cooking process of sardines, especially in batches, leads to the loss of 3,750 m³ of juices annually, which is disposed of into the sewage. These discarded juices, composed of water, steam condensates, and meat particles, constitute approximately 5% of the processed sardine weight. Using a centrifugal separator, 375 tons of oil and proteins can be efficiently recovered and redirected to the fishmeal factory.

With a PBP of less than six months, these industrial symbiosis measures offer substantial benefits and present a financially sound and environmentally responsible solution for a company like CIBEL.

Scaling up pilot results to the Moroccan fish industry sector

The pilot project at CIBEL's fish canning and fishmeal factories resulted in the identification of measures leading to substantial gains, including a €7 million increase in economic benefits, 16,000 MWh savings in energy, 210,000 cubic meters of water preservation, and a 5,000-ton reduction in CO_2 emissions with an overall PBP of two years.

Not all companies in 'Morocco's fish processing sector would necessitate implementing the measures identified at CIBEL; for some, these measures constitute an impassable technology gap and for the modern ones, some technologies are already in operation. The resource efficiency measures can be divided into three tiers. Low-challenge projects, such as classic RECP practices in single units, are economically and environmentally profitable for 50-75% of Moroccan fish processing companies due to their simplicity and short payback period. Medium-challenge projects require industrial symbiosis and are suitable for an estimated 50% of companies that require technical studies and larger investments. High-challenge projects involve innovative, high-value end products requiring time and coordinated efforts to enter markets like food, cosmetics, or pharmaceutical niches. According to the market dynamics study conducted during the project, only one or two Moroccan companies can enter these high-competing markets per year, driven by a global annual growth of 5 to 10%.

Based on the pilot project outcomes and tailored extrapolation factors, based on the three outlined tier levels, an upscale analysis conducted after the project implementation identified that the potential economic benefits are estimated at €67 million per year for the national fish processing sector. Applying resource efficiency measures could lead to a substantial reduction in annual energy consumption (249,000 MWh), water consumption (3.6 million m³), and CO_2 emissions (86,000 tons). These outcomes present significant economic and environmental benefits. They can support the shift towards circular and resource-efficient approaches in the fish processing industry and align with 'Morocco's national blue economy strategy and the growing blue bio-economy sector.

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