Biorefineries design and implementation in crisis times

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Overview

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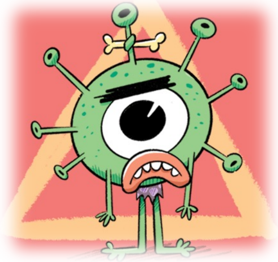
1. Introduction

Covid 2019 pandemic



Russian war in Ukraine

"Survival of the fittest is a law of nature"

The post-covid scenario causing the increase in oil prices and fertilizers

The Covid 2019 pandemics as well as the Russia-Ukraine war affected notoriously the projection and development of Biorefineries in the world against the nice purposes of Green Policies and Sustainable Development Goals.

1. Introduction

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Some **key points and strategies** to develop Biorefineries in the next 15 years are:

01 The biorefinery concept must turn to a mandatory approach or way of sustainability in Biomass processing .

02 Small and Middle scale Biorefineries are preferred over large-scale sizes to ensure fair distribution of resources especially in crisis times.

03 The products governing the future of Biorefineries are food (including food additives), feed, bioenergy, and biofertilizers.

04 The accurate and robust design of Biorefineries is mandatory and it should include the sensibility analysis.

05 The context and the social impacts should be strengthened in next years as part of the sustainability analysis.

2. Diversified Pandemic effects

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Destabilization in the health systems

Poor countries had a limited access to vaccines and respirators

Industry

The rich countries had a **limited access to basic raw materials** to produce chips, affecting the technology and automotive industries

Tourism and mobility

Transportation restrictions were the main factor that affected the companies, with continuous **disruptions in their supply chain**.

Public policies

The pandemic havoc was translated into **current high informal work rates, increasing the social inequality**.

ECONOMY

2. Diversified Pandemic effects

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Businesses of digital and pharmaceutical sector (*e.g.,* Apple, Microsoft, Gilead Sciences and Pfizer) raised their R&D investments

The universities and research institutions had a fast reaction to critical needs that demonstrated its collaborative and cooperation abilities, effective use of tools and, academic and scientific resources

Due to mobility restrictions, the emission of pollutants and greenhouse gases decreased.

The industries related to care products, delivery services and online shopping gained an important place and were essentials

The pandemic tested the responsiveness, adaptability and flexibility of all companies, institutions, and entities

It opened way to identify new opportunities, processes, products, and services.

3. Post-pandemic opportunities on bioeconomy and biorefineries

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The concept emphasis is placed on **sustainability**, **multiproduct processes** (*e.g.*, biorefineries), **integral use of biomass** and, **waste and residues valorization**.

CIRCULAR ECONOMY

Source: https://vietnamcirculareconomy.vn/

3. Post-pandemic opportunities on bioeconomy and biorefineries

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Other some **key elements that need special attention in the industry as a pandemics result** are [26]:

- Additional attention to supply chains related to a wide and diverse range of suppliers.
- Adaptable plants to high processing scales.
- Greater investments on R&D and bioprocesses.
- Modular and versatile installations.
- The regional manufacture promotes the independent regions and decentralization of processes.
- Incentivize the creation of communication and dialog channels between companies to promote the collaboration.
- More process intensification and automation.
- Better inventory management.

4. Effects of the Russia - Ukraine war on biorefineries

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Russia

Ukraine

Both countries contribute to global exports of

30% wheat

20% corn

11% oil

70% sunflower oil

(Producing together with rapeseed most of the protein in Europe)

Food security
High prices of food

Air quality
Greenhouse gas emissions

Quality and availability of water
Infrastructure affectations

Soil degradation
Ecosystems alteration

Deforestation
Biodiversity losses

All the feedstock used to produce renewable ethanol by **ePURE*** members in 2021 was grown in Europe. Of the **5.58 billion liters of ethanol** produced in 2021, **50.4% was from corn**, **21.8% from wheat**, 14.5% from sugars, and 3% from other cereals and starch-rich crops.

ePURE members – representing 85% of EU installed capacity – produced **51%** in animal feed co-products and **49%** of renewable ethanol.

9.4% of the ethanol produced was for industrial use including hand sanitizer, and 6.4% was for food and beverage use

*European renewable ethanol association (ePURE)

4. Effects of the Russia - Ukraine war on biorefineries

Corn biorefinery

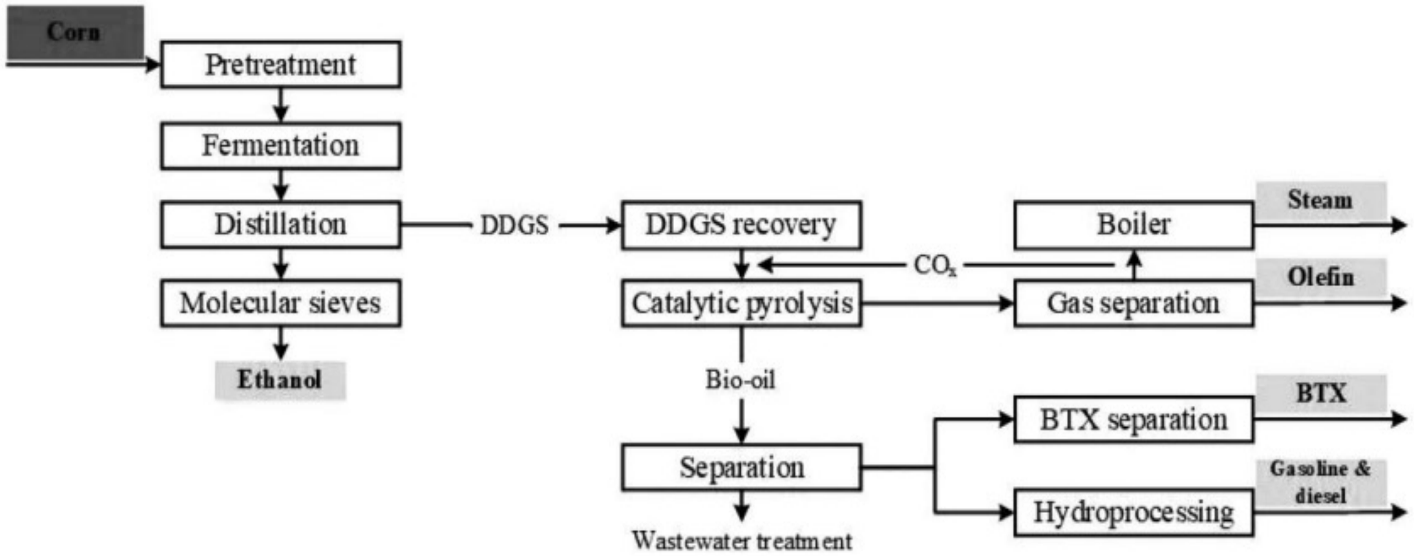

Figure 1. Scheme of corn biorefinery.

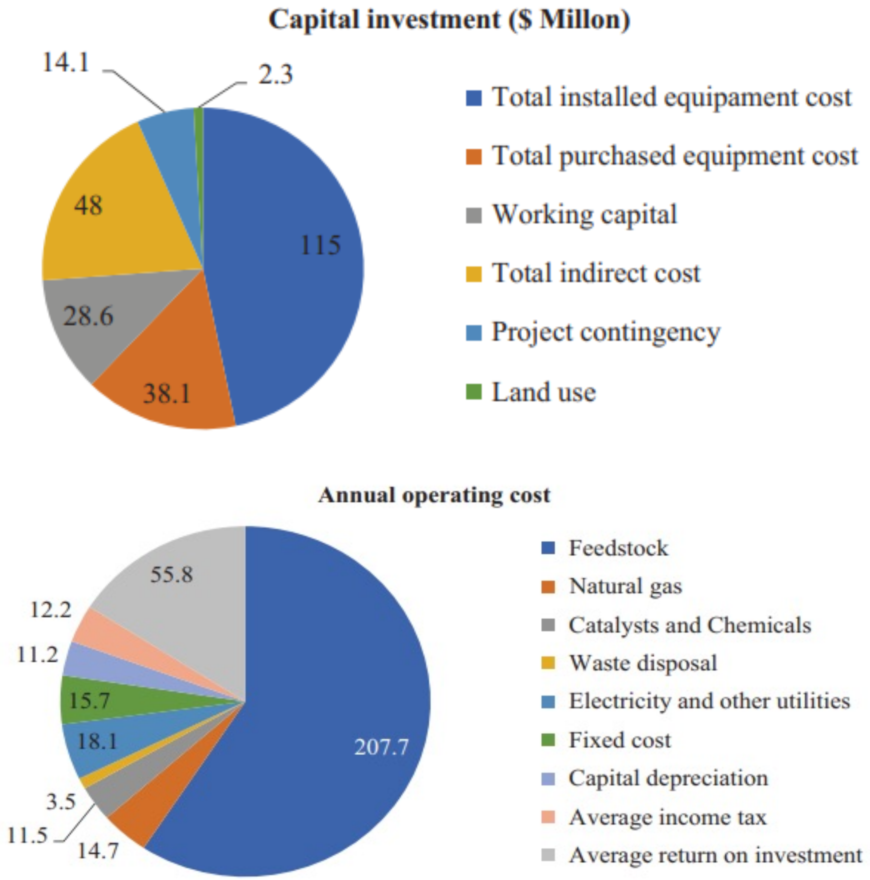

Figure 2. Distribution of capital investment and annual operating cost.

4. Effects of the Russia - Ukraine war on biorefineries

Ethanol production from lignocellulosic biomass

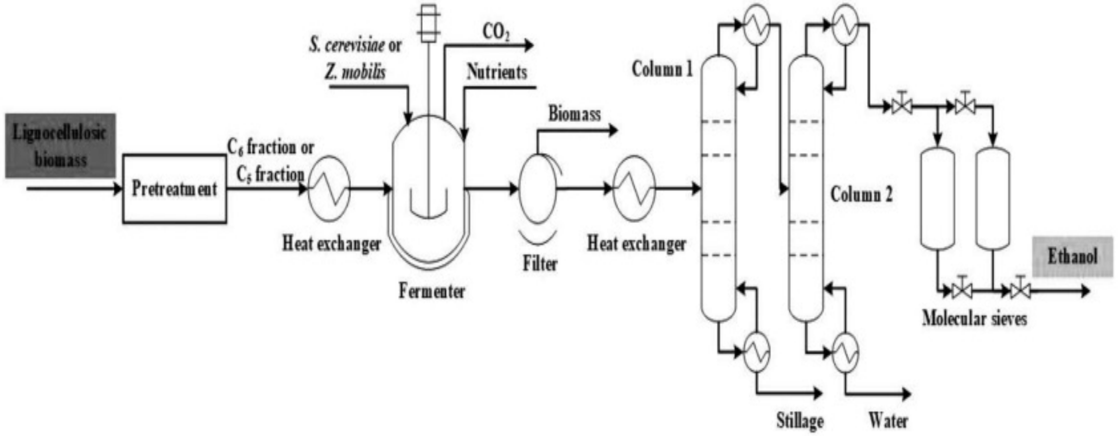

Figure 3. Scheme of ethanol production using lignocellulosic biomass.

Tabla 1. Bioethanol Production Cost from SCB, EFB, RH, and CCS. Standalone Ethanol Plant.

	SCB		EFB		RH		CCS	
Category	USD/L	Share (%)	USD/L	Share (%)	USD/L	Share (%)	USD/L	Share (%)
Raw materials [a]	0.3472	45.32	0.1948	33.71	0.1972	30.84	0.2387	35.06
Operating labor [b]	0.0037	0.48	0.0037	0.64	0.0037	0.58	0.0037	0.54
Utilities	0.2835	37.00	0.2639	45.67	0.3126	48.89	0.3098	45.52
Operating charges, plant overhead, maintenance	0.0126	1.65	0.0122	2.12	0.0130	2.04	0.0129	1.90
General and administrative cost	0.0518	6.76	0.0380	6.57	0.0421	6.59	0.0452	6.64
Depreciation of capital [c]	0.0674	8.80	0.0653	11.29	0.0708	11.07	0.0703	10.33
Total	0.7662	100.00	0.5779	100.00	0.6393	100.00	0.6807	100.00

[a] Raw material prices, SCB: US$15/ton, EFB: US$5/ton, RH: US$5/ton, CCS: US$18/ton.
[b] Used low pressure steam price was US$8.18/ton.
[c] Calculated using the straight line method.

4. Effects of the Russia - Ukraine war on biorefineries

Global economy

Politician leaders, researchers, and industrial players

The **food and energy insecurity** generates the need of an **urgent transformation towards sustainable, resilient and adaptable systems**.

BIOPROCESS - BIOREFINERY

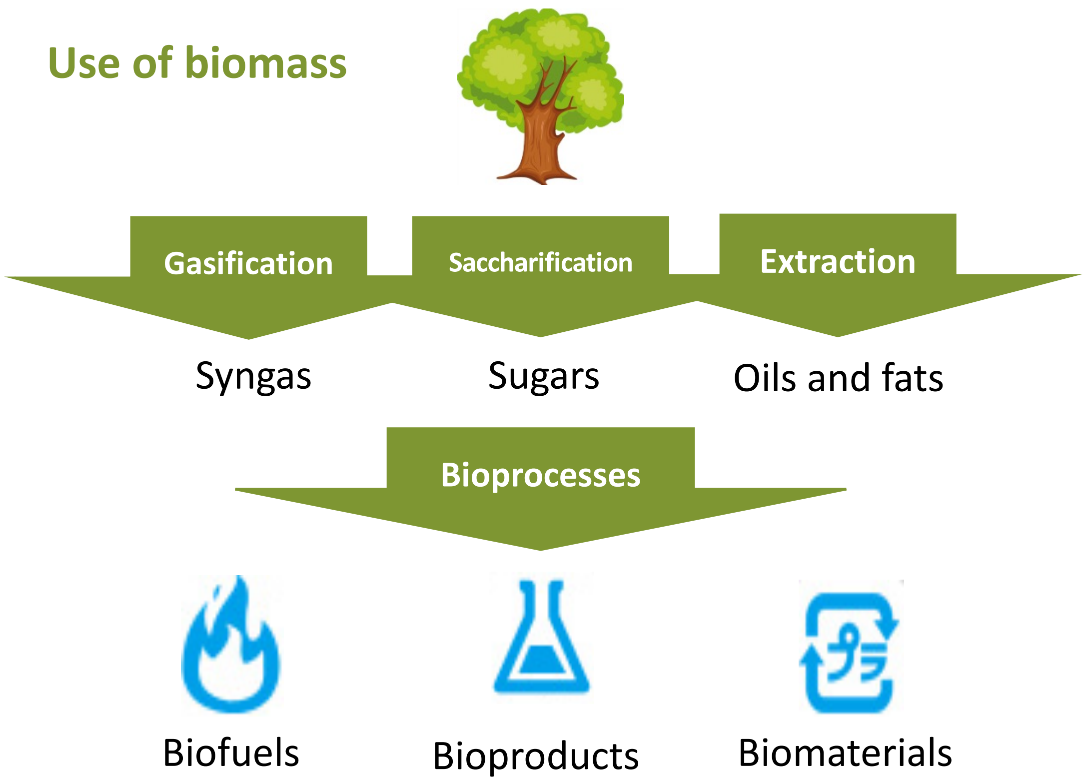

Figure 1. Graphic scheme of biorefinery concept.

5. Biorefineries and bioprocesses flexibility

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Flexibility

The adaptation capacity of a process to a set of uncertain parameters. Is associated to changes of demand and supply. The suitable use of flexibility in a process should reduce the cost of external factors

Strategic flexibility

Related to the plant adaptability to external factors as the market, new trends and government policies.

Operational flexibility

Refers to the plant capacity to operate outside the optimal conditions without affect its technical performance.

6. Case study. Sugar mills

Scenarios Description

Scenario 1: The production of sugar, ethanol and electricity from sugar cane is analyzed. In addition, there is a cogeneration system where the cane bagasse is used.

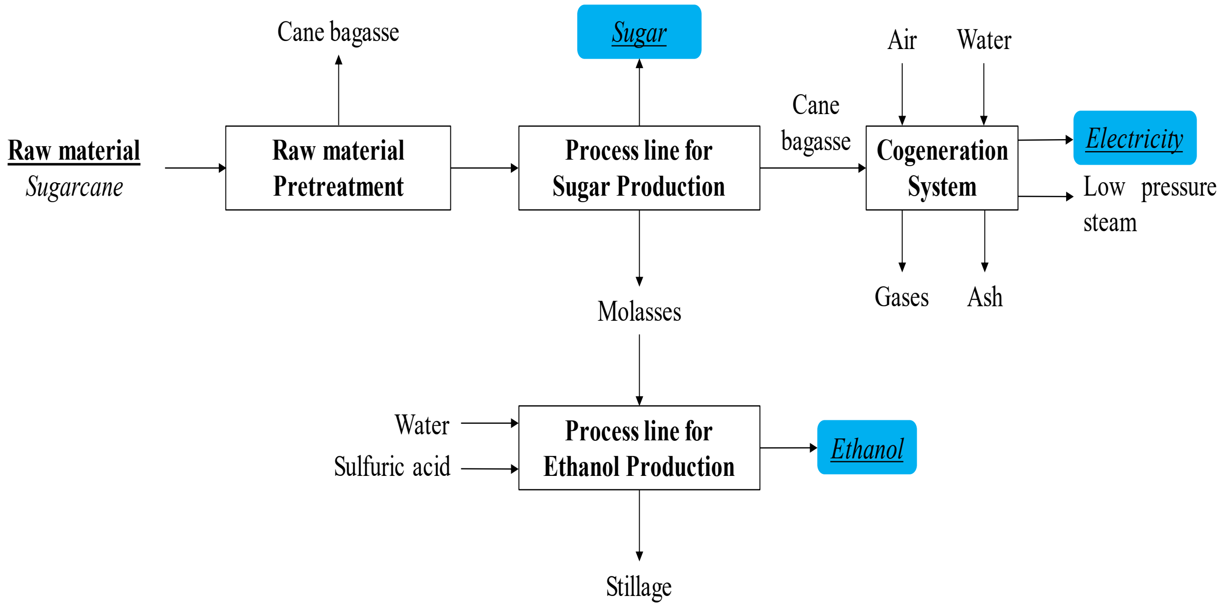

Figure 2. Flow diagram for the process described in Scenario 1.

Scenario 2: The production of sugar, ethanol and glycerinated ethanol from sugar cane is analyzed. The cogeneration system operates using stillage for the energy requirements of the process.

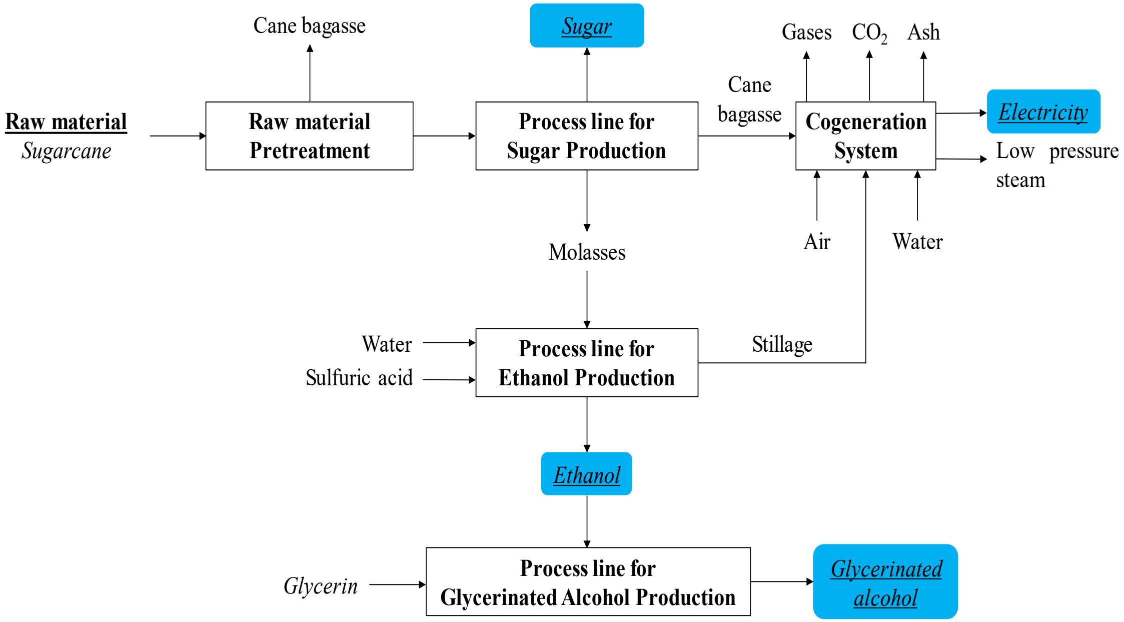

Figure 3. Flow diagram for the process described in Scenario 2.

6. Case study. Sugar mills

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Methodology

Economic Assessment

Each scenario is analyzed using the Aspen Process Economic Analyzer (APEA) from Aspen Plus V9.0 software.

Table 2. Raw material used for each biorefinery scenario.

Scenario 1	Scenario 2
Sugarcane	Sugarcane
Calcium hydroxide	Calcium hydroxide
Sulfuric acid	Sulfuric acid
Molasses	Molasses
Water	Stillage
	Sludge
	Glycerin
	Water

Table 3. Parameters for economic evaluation of each biorefinery scenario.

Operating time	8000 h/year
Shifts	3 per day
Working time	8 h/day
Tax rate	35%
Interest rate	13.00%
Operators wage	313.55 $USD/month
Project lifetime	20 years
CEPCI 2023	815.98

SELLING PRICE

Fuel alcohol
0,70 $USD/kg

Glycerinated alcohol
3,42 $USD/kg

aspentech

Environmental Assessment

The Waste Reduction Algorithm (WAR) software is employed for the analysis of each biorefinery scenario. The following impact categories are considered to calculated the Potential Environmental Impacts (PEI).

Impact Categories

HTPI: Human Toxicity Potential by Ingestion.

HTPE: Human Toxicity Potential by Exposure.

TTP: Terrestrial Toxicity Potential.

ATP: Aquatic Toxicity Potential.

GWP: Global Warming Potential.

ODP: Ozone Depletion Potential.

PCOP: Photochemical Oxidation Potential.

AP: Acidification Potential.

EPA United States Environmental Protection Agency

6. Case study. Sugar mills

Results

Aspen Process Economic Analyzer is used for the economic assessment of each scenario.

Table 4. Energy requirements for each biorefinery scenario.

Source	GJ/t	
	Scenario 1	Scenario 2
Cooling	3.70	4.18
Heating	2.66	1.73
Electricity (net)	0.37	0.65

Table 5. Economic metrics for each biorefinery scenario.

Scenario	Scenario 1	Scenario 2
Feature	Million USD/year	Million USD/year
Payout period (years)	4.27	3.83
NPV* (M. USD/year)	147.19	210.15

*Net Present Value.

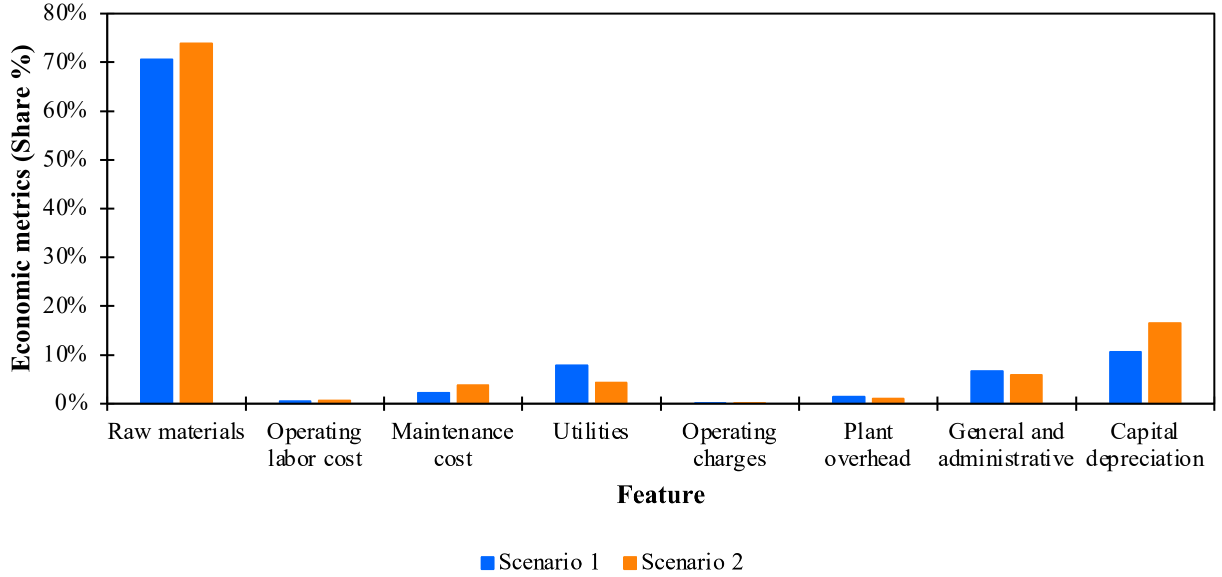

Figure 4. Economic metrics distribution for each biorefinery scenario.

Potential environmental impacts is evaluated using the software WAR GUI.

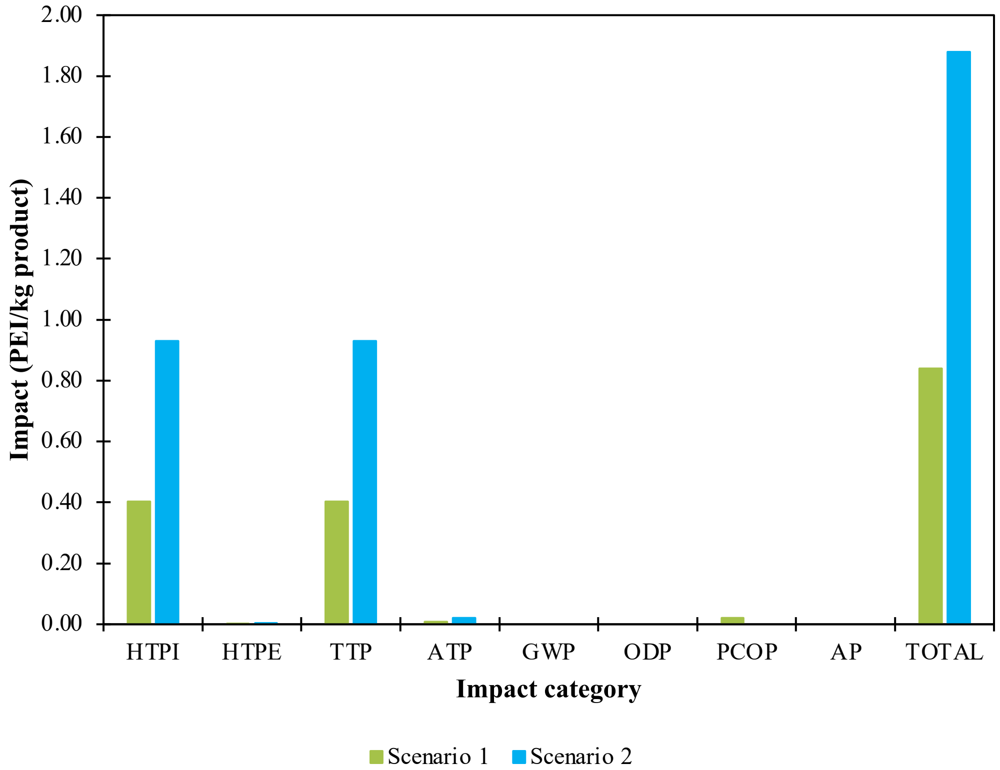

Figure 5. Potential Environmental Impacts distribution for each biorefinery scenario.

7. Conclusions

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- The biorefinery concept has more importance today than 3 or 4 years ago as the world understood in dramatic way how the right and sustainable use of resources, including biomass, ensures the future of humans in the earth. But at the same time the green policies were so weak that the challenges for their stability in crisis times were not accomplished.
- The proposed key points and strategies are demonstrated to satisfy the resilience of our countries to the crisis times that could come in next 15 years.

Regarding the case study:

- **An addition of a biogas production plant using stillage** as raw material improves the energy balance of the process, **allows to supply 100% of the total energy demand** of the process. This fact increases process resilience and energy security (energy matrix diversification)
- A **change from fuel ethanol production to glycerinated alcohol is an easy way to demonstrate the versatility concept** of biorefineries since this change increases economic pre-feasibility and resilience of the process even for a maximum of one year (but the technology as well as the logistics restrictions affected these advantages

Acknowledgments

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Continuing…

Questions?

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