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Integration of a Colombian biorefinery from industrial palm oil waste into the circular economy

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Introduction & Background

In Colombia, due to its market abroad, palm cultivation is a major non-food agricultural commodity. The volume of production places Colombia as the sixth exporter of palm oil in the world. Furthermore, palm oil mills produce approximately two tons of concentrated solid wet biomass per ton of primary product commercialized (oil and kernel) [1].

The aim of this research is to develop the circular economy approach in the Colombian palm oil industry, to account for the agriculture supplies and demands in a representative sample of the process chain. This study allows the characterization of waste to be used in palm oil mill bio-refineries as a representative sample in order to identify potential risks. In addition, the work adds not only criteria for assessing the agricultural palm sector to establish indicators for a sustainable circular economy, but also methodologies based on LCA to allow efficient management of resources, nutrients and agrochemicals in order to quantify the required amount to produce a given product. The knowledge of these parameters permits the identification of those elements that influence its magnitude, so that, different alternatives can be used to enable the sustainability of the oil palm industry.

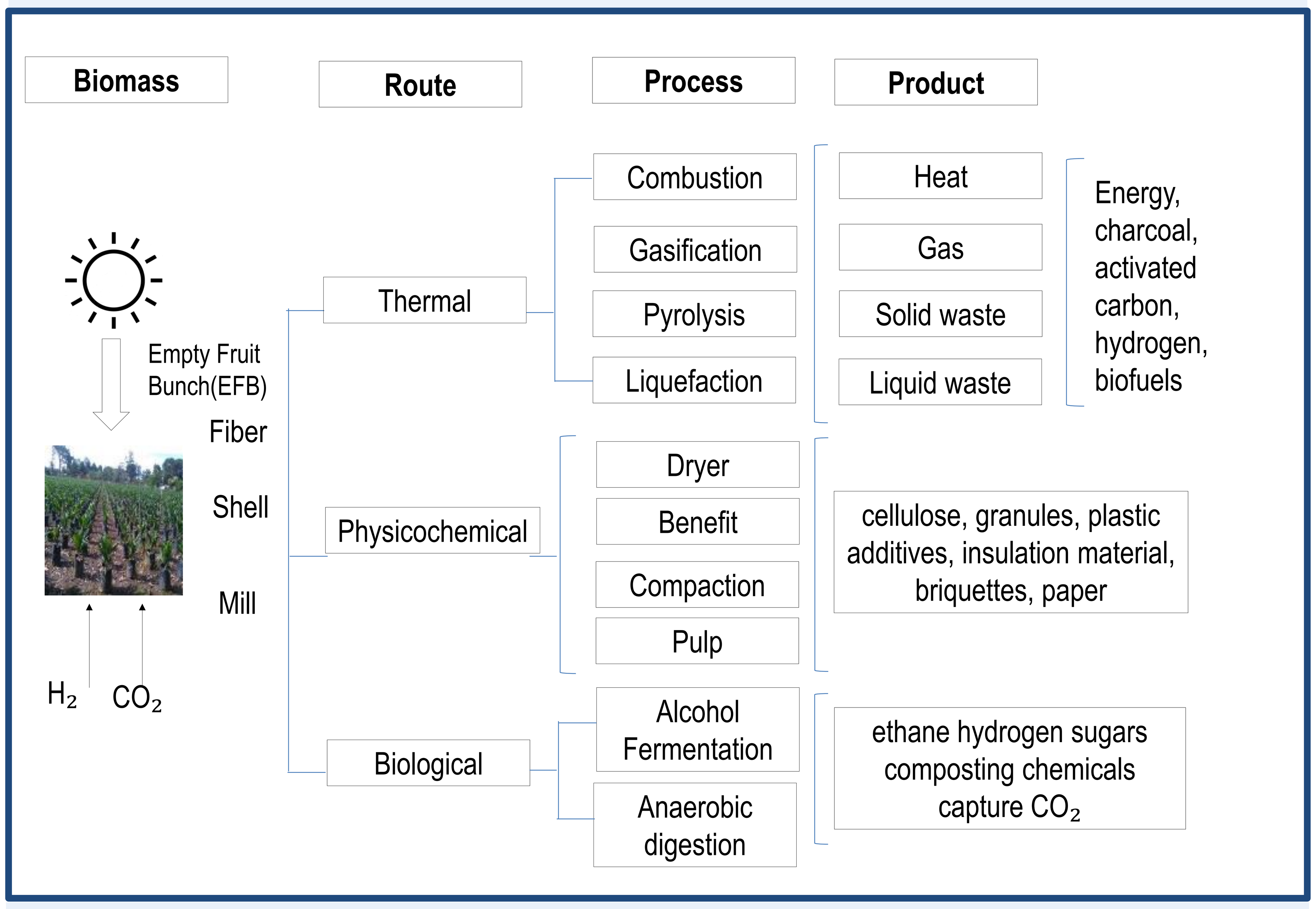

Fig. 1. Alternatives for the use of palm biomass as part of the conversion of biorefineries [1].

Materials & Methods

For the elaboration of the LCI it is necessary to start from a series of assumptions and hypotheses that allow completing these data. Some of the main methodological hypotheses that support the development of the inventory and facilitate its analysis are: i) Inter-American Development Bank [2], and ii) International Reference Life Cycle Data System (ILCD) Handbook [3].

The collection of secondary information was taken from the Ecoinvent v2.2 database [4]. The aspects to take into account in the LCI are the following:

- Description of the unit processes (balance of matter and energy).
- Calculation procedures (they must be referred to the functional unit).
- Assignment criteria.
- Allocation of flows to products and co-products as established in the definition of objective and scope.
- Data collection procedures.
- Calculations.

In this work, a Life Cycle Impact Assessment (LCIA) was calculated considering the following impact categories [5]: Potential impacts in terms of Global Warming, Acidification, Eutrophication and Ozone Layer Depletion (Table 1).

Results & Discussion

As shown in Figure 2, each of the stages of the production process and the raw materials used to make a schematic diagram of the system's input and output were identified. The aspects to take into account in the realization of an LCI analysis were those related to the flows of materials and energy with the functional unit, the need for assignment and the allocation methods and the availability of the data. Subsequently, the necessary quantities of each raw material were calculated to finally enter the data in a commercial software (*SimaPro®*) in order to calculate the potential impacts in each stage.

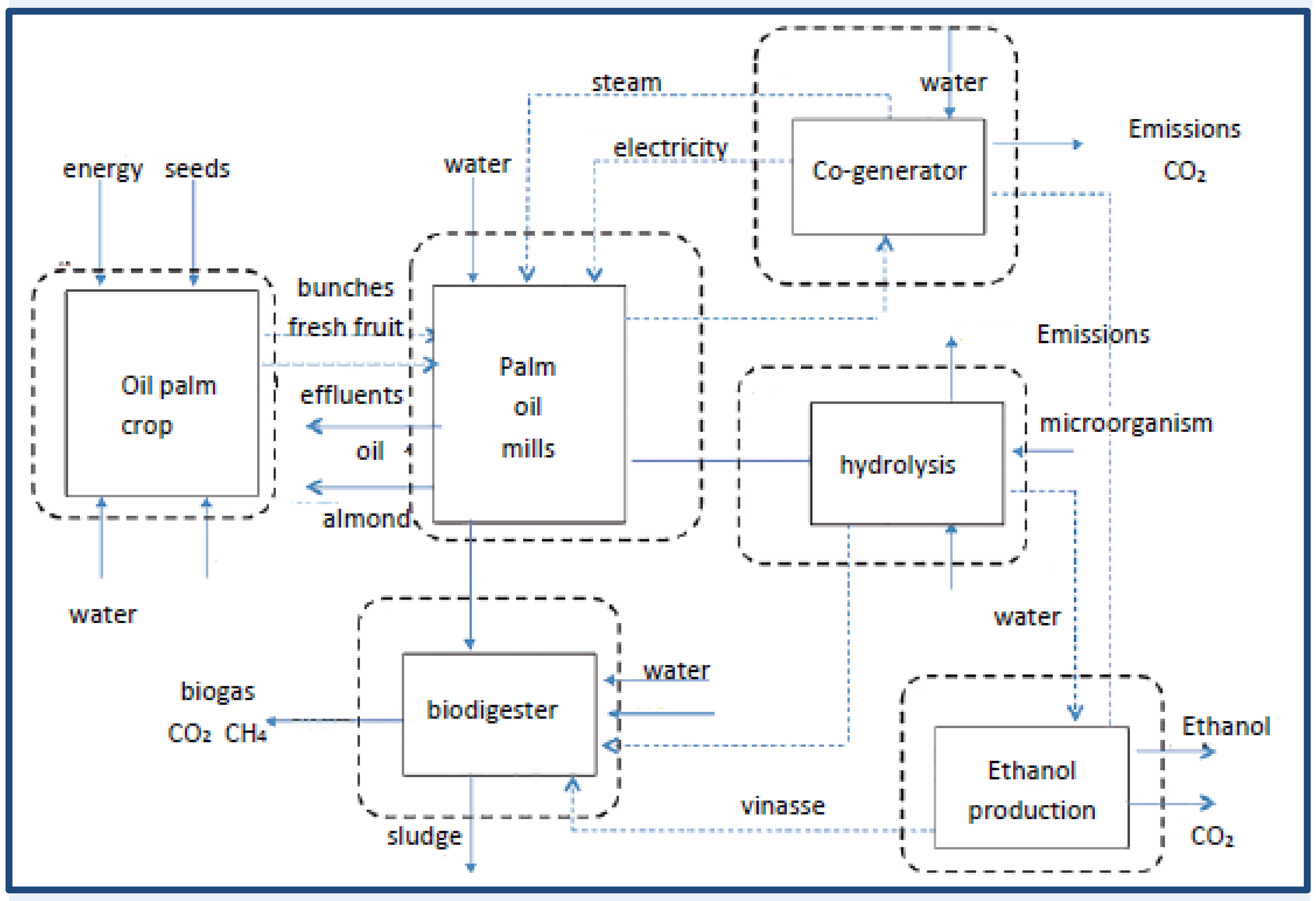

Fig. 2. System boundaries for the LCI of a biorefinery from oil palm crop [5].

Table 1. Preliminary impacts per ton of Fresh Fruit Bunch (FFB) (Adapted from Ecoinvent [4]).

Impact category	Quantity	Unit
Global Warming	1.786	kg CO_2 eq
Ozone Layer Depletion	4.58 E-08	Kg CFC eq
Acidification	8.4 E-02	Kg SO_2 eq
Eutrophication	4.82 E-03	Kg PO_4 eq

Conclusions & Future Developments

An LCI in the Colombian palm crop, in order to account for agricultural supplies and consumption in a representative sample of the crop, was developed.

Likewise, an inventory was created in this field for future decision making towards the sustainability of resources and the optimization of processes by companies of palm growers as part of their environmental responsibility policy.

This preliminary review presents an exploratory methodological development for an LCA, as well as evaluation of life cycle sustainability to support the evaluation of circular economy strategies in a cradle to cradle approach.

If cogeneration systems are not implemented and if existing boilers reduce the use of fiber due to environmental limitations and only consume a fraction of what is currently used to generate the steam, there would be greater amounts of biomass for the production of fuels and biological products.

References

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