

Diesel displacement in the sugarcane ethanol life-cycle: a comparative analysis of different integrated systems



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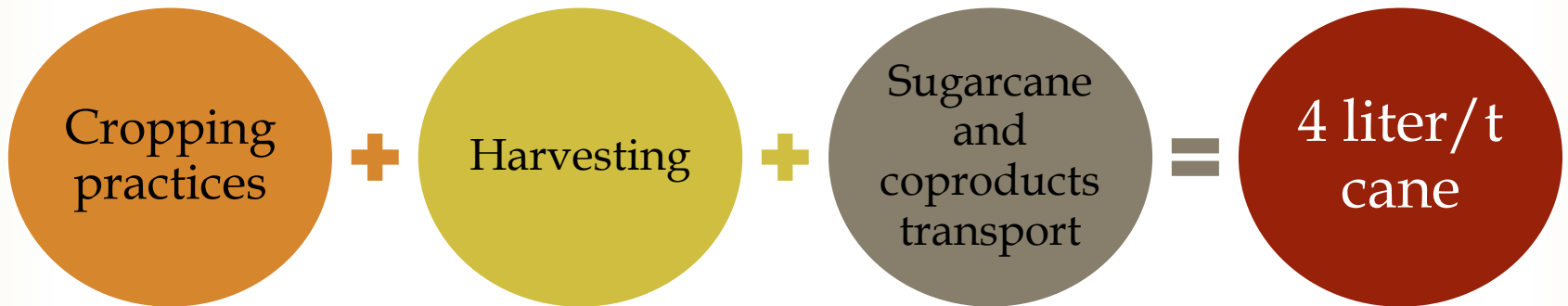


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The sugarcane sector in Brazil



High diesel consumption



How much did the sector consume?

→ 2.7 billion liters of diesel in 2014 season → 4% of the national consumption (EPE, 2013).

→ Upward trend due to the mechanical harvesting.

Brazil:

→ 3rd /4th largest producer of biodiesel

Goal



- ❧ This study aims to explore three integrated production systems applied to the sugarcane sector in Brazil focused on diesel displacement. We assessed the energy balance and the GHG emissions.
- ❧ The integrated systems are:
 - ❧ Soybean-sugarcane
 - ❧ Algae-sugarcane
 - ❧ Palm-sugarcane

Methodology

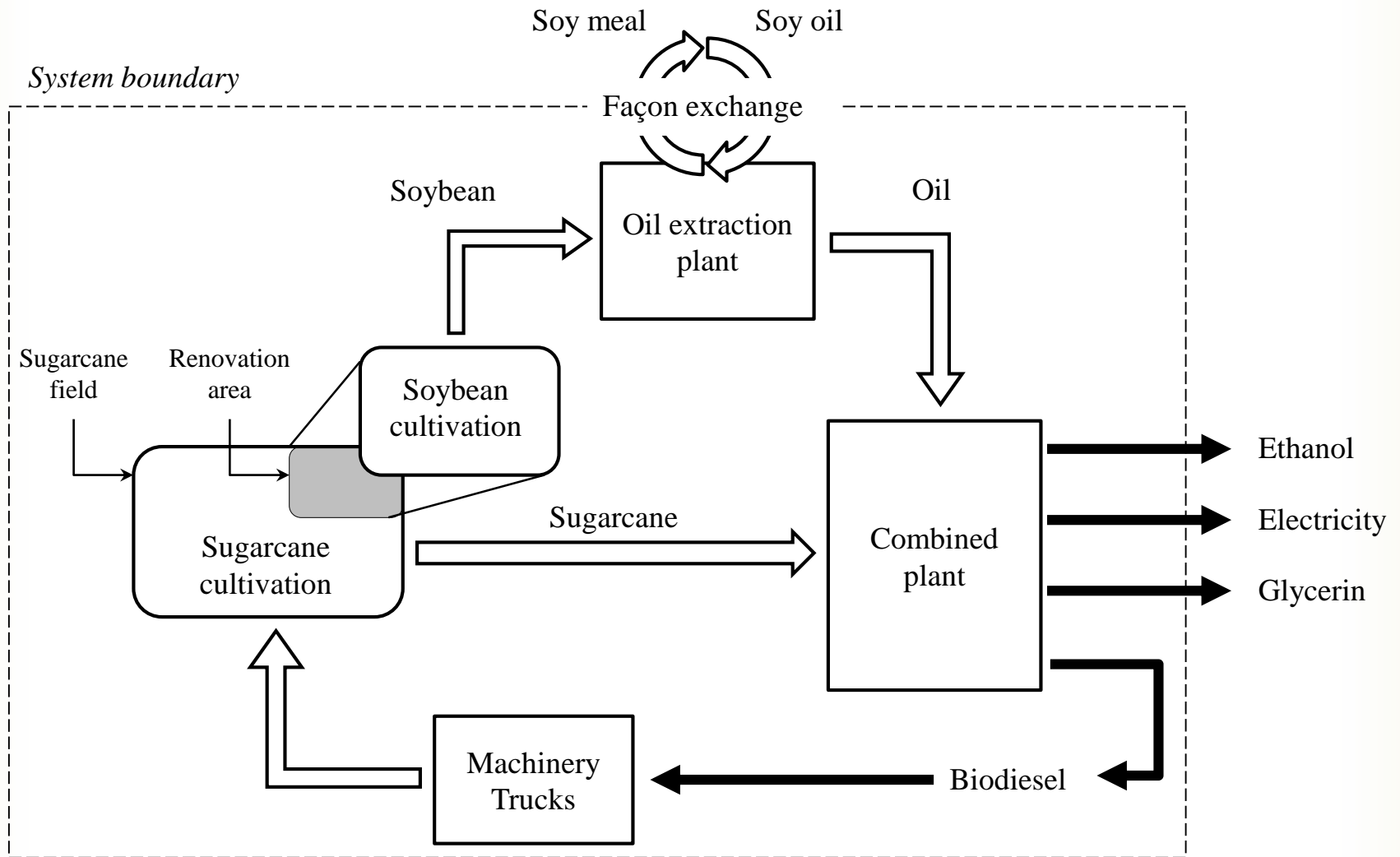


- ❧ Life Cycle Assessment → Well-to-gate analysis
 - ❧ GHG emission
 - ❧ Fossil Energy Use

- ❧ Uncertainty: Monte-Carlo simulation → Crystal Ball[®]

- ❧ Data
 - ❧ Sugarcane and soybean sectors
 - ❧ Sugarcane mills, biodiesel industries, sugarcane suppliers in the States of São Paulo, Mato Grosso and Goiás.
 - ❧ Algae
 - ❧ Literature and SAT Company (NDA)
 - ❧ Palm sector
 - ❧ Literature and Agropalma

SYSTEM 1: Soybean-Sugarcane Integrated Production



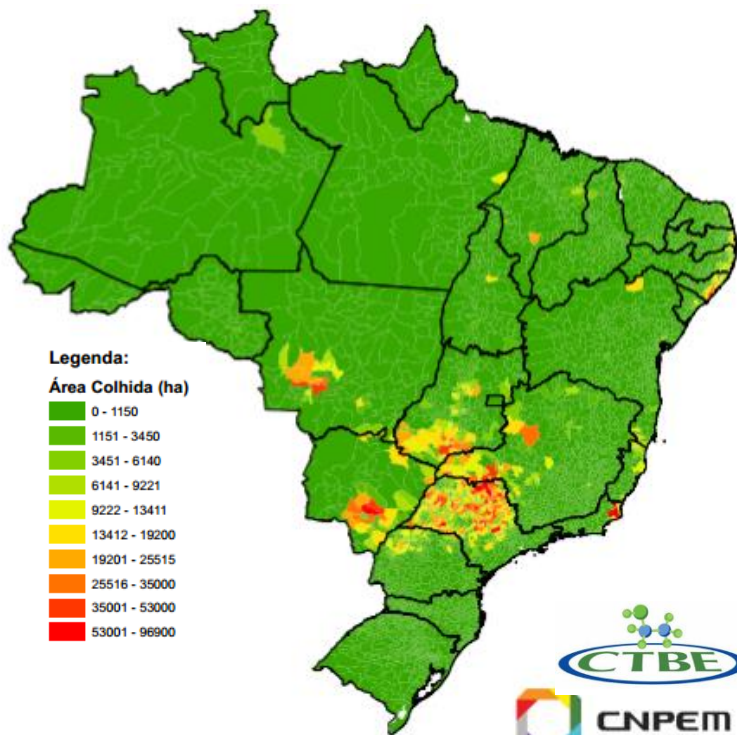
SYSTEM 1: important remarks



☞ Sugarcane (Conab, 2014/15)

☞ Area: 9,000,000 ha

☞ Production: 672,000,000 tons



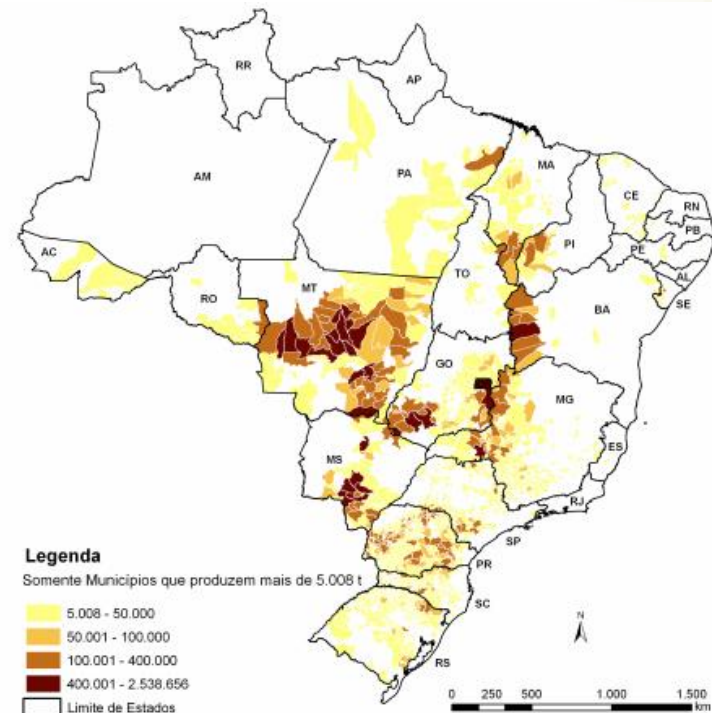
Reference: IBGE

☞ Soybean (Conab, 2014/15)

☞ Area: 30,000,000 ha

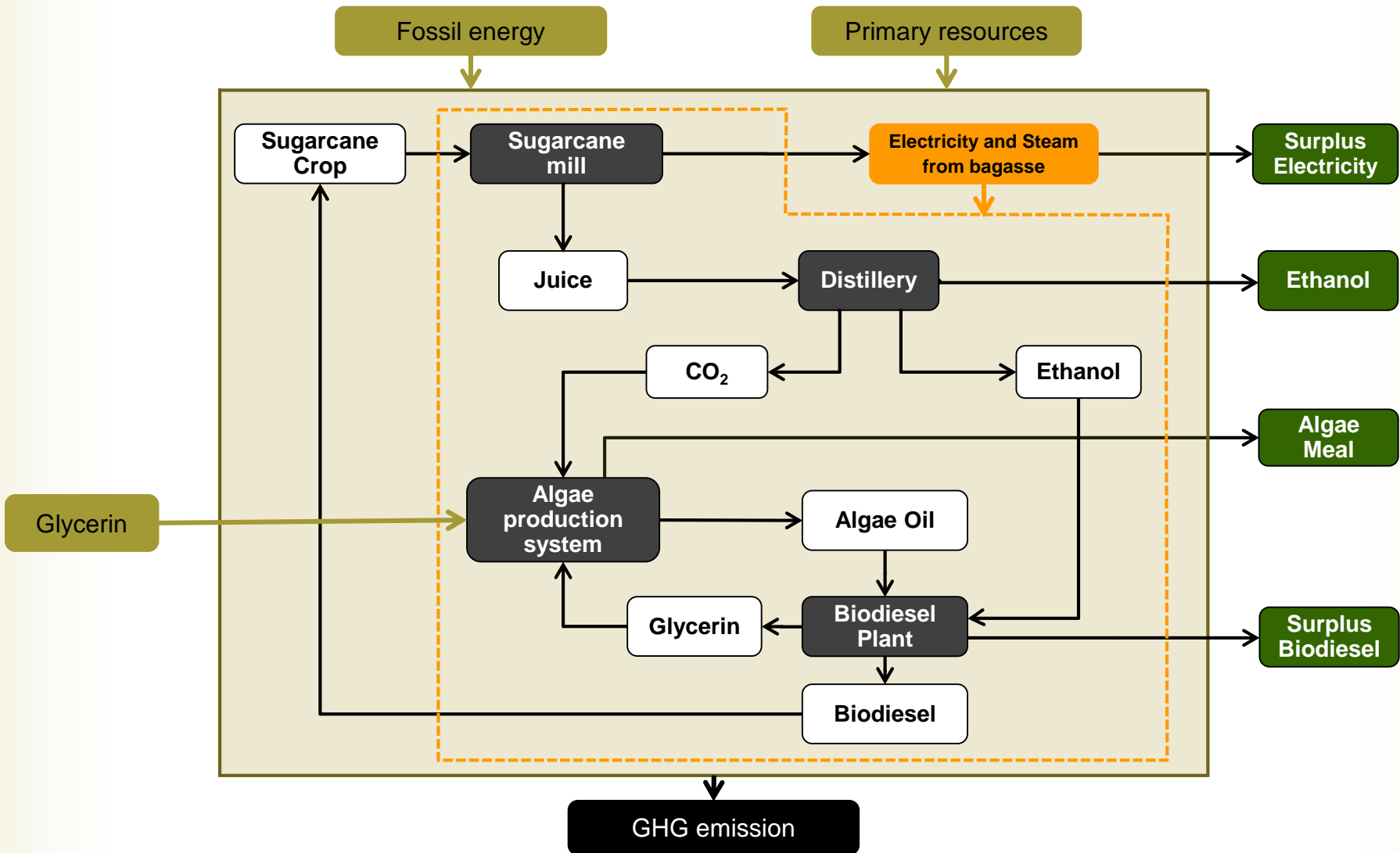
☞ Production: 86,000,000 tons

☞ 80% of the biodiesel source



Reference: CONAB, 2014.

SYSTEM 2: Algae-Sugarcane Integrated Production



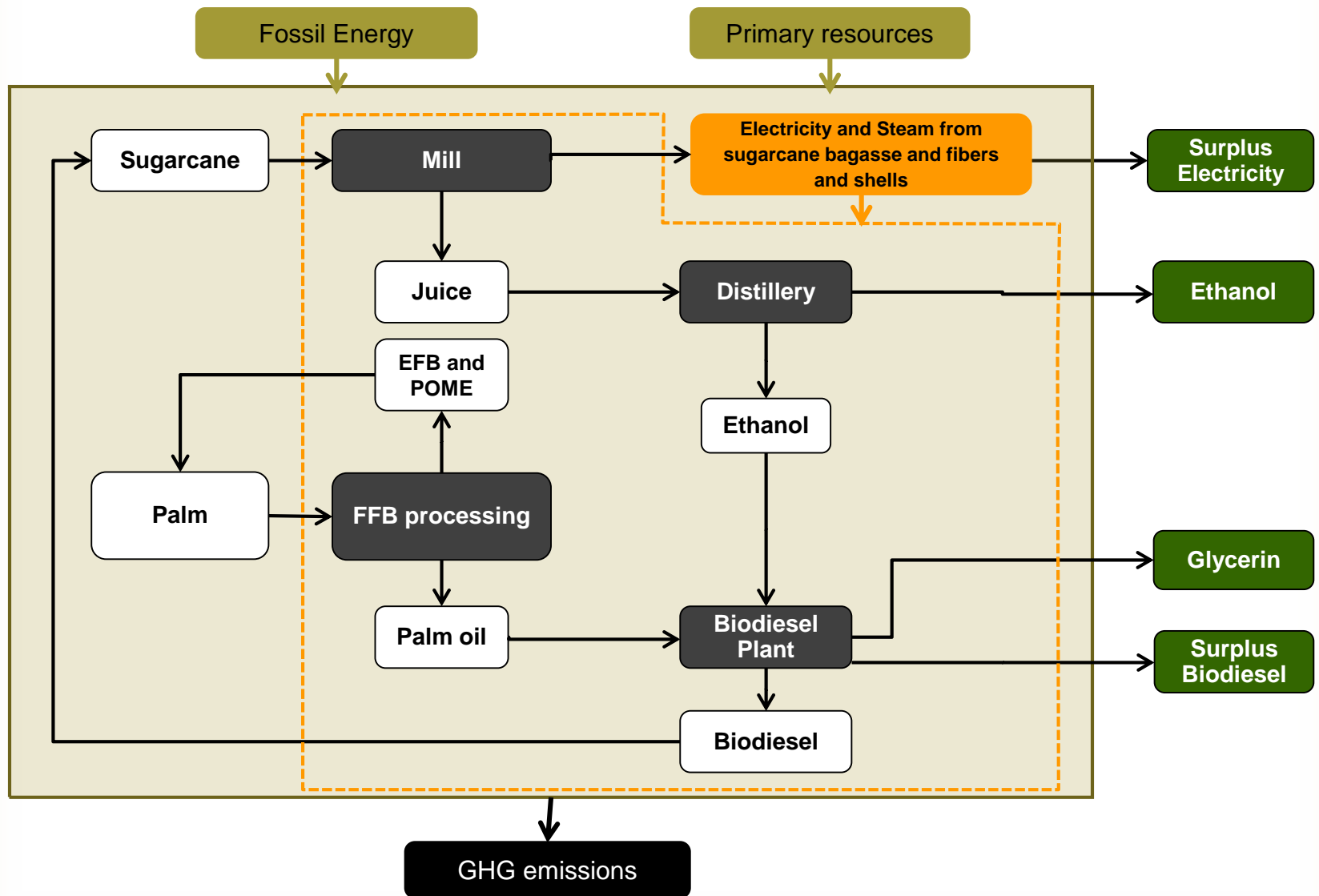
* **Note:** dark grey boxes: processes; white boxes: products consumed inside the system; green boxes: output products; orange boundary: energy flow, which supplies all the process; and black arrows: mass flow.

SYSTEM 2: important remarks



- ❧ CO₂ available from fermentation (pure) and bagasse burning.
- ❧ Biodiesel production is limited by the CO₂ availability.
- ❧ Due to a favorable climate, Brazil has the potential to become a major algae producer (Franz et al., 2012).

SYSTEM 3: Palm-Sugarcane Integrated Production



* **Note:** dark grey boxes: processes; white boxes: products consumed inside the system; green boxes: output products; orange boundary: energy flow, which supplies all the process; and black arrows: mass flow.

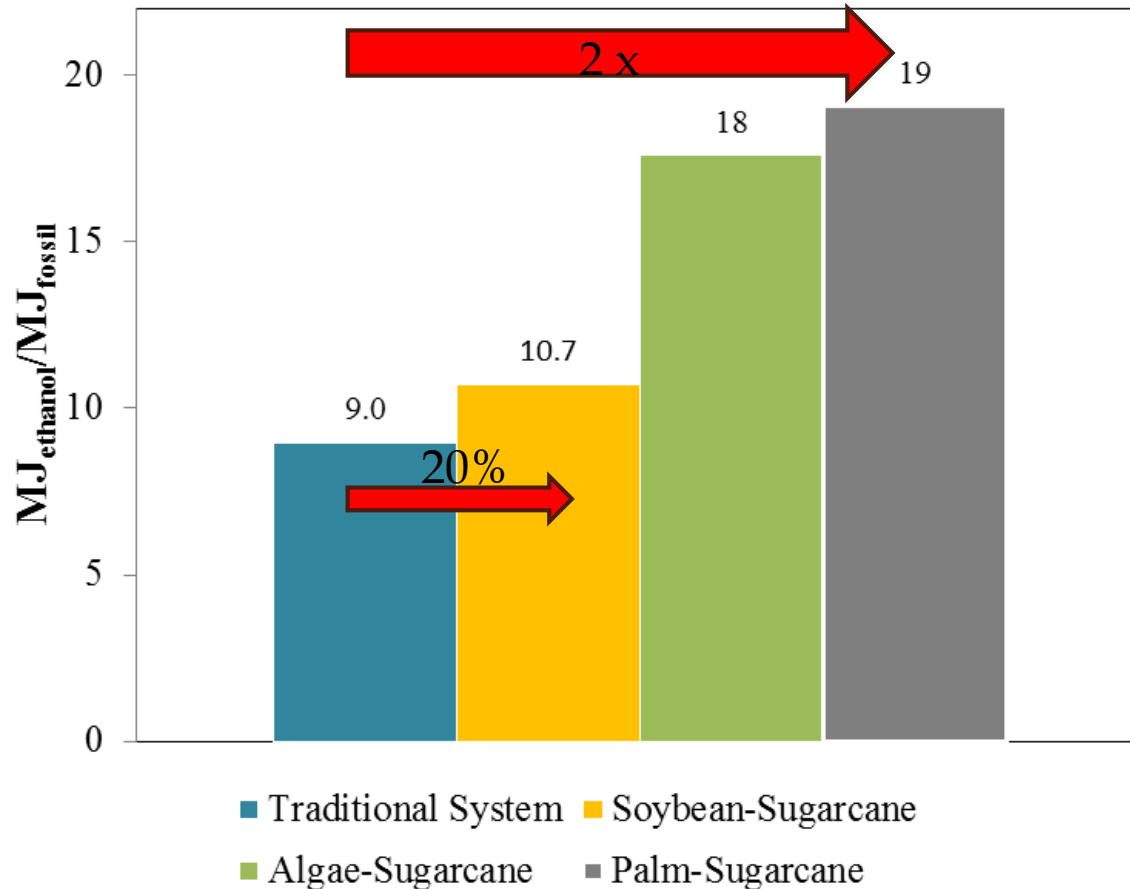
SYSTEM 3: important remarks



- œ Palm → main feedstock used for oil production worldwide (food and chemical industries).
- œ Over ten years, the palm oil has remained as the lowest price in the international market (MPOB, 2012).
- œ Embrapa experiment: Promising results of palm under irrigated conditions in Cerrado region.
 - œ Irrigation: POME and vinasse

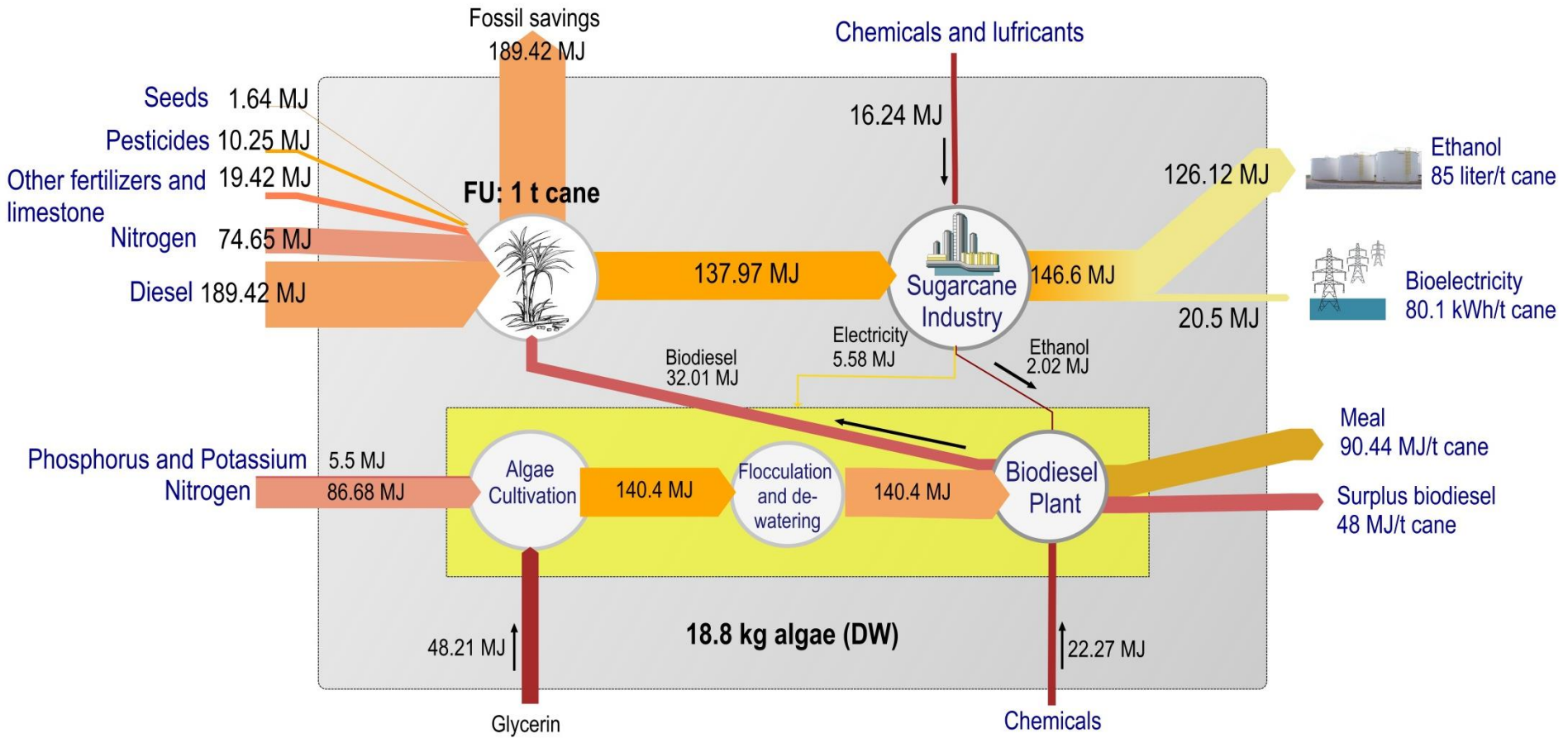
RESULTS...

Energy Balance (EROI)

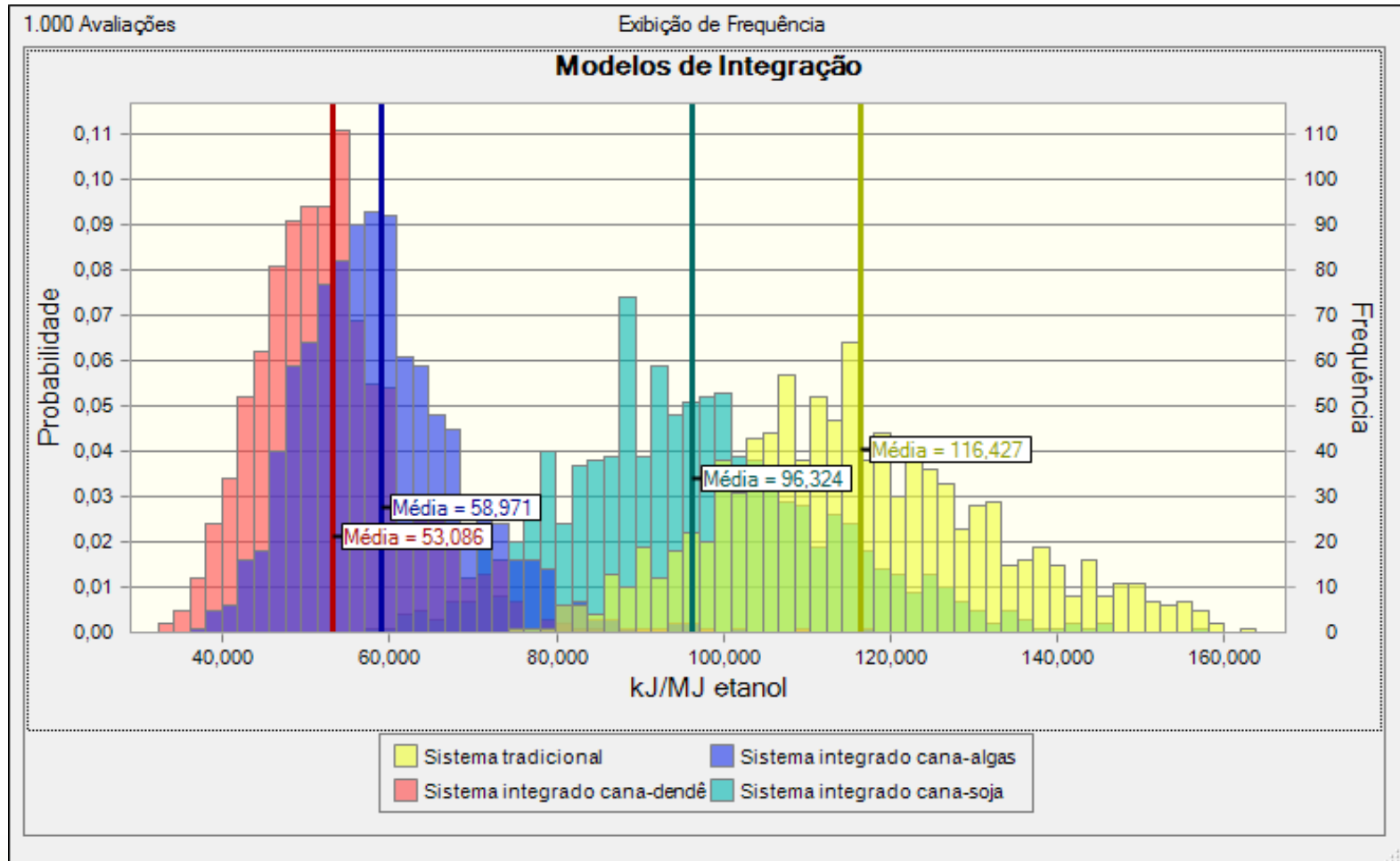


Energy Flow

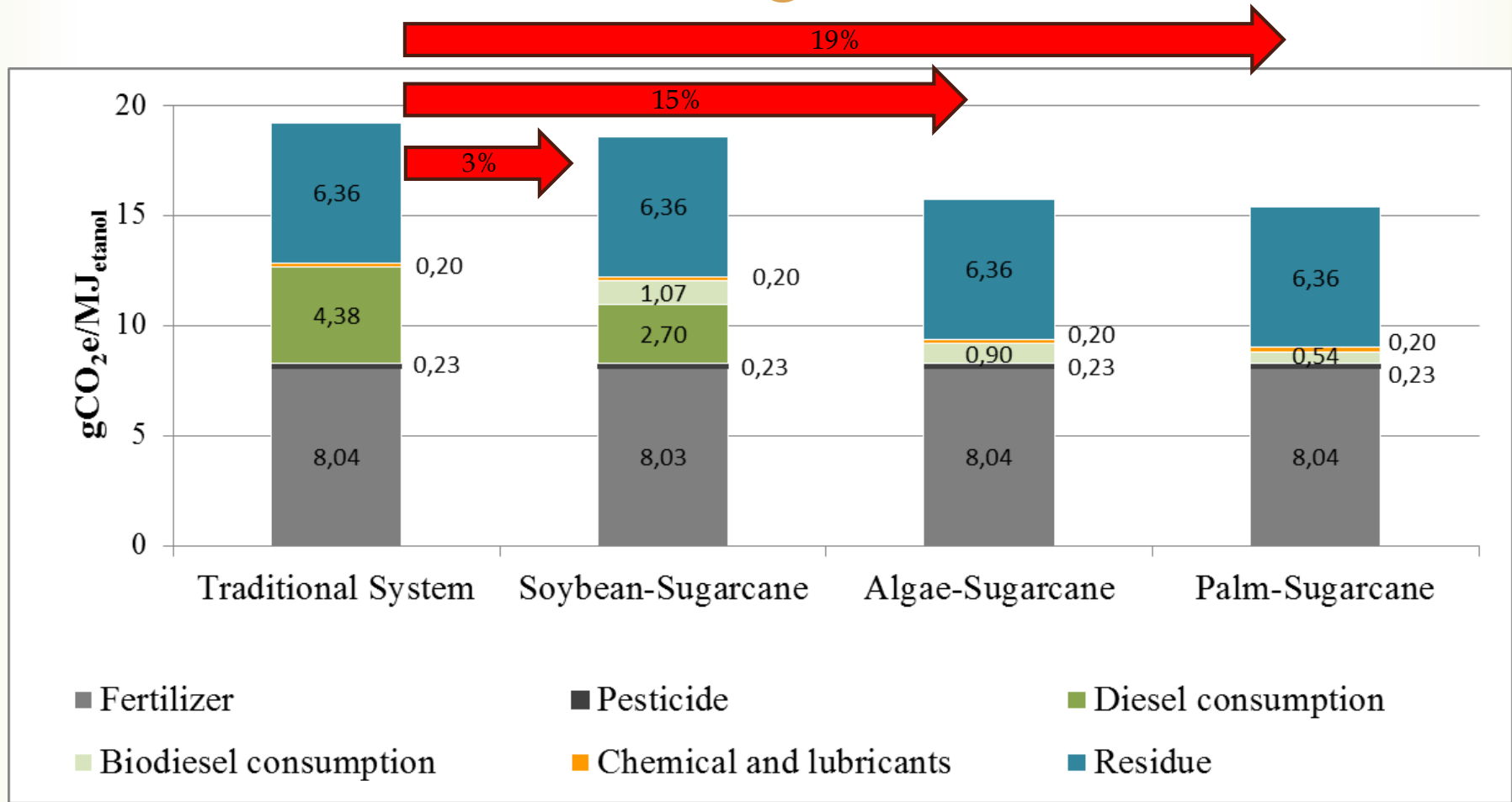
REFERENCE: 1 TON OF SUGARCANE = 18.8 kg ALGAE (DW)



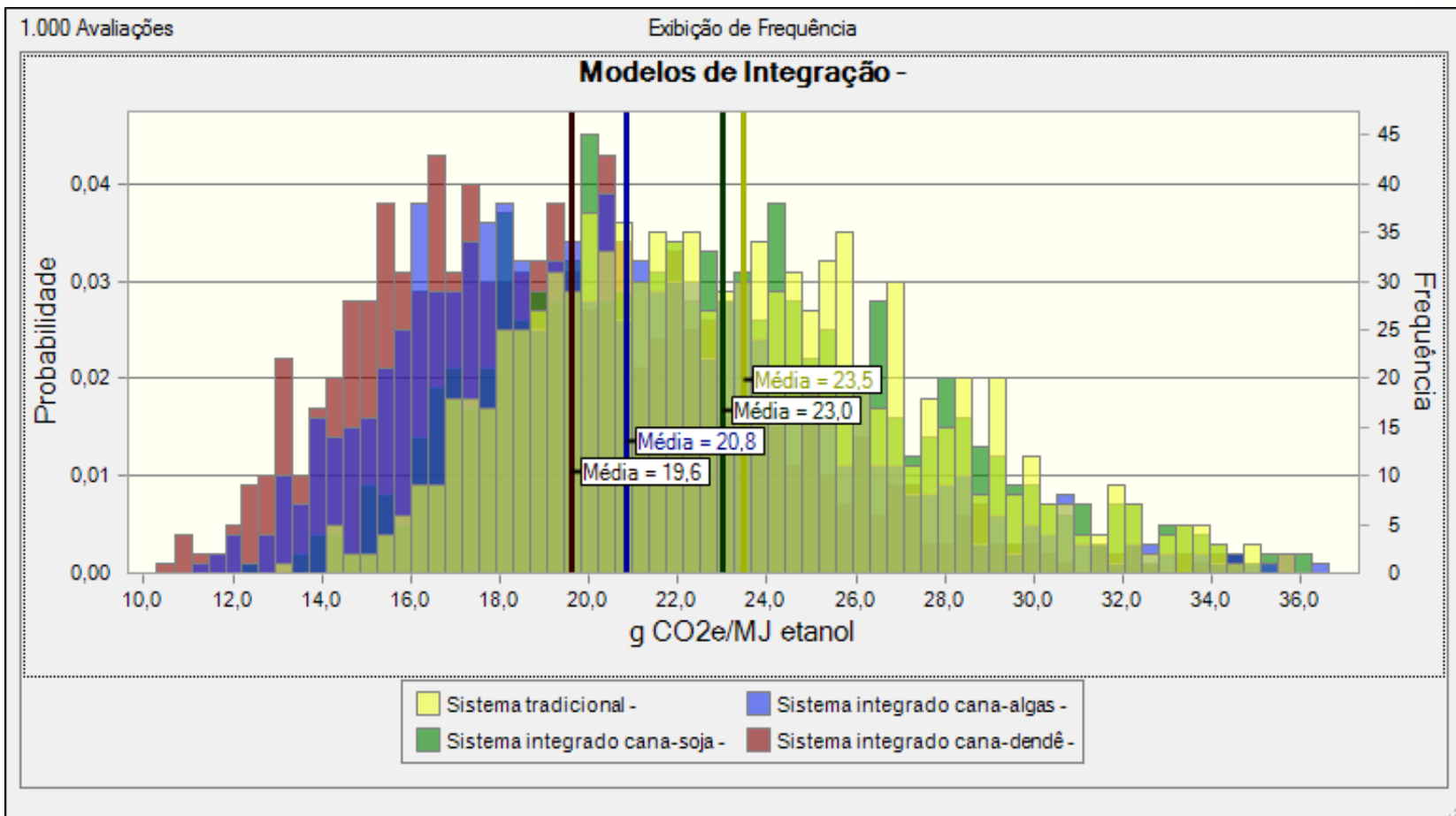
Fossil Energy Use



GHG emissions



GHG emissions



Final Remarks



- Algae-Cane and Palm-Cane integration are the best options in terms of environmental aspects.

HOWEVER...

- Algae technologies are still under development
- There are many uncertainties regarding palm cultivation under irrigated conditions
- Soybean is a well-established culture and in short-term it seems to be the best option to be integrated to the sugarcane sector.
- Other opportunity costs can discourage the diesel displacement. Ex: biodiesel auction, high oil price market, etc.

Takeaway message



- ❧ The use of ethyl route is an important aspect of the proposed integrated system
 - ❧ 80% of the biodiesel factories use methanol → US\$ 250 million was spent in methanol importation in 2012
- ❧ Local consumption of biodiesel
 - ❧ Avoid logistic problems
 - ❧ Avoid long distance transportation of biodiesel
- ❧ Diesel imports
 - ❧ Brazil imported 8.1 billion liters of diesel, equivalent to 6.6 billion dollars
- ❧ Diesel consumption will increase 65% until 2030 [MME, 2007] → 8 million ha of soybean (B5)

Acknowledgment



THANK YOU FOR
YOUR ATTENTION!!!



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