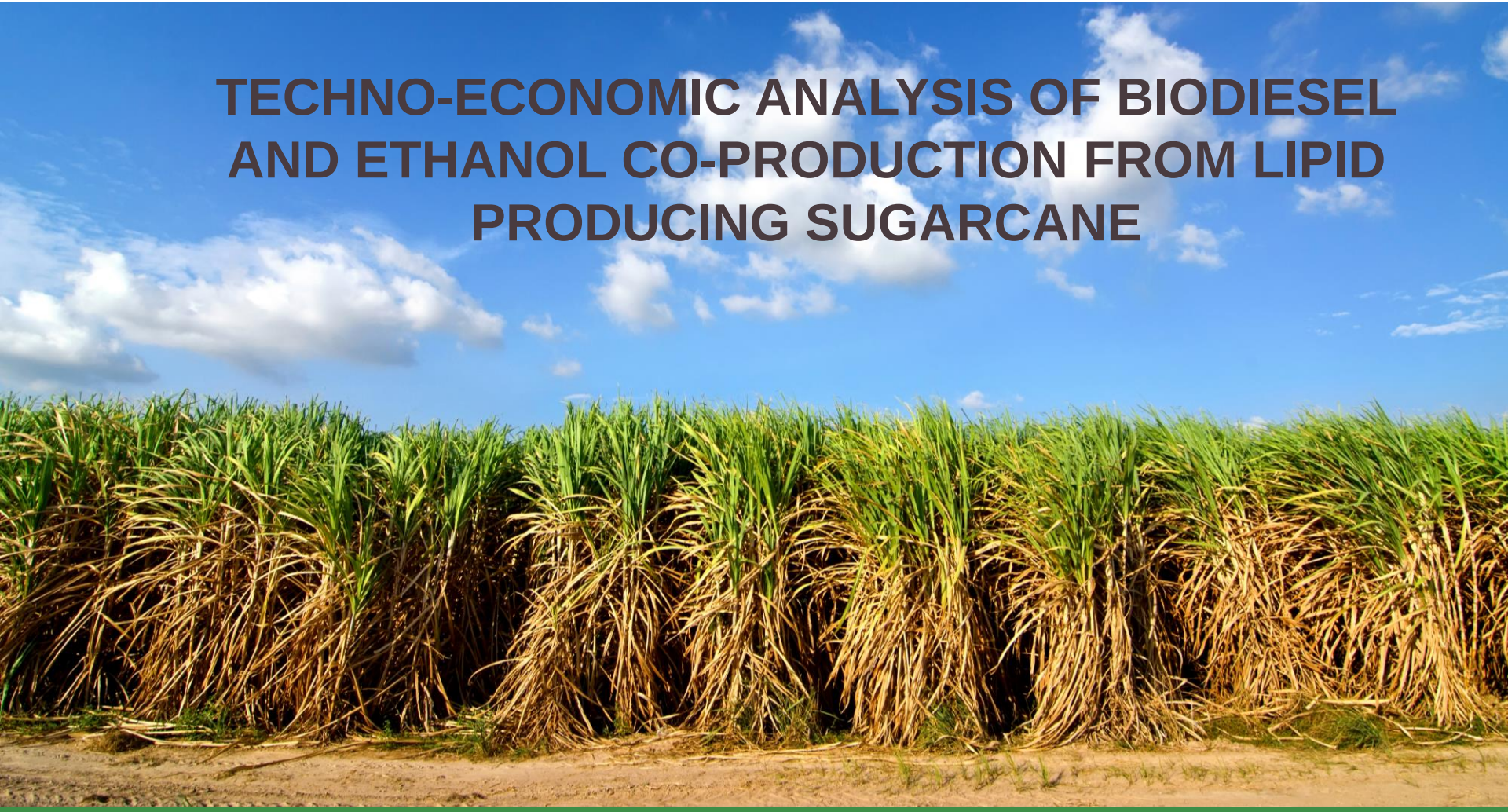
TECHNO-ECONOMIC ANALYSIS OF BIODIESEL AND ETHANOL CO-PRODUCTION FROM LIPID PRODUCING SUGARCANE

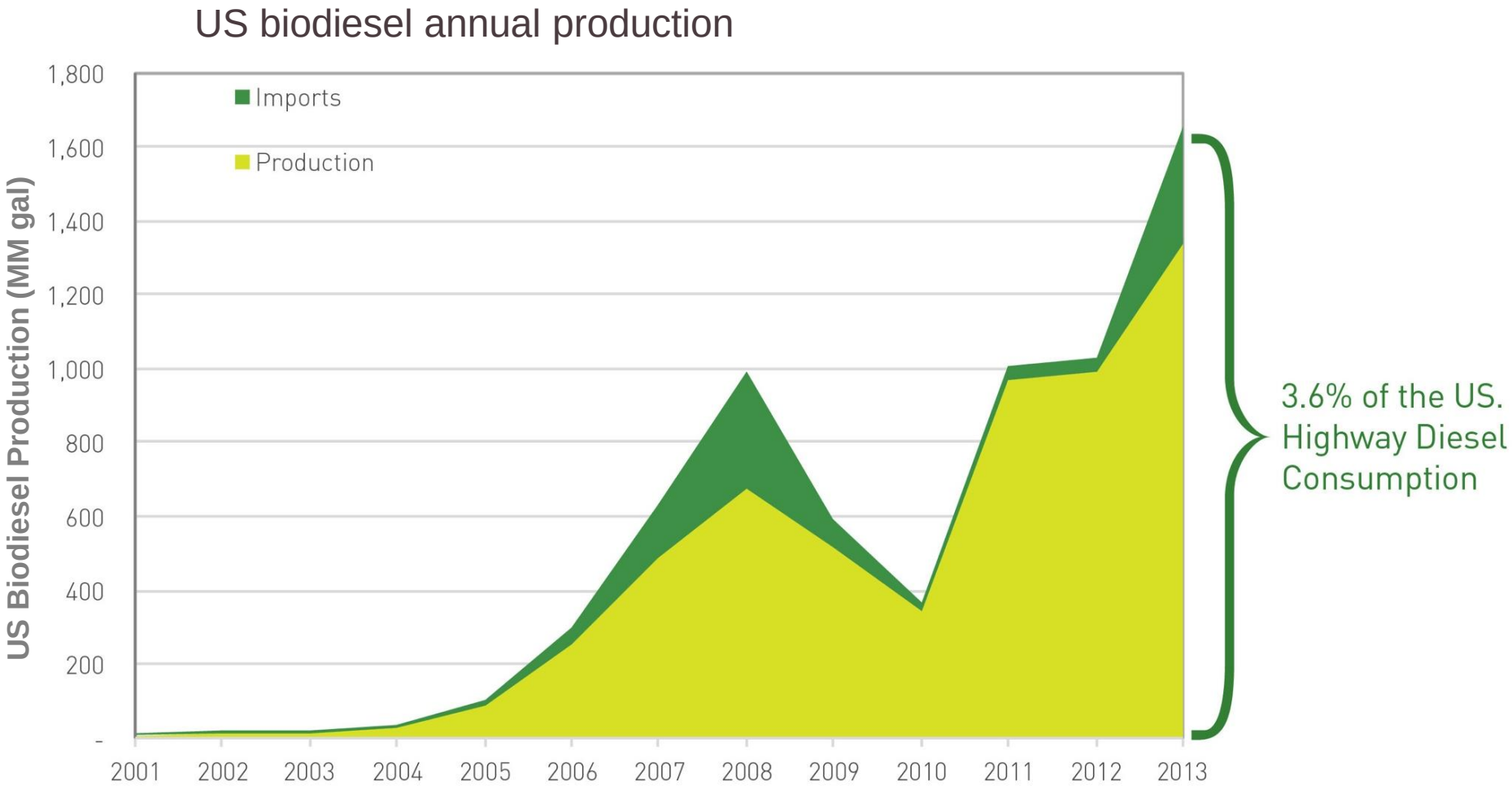


Haibo Huang, Stephen Long, Vijay Singh
Agricultural and Biological Engineering
University of Illinois at Urbana Champaign

PETROSS

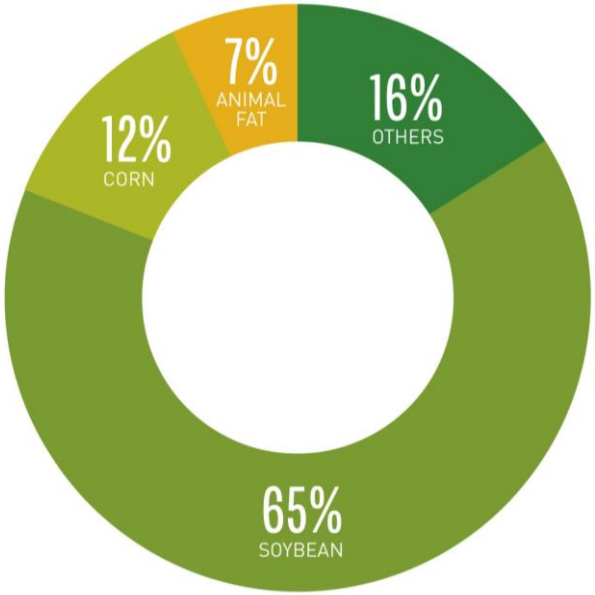
PARTNERS: UF UNIVERSITY of FLORIDA · University of Nebraska Lincoln · BROOKHAVEN NATIONAL LABORATORY · arpa·e · ILLINOIS UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

GROWING MARKET FOR BIODIESEL



Biodiesel production in the U.S. increased by more than 10 times for past 10 years

Main feedstock for biodiesel production:



Even if all the vegetable oils and animal fats were used to produce biodiesel, it would only displace 11% of the current diesel demand.

Future growth has to come from advanced biofuels made form other domestically produced feedstock.

Sugarcane: the right crop for the job

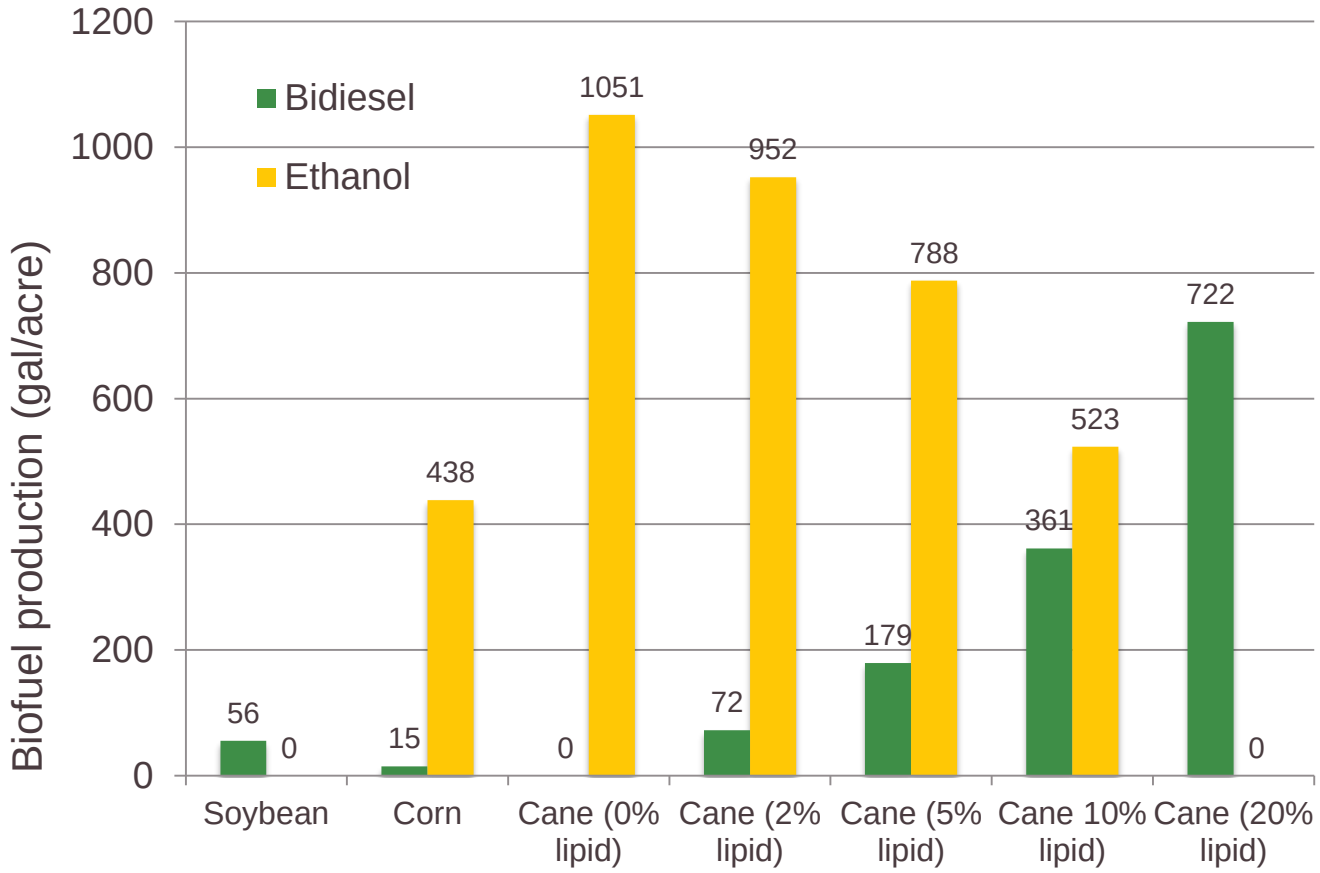
- One of the world's most productive crops
- Already established in the US
- Drought tolerant
- Thrives in poor soil with little fertilizer
- Can be grown on marginal lands that are currently unproductive

- Plants already naturally produce oil
  - Use it as part of their metabolism
- By up-regulating the genes that make oil and down-regulate the genes that use it
  - Oil is stored in stems
- Currently we have achieved lipid cane with 5% oil (dry basis)
- Goal is to achieve 20% oil (dry basis) in Lipid cane

Lipid cane techno-economic models were developed and compared with the current existing soybean and corn processing plants

- Lipid cane process model with lipid content of 0%, 2%, 5%, 10% and 20%
- Soybean-biodiesel process model with solvent (hexane) exaction
- Corn-ethanol process model with oil extraction from thin stillage

TOTAL VALUE OF PRODUCTS / ACRE OF LAND USE

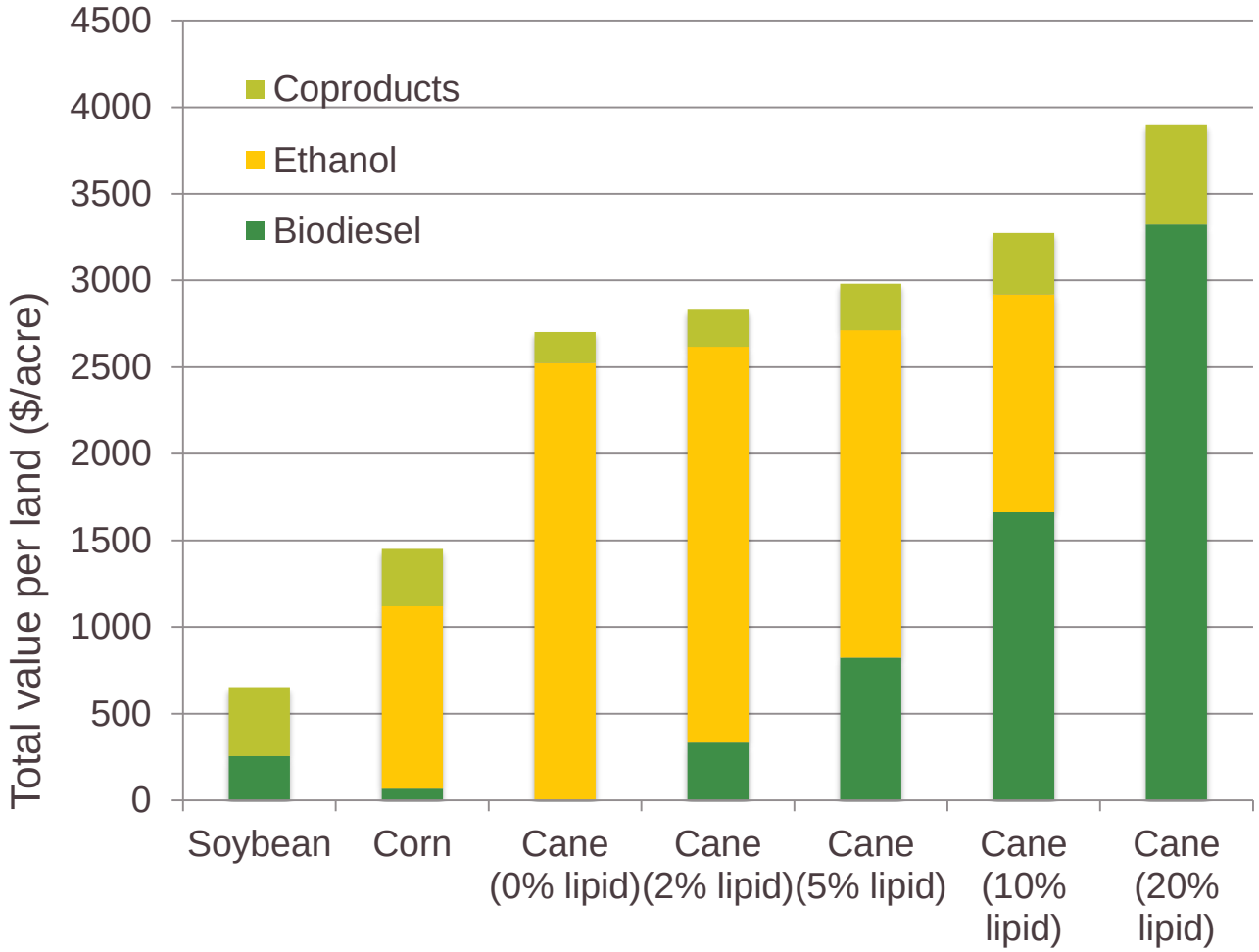


Assumptions:

a) Soybean Yield: 1.1 ton/ac; Corn yield: 3.7 ton/ac; Cane yield: 15 dry ton/ac

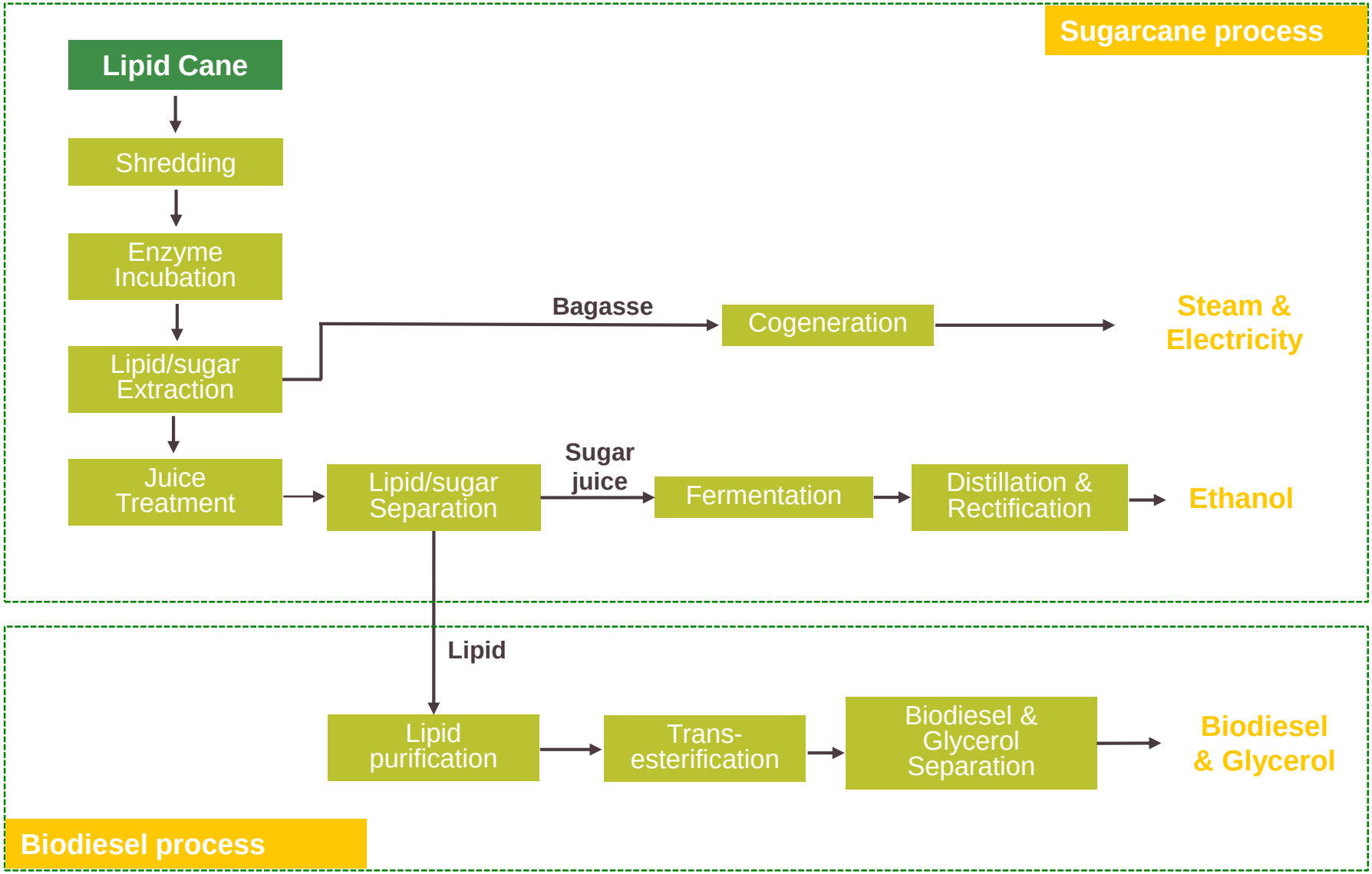
b) Increased photosynthesis can keep the lipid cane yield same as conventional sugarcane

TOTAL BIOFUELS PRODUCTION / ACRE OF LAND USE



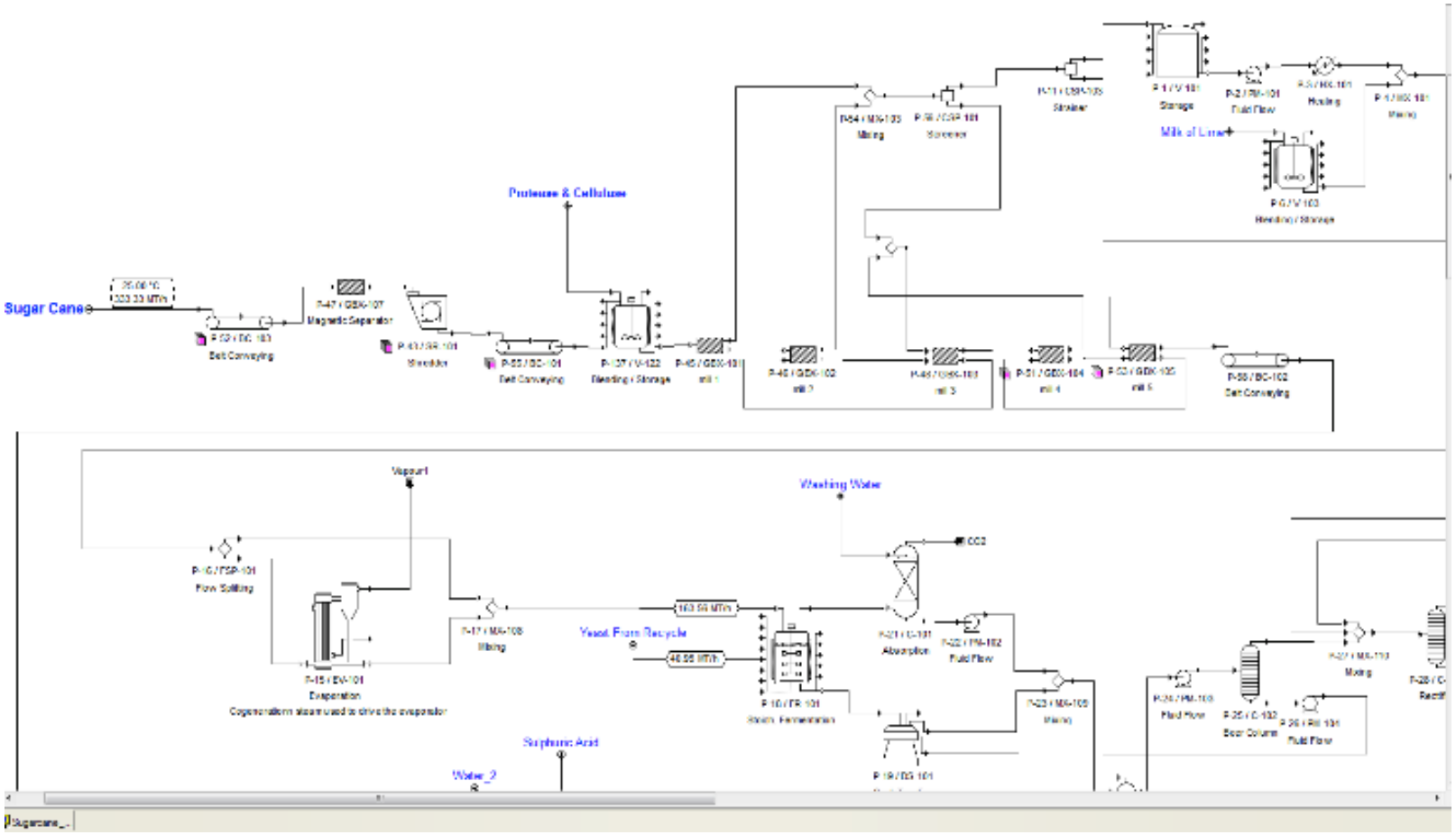
Ethanol - $2.3/gal, Biodiesel - $4.5/gal, Soy Meal – $480/MT, DDGS - $260/MT, Electricity: $0.065/kwh

FLOW DIAGRAM FOR LIPIDCANE PROCESS



Parameters	Values
Plant Operation (MT/year)	1,600,000
Extraction Efficiency - sugar extraction in the mill tandem	96%
- Lipid extraction in the mill tandem	90%
- sugar loss during purification	1%
- lipid loss during purification	2%
Conversion Efficiency - Fermentation to produce ethanol	90%
- Transesterification to produce biodiesel	99%
- Boiler (65 bar pressure)	80%
- Turbine	85%
End/Intermediate Products - Anhydrous ethanol purity	99.7%
- Biodiesel purity	99.2%
- Crude glycerol	80%
- Bagasse moisture content	~50%

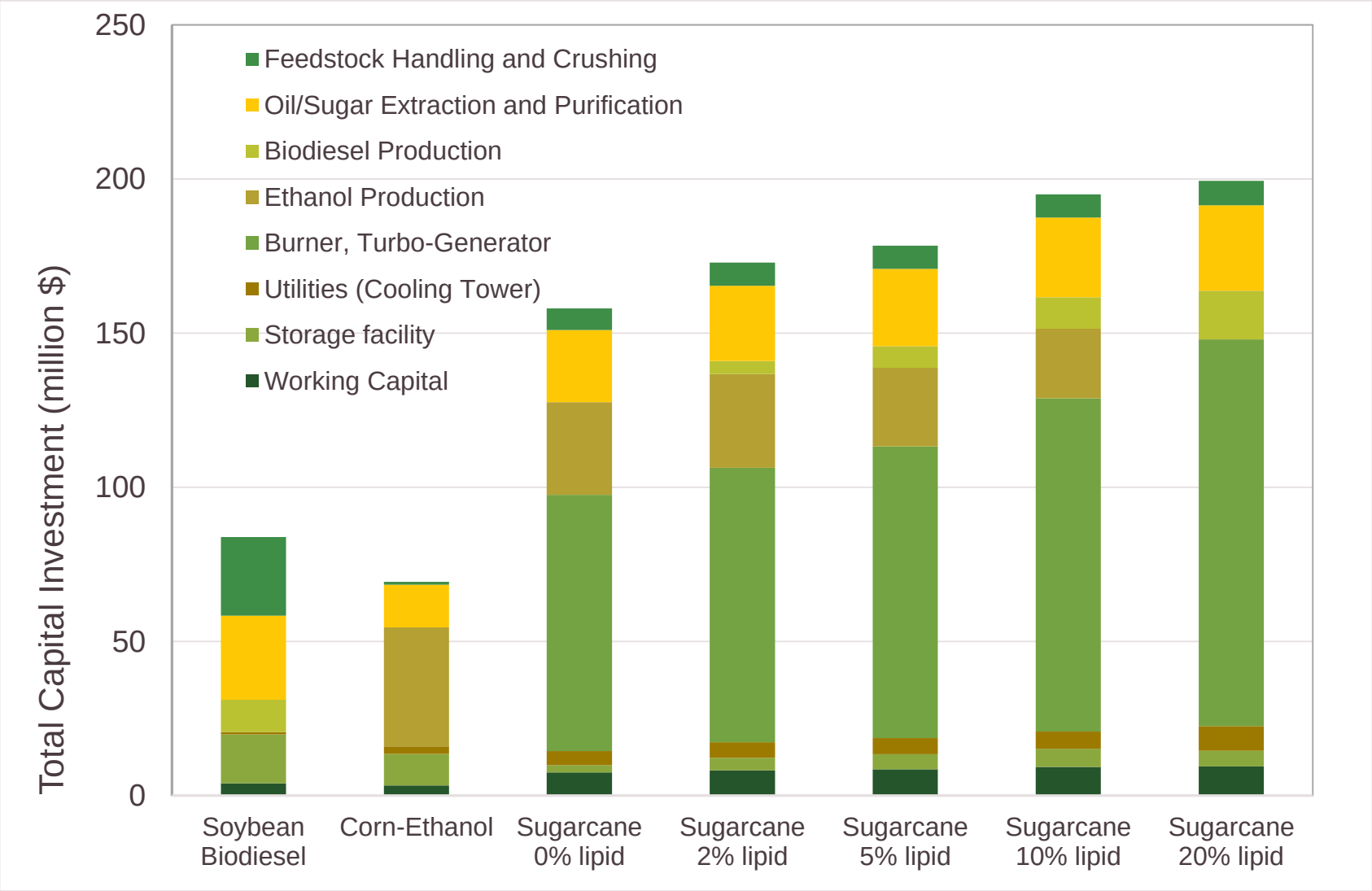
Parameters	Values
Input - Sugarcane ($/MT)	40
- Enzyme Cellulase ($/MT)	500
- Methanol ($/MT)	547
Output - Ethanol ($/gal)	2.3
- Biodiesel ($/gal)	4.5
- Crude glycerol ($/MT)	170
- Electricity ($/kWh)	0.06
Project life and Linear depreciation (years)	20
Salvage value ($)	0
Fixed Capital Investment	3 times of the Equip. Purchase Cost
Working Capital	5% of the Fixed Capital


Sugar Cane
Protease & Cellulase
Milk of Lime
Vapour
Washing Water
Yeast From Recycle
Sulphuric Acid
Water_2
Flow Splitting
Evaporation
Mixing
Absorption
Fluid Flow
Storage
Heating
Beer Column
Rectif
Belt Conveying
Magnetic Separator
Shredder
Blending / Storage
Sugarcane_

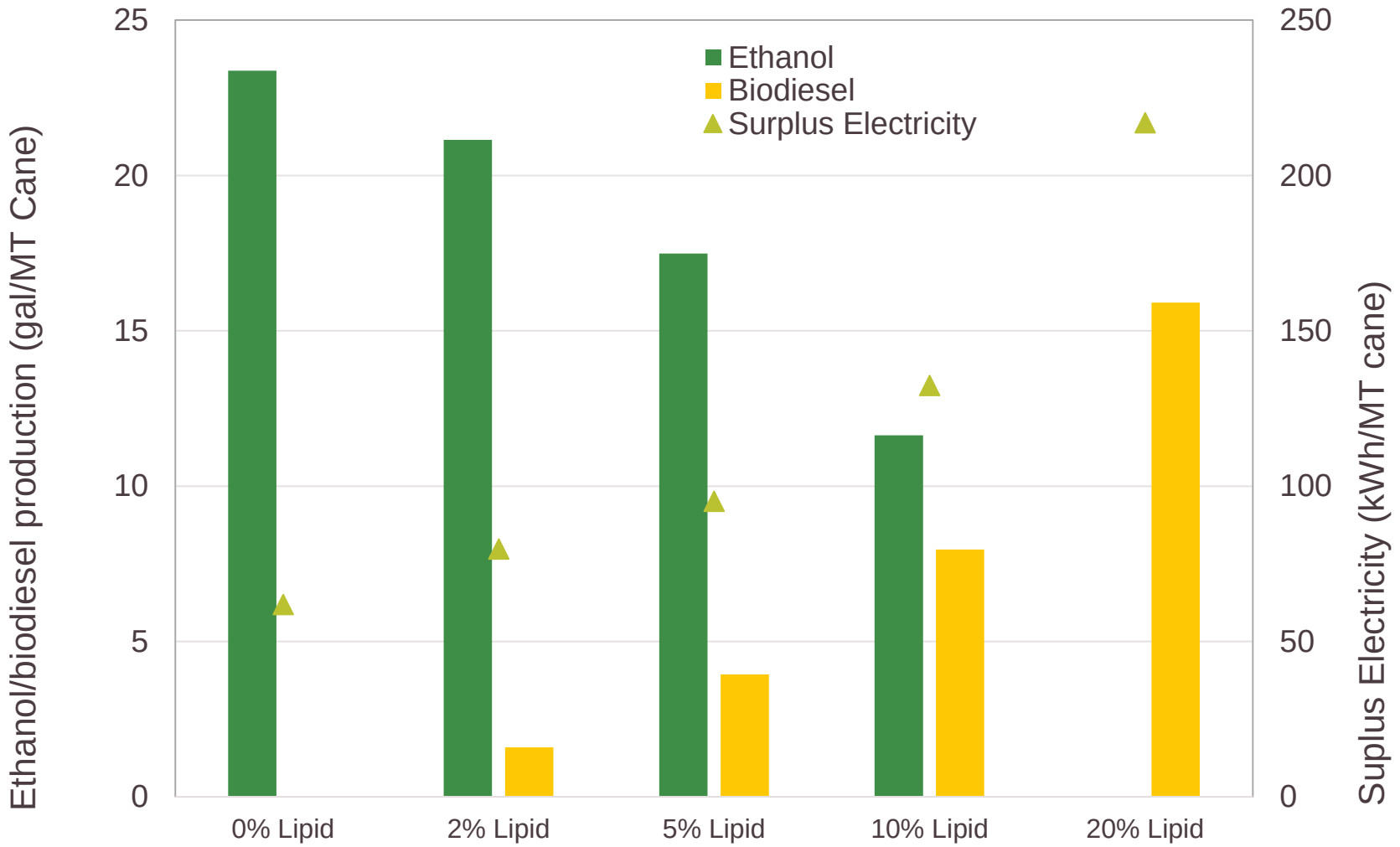
BASIC MODEL VERIFICATIONS WITH TWO PROCESSING PLANTS - SUGARCANE WITH 0% LIPID

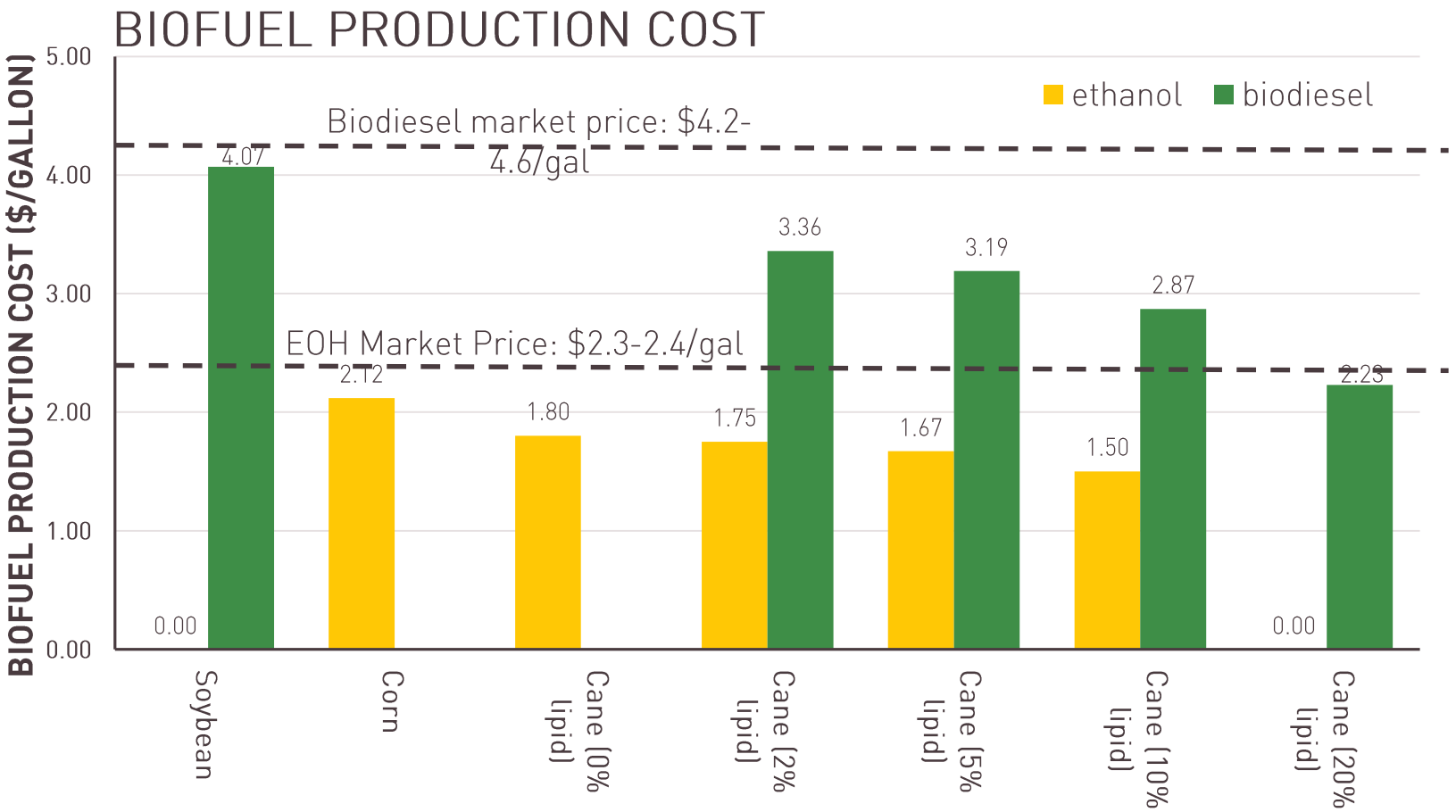
Parameters	Data from Model	Information from processing plants
Sugar Extraction Rate	96%	95.8 -97%
Bagasse Production	306 kg/TC (MT Cane)	260-300 kg/TC
Sugar concentration before fermentation	21.2%	One plant use 20%, one plant use 22%
Ethanol Concentration after fermentation	9.02%	8-9%
Filter Cake Production	40.8 kg/TC	35-40 kg/TC
Ethanol Production	23 gal/TC	21-23 gal/TC
Electricity for Process Surplus Electricity Sold	30 kWh/TC 61 kWh/TC	23 kWh/TC and 30 kWh/TC 68 kWh/TC (data from CTBE)
Capital Investment	$108/TC capacity	Roughly $90-$100/TC capacity (Brazil)
Parameters	Data from Model	Information from processing plants

SIMULATION RESULTS – TOTAL CAPITAL INVESTMENT



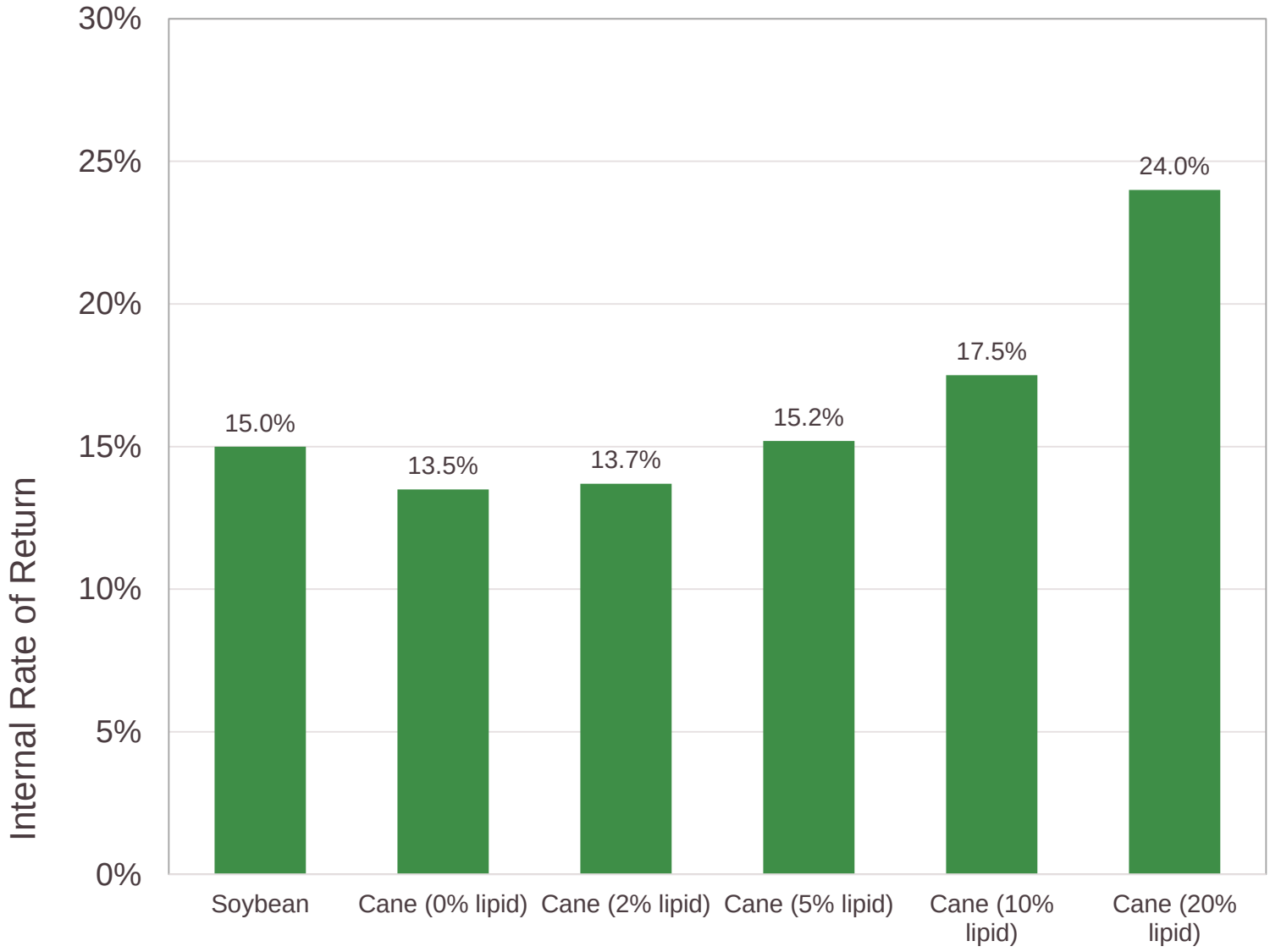
BIOFUEL PRODUCTION FROM EACH TON OF LIPID CANE



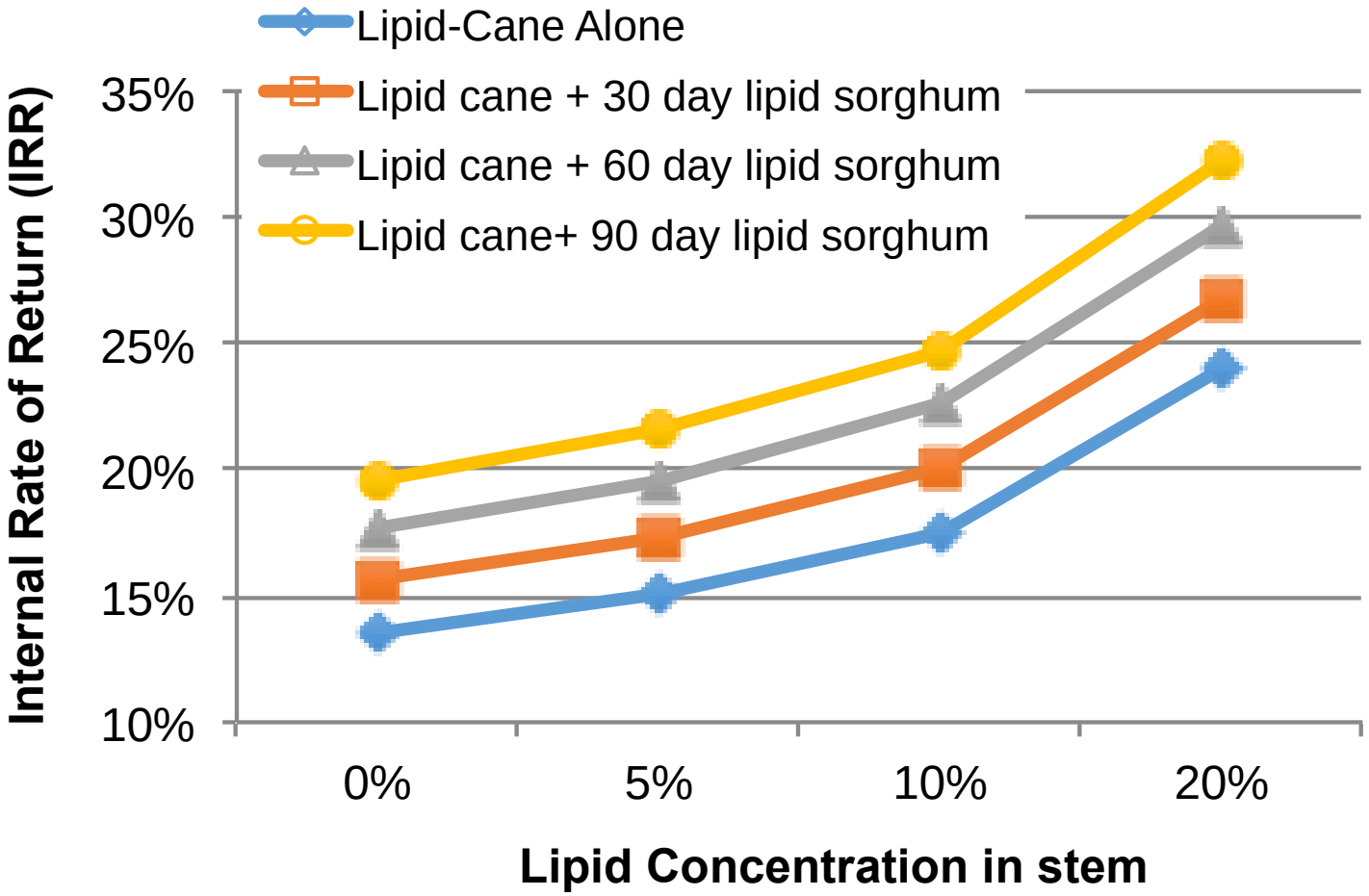


Both Ethanol and biodiesel production cost decreased with increasing in lipid content in sugar cane.

INTERNAL RATE OF RETURN (IRR)



- Techno-economic models of lipid-cane processes to co-product ethanol and biodiesel was developed;
- Compared to corn and soybean, lipid-cane can provide higher ethanol and biodiesel yield per hectare of land use;
- By increasing the lipid content in lipid-cane from 2 to 20%, the biodiesel production cost decreased from $3.36/gal to $2.23/gal;
- By increasing the lipid content in lipid-cane from 2 to 20%, the internal rate of return of the lipid-cane process increased from 13.5 to 24.0%.


Lipid-Cane Alone
Lipid cane + 30 day lipid sorghum
Lipid cane + 60 day lipid sorghum
Lipid cane+ 90 day lipid sorghum
Internal Rate of Return (IRR)
35%
30%
25%
20%
15%
10%
0%
5%
10%
20%
Lipid Concentration in stem

www.petross.illinois.edu

michiels@illinois.edu

The information, data, or work presented herein was funded in part by the Advanced Research Projects Agency-Energy (ARPA-E), U.S. Department of Energy, under Award Number DE-AR0000206.