Biofuels from coastal deserts: the sustainability case for a *Salicornia bigelovii*-based biorefinery

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Introduction

Masdar Institute

The **Masdar Institute of Science and Technology** (Masdar Institute) is a graduate level, research-oriented university which is focused on alternative energy, sustainability, and the environment.

Introduction

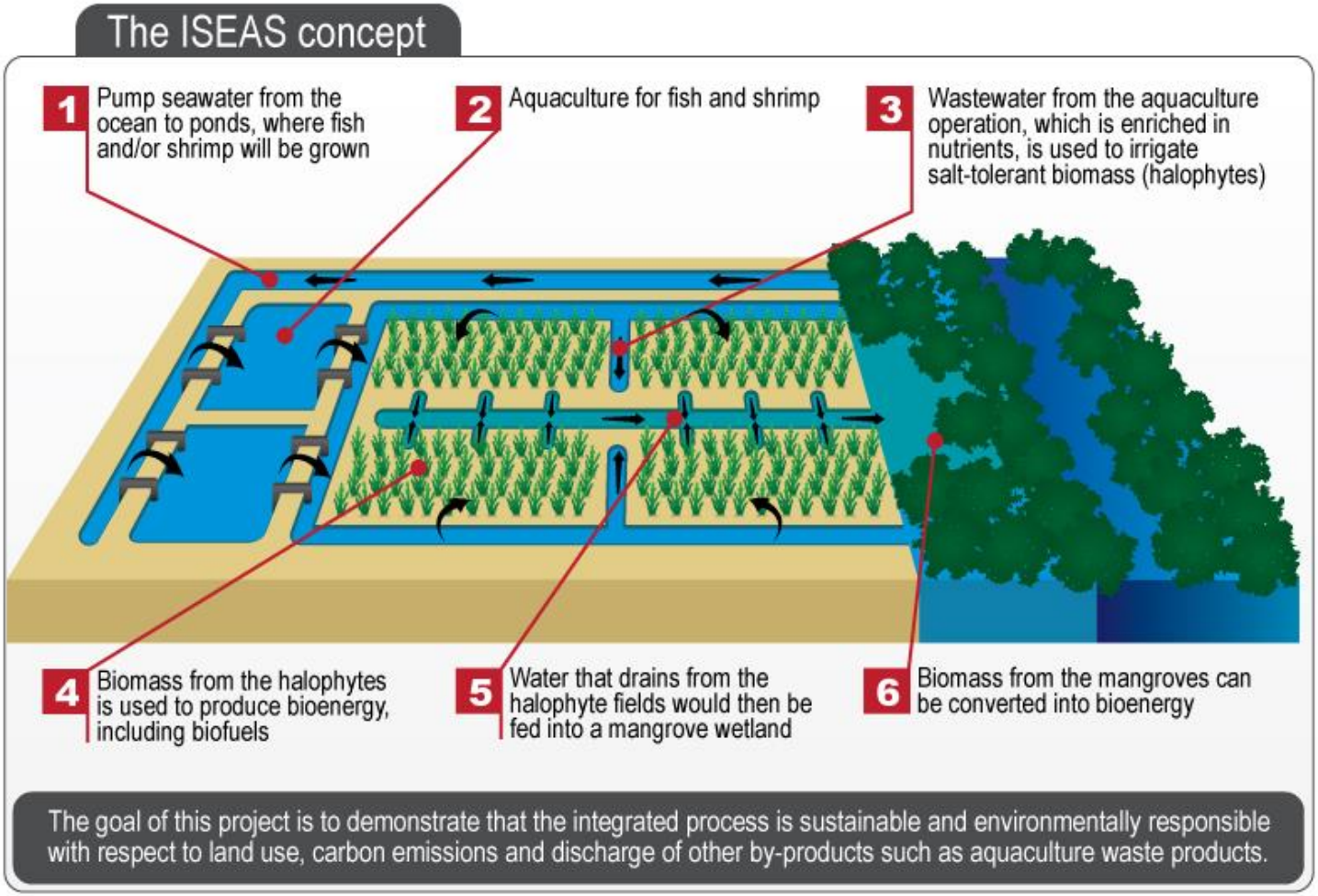
SBRC

- The Sustainable Bioenergy Research Consortium was established by the Masdar Institute of Science and Technology.

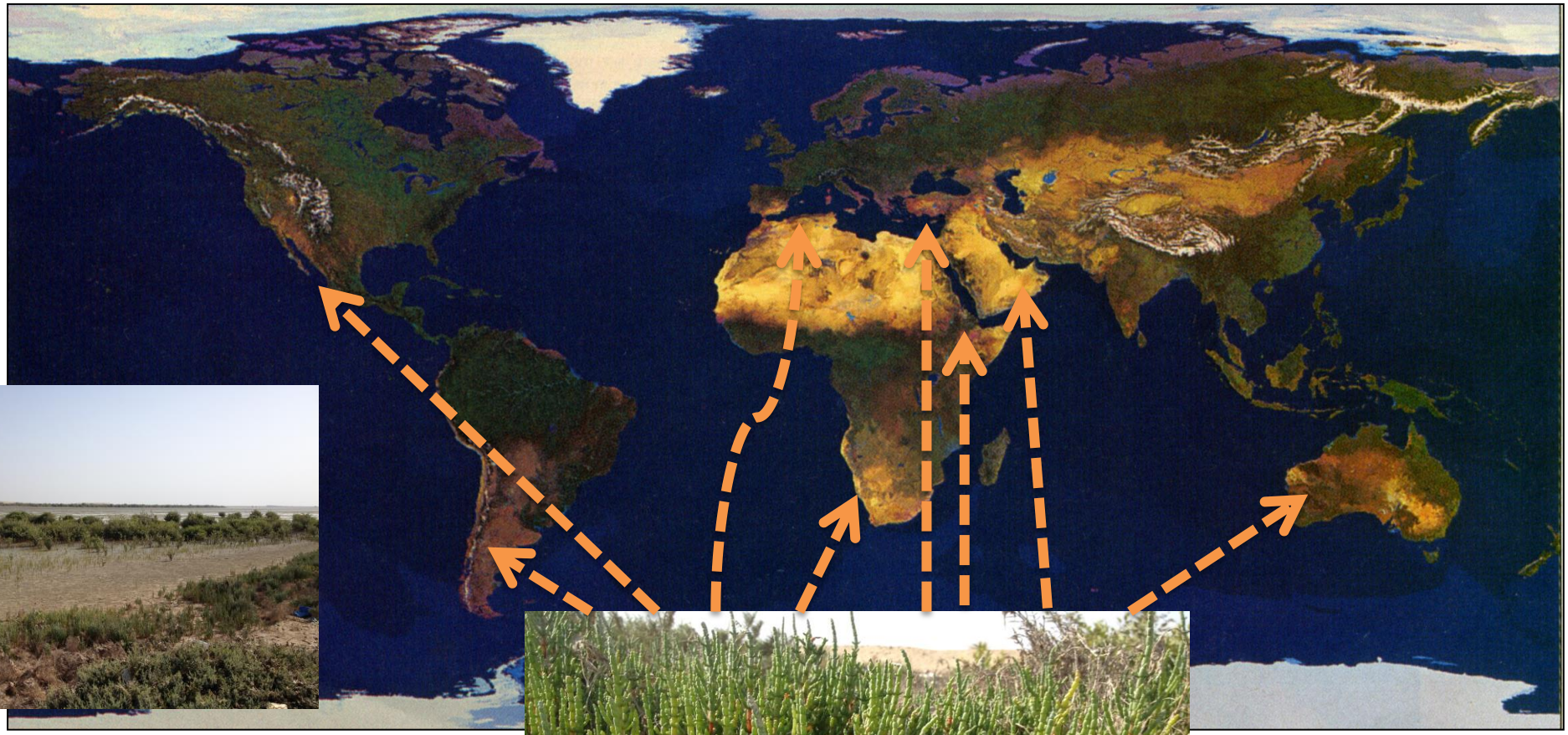
- The SBRC is focused on research in sustainable biofuels and biomaterials derived from the conversion of plant oils and biomass.

Introduction

ISEA



Objective



Feedstock

Feedstock: *Salicornia bigelovii*

- **Salt-tolerant oil crop**
- **Can grow on every continent, excluding Antarctica**

Composition Data

Table 1. Salicornia straw waste chemical composition before and after being washed, as experimentally obtained (Chaturvedi, 2013)

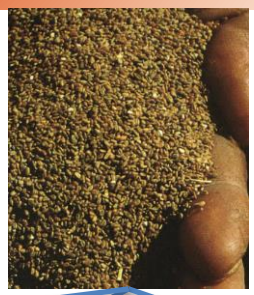
Components	% of Dry Weight, before washing	% of Dry Weight, after washing
Glucan	10.15	25.79
Xylan	7.95	21.57
Arabinan	6.93	5.73
Klason lignin	5.82	7.69
Structural ash	6.8	5.51

- Oil represents 28% of the seeds
- Protein represents 31.2% of the seeds

Chaturvedi, T. (2013). *Evaluation of Bioenergy Production from Lignocellulosic Biomass of Salicornia Bigelovii.* Masdar Institute, UAE.

Methodology

Different scenarios



Scenario #1

- Ethanol
- Biogas
- Biodiesel

Scenario #2

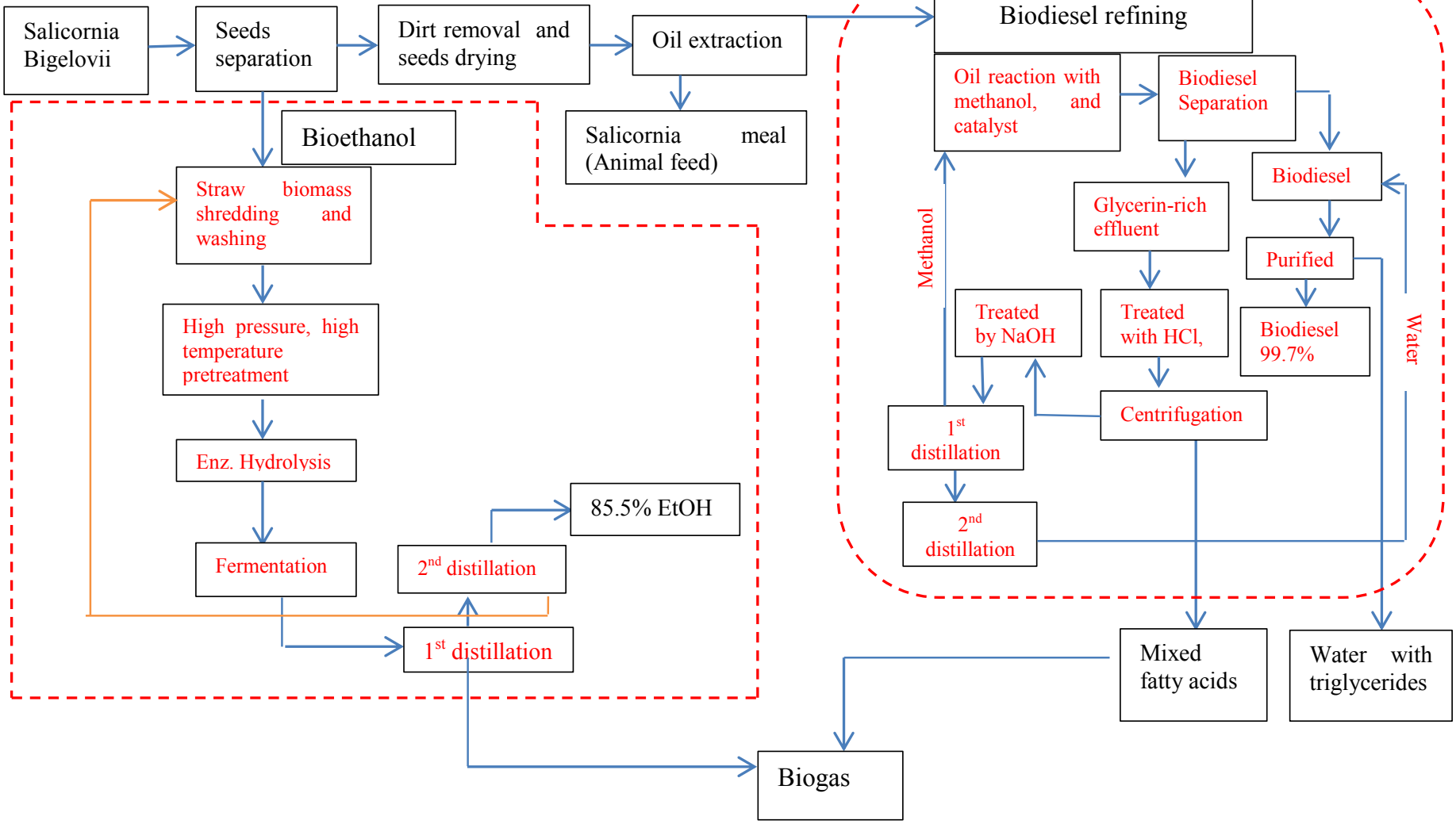
- Biogas
- Biodiesel

Scenario #3

- Biogas
- Biodiesel

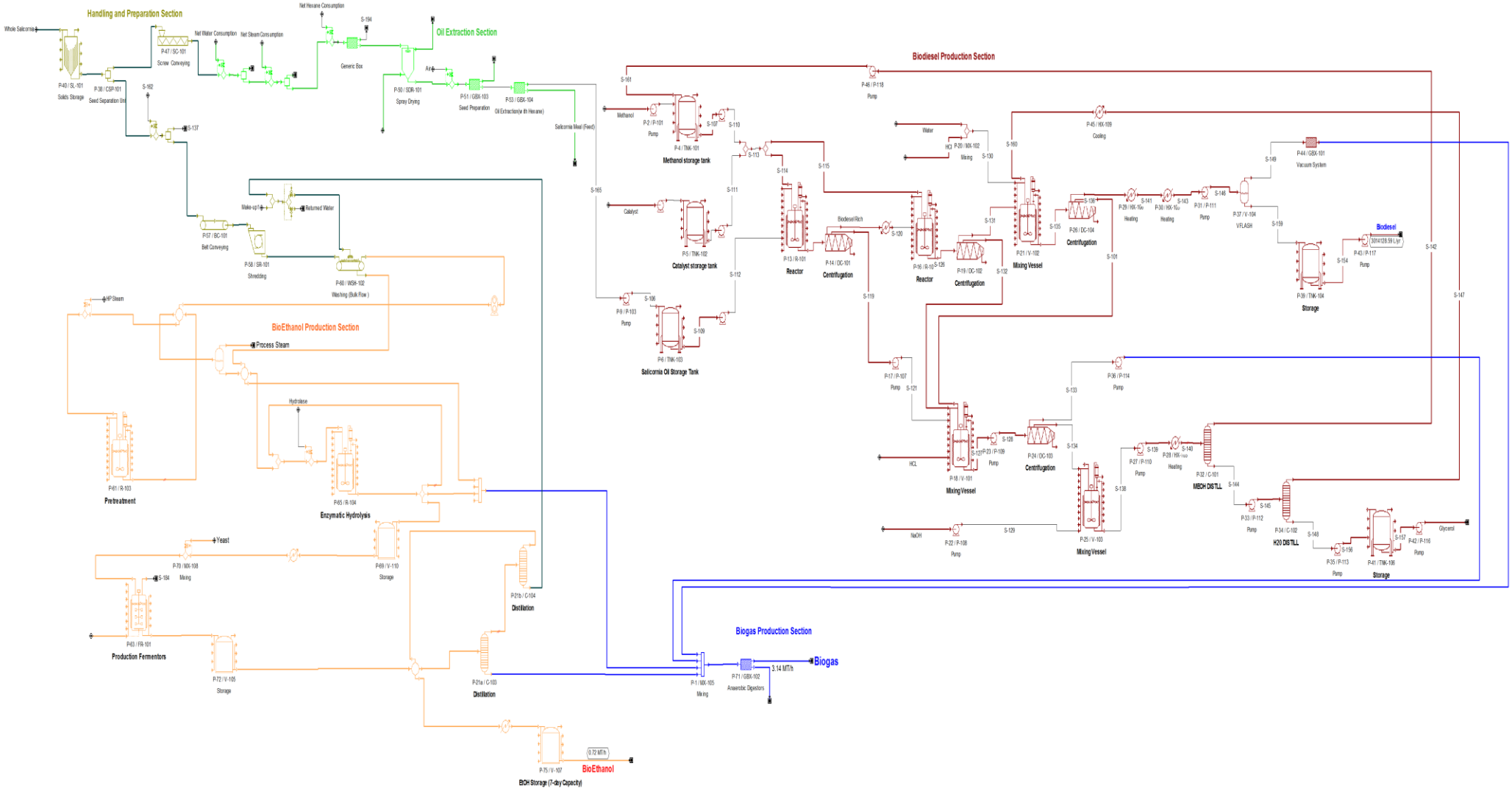
Methodology

Scenario #1



Methodology

SuperPro® Designer

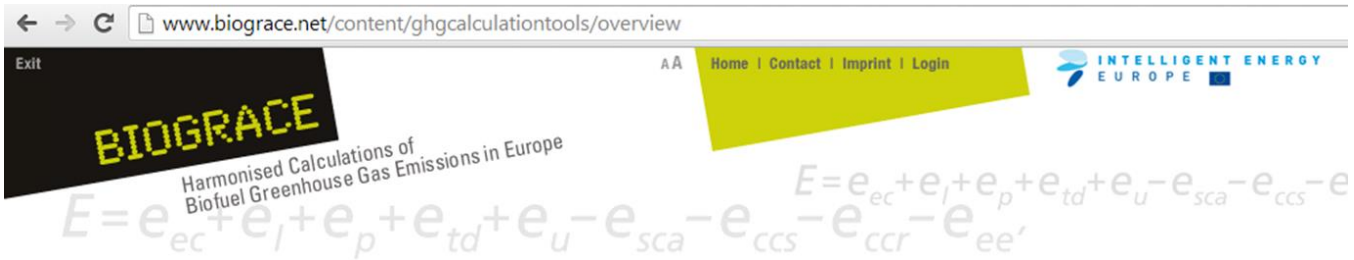


Methodology

Life Cycle Assessment (LCA)

- Greenhouse Gas emission (GHG) and Energy Return On Investment (EROI) were subjects of analysis and evaluation throughout this study.

- Data for energy content and CO_{2eq} emission of the materials, utilities and energy sources used in our process were based on values obtained from **SuperPro®** combined with harmonized calculations of **biofuel GHG in Europe**; attained from the European Commission protocol (Annex V of the Renewable Energy Directive - 2009/28/EC).



Key numbers/assumptions

Item/equipment	Notes/values
Process	Continuous process, 330 working days
Total land area	5000 ha
Biomass yield (Kg/ha/yr)	16247.00 (Russel W. Stratton, 2010).
Seeds production (gseeds/Kg total mass)	122 (Russel W. Stratton, 2010).
Salicornia bigelovii	Ranged from 0.01$/kg to 0.05406$/kg
Capital equipment cost	costs were based on the model published by the joint bioenergy institute.
Hexane-extraction plant capital cost	Based on rapes' seeds plant

Russel W. Stratton, H. M. W., James I. Hileman. (2010). Life Cycle Greenhouse Gas Efrom Alternative Jet Fuels *Project 28*: Massachusetts Institute of Technology.

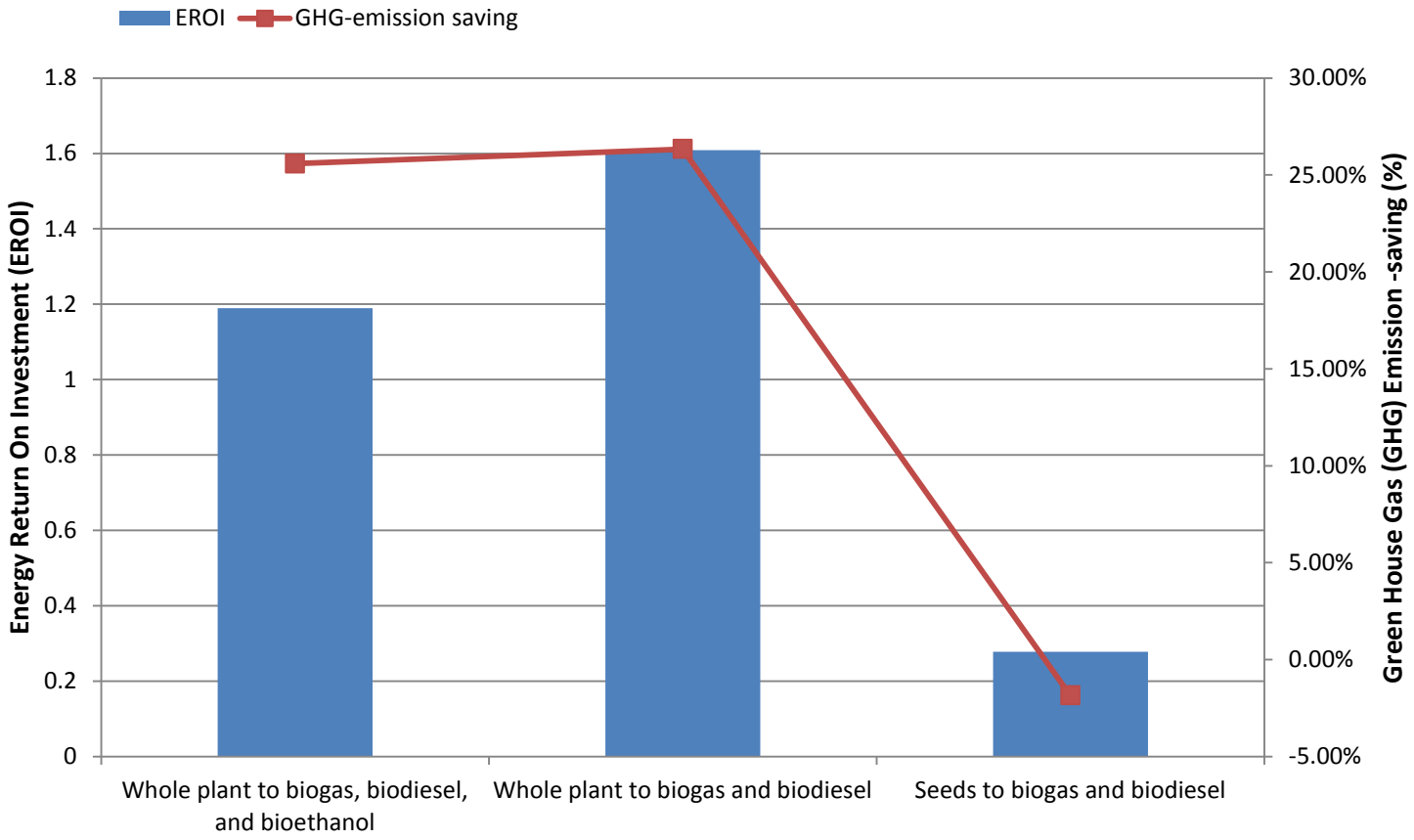
Results and Discussions

Economic and material results

Economic Parameters	Scenario 1 (Whole biomass to Biodiesel, bioethanol and biogas)	Scenario 2 (Whole biomass to Biogas and Biodiesel)	Scenario3 (Seeds nly to Biodiesel and Biogas)
Total Investment ($)	45,659,000.00	39,300,000.00	24,943,000.00
Total Revenues ($/yr)	36,730,000.00	27,131,000.00	8,149,000.00
Operating Cost ($/yr)	31,536,000.00	18,298,000.00	9,565,000.00
Gross Margin (%)	17.3%	36.4%	-17.4%
Payback Period (Year)	4.3	2.9	26.6
IRR before Taxes (%)	25.55	46.48	-

Results and Discussions

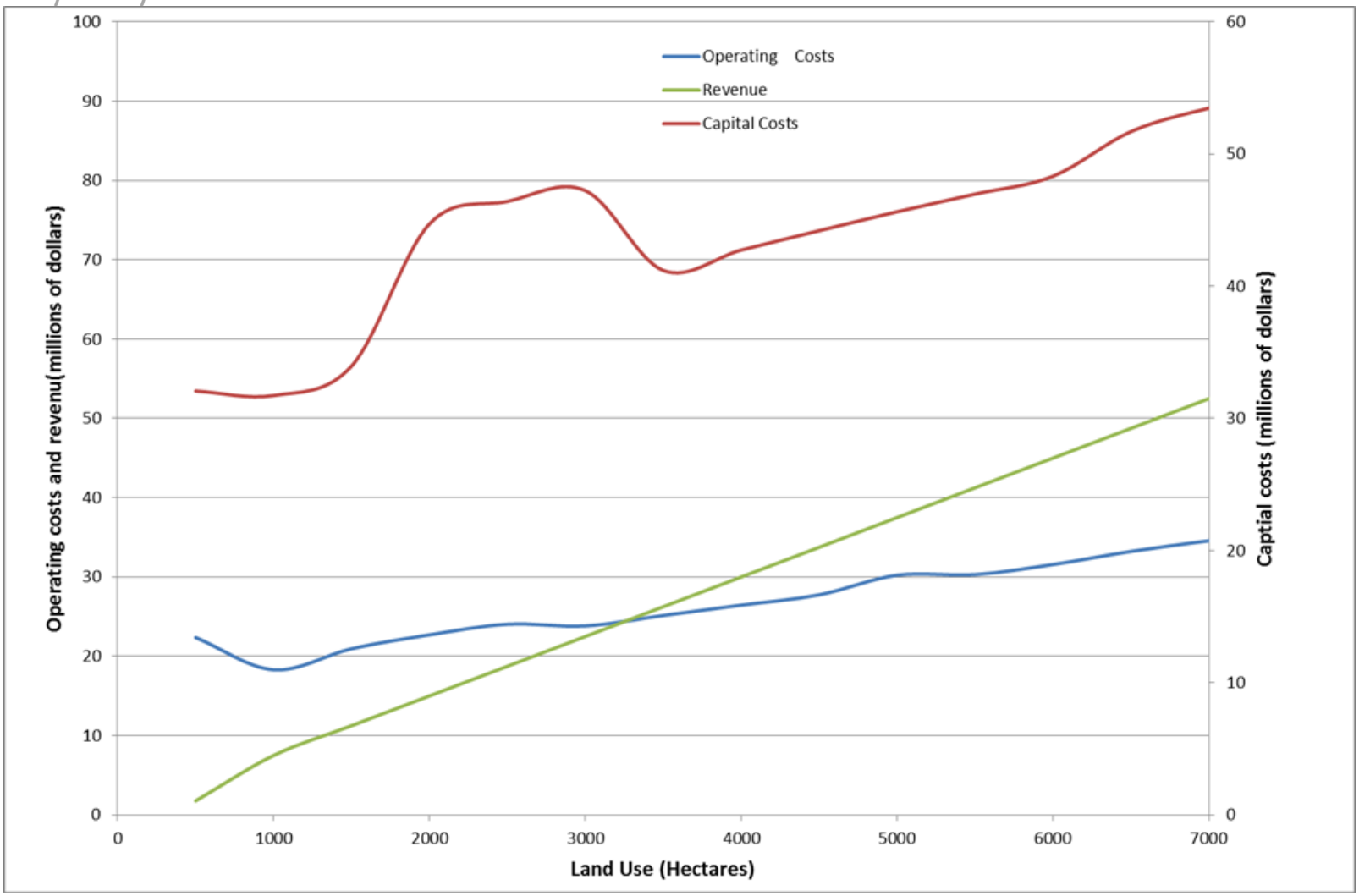
EROI and GHG results



EROI and GHG emission savings for the three different scenarios

Results and Discussion

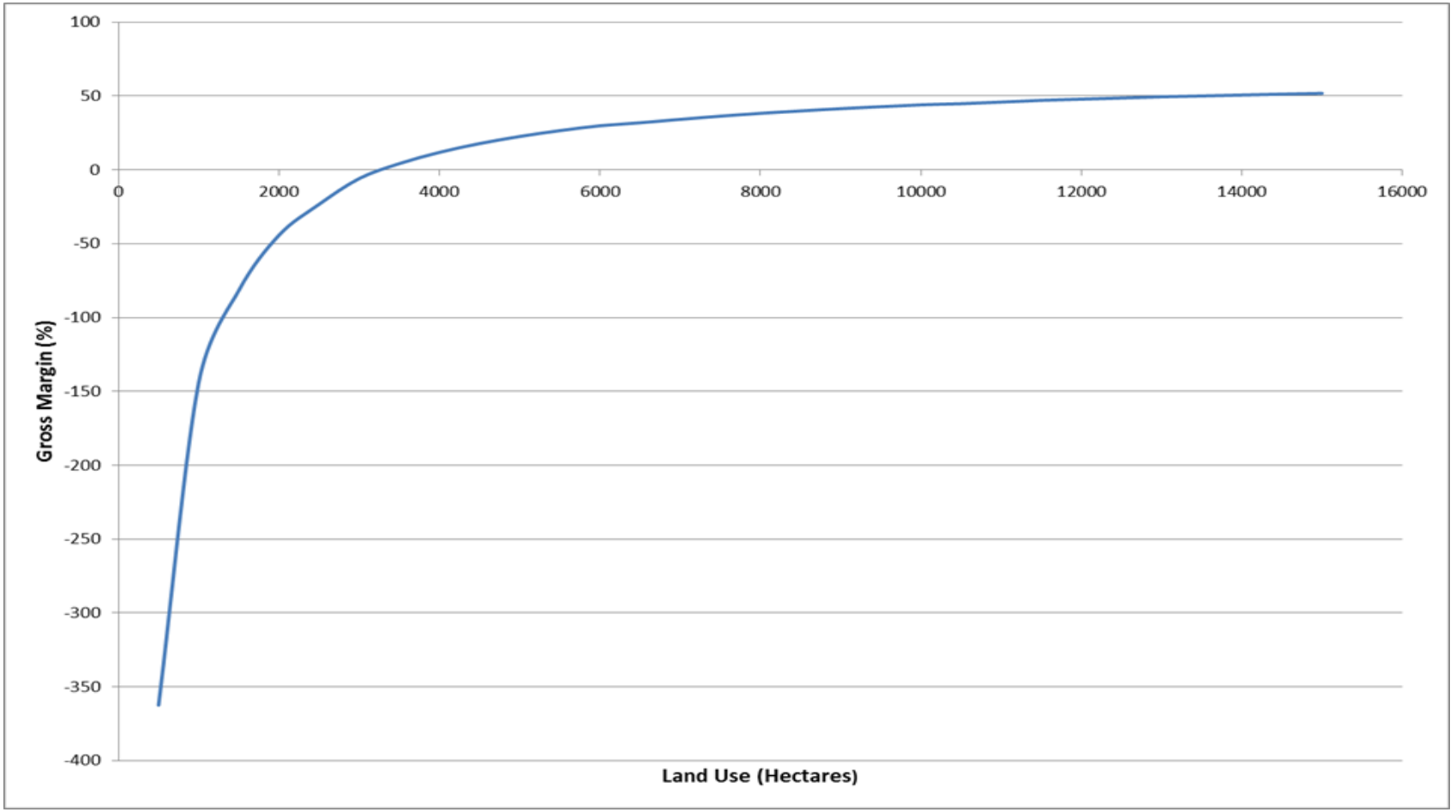
Sensitivity analysis



Variation of costs with land cultivated

Results and Discussion

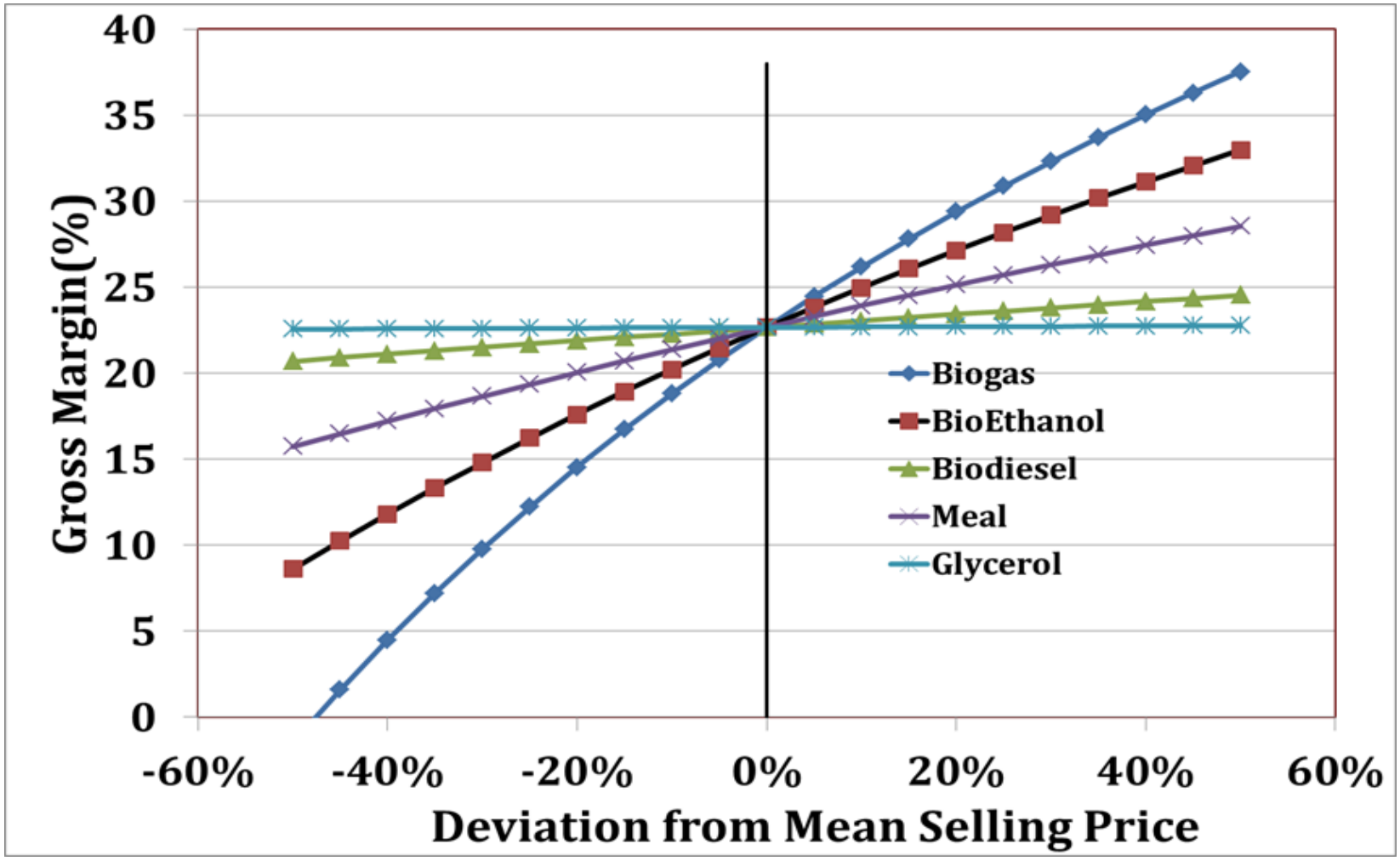
Sensitivity analysis



Variation of Gross margin with land cultivated

Results and Discussion

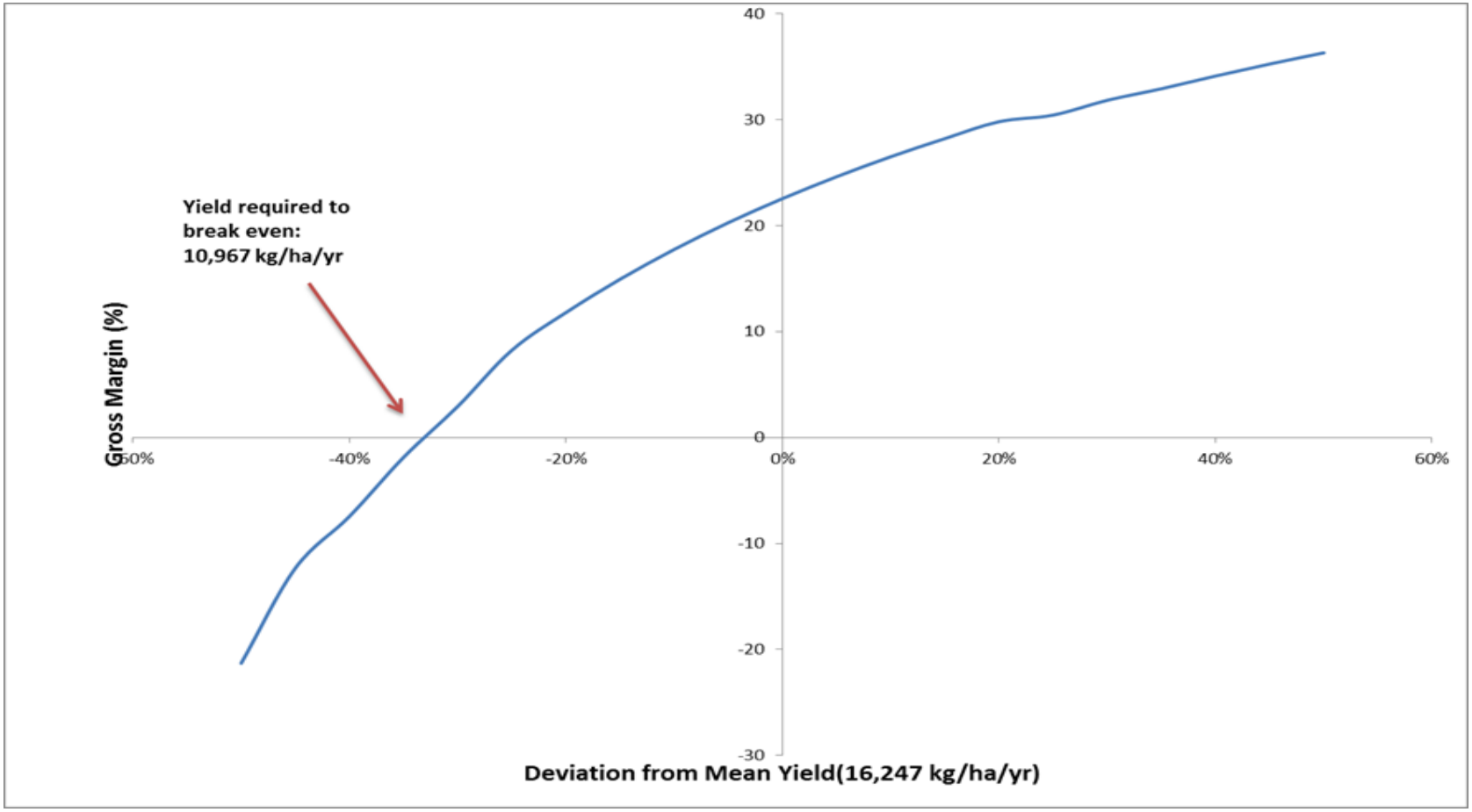
Sensitivity analysis



Effect of selling prices on biorefinery profitability

Results and Discussion

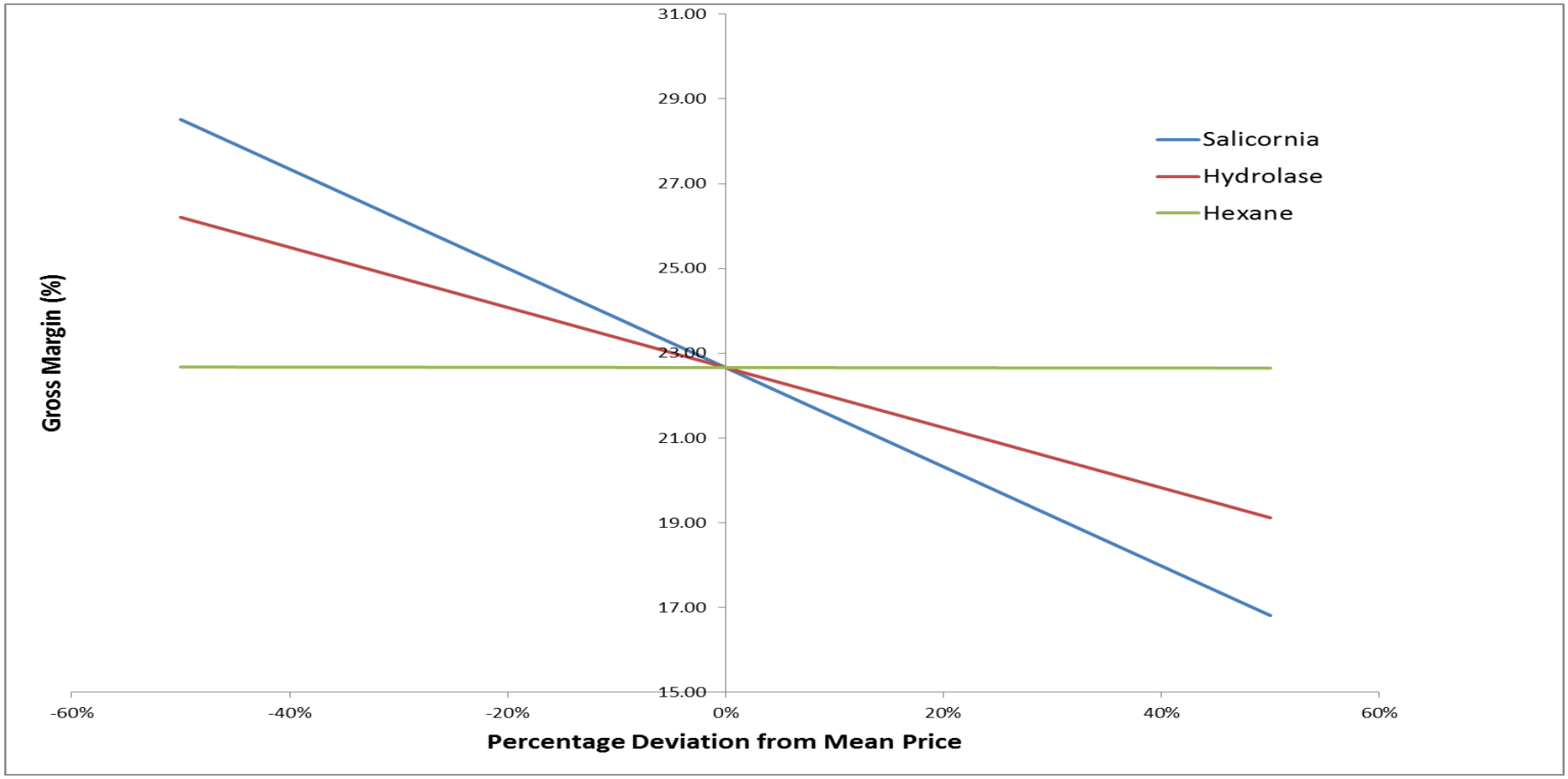
Sensitivity analysis



Effect of Salicornia yield on process profitability (based on 5,000 hectare farm)

Results and Discussion

Sensitivity analysis



Effect of some cost prices on biorefinery profitability

Conclusion

- A Salicornia-based biorefinery is both economically feasible and environmentally sustainable.
- Salicornia-based biorefinery showed comparable EROI values to first generation-based biorefineries, despite the energy intensive pre-treatment processes involved.
- It is critical to optimize the bioethanol process (reducing capital and operating costs) in order to minimize the economic risk associated running a biorefinery with biogas as the main product.

Thank You

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