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Bio-energy from Sugarcane in Southern Africa

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CONTENTS

Sugarcane Production

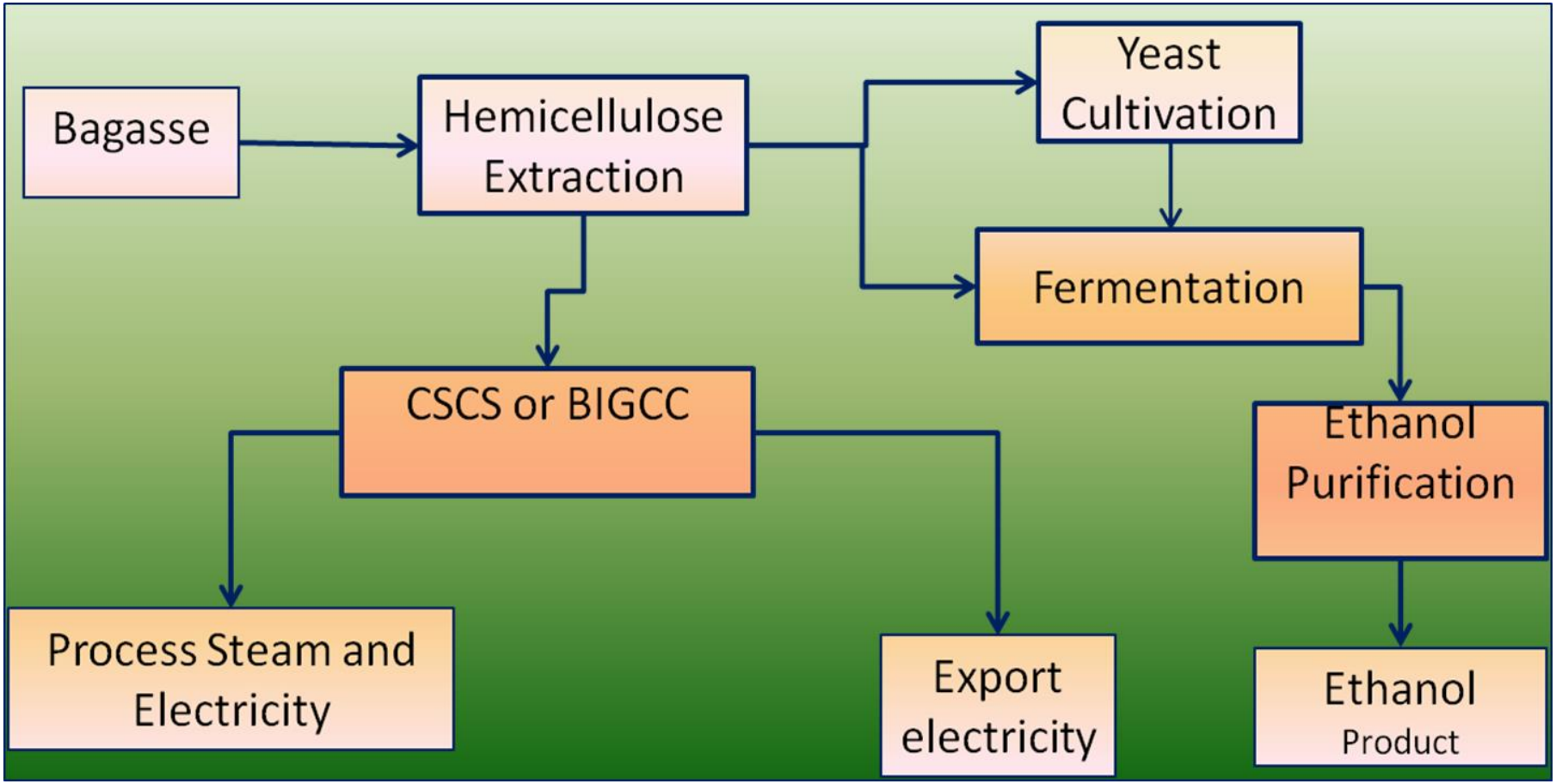
- Sugarcane in South Africa
  - Less than ideal growing conditions
- Significant number of small-growers in SA, but on the decline
  - 20 000 to 30 000 ha available for expansion
- Watson et al. (2011): 6 million hectares of underutilised land in Southern Africa for sugarcane cultivation
  - Soil quality, climate, biodiversity, food production, ecology considered
  - New sugar mills and/or distilleries

Existing Sugar Industry

- 2.3 MT annual production, mostly for SADC
  - Significant export, unstable prices
- **Co-gen for electricity** done at limited scale
  - Increases based on negotiating price (subsidy)
  - Upgrade of mill efficiency for bagasse supply
  - Residues increase fibre by 25% (burnt)
- **Ethanol and sugar co-produce (biofuels)**
  - Petroleum refineries mandated to 10% ethanol blends from licensed suppliers
  - Subsidy support for blending to 2%: Oversubscribed? Sugar industry share?

Co-production of Ethanol and Electricity from Fibre

- Increase bagasse through mill upgrades and combine with harvesting residues
- Experimentally verified process performance



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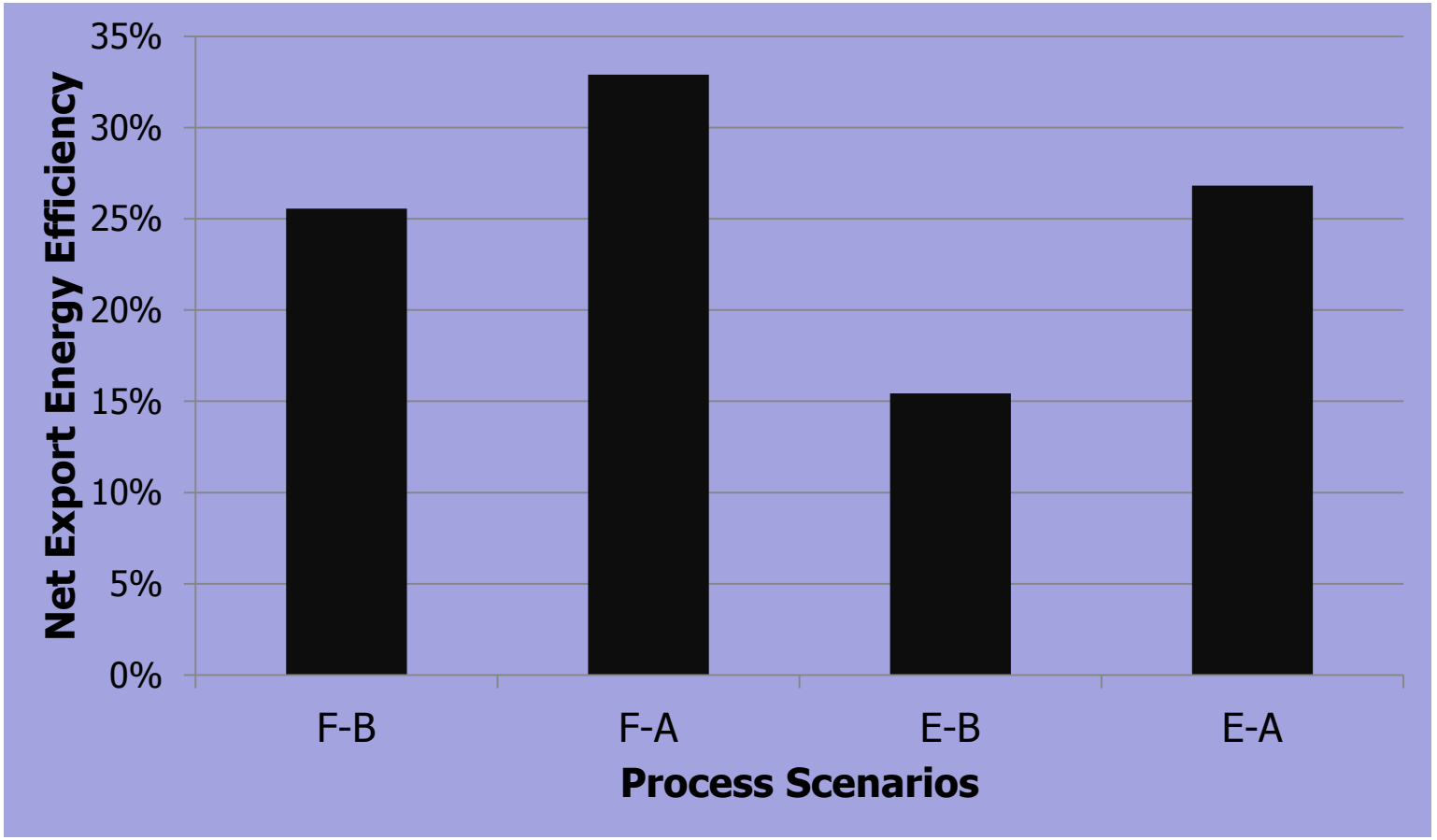
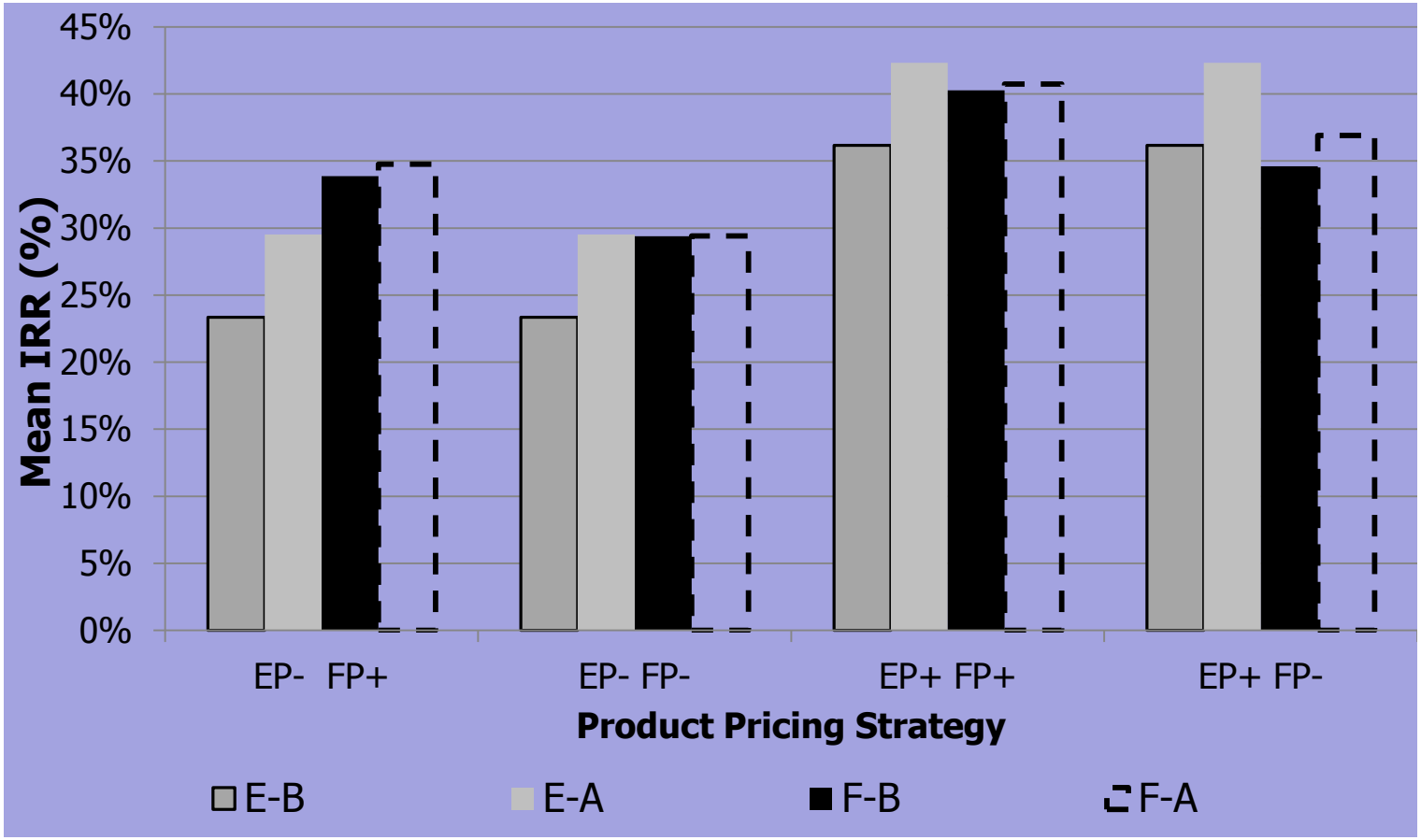
Ethanol-Electricity vs. Electricity Only from Sugarcane Fibre



F-C = Basic Ethanol Co-Production; F-A = Advanced Ethanol Co-Production

E-B = Basic Electricity Generation; E-A = Advanced Electricity Generation

Ethanol-Electricity vs. Electricity Only from Sugarcane Fibre



EP **-** = Electricity Price on Low Premium; EP**+**= Electricity Price on High Premium

FP **-** = USA Ethanol data for Fuel Price ; FP**+** = Brazilian Ethanol data for Fuel Price

Co-production of Ethanol and Electricity from Fibre

- Ethanol co-production with electricity gives higher overall energy efficiency than electricity production only
- At high electricity and ethanol prices, electricity is economically slightly more attractive
- At low prices ethanol-electricity is economically preferred

BUT

- Electricity prices in SA are regulated by NERSA:
  - Maximum IRR attainable for Independent Power Producer is 17%
- Ethanol has many market opportunities => diversify income

Small-scale Distilleries?

- Expansion potential in SA/Africa sugarcane cultivation
- Ethanol pricing in South Africa (biofuels):
  - Wholesale gasoline prices, corrected for energy content
  - Without subsidy: US$0.56/litre
  - With subsidy: US$0.75/litre
  - Below 1.2MLY EtOH is exempted from taxes/levies: Wholesale US$0.88/litre (no subsidy)
- Gasoline demand in SA stable for +10 years
  - 10% ethanol blend will result in over-production of gasoline; refinery closures due to imbalance
- 50% ethanol stoves saves production costs

Grain Ethanol at Small-Scale?

- Case study: Western Cape drylands
- 700 000 ha small grains in 1980's (regulated market)
- Reduced to 500 000 (1996) and 200 000 (today) due to free market (cheap imports)
- Economically unviable, marginal lands => available to new, small, emerging farmers
- Long-term control of food-pricing:
  - Non-food grains on marginal lands have no risk
  - Grain sorghum not well-suited to WCape
  - Triticale: Low inputs, robust, high starch
  - Subsidy as means new farmer development

Sugarcane Crop Development

- Improved yields per hectare for cost-effectiveness
- Increasing fibre yields is opportunity for bio-energy:
  - More bagasse available for energy, without affecting sucrose/juice yield per hectare
  - Fibre properties (energy content, processibility) should also be optimised
  - E.g. pretreatment-hydrolysis requirements/yields

Sugarcane Bagasse to Ethanol

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1. **Selection from 115 sugarcane varieties => 34 => 6**

2. **Optimisation of pretreatment conditions (**temperature, time and acid concentration) **of six varieties and an industrial bagasse**

3. **Pilot scale pretreatment**
Evaluation of pretreatment conditions leading to high fermentable sugar yield and low by product

4. **Process integration:** Hydrolysis-fermentation via SSF of pressed slurry from pretreatment

Small-scale Pretreatment

Steamgun Pretreatment

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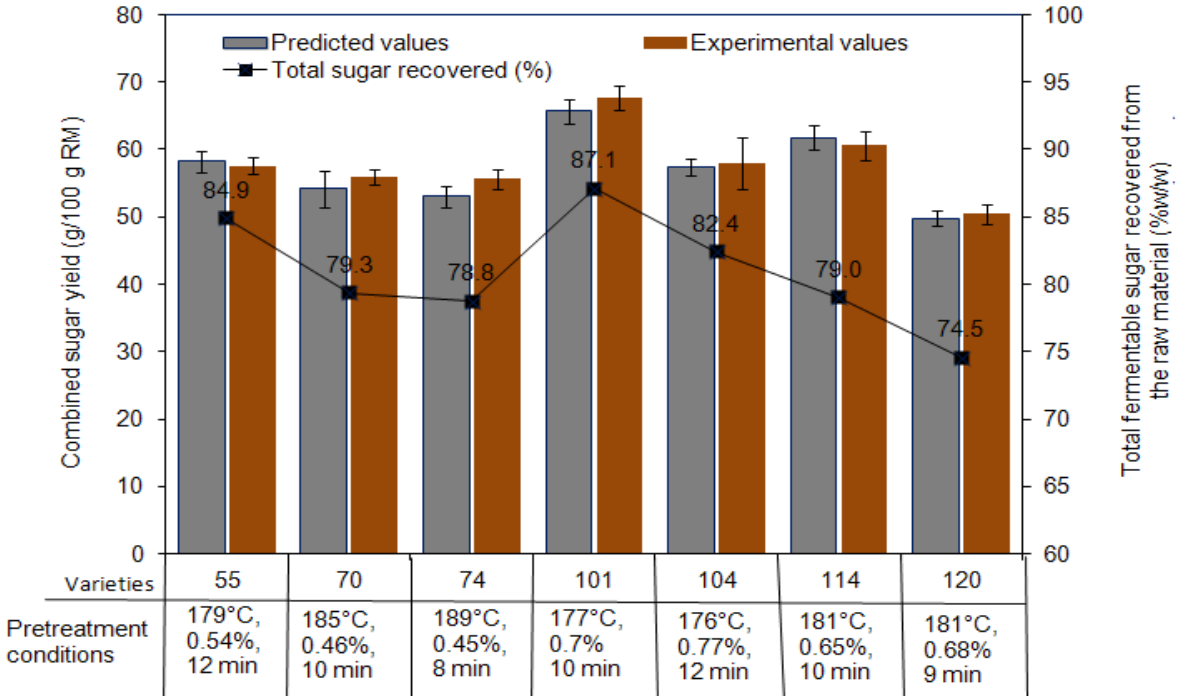
Pretreatment Optimisation



Findings

- Different pretreatment requirements per variety
- Industrial bagasse high lignin = more severe conditions

Range of conditions may lead to maximise the sugar yield

	Acid (%w/w)	Severity factor
Xylose	0.45 — 0.65	2.86 — 3.35
Glucose	0.45 — 0.65	3.32 — 3.85
Combined sugar	0.45 — 0.77	3.23 — 3.52

Low severity should go with high acid loading

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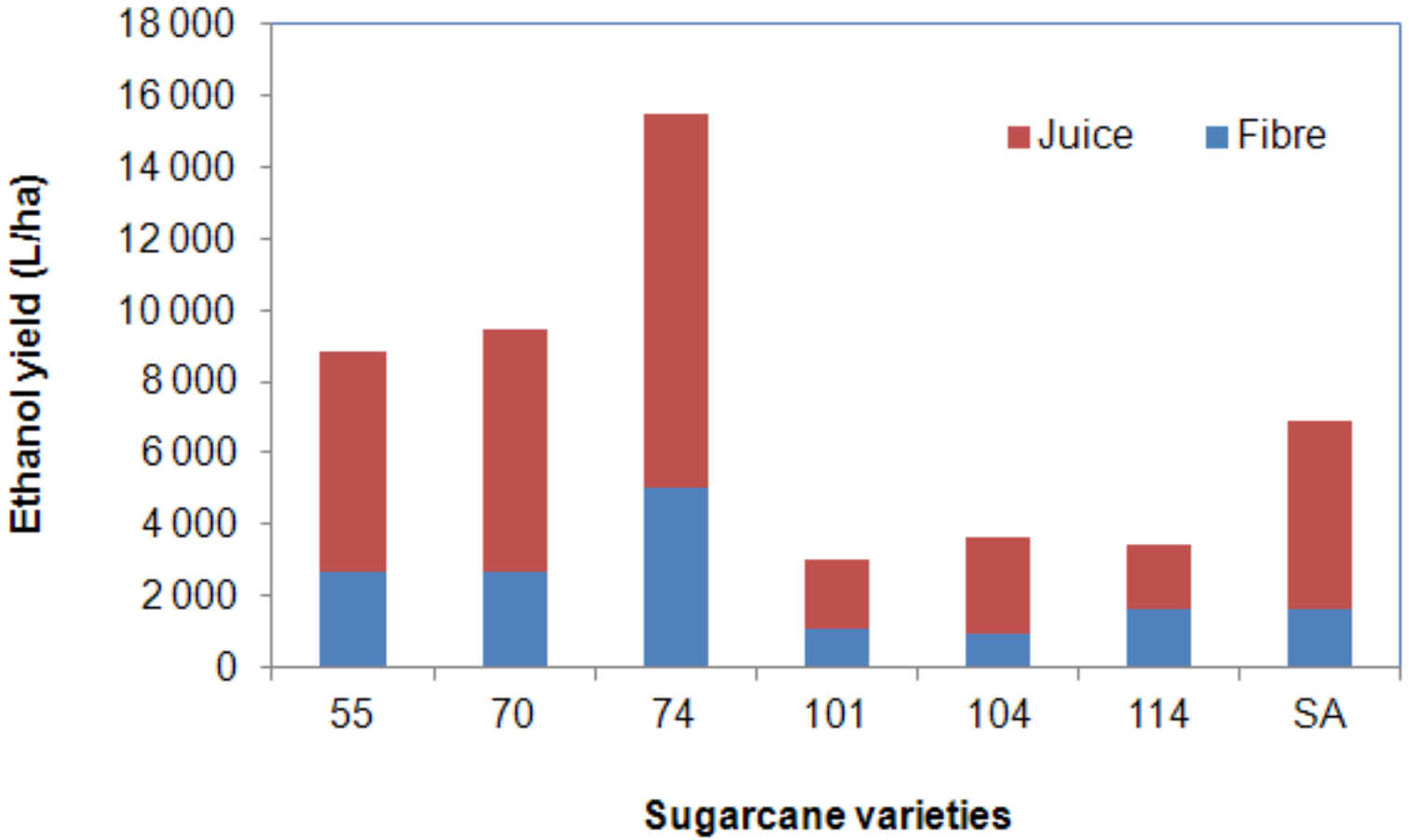
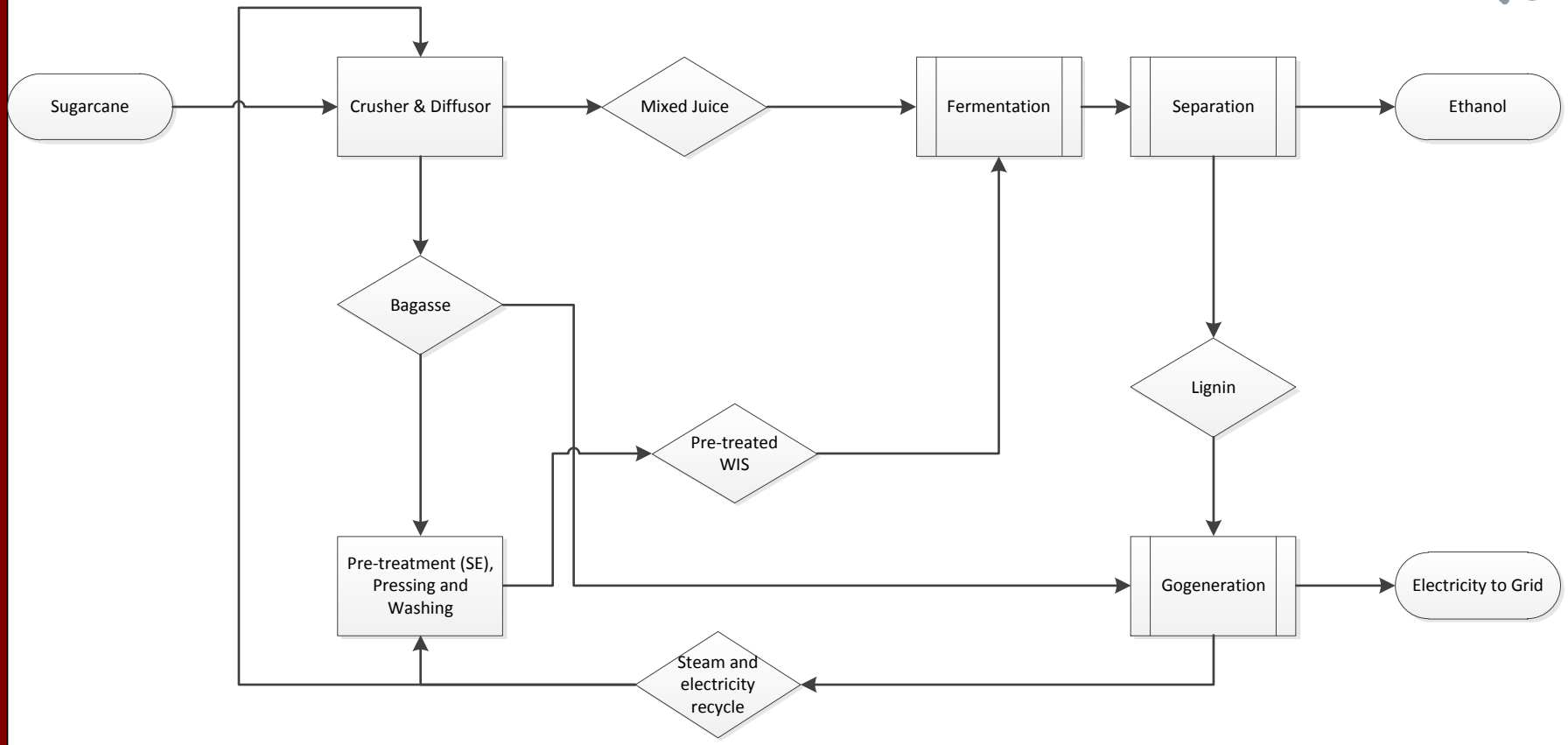
Co-location of 1st and 2nd Generation Ethanol



Integrated 1G2G Ethanol Production



Simultaneous Saccharification and Fermentation vs. Separate Hydrolysis and Fermentation, incl. cell recycle

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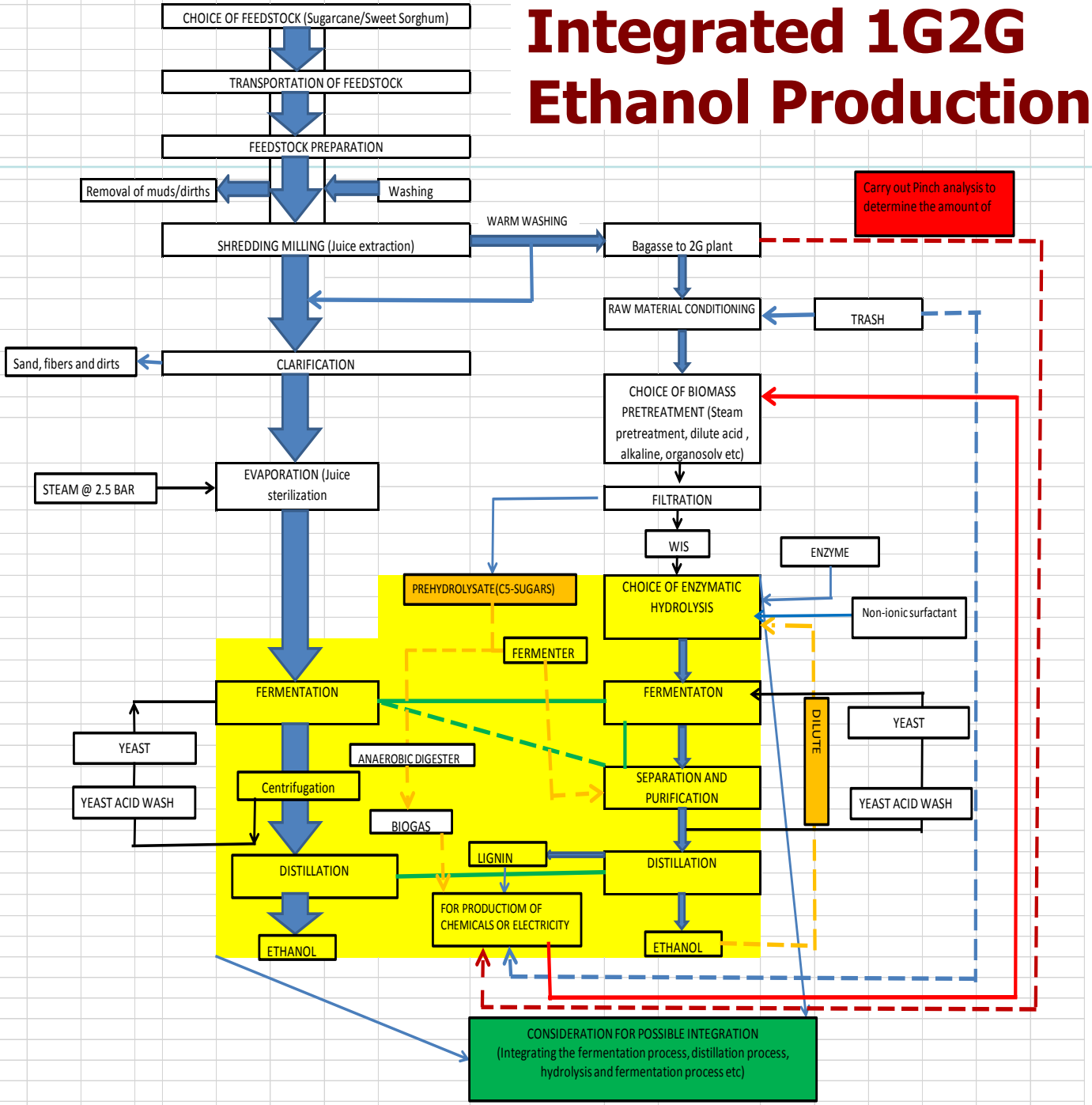
Integrated 1G2G Ethanol Production



Biorefineries for Bio-energy

- Define possible biorefinery scenarios, experimental investigation, modelling and comparisons
  - Efficiency, economics, environmental impacts
- Co-products from sugarcane lignocellulose:
  - Furfural – ethanol/butanol – electricity
  - Organic acids – ethanol/butanol – electricity
  - Hemis biopolymers – ethanol/butanol – electricity
  - Ethanol – lignin-derived chemicals – electricity

Alternatives to Consider

- Expansions in the existing sugar industry
- New, large-scale distilleries
- New, small-scale distilleries
- Biorefineries
- Crop development
- Zero- or negative-cost feedstocks, e.g. wastes from paper
  - Paper sludge to ethanol
  - Spent sulphite liquor (xylose) to ethanol

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Thank you

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