Reducing Costs and Increasing Sustainability of Ethanol as a Feedstock for Alcohol-to-Jet

Technology advancements delivering sustainability solutions

August 2023 | Presented by An Grobler, MicroBioGen Business Development

MicroBioGen. Sustainable biological solutions for a finite world.

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Global SAF Industry Opportunity

MicroBioGen's advanced fermentation technology significantly improves the sustainability, efficiency & economics of SAF by improving the conversion of biomass-to-alcohol for alcohol-to-jet

1. SAF is the future fuel for the aviation industry globally
2. How can SAF be produced more economically and sustainably?
3. MicroBioGen's yeast is key to ethanol production efficiency
4. MicroBioGen expects strong growth in 2G ethanol plants globally to meet emerging SAF demand
5. Future of sustainable ethanol for SAF requires fully integrated ethanol plants that deliver fuel as well as feed/food solutions

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MicroBioGen: Company Highlights

Founded in
2001

Partnered with
Novozymes
since 2014

8 ethanol products
commercialised

World Leading
Yeast Innovation As a Service

ESG focused
Already the leading biocatalyst solution provider for ethanol

1 Partner
8 Collaborators
Global license & collaboration model

Multi-Industry Platform Technology
Fuels | Feed | Foods | Biochemicals

Unparalleled library of
Elite Yeast Genetics

65%
Revenue Growth
(4-year CAGR)

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MicroBioGen Leverages The World's Most Widely Used Microorganism

Corn / Sugar

Plant matter

Flour

Grapes / Hops etc

Saccharomyces cerevisiae

(Commonly known as Bakers'/Brewers' yeast)

Yeast converts carbohydrates (starch or sugar) into carbon dioxide and valuable compounds such as alcohols

Biofuels

Animal feed

Bread

Beverages

Yeast underpins ~US$2 trillion in products globally, ranging from Biofuels, Beverages and Alternative Proteins to Pharmaceuticals, Biochemicals and more

Refer to Disclaimer. This is general information only.

Platform Technology Delivers Unmatched Industrial Performance

Step 1: **Elite Genetics** are developed and continuously improved over time
Step 2: **Stacking** enables characteristics to be selected and combined based on a customer's specific requirements

MicroBioGen's elite yeast genetic library - examples

Application	Ethanol tolerance	Temperature tolerance	Acid resistance	Osmotic stress resistant	Low glycerol by-product	Produce enzymes non-GM	Convert xylose to ethanol	Grow on organic acids	High protein	Grow on glycerol
1G bioethanol[1]	✓	✓	✓		✓					
2G bioethanol[2]	✓	✓	✓	✓	✓		✓	✓	✓	✓
Feed yeast						✓		✓	✓	✓
Baking yeast			✓	✓		✓		✓		✓
Industrial Benefits		Robustness			Optimisation			Innovation / Agility		

1. First-generation (1G) biofuels: Biofuels produced from food crops, e.g. corn or sugarcane
2. Second-generation (2G) biofuels: Biofuels produced from agricultural waste products, e.g. timber offcuts, crop residues or waste sugarcane pulp (bagasse)

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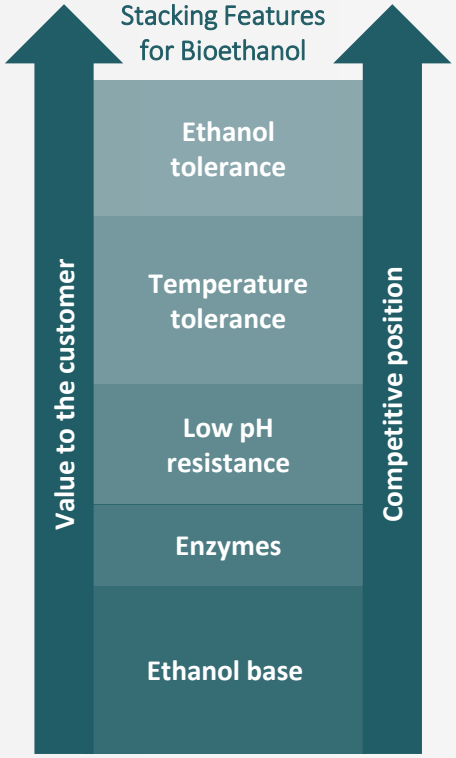
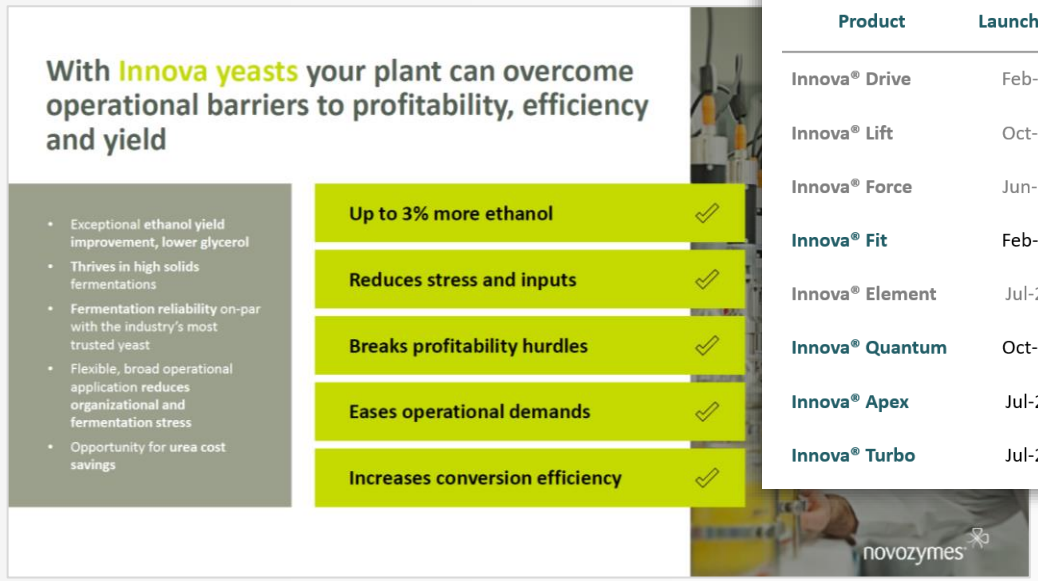
MicroBioGen/Novozymes Collaboration – Case Study

Through the incorporation of multiple unmatched improvements into bioethanol strains, efficiency and sustainability improved



MicroBioGen/Novozymes developed yeast (Innova®) is the leading bioethanol producer in North America - the world's largest bioethanol market



Market Segmentation: The Innova® Series of Yeasts

Product	Launch date	High acid tolerance	Enzyme expressing	Non-GM	Faster	Higher yield
Innova® Drive	Feb-18	✓	✓		✓	
Innova® Lift	Oct-18	✓	✓			✓
Innova® Force	Jun-19	✓	✓		✓	✓
Innova® Fit	Feb-20			✓	✓	✓
Innova® Element	Jul-21	✓	✓		✓	✓
Innova® Quantum	Oct-21	✓	✓			✓
Innova® Apex	Jul-22	✓	✓		✓	✓
Innova® Turbo	Jul-22	✓	✓		✓	✓

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"Novozymes' Innova platform is the most robust yeast in the marketplace…"

- Novozymes

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Ethanol As A Feedstock For Jet Fuel

- Global jet fuel consumption >360 billion liters (~80 billion gallons) per year
- To produce ~1 billion liters of SAF via ethanol-to-jet (ETJ) requires ~2 billion liters of ethanol
- Require ~700 billion liters of ethanol as feedstock for SAF per year
- Currently, global ethanol production is ~120 billion liters (31.7 billion gallons) per year

Global ethanol production will have to be increased by almost 6 times to meet SAF demand

- How can we protect arable land and existing food crops?
- How will we feed a growing global population?

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Attfield, P.V.; Bell, P.J.L.; Grobler, A.S. Reducing Carbon Intensity of Food and Fuel Production Whilst Lowering Land-Use Impacts of Biofuels. Fermentation **2023**, 9, 633. https://doi.org/10.3390/fermentation 9070633

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Sugar-to-Jet: Leveraging MicroBioGen's Technology

Sustainably Converting Biomass Sugars → Alcohol → Jet Fuel

Multiple Routes to Sustainable Aviation Fuel

There are multiple ways to produce SAF. All have different costs, substrate availability and sustainability credentials

Oil Seed Plants — Only a small part of the plant is utilised

Algae — Prohibitively high costs

Fats, Oils and Greases — Limited availability

Industrial CO and CO_2 — Cost and availability long term

Biomass Sugars — Opportunity to improve efficiency and sustainability?

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MicroBioGen Yeast Maximise Usage of Biomass Sugars

Improving the conversion of biomass sugars to ethanol for alcohol-to-jet (ATJ) presents multiple advantages

Key Advantages: Improved Conversion of Biomass Sugars → Alcohol → Jet Fuel	
1. Availability	Most available biomass sources are sugar based
2. Single molecule	Ethanol is a single molecule - simplifying process
3. Efficiency	>90% energy conversion efficiency from sugar to ethanol
4. Waste-to-food	Can upgrade side streams to high value food/feed
5. Negative CI score	Through CO_2 sequestration, negative CI score possible

"Saccharomyces"
"sugar-fungus"
(Latinized Greek)

"cerevisiae"
"of beer"
(Latin)

MicroBioGen's technology presents a number of significant opportunities to improve the efficiency and sustainability of ethanol production.

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Sugarcane: Leading Candidate for Alcohol-to-Jet

Using Sugar Cane as Substrate for Sustainable Ethanol Production	
Advantages	**Disadvantages**
○ Sugarcane biomass yield = high	○ Processes could be more efficient
○ ~50% sugarcane biomass = readily available sugars	○ Vinasse not valorised
○ Compelling CI score vs starch ethanol	○ Fermentation efficiency declines over the season
○ Waste streams - potential revenue opportunity?	○ Production costs are high

Bagasse = Dry pulpy fibrous material that remains after extracting sugar juices from crushed sugar cane
Vinasse = Vinasse is the liquid waste that remains after distilling ethanol from sugar juices or molasses

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Achieving Maximum Conversion Efficiency and Sustainability

MicroBioGen's yeast innovation has application in both 1G and 2G ethanol plants

MicroBioGen's Advanced Fermentation Technology Breakthroughs		
#1	Yeast that can grow at industrial rates on vinasse	1G & 2G
#2	Faster and higher yielding yeast	1G
#3	Stacking a single yeast with #1 and #2 (in progress)	1G
#4	Optimised GM yeast* that can convert biomass sugars (C6 and C5) to ethanol	2G

*In collaboration with Novozymes

Bioethanol is classified based on the type of feedstocks used

1G (First-generation ethanol)
Feedstocks = Food crops
E.G. CORN | SUGARCANE | BEET MOLASSES

2G (Second-generation ethanol)
Feedstocks = Non-food biomass
E.G. AGRICULTURAL AND FORESTRY RESIDUES | DEDICATED ENERGY CROPS | BAGASSE

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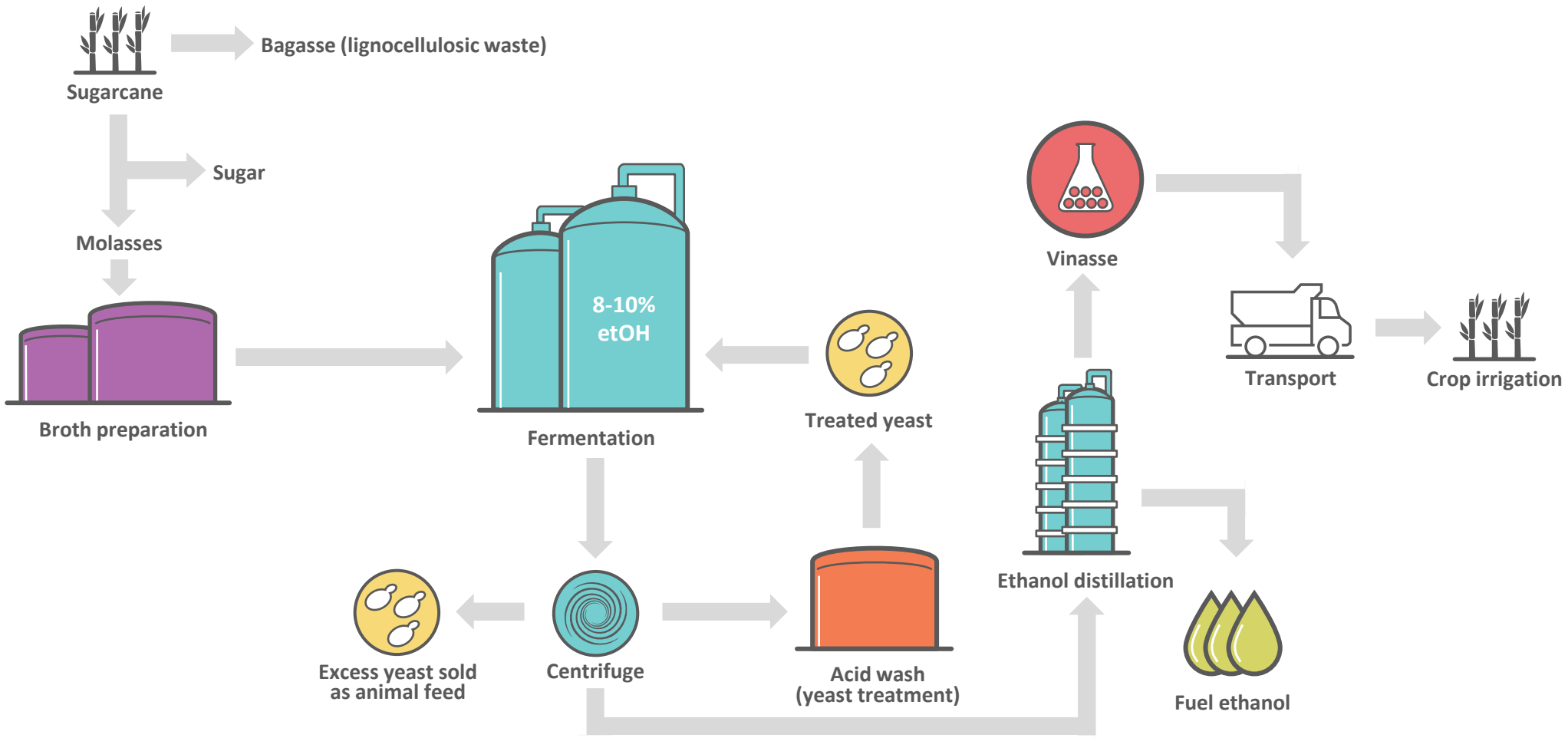
Advanced Fermentation Technology for 1G Ethanol

Key benefits for 1G sugarcane ethanol plants

Industry Standard 1G Sugarcane Ethanol Plant



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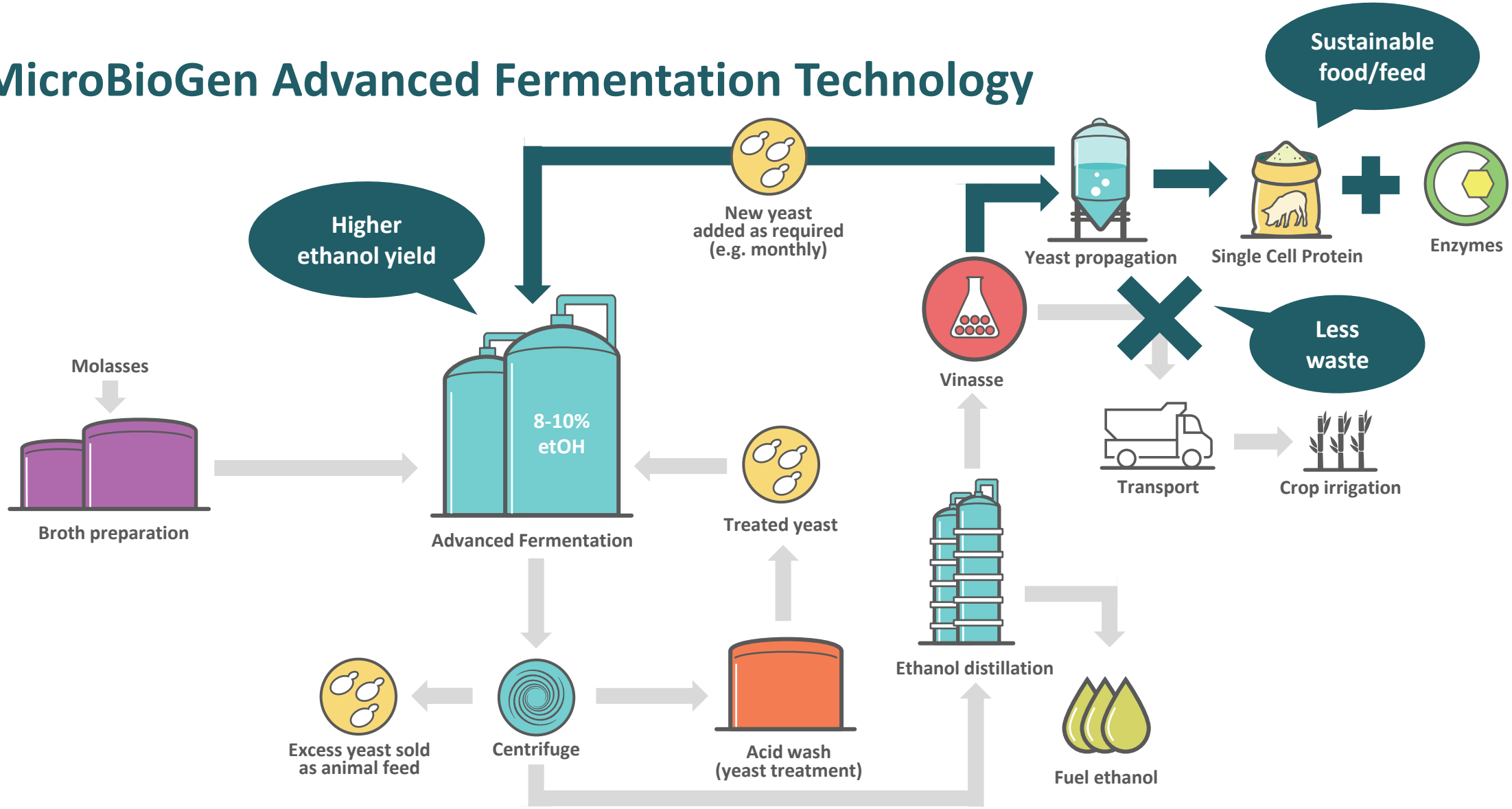
MicroBioGen Advanced Fermentation Technology



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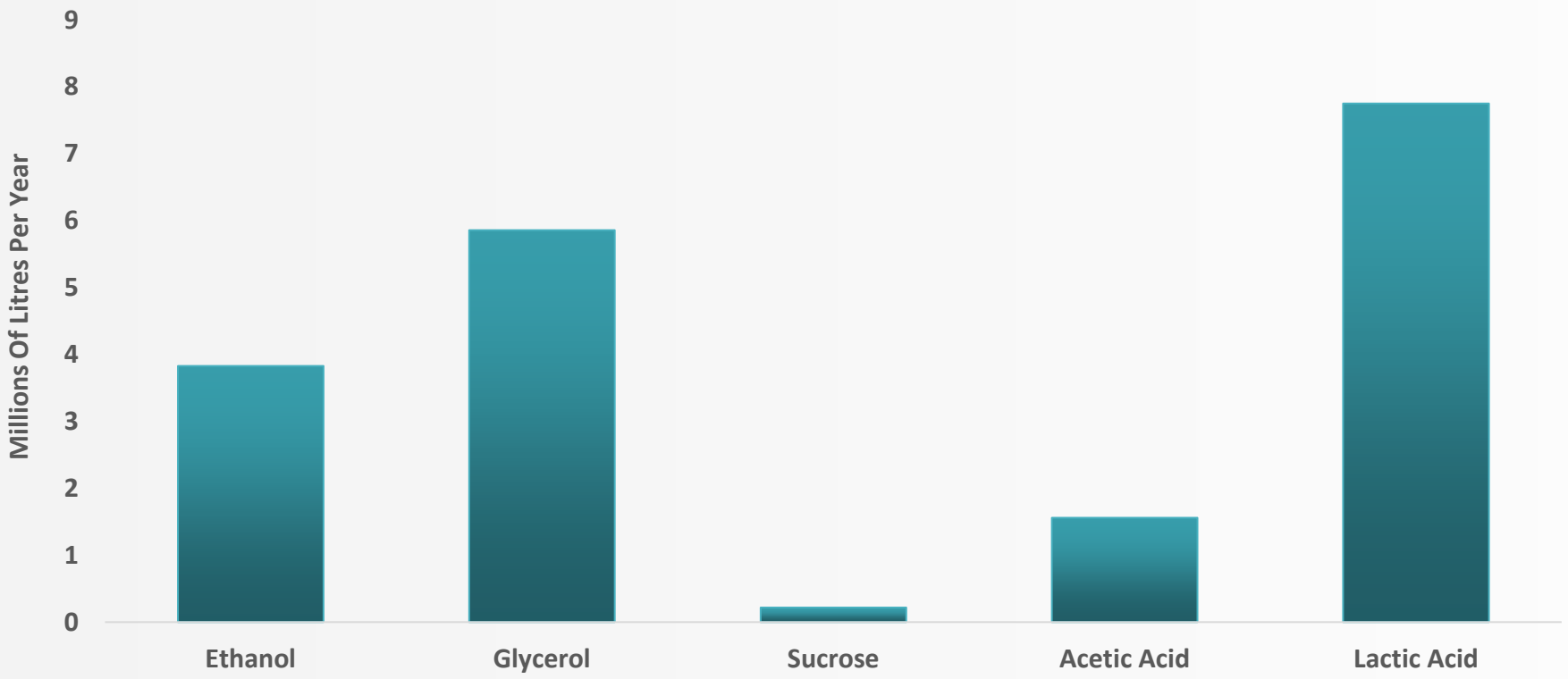
Typical Utilisable Carbon in Vinasse – 100ML/year Plant (Brazil)



Data based on Reis and Hu: University of Minnesota 2017

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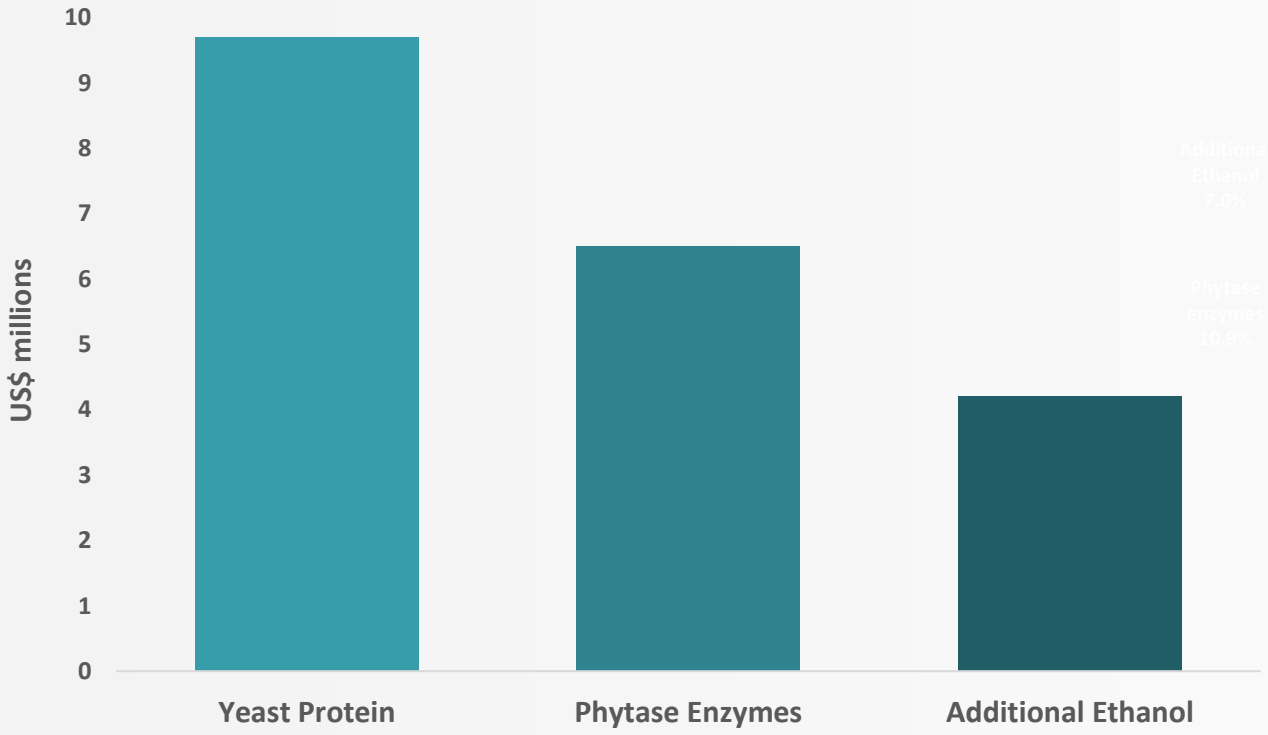
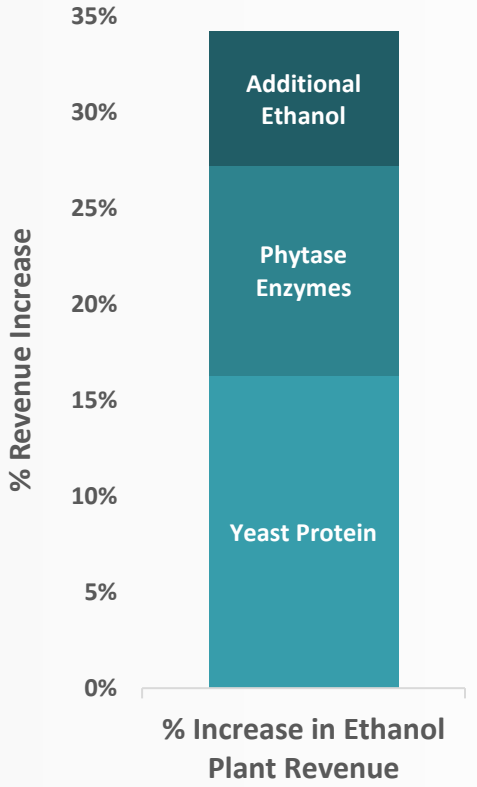
Significant Value-Add & Revenue Diversification Opportunity (1G)

Estimated value for upgrading vinasse to protein and phytase enzymes

In a 100 million L/year ethanol facility – just over 8,000 t of yeast produced





Total Ethanol Facility Revenue Increase

>30%

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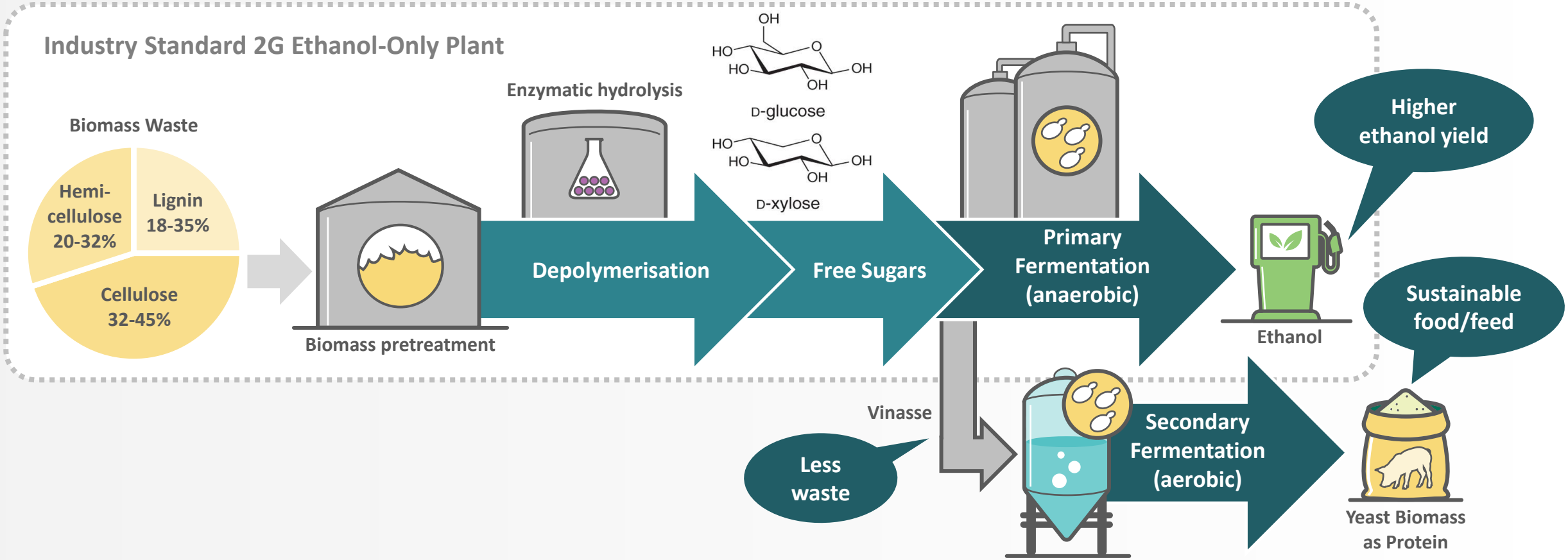
Advanced Fermentation Technology for 2G Ethanol

Key benefits for 2G sugarcane ethanol plants

MicroBioGen Technology for an Integrated 2G Food and Fuel Refinery

More Ethanol, Food/Feed and Materially Less Waste



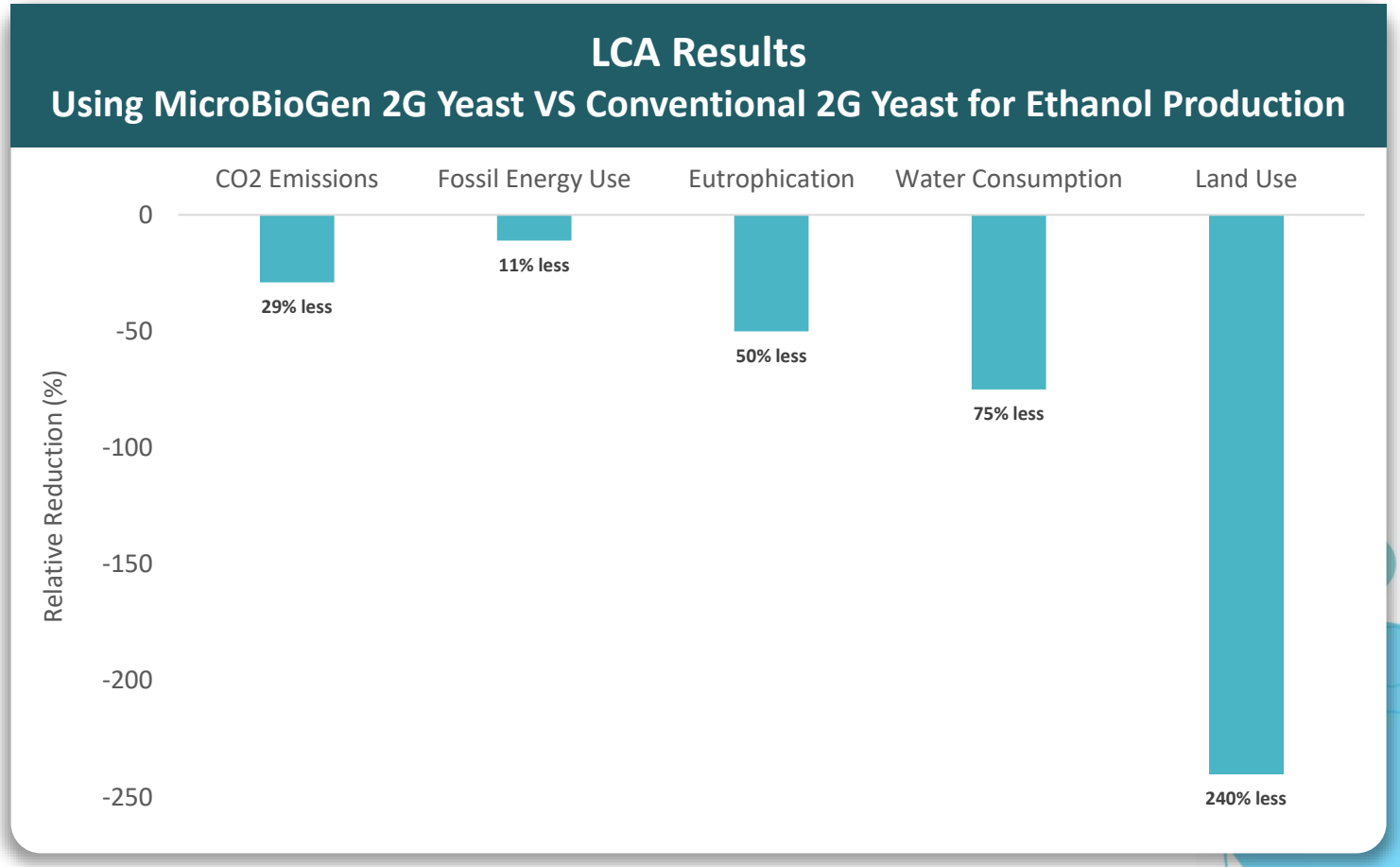
How MicroBioGen Yeast is Optimising 2G Fuel and Feed Biorefineries

- 15-year R&D project
- Recently completed A$8M optimization
- Collaboration with Novozymes, half-funded by Australia's Federal Government

Outcomes

An independent, peer-reviewed Life Cycle Analysis (LCA) indicated significant ESG benefits could be achieved across several key measures

LCA Report: https://microbiogen.com/wp-content/uploads/2021/07/Lifecycles_Microbiogen_ProofofConcept_final_for-public-release-1.pdf



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novozymes

Australian Government
Australian Renewable Energy Agency
ARENA

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Thank You

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