Biological innovations fuel a growing bioresource economy

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Novozymes
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California Bioresources Summit

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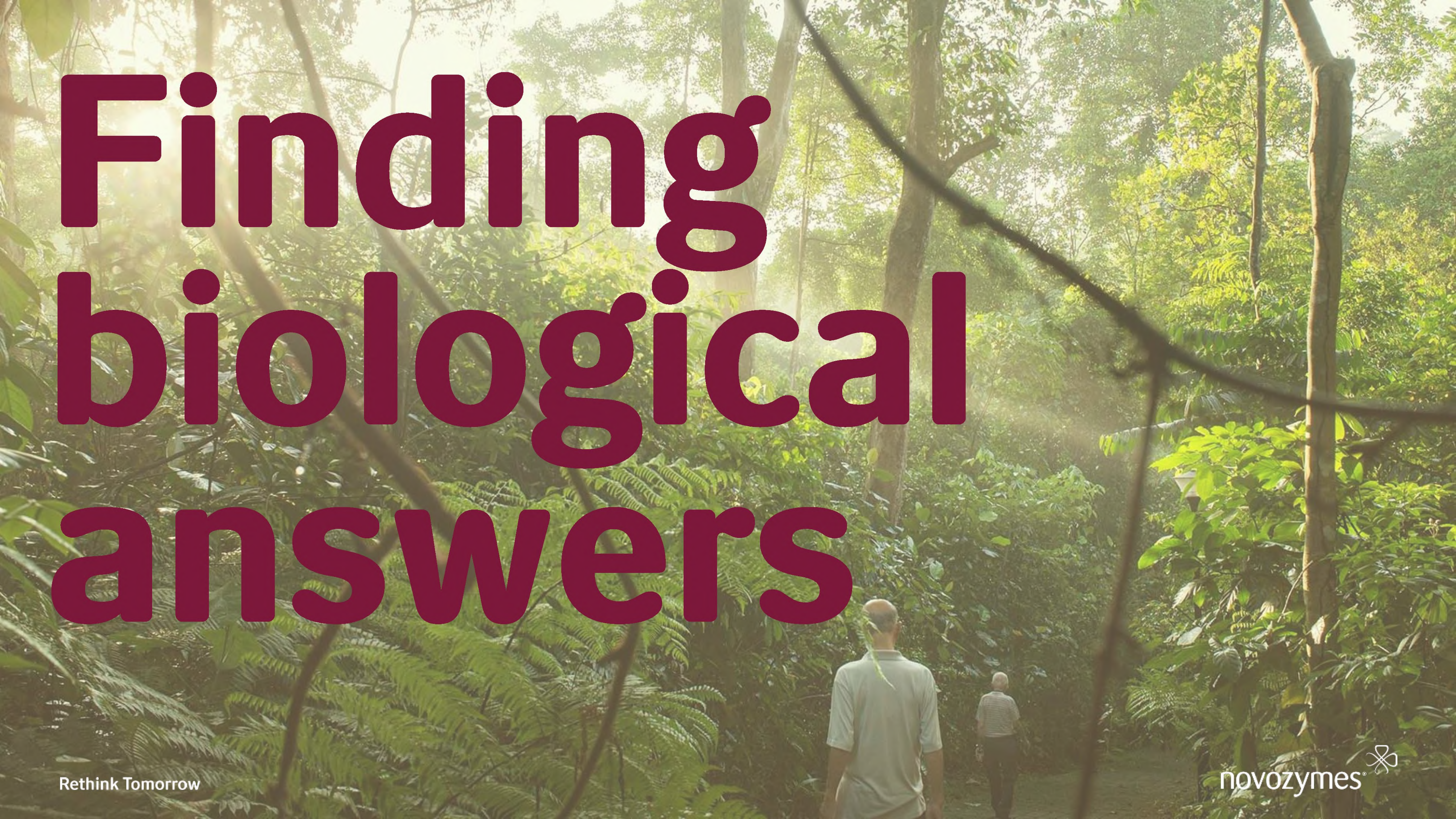
Finding biological answers
Rethink Tomorrow
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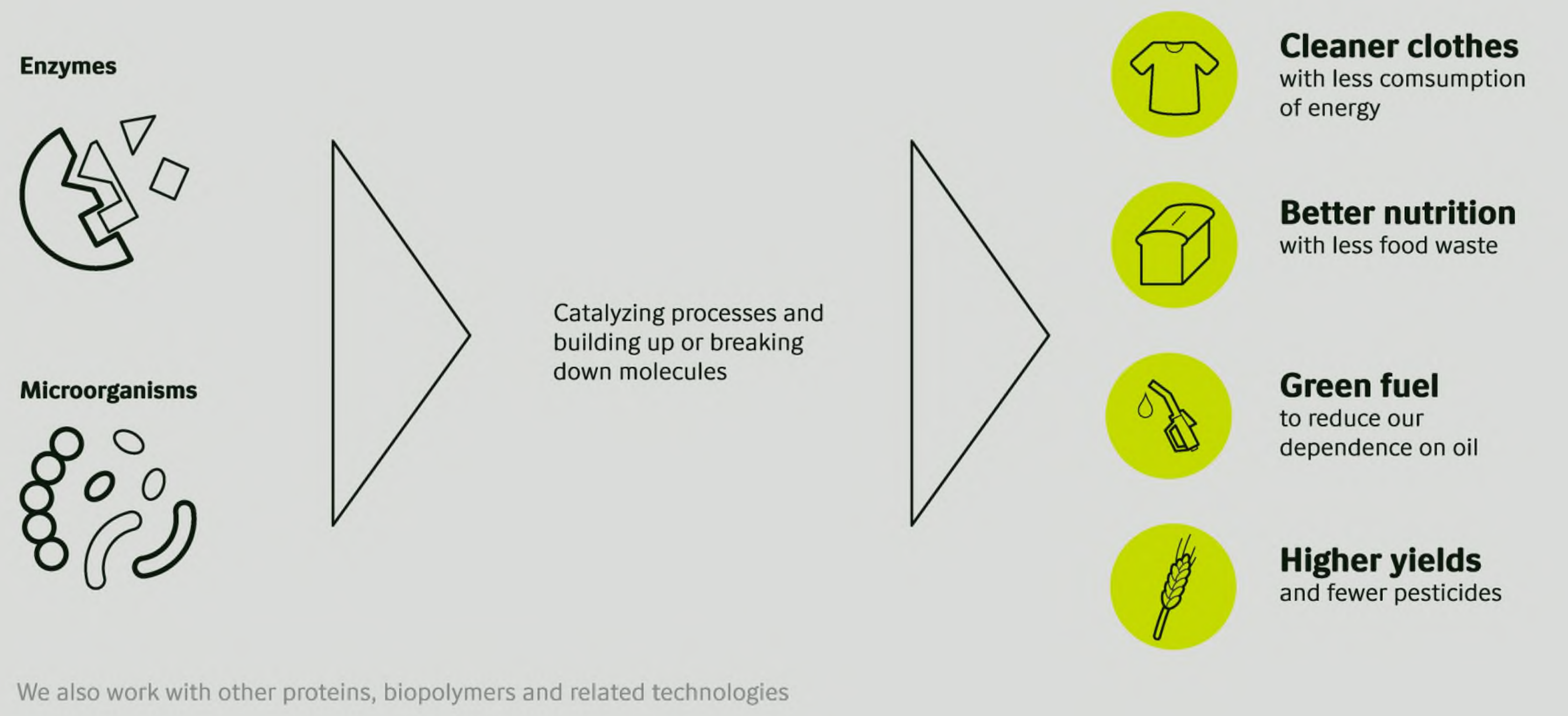
Biotechnology innovation – what is it?

Sometimes the greatest answers in life are found in its smallest components



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Novozymes is the bioinnovation leader- in a broad range of industries

Household Care

Agriculture

Bioenergy

Animal Health & Nutrition

Food & Beverages

Textile

Pulp & Paper

Leather

Wastewater Solutions

Across the agricultural value chain

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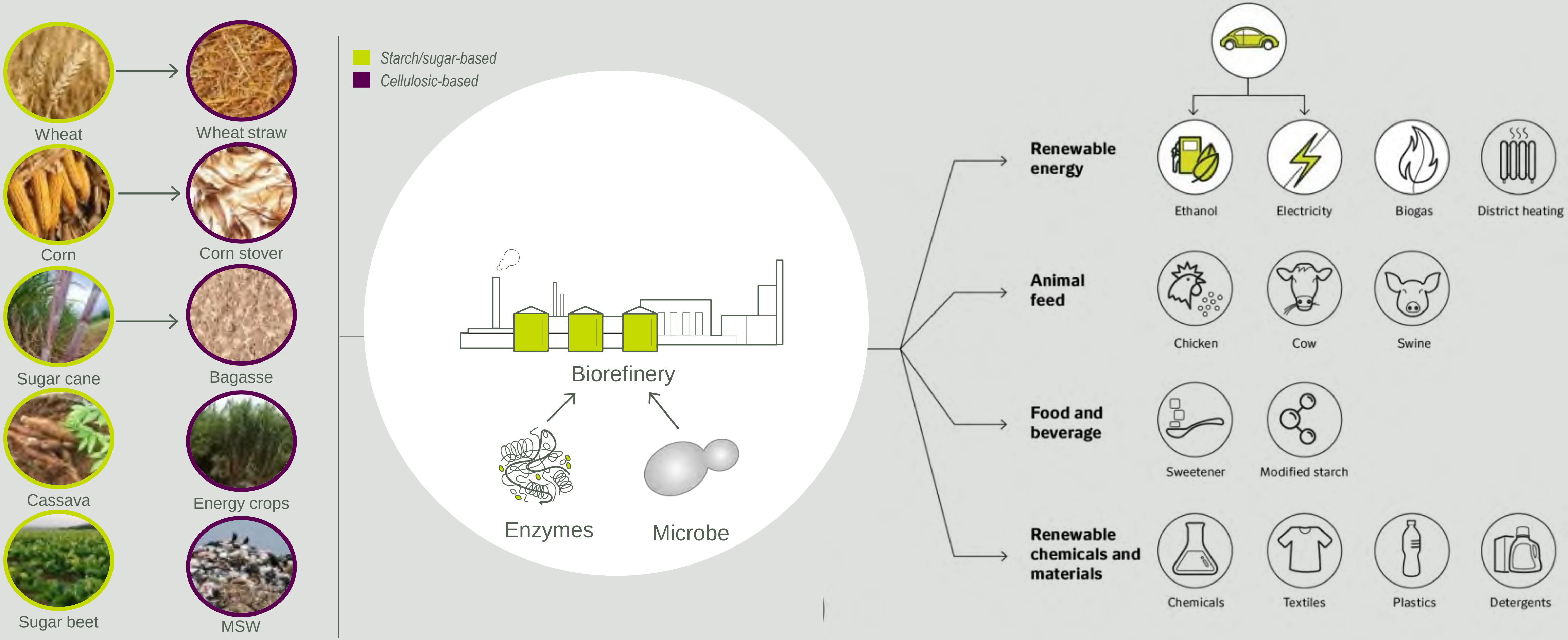
Biorefineries- transforming bioresources to diverse products



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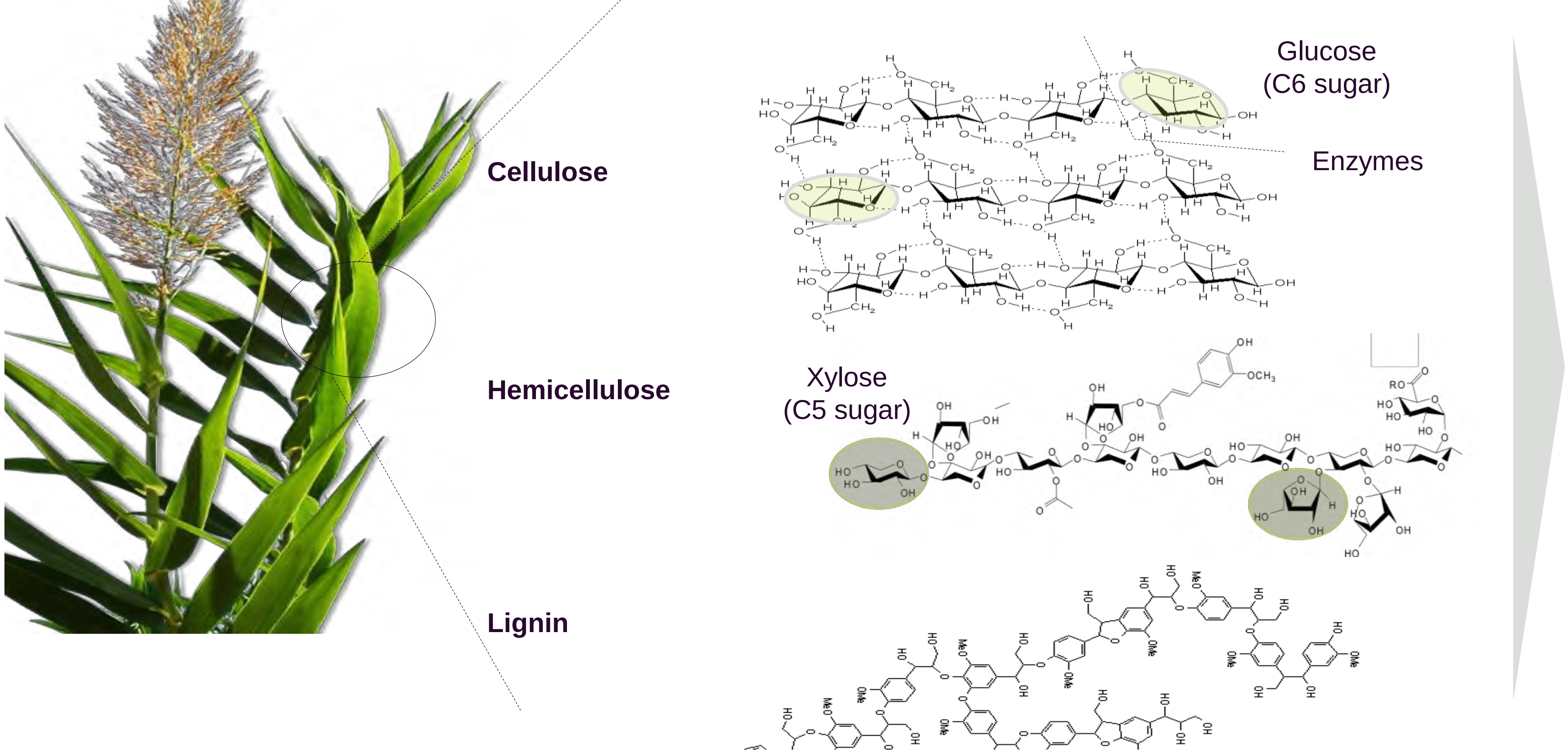
Enzymes enable the release of sugars from complex plant structures (lignocellulose)

Lignocellulose structure



- Enzymes are key to effective and cost efficient ethanol production, releasing C5 and C6 sugars from the biomass
- During the fermentation process, yeasts or other microorganisms convert the sugars into products
- Lignin is typically used for generating steam and power

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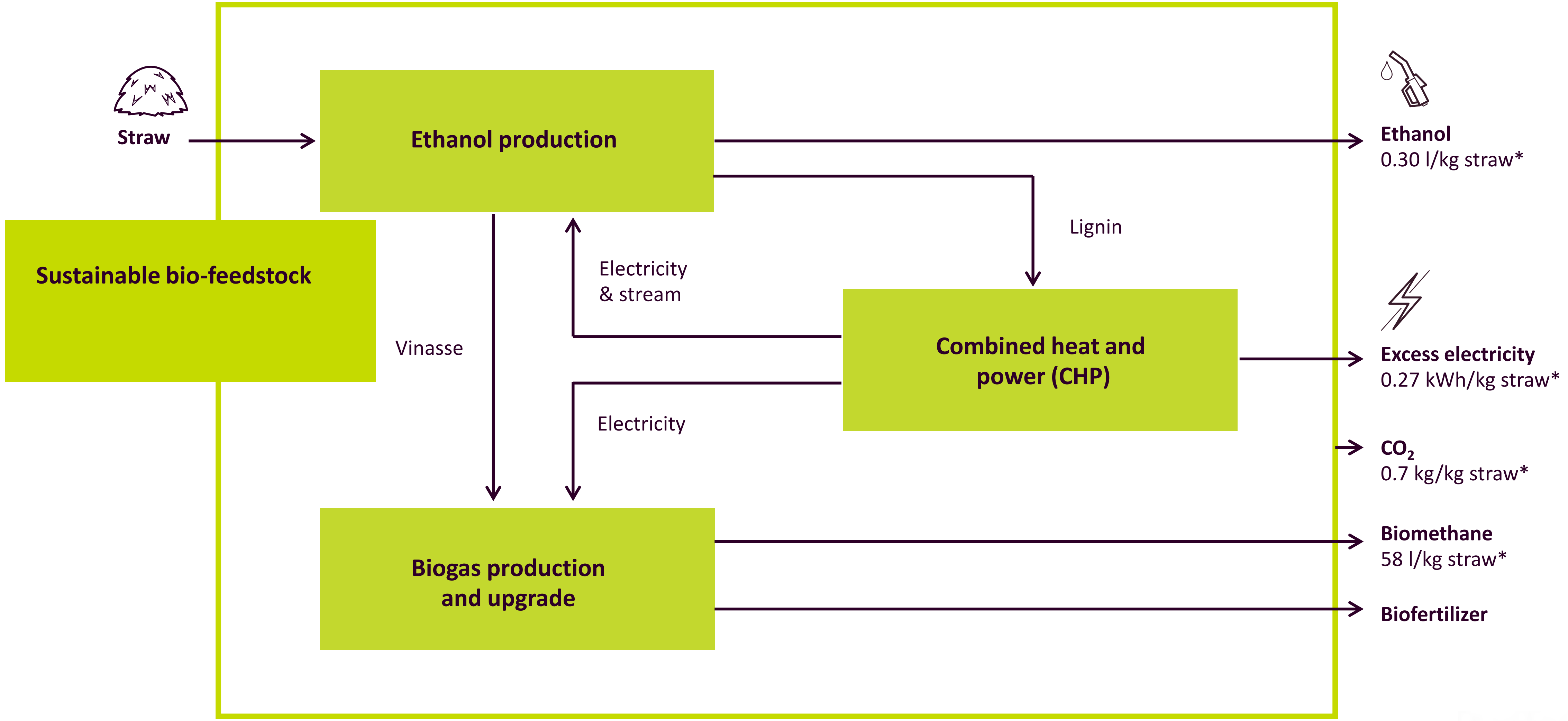
Example of an integrated cellulosic biorefinery



*Dry matter

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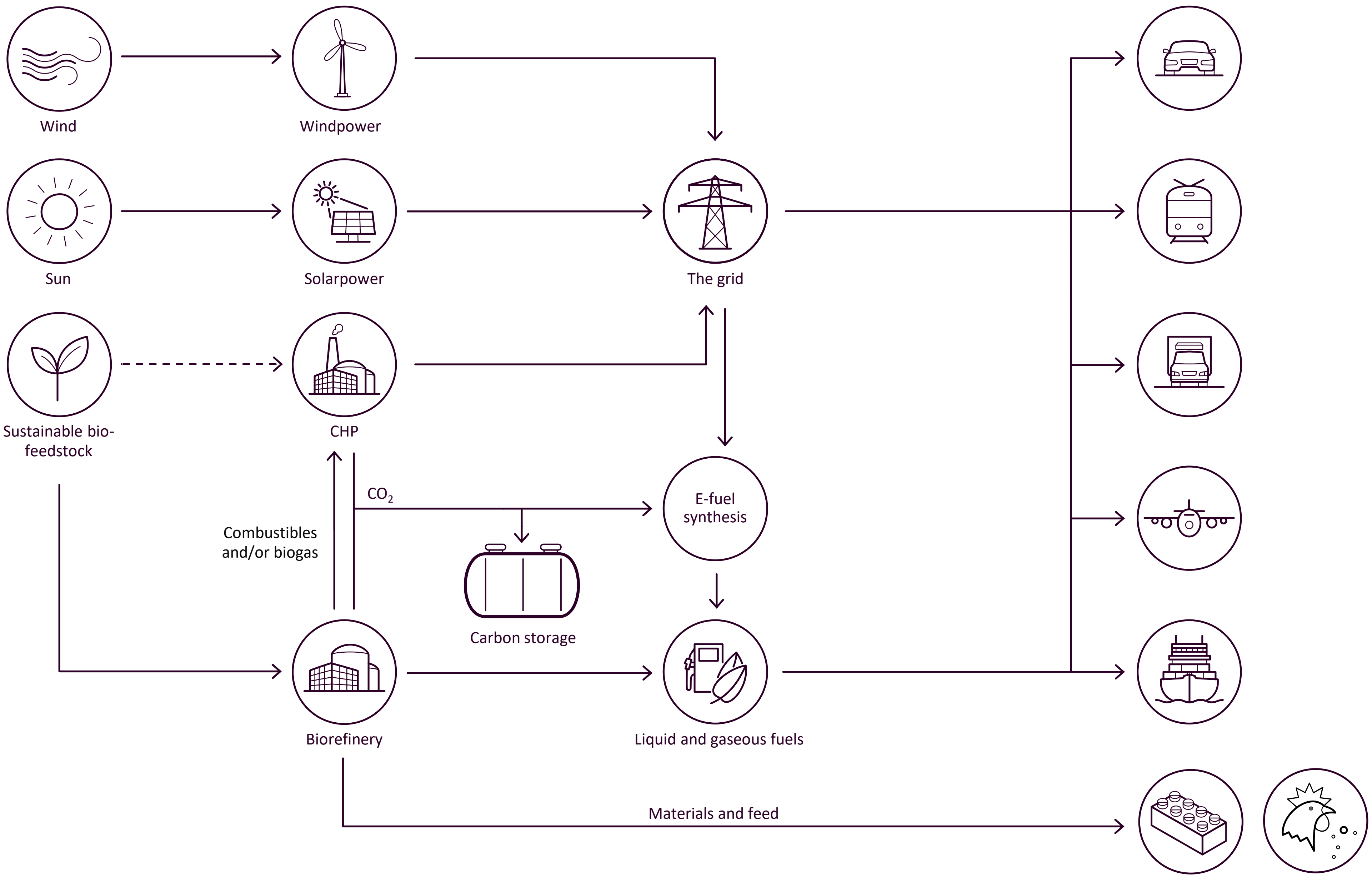
The vision of a fossil-free energy and transport system



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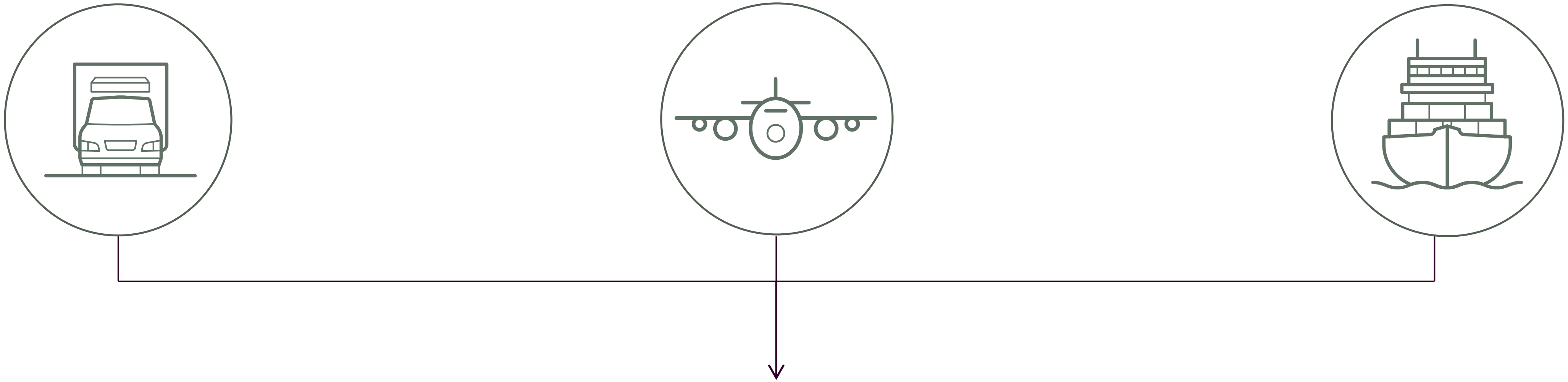
Heavy-duty transportation is not as easily electrified, and will emit more than light-duty



60-70%

of transport CO_2 emissions in 2050

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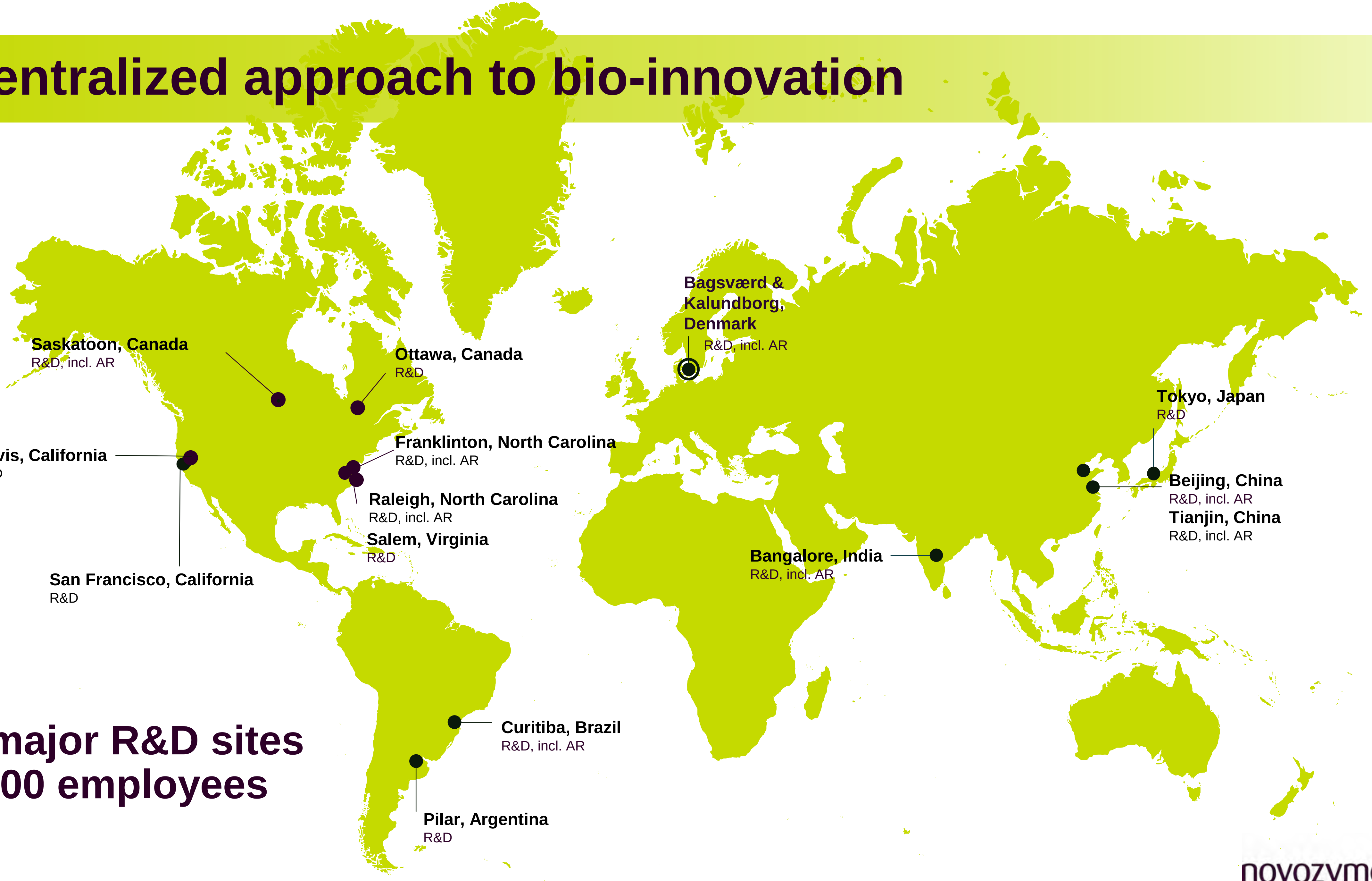
Decentralized approach to bio-innovation



14 major R&D sites
~1400 employees

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Raizen’s Costa Pinto Plant in Piracicaba (SP, Brazil)

- Capacity 11 mGal/ yr
- Sugarcane bagasse
- “Bolt on” at existing sugarcane biorefinery
- In operation since late 2015

* Source: novoCana.com 22 Mar 2017

st1 Cellunolix® Kajaani plant in Finland

Ethanol Capacity 2.6 mGal/yr

- Additional side products: lignin, biogas, turpentine, furfural, vinasse,

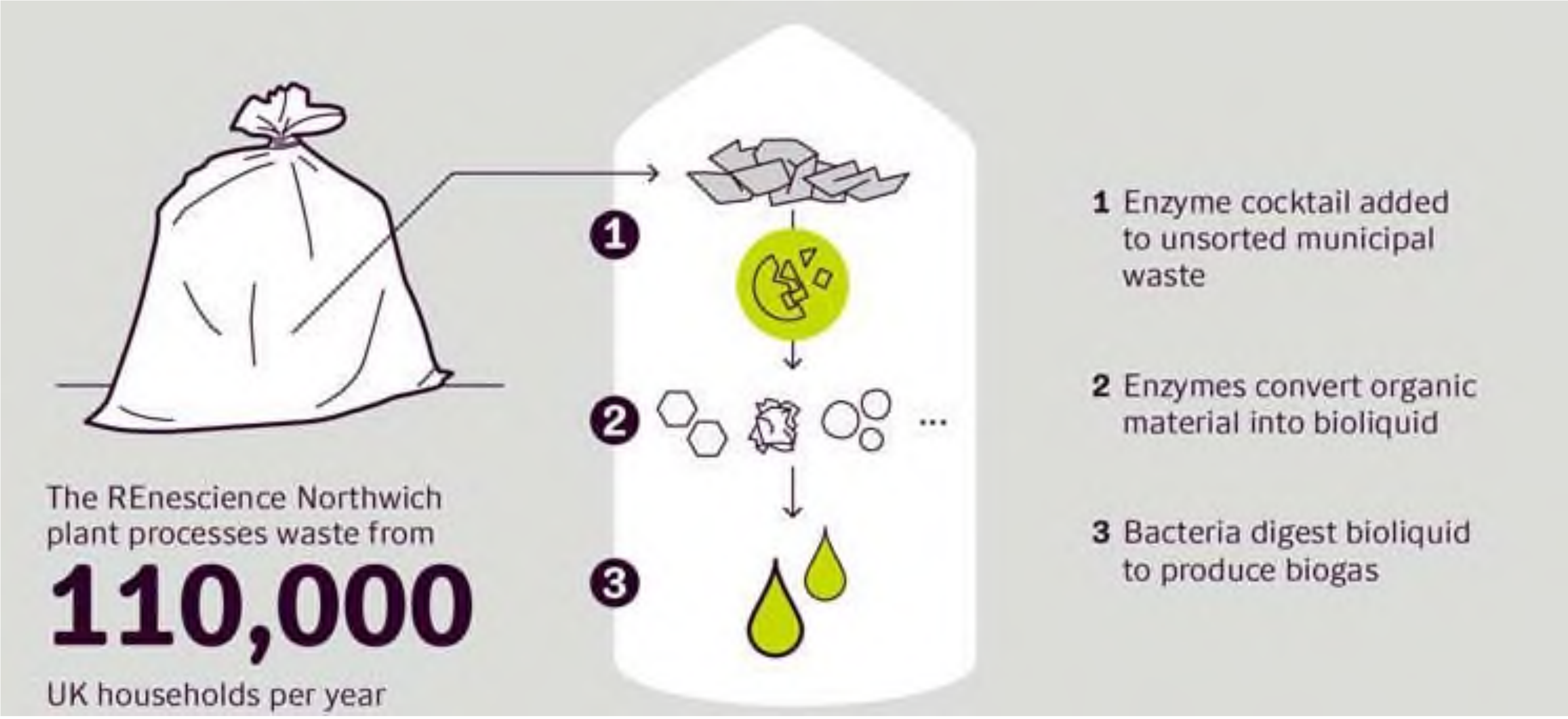
First of a kind process optimized for softwood

- Sawdust (80 % pine & 20 % spruce)

Plant in operation since 2017

Renescience- Household waste to green energy

Northwich plant in UK-operational since 2017



First full-scale bio plant in the world capable of handling household waste by means of enzymes.

Unsorted MSW waste to power, sorted glass/metal/plastics, solids (for incineration)

generate around 5 MW of electricity which is enough to power around 9,500 typical households

https://www.novozymes.com/en/news/news-archive/2016/06/novozymes-and-dong-energy-enter-into-agreement-on-biological-waste-sorting

Current commercial biomass conversion plants using biochemical pathways

"Steel in the ground"

… **~ USD 2 BN** Total Investment Cost…

…with an EtOH production capacity of **~130 M** gal/yr

…on **3** continents

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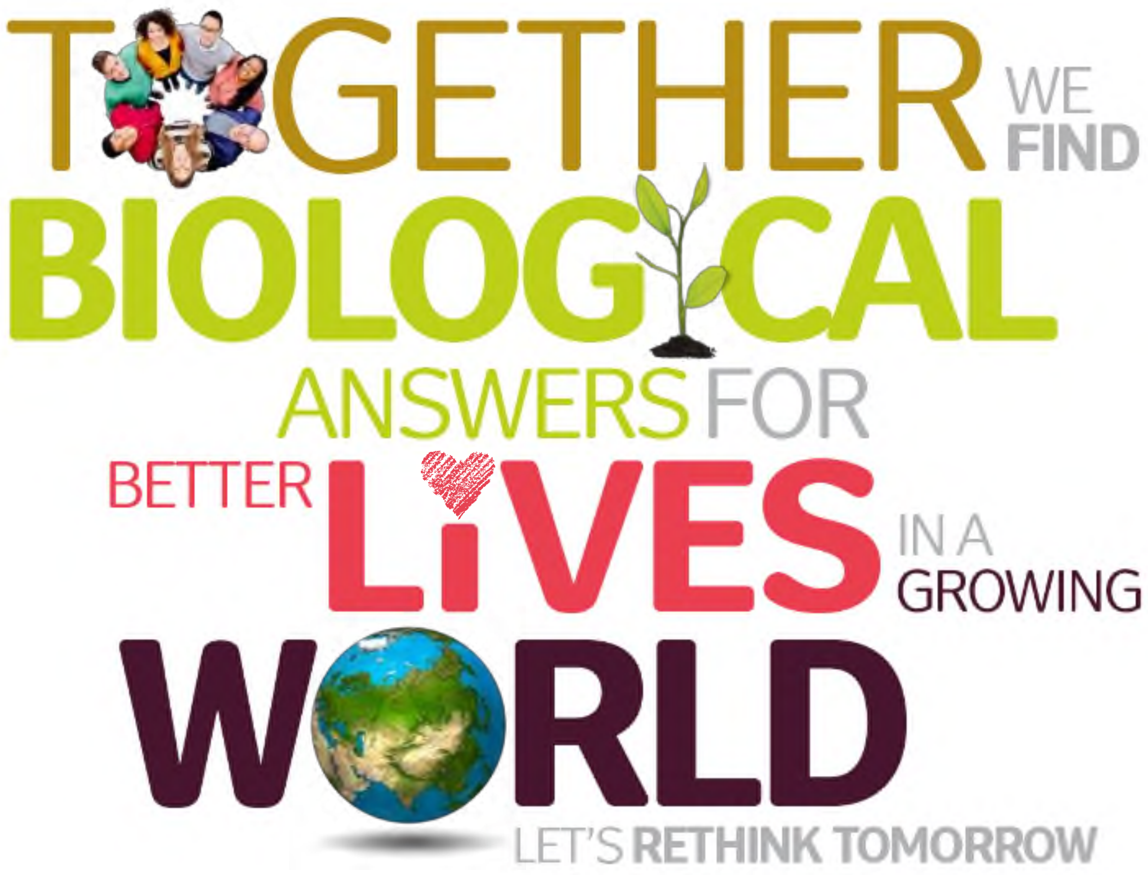
Conclusions

- Novozymes brings diverse technology options relevant for expanding sustainable use of bioresources

- Path to decarbonization relies on biorefineries, along with electrification – Green carbon and Green electrons

- Continue expansion of products in biorefineries, while learning from global “first movers”



Questions

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18 years of continuous development has enabled a new industry

2001

One of largest R&D investments in Novozymes' history was initiated

2005

Biomass conversion pilot plants worldwide testing Novozymes enzymes

2009

Launch of Cellic® CTec for the first cellulosic ethanol demonstration plants

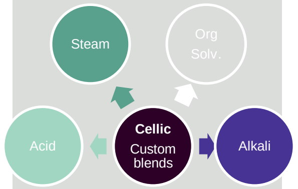
2013

The first commercial cellulosic ethanol plant: Crescentino, using Cellic® enzymes

2014

Exclusive partnership with Brazil's largest sugar-based ethanol producer

2015



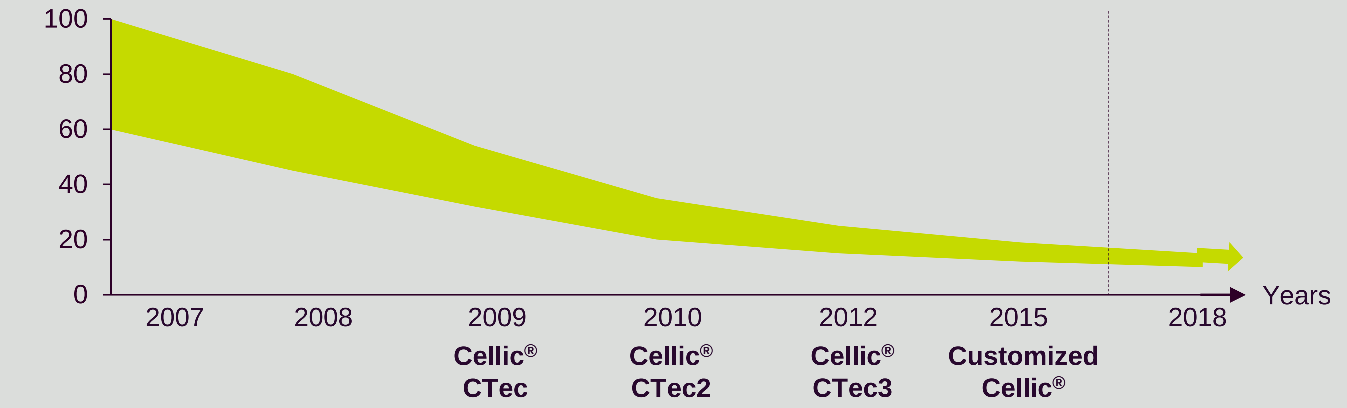
Launch of first Cellic® customized products- significant cost reductions for key customers

2017+

Expansion and diversification of commercial processes

Foundation | **Pilot stage** | **Demo stage** | **Initial commercial stage** | **Optimization stage**

Enzyme use costs (indexed)



Customized Cellic® enzyme technology: customization of enzymes to match specific process and feedstock

Novozymes Yeast -Cellerity®

With Cellic®, providing full biotechnology package to cellulosic ethanol producers

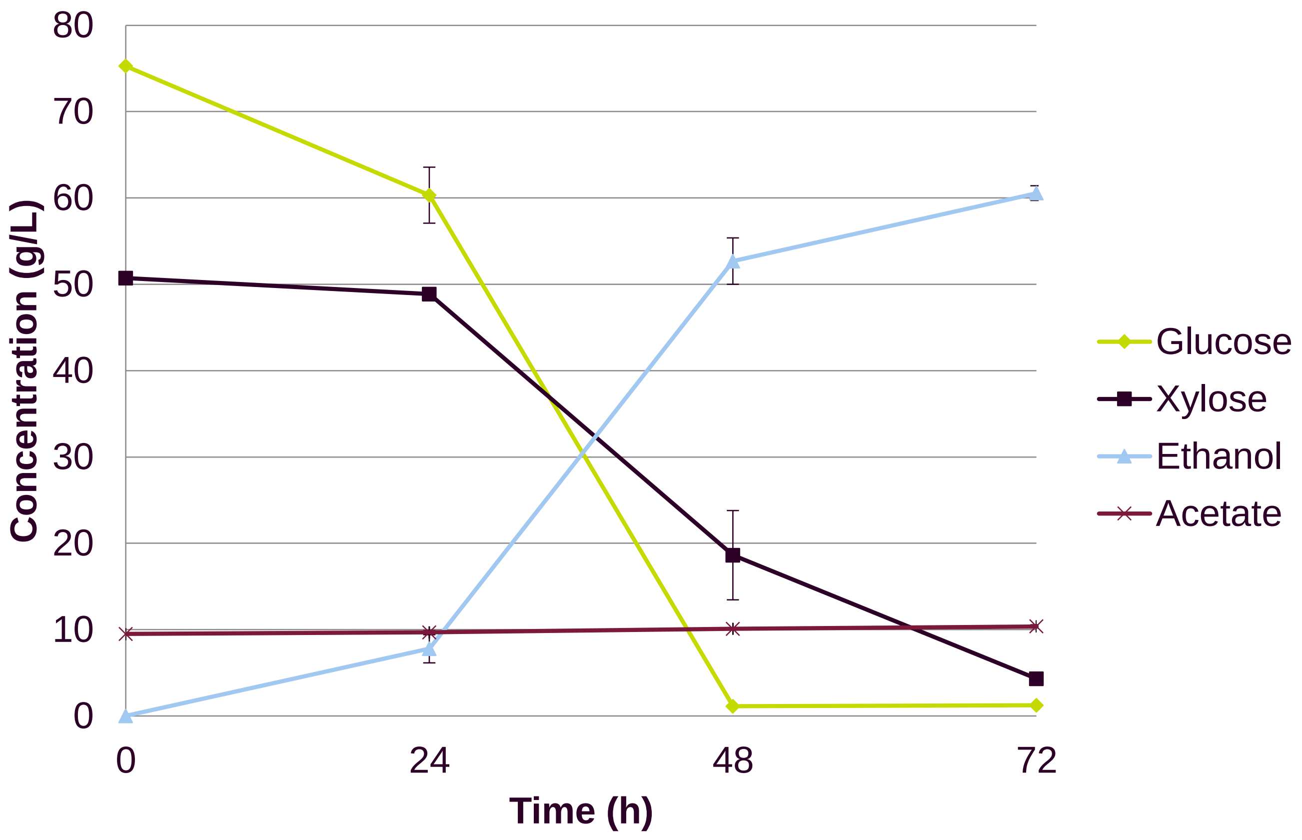
Stable
- Stable diploid industrial yeast strain able to ferment C5/C6 biomass slurries at 15-20% TS.
- Propagates on industry standard substrates without costly supplemental nutrients

Robust
- Typical yeast pitch of 0.5 to 1 gDCW/L
- Rapid xylose conversion even at high acetate levels.
- Temperature tolerant to temporary excursions above 35°C

Substrate utilization
- >85% total sugar utilization (>90% glucose,>80% xylose)

Speed
- Fast fermentation (complete within 48-72 hours depending on %TS and pitch)
- Fast xylose consumption throughout fermentation, specific uptake rates of 1.2 g/L/h have been observed.

NREL Acid Pretreated Corn Stover
20% TS, 1 g DCW/L, pH 5.5, 2 g/L urea, 35°C



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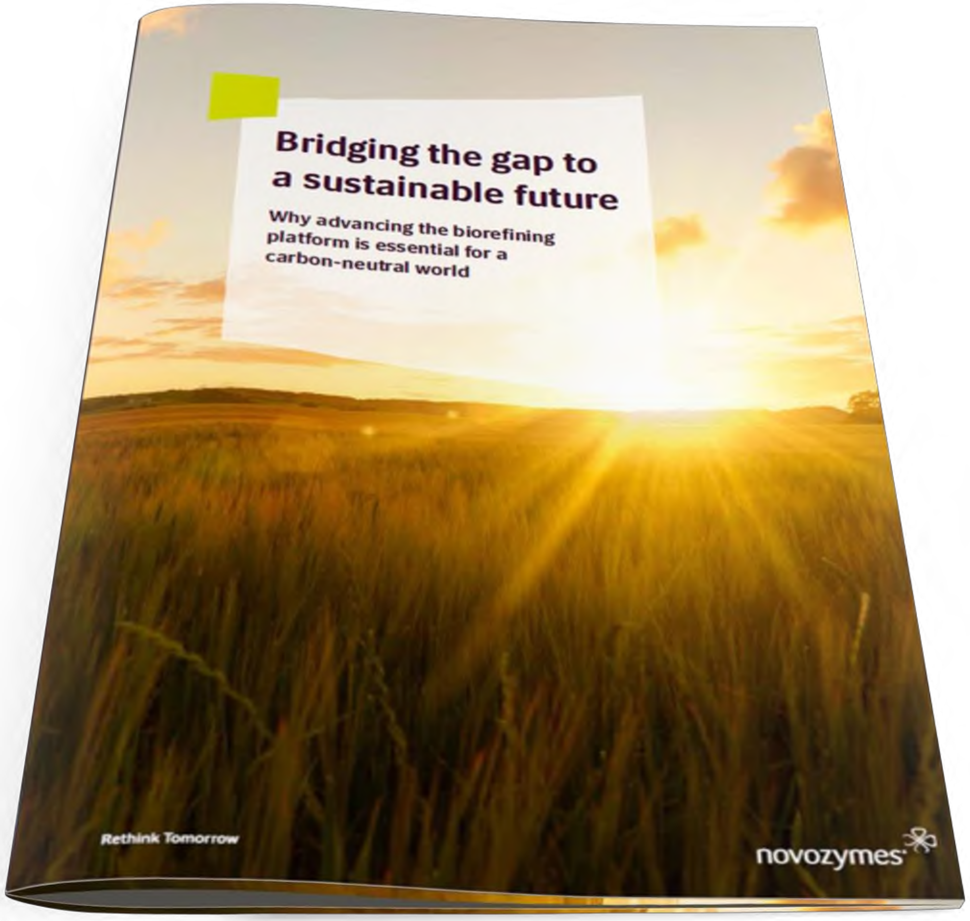
Bridging the gap to a sustainable future

- Is a call to define an effective pathway to mitigate climate change
- Is Novozymes contribution based on what we know works
- Is intended to start a conversation and an invitation to work together
- Is a living document (not final) for all to access and use without restrictions

Find the report on Novozymes.com



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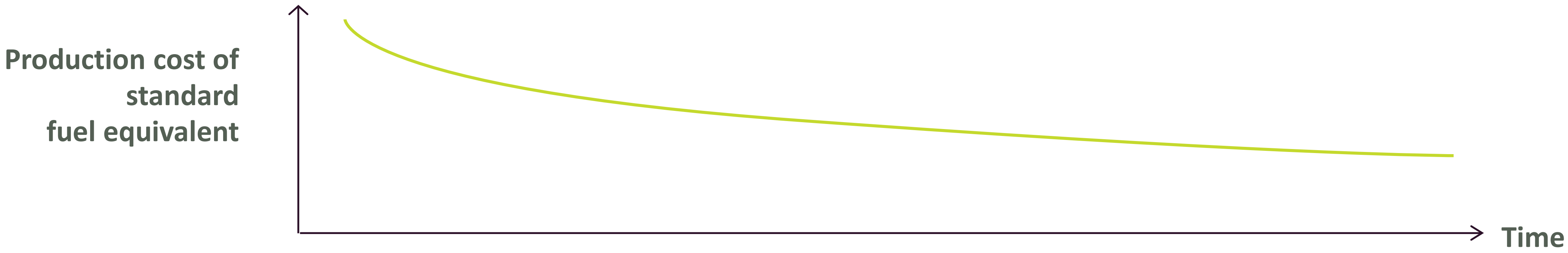
Biorefining is a platform that will develop and adapt over time

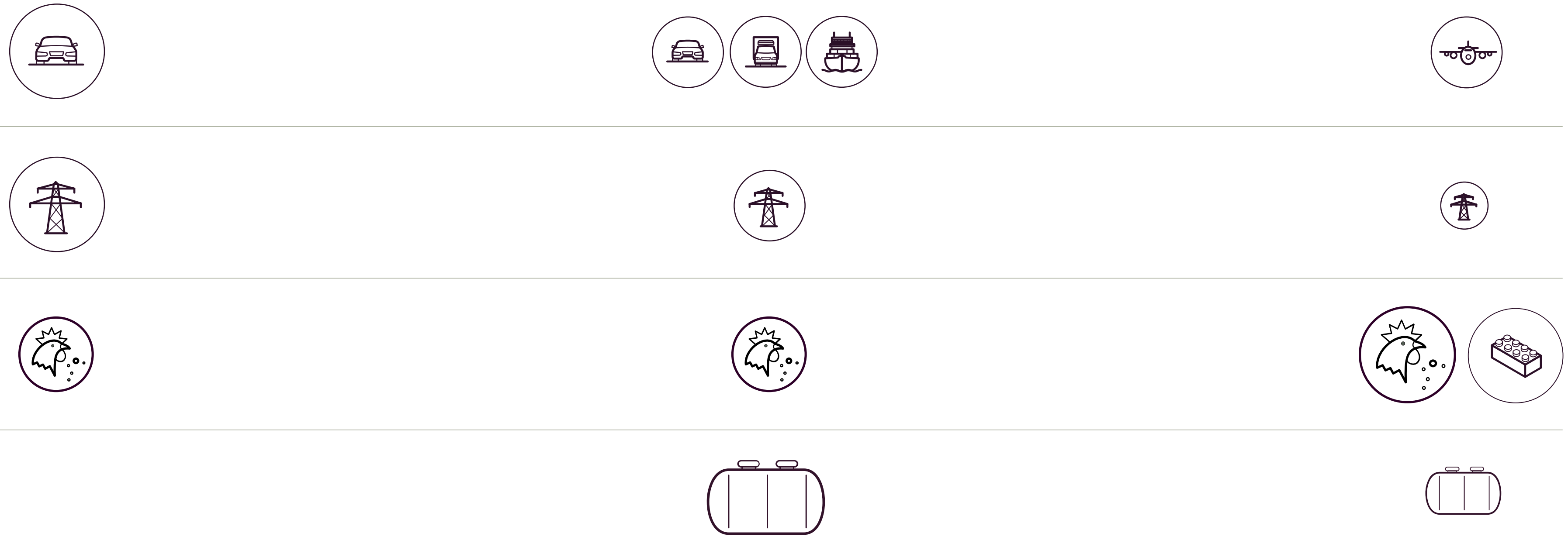


Fuels

Electricity

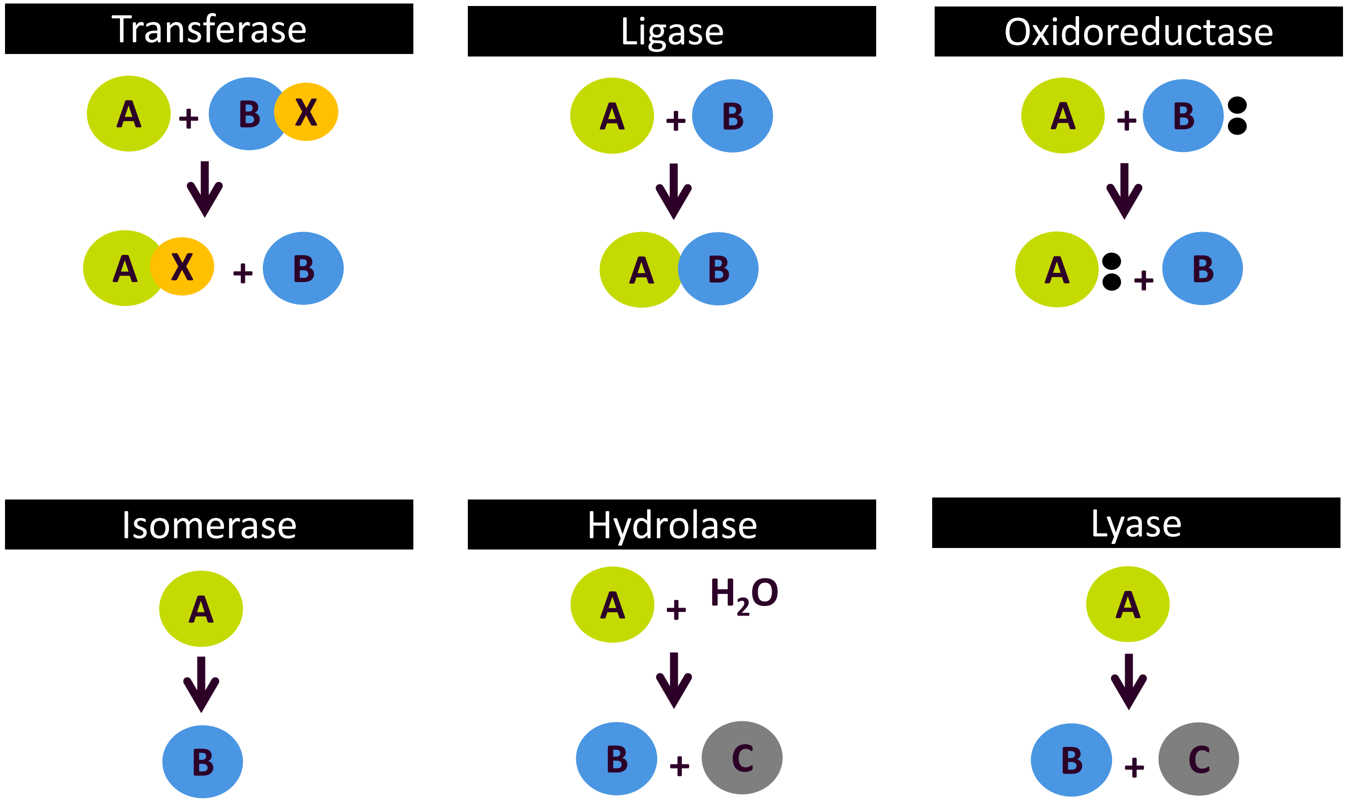
Feed / food /
chemicals / materials

Carbon capture
and storage



Typical enzymes used in industrial processes

Class	Industrial enzymes
Oxidoreductases	Peroxidases (Catalases) Glucose oxidases Laccases
Transferases	Fructosyltransferases Glucosyltransferases
Hydrolases	**Amylases** **Cellulases** **Lipases** **Pectinases** **Proteases** **Pullulanases** **Phytases**
Lyases	Pectate lyases Acetolactate decarboxylases
Isomerases	Glucose isomerases
Ligases	No products at the moment



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