



# **A NEW WAVE IN BIO-BASED MATERIALS**

**De-bottlenecking biorefineries & creating  
maximum value for biomass**

**WHY?**

**We have a  
tremendous  
amount of oil  
based materials  
and products in  
our lives.**

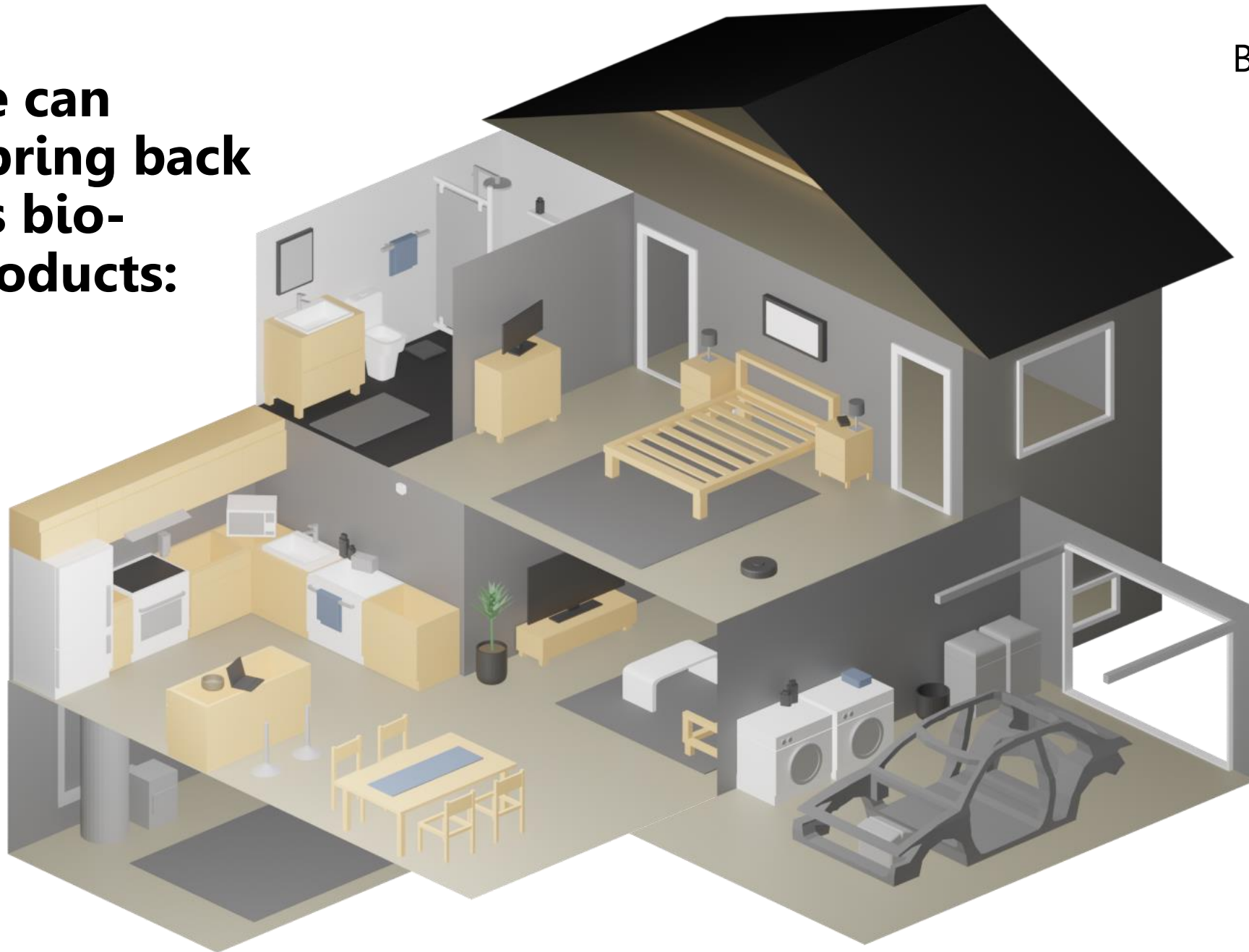


**We have a  
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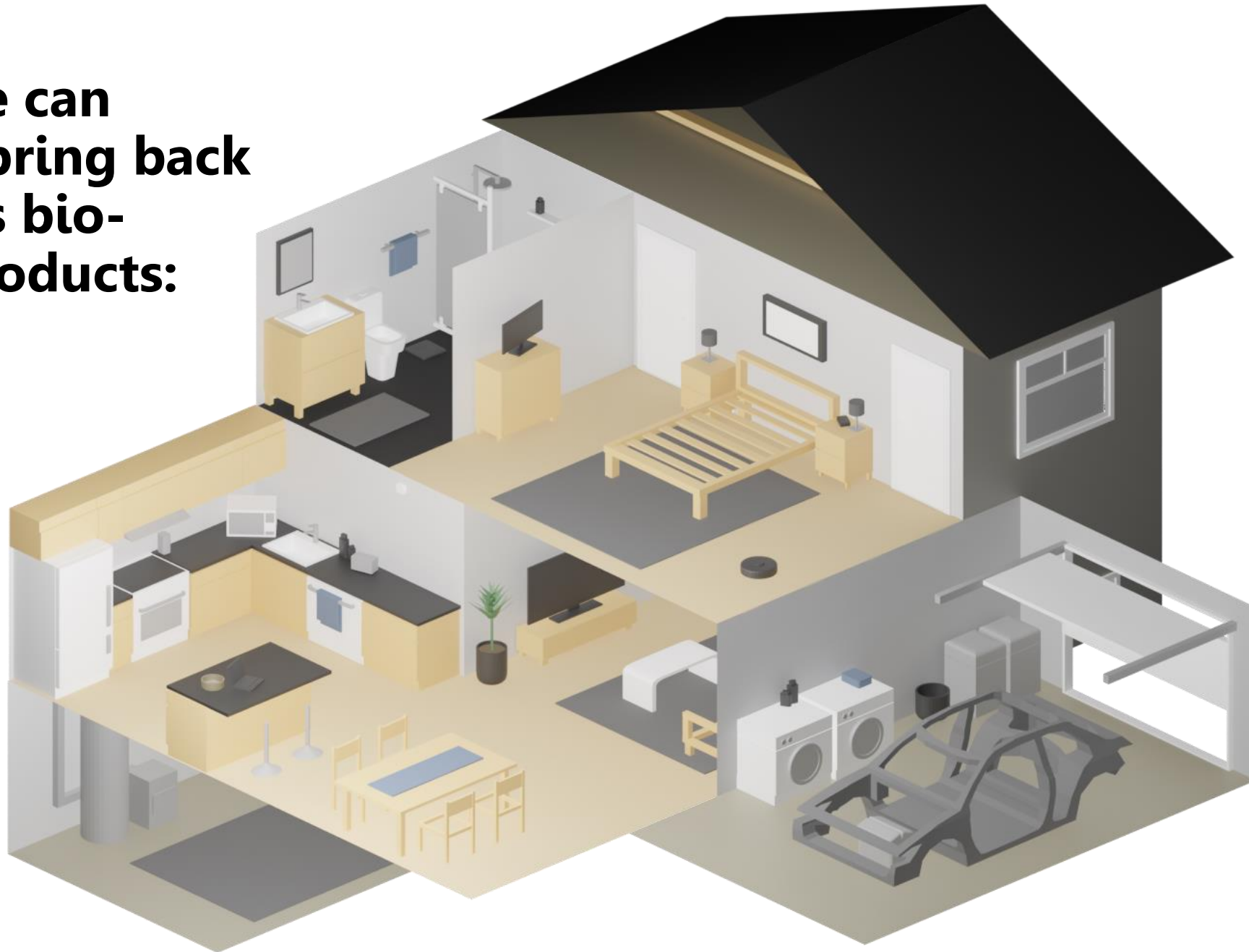
**These we can  
already bring back  
to you as bio-  
based products:**

Sugar-based  
Bioplastics and  
lignin-based  
composites



**These we can  
already bring back  
to you as bio-  
based products:**

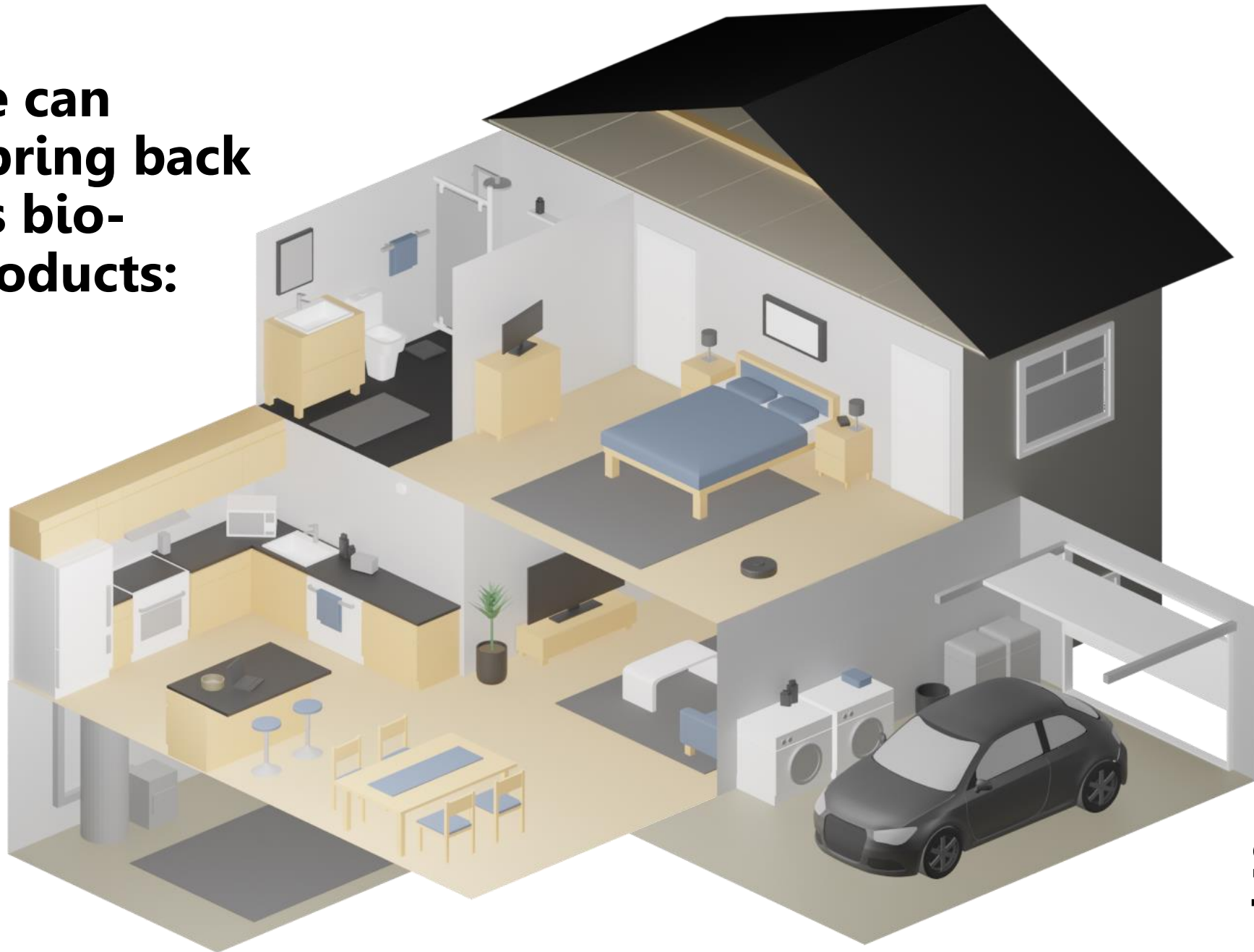
Lignin-based  
resins and  
adhesives,  
wood-fibre  
composites





**These we can  
already bring back  
to you as bio-  
based products:**

Lignin-based  
foams and  
composites



**See?  
That's  
everythi**

# WASTE:

**Oil**

versus

**Renewable  
materials**

Low

**Raw material variability**

High

High

**Yield-to-products**

Low

Adds Carbon to the system

**Carbon capture**

Has high potential to capture carbon

Cumulates to environment

**End-of-life**

Has high potential for recycle or degradation



A photograph of a sunlit forest floor. Sunlight filters through the dense green foliage, creating bright patches of light on the ground and leaves. The foreground is mostly in shadow, while the background is brightly lit. The text is overlaid on the left side of the image.

**We need to  
find **NEW**  
**SOLUTIONS.****

## *Vocabulary*

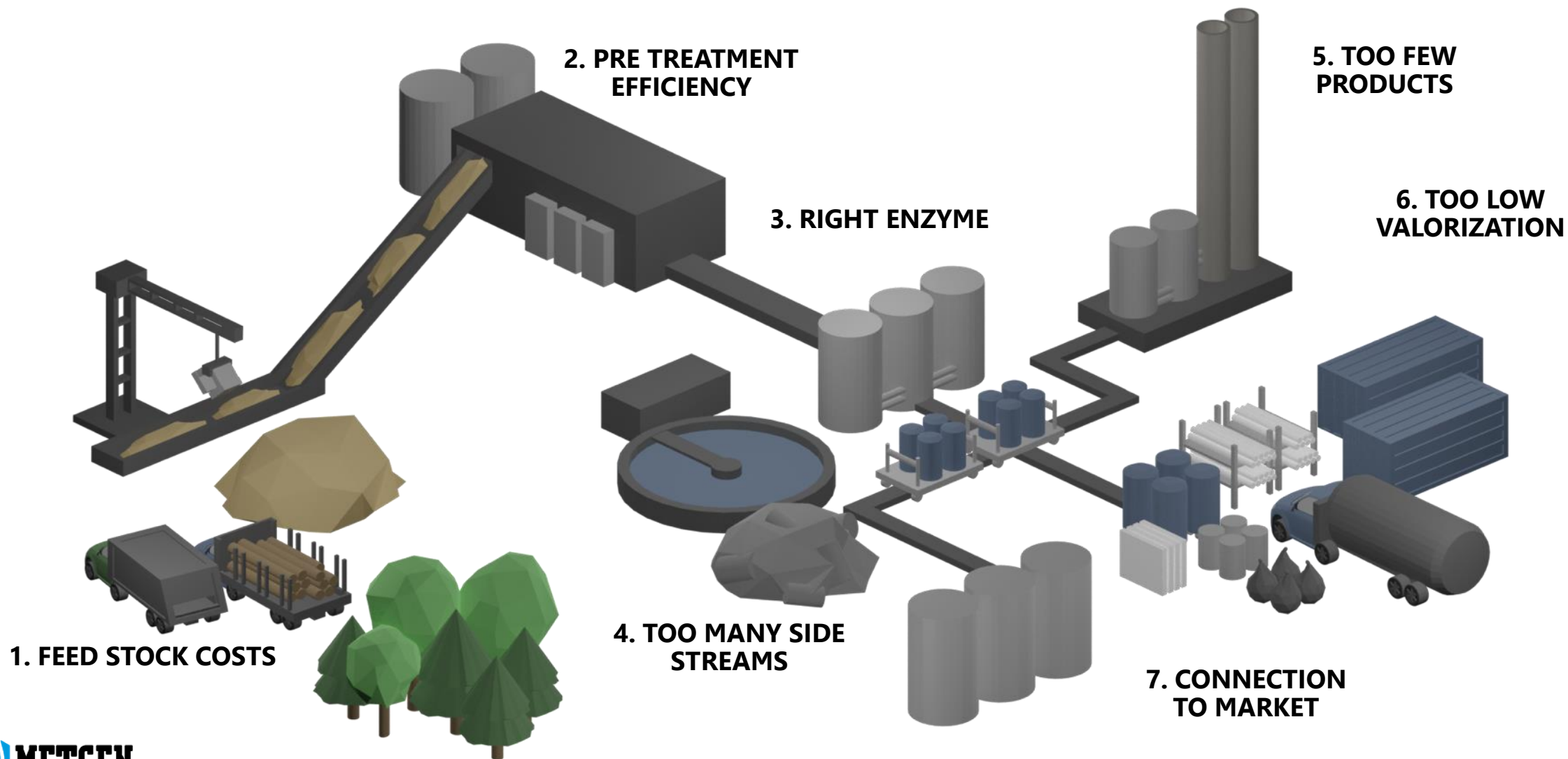
# BIOREFINERY

The **coproduction** of a range of **biologically**-based products (food, feed, materials, chemicals) and **energy** (fuels, power, heat) from **biomass**

# LIGNOCELLULOSIC

Lignocellulose refers to plant dry matter (biomass), so called lignocellulosic biomass. It is the most abundantly available raw material on the Earth for the production of renewable fuels, chemicals and materials. It is composed of carbohydrate polymers (cellulose, hemicellulose), and an aromatic polymer (lignin)

# THE BIG PICTURE: HAVE A BIOREFINERY AND MAKE IT WORK

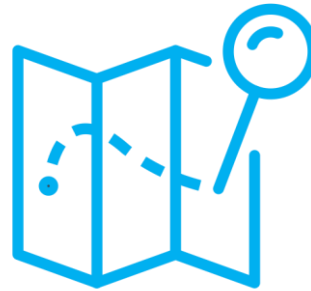


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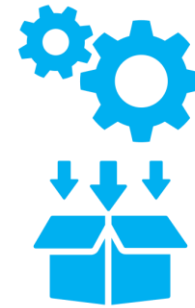
## FEEDSTOCK COSTS



Selection  
of material



Location



Market supply  
and demand



Regulation



Technologies



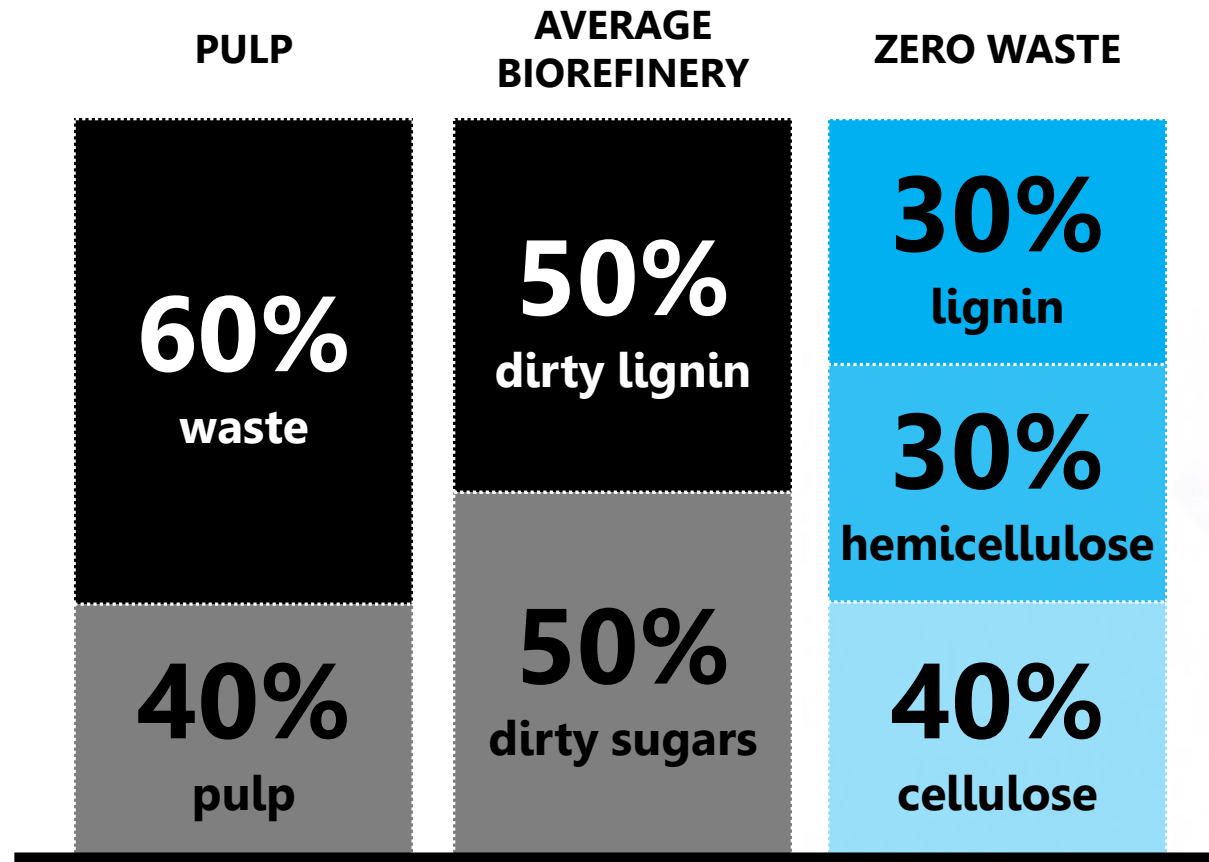
Sustainability

**“You do not want to  
replace all plastic with  
one feedstock. It's not  
sustainable.”**



# 2

## PRE TREATMENT EFFICIENCY



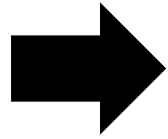
**/// Enzyme technologies  
can be integrated part  
of the refinery concept  
– we have just the  
model for you!”**

# 3

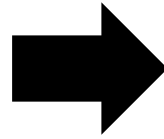
## RIGHT ENZYME AND RIGHT PRICING



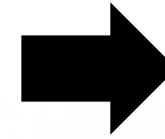
**SUBSTRATE**  
Specific solutions



**HYDROLYSIS &  
DETOXIFICATION**  
Sugar platform  
SUNO™



**BIOCHEMICAL  
CONVERSIONS**  
Chemical building blocks  
PURECO™ & METNIN™



**SIDE STREAMS AND  
ENVIRONMENT**  
Water & Biogas  
FORICO™ & FORCI™

Enzymatic technologies work seamlessly with chemical and mechanical solutions creating a full value chain.



A top-down view of numerous small, white, oval-shaped bags filled with various spices. Each bag has a metal scoop resting inside. The spices vary in color and texture, including bright red powders, yellow powders, dark brown granules, light beige powders, and whole spices like cinnamon sticks and dried red flowers. The bags are arranged in a grid-like pattern on a dark surface.

**FINDING THE RIGHT ENZYME IS  
LIKE MIXING YOUR OWN SPICES**



# BENEFIT OF TAILORED HYDROLYSIS ENZYMES

Every substrate can be addressed with multitude of enzymes, and a failure to find an optimal one leads to overdosing, low process yields, increased waste volumes and – what is worst – loss of money.

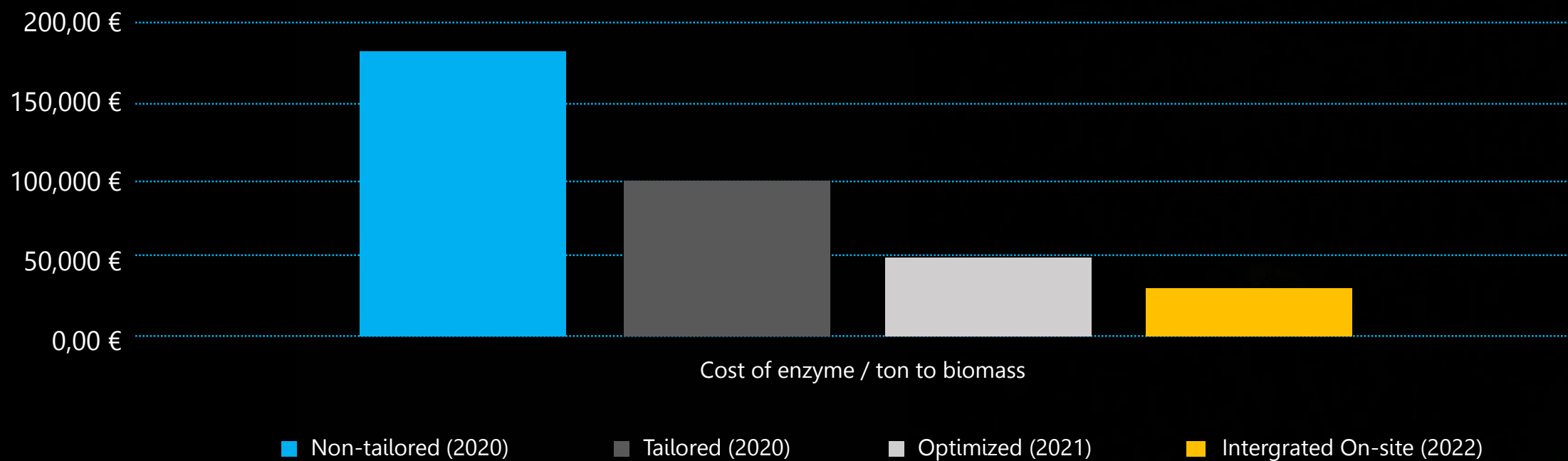
MetGen's production strains and processes together with the flexible business model allow for licensing and on-site manufacturing options.

Collaboration with other players in the value-chain lowers the technology costs even further.



# COST OF ENZYME / TON OF BIOMASS

## COST PROJECTION FOR HYDROLYSIS ENZYMES FOR >90% SUGAR YIELD FOR AN ASIAN BIOREFINERY PROJECT



**“Biomass is not oil –  
it’s a soup of the day.”**

# 4

## **TOO MANY SIDESTREAMS AND TOO MUCH WASTE.**

**One-product-in-one-product-out is outdated and wasteful model**

Waste is expensive!

**Traditional process uses 40.**

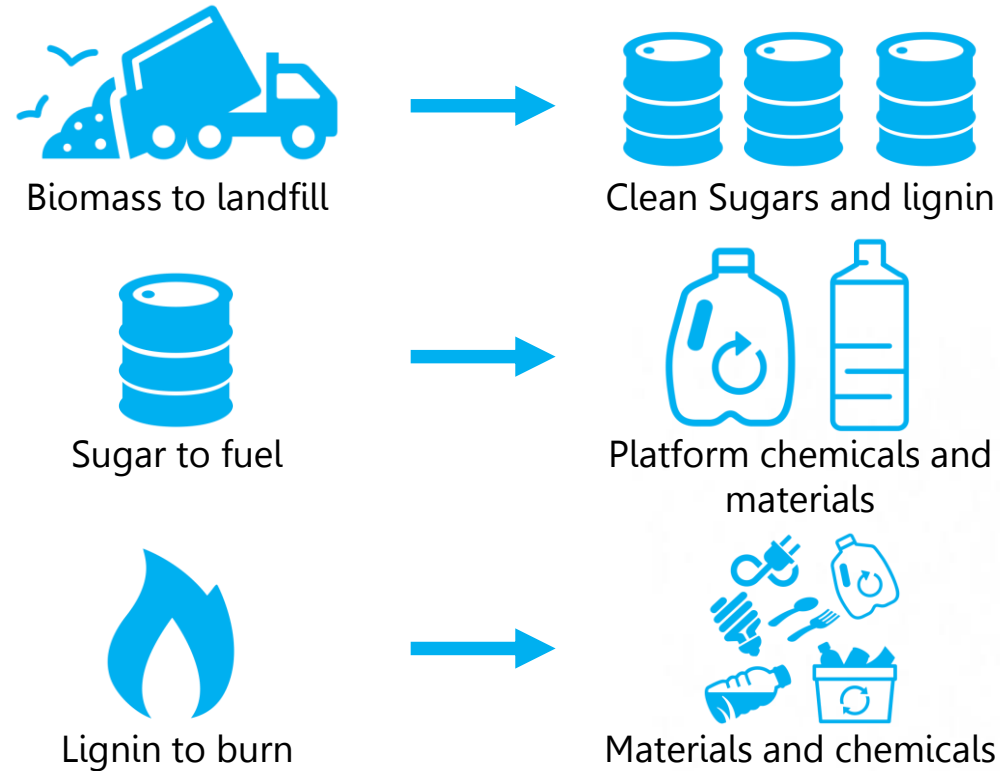
**We can extend this to 95 %**

**GOAL IS ZERO-WASTE**

**// These things are not complicated, they are very black and white."**

# 5

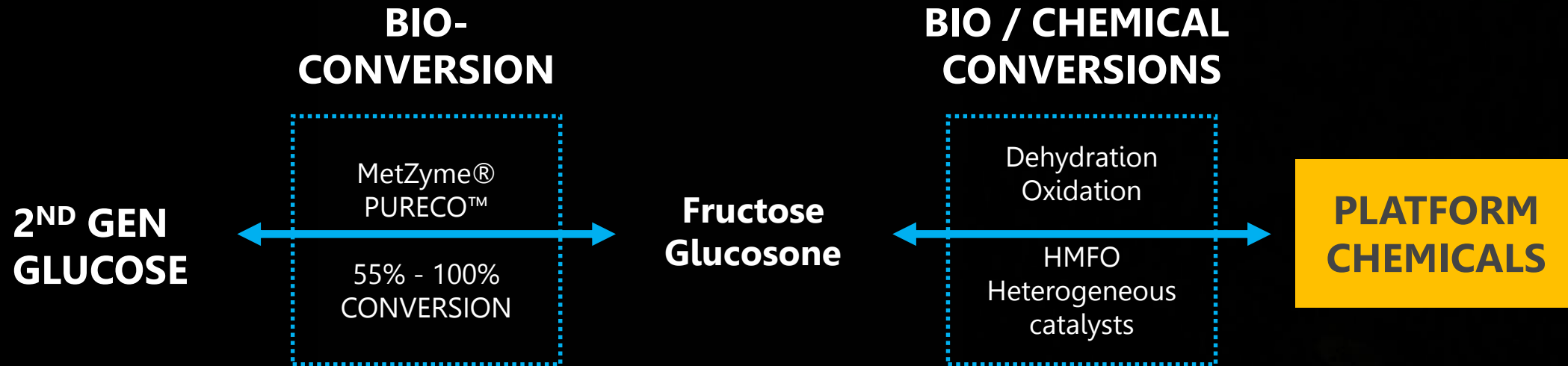
## TOO LOW VALORIZATION



**HOW TO DO THIS?**



# STREAMLINED CHEMO-ENZYMATIC ROUTE TO BIOPLASTICS AND PLATFORM CHEMICALS



## MetGen's patent-filed processes enable:

- Complete C6 conversion
- Use of 2nd Gen sugars
- Streamlined processes and higher yields
- New routes to platform chemicals

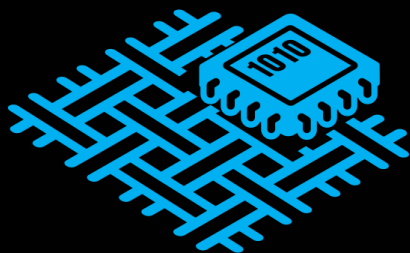
# ENZYMATIC SOLUTIONS FOR FIBRE MODIFICATION



Nanocellulose & MFC



Textiles



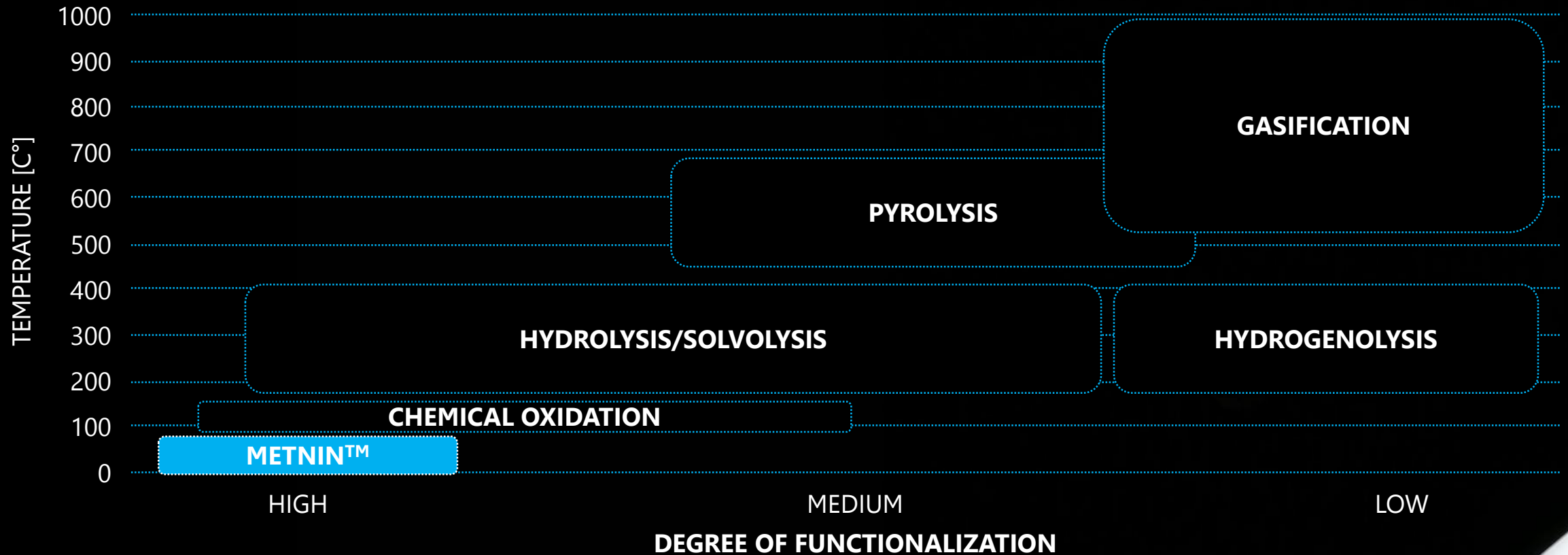
Grafting and surface charge



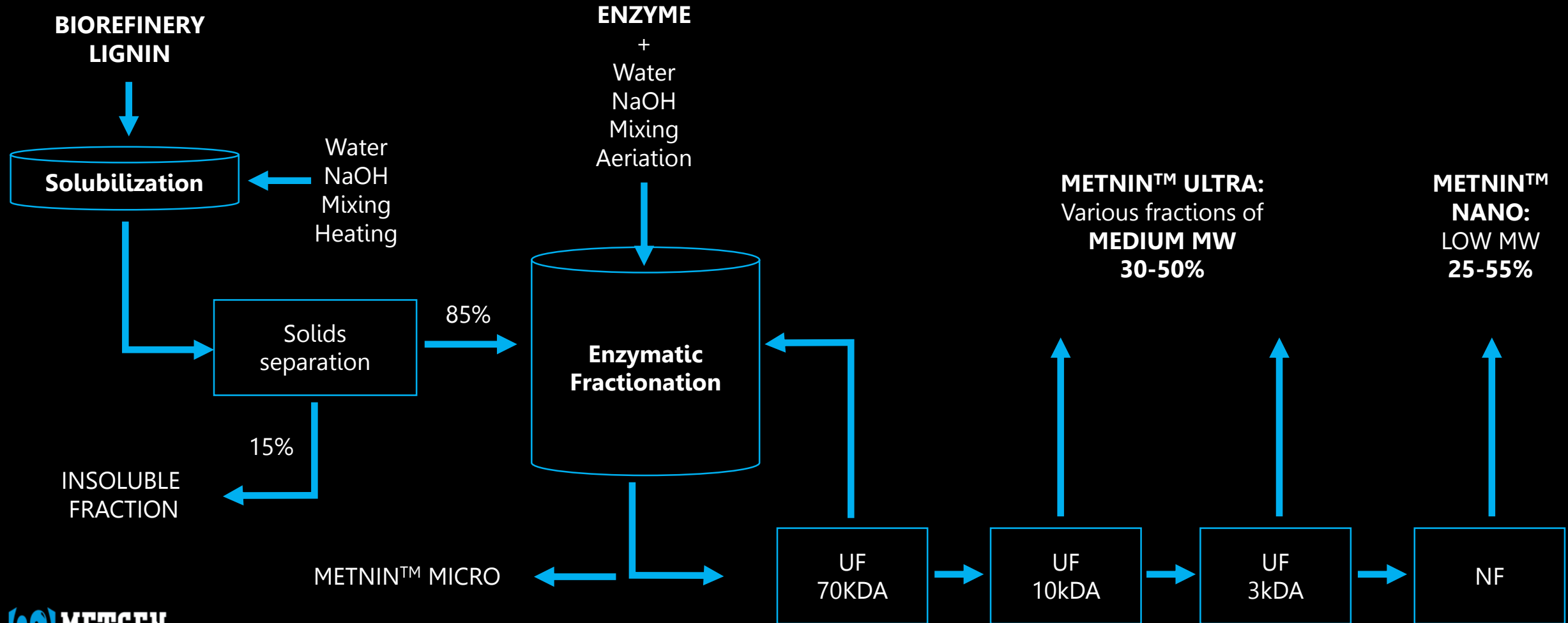
Recycling

**“You don’t make sneakers, loudspeakers or dashboards out of crude oil. You use refined fractions.”**

# ENZYMATIC LIGNIN VALORIZATION WITH **METNIN™** TECHNOLOGY

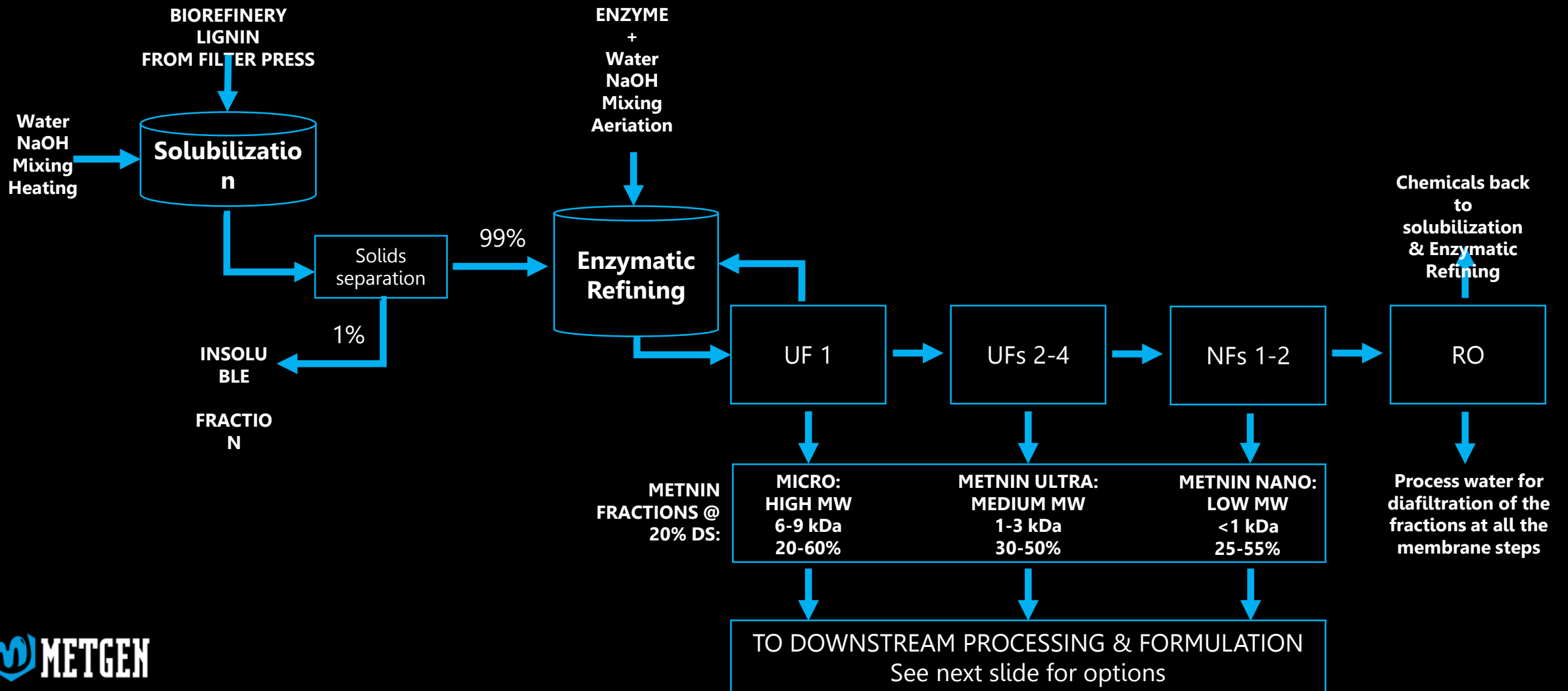


# ENZYMATIC LIGNIN FRACTIONING PROCESS





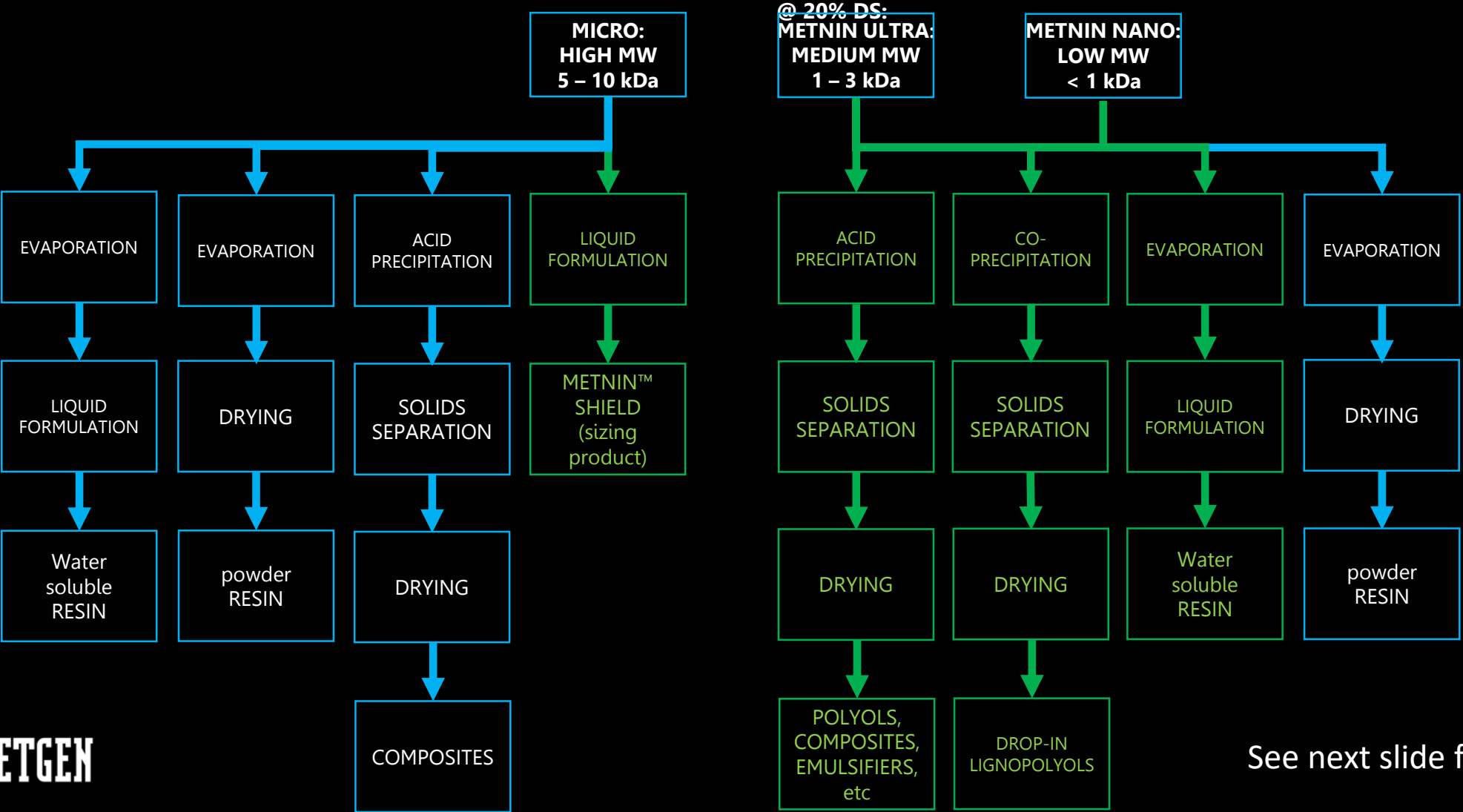
# ENZYMATIC LIGNIN FRACTIONING PROCESS



# POTENTIAL DOWNSTREAM PROCESSING ROUTES

THESE ARE  
CURRENT  
FOCUS  
AREAS

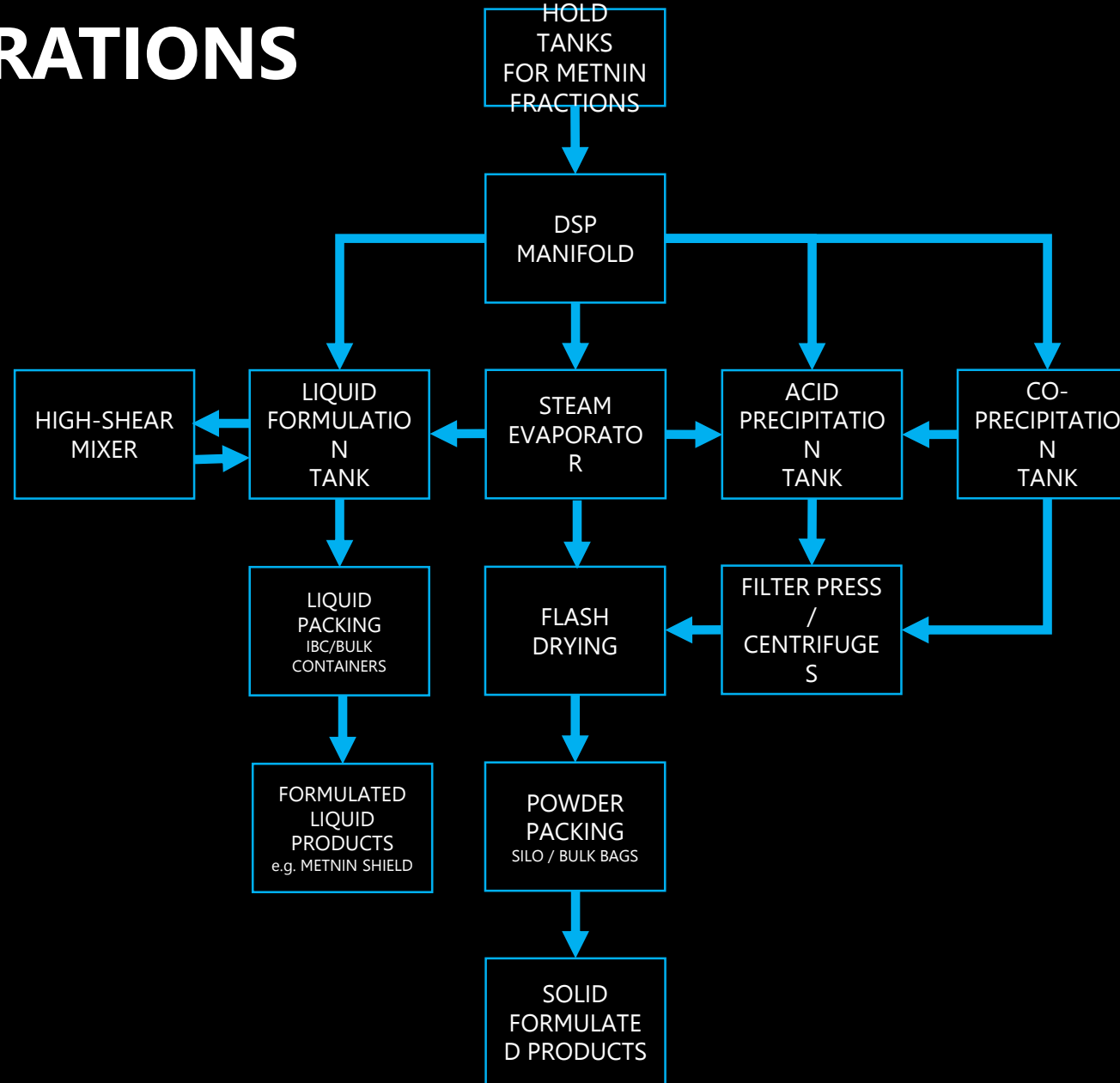
## METNIN FRACTIONS FROM MEMBRANE FRACTIONATION



See next slide for unit ops

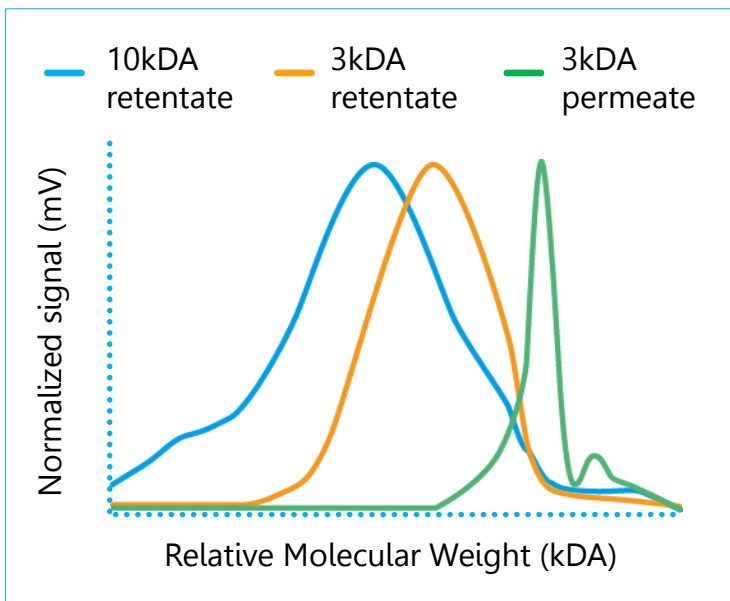


# UNIT OPERATIONS

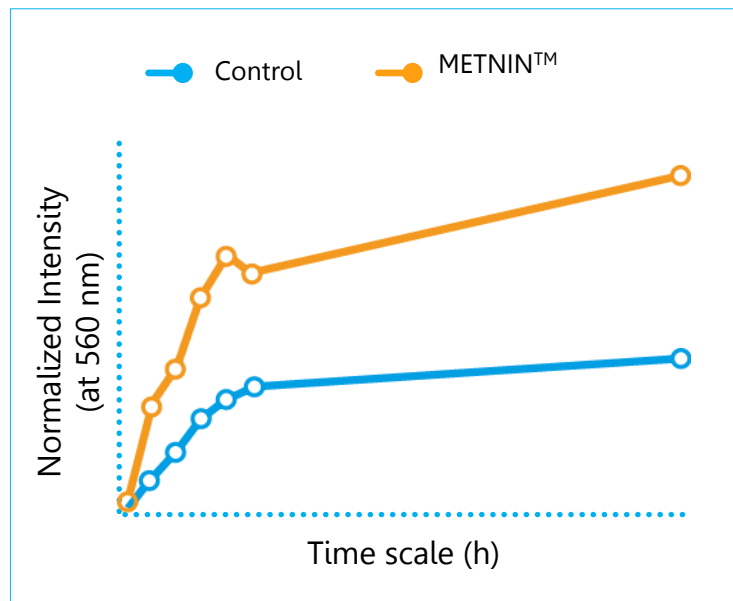


# METNIN™ IMPACT ON LIGNIN

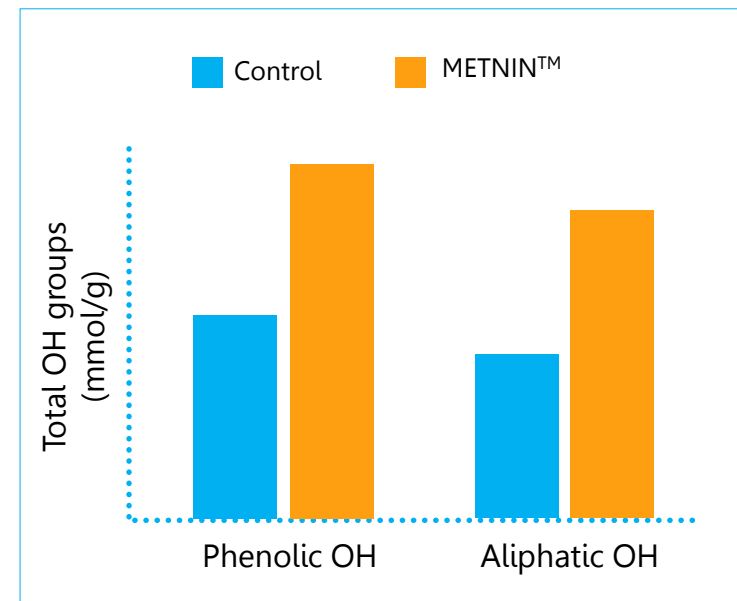
## FRACTIONATION



## DEMETHYLATION



## ACTIVATION

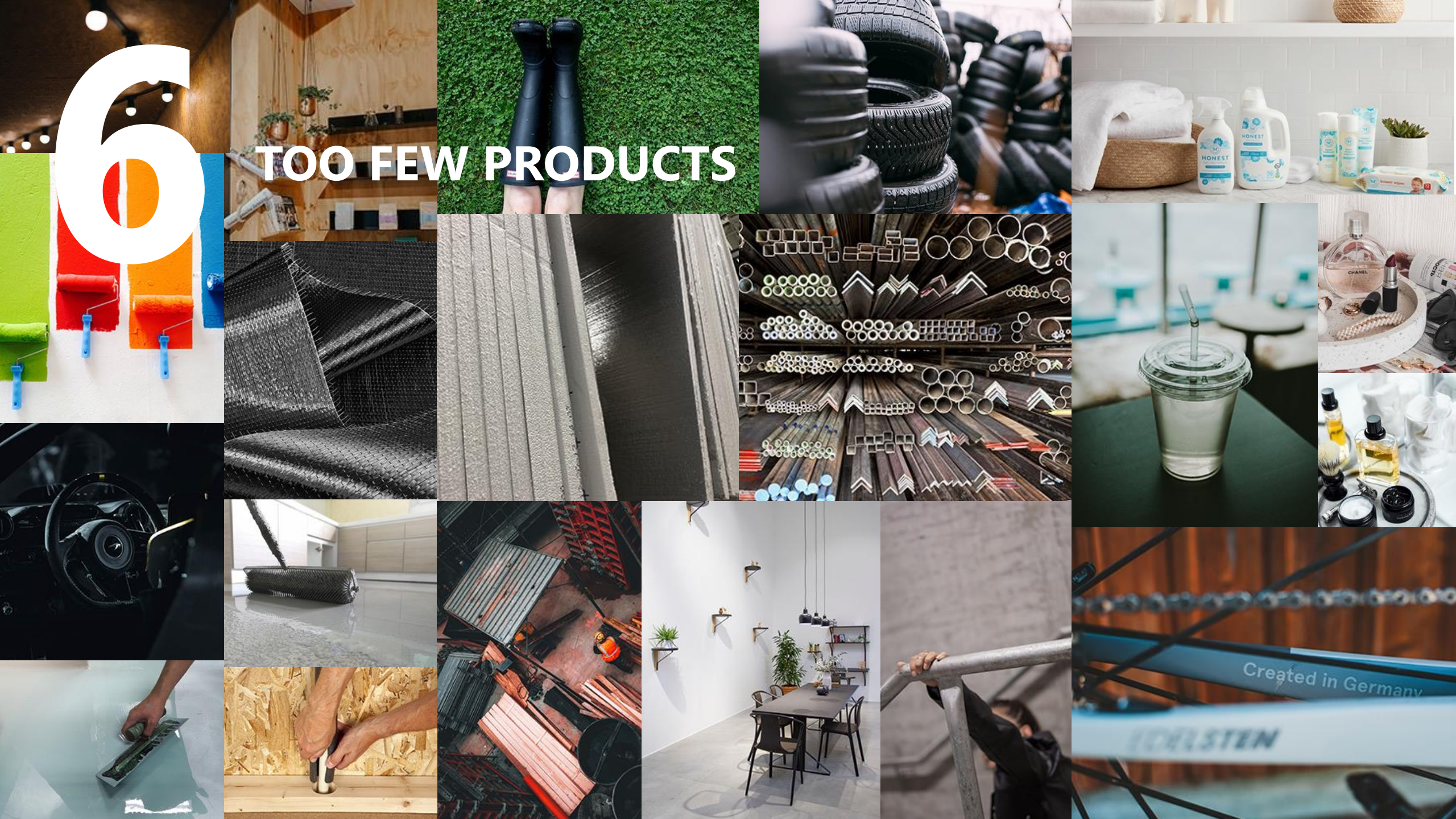


Analysis provided by Prof. N. Labbé et al.  
Department of Forestry, University of Tennessee, USA.



6

TOO FEW PRODUCTS





# 6

## TOO FEW PRODUCTS

**Resins**




**Polymers**

**Barriers and  
coatings**

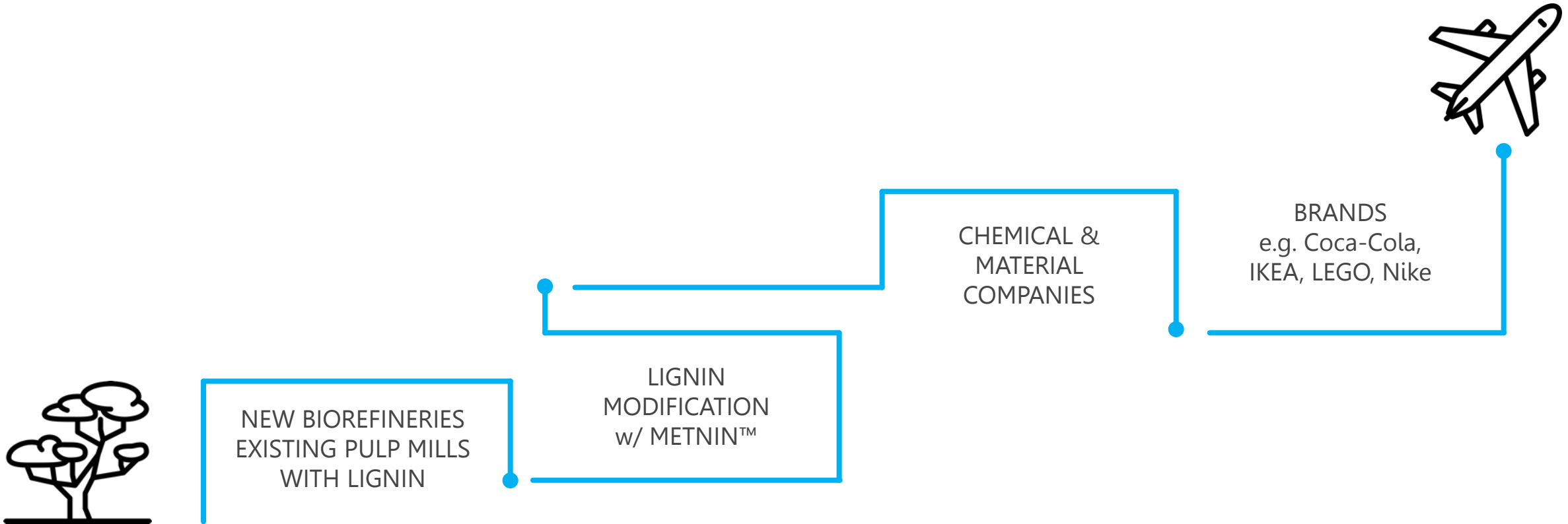


# ENZYMATIC LIGNIN REFINING ADDS VALUE

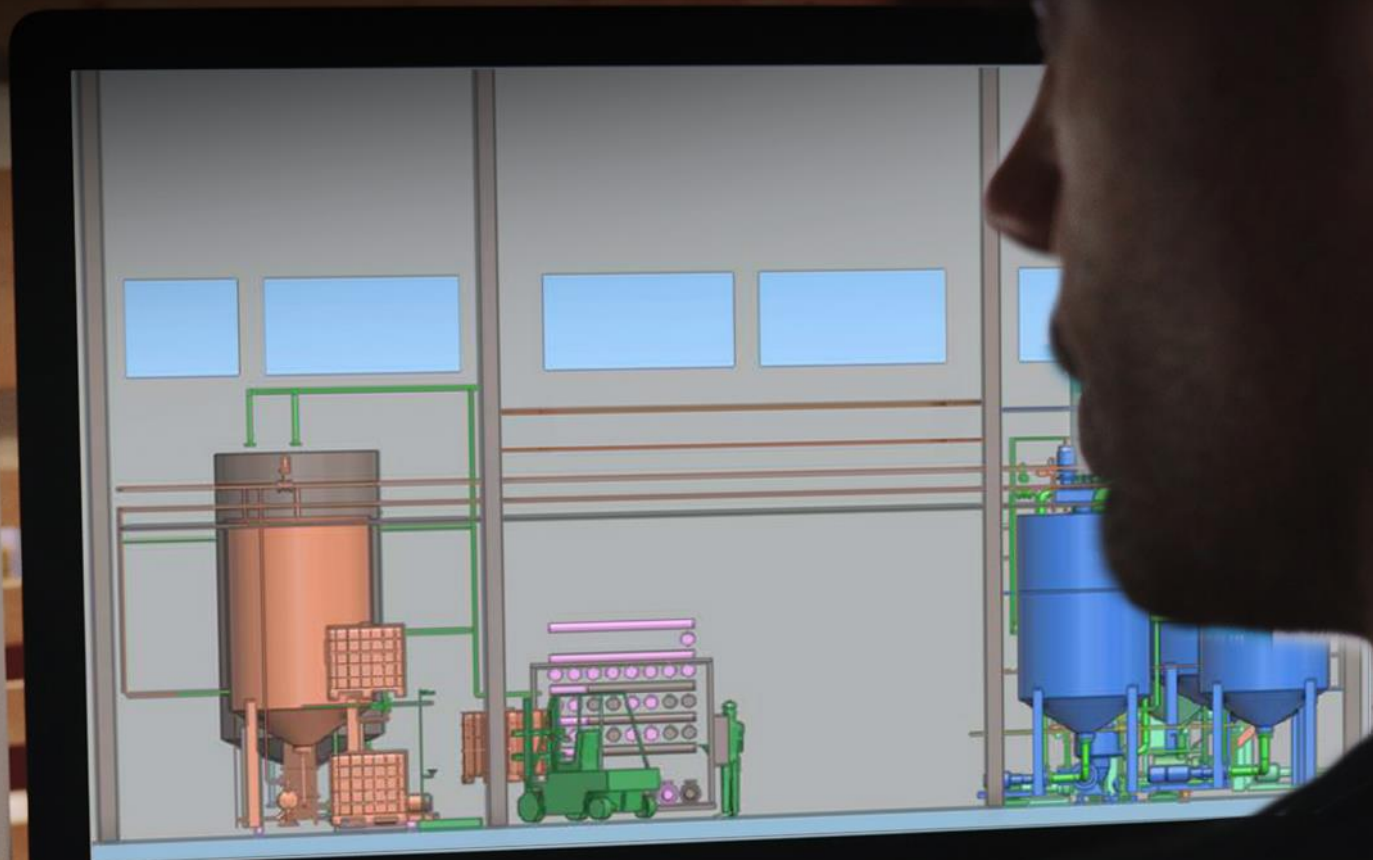
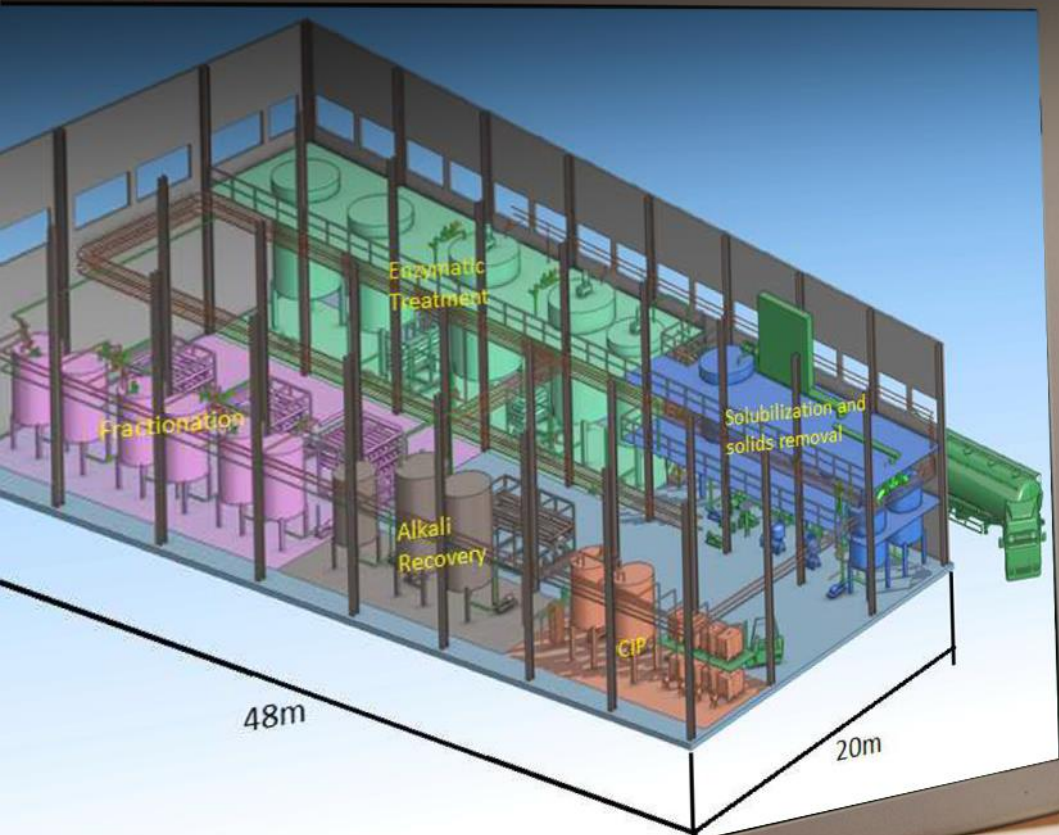
|  <b>METGEN</b> | <b>MOLECULAR WEIGHT</b>                      | <b>REACTIVITY &amp; SOLUBILITY</b> | <b>APPLICATION</b>    | <b>BIO-EQUIVALENT OF</b>              | <b>PRICE</b>               | <b>COLLABORATION PARTNER PRODUCTS</b>   |
|---|--|------------------------------------|-----------------------|---------------------------------------|----------------------------|---|
| <b>CURRENTLY AVAILABLE LIGNIN</b>   | 5–100 kDa                                    | Poor                               | Fuel                  | Oil/<br>Electricity                   | <b>50–100<br/>€/ton</b>    | Fuel,<br>thermoplastics,<br>fillers   |
| <b>ENZYME ACTIVATED LIGNIN</b>  | METNIN<br>MICRO<br>3–50 kDa                  | Medium                             | Resins &<br>Adhesives | Phenol<br>Form-<br>aldehyde           | <b>400–500<br/>€/ton</b>   | MDF, plywood,<br>epoxy, and paint<br>resins, carbon black   |
| <b>ENZYME DEPOLYMERIZED LIGNIN</b>  | METNIN<br>ULTRA<br>0,3–2 kDa                 | Good                               | Foams &<br>Composites | Polyols                               | <b>1000–2000<br/>€/ton</b> | Insulation panels, flexible<br>foams, furniture,<br>construction material, car<br>tires, barrier coatings |
| <b>ENZYME DEPOLYMERIZED FRACTIONS</b>   | METNIN NANO<br>0,3 kDa<br>0,5 kDa<br>0,7 kDa | Excellent                          | New materials         | Speciality<br>Chemicals &<br>Polymers | <b>&gt; 2000<br/>€/ton</b> | Coatings, Plasticizers,<br>Cosmetics, carbon<br>nanofibers, flavors,<br>fragrances, detergents            |



# FROM FOREST TO BRANDS – WHERE METNIN™ FITS?



# BASIC ENGINEERING PACKAGE



# INVESTMENT COST

PLANT CAPACITY (feed)

**7 kt**  
**DS/year**

BUILDINGS  
**1120 k€**

TOTAL  
INVESTMENT  
COST  
**5850 k€**

EQUIPMENT  
**2780 k€**

OTHERS  
**1950 k€**

Precision of cost  
**+/- 20 %**

# CASH FLOW

OPERATING DAYS  
**350 days/year**

TOTAL INVESTMENT COST  
**5850 k€**

PLANT CAPACITY (feed)  
**7 kt DS/year**

RAW MATERIAL UTILIZATION  
**70%**

RAW MATERIAL COST  
**300 €/t DS**

OPERATING COST  
**150 €/t DS**

PRODUCT PRICE  
**1100 €/t DS**

OPERATING  
COST  
**-735 k€**

INCOME  
**5390 k€**

CASH FLOW  
**2555 k€  
/year**

RAW  
MATERIAL  
COST  
**-2000 k€**

# INVESTMENT COST

PLANT CAPACITY

**7 kt**  
**DS/year**

CASH FLOW  
+2,55 M€  
/year

TOTAL  
INVESTMENT  
COST

**5,85 M€**

PLANT CAPACITY

**50 kt**  
**DS/year**

CASH FLOW  
+18,25 M€  
/year

TOTAL  
INVESTMENT  
COST

**28 M€**

**/// Valorization of lignin has  
a hell of an impact."**

# 7

## CONNECTION TO MARKET

“ Future of leadership is like  
conducting an orchestra where  
everyone plays their own instrument  
– with passion.”



# 7

**CONNECTION  
TO MARKET**

**There is no reason to build  
a bridge unless you have  
a vision of the other side.**

**WE BUILD BRIDGES.**

Open innovations

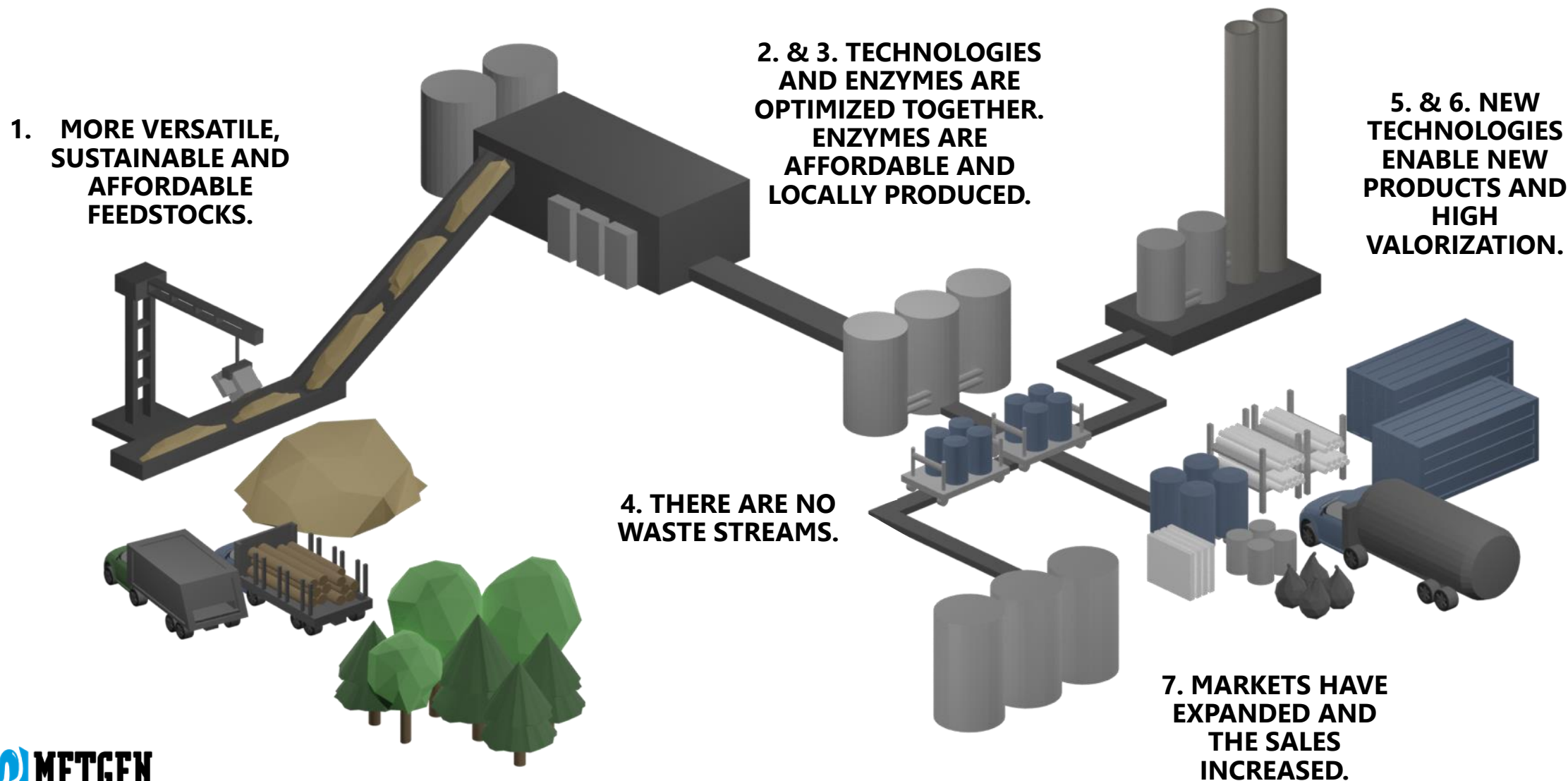




**We know**

**HOW to do this.**

# THE BIG PICTURE: HAVE A BIOREFINERY AND MAKE IT WORK



**“This is a true refinery,  
not a waste generator.”**

# ACKNOWLEDGEMENT OF PUBLIC EU H2020 FUNDING



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**MetGen** – the friendly enzyme  
company invites you to join in  
the bio-based industry  
revolution.



