



# Lignin-based thermoplastics

A non-compromising solution for an industry in transition

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# Lignin Industries

Building the most cost efficient and easily scalable CO2 reduction for a plastics industry in urgent need of transition

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## Vision

**A world where sustainable plastics are the norm, not the exception**

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## Mission

**Re-shaping the future of plastics through the power of lignin**

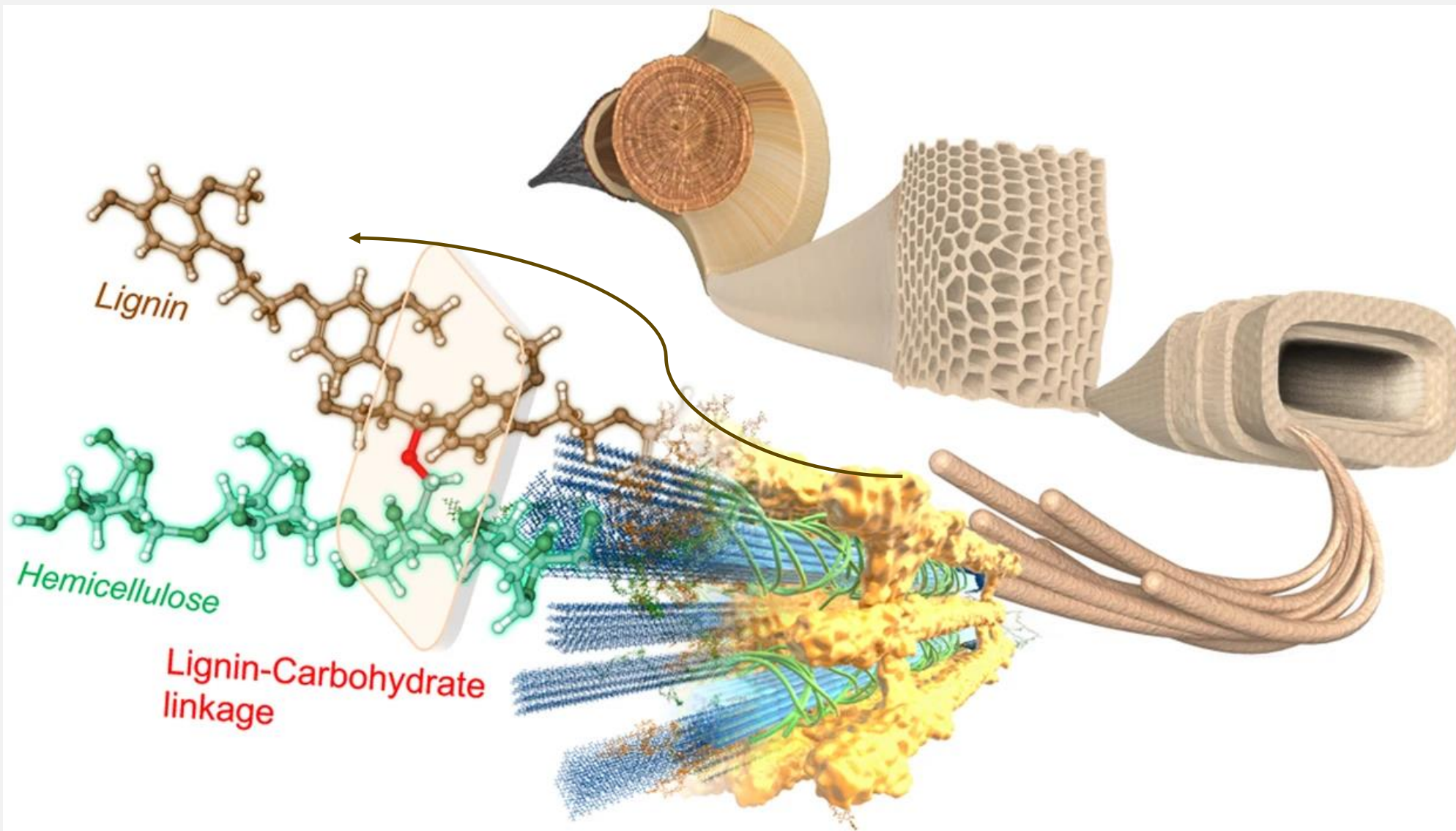


# Re-shaping the future of plastics through the power of lignin

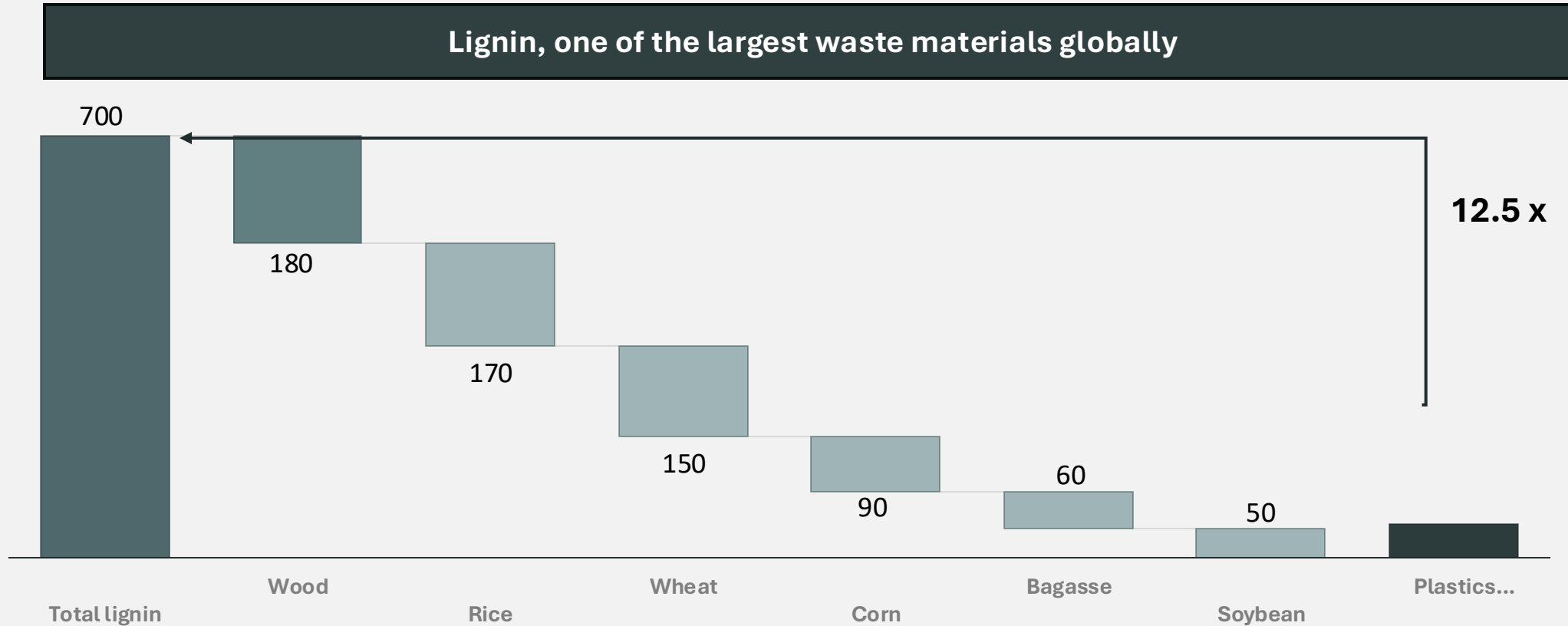
- » Founded in Sweden 2018 by Christopher Carrick
- » 20 FTEs
- » First production plant in Knivsta north of Stockholm with 2000 tons p.a. capacity
- » Patented technology to transform lignin into a renewable bio-based thermoplastic, Renol®
- » Building the most cost efficient and easily scalable CO2 reduction
- » Applications within LDPE films, PP and ABS moulds among others
- » 160 MSEK raised so far



# This is lignin

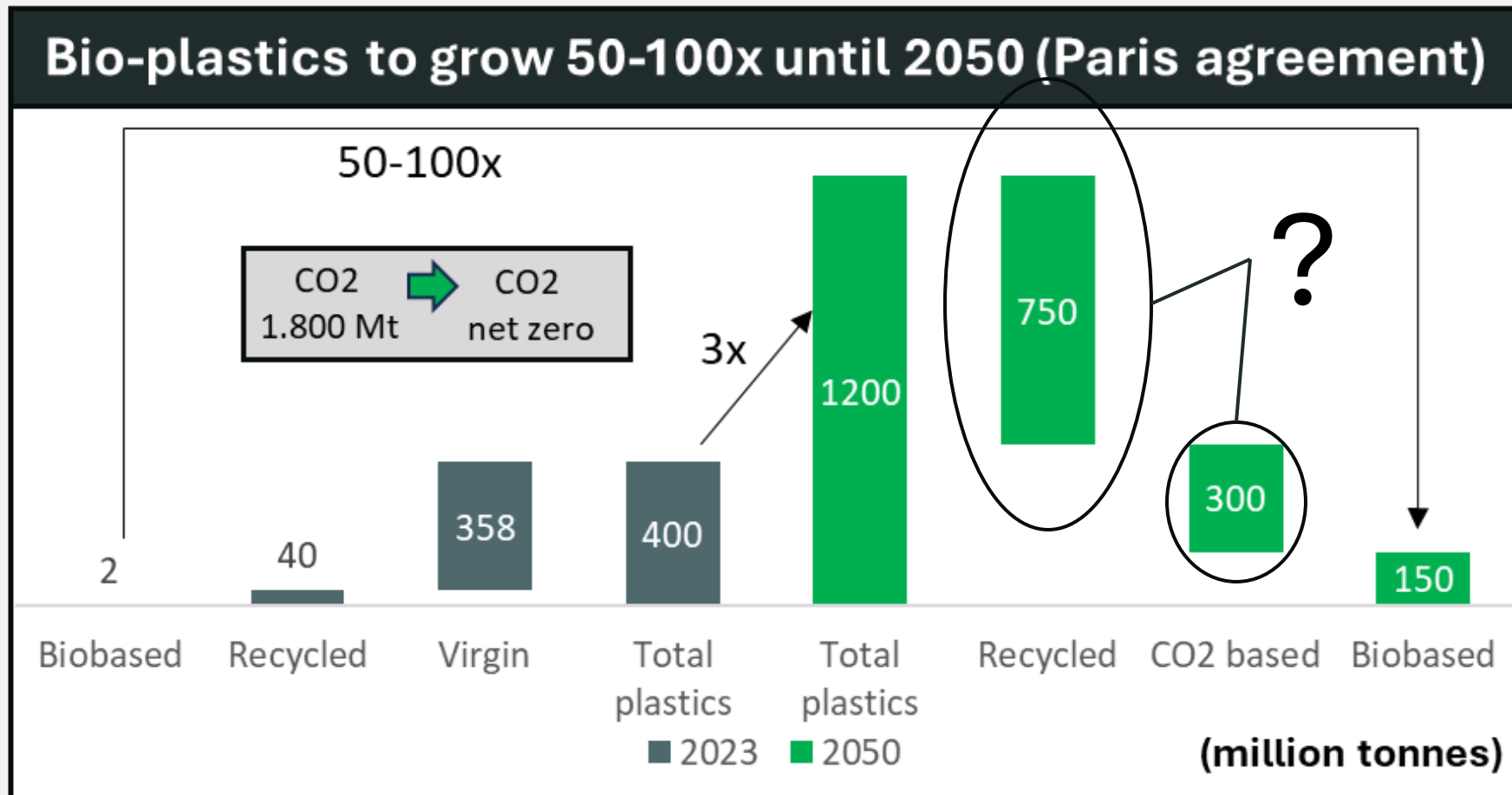


# Our solution uses Lignin - the untapped natural resource



- » Lignin is a large part of anything that grows in nature – 30% of a tree is lignin!
- » Annual volumes of Lignin is over 700 million tonnes
- » Lignin is treated as waste, it is typically burnt or just left to degrade in nature

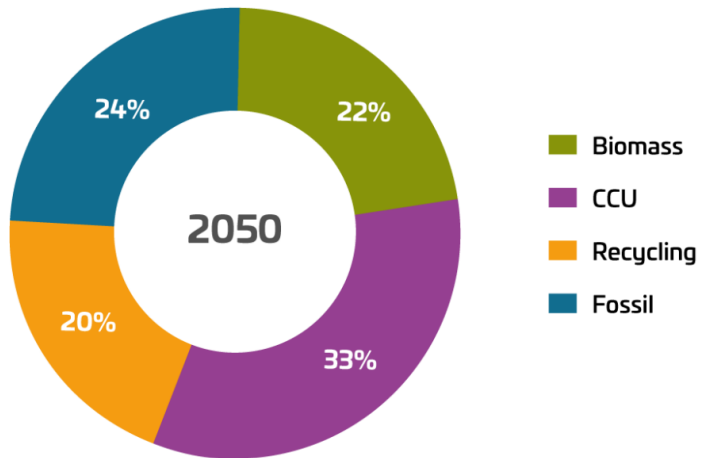
No matter how you look at it – there are some big gaps to fill until 2050



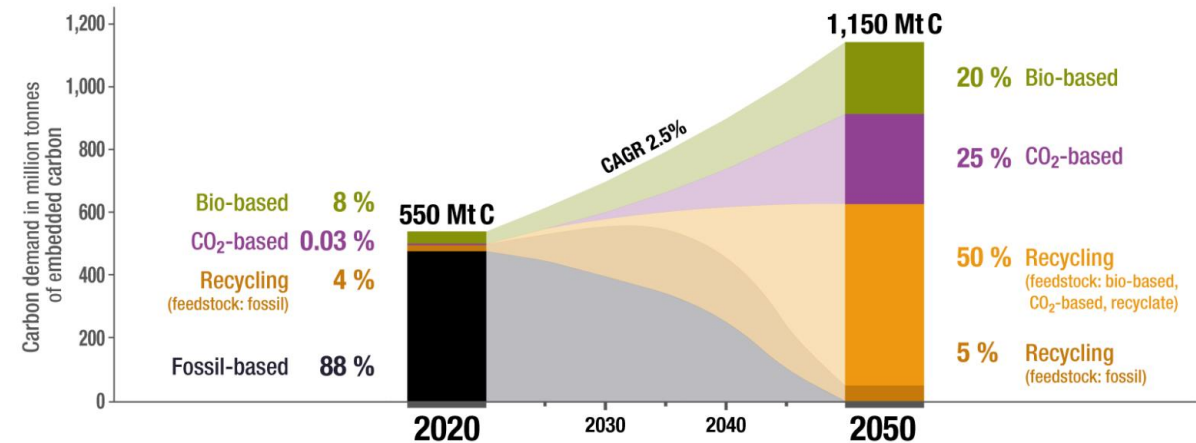


# All reports have been increasing the forecasted numbers for biomass usage by 2050

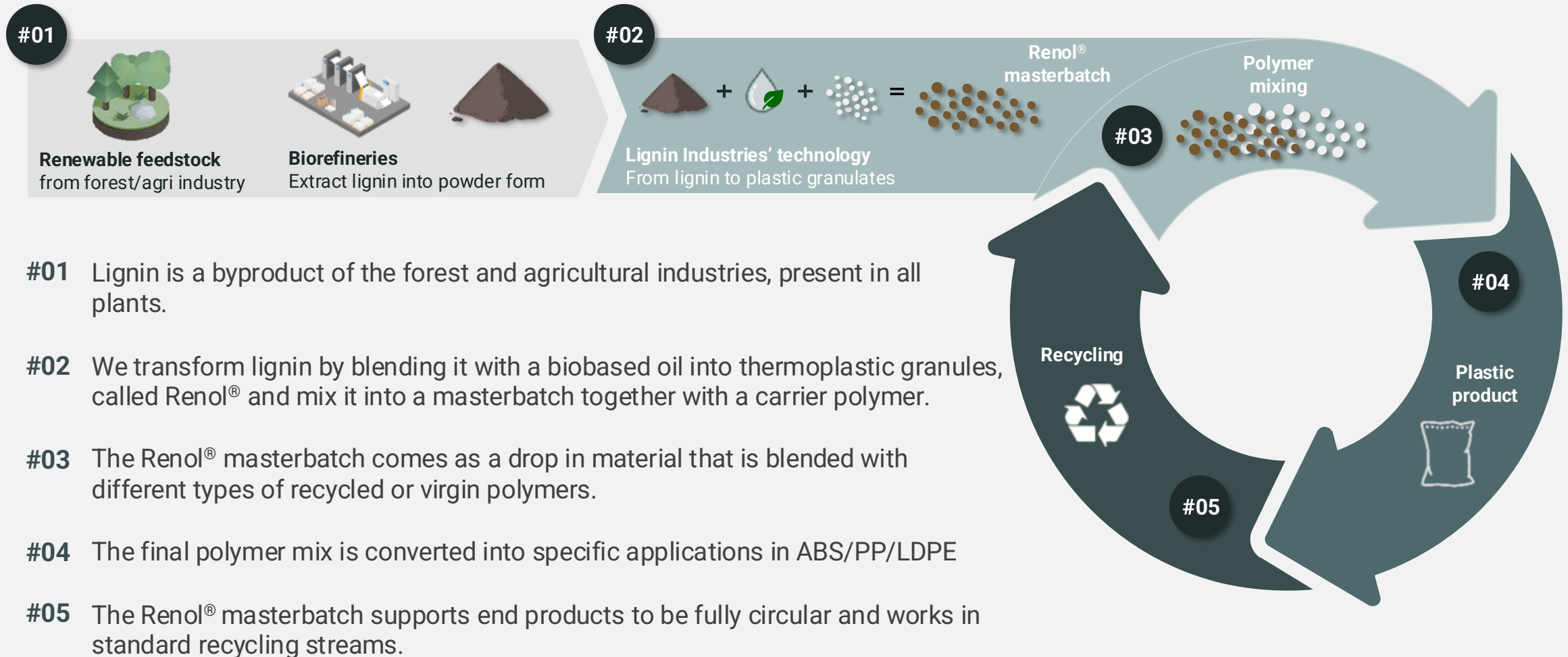
## Net-Zero Chemical Industry – Mean Feedstock Shares (%) Across 16 Scenarios From 9 Reports



## Carbon Embedded in Chemicals and Derived Materials updated nova scenario for a global net-zero chemical industry in 2050



# Using lignin-based thermoplastics can replace up to 40% of the fossil raw materials





# Renol® is *actually working* and meets all important requirements



## Truly sustainable

Renol® is biobased and enables final products to meet Paris targets already today



## Truly circular

Renol® is based on a biobased secondary (waste) material recyclable in standard recycling infrastructure



## High-performing (process and product)

Processed in existing process and tooling with same or improved capacity



## Easily scalable

Large availability of raw material and no/very low CAPEX needed to increase production



## Cost competitive

The most cost-efficient bio-plastic on the market when we scale(?)









# Renol<sup>®</sup> does not hinder recyclability of end applications

Renol<sup>®</sup> is recyclable both in standard open- and closed-loop recycling streams

	Sortability	Processability	Mechanical properties
<b>Renol<sup>®</sup> in ABS</b>	<ul style="list-style-type: none"><li>✓ Closed loop</li><li>✓ Open loop N/A</li></ul>	<ul style="list-style-type: none"><li>✓ Processable at temperatures up to at least 230°C</li></ul>	<ul style="list-style-type: none"><li>✓ Maintains properties better than virgin ABS when recycled</li></ul>
<b>Renol<sup>®</sup> in LDPE</b>	<ul style="list-style-type: none"><li>✓ Closed loop</li><li>✓ Open loop below 30% Renol<sup>®</sup></li><li>✓ Two InterZero certifications received (more in process)</li></ul>	<ul style="list-style-type: none"><li>✓ Processable at temperatures up to at least 230°C</li></ul>	<ul style="list-style-type: none"><li>✓ Maintains properties better than virgin LDPE when recycled</li></ul>
<b>Renol<sup>®</sup> in PP</b>	<ul style="list-style-type: none"><li>✓ Closed loop</li><li>✓ Open loop below 35% Renol<sup>®</sup></li></ul>	<ul style="list-style-type: none"><li>✓ Processable at temperatures up to at least 230°C</li></ul>	<ul style="list-style-type: none"><li>✓ Maintains properties better than virgin PP when recycled</li></ul>

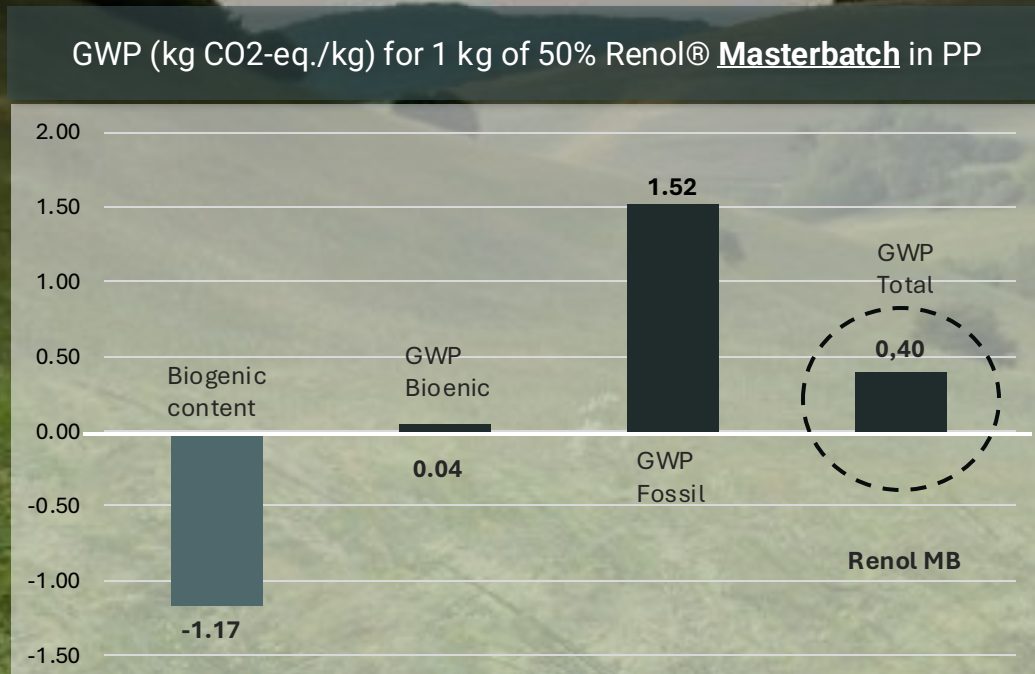


# We offer a different - and complementing - solution to existing materials in the market

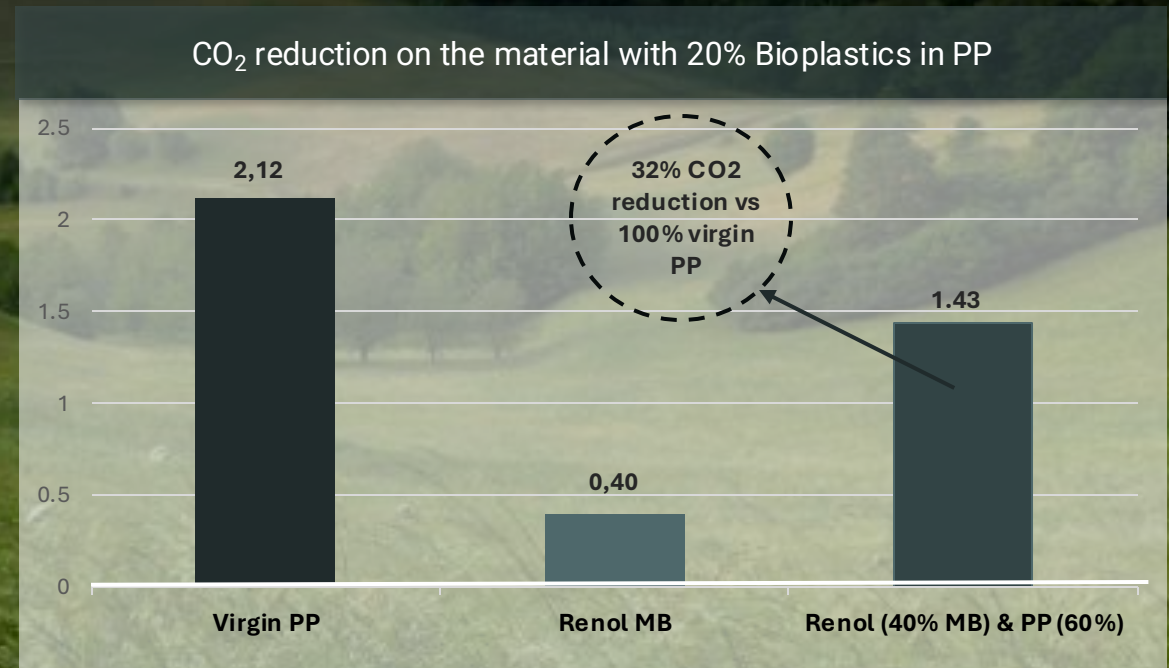
	RENOL®	PLA	Biobased PE	TPS (Starch)
				
<b>Feedstock</b>	Lignin – Forest/Agri by-product	Sugarcane - Cultivated	Sugarcane - Cultivated	Starch - Cultivated
<b>Main Geography</b>	Europe, North America	North & South America, Asia	South America	Europe, North America
<b>Competition to food production</b>	No	Yes	Yes	Yes
<b>Resource use – Raw material = End Material</b>	0.94 ton lignin + 0.06 ton bio-oil =1 ton RENOL® = no waste	11 ton sugarcane =1 ton PLA =10 ton waste	33 ton sugarcane =1 ton Bio-PE =32 ton waste	4.2 ton potato =1 ton TPS =3.2 ton waste
<b>OPEX (costs per kg produced)</b>	Low	High	High	Low
<b>CAPEX (est. CAPEX per ton annual prod.)</b>	1000 EUR	8000 EUR	4000 EUR	3000 EUR
<b>Versatility – potential to use in different plastic applications</b>	High	Low	Medium	Low
<b>Mechanical Prop.</b>	Similar to virgin	Low	Similar to virgin	Low
<b>Processability</b>	High	Low	High	Low
<b>Carbon footprint</b>	-1.9 kg CO2/kg	2,4 kg CO2/kg	~-2 CO2/kg	~2 kg CO2/kg
<b>Recyclability</b>	High	Low	High	Low



# Using lignin-based thermoplastics opens a path to decarbonize the plastics industry



According to ISO 14040, ISO 14044 and ISO 14067.  
Cradle-to-gate data.



Indicative kg CO<sub>2</sub>-eq./kg product emissions, IPCC method.  
Ecoinvent v3.8-3.10 database. Cradle-to-gate data.  
\*Example compound, calculated as produced at Lignin Industries .

# Example research project – BioForm

Compounding



Over 500 kg  
**LIGNIN**  
INDUSTRIES AB "

Sheet Extrusion



5 mm thick sheet  
**Röchling**



Evaluation

Vacuum Forming



**autoform**





# Main challenges

- Lead times
- Make the recycling industry understand that biomaterials NEED TO BE part of the future
- Get the European plastics industry to DRIVE instead of pushing back



# Pls remember - we are different....

## **We are *NOT***

a stand-alone material

bio-degradable

bio-compostable

driving high CAPEX

## **WE ARE**

Easy to use in existing equipment

Using secondary biomass as raw material

Highly scalable

Recyclable in open loop

Brown☺







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THANK YOU

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