



Bio-based chemicals

From development to commercialization

Key success factors

PA. Bouillon – June 2024

Axens in brief

Company Profile

- Technology and catalyst provider for biofuel, biochemical, oil & gas, and petrochemical industries
- 40+ yrs. experience in biofuel & biotech
- Ownership structure: 100% IFPEN

Business areas



ALTERNATIVES &
RENEWABLES



PETROCHEMICALS



GASES



OIL
REFINING



WATER



Offices in **15** countries



3,000+
industrial units
under license



3,500+
furnaces sold



500+
modular units
references



70,000+ tons
catalysts &
adsorbents sold
each year

Axens Offer

- Integrated solutions
- Covers the entire value chain

Axens
HORIZON

Axens
SOLUTIONS

Heurtey
Petrochem
SOLUTIONS



Transition to a Lower Carbon Economy: a Large Range of Solutions

ENERGY TRANSITION/CLIMATE CHANGE



Energy Efficiency

- Energy Efficiency & Low-Carbon Site Audit
- Consulting Offer for Decarbonization
- High Efficiency Equipment
- Electrical Heaters
- Optimized Heater Efficiency
- Digitalization
- CEED, Custom & Efficiency Early Design



Renewable, Low Carbon Fuels & Bio-Based Chemicals

Low Carbon Fuels

- Co-Processing
- Vegan® (HEFA)
- BioTfuel® (gasification & FT)
- Jetanol™ (ATJ)

Petrochemicals Intermediates

- Futurol® (Advanced Ethanol)
- Atol® (bio-ethylene)
- BioButterfly™ (bio-butadiene)
- Bio-TCat™ (bio-aromatics)
- 2G Sugars



Low Carbon Hydrogen

- Blue Hydrogen: Grey Hydrogen & CO2 Capture
- Hydrogen Purification
- Hydrogen Transportation (LOHC)



Carbon Capture Utilization & Storage

- Pre-Combustion: Advamine™
- Post-Combustion: DMX™
- e-Fuels



Joining Forces to Develop Innovative Solutions & Together Contribute to a Lower Carbon Economy

DURABILITY OF RESOURCES



Circular Resources

- Plastic Recycling
Rewind MIX **Rewind** PET
- TAC  **PLASTIC ENERGY**
- Tire Recycling
- Metal Recycling
- Battery Recycling
- Catalyst Pool Management
 **ORCHESTRA™**
- Spent lube-oil reprocessing
Revivoil™

POLLUTION



Air Treatment

- Air Pollution Control



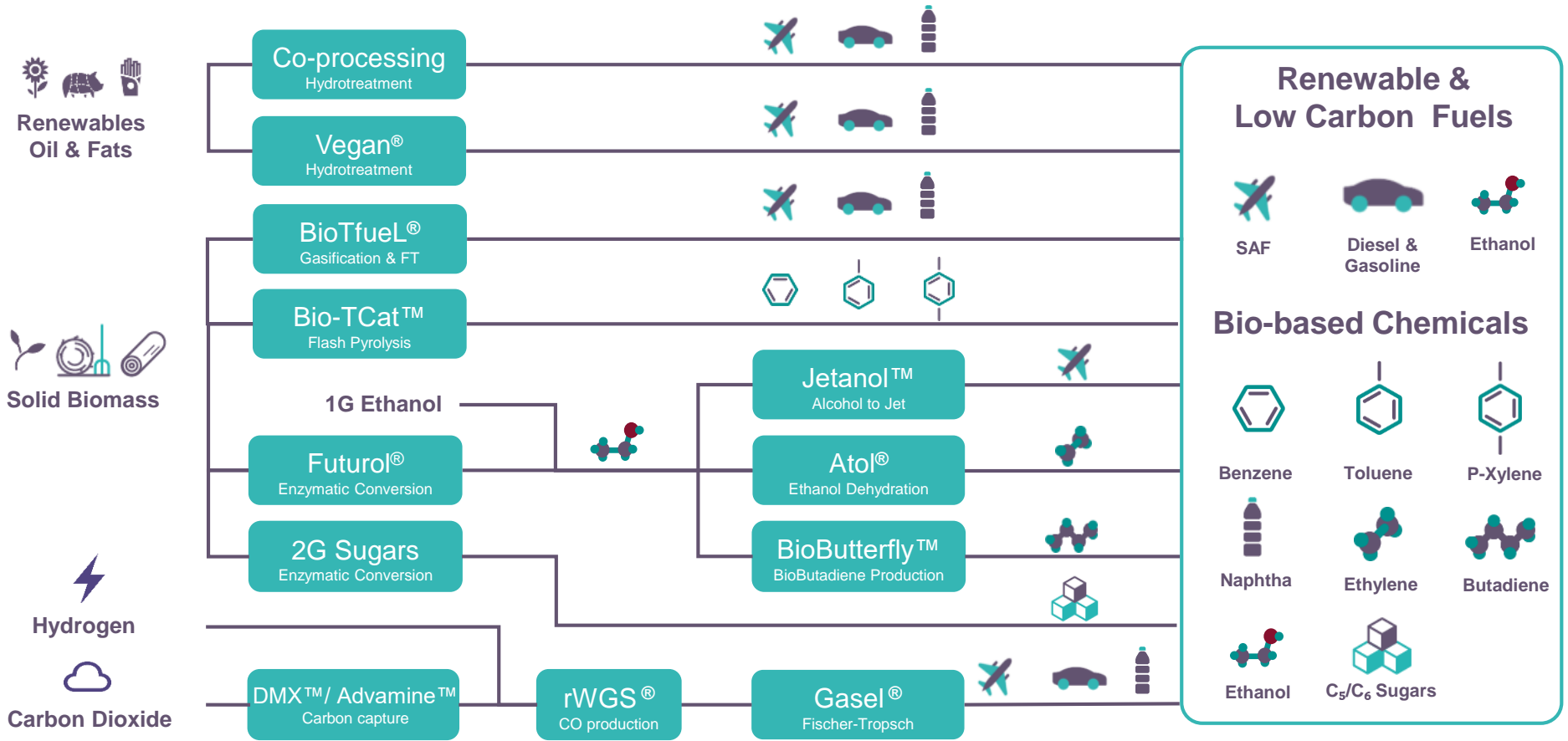
- Water Purification with a Large Portfolio of Adsorbents
- Industrial Waste Water Treatment



- Sulfur recovery
SulShine

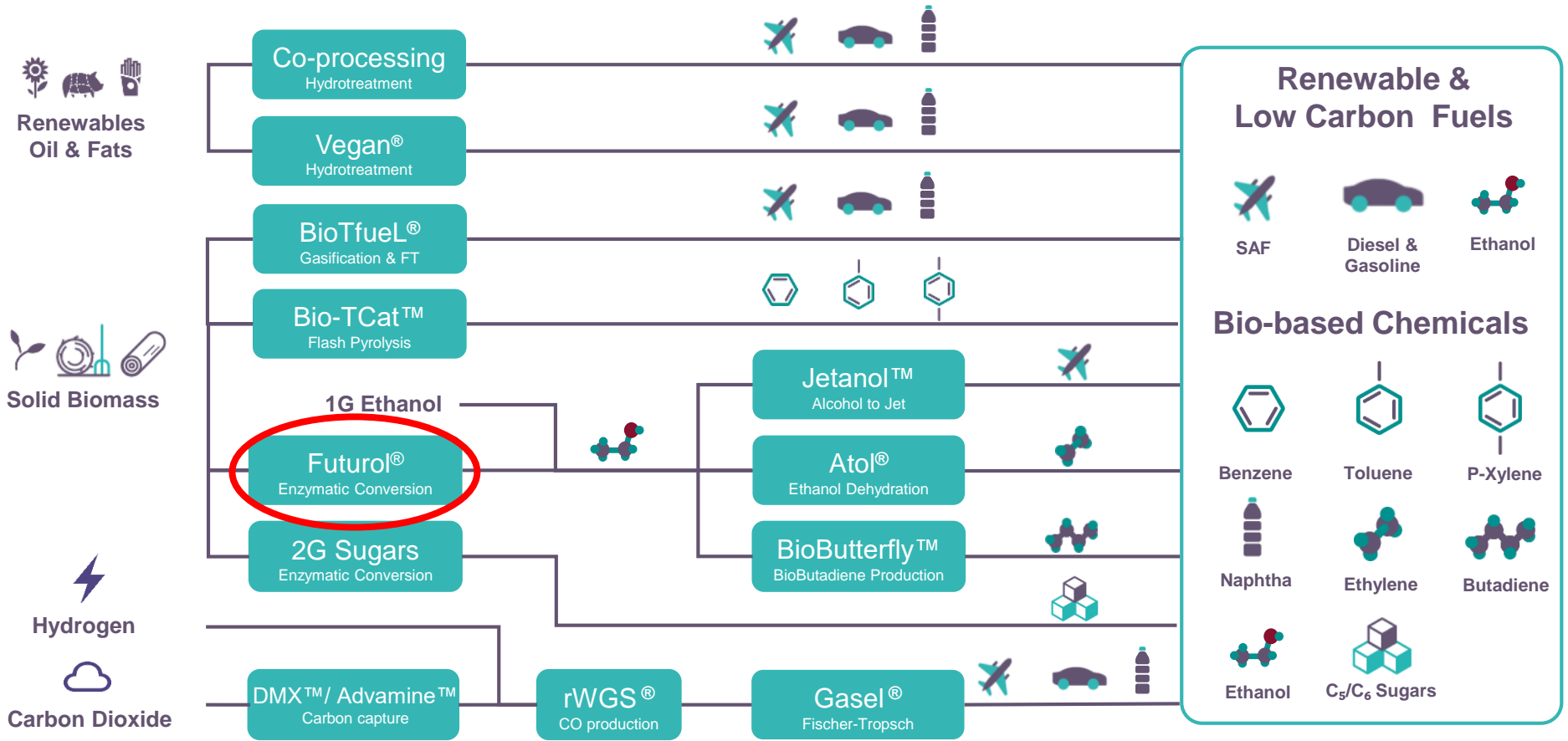


Axens Renewable / Low Carbon Fuels & Bio-based Chemical Solutions



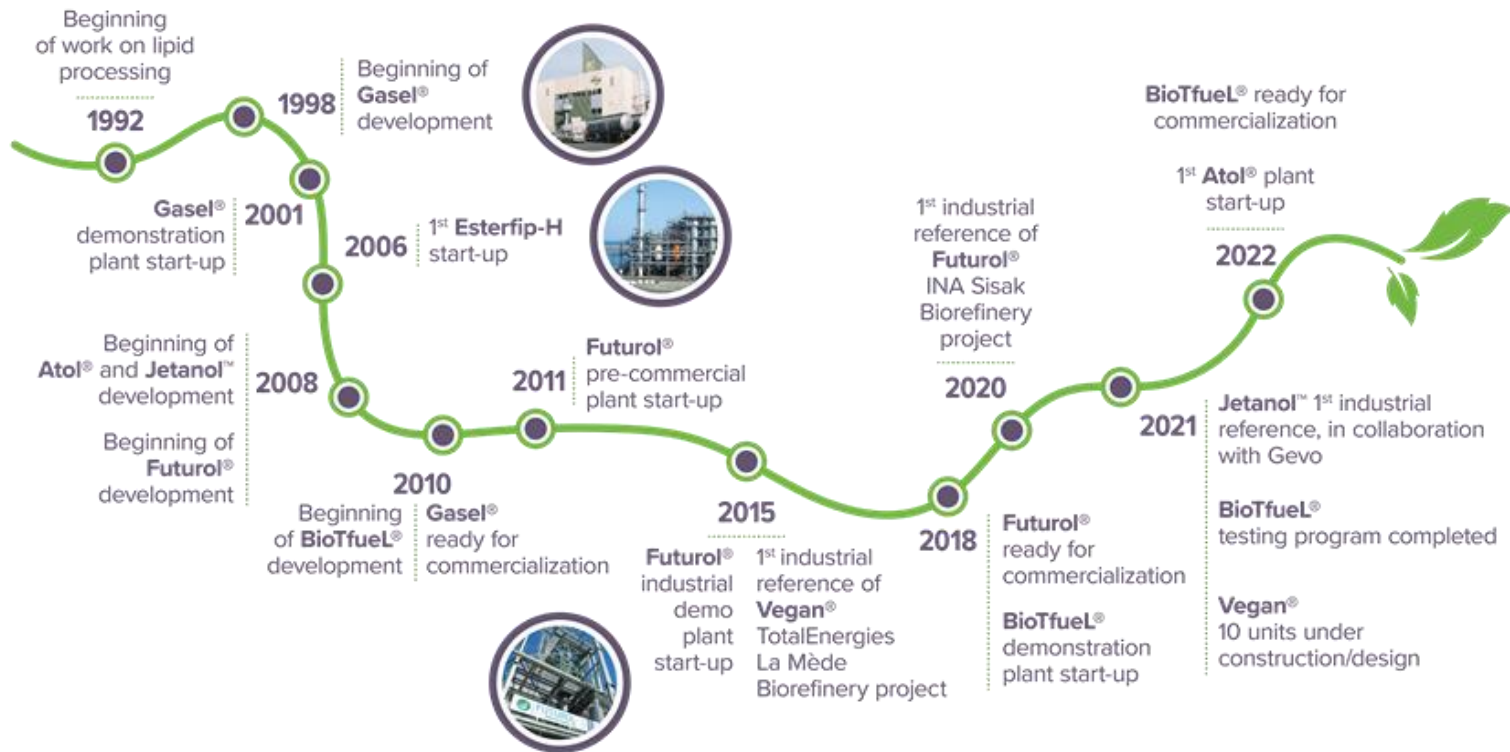


Axens Renewable / Low Carbon Fuels & Bio-based Chemical Solutions

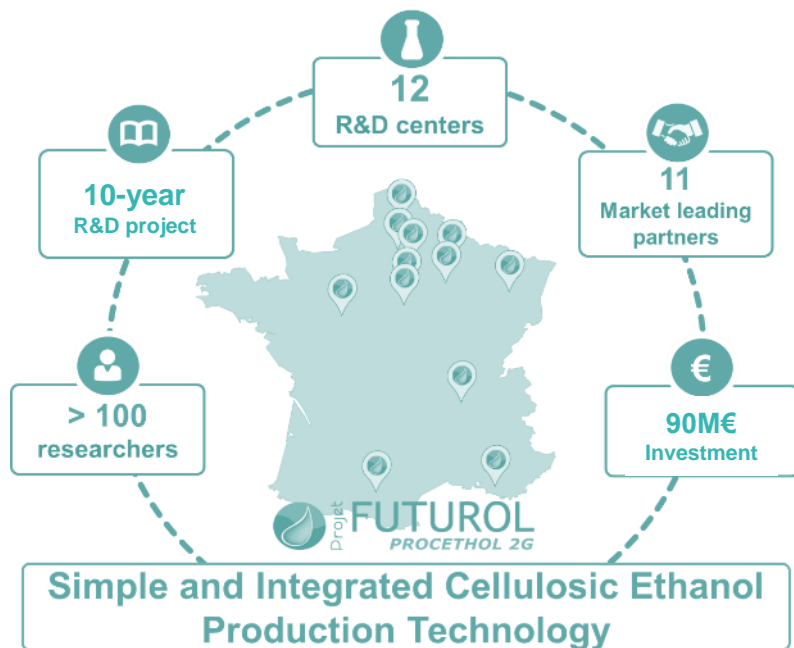


1 Introduction to Futurol® Technology

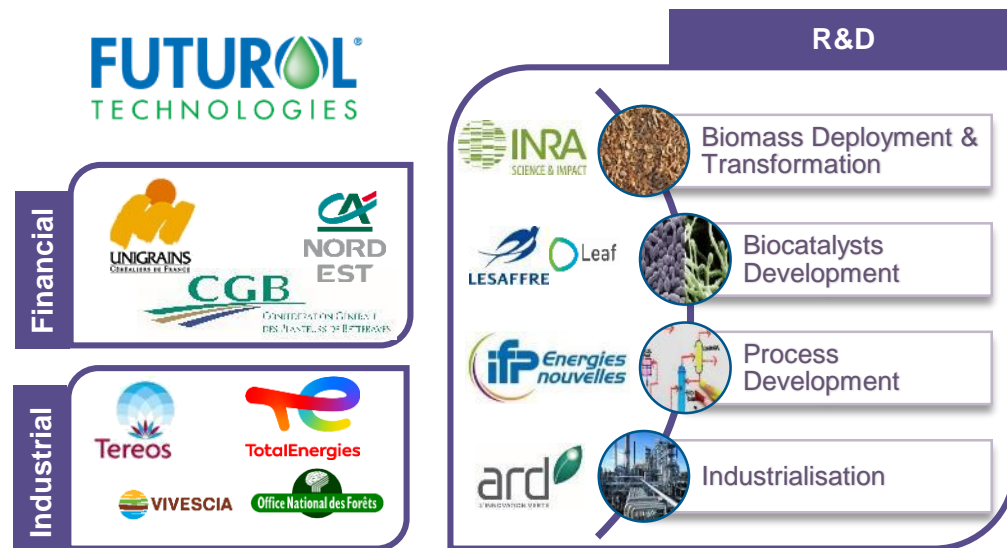
Axens Group: A Long History with Bio processes



Futurol® : Building upon Strong Know-How



› Bringing the Best Experts from Each Key Area



Futurol®: Pre-Commercial & Industrial Demo Plants




 5000m² Full Chain

 80 tons EtOH/year

 Mutifeed 1tpd (dry)



 Pilot

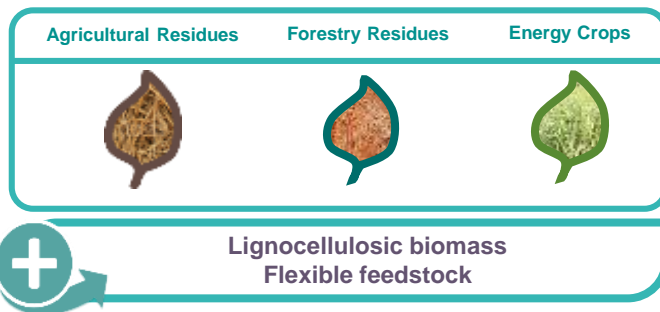
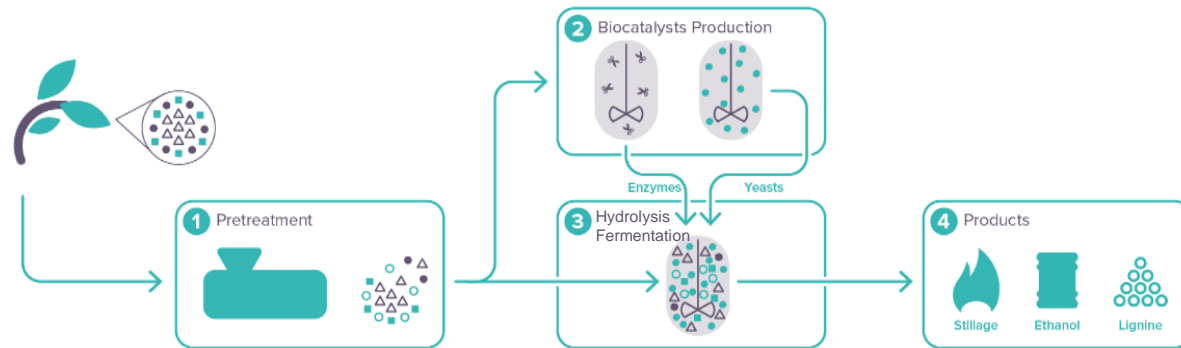
 Pretreatment & Enzyme production

 ~10 KTA EtOH

 100 tpd (dry)



Futurol® from Biomass to Advanced Ethanol



Technology key features

- ▶ Robust biomass pretreatment technology
- ▶ Fully integrated technology (energy)
- ▶ On-site production of tailor-made biocatalysts
→ Full control of operating cost
→ Less logistic, not relying on external supplier
- ▶ One-pot enzymatic hydrolysis & fermentation
→ Minimize CAPEX & OPEX, high ethanol yield

Products quality

- ▶ Advanced / Drop-in 2G biofuel
- ▶ First gate to bio-molecules platform
→ Ethylene, SAF, 2G Sugars

Commercial technology

- ▶ 1 reference (50 KTA of 2G ethanol – INA Croatia)
- ▶ 9+ years of operation of pre-commercial plant
- ▶ 2 years of industrial pretreatment plant operation

Commercial experience: INA



Customer INA

Location Croatia (Sisak)

Feedstock Wheat straw

Capacity 55 KTA of advanced bioethanol

Timeline Basic engineering & Pre-FEED
done
Pending FID

Scheme FuturoI®

Futurol® : Projects Under Development

India
Intense
commercialization efforts
(agri residues)

Far South East Asia
Close following
initiatives
(agri residues)

United States
Developing several
projects (wood
residues)

EU
Developing several
projects
(agri residues, wood)

First projects on track

Egypte

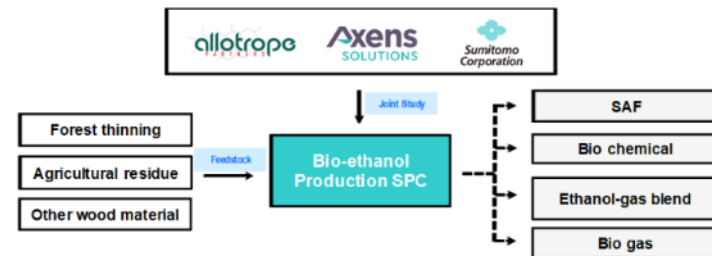
ECARU, Qalaa Holdings and Axens to Carry Out Technical and Economic studies for a Project of Second-Generation Biofuel (Advanced Bioethanol) and Sustainable Aviation Fuel (SAF) Production



USA

Allotrope Partners LLC, Axens North America and Sumitomo Corp. of Americas have reached an agreement to develop a joint study for a commercial plant producing cellulosic bioethanol, utilising the Axens Futurol® process, produced from woody biomass through Allotrope Cellulosic Development Co LLC (ACDC), a project development company based in California, US.

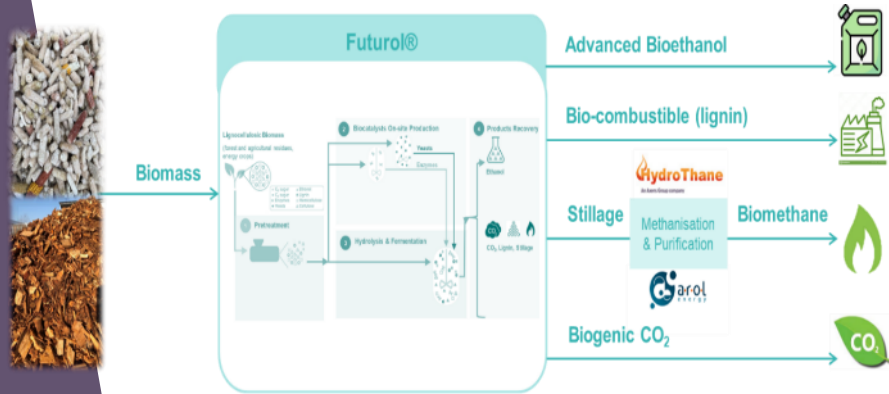
Overview of the project



First projects on track

France

NACRE project, 1st advanced ethanol bio-hub in France using Futurol® technology



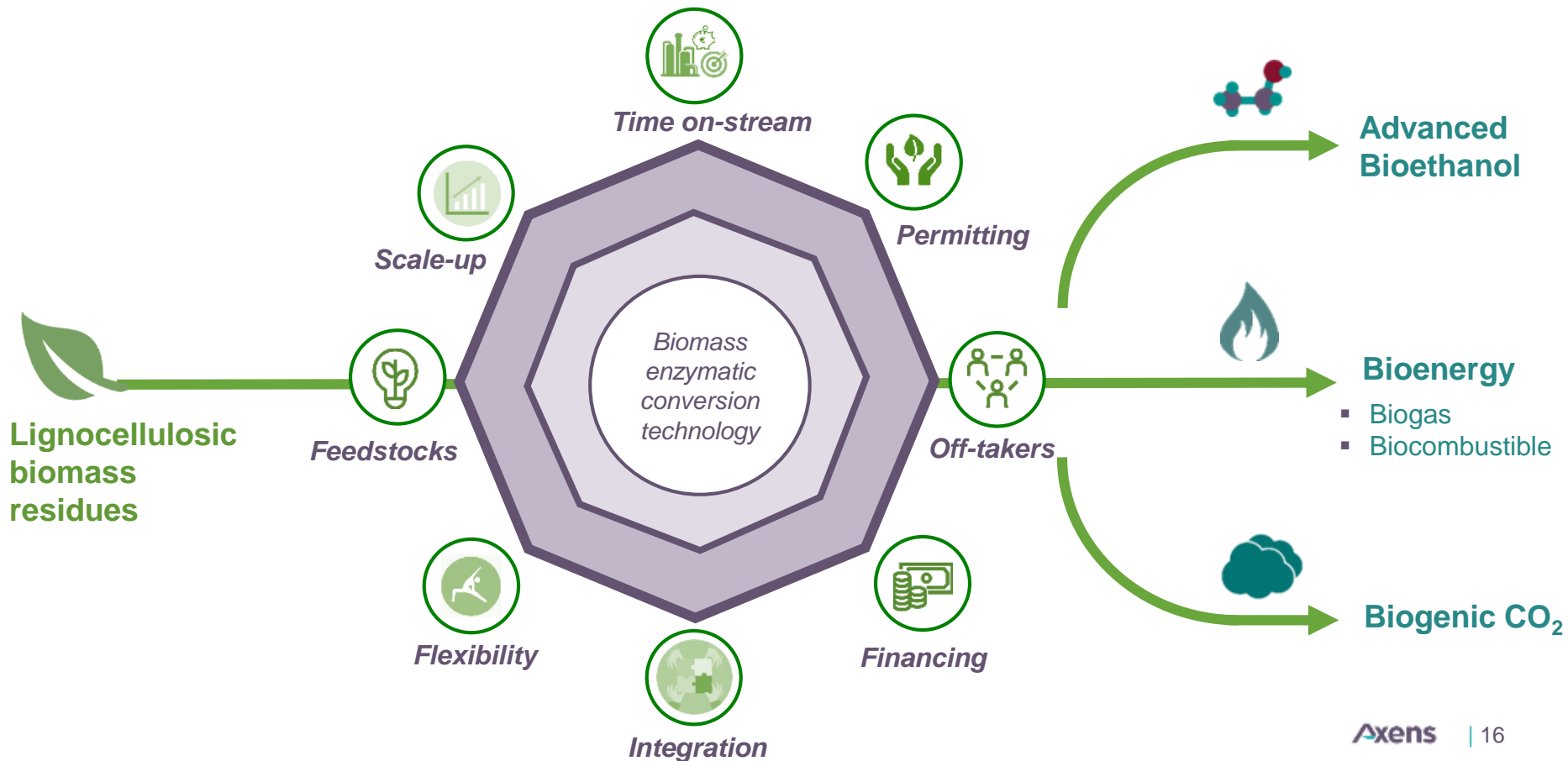
Spain

Axens supports Técnicas Reunidas to develop advanced bioethanol project in Spain



2 From R&D to industrial project

How to Deal with a Biomass to Ethanol Project?



Key learnings from the market since end of R&D phase



Feedstock

- ▶ Many different biomasses depending on the region of the projects
- ▶ Few projects on studied feedstock during R&D phase



Flexibility

- ▶ Majority of projects rely on a minimum of 2 biomasses
- ▶ Flexible technology mandatory



Technology maturity

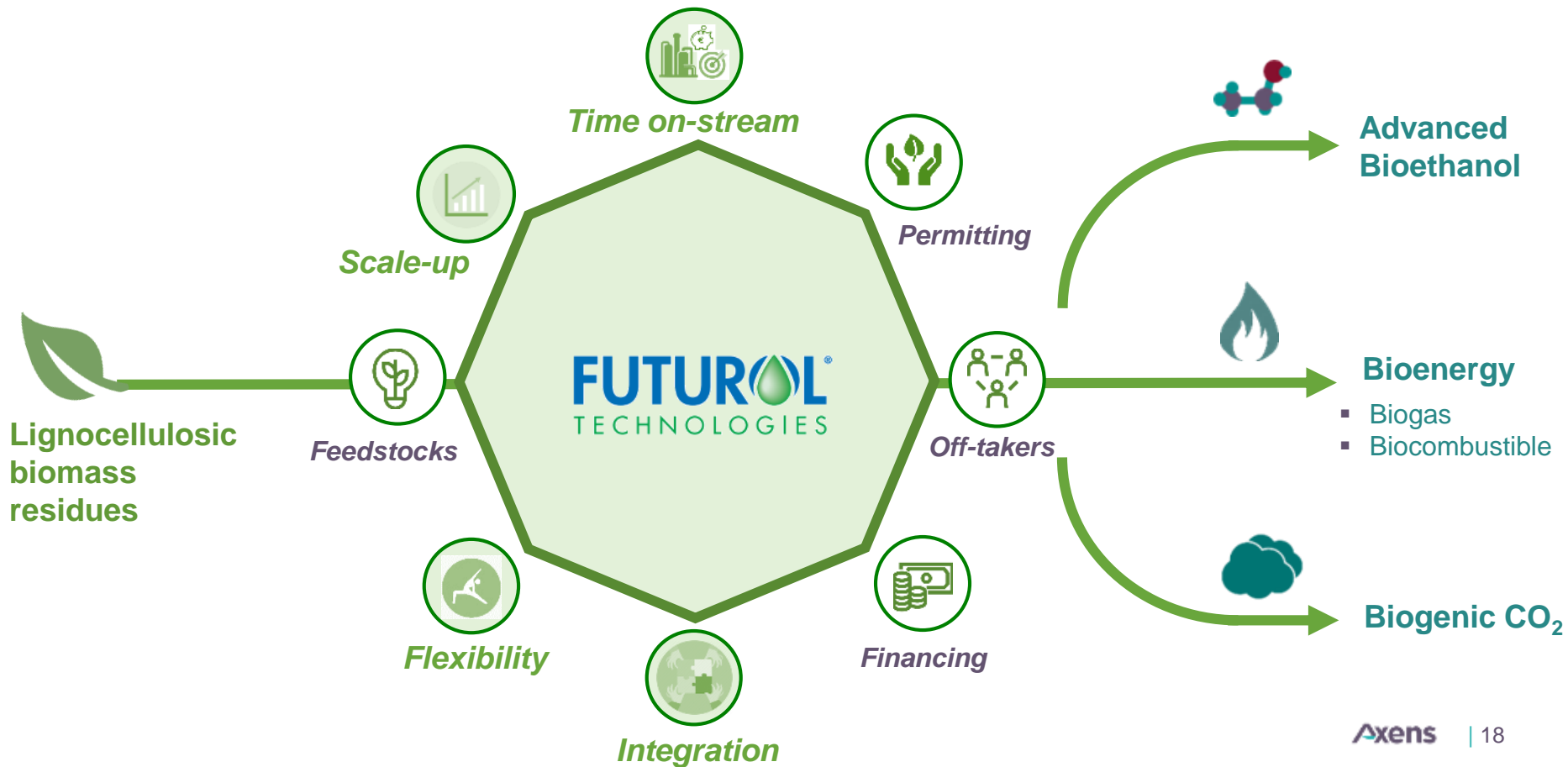
- ▶ New technologies are difficult to finance
- ▶ Scale-up and technology derisking critical for discussions with investors



Build solid business cases

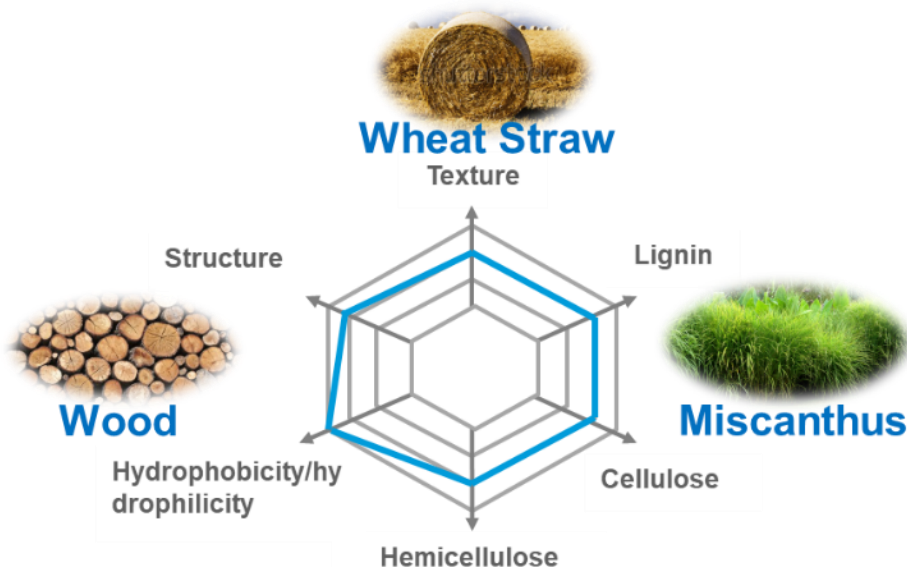
- ▶ Economical viability of the project is critical
- ▶ The market is moving (Regulation / energy context / Ethanol => SAF / biochemicals)
- ▶ Need to follow the market and adapt the technology (offtakes + coproduct valorization)

How to Deal with a Biomass to Ethanol Project?



Feedstock

Wood, Straw & Energy Crops : Futurol in its Element



Key Features

The only technology in the market having this set of biomasses at the heart of the development.

The only technology in the market that can claim proven industrial pre-treatment with wood and straw.

High feedstock flexibility while using the same Equipment.

Futurol® : For a Wide Range of Biomasses

MAXIMUM FLEXIBILITY

Wheat Straw	Rice Straw	Miscanthus	Sugarcane bagasse & leaves	Bamboo	Softwood
					
Kraft Pulp	Empty Fruit Bunches	Palm Fronds	Hardwood	Corn Cobs	Corn Stalks & Stover
					

Futurol® Technology: a Safe Derisking Strategy

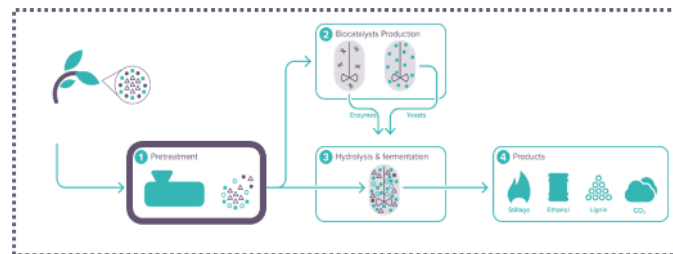


Wheat Straw	Rice Straw	Miscanthus	Sugarcane bagasse & leaves	Bamboo	Softwood	Nutshell Tree Wood & Shells
						

Kraft Pulp	Empty Fruit Bunches	Palm Fronds	Hardwood	Corn Cobs	Corn Stalks & Stover
					

Biomass pretreatment

- Proven at industrial scale (~10 KTA equivalent ethanol capacity)
- Standardization step
- Continuous & stable operation
- Flexible feedstock

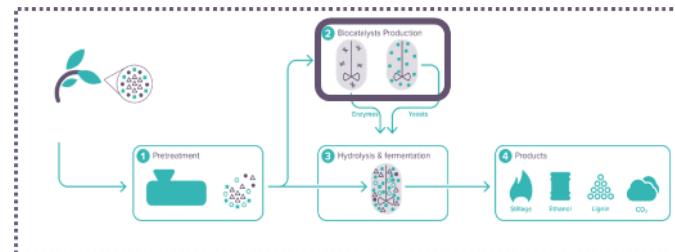


Futurol® Technology: a Safe Derisking Strategy

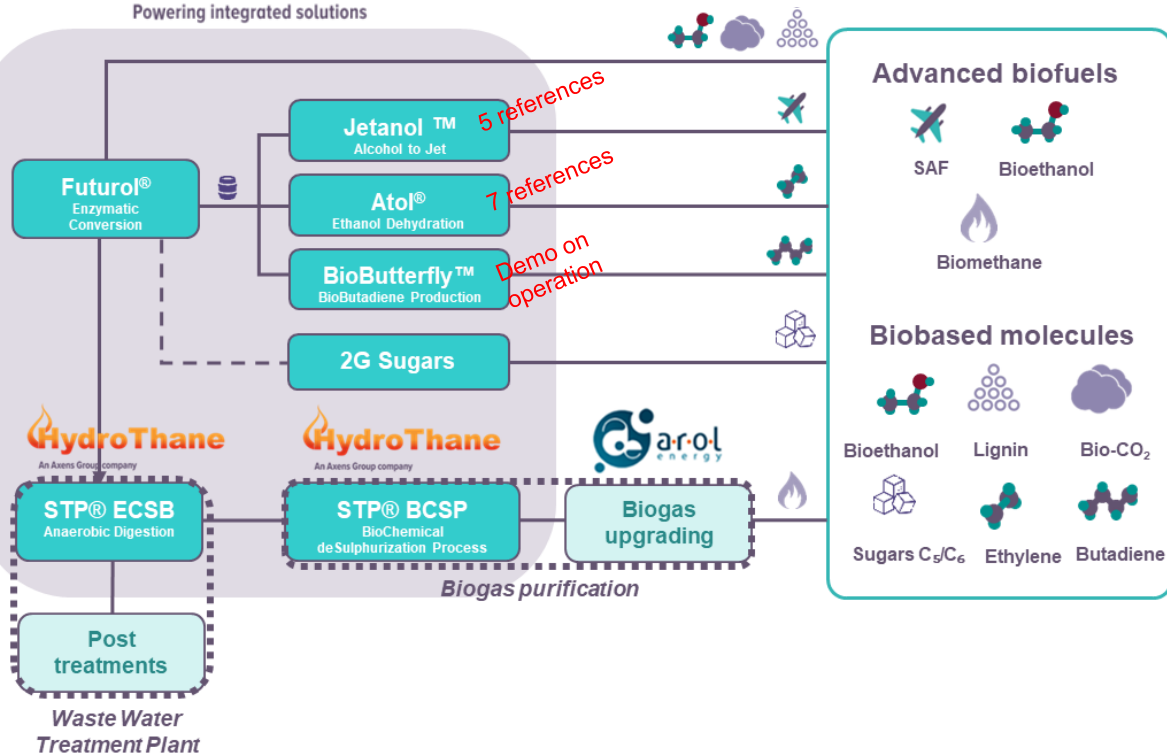


Enzymes production

- Proven at industrial scale (~15 KTA equivalent ethanol capacity)
- Validation in pre-commercial plant
- Continuous improvement with IFPEN Biotech Center

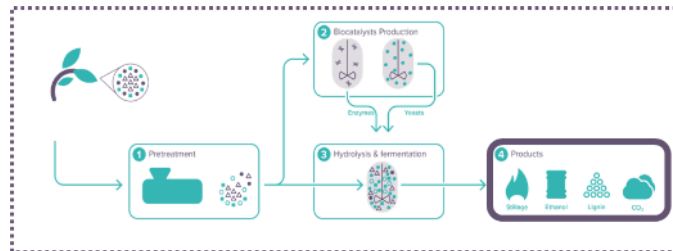


Futurol® Technology: a Safe Derisking Strategy

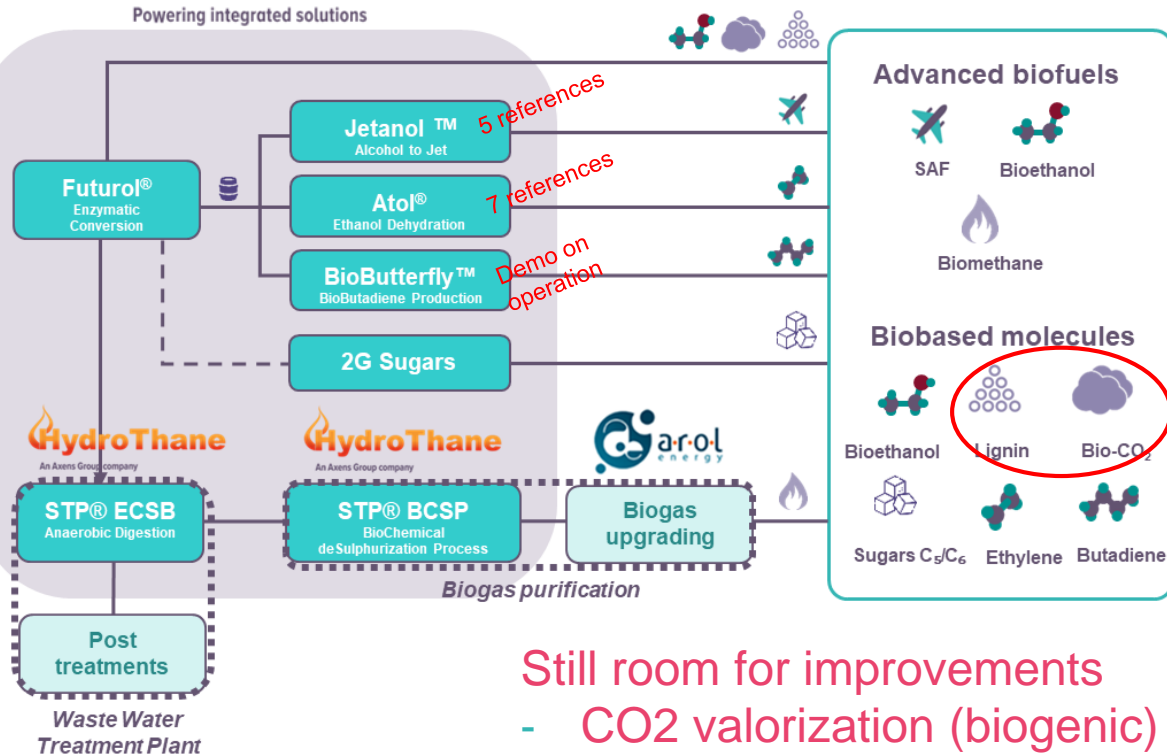


Products Integration

- Bioethanol as a platform molecule
- Bioenergy hub with lignin and biomethane
- A source of biogenic CO₂



Futurol® Technology: a Safe Derisking Strategy



Advanced biofuels

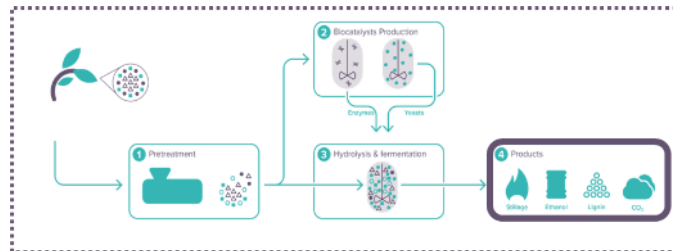


Biobased molecules



Products Integration

- Bioethanol as a platform molecule
- Bioenergy hub with lignin and biomethane
- A source of biogenic CO₂



Still room for improvements

- CO₂ valorization (biogenic)
- Lignin valorization (excl. energy)

Conclusion

- Futurol® is a flexible and robust commercial technology
- Considered by clients and investors as a de-risked technology (still under discussions...)
 - ▶ Due diligence activities (High use of scale-up work)
 - ▶ Maintain pilot tests for new feedstock (project derisking) and/or modeling activities
 - ▶ Maintain R&D to improve performances & economics (biocatalysts & technology)
- Continuous adaptation to market needs
 - ▶ Axens portfolio allows already to build solid business cases (SAF/biochemicals)
 - ▶ Need to maintain R&D efforts to anticipate future market needs (lignin valorization)

Axens
SOLUTIONS



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Thank you

Axens.net
a new digital
journey