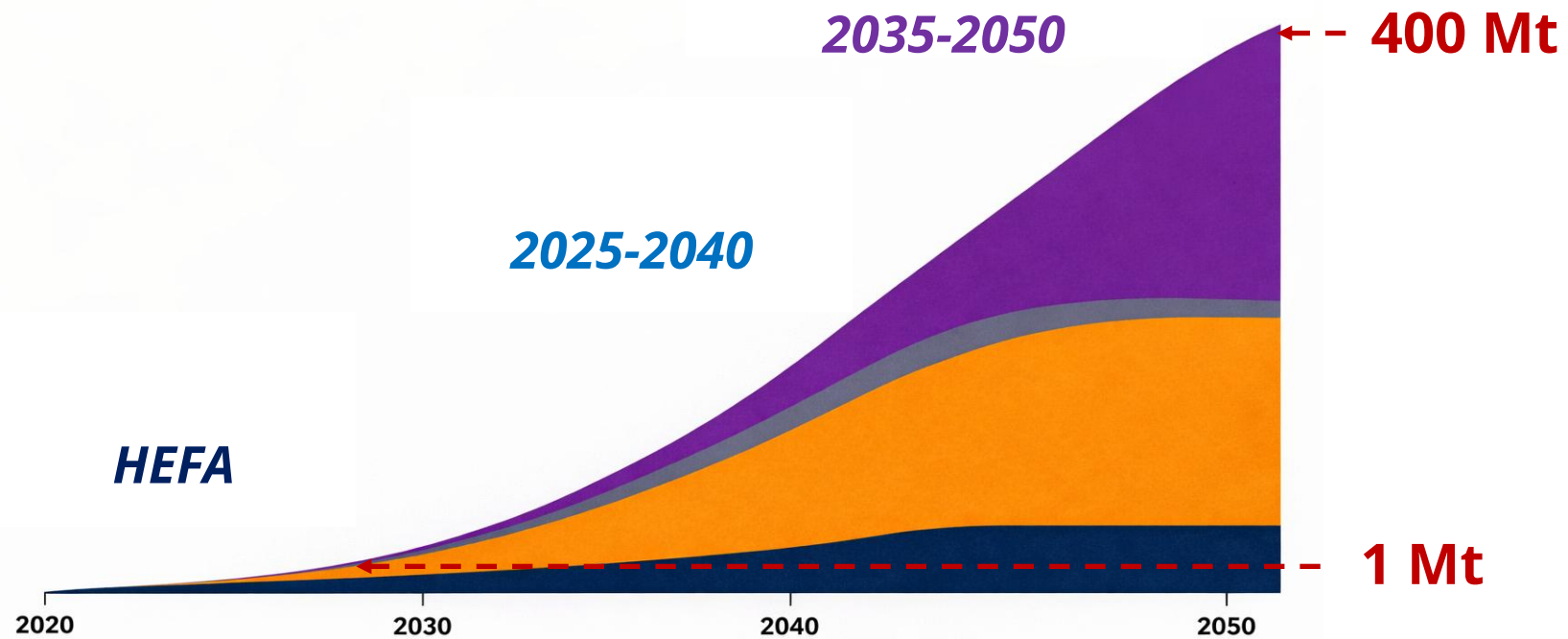




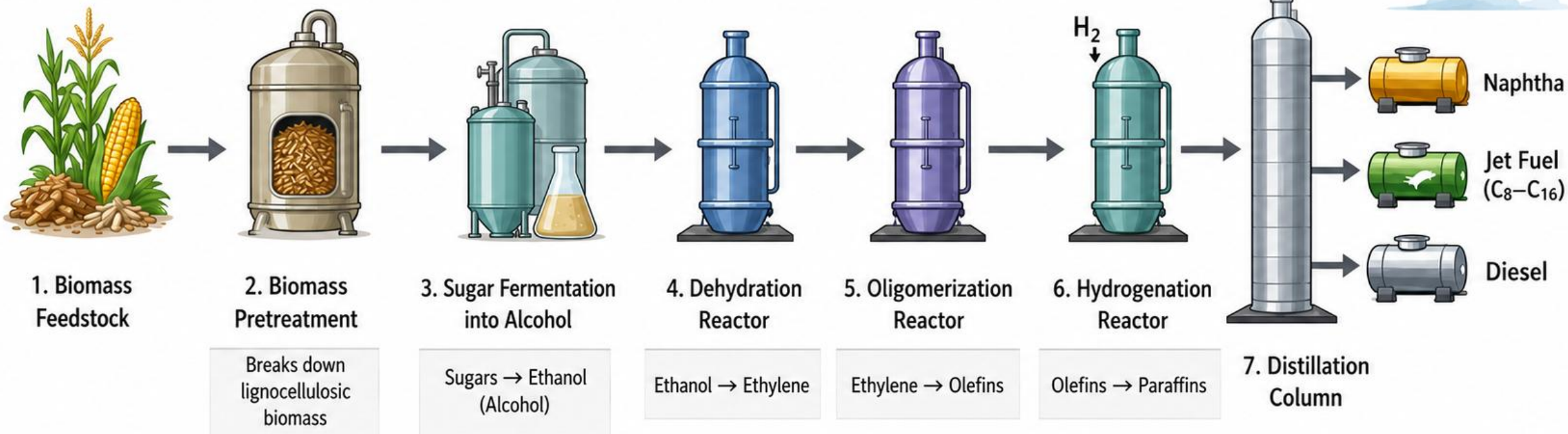
Isobutanol/alcohols to SAF

Iker Aguirrezabal Telleria
Associate Professor In Chemical Engineering
University of the Basque Country

Potential of the ATJ route

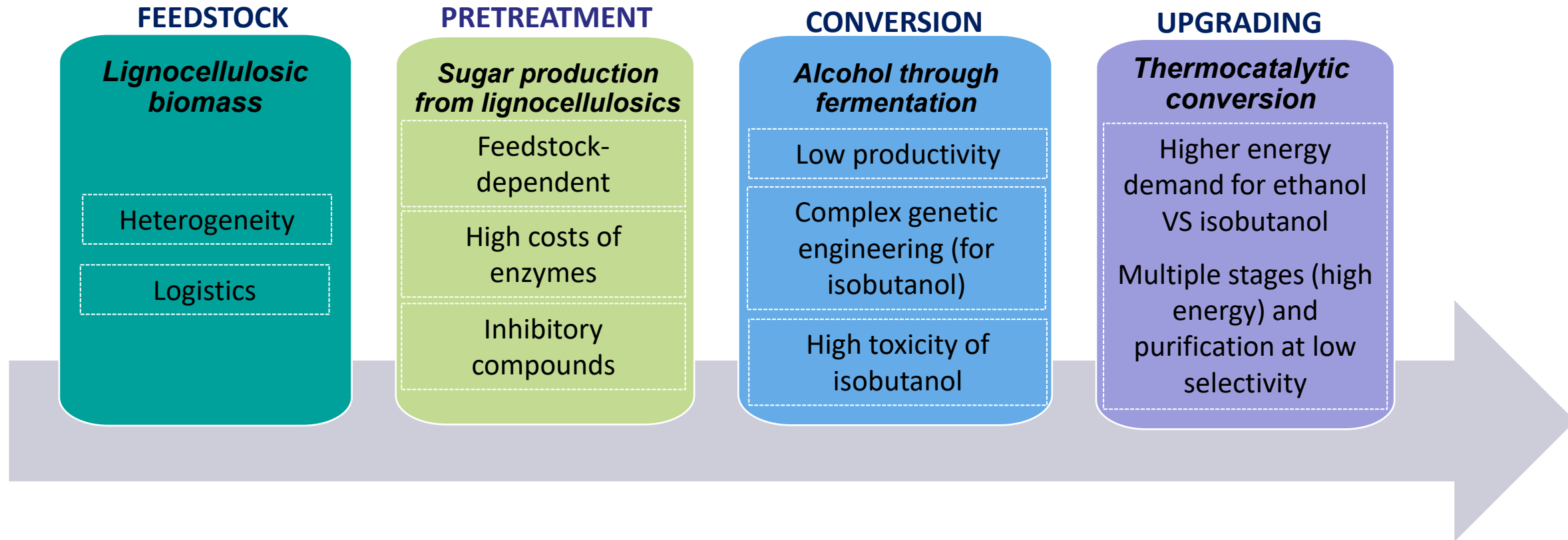


Relevant steps in ATJ



ASTM D7566 Annex A5
 ATJ-SPK (Alcohol-to-Jet
 Synthetic Paraffinic Kerosene)

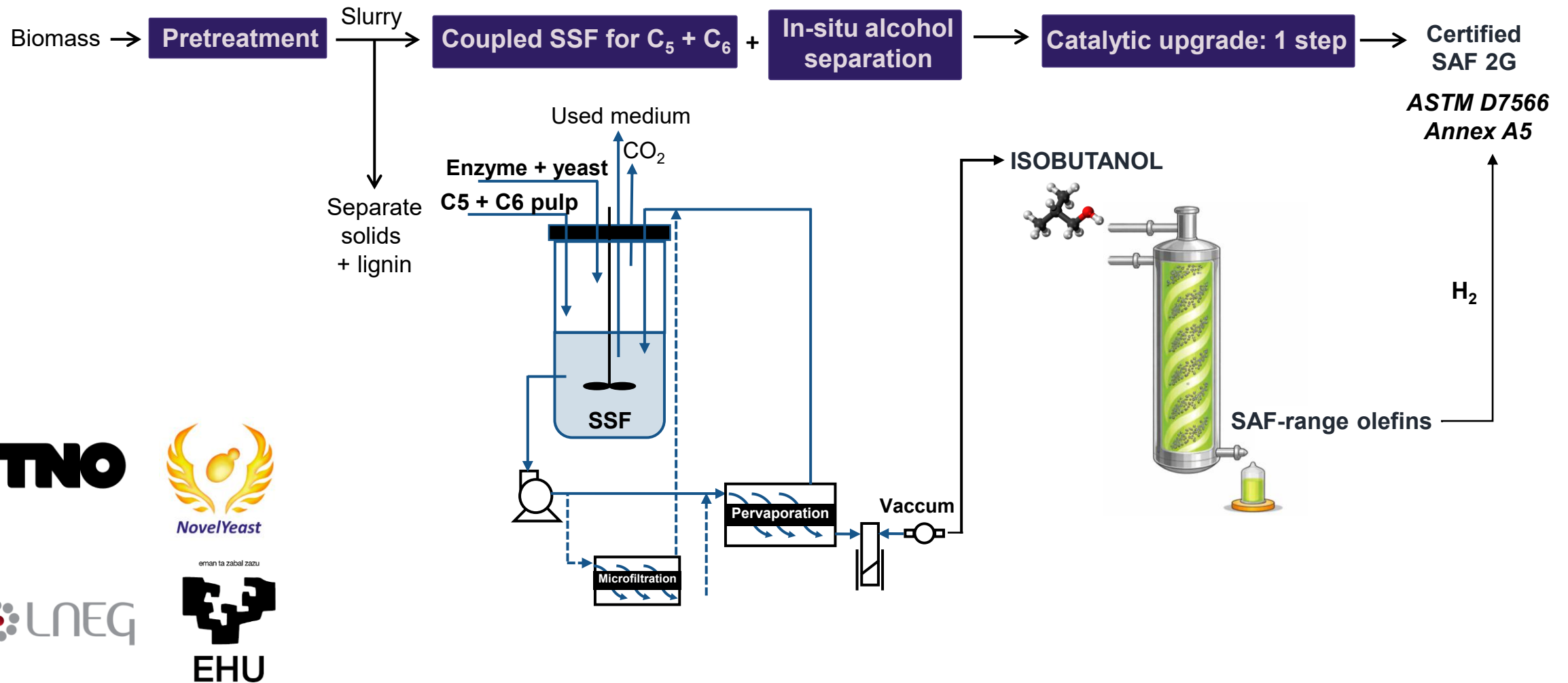
Main TECHNOLOGICAL BARRIERS towards market



Objectives

- ❖ Extract relevant biomass C5 and C6 fractions for conversion into isobutanol
- ❖ Develop an optimized yeast for the direct conversion of cellulose and C5 and C6 sugars into isobutanol
- ❖ Couple an in-situ isobutanol removal system via pervaporation membranes with a fermentation bioreactor
- ❖ Integrate catalytic steps to reduce CAPEX to reach SAF-range hydrocarbons
- ❖ Validate the final SAF product

ADVANCES in ICARUS



TNO



eman ta zabal zazu



What competition do we have?

Company / Technology	Feedstock & pretreatment	Intermediate production technology	Alcohol / Intermediate	Separation / recovery	Upgrading to SAF
	1G crops (corn, etc.)	Fermentation (ethanol)	Ethanol	Conventional distillation	Two-step catalysis + branching to SAF
	Off-gas streams or biomass gasification	Gas fermentation (ethanol)	Ethanol	Conventional distillation	Two-step catalysis + branching to SAF
	2G biomass (wood residues)	Integrated fractionation + fermentation (ethanol)	Ethanol	Conventional distillation	Two-step catalysis + branching to SAF
	1G / 2G sugars	Gas-Fermentation (engineered)	Isobutene (via fermentation)	Not required (gas product)	Oligomerisation and branching not needed
	CO ₂ + green H ₂ (PtL)	RWGS + FT (syngas)	No alcohol intermediate	Not applicable	Fischer–Tropsch to SAF
	2G biomass (C5 + C6)	Fermentation (2G yeast)	Isobutanol	Membrane recovery (in-situ)	1-step isobutanol to-SAF. Branching not needed

Optimized yeast for lignocellulosic biomass → isobutanol

Performance in lignocellulosic hydrolysates (C5, inhibitor rich)



Sorghum C5 fraction

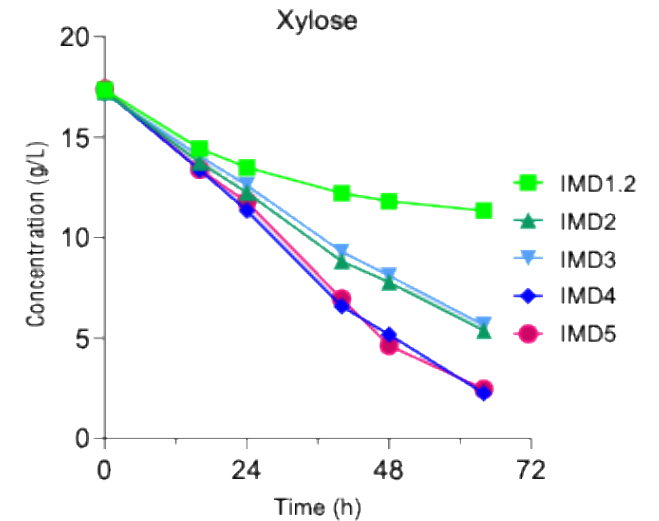
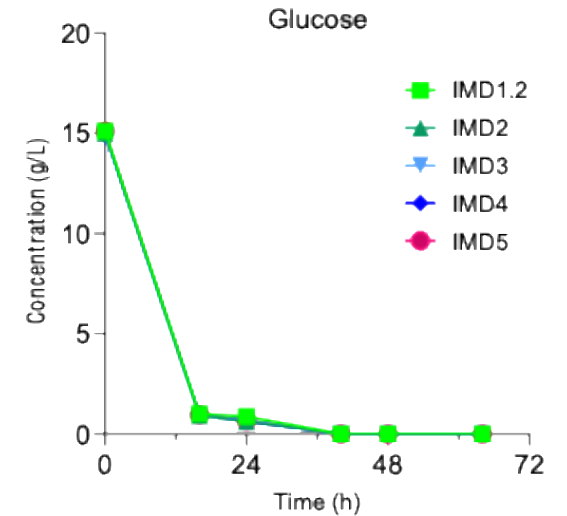
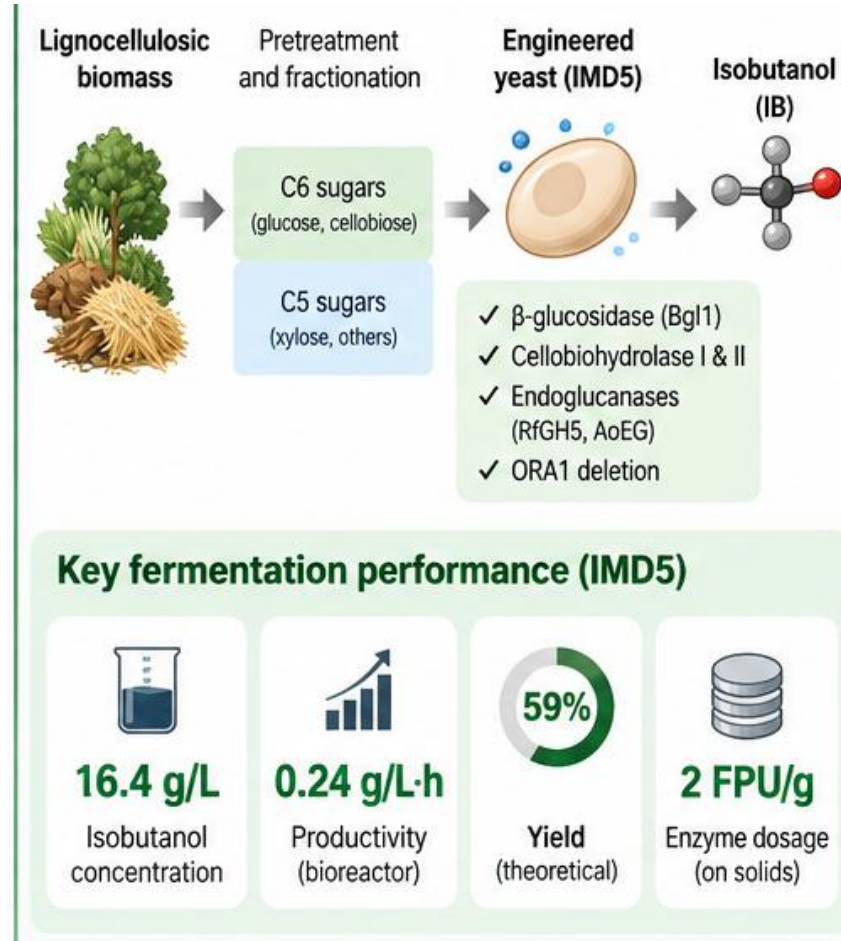
- ~8 g/L isobutanol
- 7–9 g/L acetate (tolerated)



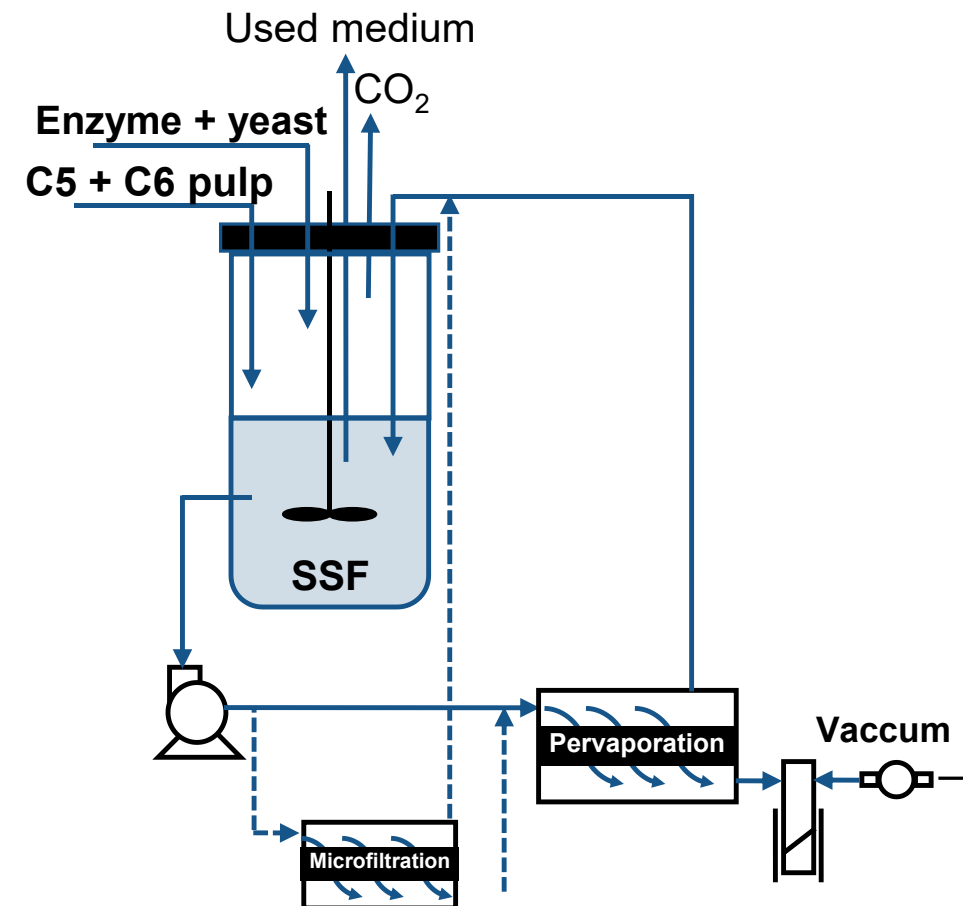
Sunn hemp C5 fraction

- >5 g/L isobutanol
- 12–18 g/L acetate (tolerated)

Improved sugar utilisation and enzyme secretion.
Further improvement of xylose conversion is needed.



Removal to preserve isobutanol productivity → advantages vs. ethanol



Key pervaporation results (PDMS membrane)

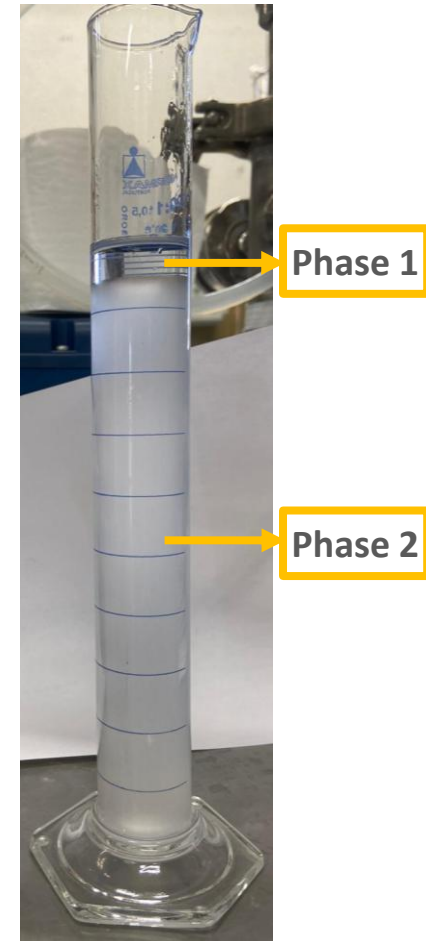
>88%	>34.4 g/h	68.8	>6 h
Isobutanol removal yield	Initial removal rate	g/m²·h Initial flux	Stable operation
			32 °C 26 mbar

Performance with real fermentation broth

Isobutanol concentration (g/L) after 1 h 40 min

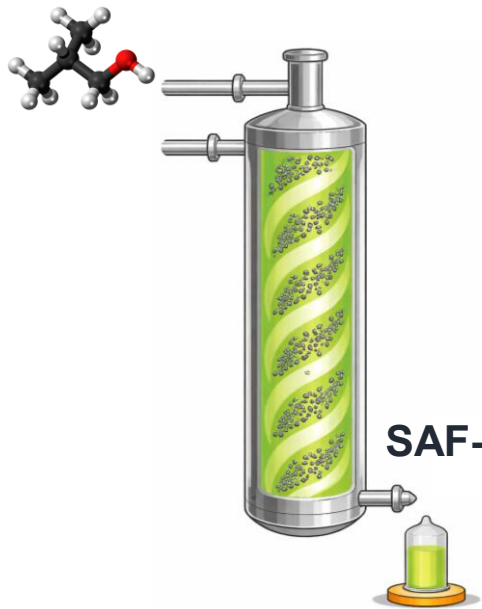
Stream	Isobutanol (g/L)
Initial feed	16.0
Retentate	0
Pervaporate	72.6

- Pervaporate also contained ~6 g/L ethanol
- Sugars remain in the retentate

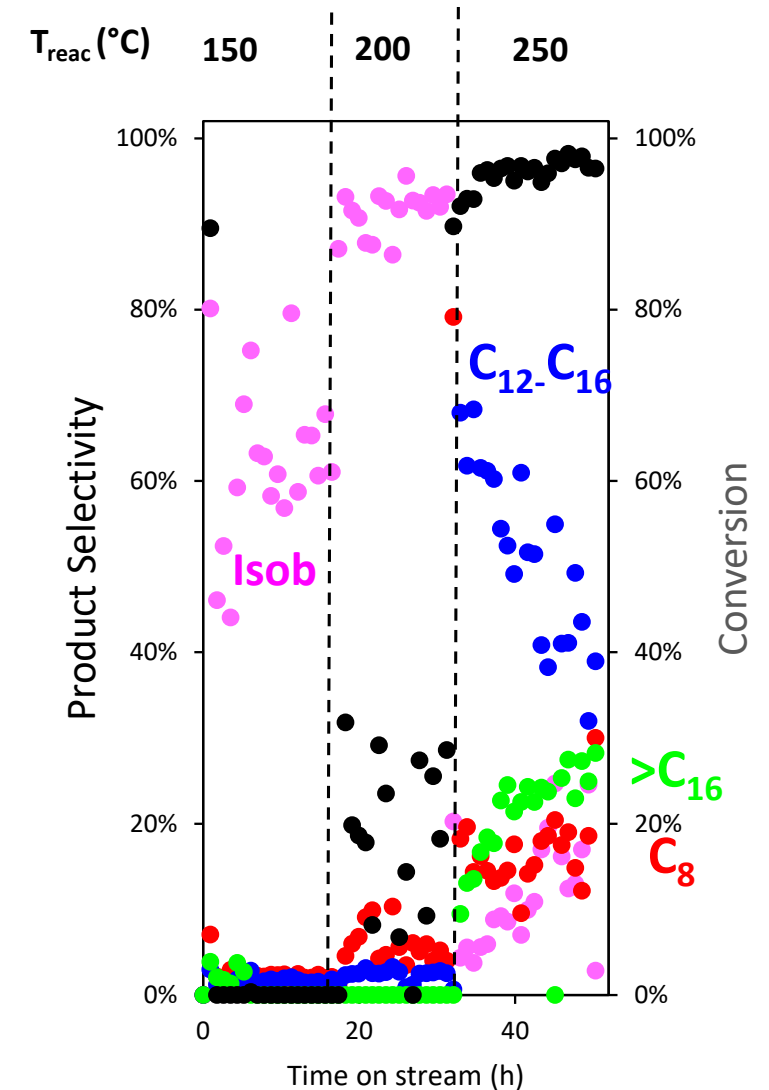
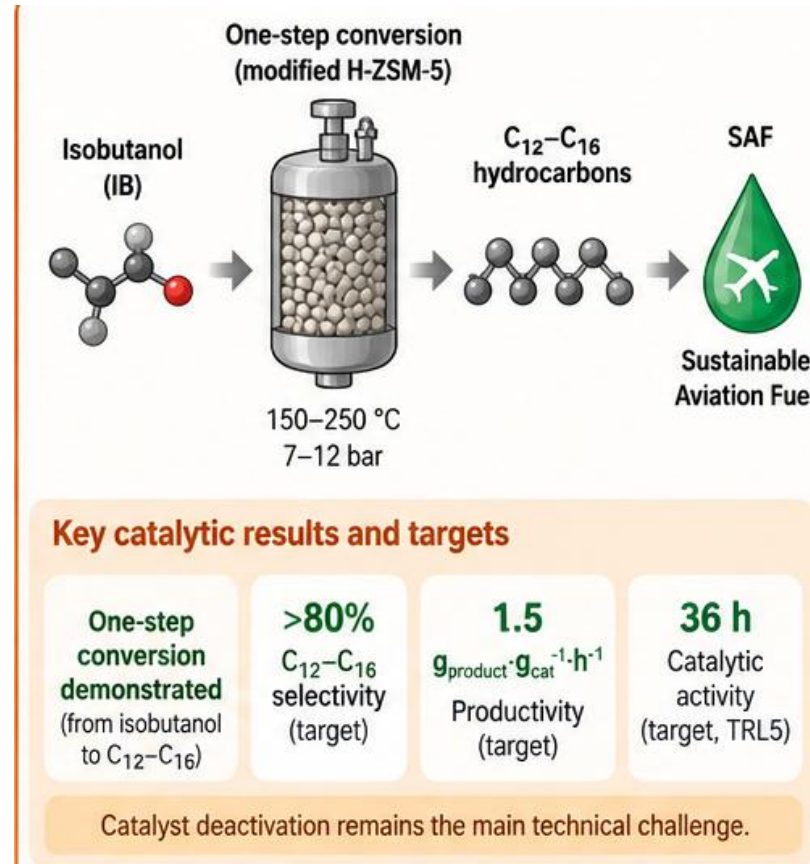


Improved isobutanol conversion to SAF → ASTM validated

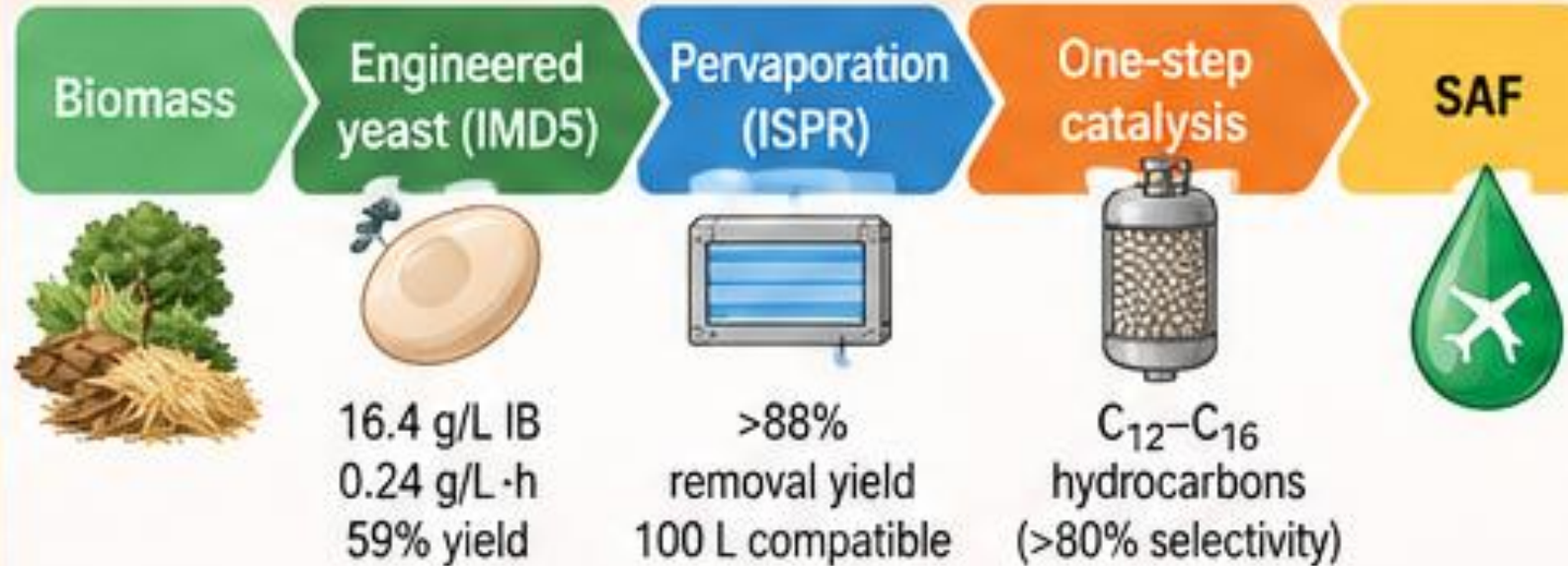
ISOBUTANOL



SAF-range olefins



Overall process chain and main achievements



Next development steps

- Improve xylose conversion and overall yeast productivity
- Long-term continuous ISPR operation and further scale-up
- Improve catalyst stability and reach TRL5 performance
- Integrate and industrialise into a robust SAF process



REFINARIA DE SINES
LABORATÓRIO



L0190
ISO/IEC 17025
Ensaíos



Relatório de Ensaios

Nome do Cliente: Centro de Investigação
Endereço: Refinaria de Sines - Edifício Planta Piloto
Produto: Keroseno
Nº. Amostragem: LB-0721/26
Origem: Unidade Piloto

Nº. DE SERIE: 2441/26
DATA DE EMISSÃO: 15/03/2026
DATA DE RECEPÇÃO: 15/03/2026
Número de Lote: Ensayo 37
Data de Colheita:

Nº Interno	LOC.	Método	Componente	Unidades	Resultado	U	Data
1760174	PONTUAL	ASTM D7153-22ae1	Ponto de Congelação	°C	<-80.0 (L.Q.)	±0.39	15/03/2026
1760174	PONTUAL	ASTM D7345-17	IBP	°C	112.2	±3.5	15/03/2026
1760174	PONTUAL	ASTM D7345-17	5% Recuperado	°C	138.3	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	10% Recuperado	°C	144.2	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	20% Recuperado	°C	159.4	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	30% Recuperado	°C	170.2	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	40% Recuperado	°C	178.8	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	50% Recuperado	°C	183.0	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	60% Recuperado	°C	186.7	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	65% Recuperado	°C	188.6	-	15/03/2026
1760174	PONTUAL	ASTM D7345-17	70% Recuperado	°C	190.3	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	80% Recuperado	°C	197.2	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	85% Recuperado	°C	202.6	-	15/03/2026
1760174	PONTUAL	ASTM D7345-17	90% Recuperado	°C	220.0	±1%	15/03/2026
1760174	PONTUAL	ASTM D7345-17	95% Recuperado	°C	242.0	±1.8	15/03/2026
1760174	PONTUAL	ASTM D7345-17	FBP	°C	265.5	±2.8	15/03/2026
1760174	PONTUAL	ASTM D7345-17	% Recuperado	%(v/v)	98.1		15/03/2026
1760174	PONTUAL	ASTM D7345-17	% Residuo	%(v/v)	1.4	-	15/03/2026
1760174	PONTUAL	ASTM D7345-17	% Perdas	%(v/v)	0.6	-	15/03/2026
1760174	PONTUAL	ASTM D7345-17	% Rec. 250°C	%(v/v)	96.5	-	15/03/2026



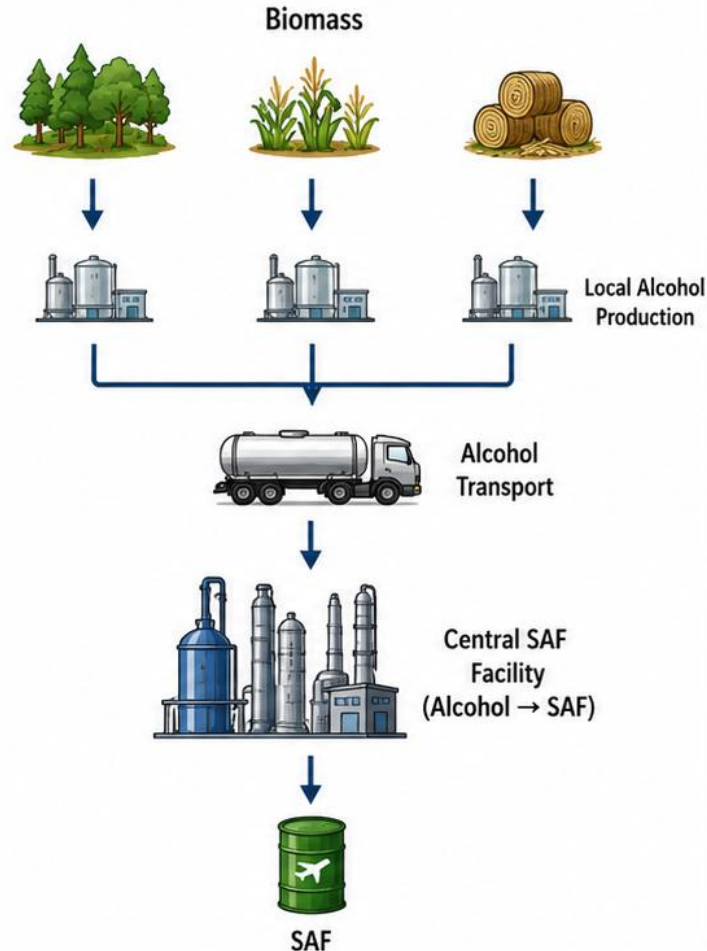
ASTM D7566Annex A5
ATJ-SPK (Alcohol-to-Jet
Synthetic Paraffinic Kerosene)

How can this technology be implemented?

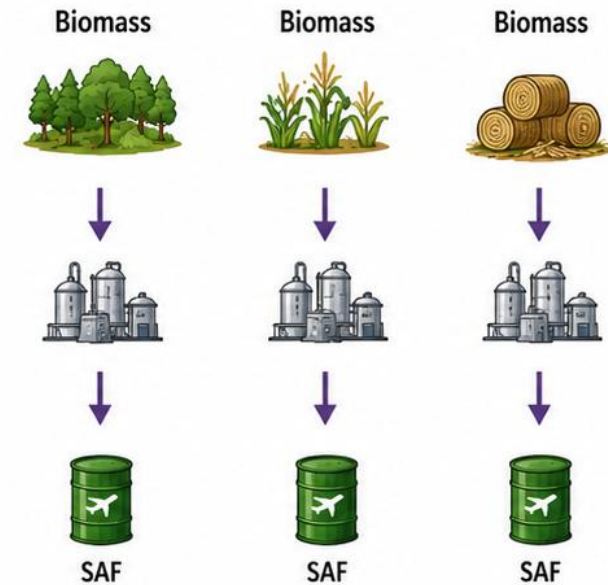
1 Centralized



2 Decentralized Alcohol Production + Centralized SAF



3 Distributed Small-Scale SAF Production





Isobutanol/alcohols to SAF

Iker Aguirrezabal Telleria
Associate Professor In Chemical Engineering
University of the Basque Country