Co-Processing for Refinery Integration of Biofuels Production

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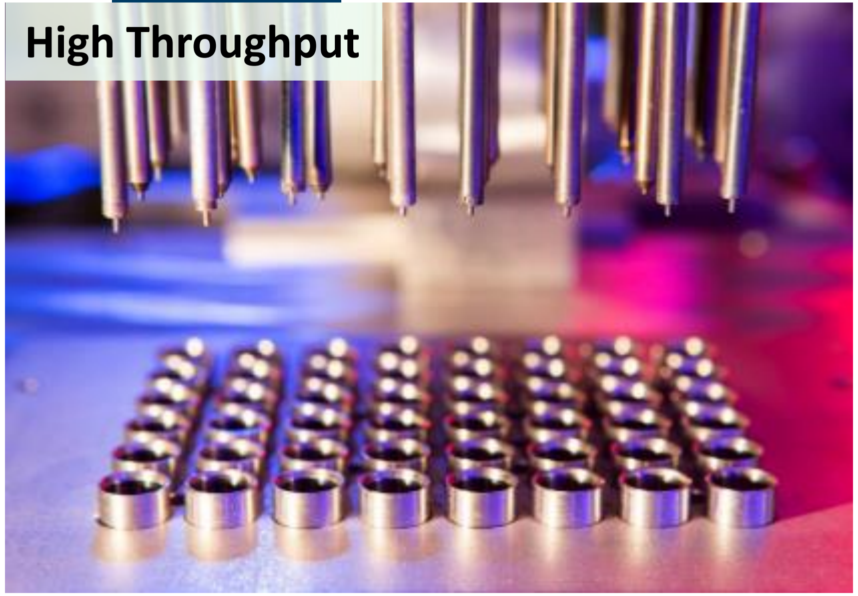
SINTEF

An independent, Norwegian Research Institute

Space Lab

Process Technology: Micro to full Pilot

High Throughput



Micro-Structured

CCS Full Pilot

Tiller Sustainability Pilot Lab

Refinery Mini Pilot

Background

- Need for rapid scale-up of production of biofuels to meet the current climate mitigation targets for transport sector
- The focus on drop-in fuels seen as a route to meet these targets based on using current transport infrastructure
- The integration with existing European refinery infrastructures could fulfil this potential through co-integration, co-processing, co-refining
  - Reduce the capital cost
  - Build on existing processes
  - Integrate with existing value chains

EU funded Projects research in Co-Processing

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Municipal Waste as feedstock toward co-processing in Refinery

WASTE2ROAD

OMV · EGE Energigjenvinningsetaten · btg-btl biomass-to-liquid · btg biomass technology group · CRF · PDC · SINTEF · cea · cnrs · VTT · TU WIEN

Lignocellulose feedstock toward co-processing in Refinery

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REPSOL · MOL · btg biomass technology group · E4tech · SINTEF · cr · VTT · AALBORG UNIVERSITY DENMARK

Gasification and Pyrolysis routes for Biofuels production

FAST CARD

REPSOL · eni · GRACE Talent | Technology | Trust™ · btg biomass technology group · JM Johnson Matthey Inspiring science, enhancing life · SAINT-GOBAIN · PDC · SINTEF · ECN Your energy. Our passion. · cnrs · NTNU · 200 YEARS GHENT UNIVERSITY · BIC SB RAS · University of Stuttgart Germany

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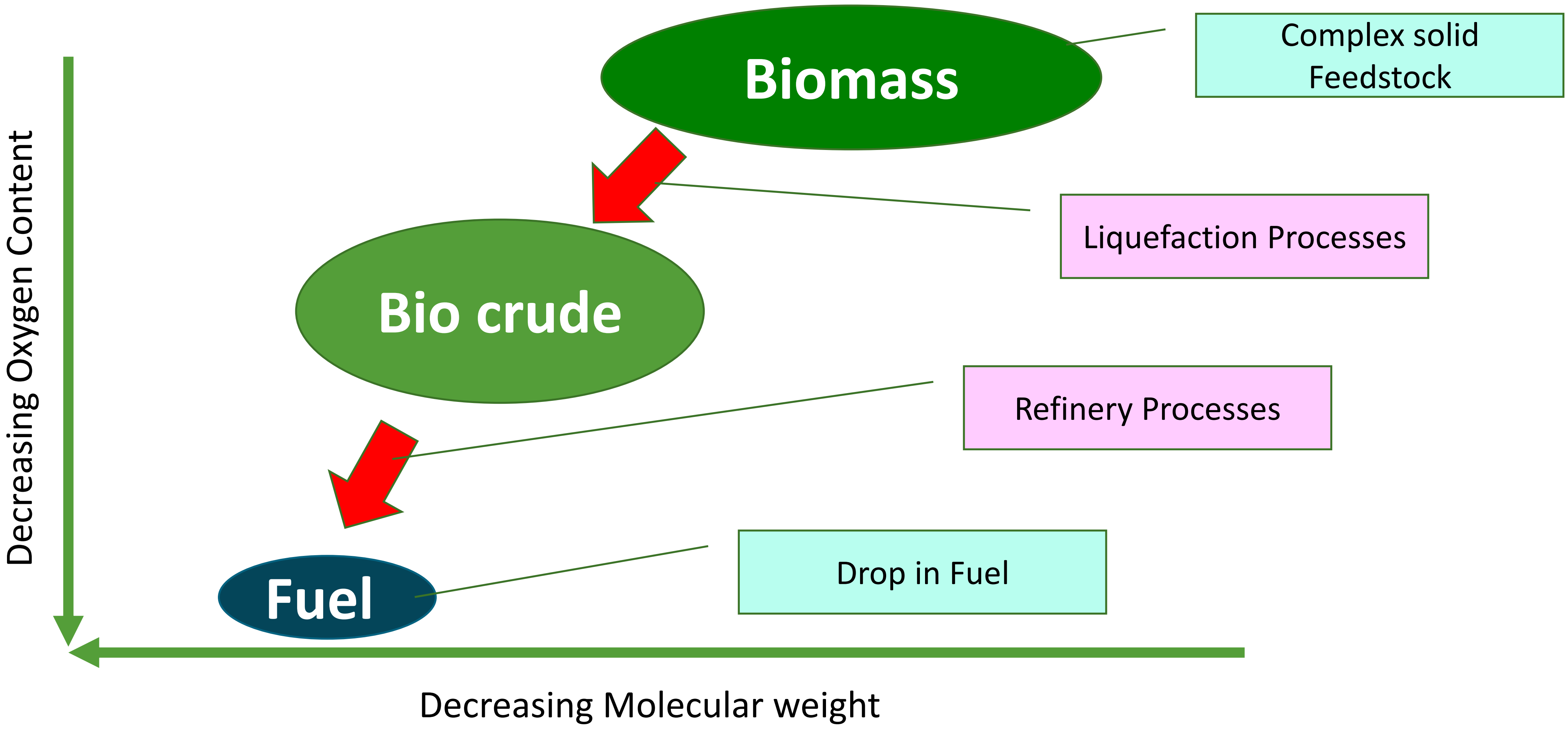
Co-processing Challenge:
Oxygen Removal + Energy densification



Lange, J-P, ChemSusChem, Volume 11, (2018)

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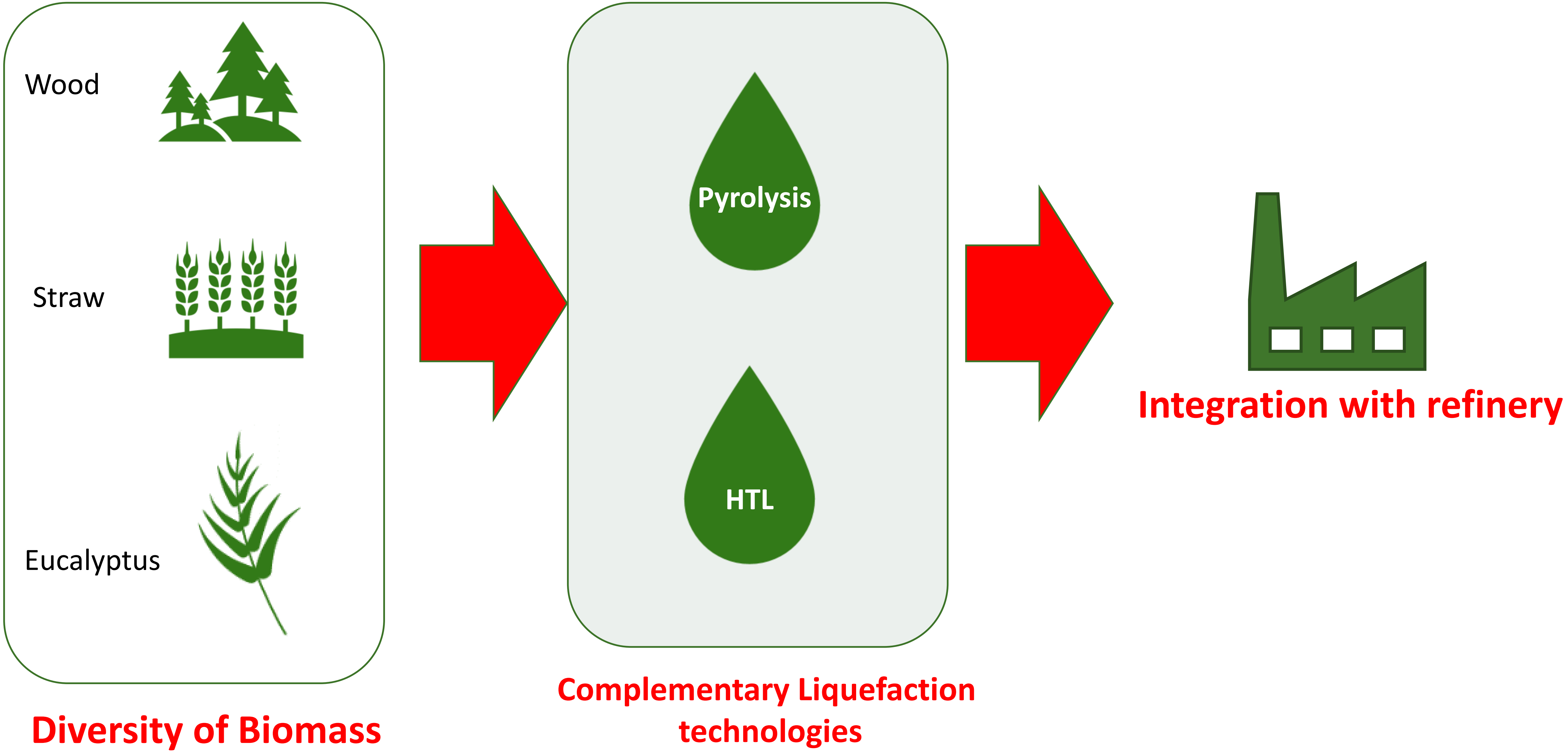
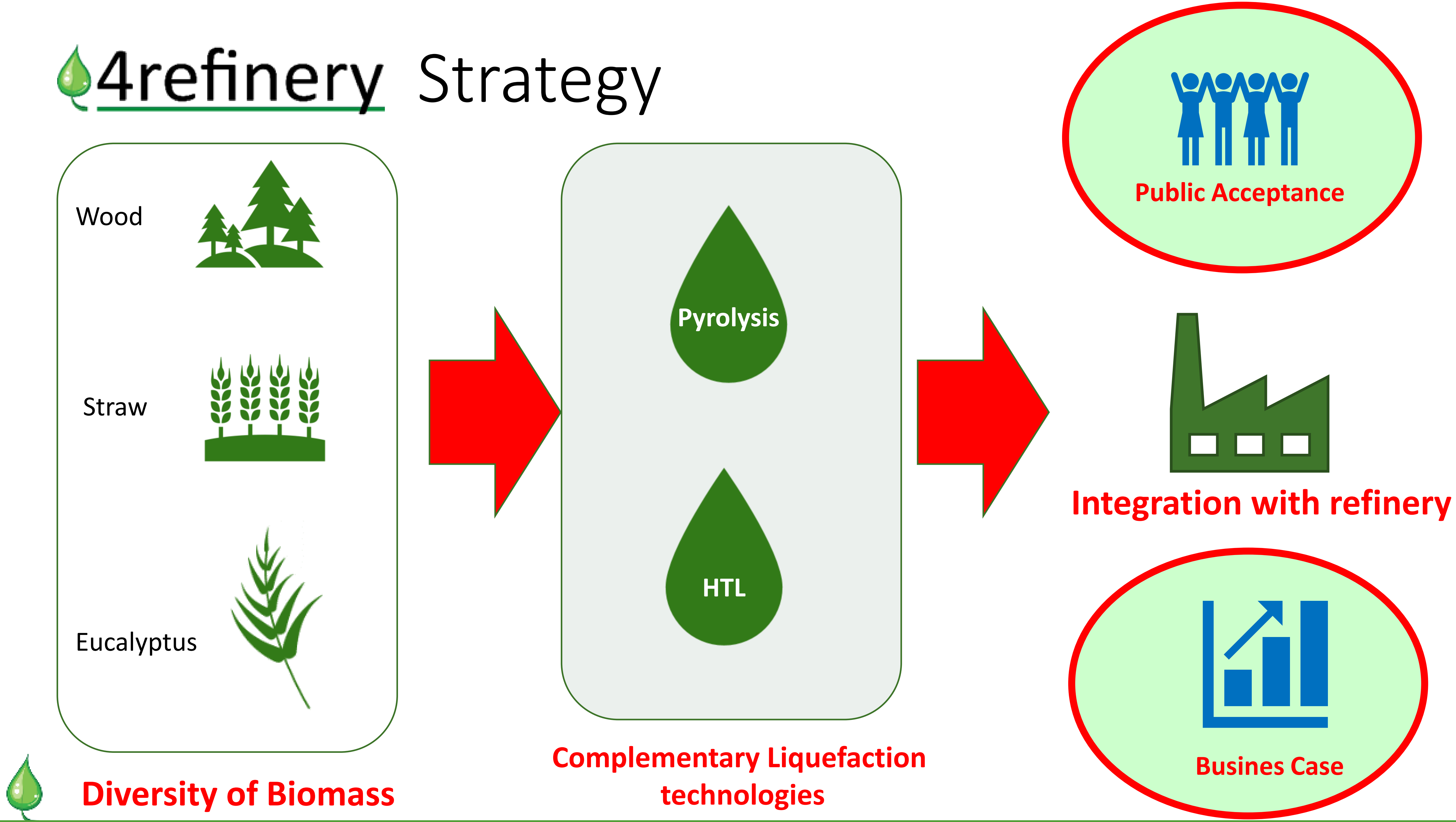
4refinery Strategy




4refinery Strategy
Wood
Straw
Eucalyptus
Diversity of Biomass
Pyrolysis
HTL
Complementary Liquefaction technologies
Public Acceptance
Integration with refinery
Busines Case

Supply chain & market assessment – **Feedstock**

CONTENT

- Supply chain structure
- Supply chain security
- Supply chain costs

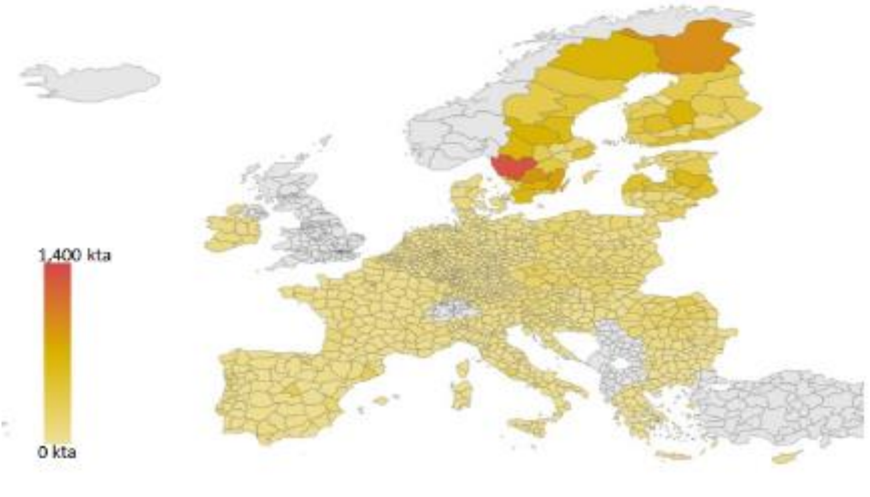
OBJECTIVES

- Estimate feedstock costs and sensitivities
- Define supply chain logistics (to identify potential suppliers/partners, and infrastructure requirements)

OUTCOME

- Biomass supply chains are relatively immature at present - vary by feedstock and region.
- Common challenges:
  - The large amounts of biomass needed lead to expensive transportation costs.
  - Introducing variability (source location) into the process complicates supply chain logistics and affects the quality and yield of the conversion process
  - Local assessment of feedstock availability needs to be performed on case by case basis to determine true level of feedstock availability

Sustainable technical potential of harvesting residues in the EU in 2030 (dry mass)



Sustainable technical potential of wood processing residues in the EU in 2030 (dry mass)

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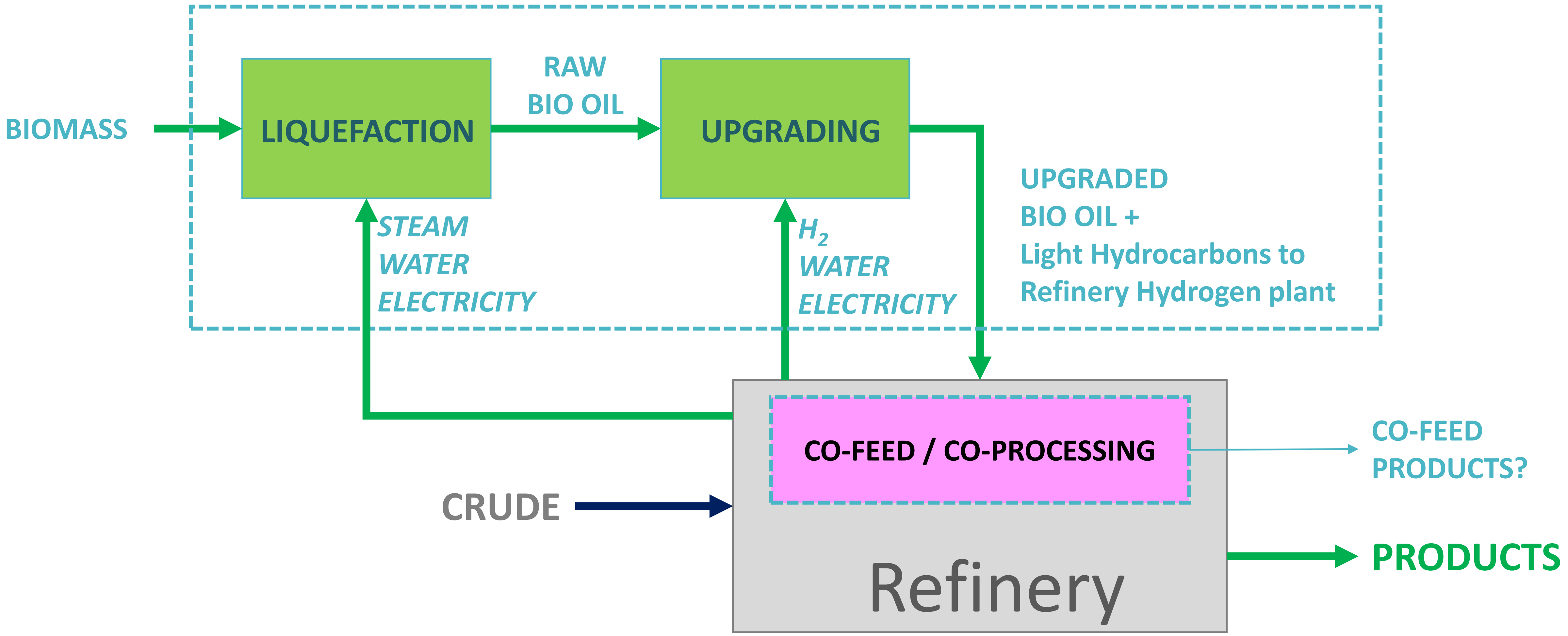
Integration to existing Refineries



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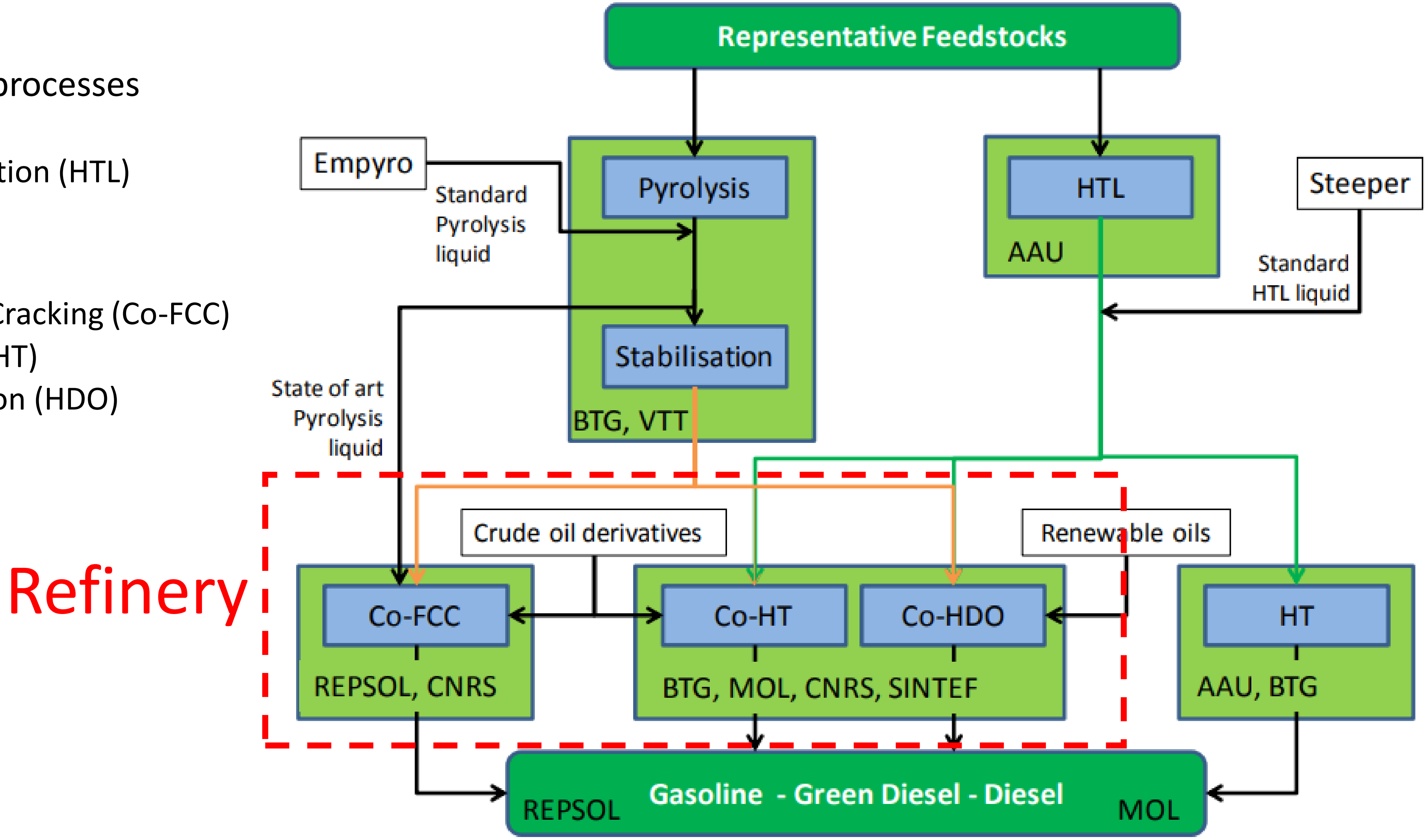
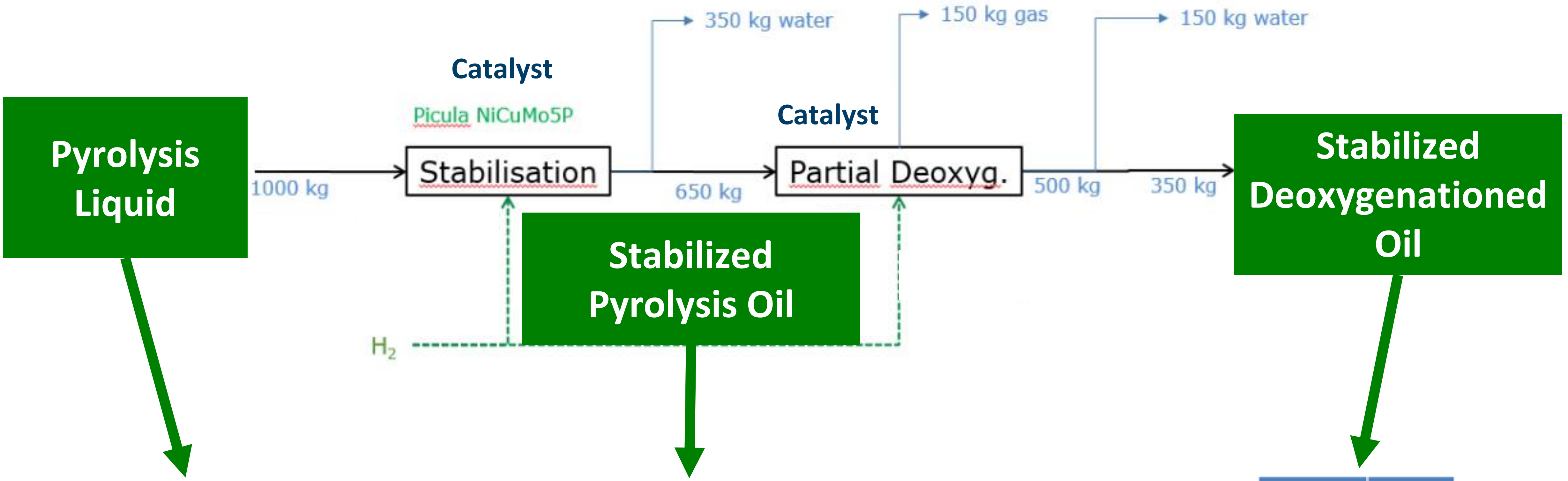
Alternative routes of bio-liquids in refinery

- Two primary conversion processes
  - Pyrolysis
  - HydroThermal Liquifaction (HTL)
- Four refining processes
  - Co-Fluidized Catalytic Cracking (Co-FCC)
  - Co-HydroTreating (Co-HT)
  - Co-HydroDeOxygenation (HDO)
  - HydroTreating (HT)
- Final products
  - Gasoline
  - Diesel
  - LPG

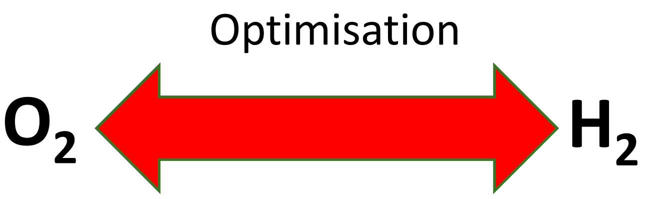


Upgrading: Optimising Oxygen for integration



wt.%	
C_{daf}	57.4
H_{daf}	6.1
O_{daf}	36.5
H_2O	22.5

wt.%	
C_{daf}	66.4
H_{daf}	8.6
O_{daf}	25.0
H_2O	4.0



wt.%	
C_{daf}	86.1
H_{daf}	12.5
O_{daf}	1.2
H_2O	0.2

4refinery - Scenarios FOR integration of bio-liquids in existing REFINERY processes
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Techno-Economic Evaluation building MODELS for range of alternatives for Refinery integration

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Step 1	Stabilization	Deoxygenation	Co-processing	Product
Pyrolysis FCC-1-P *Forest residue*			Co-FCC FCC-1-C *VGO*	Gasoline
Pyrolysis FCC-2-P *Eucalyptus*			Co-FCC FCC-2-C *VGO*	Gasoline
Pyrolysis FCC-3-P *Straw*			Co-FCC FCC-3-C *VGO*	Gasoline
Pyrolysis FCC-4-P *Forest residue*	Stabilization FCC-4-S		Co-FCC FCC-4-C *VGO*	Gasoline
Pyrolysis FCC-5-P *Eucalyptus*	Stabilization FCC-5-S		Co-FCC FCC-5-C *VGO*	Gasoline
Pyrolysis FCC-6-P *Straw*	Stabilization FCC-6-S		Co-FCC FCC-6-C *VGO*	Gasoline
Pyrolysis FCC-7-P *Forest residue*	Stabilization FCC-7-S	Deoxygenation FCC-7-D	Co-FCC FCC-7-C *VGO*	Gasoline
Pyrolysis HT-1-P *Forest residue*	Stabilization HT-1-S	Deoxygenation HT-1-D	HT HT-1-C	Gasoline/ diesel
Pyrolysis HT-4-P *Forest residue*	Stabilization HT-4-S	Deoxygenation HT-4-D	Co-HT HT-4-C *SRGO*	Diesel
HTL HTL-1-P *Forest residue*			HT HTL-1-C	Diesel
HTL HTL-3a-P *Straw*			HT HTL-3a-C	Diesel
HTL HTL-3b-P *Straw*			HT HTL-3b-C	Diesel
HTL HTL-4-P *Forest residue*			Co-HT HTL-4-C *SRGO*	Diesel
Pyrolysis HDO-4-P *Forest residue*	Stabilization HDO-4-S	Deoxygenation HDO-4-D	Co-HDO HDO-4-C *Rapeseed oil*	Diesel

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Techno-Economic Evaluation building MODELS for range of alternatives for Refinery integration

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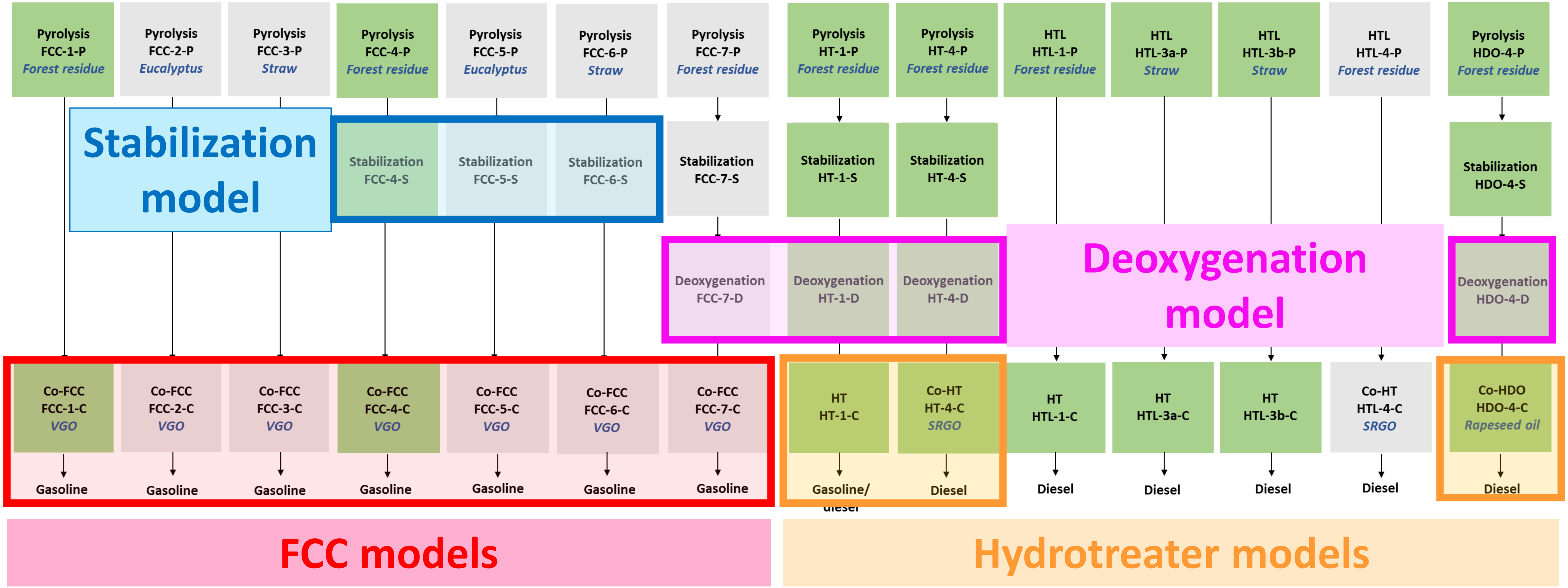
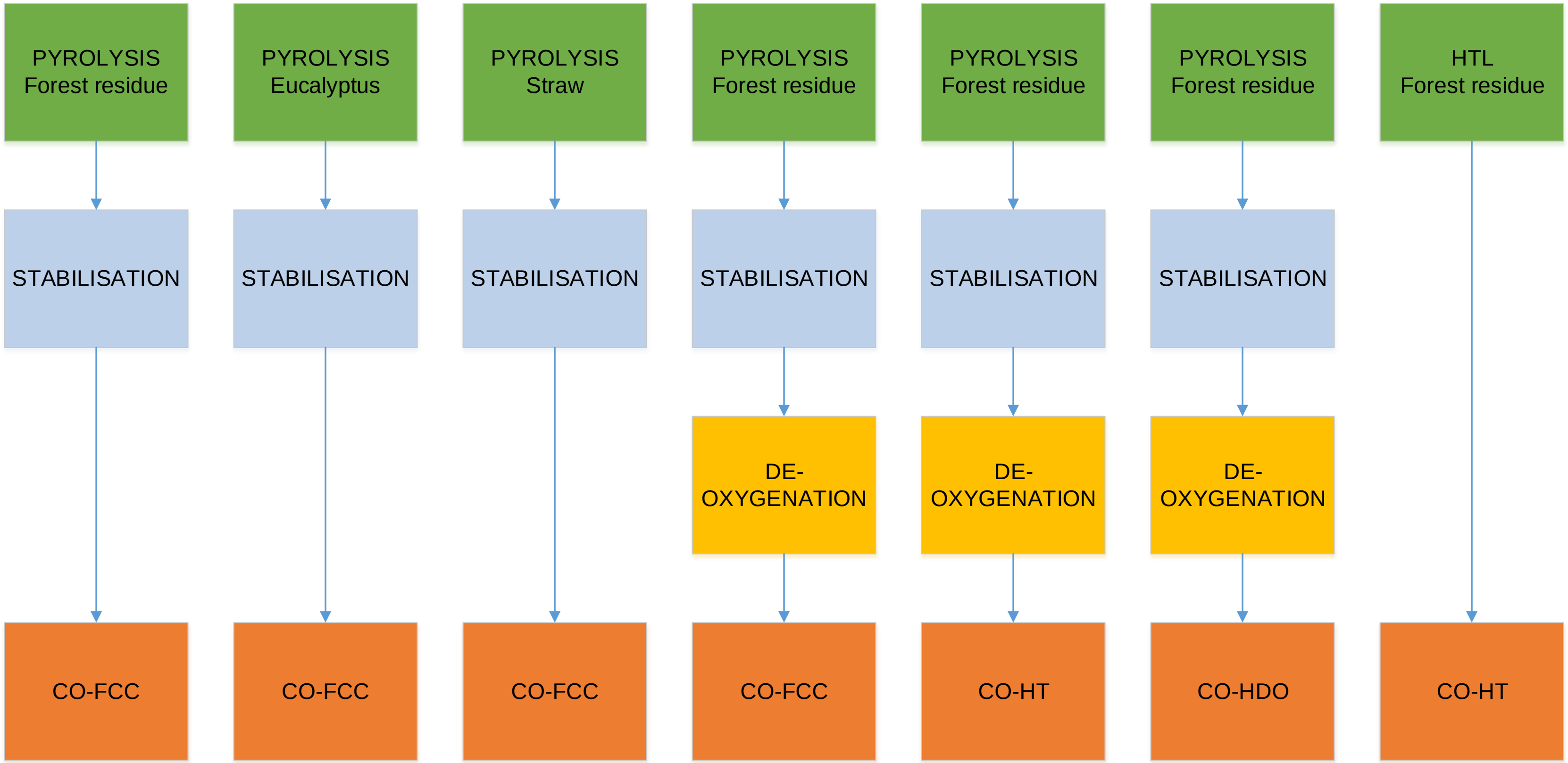


Feedstock/Location: Final selection of value chains

- **Forest residue:**
  - Northern Europe
  - Baltics
- **Eucalyptus:**
  - Southwestern Europe (Spain)
- **Straw:**
  - Central Europe
  - Denmark



Scenario analysis:
Ranking of Technical and Economic feasibility

Treatment	Post-treatment	Final refining	Raw material	Location	Technical feasibility	Economic feasibility
Pyrolysis	Stabilisation	co-FCC	Forest residue	Baltics	++	+++
			Forest residue	Northern Europe	++	++
			Eucalyptus	Spain	+	++
			Straw	Central Europe	---	+++
			Straw	Denmark	---	+
	Stabilsation Deoxigenation	co-FCC	Forest residue	Baltics	+++	--
		co-FCC	Forest residue	Northern Europe	+++	---
		co-HT	Forest residue	Baltics	-	-
		co-HT	Forest residue	Northern Europe	-	--
		co-HDO	Forest residue	Baltics	+++	--
		co-HDO	Forest residue	Northern Europe	+++	---
HTL	-	HT	Forest residue	-	---	not defined

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Evaluating Business Cases for scenarios

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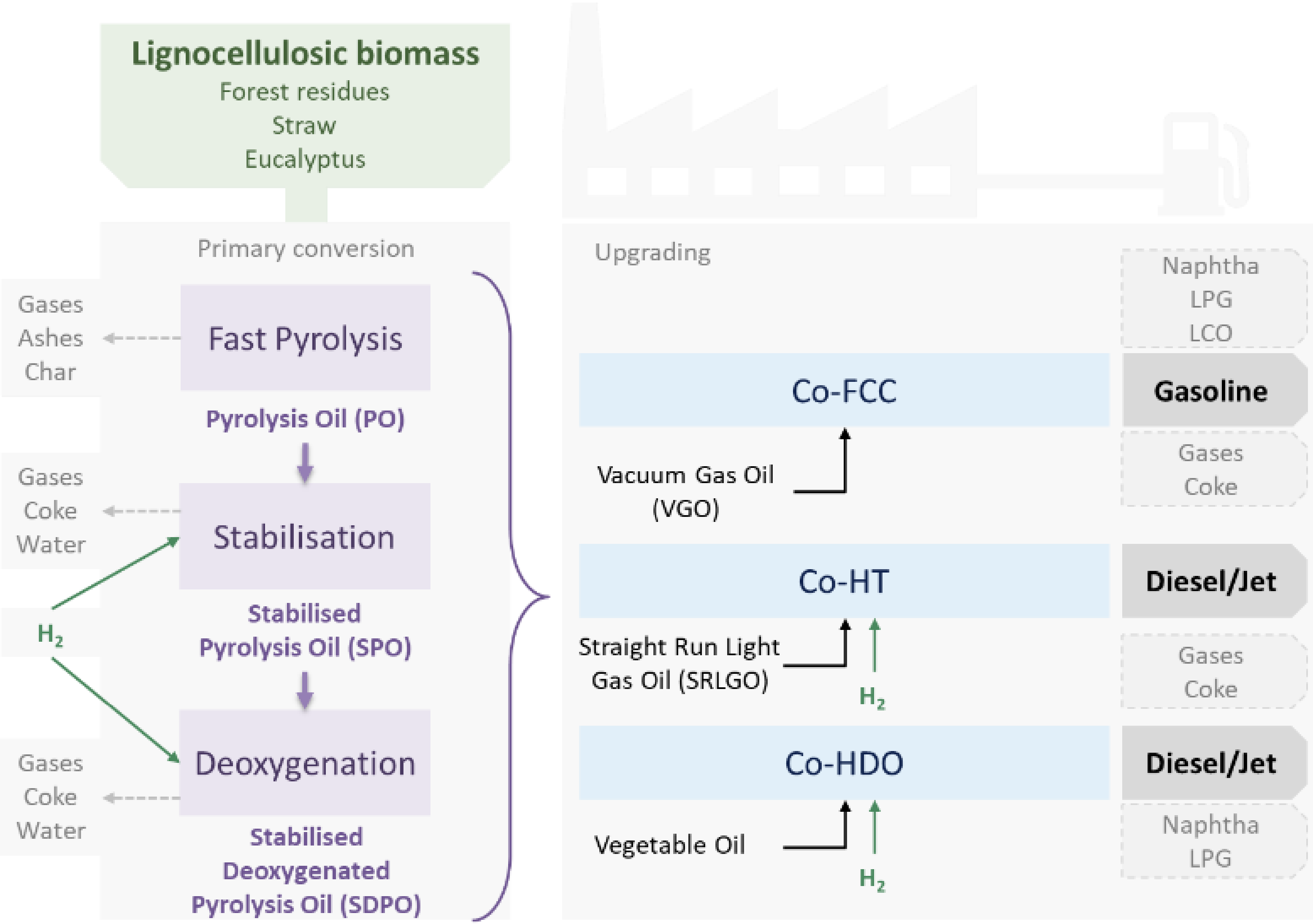
Business Case	Raw Material	De-centralised Pre-processing	Refinery Processing	Product
FCC-1	Forest Residue	**Fast Pyrolysis** N plant(s)	**FCC**	Gasoline
HTL-1	Forest Residue		**HTL** 1 plant → **HT**	Diesel
HT-1	Forest Residue	**Fast Pyrolysis** N plant(s)	**UPGR** 1 plant → **HT**	Diesel

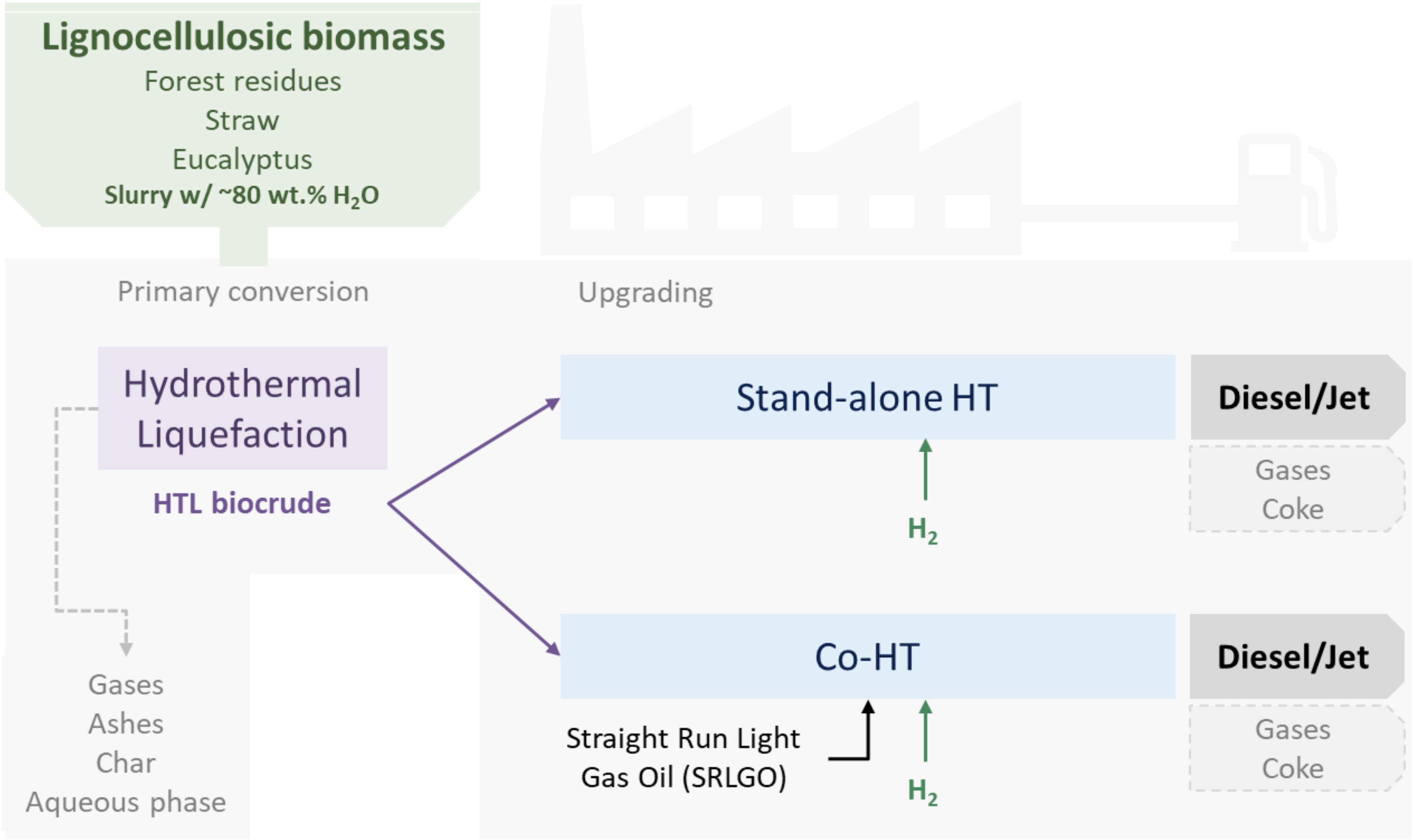
Overall Conclusions (1)

- There is significant potential to make use of existing EU refineries
- HTL less mature than FP – Still technical challenges to be tackled in the near-future
- Co-HT less mature than co-FCC - but there are significant mid-to-long-term opportunities for co-HT
  - The aviation and shipping industries present a longer-term market for co-processed fuels.
  - Support and initiative focused on SAF and sustainable shipping



Overall Conclusions (2)

- Lignocellulosic biomass supply chains are relatively immature at present, though vary by feedstock and region.
    - EU has high feedstock potential but local level feedstock assessments will be needed to determine the true level of feedstock availability
    - Decentralised primary conversion steps can simplify the supply chain
- Competitive pricing is the main factor for the market integration of co-processed fuels

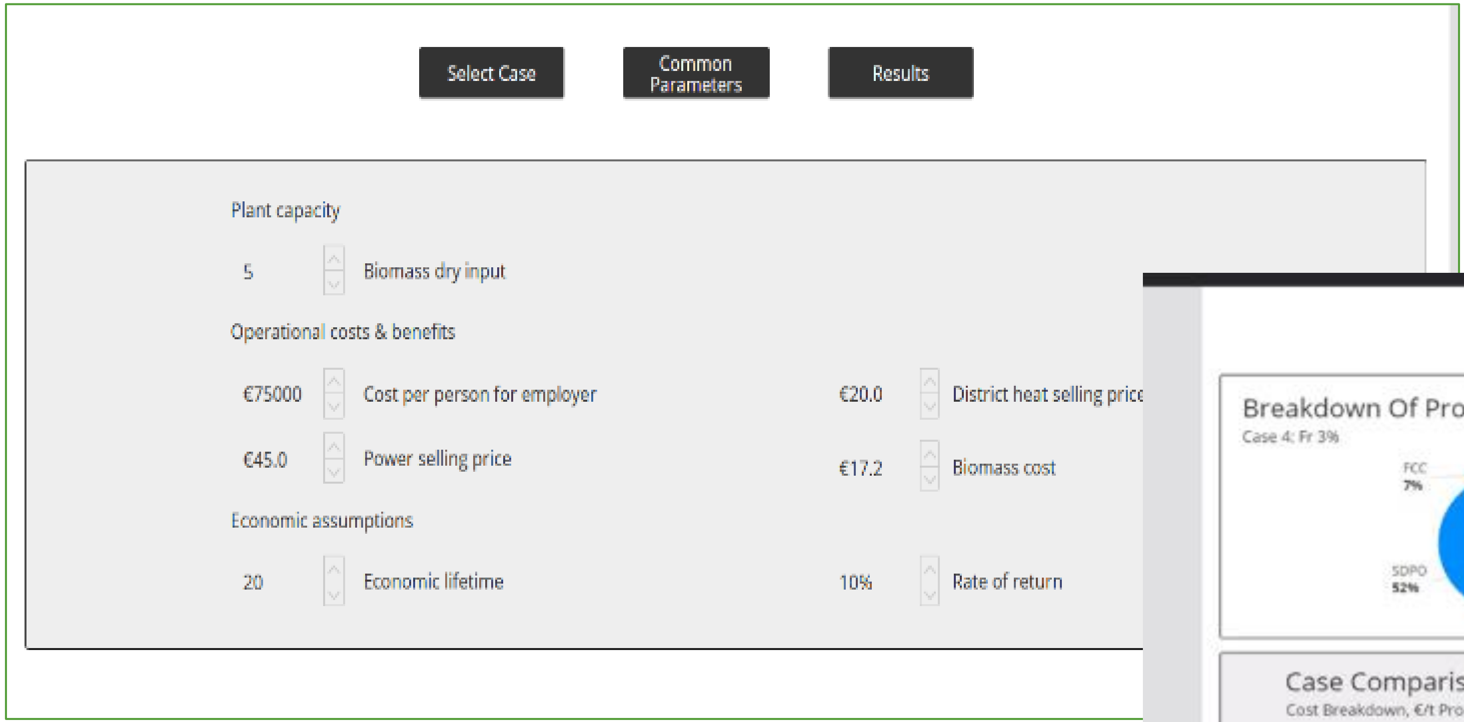


Public acceptance - Overall Findings

- The public is in general found to be **supportive of biofuels**, although public knowledge and understanding of biofuels is found to be limited.
- Thus, **public opinion is vulnerable to dominant discourses and media frames** and can be **swayed** by these.
- **Knowledge is found to be a key element in the shaping of public opinion**, and awareness of unintended consequences of biofuel implementation diminishes public support.
- Some **potential drawbacks** related to biofuels, such as land requirements, iLUC (indirect land use change), and biodiversity impacts, **seem to be seldom understood by the public**, which raises the **importance of knowledge** increase and a **factual transparency** of these critical aspects.
- This becomes increasingly important as large scale production of biofuels are developed.

- Balanced and transparent reporting of involved risks and benefits will be key to continued **public support** and a **stable investment-environment**.

Final developments: Toolbox for scenario analysis



- Based on database and models developed in the 4Refinery Project
- To be accessible for scenario analysis

Acknowledgements to 4Refinery Consortium

Process Model and Techno-Economis

Sustainability

Liquefaction Processes

Bio-crude

Refinery Processing Technologies

Advanced Biofuel

Public Acceptance

Business Models

Thank you for your attention!

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