Future Diesel-like renewable fuels - A literature review

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Contents

Reference box for additional comments

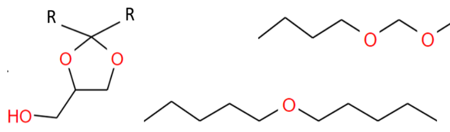
Motivation

- **Commercial HDV transportation is primarily powered by internal combustion engines (ICE)**
- **Although electrification is proposed, long-distance transport will still significantly rely on ICE in the next 10 years**
  - *To decarbonize these vehicles, the development and use of low-carbon fuels by 2030 is essential*
- **Goal: identify the relevant renewable diesel-like options for 2030 by considering the following aspects**
- **➔ Sustainability and scalability by 2030**
  - *Consider feedstock type and availability, production cost, process maturity and life-cycle greenhouse gas emissions as key parameters*
- **➔ Compatibility with legacy and future fleet**
  - *Consider combustion, after-treatment efficiency, hardware compatibility and durability as key parameters*
  - *Limited to no modifications to the vehicles' settings and hardware*
- **➔ Fuel specifications adaptation?**
  - *Need to adapt fuel specifications to allow higher blending ratio of renewable fuels in the conventional diesel 'EN590' pool and go beyond the blending wall?*

Structure of the study

Focus of this presentation

Task 1. Resources → Processes → Renewable components



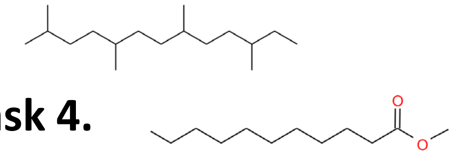
Task 2. Combustion system compatibility

Task 3.

LCA & Eco assessment of selected novel components

Blending optimisation with conv. fuels

Task 4.



LCA & Eco assessment of selected energy paths toward FAME and paraffins

Blending optimisation with conv. fuels

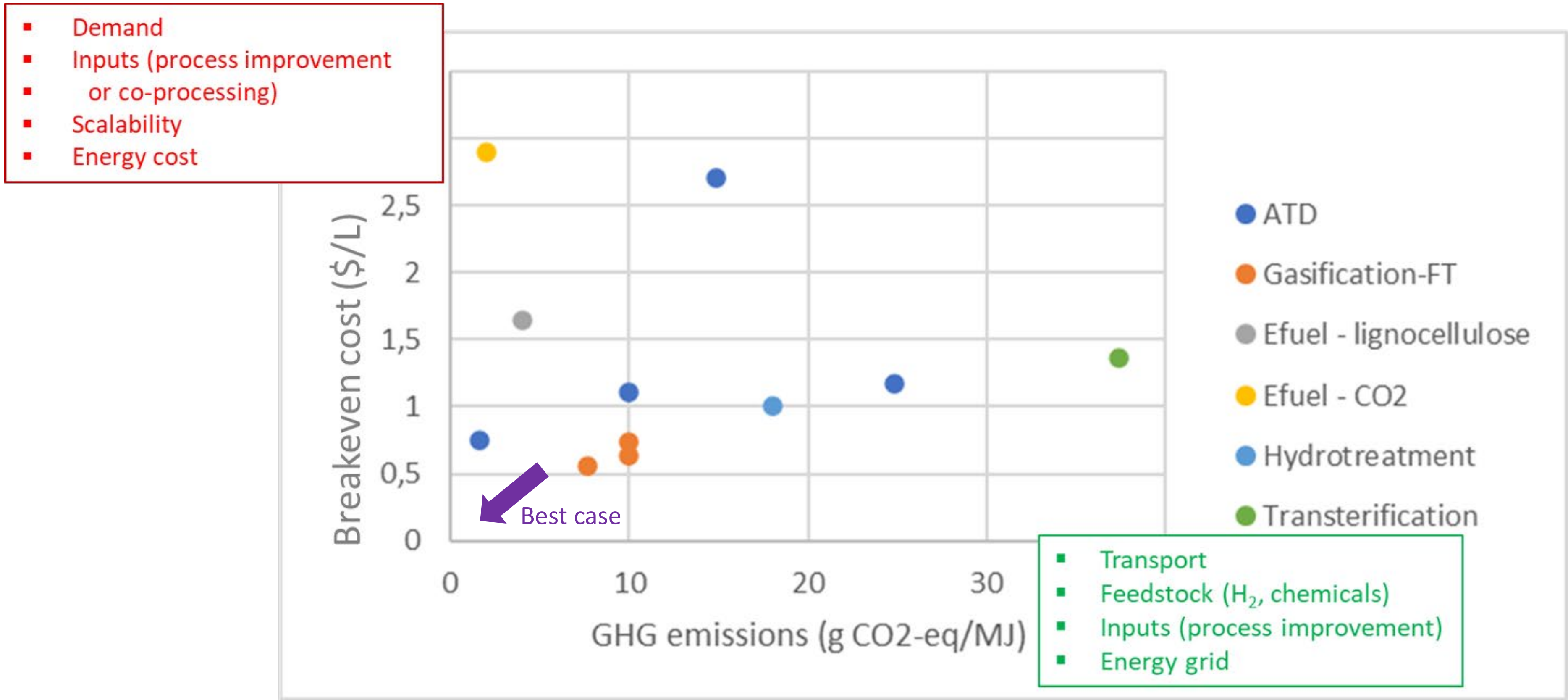
Task 5. Stakeholders Interviews

Task 6. Research needs & Conclusions

Selected pathways - Feedstock, process and product

	Resource	Process	Product	Comments / Research needs
	Lignocellulose	Fermentation ATD	Paraffinic distillate	Industrialised technology Flexibility to other products ➔ diesel or kerosene optimisation impacts?
	Lignocellulose	Gasification - FT	Paraffinic distillate	Technology close to industrialization - Optimisation prospects Flexibility to other products but integrability and adaptation to lignocellulose required
	WCO / Animal fat / Energy crop oil	Hydrotreatment of triglycerides	Paraffinic distillate (HVO / HEFA)	Industrialised technology Application to a wider range of resources Integration of renewable H2?
	WCO / Animal fat / Energy crop oil	Transesterification	FAME	Industrialised technology – adapted to small scale /close to resource Blending constrains
E-fuel Focus on hybrid process	Lignocellulose	eFuel – Lignoc.	Paraffinic distillate	eH2 and RWGS technology to industrialise Optimisation prospects (electrolysers, CO2 capture, CO/CO2 from biomass) High flexibility to other fuels
	CO2	eFuel – CO2	Paraffinic distillate	

LCA - TEA of selected pathways



- The sensitivity to the resource can be very different for the energy pathways (ATD)
- Best CO_2 score for ATD and E-fuel
- Good compromise for distillate from gasification + FT pathway

Biomass conversion yields to renewable fuels

Hypothesis : Full conversion of FT-wax into distillate

Pathway	Feedstock	Mass yield
Fermentation – AtD	Sugarcane	9 ↔ 12%
Oil hydrotreatment	Waste cooking oils	90 %
	Lard and beef tallow animal fats	92 ↔ 97%
Transesterifcation	Waste cooking oils	83 ↔ 97%
	Animal fats	93 %
Gasification + Fisher-Tropsch	Biomass	14 ↔ 26%
E-fuel from lignocellulose	Biomass + electricity	47 ↔ 52%
Lignocellulose hydrotreatment	-	No data found
E-fuel from CO_2	-	No data found

Potential middle distillate production

Based on biomass availability by 2030

- Projected renewable fuel production assuming all the sustainable biomass* for bioenergy by 2030

Conservative approach with most mature techonolgies

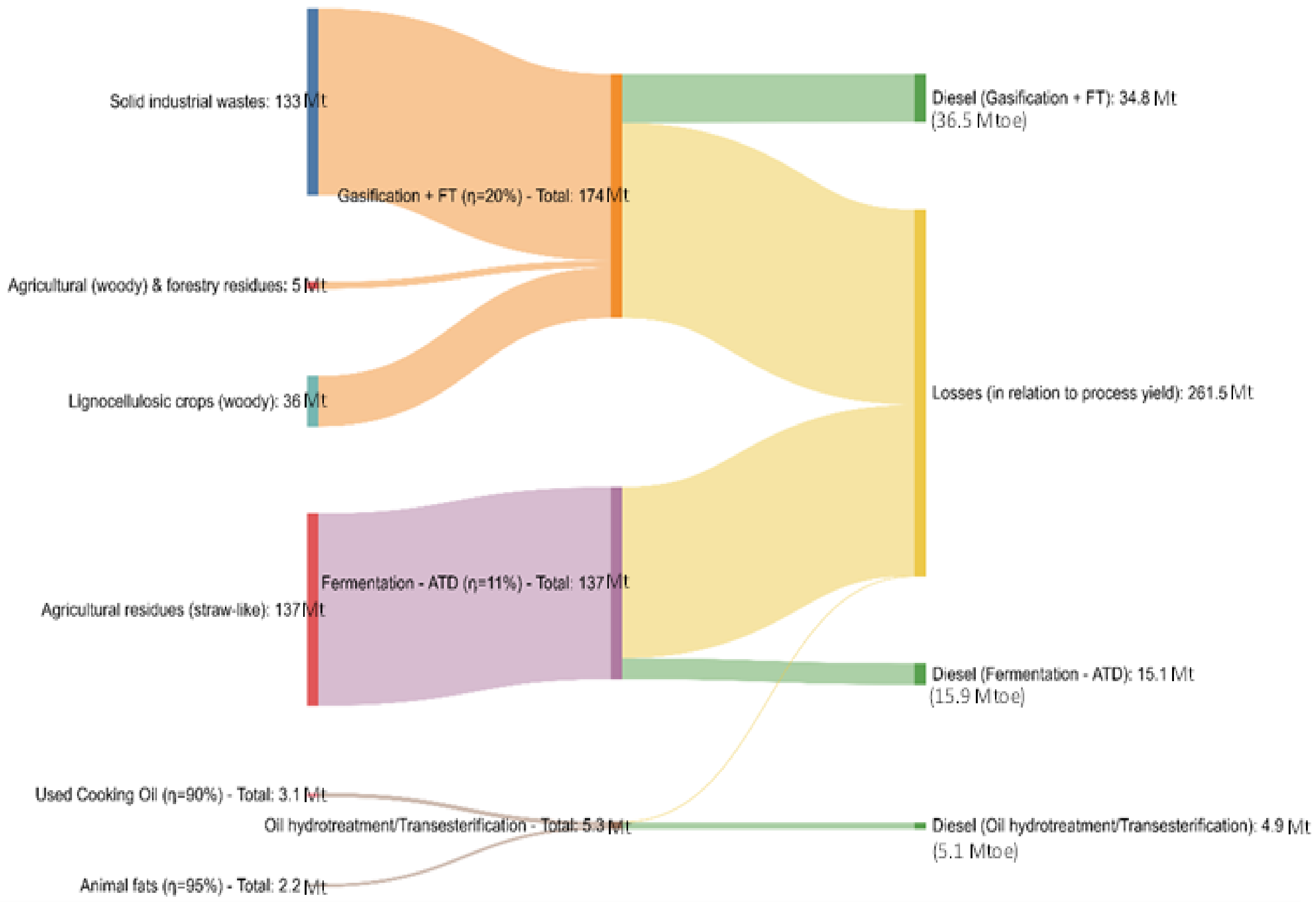
Assuming availabitily of renew. electricity

Pathway	Fuel	Feedstock	Projected feedstock (Mt)	Estimated advanced renew. fuel quantity (Mt)	Estimated advanced renew. fuel quantity (Mt)	
			Imp. Coll. data	Imp. Coll. data	Literature review	
Fermentation – AtD	Paraffinic fuel	Solid industrial waste (secondary agro & forest industries)	133 → 191	-	14.6 → 21.0	New
		Agricultural residues (straw-like)	137 → 165	-	15.1 → 18.2	
		Lignocellulosic crops (grassy)	36 → 108	-	4.0 → 11.9	
Oil hydrotreatment	HVO	Used Cooking Oil (UCO)	3.1	2.6	2.8	✓
		Animal fats	2.2	1.87	2.1	
Transesterification	FAME	Used Cooking Oil (UCO)	3.1	-	2.8	New
		Animal fats	2.2	-	2.0	
Gasification + Fisher-Tropsch	Paraffinic fuel	Solid industrial waste (secondary agro & forest industries)	133 → 191	27.9 → 40.1	26.6 → 38.2	✓
		Agricultural (woody) & forestry residues	5 → 7	1.0 → 1.5	1.0 → 1.4	
		Lignocellulosic crops (woody)	36 → 108	7.6 → 22.7	7.2 → 21.6	
E-fuel from lignocellulose	Paraffinic fuel	Solid industrial waste (secondary agro & forest industries)	133 →191	53.2 → 76.4**	66.5 → 95.5	✓
		Agricultural (woody) & forestry residues	5 → 7	2 → 2.8**	2.5 → 3.5	
		Lignocellulosic crops (woody)	36 → 108	14.4 → 43.2**	18 → 54	

**Sustainable biomass availability in the EU, to 2050 – Imperial College London*
***ICL report estimated advanced renew. fuel quantity as for 2050*

Renewable middle distillates production potential by 2030

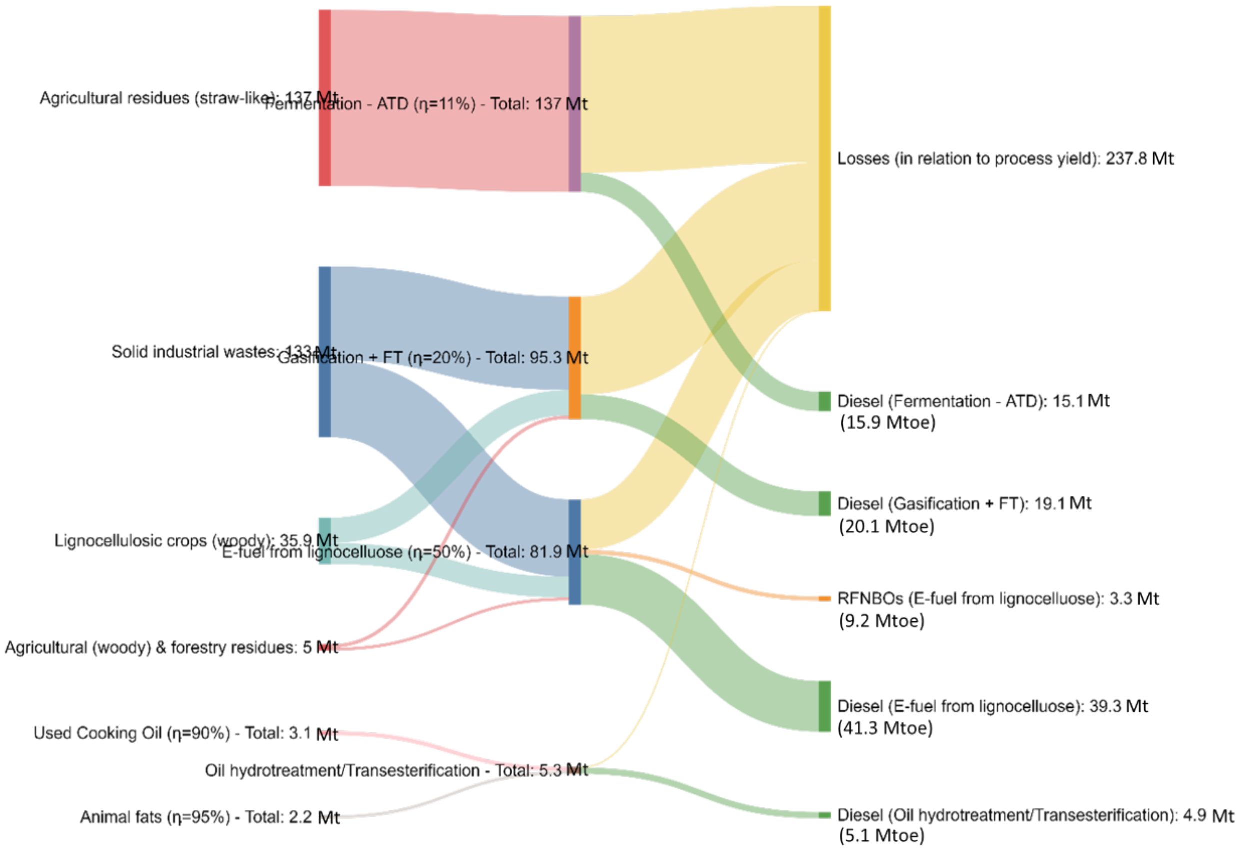
- Considering **high TRL processes only,** the renewable diesel production <u>potential</u> considering sustainable biomass availability by 2030 ranges between **57 and 88 Mtoe/y** (i.e. 24-37% of demand for middle distillates which is estimated at 241 Mtoe out of 350 Mtoe for the transport sector in 2030)



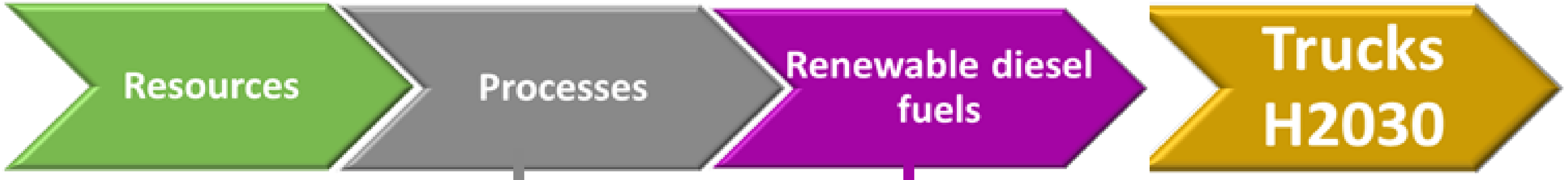
Renewable middle distillates production potential by 2030

- Adding (former) **regulatory objectives for RFNBOs** (2.6% ener.), the renewable diesel production <u>potential</u> considering sustainable biomass availability by 2030 ranges between **92 and 123 Mtoe/y** (i.e. 38-51% of demand for middle distillates in 2030)

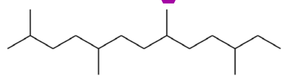
Distillates production requirement in Mt (low resources mobilization and RFNBOs target)



Evaluation of blending behaviour & opportunities



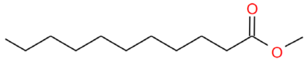
Gasification - FT
eFuel - lignoc.
eFuel - CO2
Hydrotreatment Lignoc.
Hydrotreatment oil
Fermentation ATD
Transesterification



Paraffins
FT type of product → **FT best and worst**

Paraffins
HDT type of product → **HDT best and worst**
Energy crops (EC)
Animal Fats (AF)
Waste cooking oil (WCO)

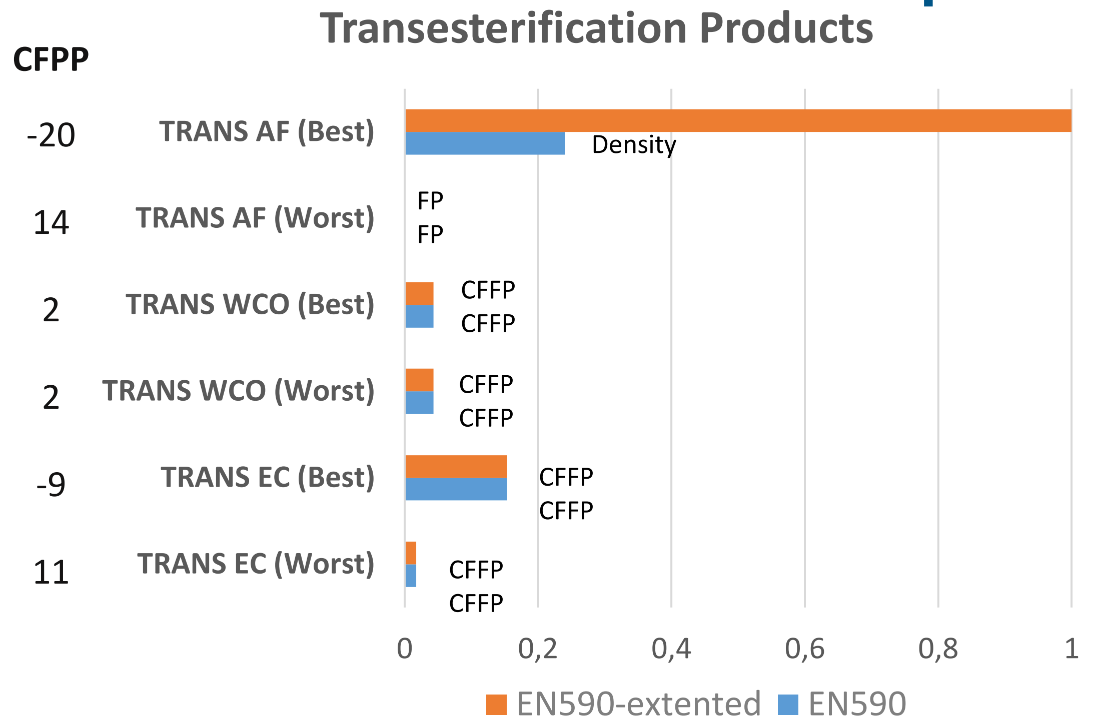
FAME → **TRAN best and worst**
Energy crops (EC)
Animal Fats (AF)
Waste cooking oil (WCO)

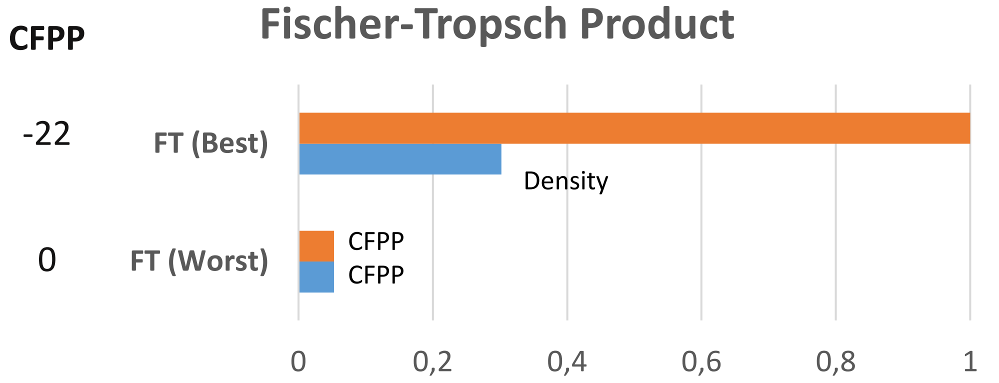


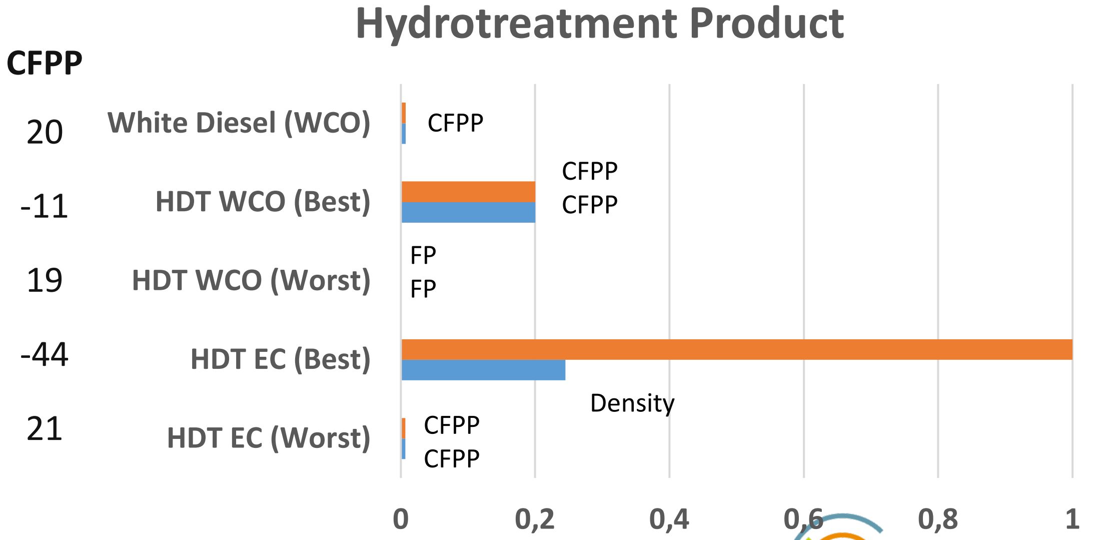
- ✓ Characterisation of fuel variability
- ✓ Definition of mixing rules (focus on cold flow properties but includes CN, FP, Density and Viscosity)
- ✓ Blending optimisation with and without additives
- ✓ Sensitivity from relaxed specifications

Blending limits - Conservative approach (MODEC model)

Base fuel CFPP: -25°C / Spec. Limit: -20°C (Class F)



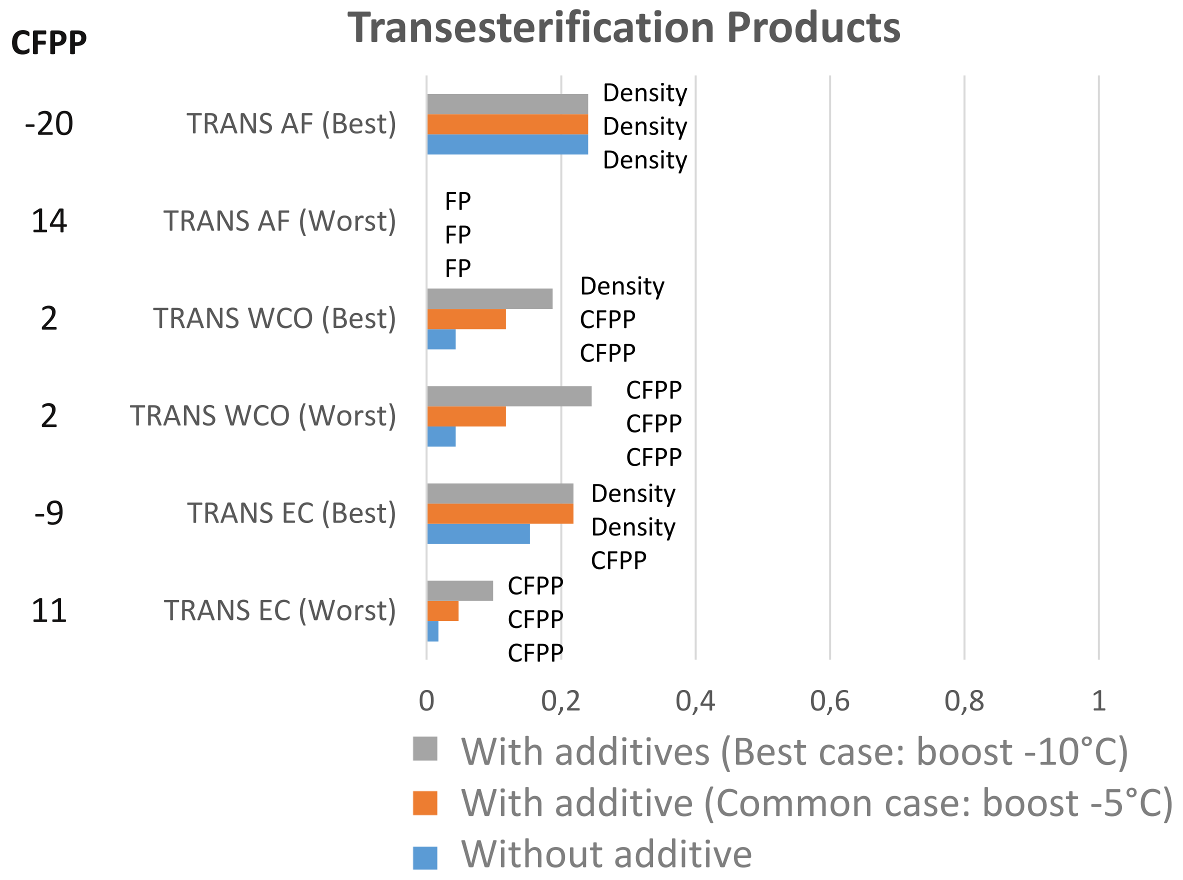


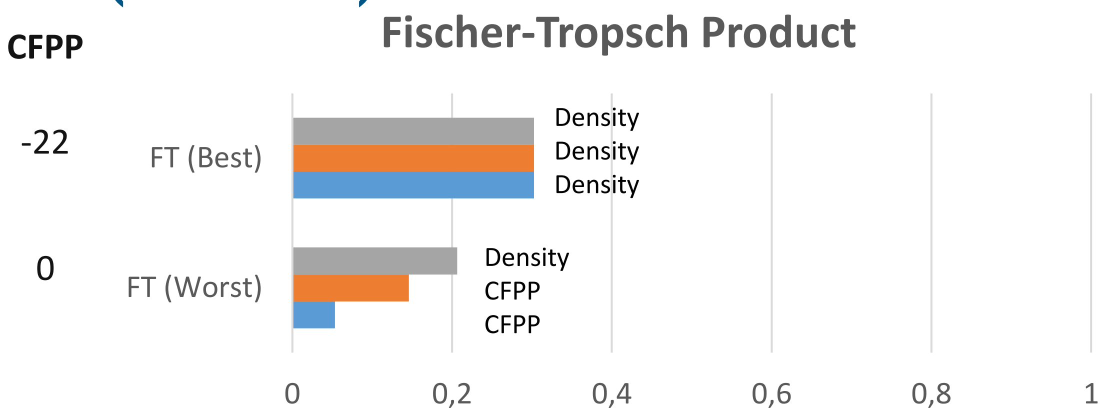


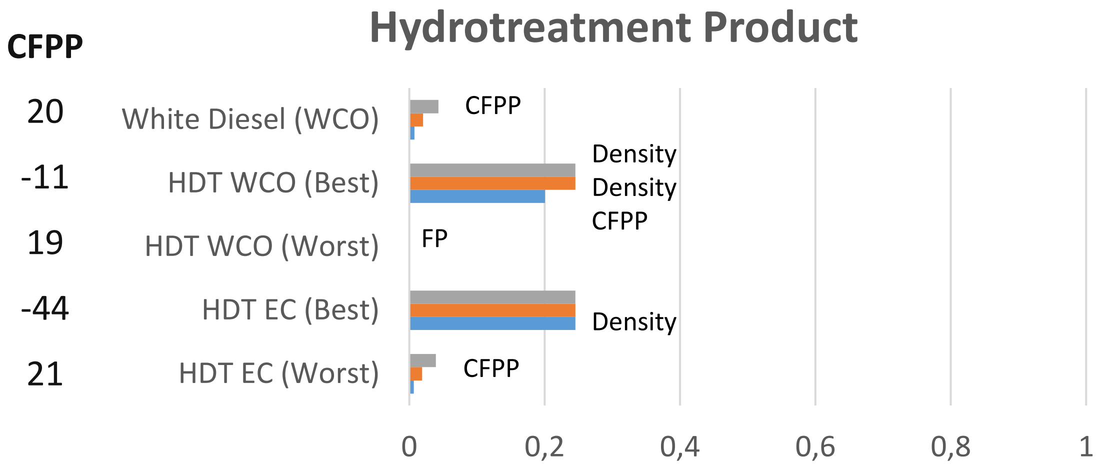
- Density and cold flow are the main constraints.
- Not shown here but a different model would lead to 5-10 points increase once the CFPP is the limiting factor
- Main advantage of extended specification is to be less density dependent for significant energy path (AF trans / HDT of energy crops / FT)
- CFPP is the constraint otherwise and limits greatly the incorporation rate
- FP can be a constraint for selected low-quality feedstocks (Worst HDT WCO/Trans AF)

Blending limits - Additive impact - Focus on EN590 boundaries

Base fuel CFPP: -25°C / Spec. Limit: -20°C (Class F)





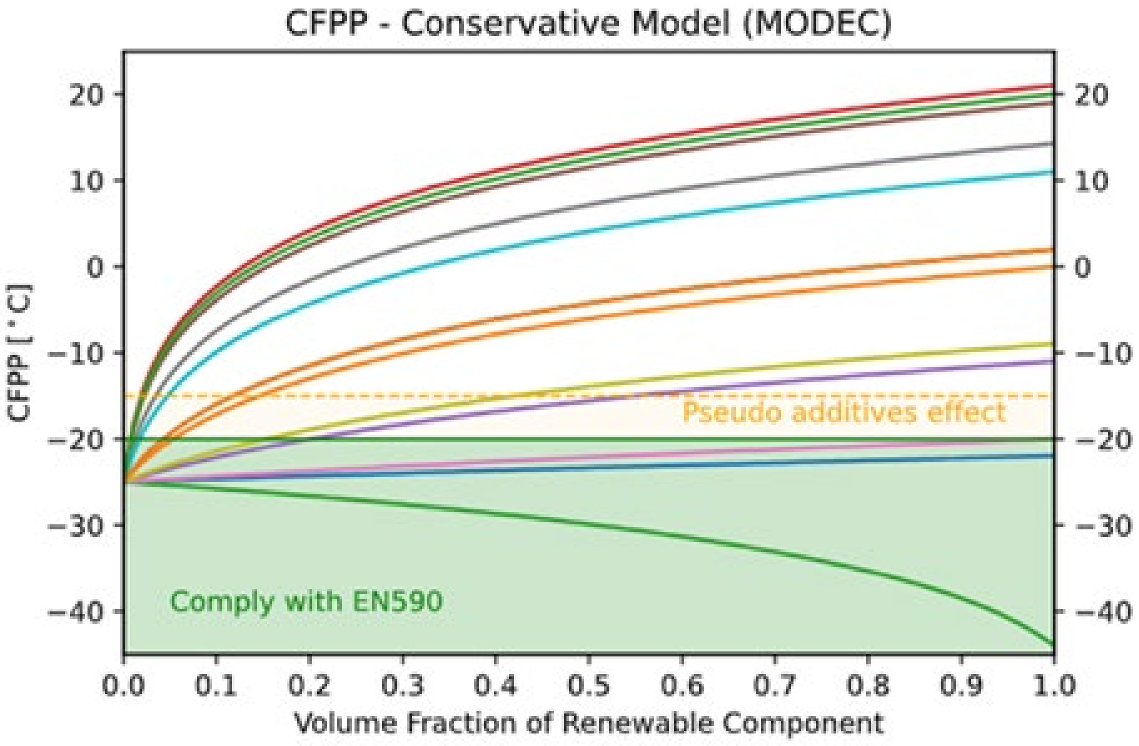


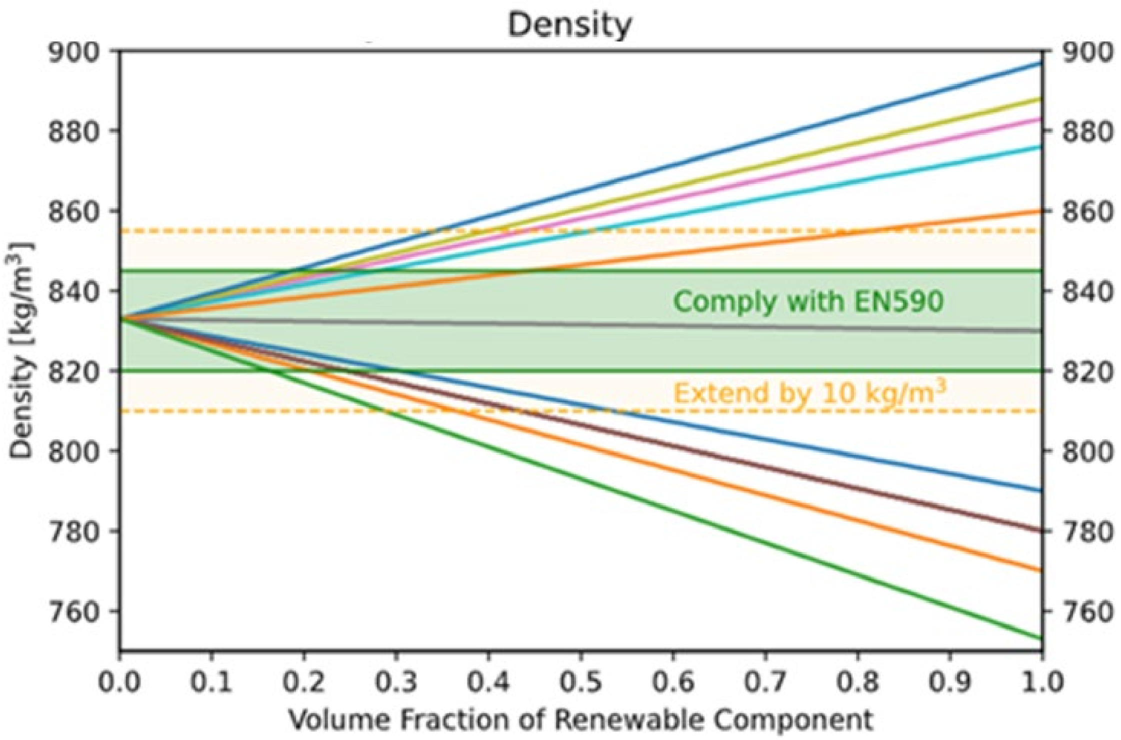
- Additivation only improves cold flow properties (Cetane number is not a limit)
- The use of cold flow improver increases the blending ratio from about 5 to 20 points. The increase being lower for higher CFPP temperatures. Nevertheless, the density can become a constraint before this maximum increase is reached (e.g. TRANS WCO or EC, FT, HDT WCO).

- For every “best” energy path, the density is either the first constraint or it becomes quickly the limit if the cold flow improver additive is used.

Insights into possible fuel specifications evolutions for an increased renewable content

- CFPP and Density are the main constraining properties
- Figures below illustrate CFPP and density blending behavior for all energy paths identified





- Rapid CFPP increase at low blending ratio limiting the biocomponent concentration.
- Adjusting the standards for CFPP may be difficult due to operating/logistic constraints.
- Improving the cold flow properties of renewable diesel products through various means is potentially an important lever for maximizing the use of sustainable products.

- Only one product identified is fully compatible with EN590 density range
- Extending the EN590 density limits by ±10 kg/m3 (arbitrarily chosen for demonstration only) could lead to increase in the maximum blending ratio by about 15-25% (best case by 35%).

Summary

Resources | **Processes** | **Renewable diesel fuels**

Lignocellulose

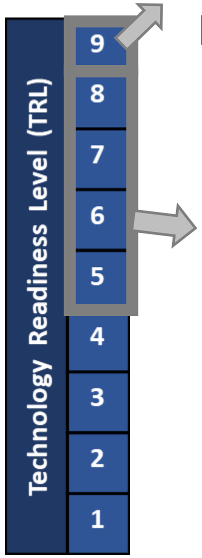
- *agricultural & forestry residues*
- *woody and grassy energy crops (no oil)*
- *industrial residues (biomass residues)*

Conv. resources

Advanced resources

Used oil or animal fats

Atmospheric CO_2 + renewable energy (Direct Air Capture)
industrial off-gases (Concentrated CO_2 sources)



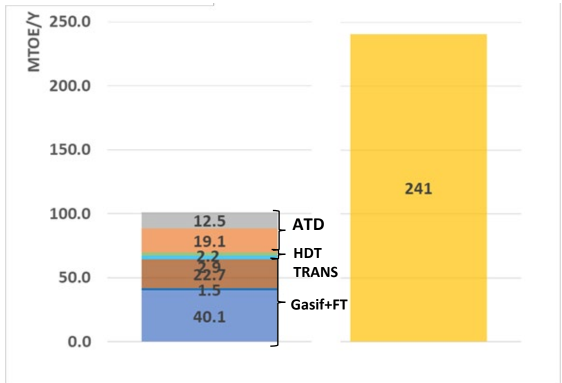
Transesterification
Hydrotreatment oil
Fermentation (ATF)

Gasification + FT
E-Fuel – CO_2
E-Fuel – Lignoc.
Hydrotreatment Lignoc.

Processes upgrade potential/requirements:

- pre-treatment/process opti for various feedstocks
- H_2 integration for further GHG reduction
- Better LCA/TEA evaluation (standard for LCA)
- Production capacity increase to convert biomass potential

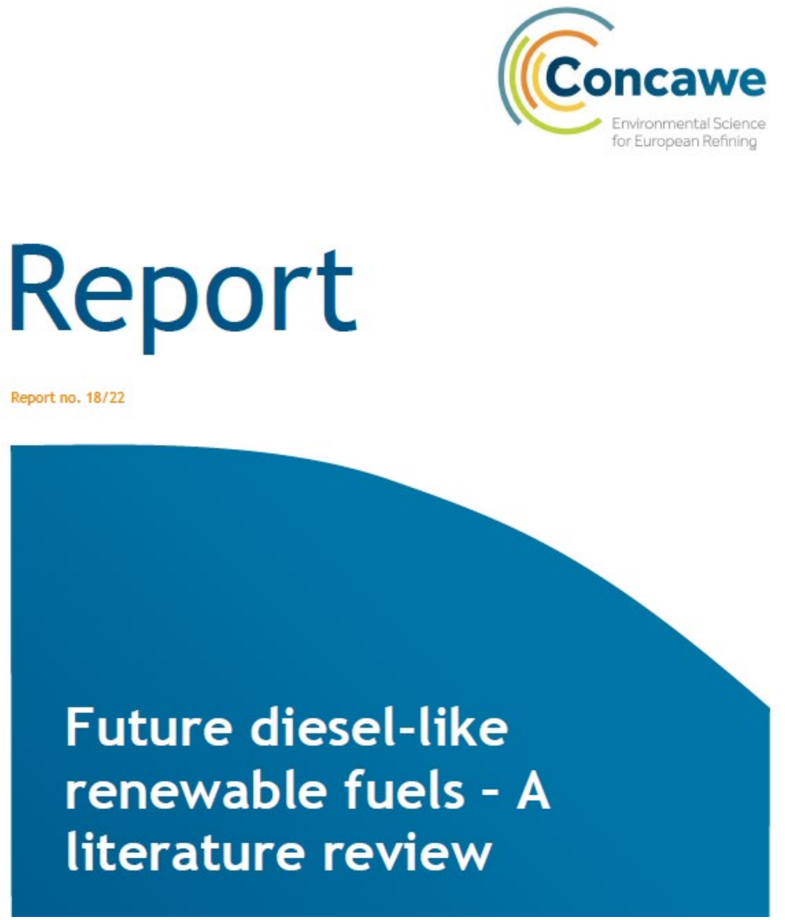
- **FAME and Paraffins variabilities mainly affect cold flow properties and density**
- **Density is the main EN590 constraint for increasing renewable content. Cold flow property improvement can contribute to increase up to 20 points the renewable content but is feedstock dependent**
- **Blending behavior estimation with conventional fuels could be further improved due to limited data for FAME/paraffins blends**
- **Competition with other sectors especially for paraffins in the next decade**



Biomass and green H_2 potential availability ➔ Production potential up to 24-51% of expected middle distillate demand by 2030

Read more

- **Concawe report**
  - https://www.concawe.eu/wp-content/uploads/Rpt-22-18.pdf



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Thank you for your attention

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