Potential of F-T Syncrude in European Refining Industry

FLEXCHX Workshop
3.4.2019

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Contents

1. Objectives

Objectives of Work Package 7 – Integration of FT products to refineries

Completed work in Task 7.1

1. What refinery units and other processing plants (e.g. biofuel facilities based on HVO) can process F-T syncrude?
2. How is it (technically) feasible to introduce F-T syncrude into refineries?
3. What are the market conditions for the European refining industry and potential products derived from F-T syncrude?
4. What are the most likely partnership opportunities?

Next steps

1. Task 7.2: Case studies and business concepts
2. Task 7.3: Risk assessment for using F-T products in final refining of transport fuels

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2. Introduction

Introduction

- FLEXCHX units produce Fischer-Tropsch synthesis product, so-called F-T syncrude
- The FLEXCHX unit uses cobalt-based low temperature Fischer-Tropsch synthesis
  à the baseline for this study was the composition of Co-LTFT syncrude, derived from literature
- At the FLEXCHX unit the syncrude downstream processing involves cooling, resulting in three syncrude fractions
  - Naphtha,
  - Distillate and
  - Wax
- Eight different co-processing pathways for FLEXCHX syncrude were defined for seven product
- The potential integration facilities were an oil refinery, steam cracker and an HVO plant
- The European product market for interesting products was defined, including current demand, market outlook and supply structure

Studied FLEXCHX F-T syncrude co-processing product opportunities

Oil refinery
- Motor-gasoline
- Diesel
- Jet fuel

Steam cracker
- Ethylene
- Propylene

HVO plant
- Renewable diesel
- Renewable jet

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3. F-T syncrude co-processing

Definition of FT syncrude

- FLEXCHX syncrude composition was estimated in order to estimate suitability for different co-processing methods
- Assumed composition was cobalt-based low-temperature Fischer-Tropsch syncrude derived from literature

Product fraction	Carbon range	Share of product fraction (%)
Tail gas	C1-C2	7
LPG	C3-C4	5
Naphtha	C5-C10	20
Distillate	C11-C22	22
Wax	>C22	44
Aqueous product	C1-C5	2

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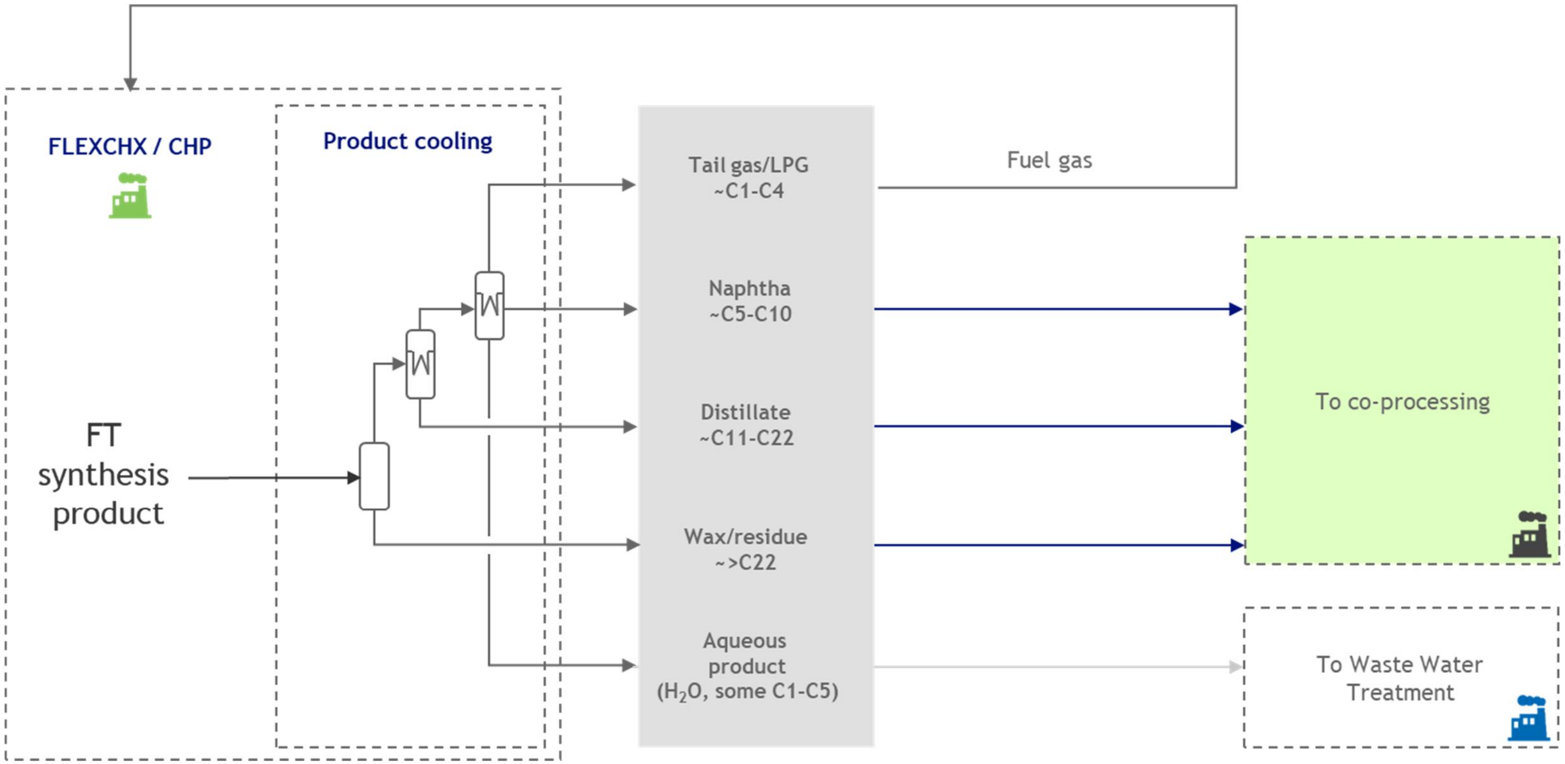
F-T syncrude fractionation scheme



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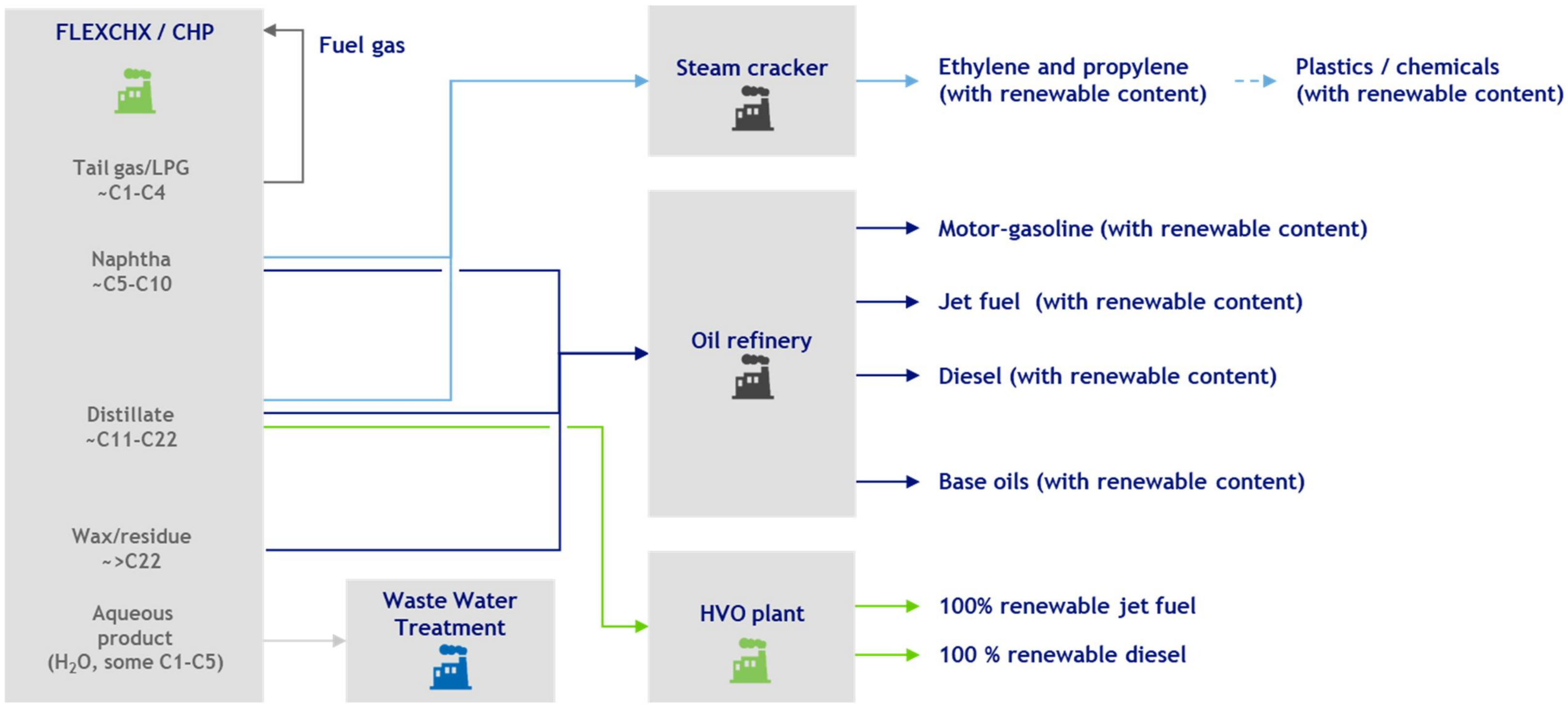
Potential FLEXCHX syncrude integration pathways



F-T syncrude feedstock properties

FT fraction as feedstock for product	Positive	Negative
F-T naphtha for motor gasoline	• Renewable hydrocarbon gasoline component • Sulphur-free feedstock	• Low octane number • High olefin content
F-T distillate for diesel	• Mainly n-paraffins; high cetane number • Mainly n-paraffins (low density) à good density adjuster for fossil diesel • Possibly suitable as direct diesel blendstock • Sulphur-free feedstock	• Mainly n-paraffins; poor cold flow properties. Isomerization required, which is typically not available for diesel range in oil refineries
F-T distillate for jet fuel	• Mainly n-paraffins (low density) à good density adjuster for fossil jet • No aromatics à good smoke point adjuster for fossil jet • Sulphur-free feedstock • Low oxygen and metal content à low hydrotreatment requirement at an HVO plant	• Mainly n-paraffins; poor cold flow properties. Isomerization required (which available at HVO plants).
F-T wax (~C23-C45) for base oils	• Practically solely n-paraffins (very high viscosity index) à excellent feedstock for Group III base oils	• Practically solely n-paraffins (poor pour point); Hydroprocessing base oil unit required for co-processing
F-T wax for transportation fuels	• Sulphur- and metal-free feedstock for cracking • Hydrocracking increases the degree of branching, improving the cold flow properties of the cracked products	• Cracking produces a range of products, including lights
F-T naphtha and distillate for ethylene and propylene	• n-paraffins are excellent feedstock for steam cracker	• High olefin content (can cause coking); hydrotreatment of F-T naphtha/distillate possibly required prior co-feeding • Feed may contain oxygenates. Depending on type, oxygenates can create technical issues in crackers

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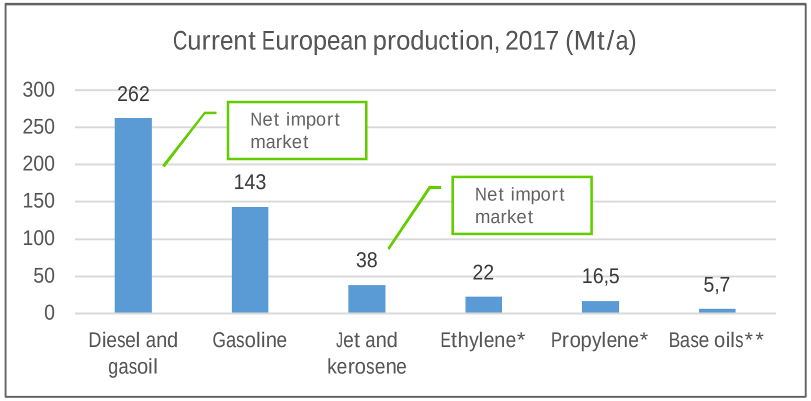
F-T syncrude co-processing suitability

F-T fraction to be co-processed	Main product	Integration facility	Co-processing suitability	Investment needs	Technical attractiveness
F-T naphtha	Motor gasoline	Oil refinery	No major technical limitations	No major investment needs	Good
F-T distillate	Diesel	Oil refinery	Possibly suitable for direct blending Cold flow properties a limiting factor	Isomerization required for high blends	Good/ Adequate
F-T distillate	Renewable diesel	HVO plant	No major technical limitations	No major investment needs expected	Good
F-T distillate	Jet fuel	Oil refinery	Expected poor cold flow properties for product with existing refinery units	Isomerization required for high blends	Poor
F-T distillate	Renewable jet fuel	HVO plant	No major technical limitations Isomerization typically included in HVO plants	No major investment needs expected	Good
F-T wax (as one fraction)	Base oils	Oil refinery	No major technical limitations	No major investment needs expected	Good
F-T wax (two fractions)	Base oils	Oil refinery	No major technical limitations	Fractionation of F-T wax cut required	Good
F-T wax	Transportation fuels	Oil refinery	No major technical limitations	No major investment needs expected	Good
F-T naphtha and/or distillate	Ethylene and propylene	Steam cracker	Olefins in feed can cause coking Pre-treatment possibly required	Possibly hydrotreatment required as feed pre-treatment	Adequate/Poor

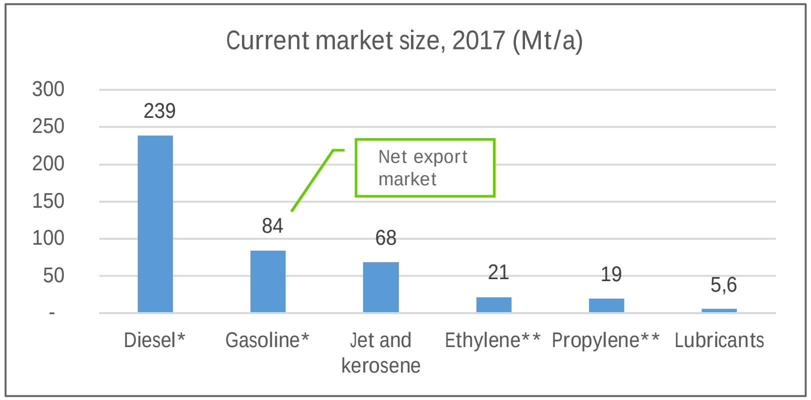
4. Product market

Market introduction

- Current and future markets were evaluated for
  - Transportation fuels: Diesel, gasoline, jet fuel
  - Other products: Ethylene, propylene and base oils/lubricants
- The study focused on European markets
- The combined market size for these products is 440 Mt/a
- There is a major diesel-gasoline imbalance in Europe (demand and import high for diesel, supply and export high for gasoline)
  - Due to refinery configuration and long-declining gasoline demand
- The demand of renewable fuels is mainly driven by targets to reduce carbon emissions and related mandatory quotas for renewable energy share in transport



*2016
**capacity



*Includes renewables
**2016

Market summary

	European market size 2017, Mt/a	Market prospects, CAGR %/a up to 2035	Growth hindering factors for fossil products	Share of renewables in Europe	Demand drivers and trends for renewables	Substituting renewable solutions	Fossil/ Renewable product price EUR/t	Overall market attractiveness for a renewable product up to 2035	Overall market attractiveness for a renewable product post 2035
Jet and kerosene	68 Mt/a	0,5	More efficient aircrafts, higher oil prices, marine bunker demand increase	Only small volumes in test and local flights	Increasingly ambitious renewable energy share targets	Renewable aviation fuel	560 Significant higher price (due to cost)	Medium à High	High
Diesel	239 Mt/a	-1,0	More efficient vehicles, electric cars, diesel bans	Ca. 5 %	Increasingly ambitious renewable energy share targets	Biodiesel (FAME), Renewable diesel (HVO)	530 1270 (HVO)	Medium	High in segments using diesel, e.g. heavy duty transport
Motor-gasoline	86 Mt/a	-1,5	More efficient vehicles, electric cars	Ca. 5 %	Increasingly ambitious renewable energy share targets	Ethanol, other oxygenates, biogasoline	555 660 (ethanol)	Medium	Low
Base oils	5,6 Mt/a	1 (globally 2016 to 2031)	Dependency on automotive industry	None	More environmentally friendly product opportunity	Renewable base oils (based on vegetable oils)	825 (Group III)	Medium	Medium
Ethylene	25 Mt/a	0,0 (2016 to 2021)	Strong competition from ethylene derivatives from U.S. and China	None	Brand owners' willingness to develop renewable consumer products	Bio-ethylene (from ethanol)	1100	Low	Low (unless production costs decrease)
Propylene	17 Mt/a	0,6 (2016 to 2021)	Strong competition from propylene derivatives from U.S. and China	None	Brand owners' willingness to develop renewable consumer products	Bio-propylene (not in production)	940	Low	Low (unless production costs decrease)

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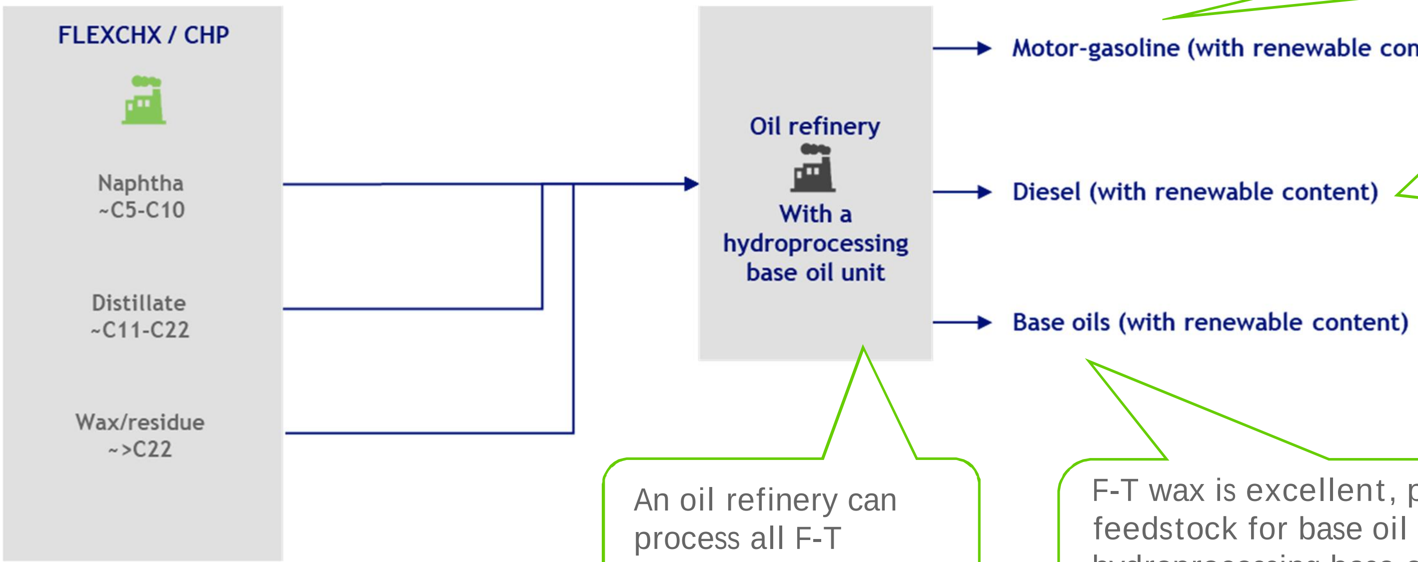
5. Integration cases

Integration case 1

Oil refinery with a hydroprocessing base oil unit



Gasoline production (catalytic reforming) is sensitive to heavy components à naphtha fraction quality needs to be considered

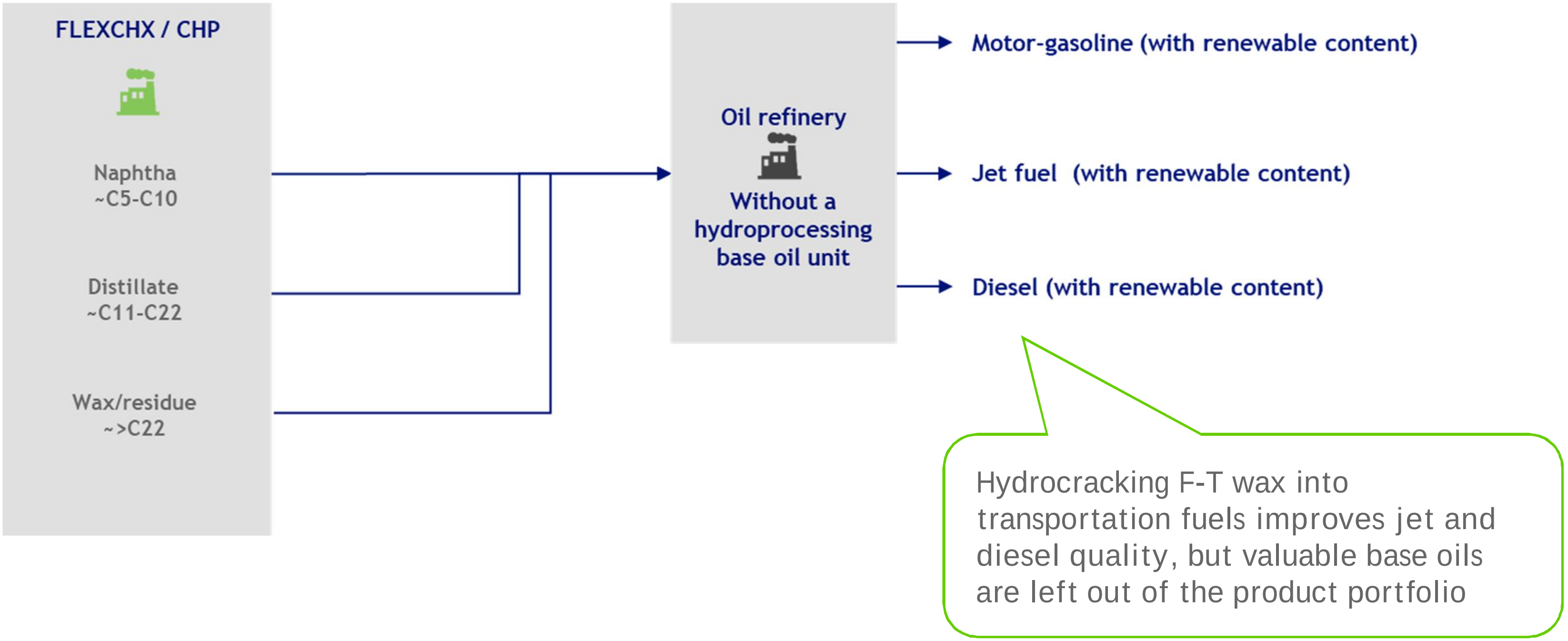
Blending distillate to diesel is an opportunity: by-passes hydroprocessing step, saves in production costs

An oil refinery can process all F-T syncrude fractions

F-T wax is excellent, paraffinic feedstock for base oil production in the hydroprocessing base oil unit à base oil end product quality could be improved (better price)

Integration case 2

Oil refinery without a hydroprocessing base oil unit

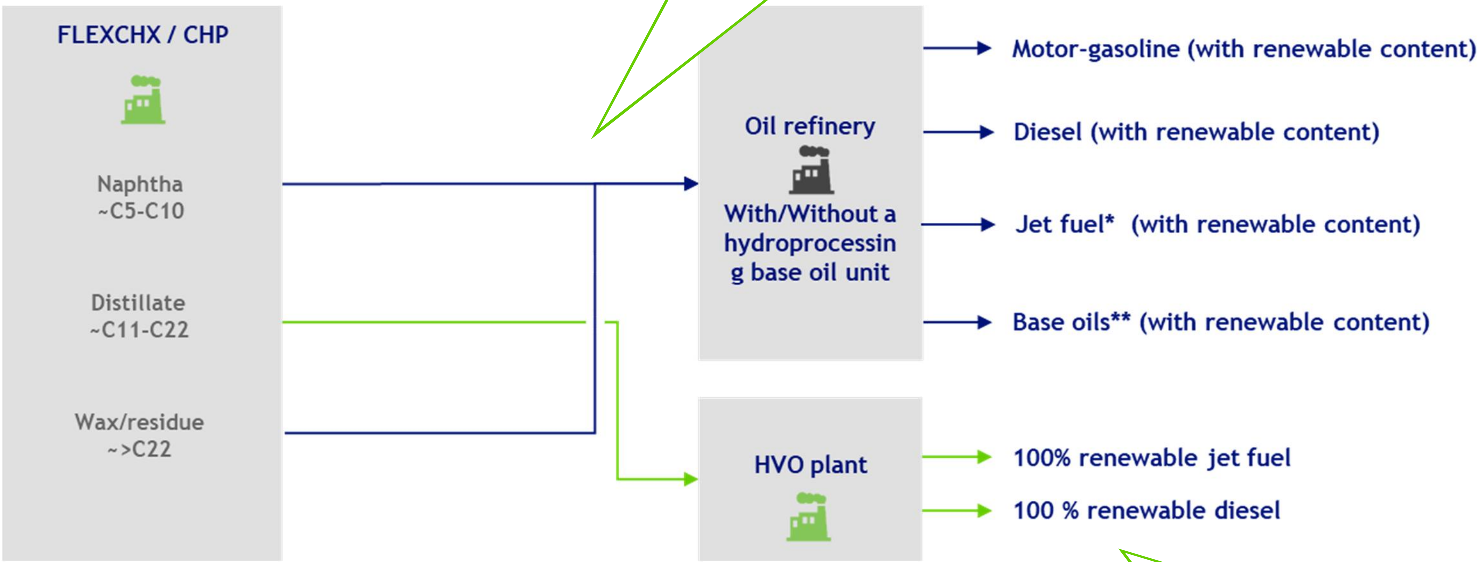


Integration case 3

HVO plant and oil refinery

An HVO plant can only process the distillate, other fractions need to be processed at an oil refinery

An ideal integration case is an HVO plant with an oil refinery at the same site



Renewable jet fuel and diesel have better quality thanks to the isomerization available at the HVO plant

*Produced in a refinery without a base oil unit
** Produced in a refinery with a base oil unit

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6. Next steps for project

Work continues with business concepts

Task 7.2 – Case studies and business concepts

Objectives:

- What is the most optimal scenario of utilizing F-T syncrude in a refinery/HVO plant
- Planning of how to realize the required process changes and how to increase the capacity gradually
- Estimating the maximum price of FT wax from downstream operation (refiners or other upgraders) perspective (in the present and future European energy system)
- Identification of possible business cases and partnerships between CHP and refinery industries

Main work method is collaboration with refinery and CHP plant partners

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Thank you.