FLEXCHX
Potential of F-T Syncrude in European Refining Industry

COMSYN Workshop
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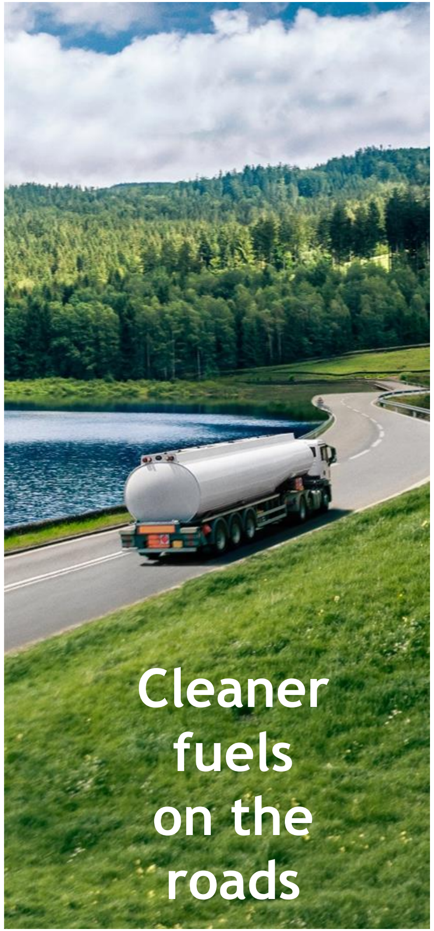
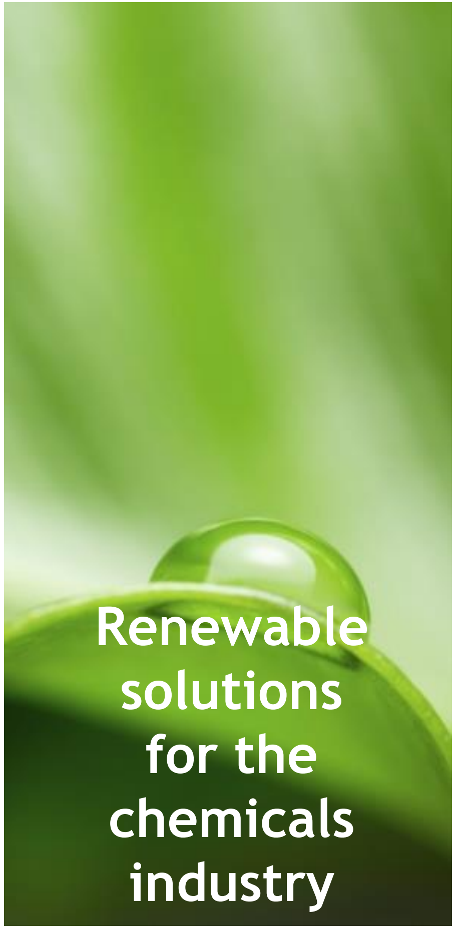
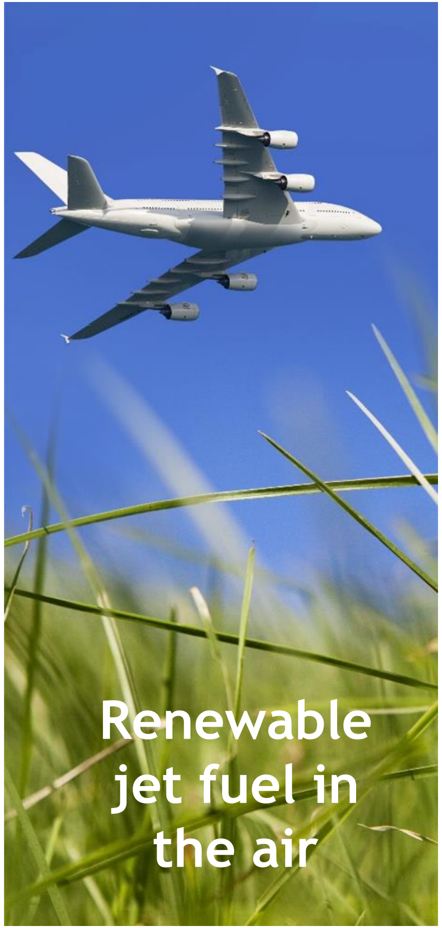
NESTE ENGINEERING SOLUTIONS


Cleaner fuels on the roads


Low-sulfur bunker fuel at sea


Renewable solutions for the chemicals industry


Renewable jet fuel in the air

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Taking care of health, safety and the environment is essential in our actions.

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Flexible combined production of power, heat and transport fuels from renewable energy sources

FLEXCHX

- Acronym: FLEXCHX
- Funding scheme: RIA
- Duration: 36M, March 2018 – February 2021
- H2020 funding: 4 489 545 €
- Coordinator: Esa Kurkela, VTT
- Project Officer: Daniel Maraver de Lemus
- Consortium: VTT (Finland), Enerstena (Lithuania), INERATEC (Germany), Deutsches Zentrum Fuer Luft - Und Raumfahrt e.V., Germany-DLR (Germany), HELEN (Finland), Kauno Energija (Lithuania), Lithuanian Energy Institute (Lithuania), NESTE Engineering Solutions (Finland), Johnson Matthey (UK) and Grönmark (Finland)

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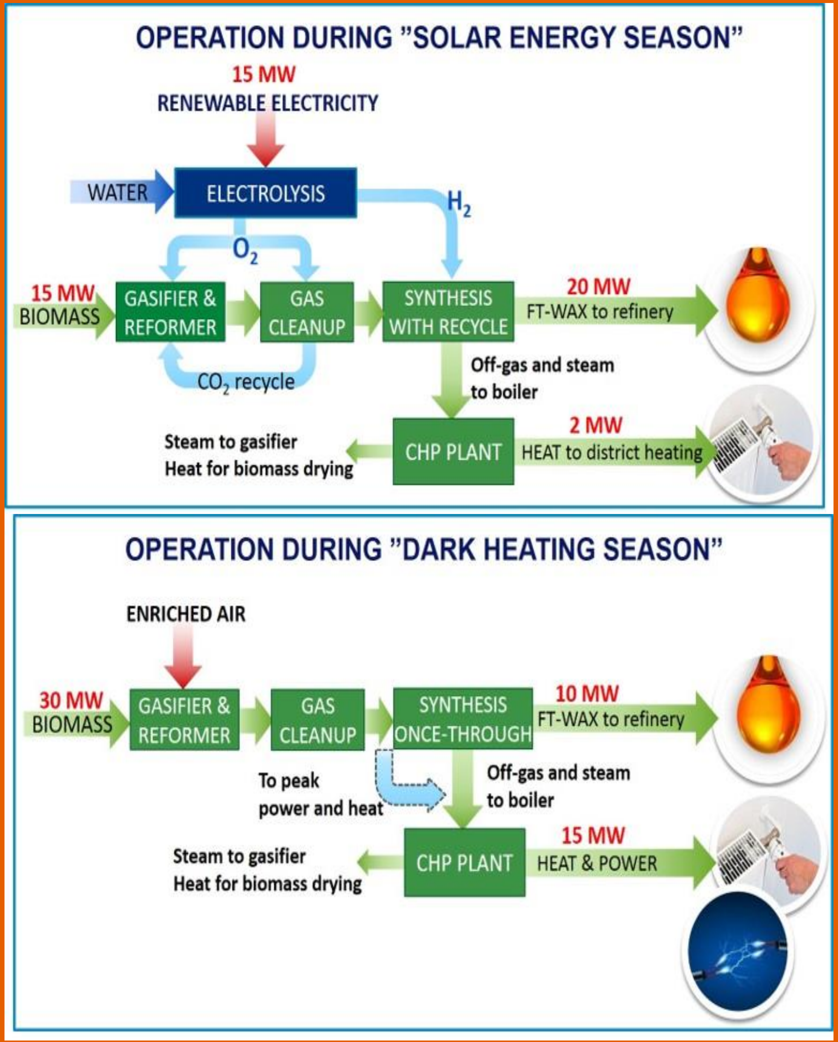
www.flexchx.eu

FLEXCHX

OBJECTIVE

- **FLEXCHX project presents an economical way to utilize CHP-plants and district heating networks as part of the future European energy system.**
- **Tri-generation of power, heat and intermediate product (FT wax) for the transport sector is used to address the challenge of the poor match between the availability of solar energy and the demand for heating.**

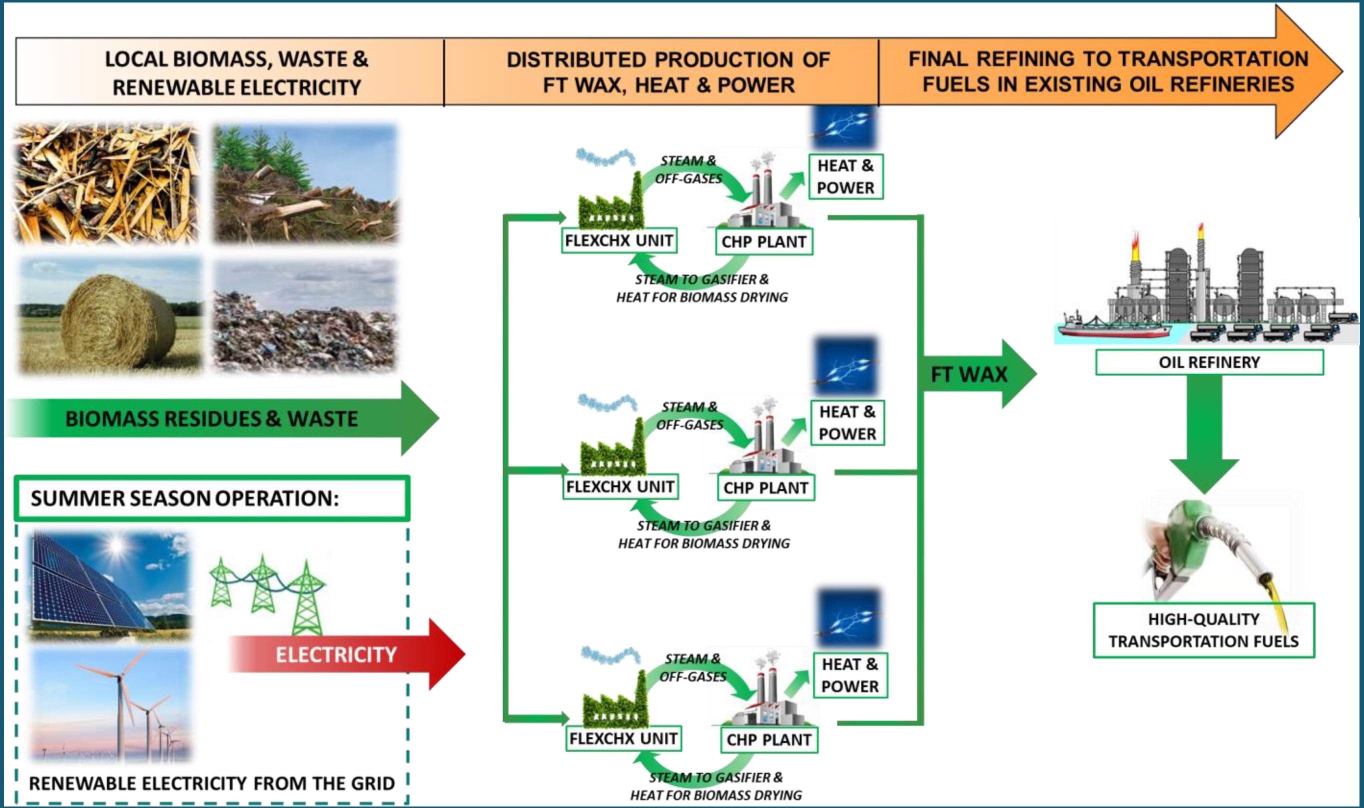


VISION

- To realise a process for **optimal use of the seasonal solar energy supply and available biomass resources**
- Satisfy the seasonal demand for heat and power, and to produce low-GHG fuels for the transport sector.

FLEXCHX

The conceptual idea of distributed production of heat, power and bio-FT products combined with centralized refining to high-quality transportation fuels



Work Packages

WP1 Coordination and Management (VTT)

WP2 Concept development (ENERSTENA)

WP3 Gasification and raw gas cleaning (VTT)

WP4 Reforming and final syngas cleaning (JOHNSON MATTHEY)

WP5 Flexible FT synthesis (INERATEC)

WP6 Validation of the key enabling technologies (VTT)

WP7 Integration of FT products to refineries (NESTE ENGINEERING SOLUTIONS)

Petrašiūnai power-plant, Lithuania

SXB pilot plant, VTT, Finland

Contents

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1. Objectives

Objectives of NES work
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
  → 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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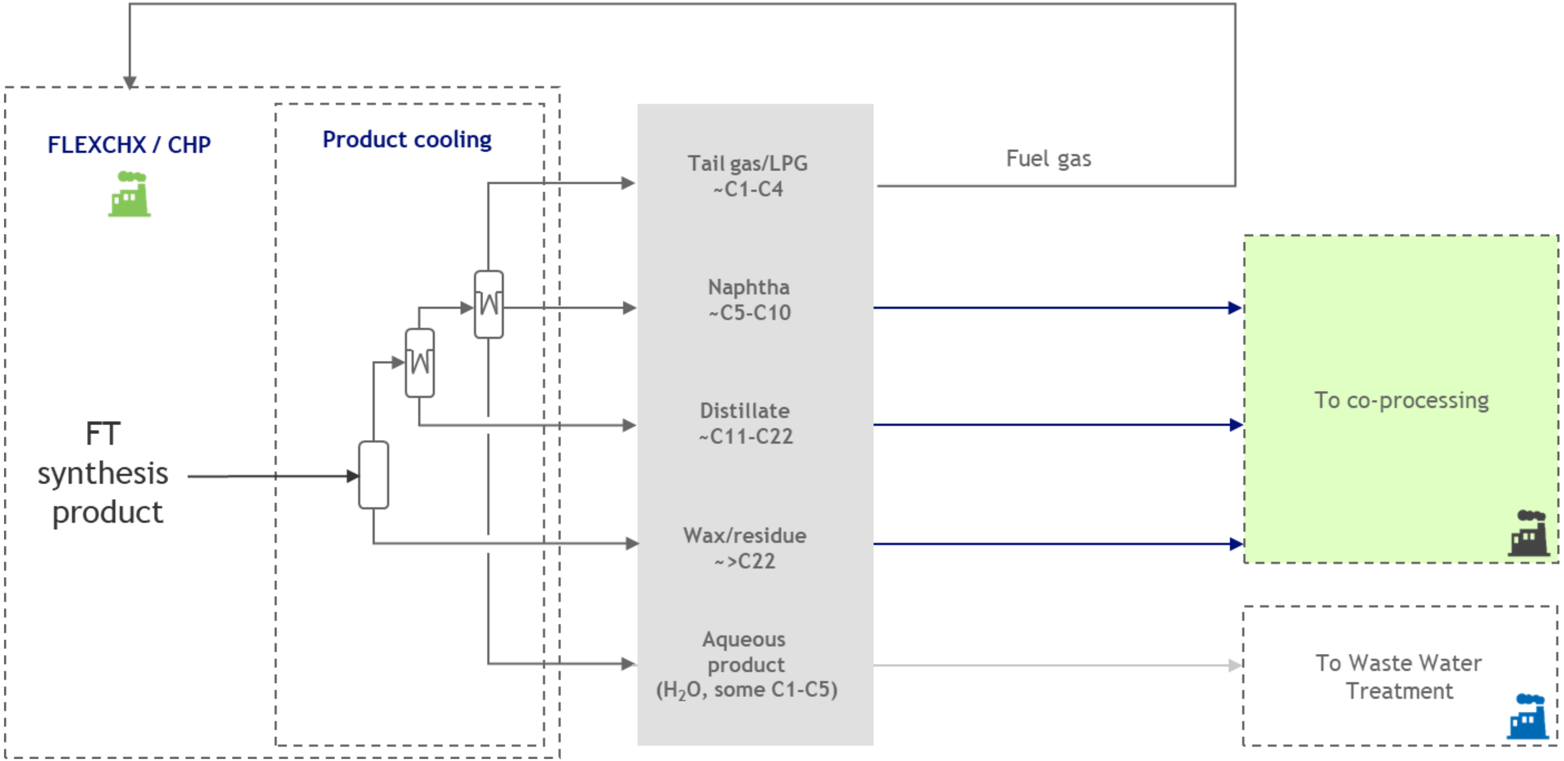
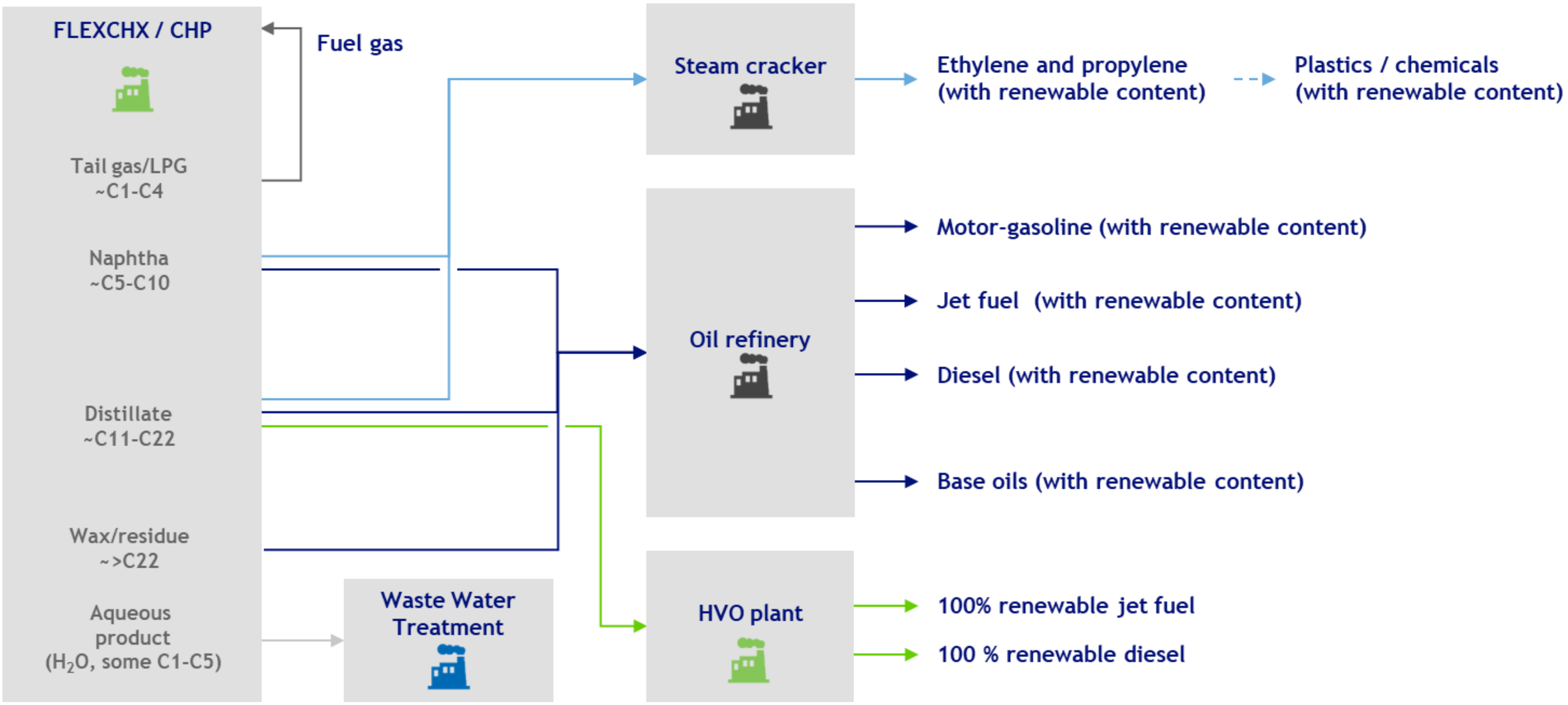
F-T syncrude fractionation scheme



Potential FLEXCHX syncrude integration pathways



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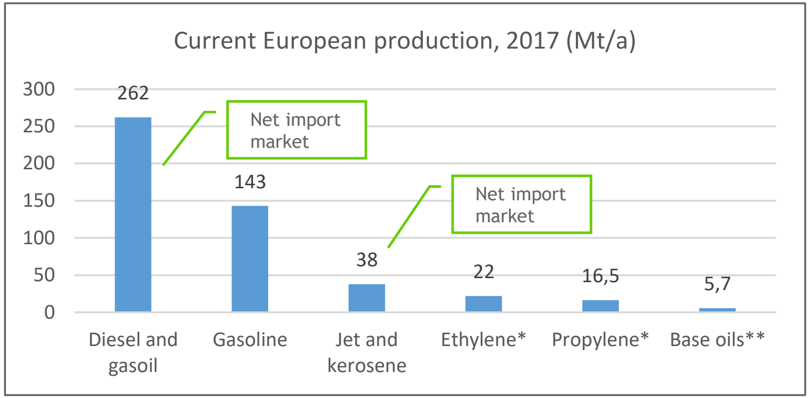
F-T syncrude co-processing suitability

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	Base oils	Oil refinery	Hydroprocessing base oil unit required	No major investment needs expected	**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

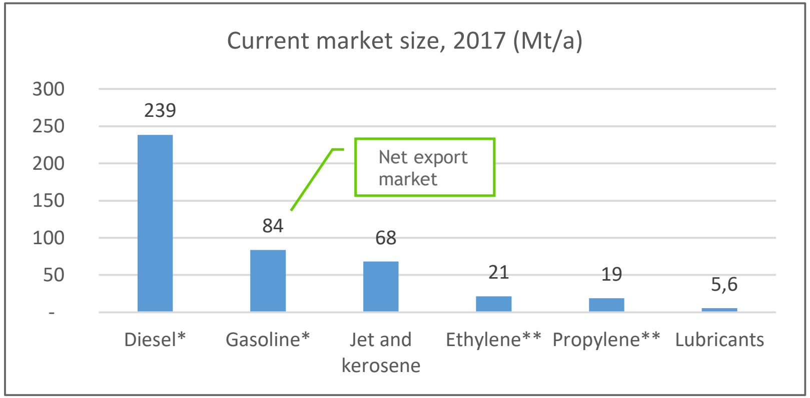
4. Product market

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

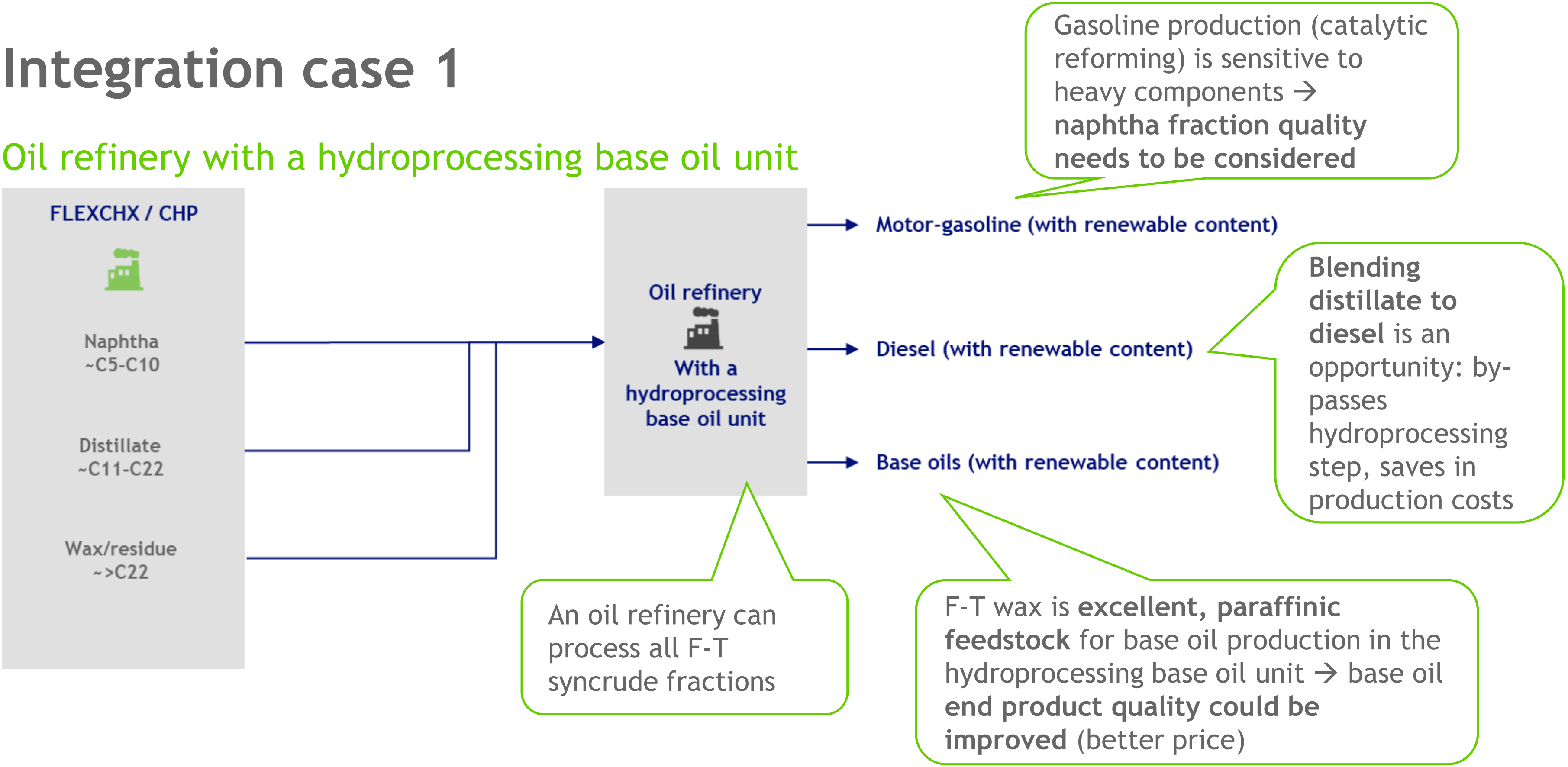
Market summary

	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 → 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)

5. Integration cases

Integration case 1

Oil refinery with a hydroprocessing base oil unit



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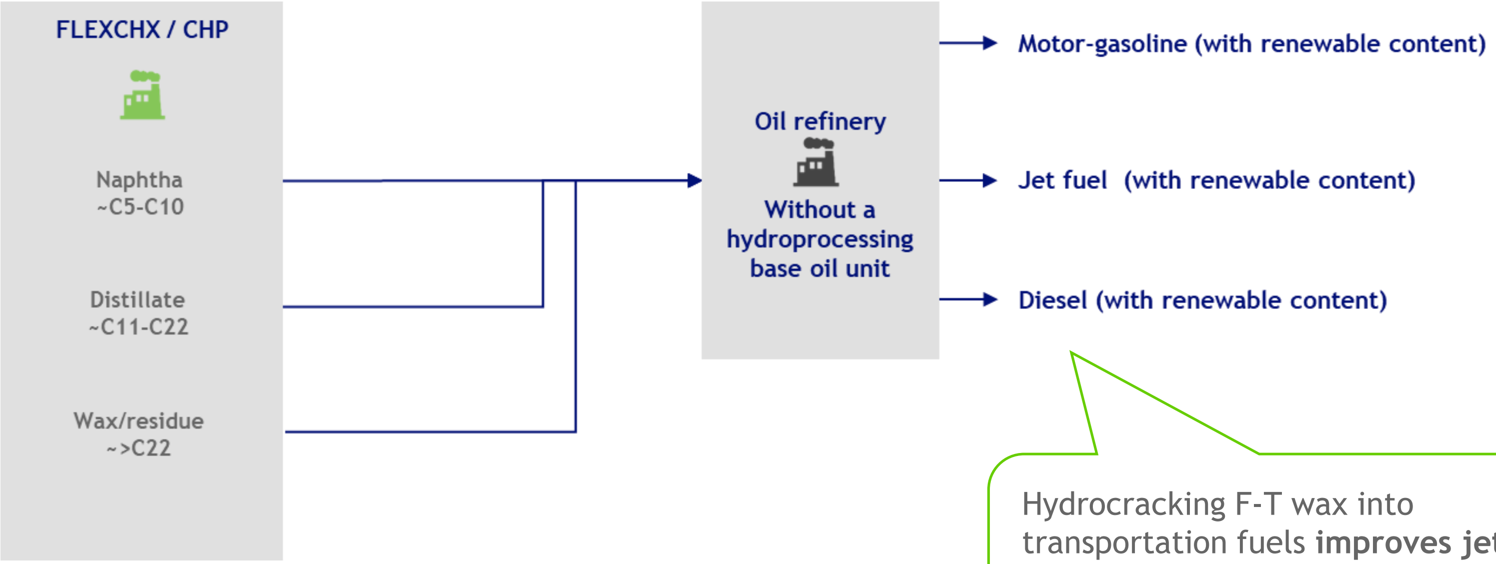
Integration case 2

Oil refinery without a hydroprocessing base oil unit



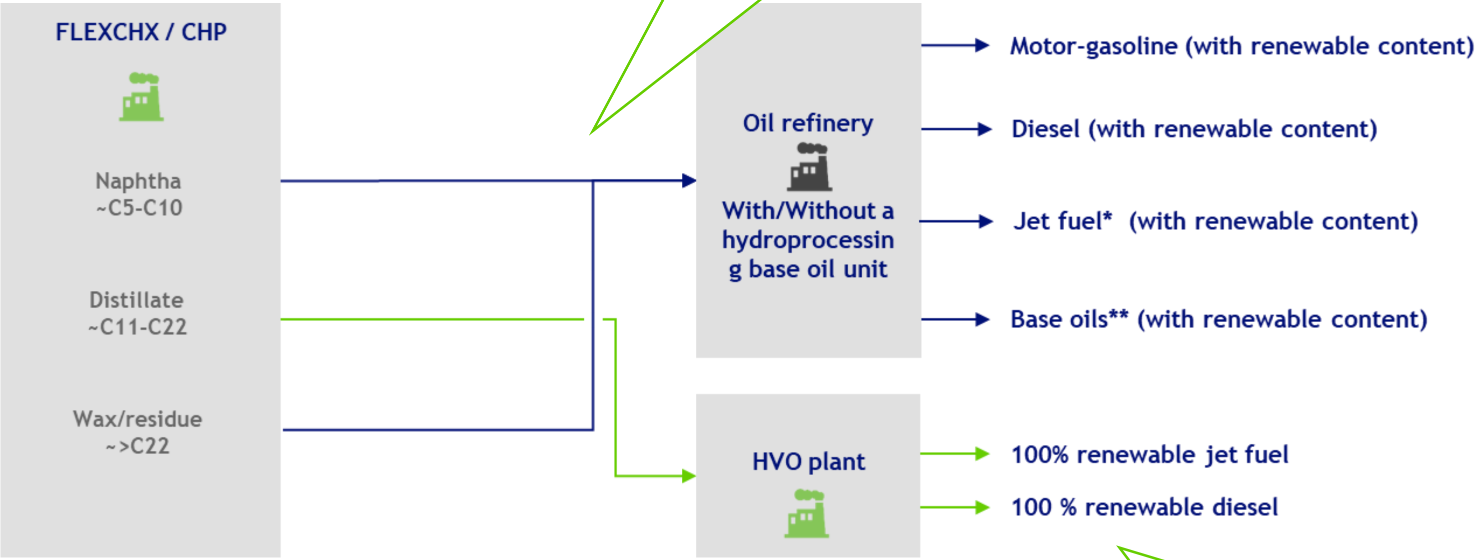
Hydrocracking F-T wax into transportation fuels **improves jet and diesel quality**, but valuable base oils are left out of the product portfolio

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

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

Thank you.