WASTE2ROAD

Biofuels from WASTE TO ROAD transport

LC-SC3-RES-21-2018 (818120)

Deliverable Report

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Deliverable name	Training seminars
Lead beneficiary	VTT
Contributors	Kristian Melin, Robbie Venderbosch, Mieke Nieder-Heitmann, Tamer Alhalabi, Christian Lindfors, Anne Roubaud, Helene Lutz, Rune Lødeng, Johnny Stuen, Gerhard Muggen and Marjut Suomalainen
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Description of the deliverable content and purpose

The objective of WP 7 is to provide a robust mechanism for the dissemination and communication of the Waste2Road project activities and results. WP 7 will promote the Waste2Road project and results as widely and as efficiently as possible to all relevant stakeholders, scientific publications and media. A variety of platforms will be used to reach different stakeholders from public and private organizations, colleagues from related European projects, graduate students and the press. VTT and PDC will organize with the project partners two seminars for higher level students using Aspen Plus as a tool to evaluate and develop biogenic waste co-refining and involve in a workshop in the field of refinery processing, where results from these flow sheeting activities can be further exploited. The first biomass liquefaction modelling webinar was held in 22nd of April 2020 for higher-level university students together with the 4Refinery EU project at Aalto University in Finland. The second seminar was organized 20th of April 2021 for students around Europe. This deliverable D7.4 “Training seminar” highlights the content of webinars presentations that were presented by VTT, RESPOL, MOL, BTG, Aalborg University, PDC, CEA, TU Wien, Sintef, EGE and BTG Bioliquids.

The deliverable D7.4 will be submitted twice during the project period, at M24 and at M42. This deliverable is a second version, including the results from both the first and second seminar.

Table of Contents

1 Introduction

Biomass liquefaction modelling webinars were held on 22nd of April 2020 and 20th of April 2021 for higher-level university students. Webinar presentations covered several aspects of modelling biomass in fast pyrolysis and hydrothermal liquefaction processes. Different experiences in co-processing of bio-crudes in refineries have been presented as well. The first webinar was held basically for the chemical engineering and plant design students at Aalto University, but the event was also open for other people from the industry. The second seminar was organized for students around Europe. The webinars were very successful with approximately 40-50 participants in each seminar. Appendix contains some slides that were presented in the webinars.

2 Webinar program

Both webinars were focusing on the production of biocrudes by fast pyrolysis and HTL and co-processing the biocrudes in the oil refinery. The first seminar contained also a modelling exercise for the students. The agenda for the seminars are presented in Table 1 and Table 2.

Table 1. Agenda for the first student seminar.

8:30-8:45	Logging into the webinar
8:45-9:00	Introduction to the topic of the webinar Kristian Melin, VTT Pekka Oinas, Aalto University
9:00-9:30	Latest developments in pyrolysis and upgrading
9:30-10:00	Latest developments and activities in co-processing biocrudes by FCC and other technologies Rebeca Yuste Pilar, Repsol, Spain
10:00-10:30	Co-hydrotreatment of bio-crudes. Pilot plant experiment and engineering consideration. László Leveles, MOL Refining R&D
10:30-10:40	Break
10:40-11:10	Modelling of fast pyrolysis with COCO freeware software case Empyro fast pyrolysis plant. Robbie Venderbosch, BTG, The Netherlands
11:10-11:40	Modelling hydrothermal liquefaction processes. Thomas Pederson Aalborg University, Denmark
11:40-12:10	Modelling of biocrude upgrading including stabilization and hydrodeoxygenation with aspen and empirical modelling of co-FCC using MODDE. Kristian Melin, VTT
12:10-12:40	Techno-economic assessment of conceptual processes and life cycle costing. Mieke Nieder-Heitmann, Process Design Center, The Netherlands
12:40-13:15	Break
13:15-13:30	Introduction to Modelling exercise with Aspen Plus to modelling fast pyrolysis of the Empyro Plan in the Netherlands
13:30-15:00	Individual work for students
15:15-15:45	Demo of the modelling exercise and showing the correct results
15:45-15:50	Final words and end of the webinar

Table 2. Agenda for the second student seminar.

8:30-8:45	Logging in to the seminar
8:45-9:00	Introduction to the topic of the webinar Christian Lindfors, VTT Technical Research Centre of Finland
9:00-9:30	Fast pyrolysis of waste materials Christian Lindfors, VTT, Finland
9:30-10:00	HTL operation with waste materials Anne Roubaud, French Alternative Energies and Atomic Energy Commission (CEA), France
10:00-10:30	Co-processing of biogenic feedstocks in an FCC pilot plant Helene Lutz TU Wien, Austria
10:30-10:40	Break
10:40-11:10	Co-hydroprocessing of bio-oil to obtain diesel middle distillates fuels Rune Lødeng Sintef, Norway
11:10-11:40	Stabilization of bio-oil and modelling of fast pyrolysis using COCO software Robbie Venderbosch, Biomass Technology Group (BTG), Netherlands
11:40-12:10	Modelling hydrothermal liquefaction process Thomas Helmer Pedersen, Aalborg University, Denmark
12:10-12:20	Break
12:20-12:50	Techno-economic assessment of conceptual processes and life cycle costing Mieke Nieder-Heitmann, Process Design Center, Netherlands
12:50-13:20	Where is the energy in the city waste? Johnny Stuen, Oslo Kommune Energigjenvinningsetaten (EGE), Norway
13:20-14:00	Commercialization activities about pyrolysis Gerhard Muggen, BTG Bioliquids, Netherlands
14:00-14:05	Final words and end of the seminar

3 Webinar key learning points

Fast pyrolysis and HTL are promising technologies to convert solid biomass into an intermediate biocrude. The commercial plants in operation are using clean feedstock, but in future target is to use more waste based material. This will have a big impact not only on the primary liquefaction process, but also on the downstream upgrading processes, which are very sensitive to high metal, sulphur and chlorine contents in the biocrude.

Integration of bio-liquids in a refinery was discussed thoroughly in the webinars. Complexity of bio-crude composition was highlighted by presenting comparative overall properties of bio-liquids produced by pyrolysis and hydrothermal liquefaction. Several co-feeding points in a refinery were discussed and justified.

REPSOL, MOL, Sintef and TU Wien shared their experiences in Fluid catalytic cracking and co-hydrotreatment, respectively.

BTG and BTG Bioliquids presented the status of pyrolysis as a mature and cheap process that has great potentials especially when integrated into refineries. Furthermore, a presentation was dedicated to explain how to use COCO to model a pyrolysis process; COCO is a free modeling tool that students can use for modelling different processes.

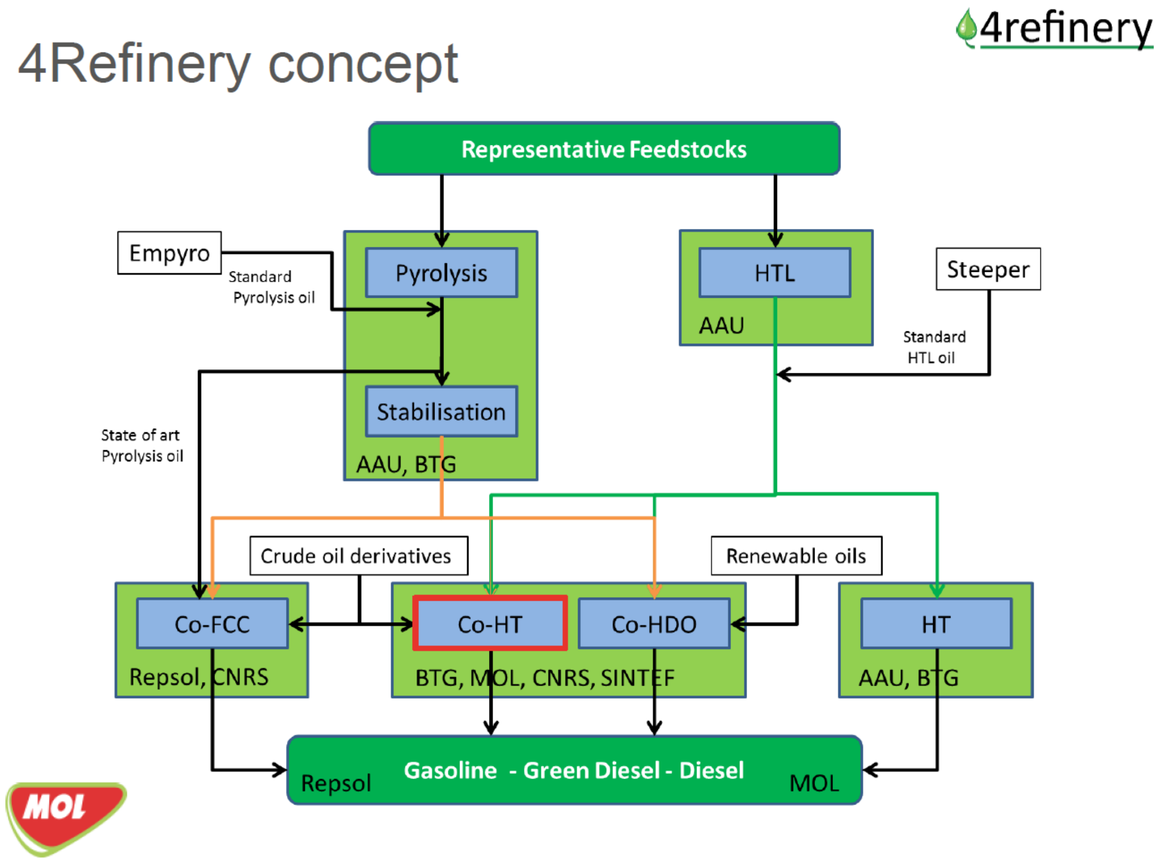
Modelling of hydrothermal liquefaction process was introduced by Aalborg University. Presentation focused on non-conventional solid approach in biomass modelling using Aspen plus. Some related calculations were highlighted as well. In addition, integration of hydrothermal liquefaction process in a refinery has been presented as a case study.

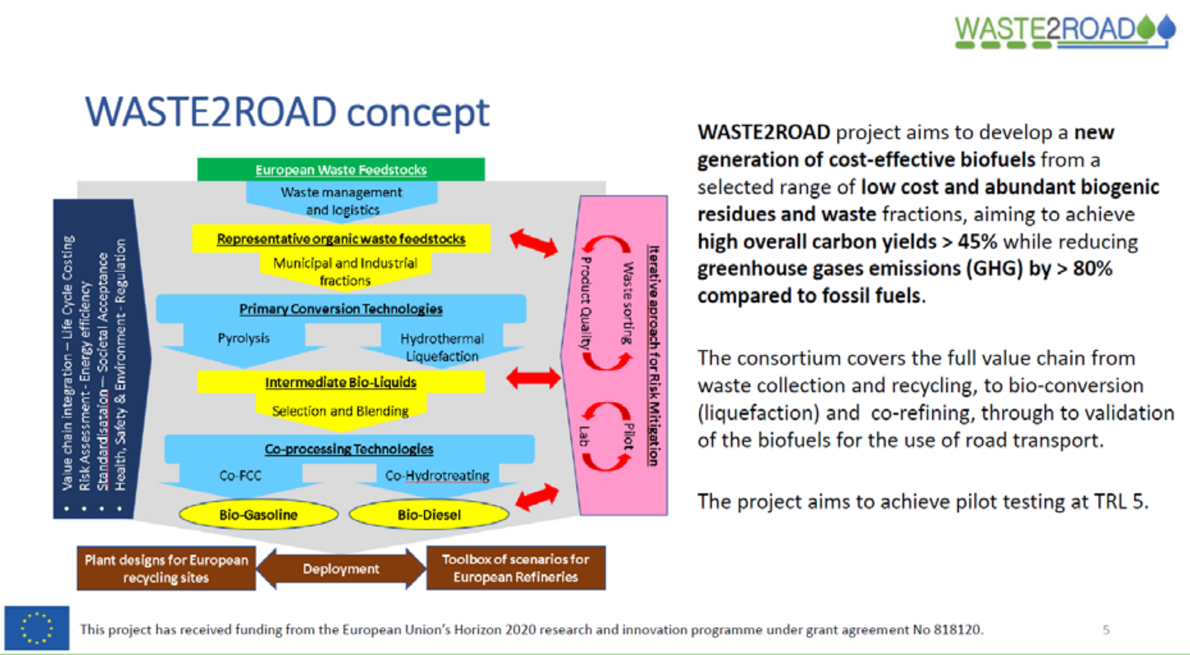
VTT presented Aspen plus as a modelling tool to find a suitable co-processing route. Modelling based on chemical composition, distillation curve or creating an empirical model were methodically explained in the presentation.

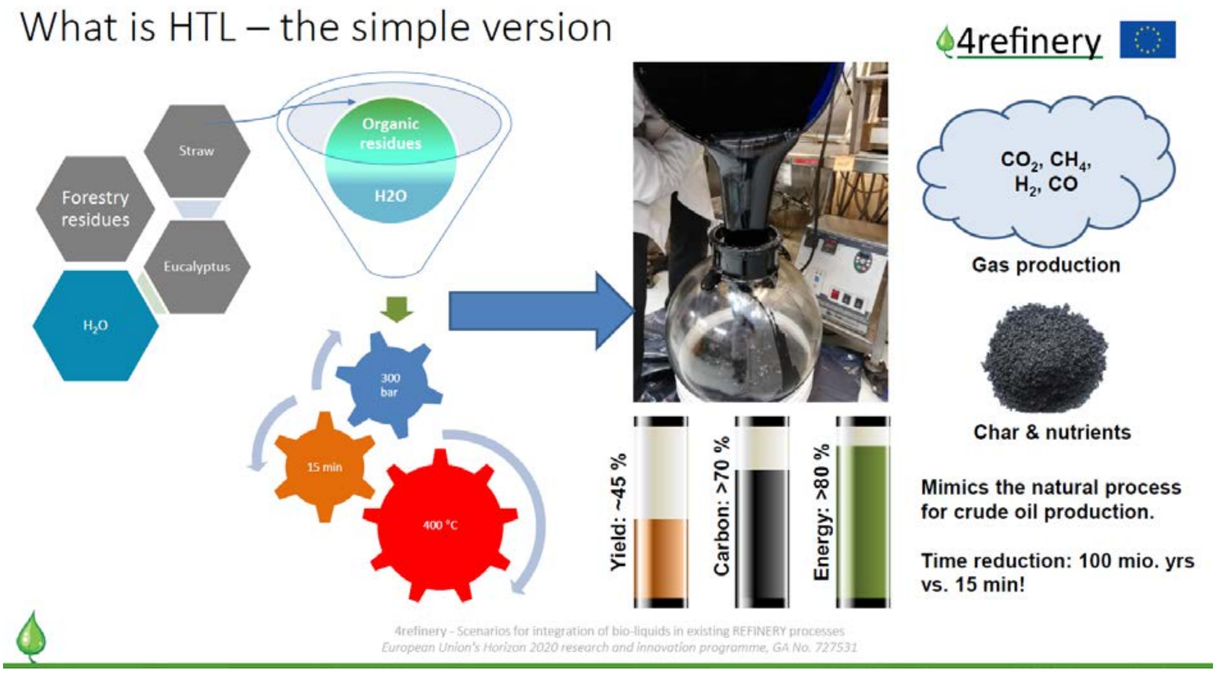
In addition to that, PDC presented detailed techno-economical assessment and life cycle costing calculations. Economic parameters such as production cost, IRR and NPV were used to present techno-economical assessment results.

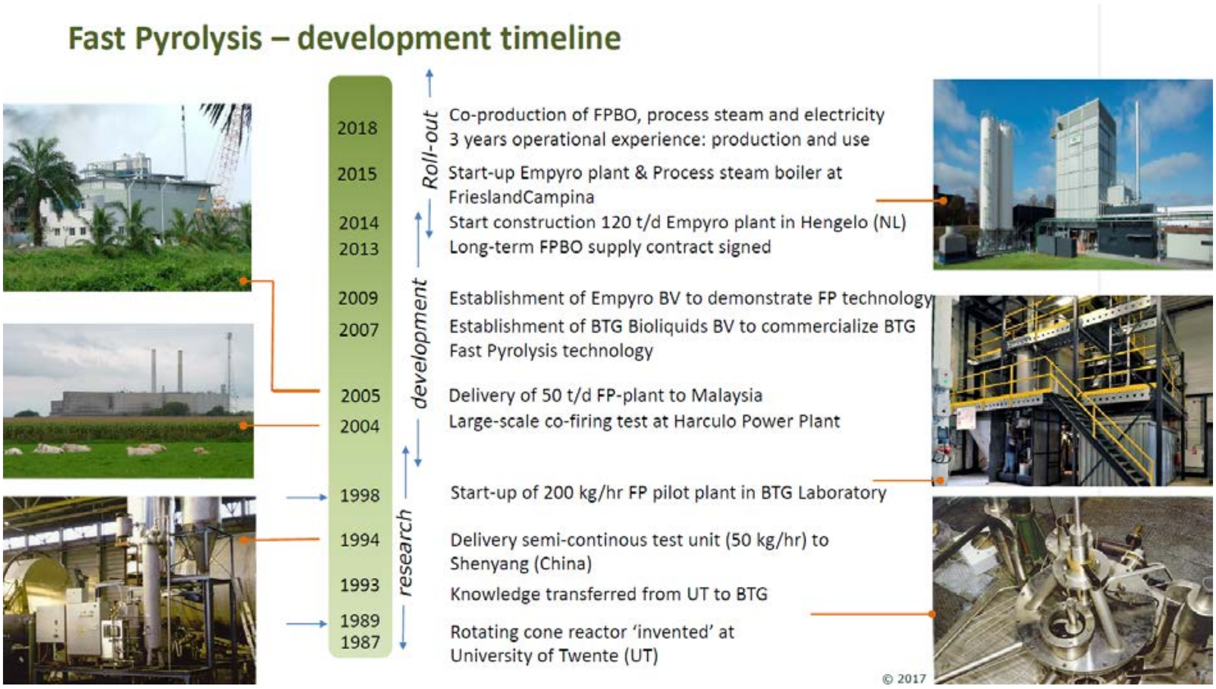
The webinar ended with a modelling exercise for students to practice using Aspen plus. Simplified simulation model was introduced to simulate the fast pyrolysis process in Empyro plant. In the exercise, biomass and pyrolysis products were modelled by using the non-conventional approach and by utilizing a yield reactor with already defined products, respectively.

4 Appendix


4refinery
4Refinery concept
Representative Feedstocks
Empyro
Standard Pyrolysis oil
Pyrolysis
Stabilisation
AAU, BTG
HTL
AAU
Steeper
Standard HTL oil
State of art Pyrolysis oil
Crude oil derivatives
Renewable oils
Co-FCC
Repsol, CNRS
Co-HT
Co-HDO
BTG, MOL, CNRS, SINTEF
HT
AAU, BTG
Repsol
Gasoline - Green Diesel - Diesel
MOL
MOL


WASTE2ROAD
WASTE2ROAD concept
European Waste Feedstocks
Waste management and logistics
Representative organic waste feedstocks
Municipal and Industrial fractions
Primary Conversion Technologies
Pyrolysis
Hydrothermal Liquefaction
Intermediate Bio-Liquids
Selection and Blending
Co-processing Technologies
Co-FCC
Co-Hydrotreating
Bio-Gasoline
Bio-Diesel
Value chain integration – Life Cycle Costing
Risk Assessment – Energy efficiency
Standardisation – Societal Acceptance
Health, Safety & Environment - Regulation
Iterative aproach for Risk Mitigation
Waste sorting
Product Quality
Pilot
Lab
Plant designs for European recycling sites
Deployment
Toolbox of scenarios for European Refineries
WASTE2ROAD project aims to develop a new generation of cost-effective biofuels from a selected range of low cost and abundant biogenic residues and waste fractions, aiming to achieve high overall carbon yields > 45% while reducing greenhouse gases emissions (GHG) by > 80% compared to fossil fuels.
The consortium covers the full value chain from waste collection and recycling, to bio-conversion (liquefaction) and co-refining, through to validation of the biofuels for the use of road transport.
The project aims to achieve pilot testing at TRL 5.
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818120.
5


What is HTL – the simple version
4refinery
Straw
Forestry residues
Eucalyptus
H_2O
Organic residues
H2O
300 bar
15 min
400 °C
Yield: ~45 %
Carbon: >70 %
Energy: >80 %
CO_2, CH_4, H_2, CO
Gas production
Char & nutrients
Mimics the natural process for crude oil production.
Time reduction: 100 mio. yrs vs. 15 min!
4refinery - Scenarios for integration of bio-liquids in existing REFINERY processes
European Union's Horizon 2020 research and innovation programme, GA No. 727531


Fast Pyrolysis – development timeline
Roll-out
development
research
2018
2015
2014
2013
2009
2007
2005
2004
1998
1994
1993
1989
1987
Co-production of FPBO, process steam and electricity
3 years operational experience: production and use
Start-up Empyro plant & Process steam boiler at FrieslandCampina
Start construction 120 t/d Empyro plant in Hengelo (NL)
Long-term FPBO supply contract signed
Establishment of Empyro BV to demonstrate FP technology
Establishment of BTG Bioliquids BV to commercialize BTG Fast Pyrolysis technology
Delivery of 50 t/d FP-plant to Malaysia
Large-scale co-firing test at Harculo Power Plant
Start-up of 200 kg/hr FP pilot plant in BTG Laboratory
Delivery semi-continous test unit (50 kg/hr) to Shenyang (China)
Knowledge transferred from UT to BTG
Rotating cone reactor 'invented' at University of Twente (UT)
© 2017

4refinery

Integration of bio-liquids in refinery

- Potential options of integration

- Three possible insertion points of bio-liquids in a refinery:
  - (1) By converting bio-liquids in stand-alone units into a crude that can be co-processed with conventional crude oil.
  - **(2) Upgrading bio-liquids into refinery-ready intermediates that are compatible with refinery streams.**
  - (3) Upgrading the liquids in stand-alone units into finished/near-finished blend stock that will be minimally processed at the refinery (drop-in fuels).

4REFINERY

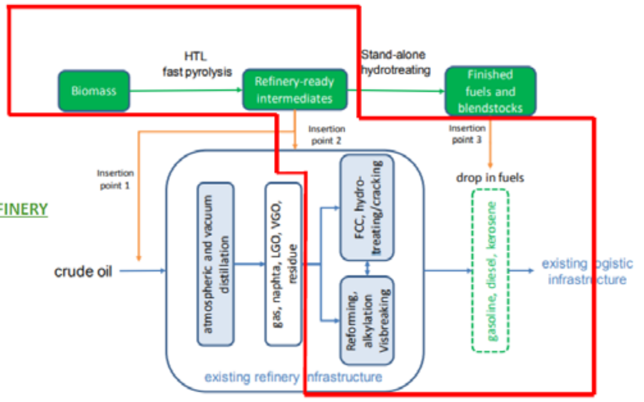


Figure 10: Insertion points for bio-liquids, biofuel intermediates, or finished hydrocarbon biofuels to integrate into existing petroleum refineries and distribution infrastructure.

4refinery - Scenarios FOR integration of bio-liquids in existing REFINERY processes
European Union's Horizon 2020 research and innovation program, GA No. 727531

WASTE2ROAD

Chemical, physical and technical challenges in processing of renewables

- **High oxygen content;** Exothermic reactions and a high consumption of hydrogen
  - Might include a high H2O content
- **Materials;** The risk of corrosion due to a high acid number, a high chlorine content and the presence of oxygenated compounds, carboxylic acids
- **Contaminants;** Deposits causing pressure drop and catalyst deactivation due to the presence of components such as Si and P, and others
- **Product Quality;** The establish on the density and cold flow properties of the end product,
- **Feedstock supply;** The ability to secure a reliable supply of renewable feedstocks of sufficient quality

W2R solution is diversity in feedstock types and technology

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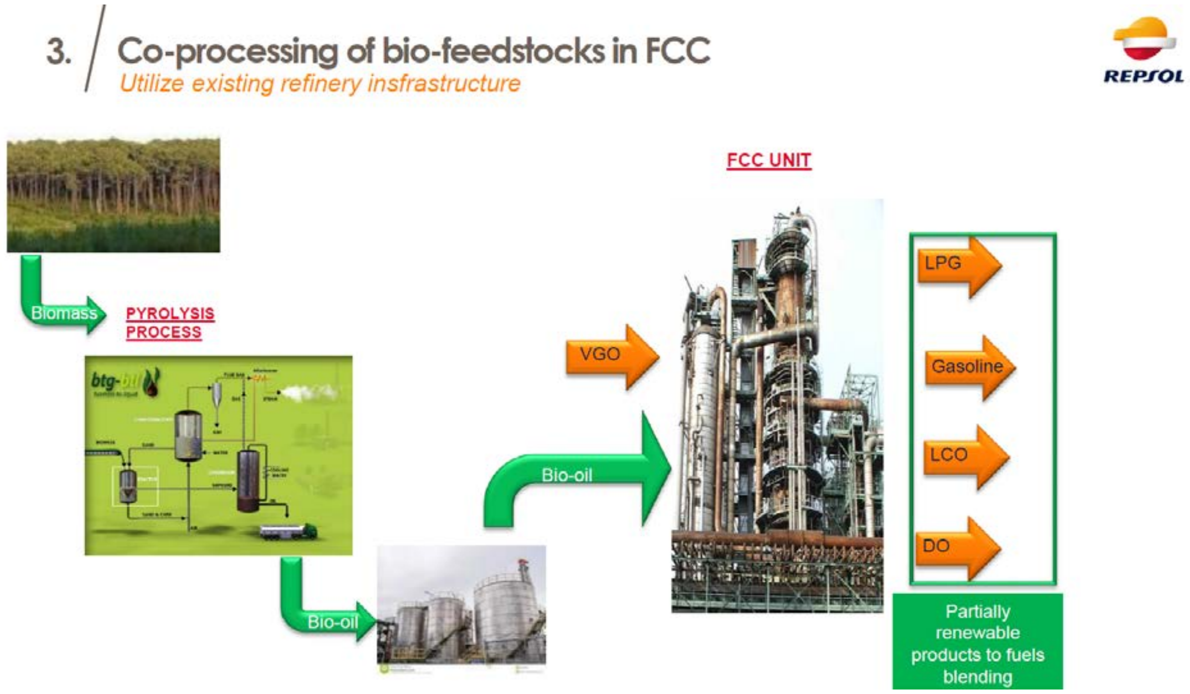
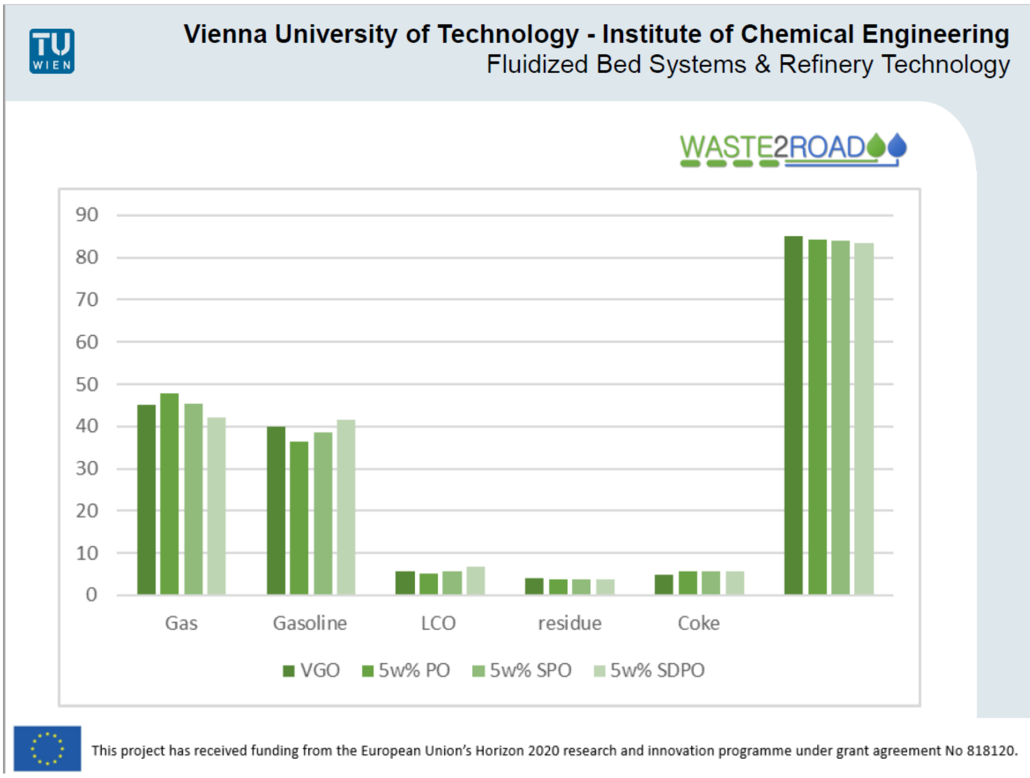
10


3.
Co-processing of bio-feedstocks in FCC
Utilize existing refinery insfrastructure
REPSOL
Biomass
PYROLYSIS PROCESS
Bio-oil
VGO
Bio-oil
FCC UNIT
LPG
Gasoline
LCO
DO
Partially renewable products to fuels blending


Vienna University of Technology - Institute of Chemical Engineering
Fluidized Bed Systems & Refinery Technology
WASTE2ROAD
90
80
70
60
50
40
30
20
10
0
Gas
Gasoline
LCO
residue
Coke
VGO
5w% PO
5w% SPO
5w% SDPO
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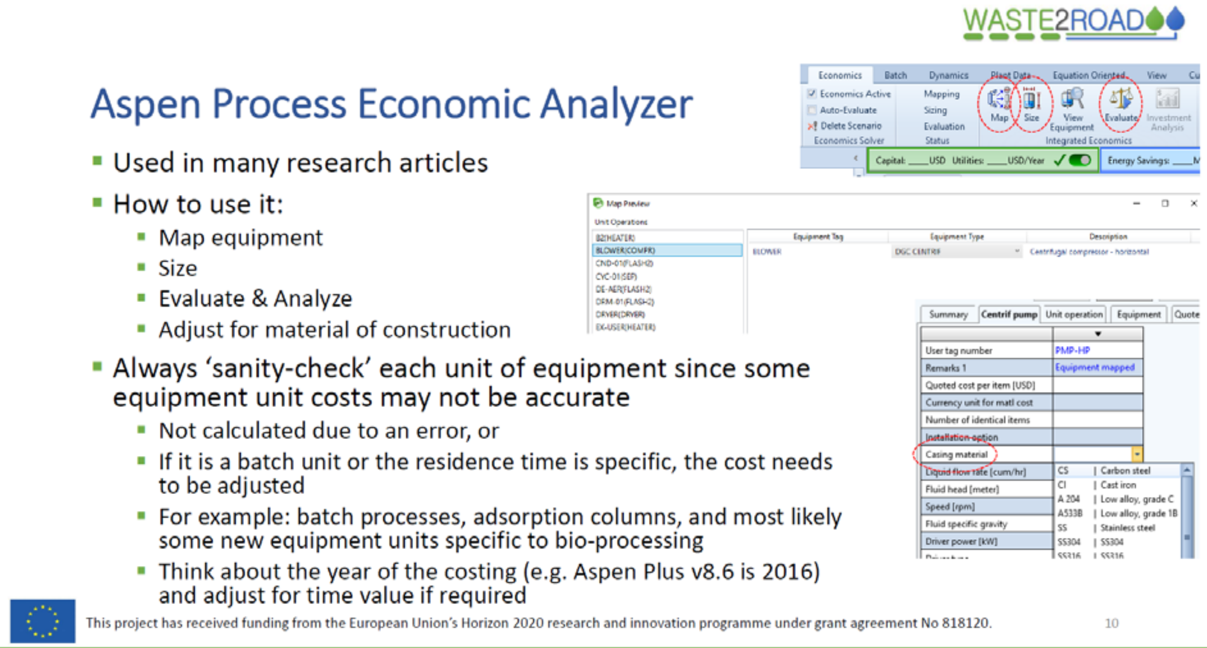
WASTE2ROAD
Aspen Process Economic Analyzer
Used in many research articles
How to use it:
Map equipment
Size
Evaluate & Analyze
Adjust for material of construction
Always 'sanity-check' each unit of equipment since some equipment unit costs may not be accurate
Not calculated due to an error, or
If it is a batch unit or the residence time is specific, the cost needs to be adjusted
For example: batch processes, adsorption columns, and most likely some new equipment units specific to bio-processing
Think about the year of the costing (e.g. Aspen Plus v8.6 is 2016) and adjust for time value if required
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10