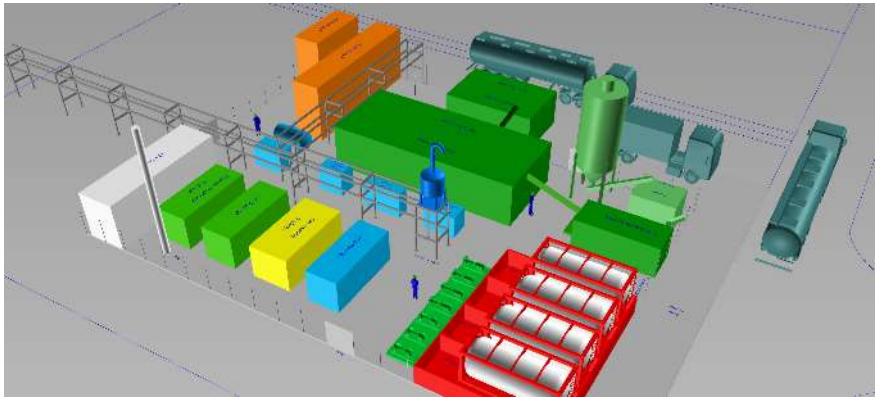
Horizon 2020 TO-SYN-FUEL:
Turning Sewage Sludge into Fuels and hydrogen



Graz

Thursday 23 Jan 2020

Nils Jäger

Andreas Apfelbacher

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grand agreement No 745749.

Fraunhofer UMSICHT

Horizon 2020 Project TO-SYN-FUEL

Project Overview

- 14,5 Million Euro funding
- Project start May 2017 (project's lifetime 60 month)
- 10 partners from 5 different countries

Fraunhofer

etaflorence renewableenergies

Susteen Technologies GmbH

eni

VTS

HYGEAR

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

UNIVERSITY OF BIRMINGHAM

LEITAT Technological Center

WRG Europe Ltd GrantCraft

Europäische Kommission

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Horizon 2020 Project TO-SYN-FUEL

Overview

- **Project Management:** all
- **Plant (TCR, PSA, HDO) Engineering and Construction:** Susteen, Fraunhofer, VTS, Hygear
- **Demonstration Phase:** Susteen, Fraunhofer, VTS, SNB, Hygear
- **Product Fuel Demonstration, Engine Tests, CHP Tests:** ENI, University of Birmingham, Fraunhofer
- **Social Sustainability:** Leitat, University of Bologna, Fraunhofer
- **Environmental Performance**: University of Bologna, Leitat, Fraunhofer
- **Exploitation and Business Potential:** Susteen, ENI, Fraunhofer
- **Regulatory Issues and Risk Management:** Fraunhofer, University of Bologna, Leitat, VTS,
- **Dissemination:** ETA Florence, WRG, Fraunhofer, ENI, University of Bologna, University of Birmingham, Leitat, VTS

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Horizon 2020 Project TO-SYN-FUEL

The Demonstration of Waste Biomass to Synthetic EN Conform Fuels and Green Hydrogen

- Contribute to the Renewable Energy Directive targets for renewable energy by validating waste feedstocks for the production of fuels
- **Demonstration of the production of green hydrogen, diesel and gasoline equivalent liquid fuels from sewage sludge**

- Showcase for future sustainable investment and economic growth across Europe
- Development of a business case, LCA and dissemination of results

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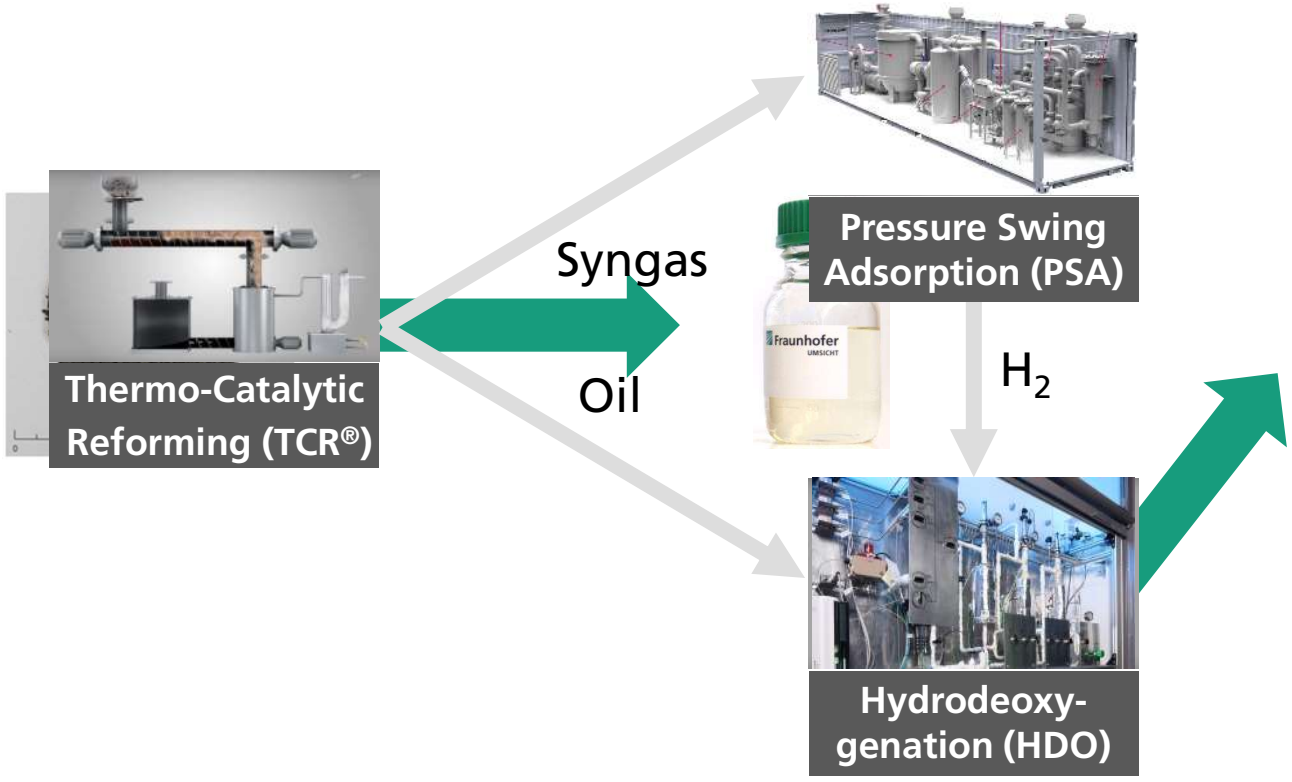
Horizon 2020 Project TO-SYN-FUEL

Core components



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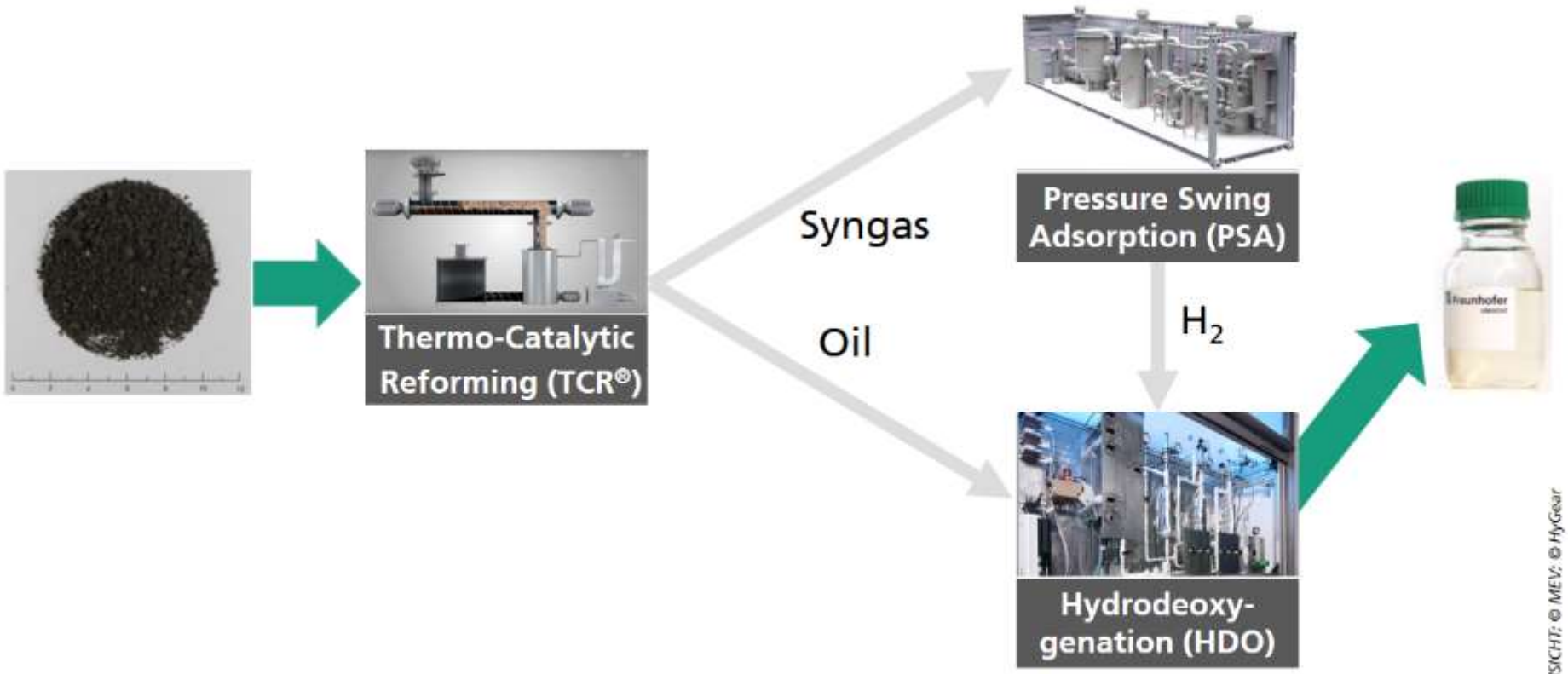
Horizon 2020 Project TO-SYN-FUEL

Core components



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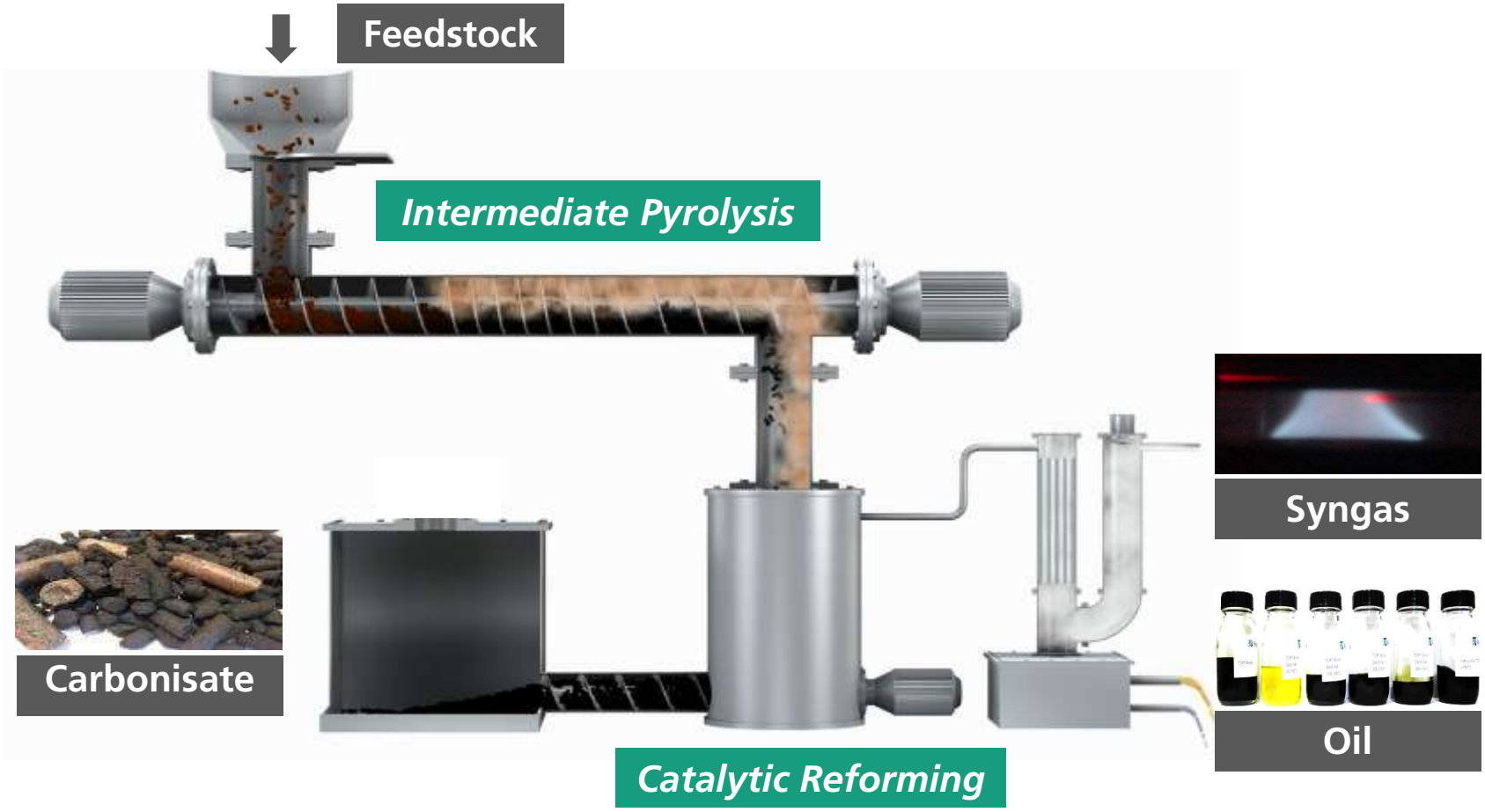
Thermo-Catalytic Reforming TCR®

A Platform Technology to use residues and to produce storable energy carriers



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Thermo-Catalytic Reforming TCR®

Bio-oil from sewage sludge

High quality, engine-ready

LHV: ≈ 34 MJ/kg

C	83.7 wt. %
H	9.0 wt. %
N	2.1 wt. %
S	0.9 wt. %
O (diff.)	3.7 wt. %
H_2O	0.6 wt. %
TAN	0.6 mg KOH/g
Ash	< 0.005 wt.%

- **Thermal stable**
- Low in O;S;N
- Low water content
- High heating value

→ Excellent Precurser for Hydrotreatment

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Thermo-Catalytic Reforming TCR®

Syngas from sewage sludge

Engine-ready gas

HHV:
≈ 14-18 MJ/m³

H_2	38 ± 3 v/v%
CO	8 ± 2 v/v%
CO_2	30 ± 3 v/v%
CH_4	14 ± 2 v/v%
C_xH_y	3 ± 1 v/v%

High Hydrogen Content is Essential for Hydrogenseparation by PSA

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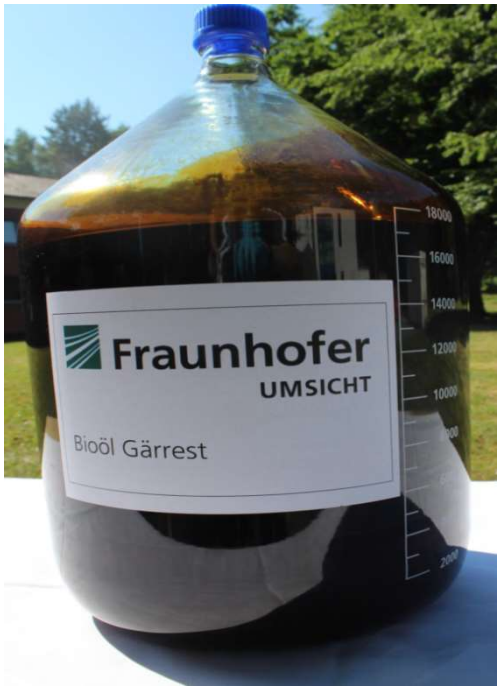
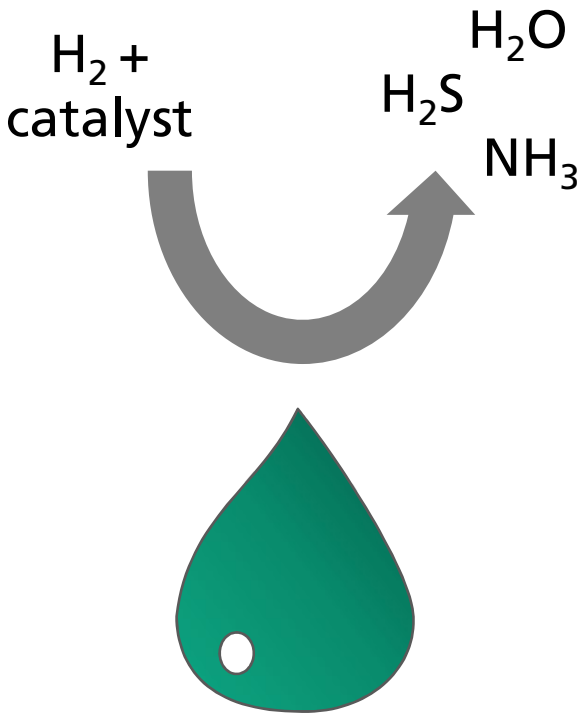
Upgrading of TCR® bio-oil for renewable fuels

Hydrotreating of TCR® bio-oil



TCR® bio-oil



260-400 °C up to 200 bar

Hydrotreated TCR® bio-oil (HBO)

thermal stability required!

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Upgrading of TCR® bio-oil for renewable fuels

Hydrotreating of TCR® oil

TCR® BIO-OIL

C	83.7 wt%
H	9.0 wt%
N	2.1 wt%
S	0.9 wt%
O (diff.)	3.7 wt%
H_2O	0.6 wt%
Ash	< 0.005 wt%

LHV	34.0 MJ/kg
TAN	0.6 mg KOH/g
Viscosity	4.4 mm²/s
Density	1014.4 kg/m³

HYDROTREATING

HYDROTREATED TCR® BIO-OIL (HBO)

C	86.2 wt%
H	13.0 wt%
N^x	0.5 - 0.0 wt%
S^x	< 0.01 wt%
O^x (diff.)	0.7 - 0.0 wt%
H_2O	0.003 wt%
Ash	< 0.005 wt%

LHV	42.25 MJ/kg
TAN	< 0.1 mg KOH/g
Viscosity	0.97 mm²/s
Density	815 kg/m³
Flash point	< - 20 °C
Yield	83 wt%

^{x}: Depending on P, T

Neumann, J.; Jäger, N.; Apfelbacher, A.; Daschner, R.; Binder, S.; Hornung, A.: Biomass and Bioenergy, 2016

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Thermo-Catalytic Reforming TCR®

Carbonisate from sewage sludge

Very low H and O content

HHV:
≈10.5 MJ/kg

C	33.5 wt.%
H	0.1 wt.%
N	3.5 wt.%
S	0.7 wt. %
O (diff.)	<<2 wt. %
H_20	<1 wt. %
Ash	62 wt. %

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Thermo-Catalytic Reforming TCR®
Phosphorous recovery from TCR-char

Gasification of char:

- Additional H_2 : Overall process produces more H_2 than required for HDO
- Recovery of Phosphorous out of gasification ash better
- Additional energy for process heat.
- Gasification of TCR char is technically tar free

TCR char and gasifier ash

Updraft gasifier at UMSICHT (cheap, no tar)

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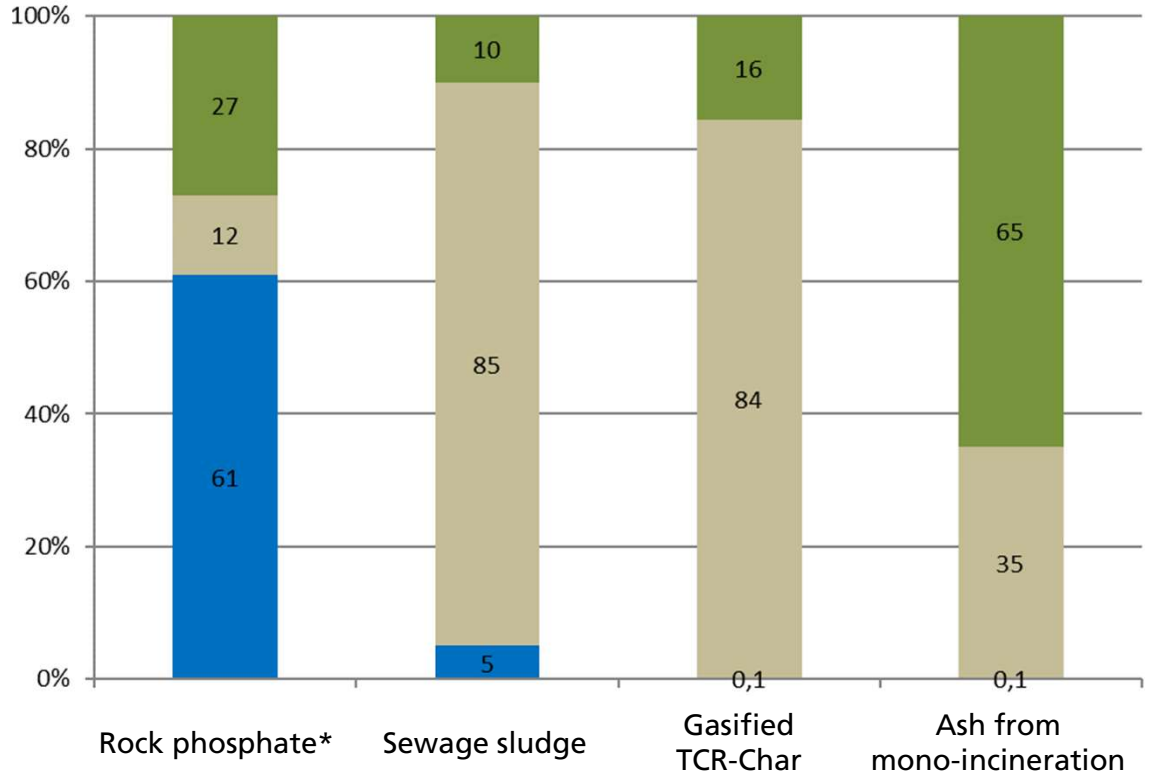
Thermo-Catalytic Reforming TCR®

Phosphorous recovery from TCR-char



*partial solubilisation

Sources: Kratz&Schnug 2008; FhU 2016, Krüger&Adam 2015

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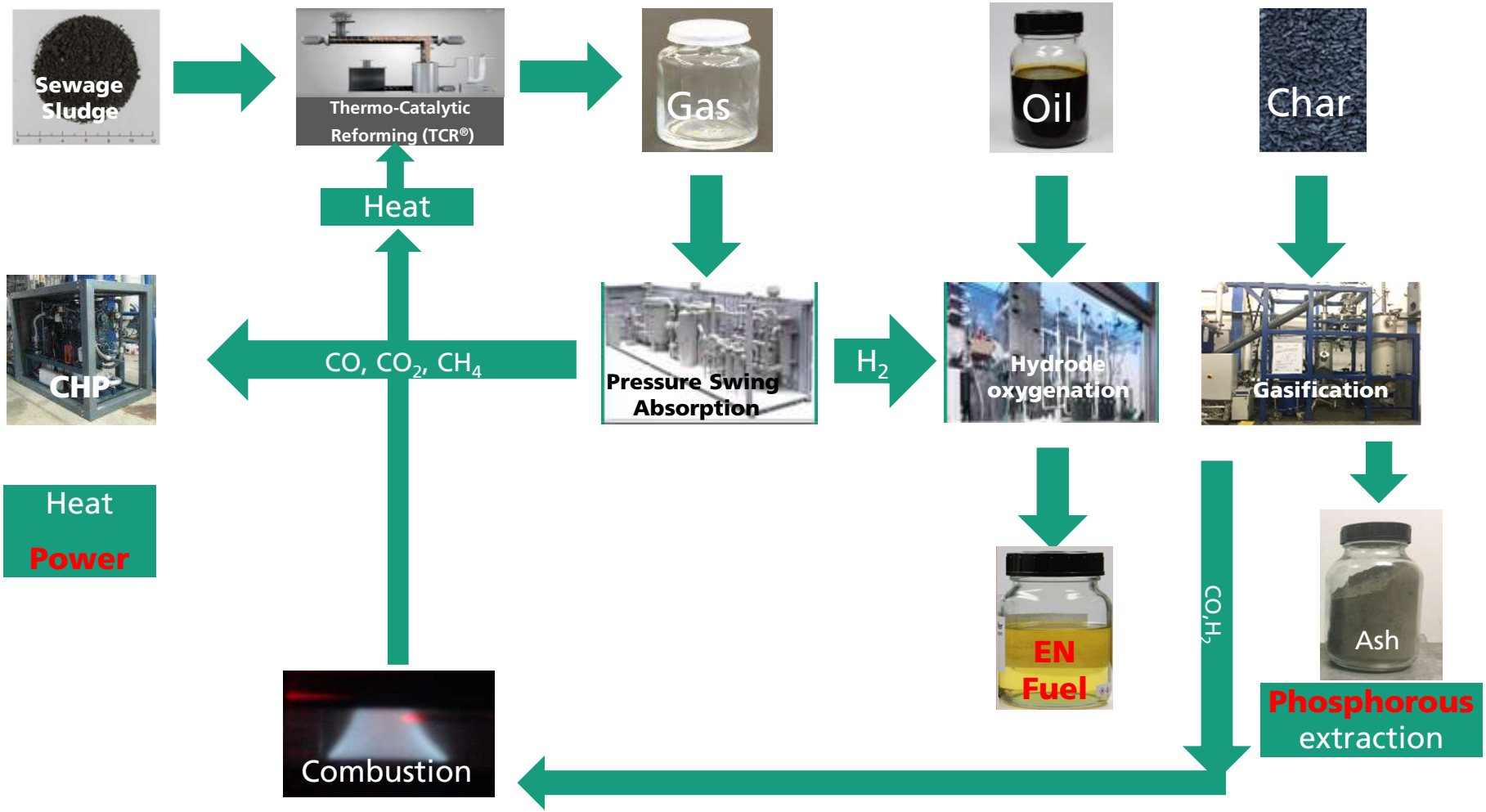
TO-SYN-FUEL:
At a Glance



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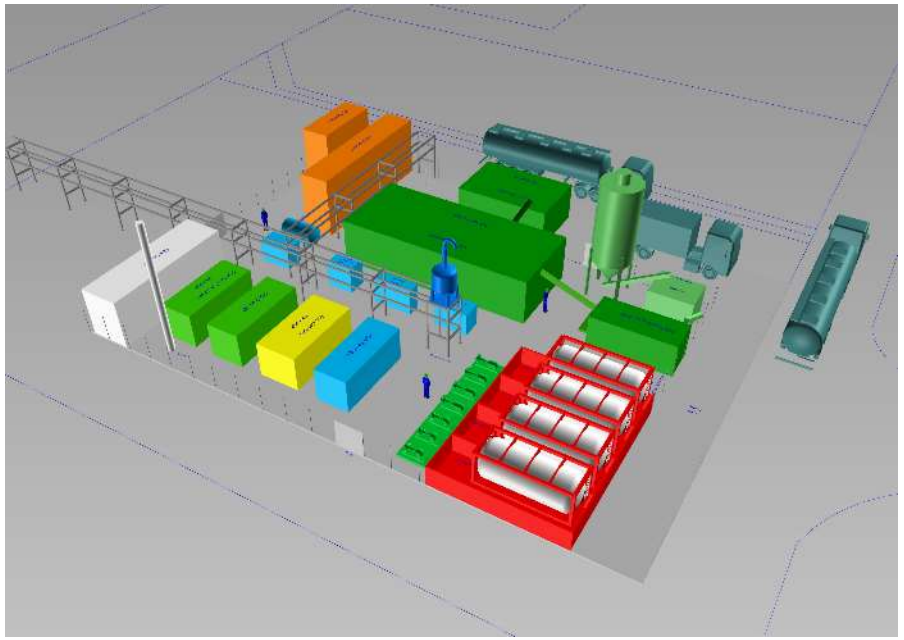
Horizon 2020 Project TO-SYN-FUEL

Next steps

- Design phase — Q3/2019
- Commissioning phase — Q2/2020
- Demonstration phase — Q3/2020-2022
  - 7000 h of operation
  - 500 kg/h of sewage sludge
  - 200 t of HDO liquid fuels



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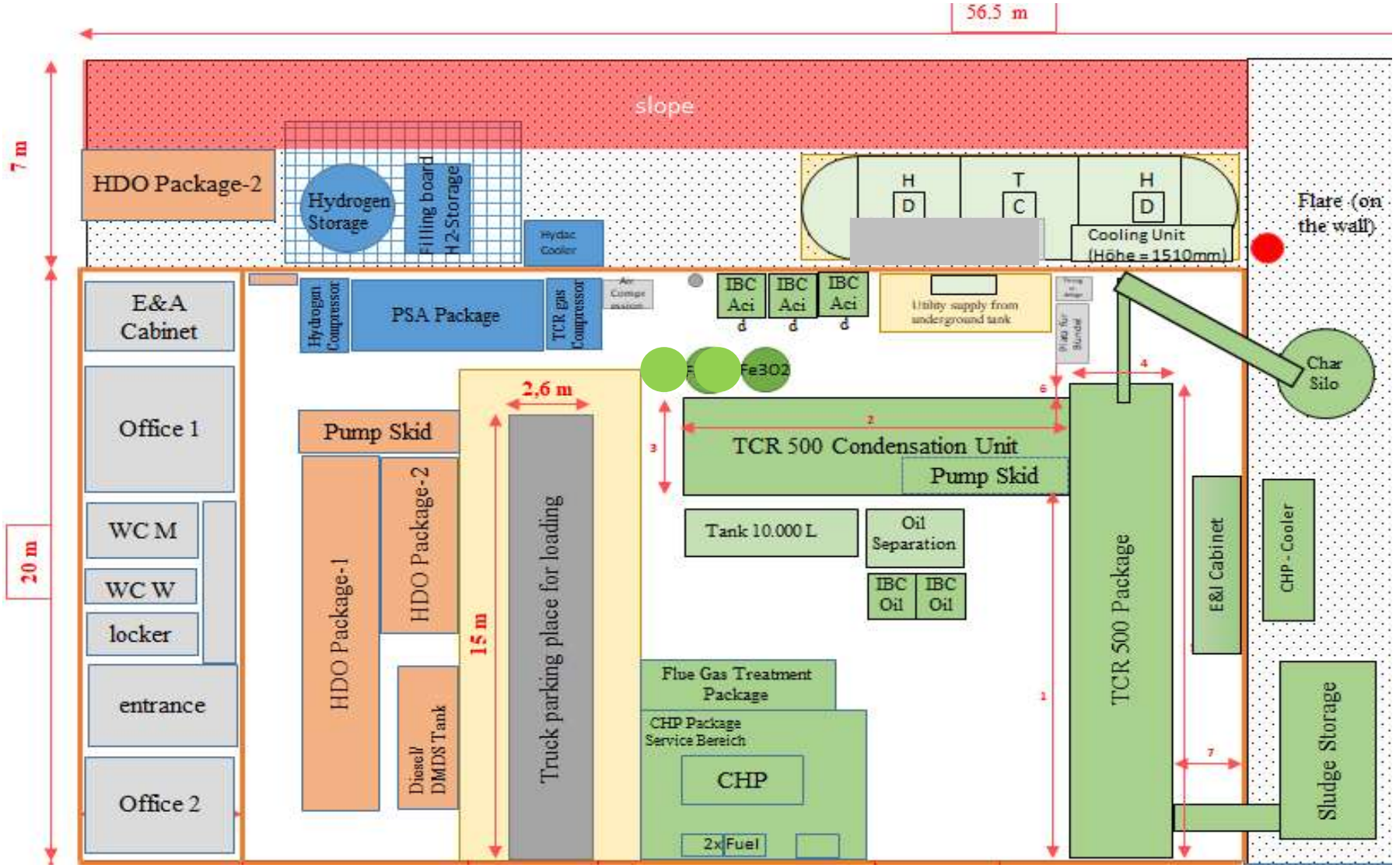
Horizon 2020 TO-SYN-FUEL Plant Overview



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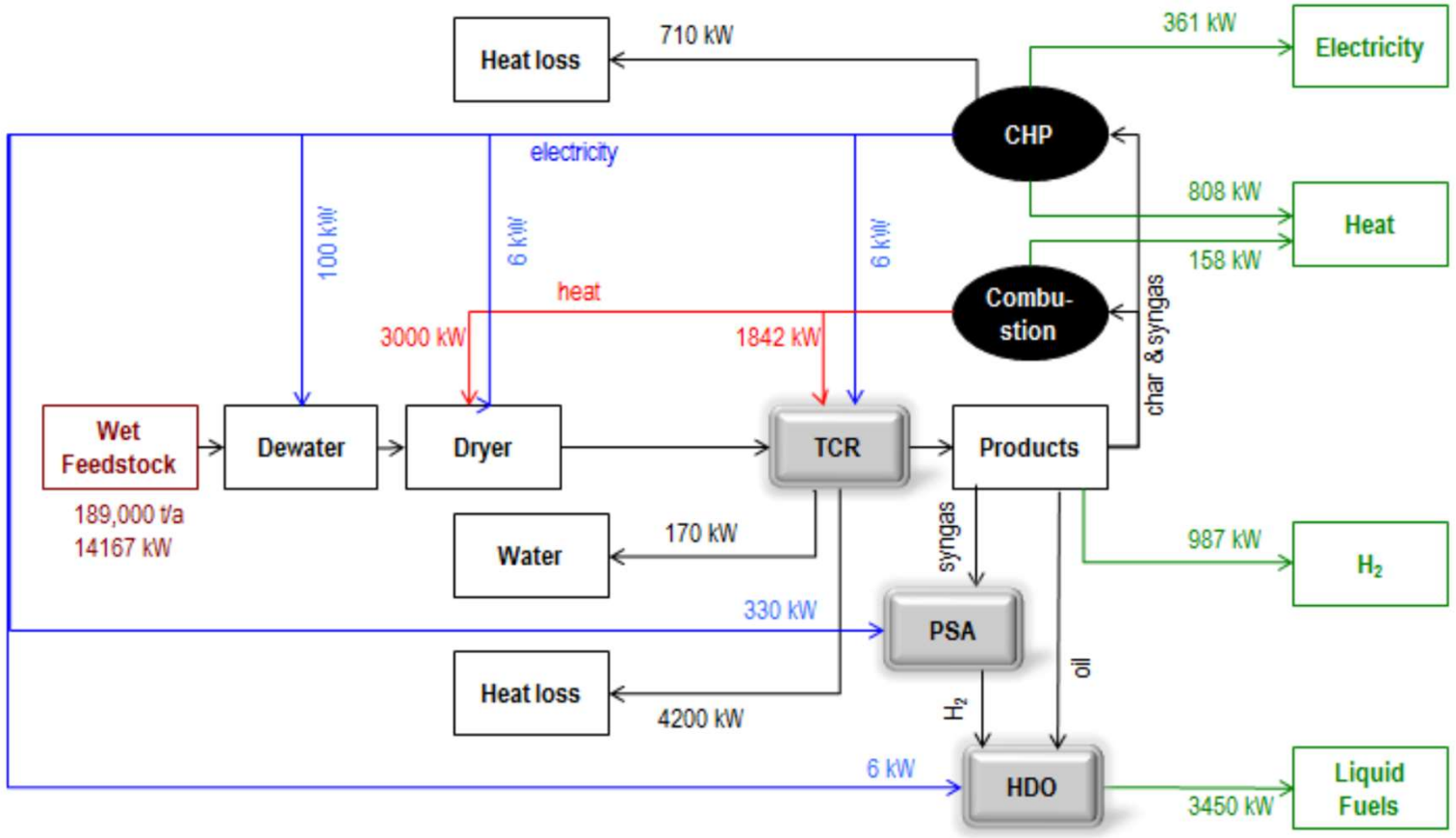
After TO-SYN-FUEL:
Scale up to a 3000 kg/h Unit



Operating Hours = 7000 per/a

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Horizon 2020 Project TO-SYN-FUEL

Stakeholders engagement

If you would like to become more involved with the project platform and include your organisation details in the TO-SYN-FUEL Stakeholder Database, please use the Stakeholder Registration Form.

http://www.tosynfuel.eu/?page_id=2489

Keep in touch with the project to learn about the development of best practices regarding market implementation, commercialization and deployment of new technologies and processes.

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Thank you very much for your attention

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