

# RWE

## **Circular economy pilot plants and projects at the RWE Innovation Centre in Niederaußem**

## **Current status and initial operational results**

IEA-Workshop Gasification und Hydrogen Production

19. April 2023, Edmonton

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# RWE has been producing electricity with passion for over 120 years. Now RWE is shaping the new energy era.

**1898**  
The future begins today, over 120 years ago.

**1914**  
Lignite as the key to inexpensive electricity.

**1928**  
RWE builds the first national power line in Germany.

**1950s**  
Electricity for the post-war economic miracle.

**1955**  
Ludwig Erhard opens Weisweiler lignite-fired power plant.

**1970s**  
Nuclear power offers security of supply.

**1976**  
Research, development and testing of renewables.

**2002**  
CO<sub>2</sub> output reduced through the use of lignite-fired power stations with optimised plant technology (BoA).

**2016**  
Founding and IPO of innogy SE.

**2019**  
Transaction with E.ON, making RWE one of the world's largest generators of electricity from renewable sources.

**Affordable**      **Reliable**      **Clean**





# Ambitious, responsible, resolute.

## With a clear goal: to be carbon-neutral by 2040.



### Core

### Coal/Nuclear

<p><b>Offshore Wind</b> </p> <ul style="list-style-type: none"> <li>• Global offshore activities</li> </ul> <hr/> <p>~1,300 employees</p>	<p><b>Onshore Wind/Solar</b> </p> <ul style="list-style-type: none"> <li>• Onshore, solar and storage activities in               <ul style="list-style-type: none"> <li>• Europe &amp; APAC</li> <li>• Americas</li> </ul> </li> </ul> <hr/> <p>~2,100 employees</p>	<p><b>Hydro/Biomass/Gas</b> </p> <ul style="list-style-type: none"> <li>• Hydro, biomass and gas plants               <ul style="list-style-type: none"> <li>• Germany, UK, NL</li> </ul> </li> <li>• Hydrogen projects</li> <li>• Kelag stake</li> </ul> <hr/> <p>~2,600 employees</p>	<p><b>Supply &amp; Trading</b> </p> <ul style="list-style-type: none"> <li>• Trading/ origination</li> <li>• Gas &amp; LNG</li> <li>• Commodity solutions</li> <li>• Gas storage</li> </ul> <hr/> <p>~1,800 employees</p>	<ul style="list-style-type: none"> <li>• German lignite and nuclear operations</li> <li>• Hard coal plants</li> <li>• 30% share in Dutch nuclear operator EPZ</li> </ul> <hr/> <p>~9,900 employees</p>
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**~28 GW Installed capacity<sup>1</sup>**

<sup>1</sup> Figures for FY 2021, pro rata installed capacity.

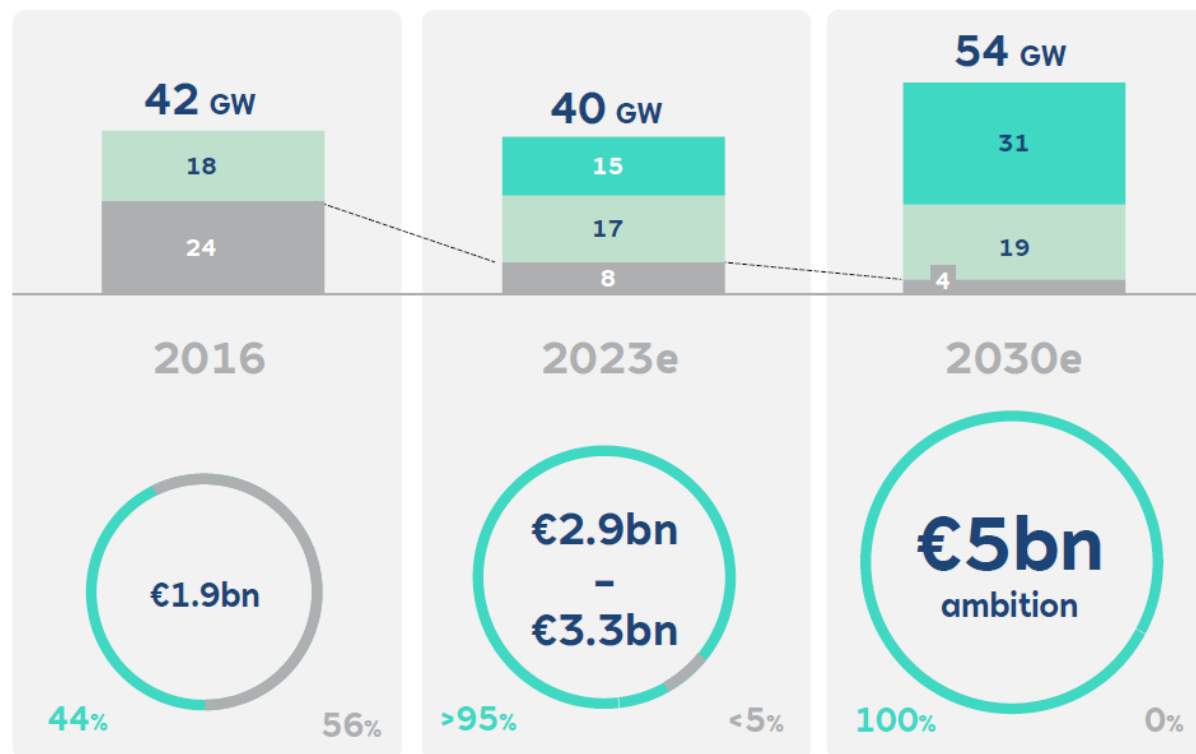
# Ambitious, responsible, resolute.

## With a clear goal: to be carbon-neutral by 2040.

### Installed net capacity

GW, pro rata

- Wind/Solar/Batteries
- Flexible generation/Hydrogen
- Coal/Nuclear



### Adj. EBITDA

- Core business
- Coal/Nuclear



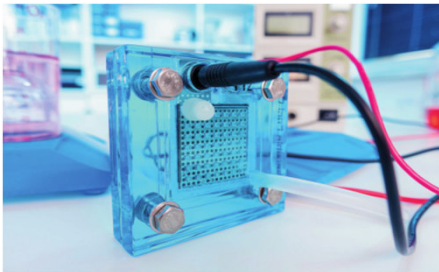
Note: The installed net capacity for Coal/Nuclear for 2023e and 2030e are based on the applicable German phaseout plans for coal and nuclear power.

# Innovatively. Sustainably. Responsibly.

## RWE is promoting technological progress.

### Hydrogen

RWE is conducting research into the possible uses of hydrogen in the GET H2 project and through the installation of a 105-MW power-to-gas electrolysis facility in Lingen, Germany. RWE is also a partner in hydrogen research in the region of Groningen, Netherlands, and South Wales, UK.



### Geothermal

EU project overseen by Geologischer Dienst NRW. RWE is using its Weisweiler power station for deep geothermal utilisation: long-term transformation of the district heating network.



### Power-to-X

Power-to-X technologies are to be developed in the Rhineland in a partnership between industry and research. The purpose is to produce synthetic fuels ("e-fuels"), e.g. methanol, from green hydrogen and CO<sub>2</sub> produced in power stations and industrial plants.



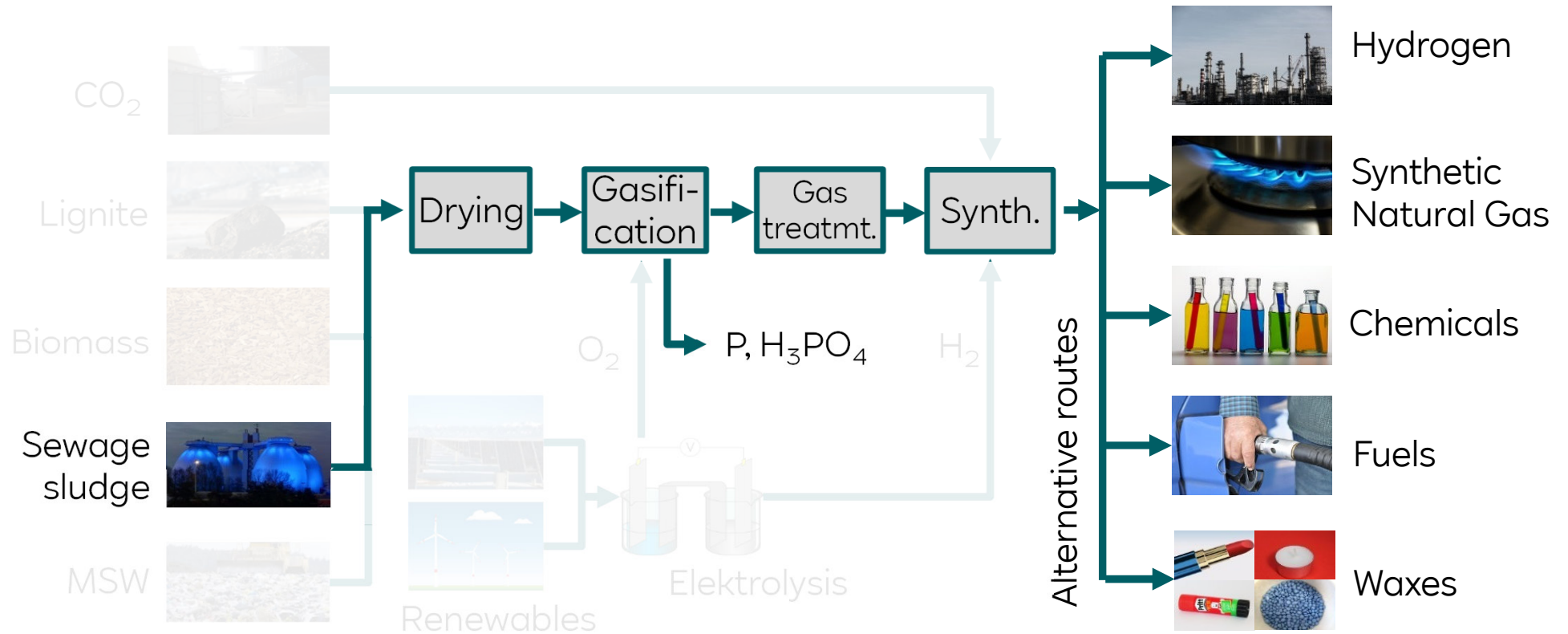
### Multi-Fuel-Conversion

RWE has a long history of thermal conversion. Focus of recent projects is the conversion of residuals and biomasses into Synthesis – gases for further use in the Chemical Industry. Running project shows possibility of phosphorus recovery from sewage sludge.



# WtP @ RWE – New options from alternative feed streams

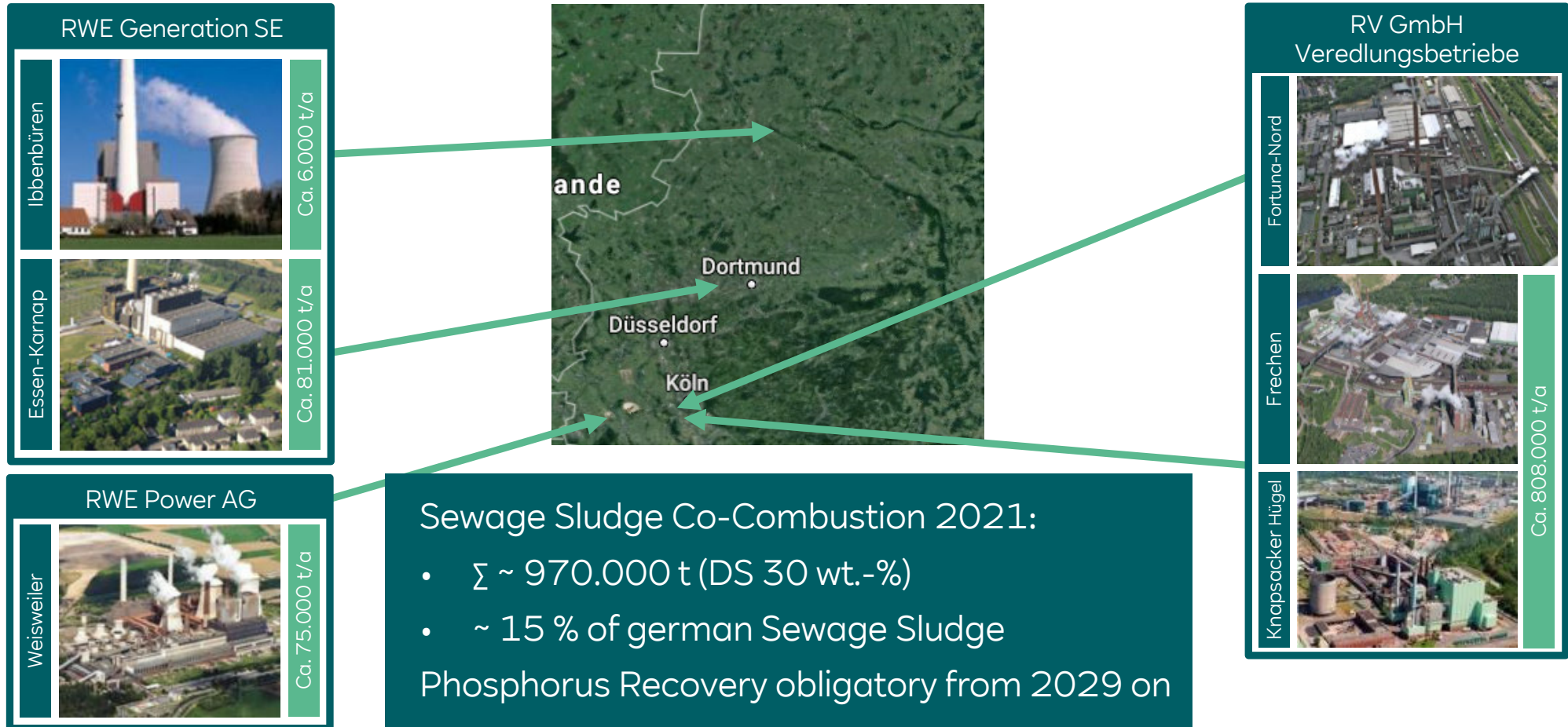
## RWE develops innovative Waste-to-Products processes



- Current focuses: Recovery of P from sewage sludge by Gasification, Waste Gasification

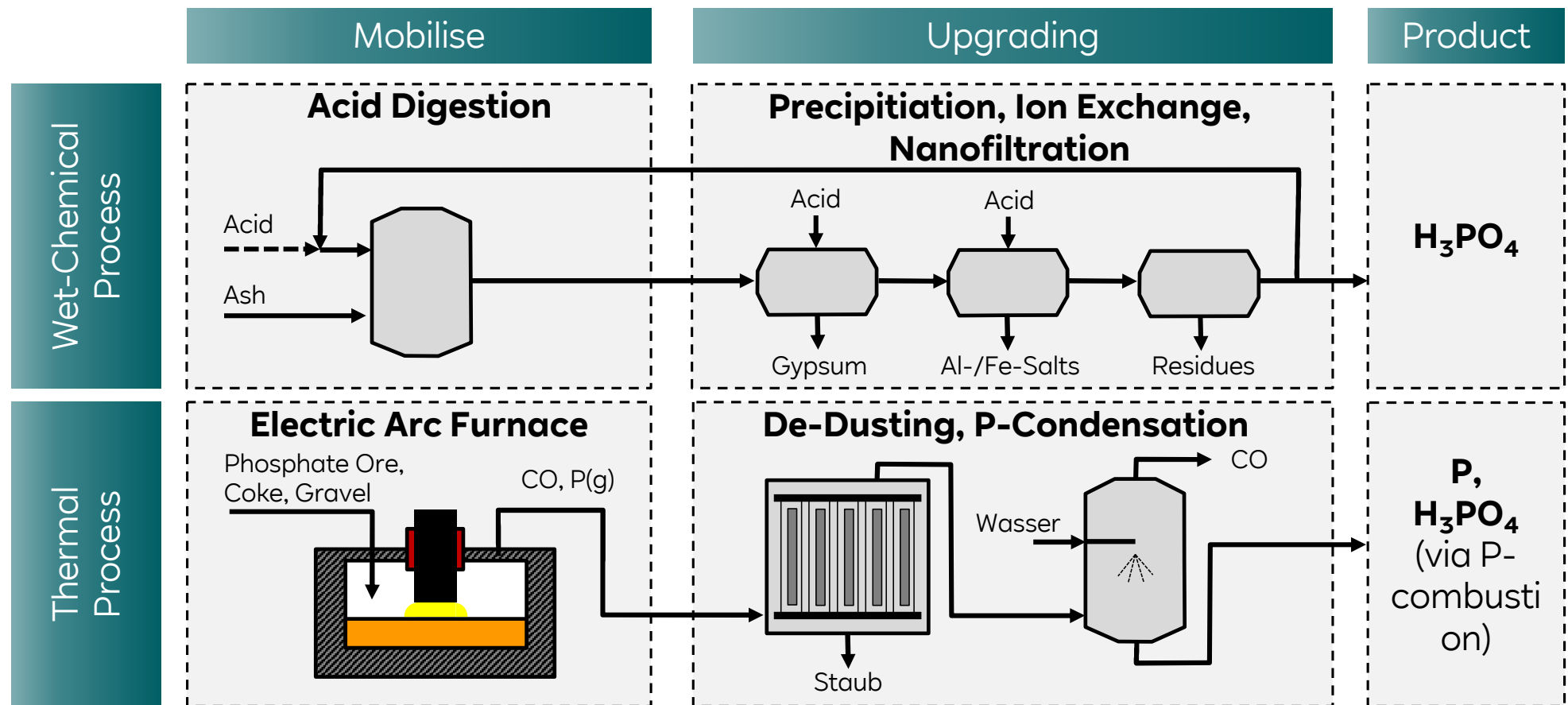
# Why Sewage Sludge?

## RWE is a reliable Partner in thermal Sewage Sludge Treatment



# Production of Phosphorus & Phosphoric Acid

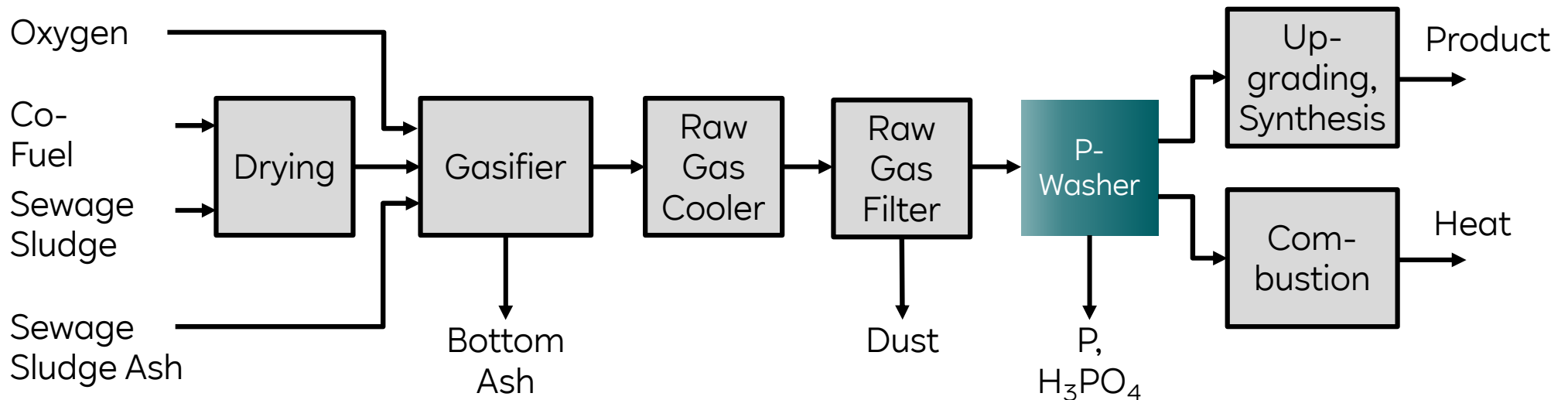
## Wet-Chemical and Thermal





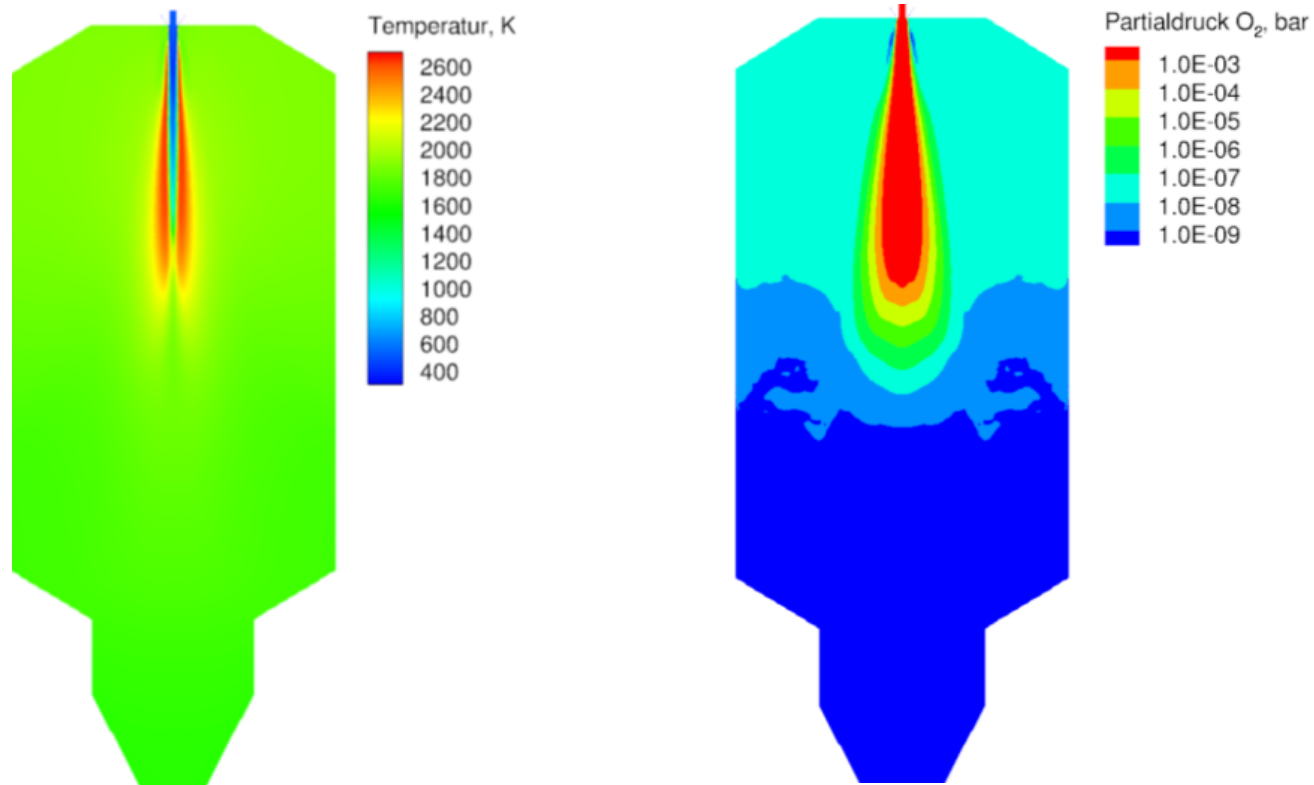
# High Temperature Conversion with in-situ-P-Recovery

## Based on thermal P-Production



- Thermal treatment of sewage sludge, recovery of Phosphorus and recovery of hydrogen and carbon in form of synthesis gas in one process step
- Phosphorus obtained in high quality form (yellow P or H<sub>3</sub>PO<sub>4</sub>)
- Blends of ash from sewage sludge combustion and a co-fuel coal are suitable inputs as well
- Extensive Lab-Scale Trials since 2016

# Entrained Flow High Temperature Conversion CFD-Simulation of Reactor



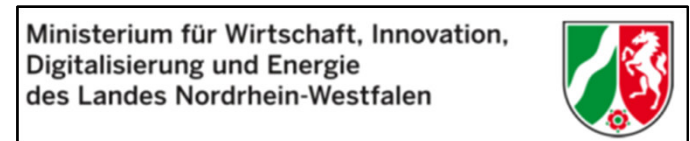
- P-Release possible in non-Flame Zone

# Project ITZ-CC

## Erection of Multi Fuel Conversion Pilot Plant (MFC)

**November 2018 – May 2023**

- **ITZ-CC** = „Virtuelles Innovations- und TechnologieZentrum Carbon Conversion“
- RWE-Subproject: Design, Erection and Operation of the MFC Pilot Plant (Entrained Flow Gasifier, max. 850 kW<sub>th</sub>)
- First Operation with Lignite in June 2021, first campaign with sewage sludge late 2021
- Partners: Fraunhofer UMSICHT, Ruhr-Universität Bochum
- Total budget of MFC-Subproject: 6.7 Mio. € (3.3 Mio. € Funding by NRW ministry of economics)



# MFC Pilot Plant in ITZ-CC

## Funded by State NRW

Funded by

Ministerium für Wirtschaft, Innovation,  
Digitalisierung und Energie  
des Landes Nordrhein-Westfalen



# ITZ CC

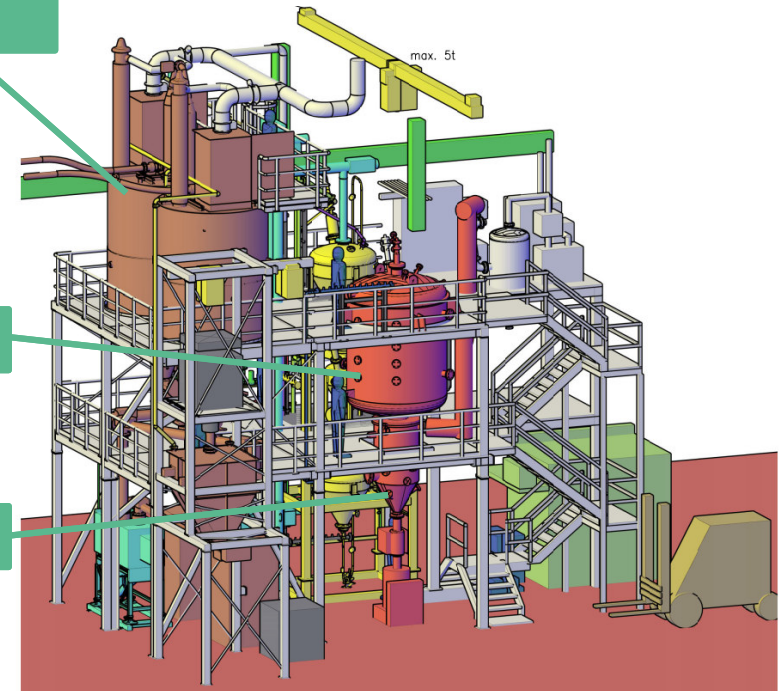
Innovations- und Technologiezentrum  
zur stofflichen Nutzung nachhaltiger Kohlenstoffquellen



Fuel Silos

Reactor

Quench



# MFC Pilot Plant in ITZ-CC

## Flow Diagram

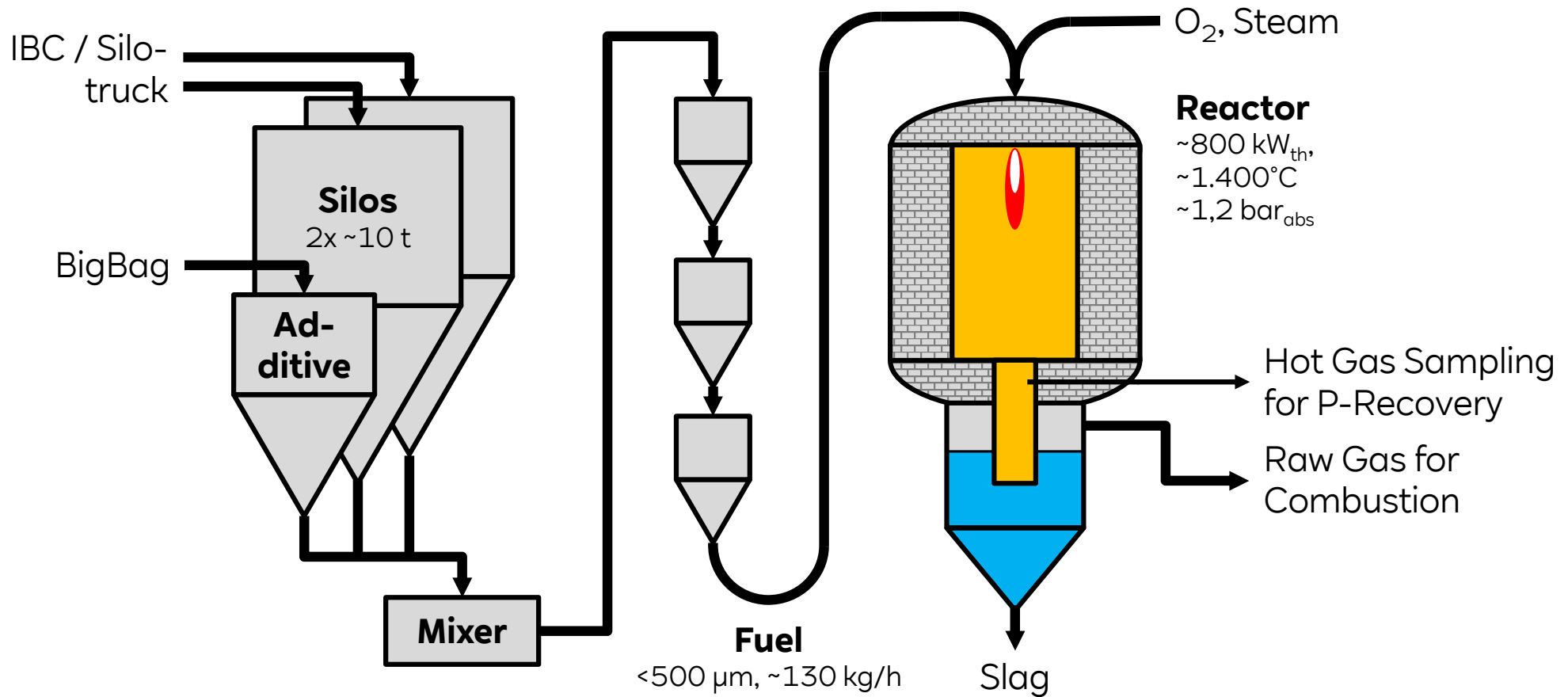
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**ITZ CC**

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zur stofflichen Nutzung nachhaltiger Kohlenstoffquellen



# MFC Pilot Plant in ITZ-CC Schedule

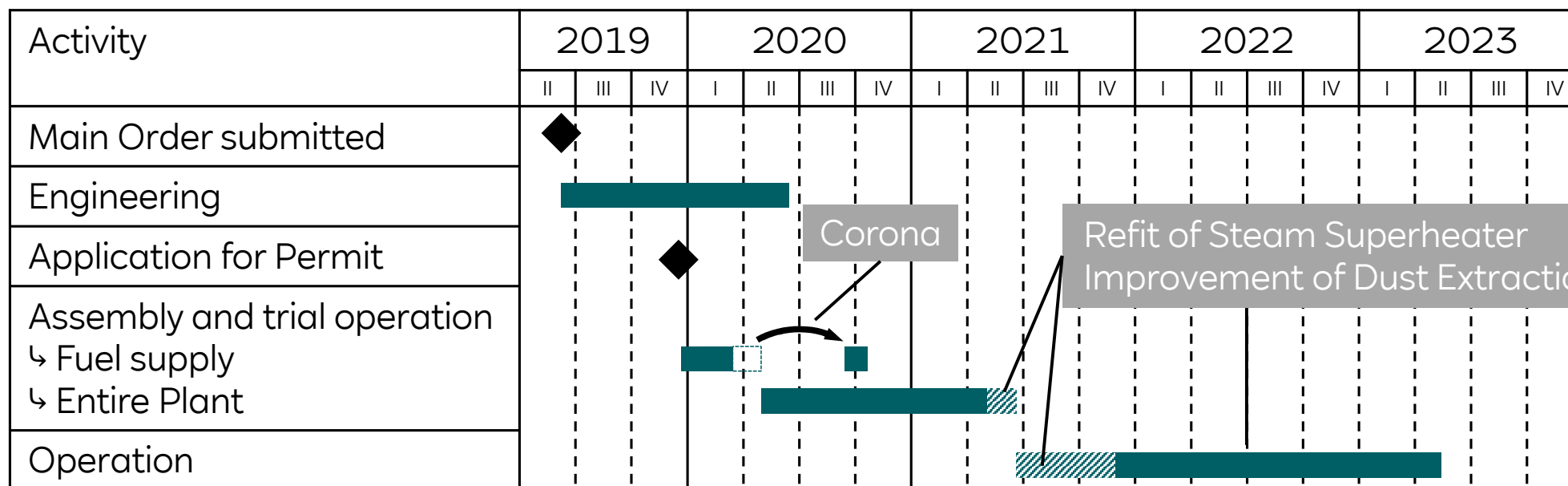
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zur stofflichen Nutzung nachhaltiger Kohlenstoffquellen



# MFC Pilot Plant in ITZ-CC

## Operational Experience

Funded by

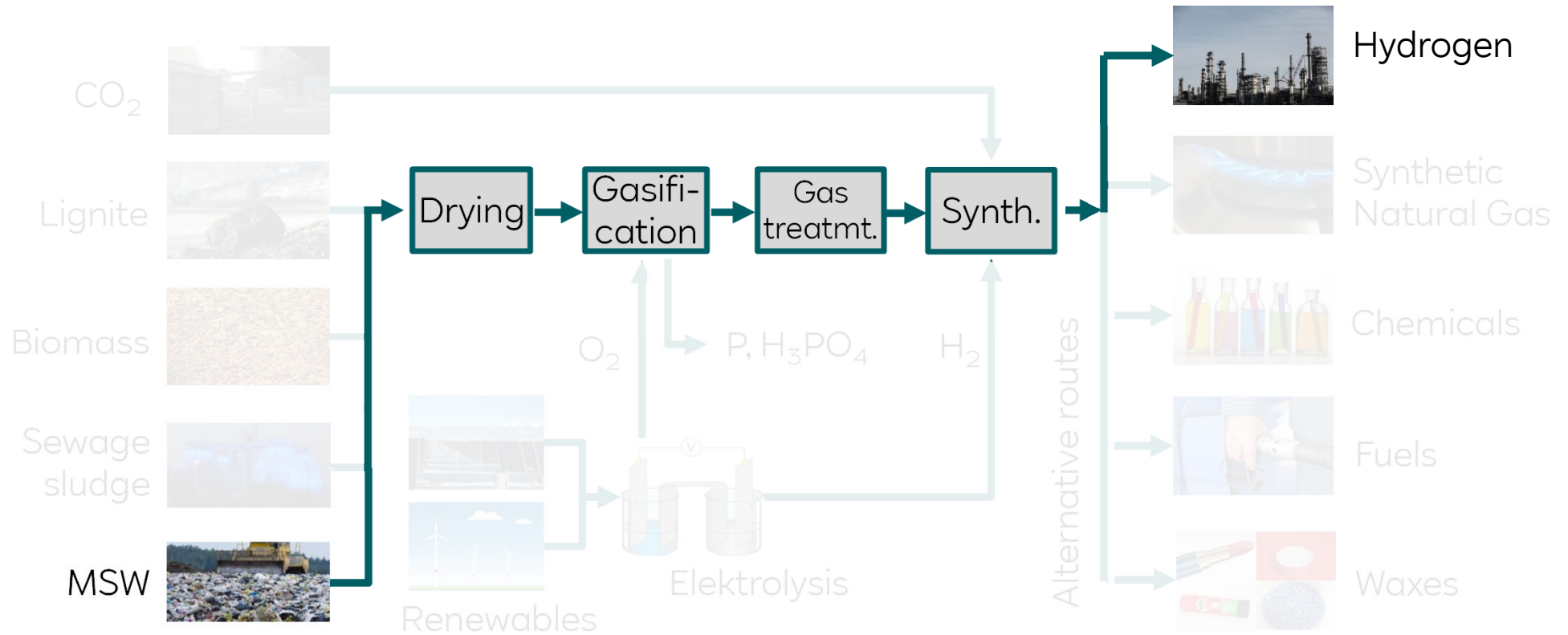


### Highlights of selected Gasification Campaigns (~1 per month, ~3 days hot operation)

- 06/2021: First Gasification Operation with Lignite by Supplier,  
“Teething Trouble” with Min-Load of Propane Burner, Dust Extraction downstream  
Reactor, Steam Supply at too low Temperature (el. Superheater required)
- 11/2021: abovementioned Modifications successful
- 12/2021: first Gasification operation with Lignite and Sewage Sludge
- 02/2022: Conversion of > 1 t of solid Feedstock into syngas
- 04/2022: first Addition of Steam as Gasification Agent
- 05/2022: interruption-free Gasification Operation for > 4:30 hours
- 06/2022: Gasification Operation incl. hot Gas Sampling
- 11/2022: Gasification Operation with 30 wt% Sewage Sludge
- Outlook:
  - Substitution of Lignite by Hard Coal (and others) for improved fluidisation & conveying
  - Modification of hot Gas Sampling

# WtP @ RWE – New options from alternative feed streams

## RWE develops innovative Waste-to-Products processes



- Current focuses: Recovery of P from sewage sludge by gasification, Waste Gasification

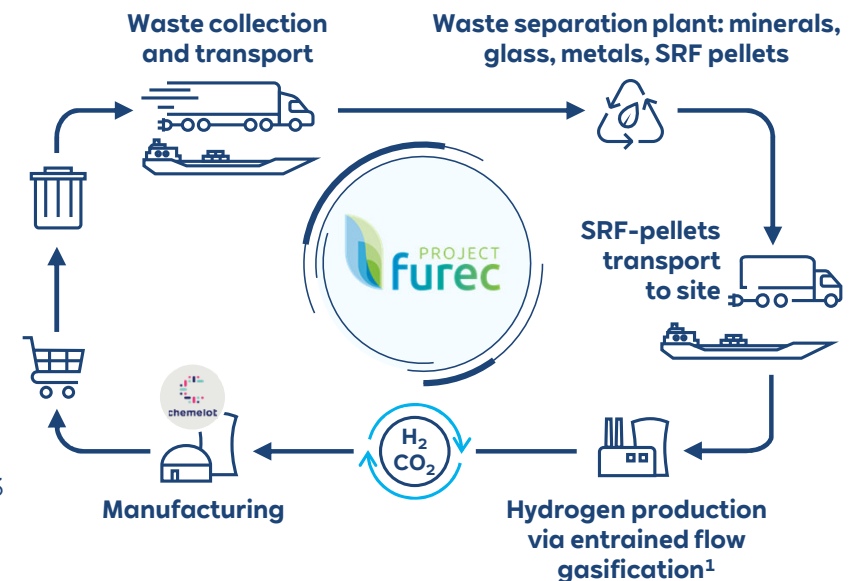


# FUREC converts non-recyclable waste into feedstock... Project FUREC („Fuse Reuse Recycle”)



## Project typicals

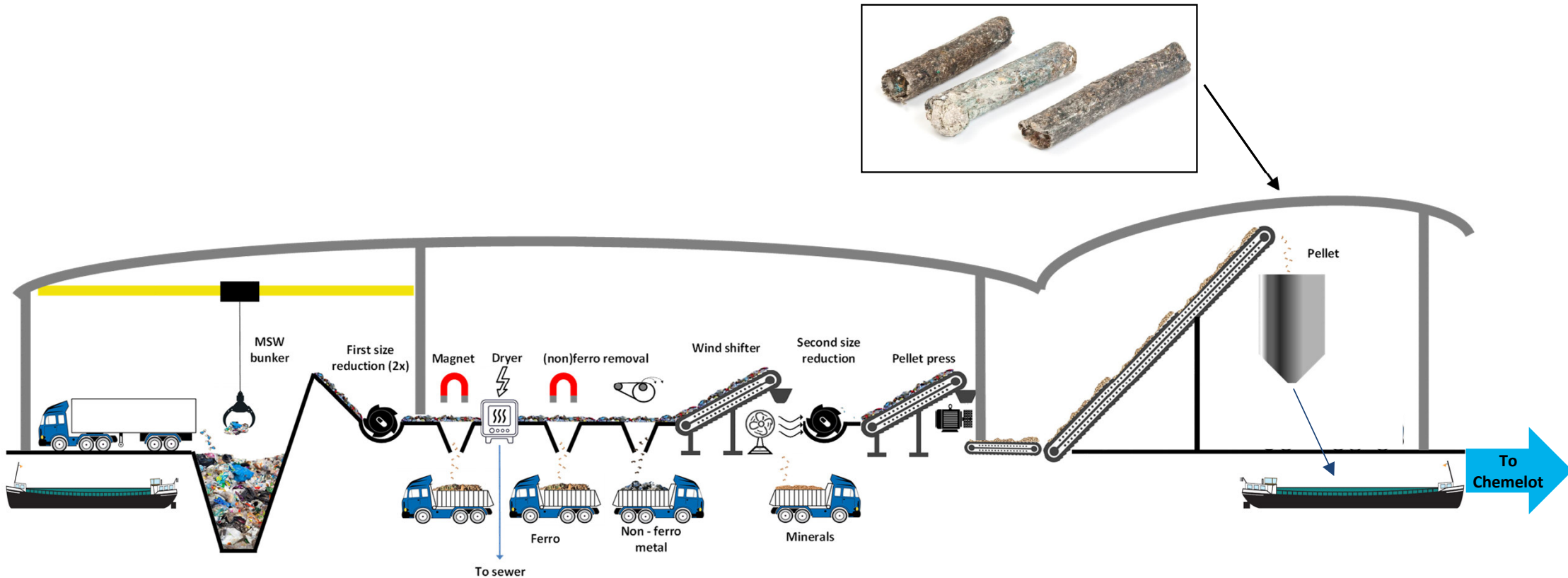
- Investment: > 500 million € in total on sites Zevenellen (Buggenum) and Chemelot
- Production: ca. 50.000 t/a H<sub>2</sub><sup>1</sup>
- Reduction: ca. 280 million Nm<sup>3</sup>/a “Groningen” natural gas<sup>2</sup>
- CO<sub>2</sub> reduction: ca. 350.000 t/a, increasing to >500.000
- CO<sub>2</sub> production: ca. 800.000 t/a ready for use/capture  
ca. 450.000 t/a of which is biogenic
- Waste capacity: ca. 700.000 t/a of MSW/non-recyclable waste<sup>3</sup>



→ **FUREC** selected for **EU Innovation Fund** January 2023

[1] equivalent of 700 MW off-shore wind park + electrolyser, [2] half of domestic gas use Limburg, [3] equivalent to 2 million inhabitants

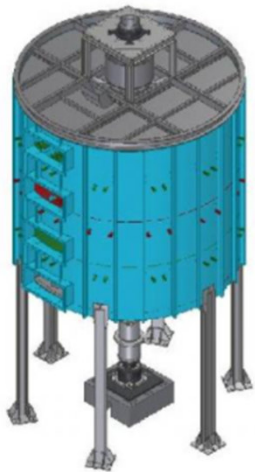
# ...via waste pre-treatment at Buggenum site ... Project FUREC („Fuse Reuse Recycle“)



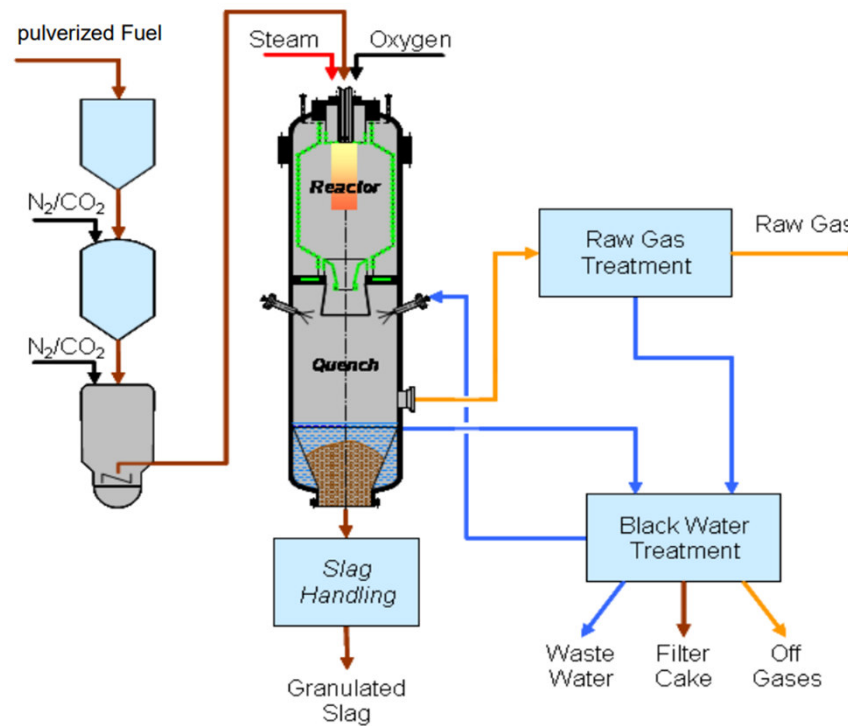
# ... and conversion into synthesis gas (CO + H<sub>2</sub>) Project FUREC („Fuse Reuse Recycle”)



## Torrefaction



## Gasification



## Syngas Clean Up



# Multiple Hearth Furnace Pilot Plant

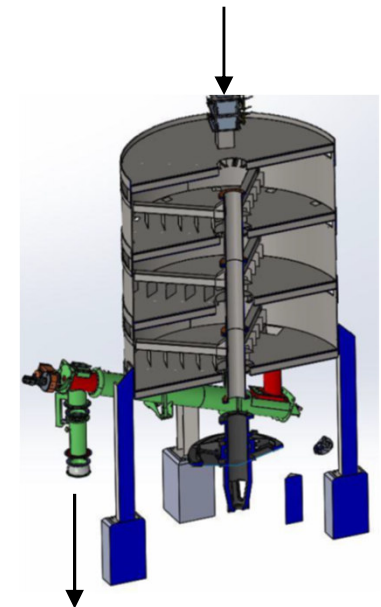
## Process & Design Basics

### Torrefaction...

- ... is a low Temperature Pyrolysis of lumpy feedstock @ 260-320 °C in order to enable grinding of fuels like
  - Biomass or
  - Pelletized RDFfor Entrained Flow Gasification (FUREC, MFC-Plant)

### MHF Pilot Plant

- Size:  $D_o = 4 \text{ m}$  |  $H_{\text{total}} = 9 \text{ m}$
- Input: 240 kg/h
- Schedule:
  - 09/2021 contract awarded to John Cockerill
  - 11/2022 first delivery of main components
  - 04/2023 start of commissioning



# Multiple Hearth Furnace Pilot Plant

## Unloading of MHF casing



# Multiple Hearth Furnace Pilot Plant

## Gissen is missen, meten is weten



# Multiple Hearth Furnace Pilot Plant

## Current Status 03/2023



# RWE pursues concrete approaches to Circular Economy

## Our energy for a sustainable life

- **Sewage Sludge Gasification**

- offers potential for efficient recovery of Hydrogen, Carbon and Phosphorus
- MFC Pilot Plant in operation since 2021
- MFC available for alternative feedstocks and collaboration

- **Gasification of Municipal Solid Waste**

- enables CO<sub>2</sub>-efficient and affordable Syngas/Hydrogen production on Industrial Scale
- FUREC Project being developed by RWE Generation NL at Chemelot site, Geleen
- RWE Power R&D-department contributes erection of MHF Pilot Plant for torrefaction of lumpy solid fuels in order to improve grindability



# RWE R&D Pilot Plants at Niederaußem

## Thank you for your attention!

Innovation path  
to the pilot plants

### Info-Center

