IEA Bioenergy
Technology Collaboration Programme

Gasification developments in Europe and the USA

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IEA Bioenergy Task 33 webinar

24. February 2021

Outline

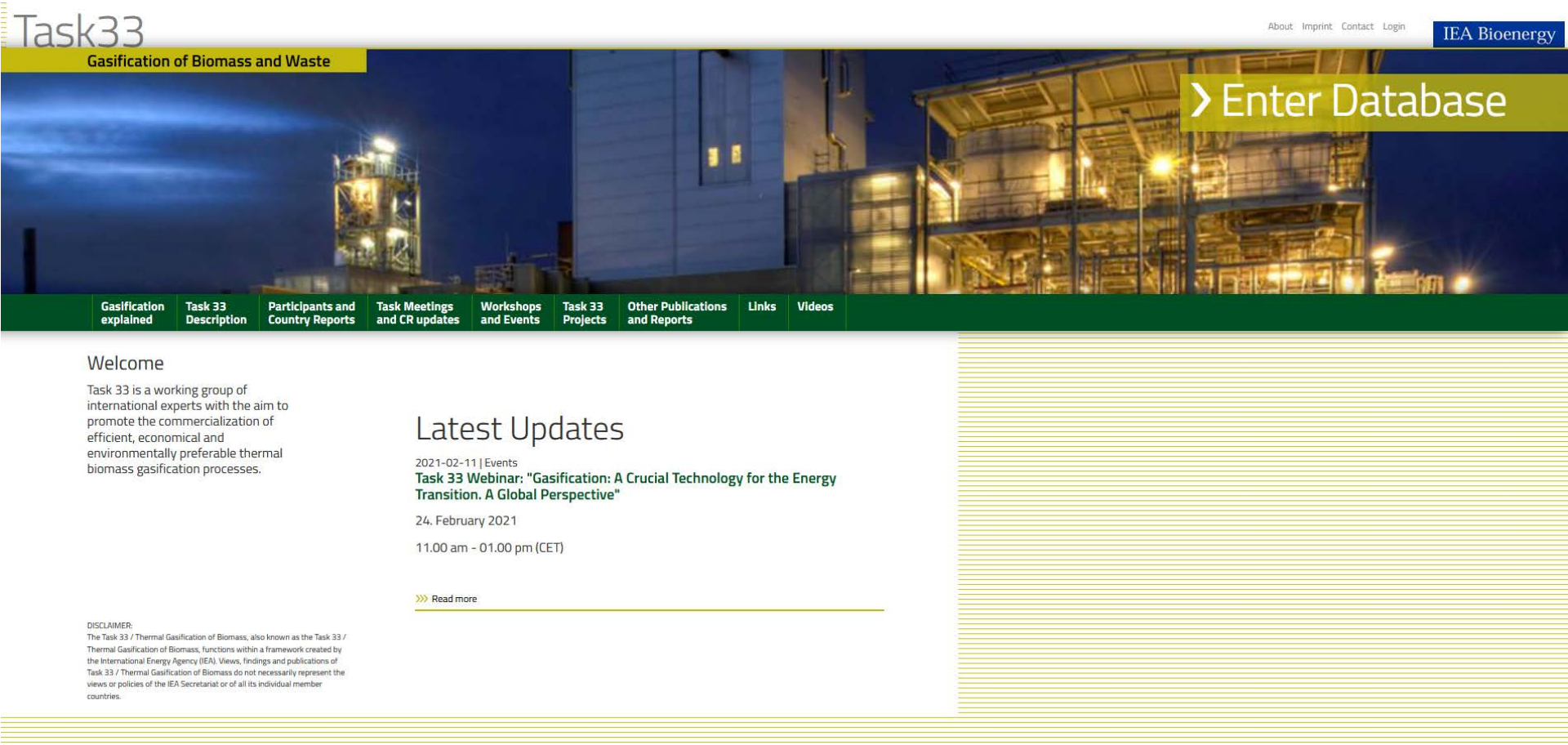
- IEA Bioenergy Task 33

- Status on gasification in
  - **Austria**
  - **Germany**
  - **Italy**
  - **NL**
  - **Sweden**
  - **UK**
  - **USA**
  - France
  - Spain

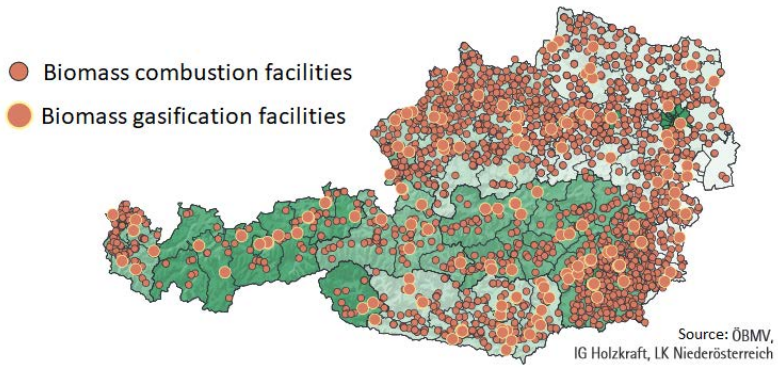
Figure source: SynCraft

IEA Bioenergy Task 33 - Gasification of biomass and waste

www.task33.ieabioenergy.com



Austria



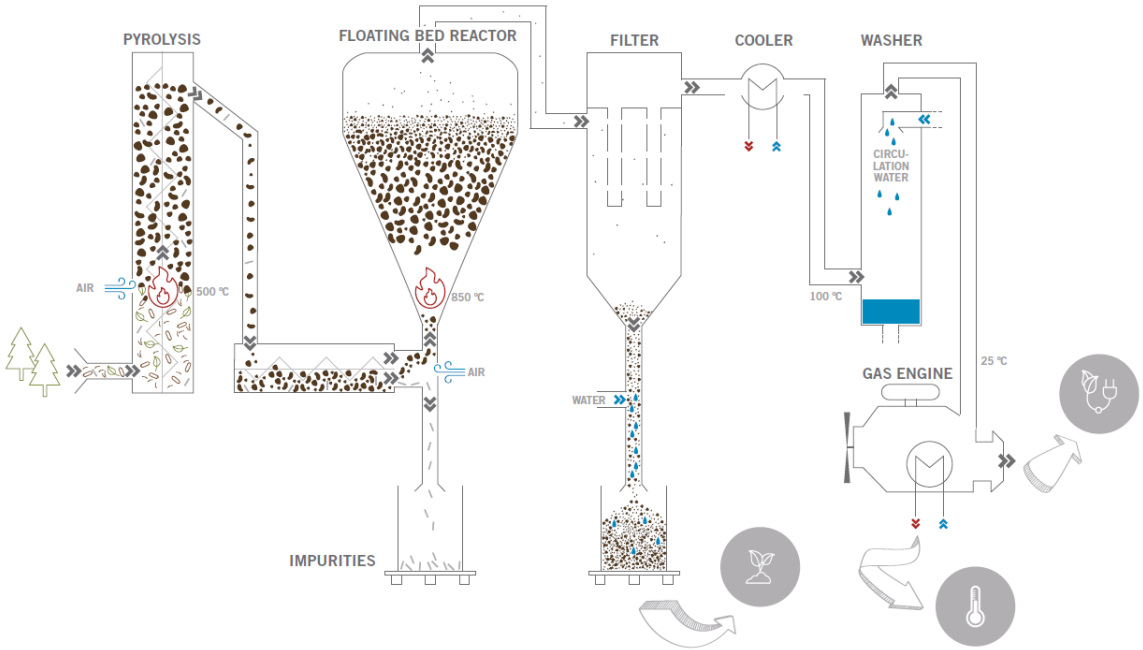
About 2 400 biomass boilers and more than 140 CHP gasification facilities in Austria.

All facilities are small scale CHP.
Besides Austrian facilities also facilites by German and Italian manufacturers.

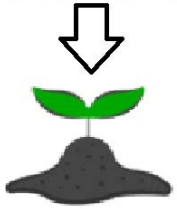
Output kWel	Output kWth
18/55	44/120
20	60
50	107
200-500	320-770
300/500	500/800
120-550	280-880

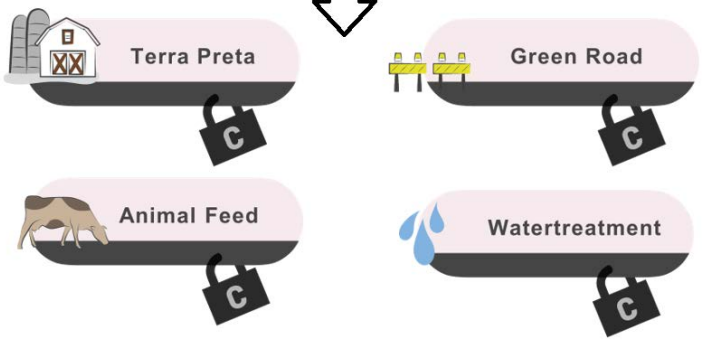
Austria

SYNCRAFT®
Das Holzkraftwerk.



1kg charcoal
is an eq. to
3 kg CO2



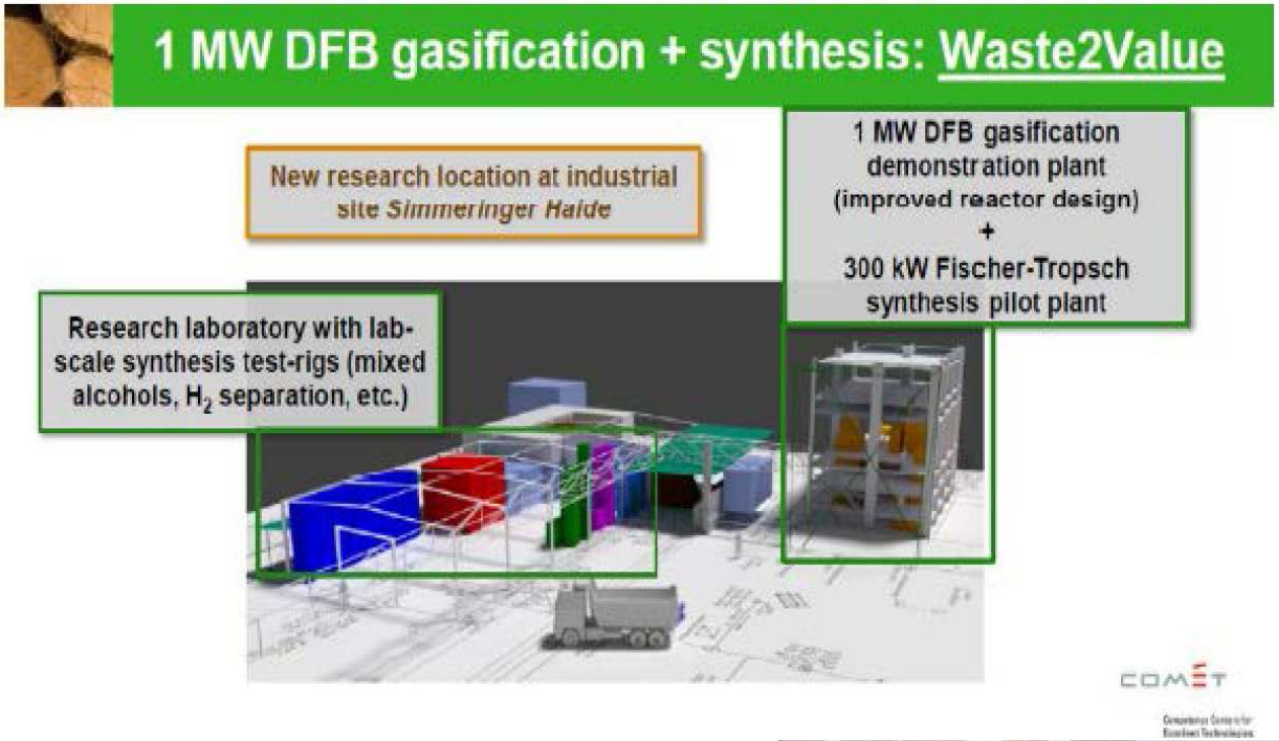


Floating fixed bed technology

Mission

negative CO_2 footprint

Austria: Project Waste2Value

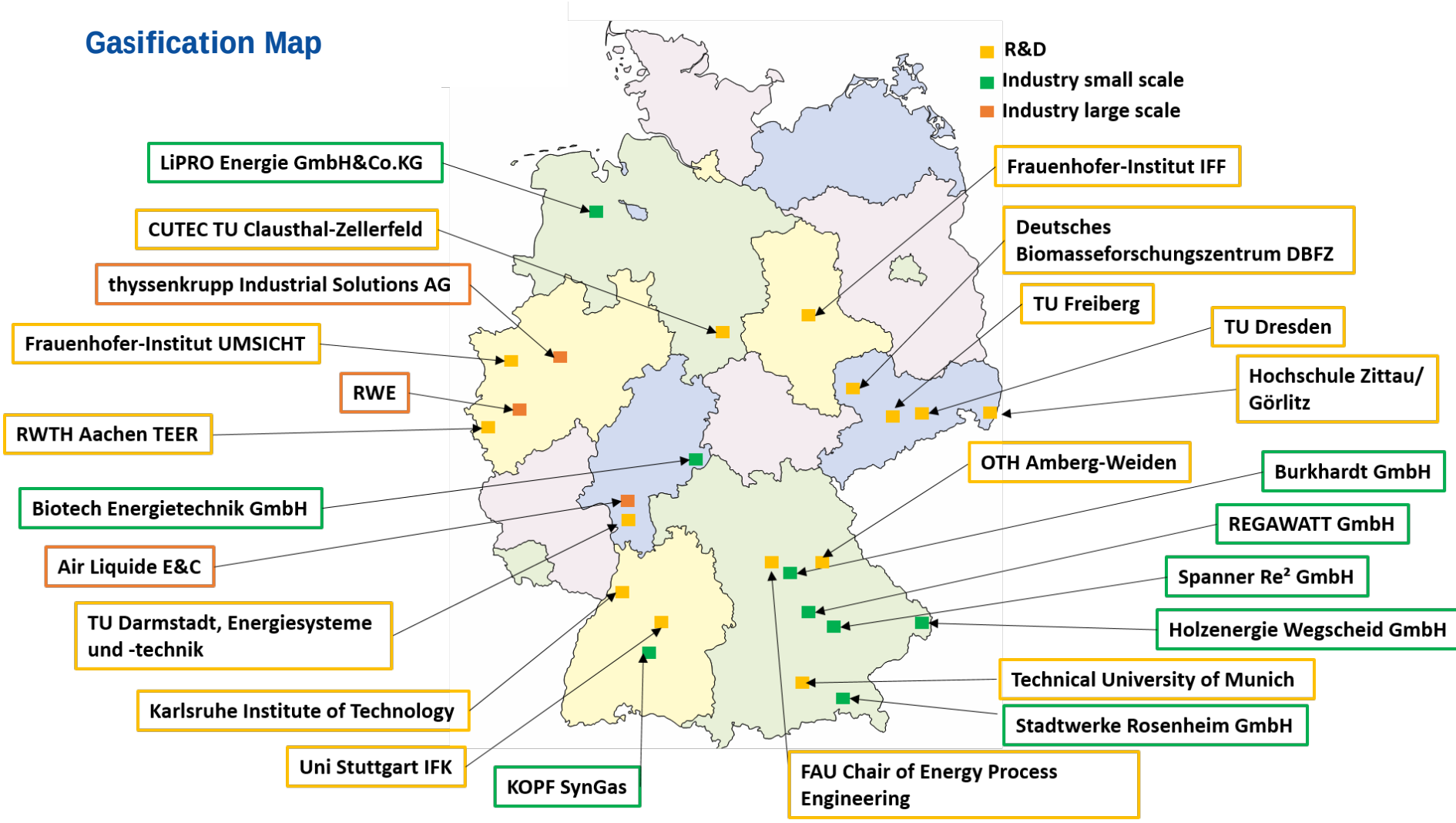


Now under construction
April 2021 first tests planed
May 2021 commissioning
June 2021 operation

IEA Bioenergy

Germany

Gasification Map



Germany

Bioliq pilot plant

Developed at KIT for production of synthetic biofuels and base chemicals from biogenic residues,

Process chain (TRL6) with:

2 MW fast pyrolysis for biosyncrude

5 MW entrained flow gasifier (40/80 bar) with high temperature gas cleaning

fuel synthesis: DME to gasoline (100 l/h)

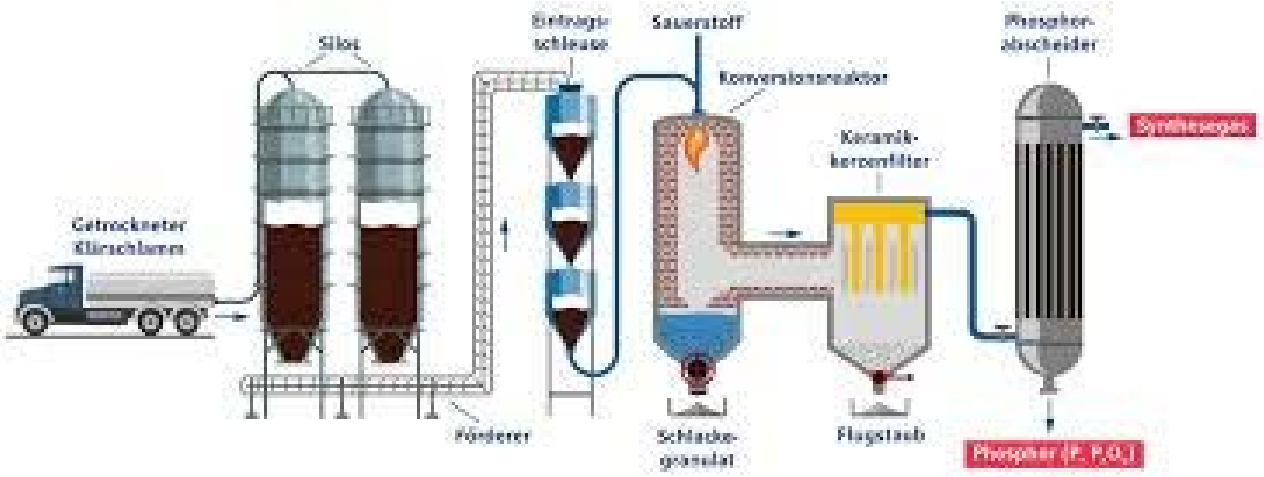
Thermo-chemical process steps in operation since 2010, synthesis since 2014

Operation 24/7 in campaigns

Germany

RWE Sewage Sludge to Phosphorus

Pilot plant in Niederaußem

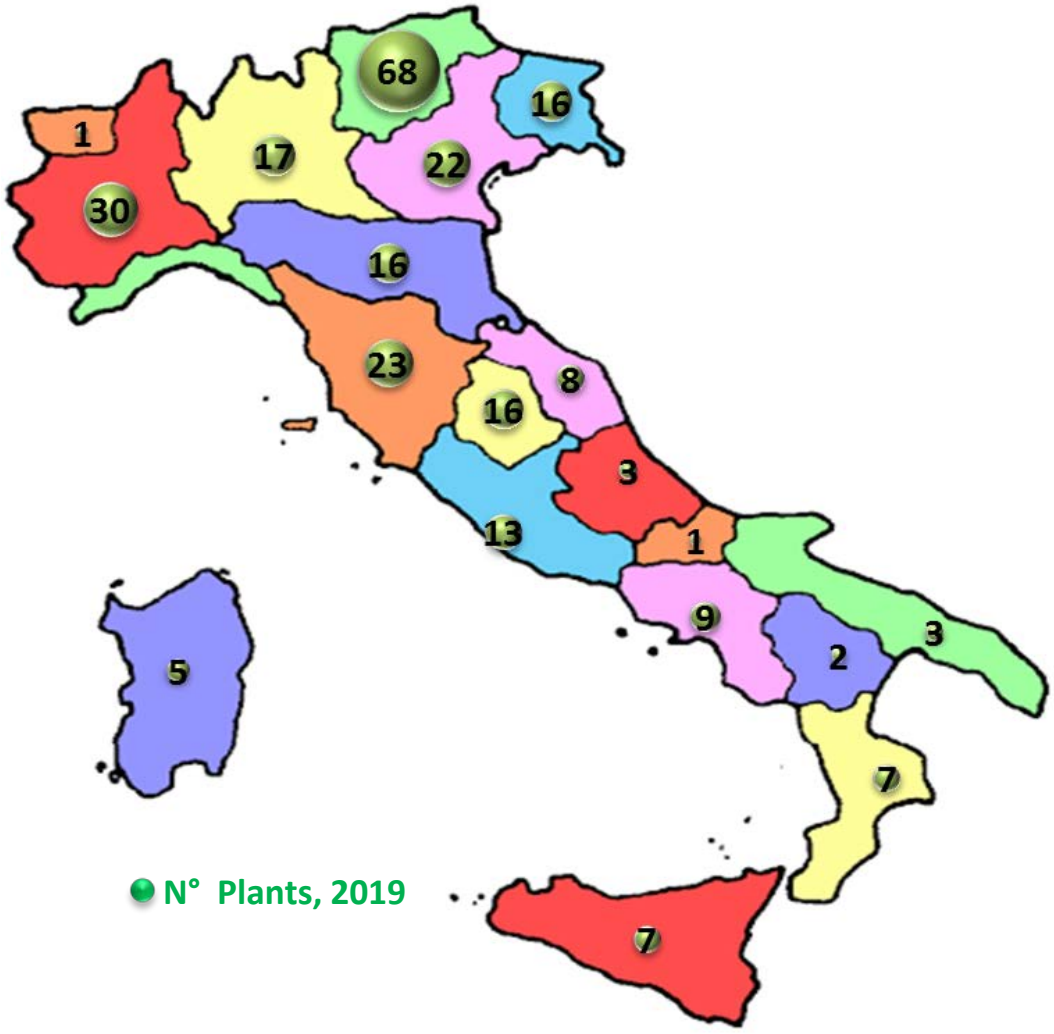


Entrained flow gasifier
Atmospheric, refractory lined, dip quench, liquid ash discharge
Feedstock: Sewage Sludge, Sewage Sludge Ash, Lignite 130 kg/h
Temperature ~1500°C

Start-Up April 2021
Funding provided by State of North Rhine Westphalia (Ministry of Economics);
Total project budget (incl. cost for plant operation): 6.7 Mio. €
- Partners: Fraunhofer UMSICHT, Ruhr Universität Bochum

Source: RWE; https://www.group.rwe/presse/rwe-power/2019-08-01-neueversuchsanlage-gewinnt-lebenswichtigen-rohstoff-phosphor-aus-klaerschlamm-zuruck

Italy - Gasification plants across Italy - 2019



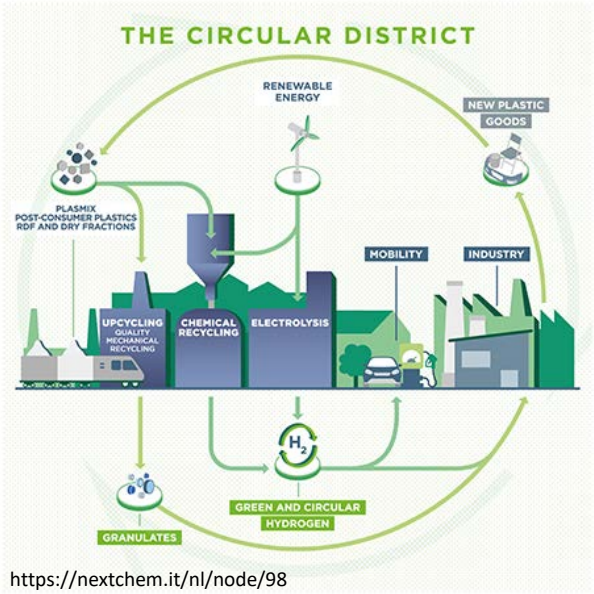
Year of ref.	2019
Total Power (kWel)	56674
Total Number	267

May 2019		
Geographical area	N° Plants	%
Northern Italy	170	63.7
Central Italy	60	22.5
Southern Italy and islands	37	13.9

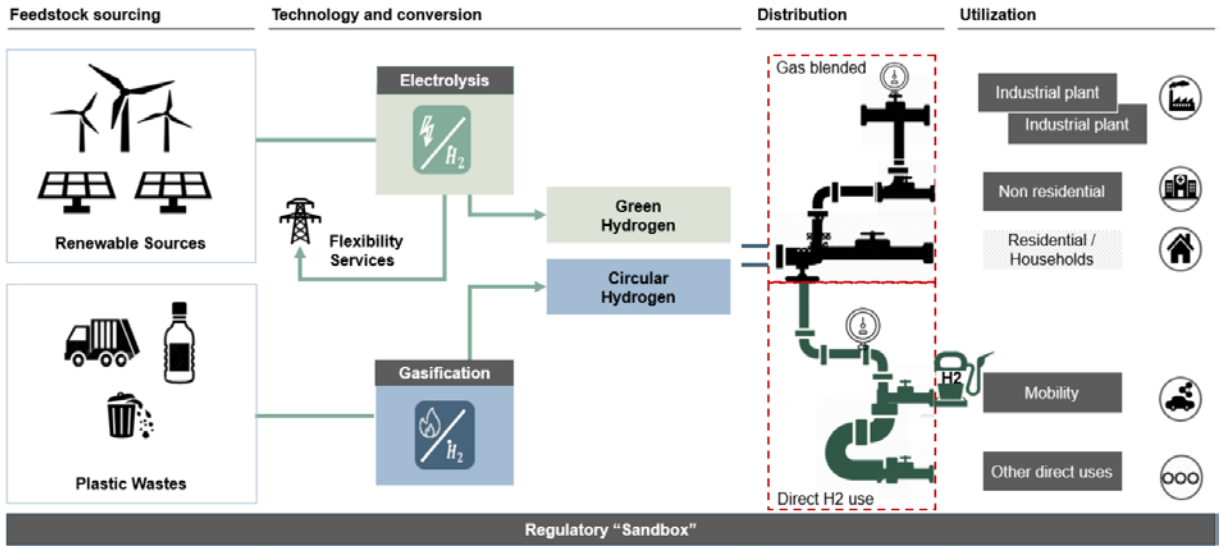
May 2019		
Geographical area	kWel.	%
Northern Italy	41760	73.7
Central Italy	9552	16.9
Southern Italy and islands	5362	9.5

Data source: GSE (Gestore Servizi Energetici, Energy Service System Operator).
See also Atlaimpianti (https://atla.gse.it/atlaimpianti/project/Atlaimpianti_Internet.html)

Italy - Initiative by NextChem & ENI - Circular District



https://nextchem.it/nl/node/98



NextChem ongoing studies to produce and therefore inject green H2 and syngas in the gas distribution networks.

- **10 June 2019**
  «Eni and Maire Tecnimont sign agreement to introduce new technology that transforms non-recyclable waste into hydrogen and methanol» (processes based on gasification are included)

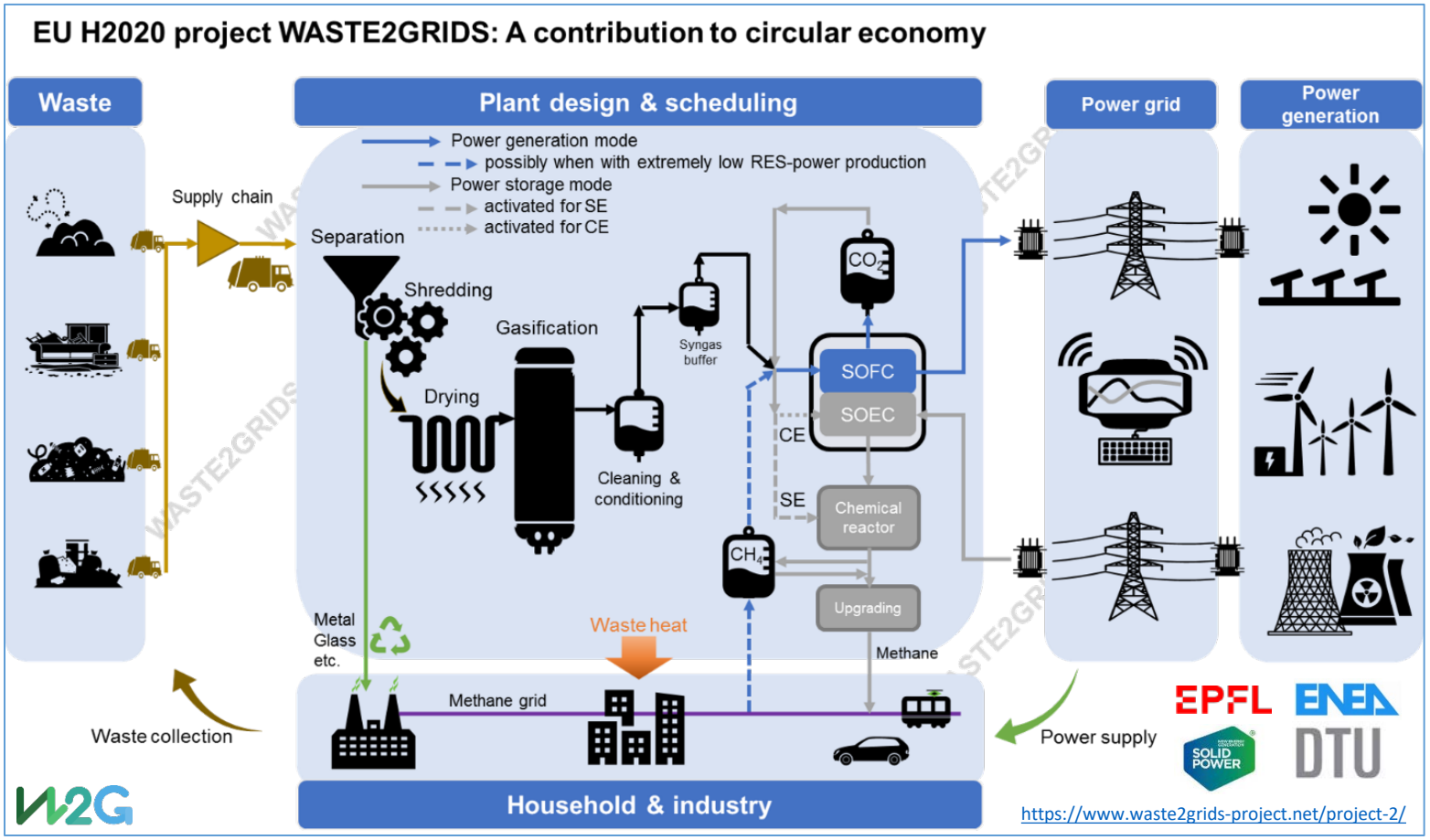
- **January 2020**
  NextChem - «The role of Green Chemistry in accelerating and enabling the energy transition, via circularity, zero carbon and biobasedproducts»
  (NextChem is the Maire Tecnimont's company for green chemistry and energy transition technologie)

- **23 July 2020**
  «NextChem and US carbon recycling company, LanzaTech sign an agreement to license the "Waste to Ethanol" process line» (syngas fermentation)

- **By 2023**
  Planned to start-up a plant for «waste to methanol», 110 kTons/year capacity, in Livorno, Tuscany.
  (more info in the form uploaded in the Task database)

Italy - project Waste2GridS

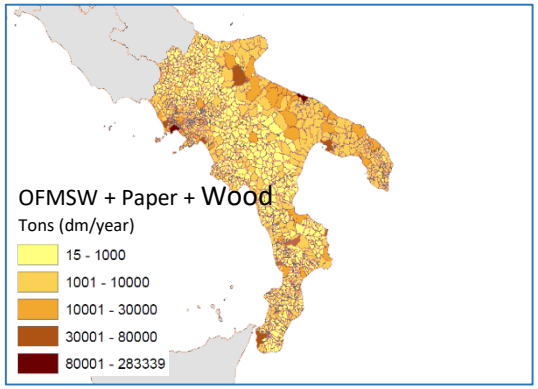
A single, dual-mode plant for power storage and generation

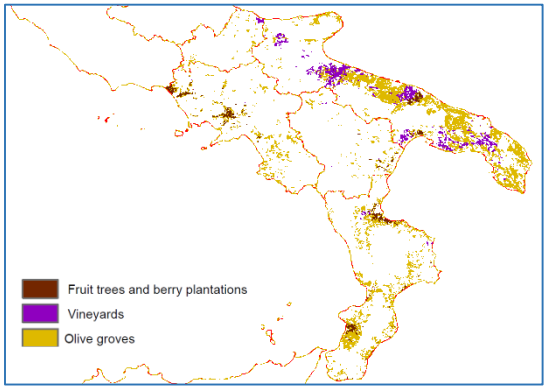


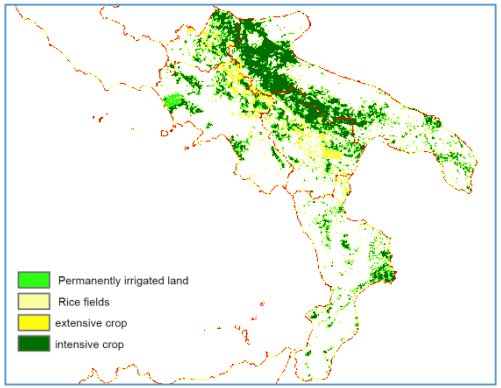
Converting WASTE to Offer Flexible GRID Balancing Services with Highly-integrated, Efficient Solid-oxide Plants

Italy - project Waste2GridS

The bio-waste potential of Agri – Residues – Italy – total 2030







Feedstock		Availability in 2030 (t)	Moisture (%-wt)	Energy content	
				LHV (MJ/kg)	MWh (dry part)
Agricultural residues	Prunings	1,221,102		18.0	6,105,510
	Straw	826,384		17.2	3,948,279
MSW - separated at origin	Organic	3,721,023	50	20.7	10,697,941
	Paper	796,697	10	18.0	3,585,137
	Wood	86,110	10	18.0	387,495
	total	6,573,817			24,724,362

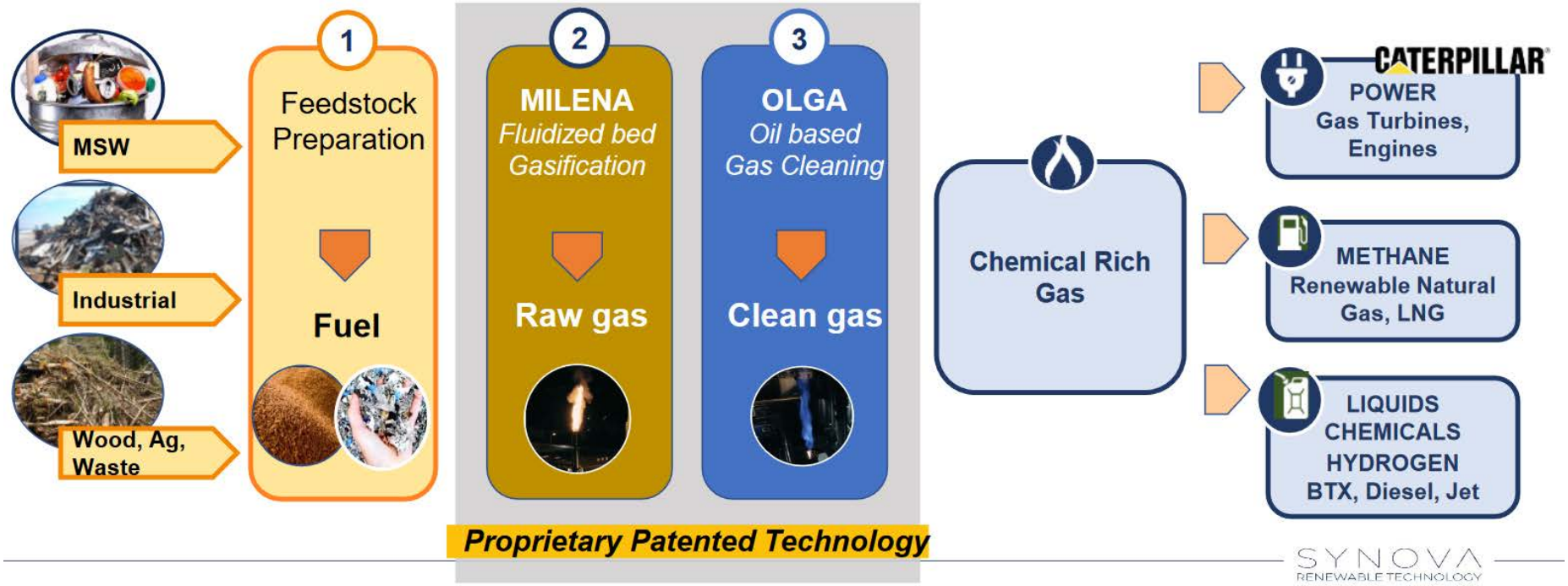
Design option[c]	Biomass LHV input [kW]	Power Production Mode[a]		Methane Production Mode[b]			
		Electricity produced [kW]	Pow Gen eff [%]	Electricity consumed [kW]	Methane produced [kg/s]	Power stored in methane [kW]	Pow. Stor. eff [%]
1	50104	21862	43.6	24287	0.84	41959	56.4
2	50104	23756	47.4	48533	1.36	67836	68.8
3	50104	25149	50.2	47692	1.36	67836	69.4
4	50104	25564	51.0	19044	0.77	38588	55.8
5	50104	26986	53.9	49638	1.36	67879	68.1

a) Via biomass gasification and use of the syngas in SOFC; b) the produced syngas is converted in CH4 by addition of H2 from electrolyzer (SOEC). The SOEC is operated using power excess from discontinuous RES.
c) Process chains designed according to the mode of plant operation coupled with methane production (power-to-methane (PowSto) mode integrated with steam electrolysis).

Ref. The potential of waste-based reversible solid-oxide plants for grid-balancing services. A. Agostini, C. Carbone, V. Motola, F. Gracceva, Y. Zong; S. You, M. Perez Forte, L. Wang. Available at: https://www.waste2grids-project.net/publications/.

The Netherlands

The Netherlands



30 -60 kW_{th} lab unit including OLGA extensively tested

- 1 MW_{th} pilot/demo unit including OLGA extensively tested
- 4 MW_{th} demo/commercial unit including OLGA , tested

The Netherlands

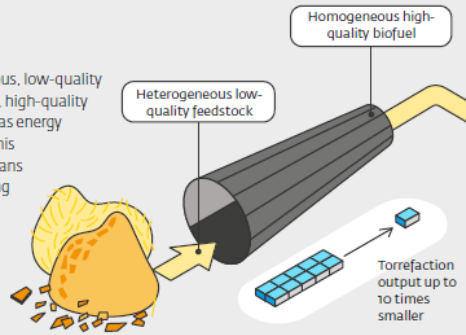
torrgas

Waste streams as feedstock

Torrefaction processes use a wide range of waste streams that would otherwise be burned or left to perish. This greatly increases the amount of waste that can be reused.

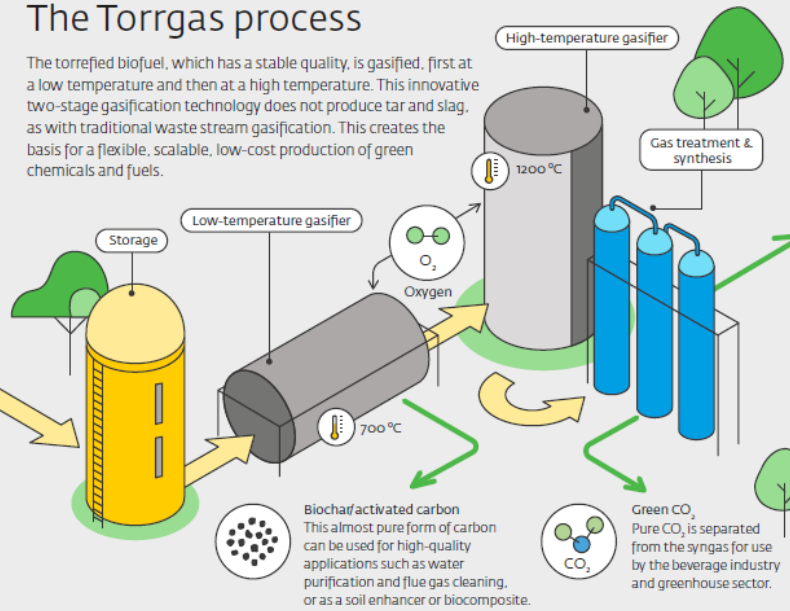
Torrefaction

Torrefaction converts heterogeneous, low-quality waste streams into homogeneous, high-quality biofuels that are around ten times as energy dense as the original feedstocks. This enables efficient transport and means torrefaction is a vital link in enabling large-scale reuse of problematic waste streams.

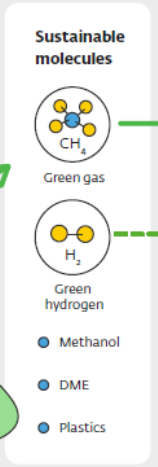


The Torrgas process

The torrefied biofuel, which has a stable quality, is gasified, first at a low temperature and then at a high temperature. This innovative two-stage gasification technology does not produce tar and slag, as with traditional waste stream gasification. This creates the basis for a flexible, scalable, low-cost production of green chemicals and fuels.



Product



Uses of green gas

The Torrgas process produces green gas from syngas. This gas is transported through gas infrastructure to users in the industrial domain (for use as a feedstock and for process heating) and to the built environment.

Benefits of the Torrgas process

Scalable
A Torrgas plant can be scaled up to 100 MW.

Fully circular
Low-quality waste streams are fully converted into high-value molecules (syngas and green CO_2) and products (biochar).

Affordable
Activities such as the scaling up and marketing of biochar and green CO_2 make it increasingly cheaper to produce syngas. So much so, in fact, that it can even compete with fossil alternatives on price.

CO_2 reduction
Waste streams are converted into usable products. This prevents combustion and carbon emissions, effectively removing CO_2 from the atmosphere.

torrgas | gasunie crossing borders in energy

The Netherlands

Project to use waste streams for hydrogen production

Capacity will be 40 kton per year of hydrogen (1000 tpd of waste)

The whole technology chain will be built:

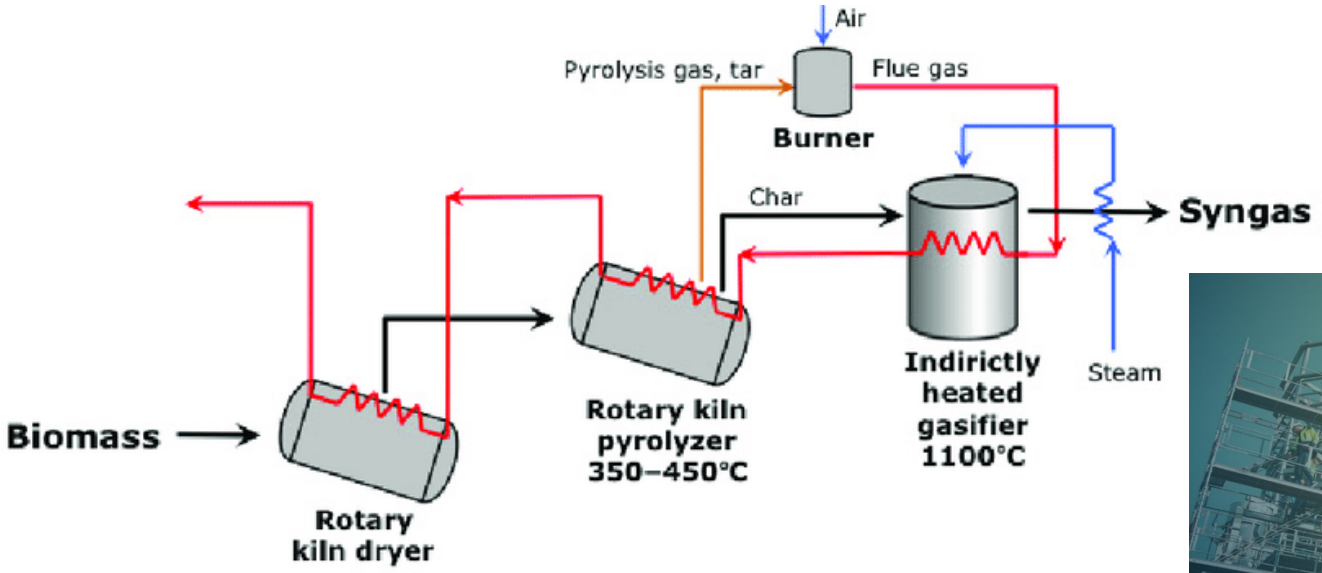
- Waste separation and drying
- Torrefaction of waste to uniform pellets
- Siemens gasification technology (EF) to produce syngas
- Hydrogen production and CO2 production

Location: Chemelot industrial site in Limburg

Process tested in Freiberg

Sweden

Cortus 6 MW WoodRoll® gasifier at the Höganäs steel plant



Cortus WoodRoll®in Mariposa (US)

Pacific Gas & Electric (PG&E) has approved Cortus and the Mariposa-project for delivery of 2,7 MW electricity.

Sweden

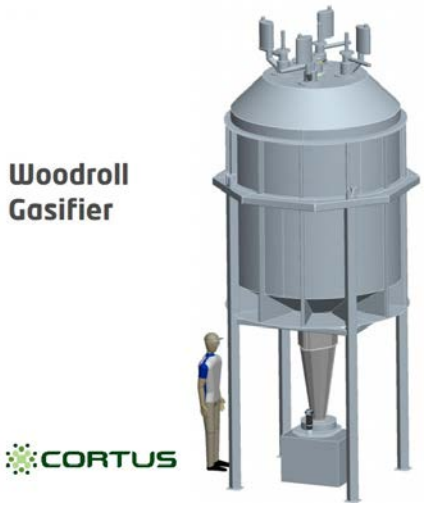
Cortus WoodRoll® & ENGIE (Fr)

Collaboration project (WoodHy) initiated 2019 on biomass-to-hydrogen project in Bordeaux, France

Cortus has a patented PSA configuration that results in about 15% more hydrogen output than other conventional systems

An order from **EngieCofely** worth 135 000 € to carry out an **Advanced Feasibility Study** of a plant for hydrogen and CO_2production

More info at http://cortus.se



Sweden

MEVA CHP-plant in Hortlax

Entrained flow cyclone gasifier based on research at Luleå University of Technology

Output: 1.2 Mw_{el} and 2.4 MW_{th}

Feedstock: small fraction fuels (sawdust, wood fibers and agricultural residues)

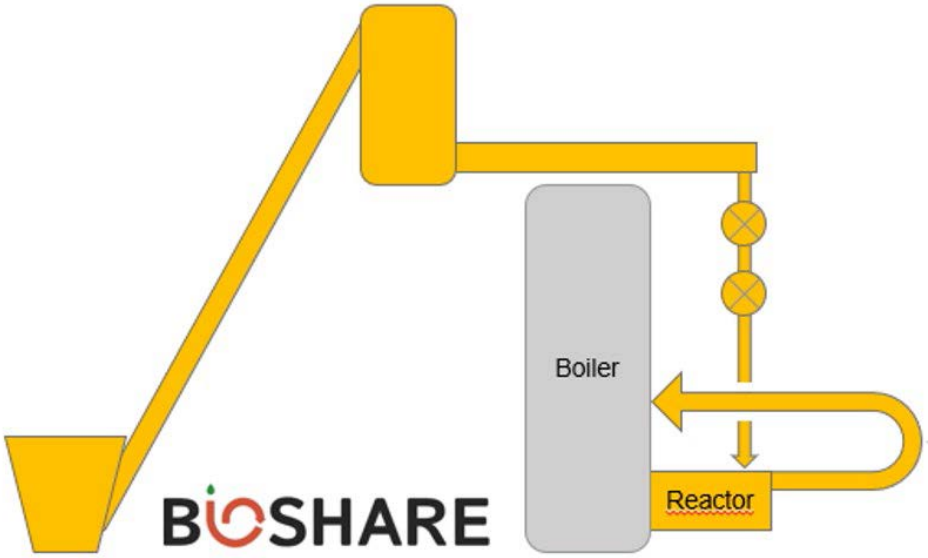
Applications: CHP, fossil process gas replacements and industrial drying processes

Joint project with Andritz-Enviroburners:
A complete gas burner test facility to enable engineering of industrial burner installations for process heat generation

More information at http://mevaenergy.com

Sweden

Project under development



The company BioShare has recently been granted funding (≈1,7 M€, 2020-2024) to demonstrate integrated gasification and pyrolysis at a CHP-plant

The reactor will be operated during three heating seasons to assess performance and gas quality with different feedstock

Also test different downstream units in pilot scale in separate projects with customers and other stakeholders.

Sweden

Projects on hold

The Gobigas plant in Gothenburg

Plant was in operation
Oct.2013 – May 2018
Now still moth-balled and for sale

Now in conservation state, but will most likely be dismantled

Official start-up October 28, 2013.

LTU Green Fuels plant

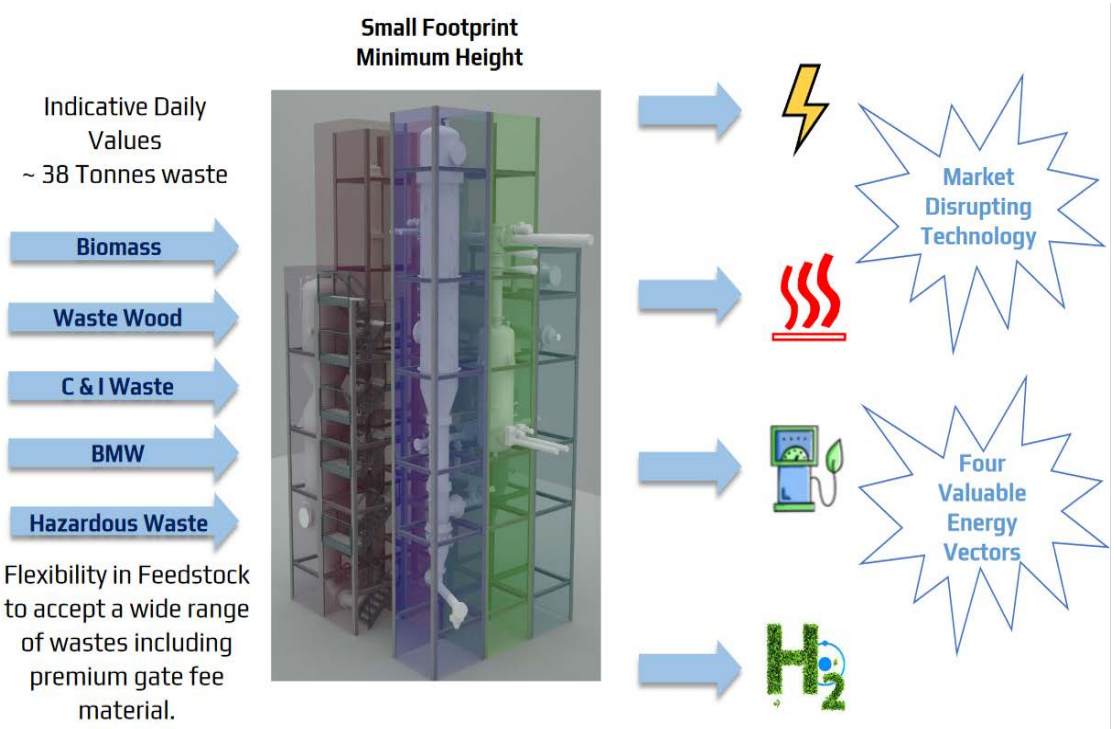
Plant in conservation state

New regional funding secured for three years to keep the plant from being dismantled and to find new projects

United Kingdom

ETI/KEW demonstration plant (near Birmingham)

Waste gasification plant (1,5 MW, pressurised fluidised bed technology) started to produce clean syngas which can be used for the generation of electricity, heat, hydrogen and liquid bio fuels.



Status Nov. 2020:

Commissioning with tests on waste wood, RDF and other feedstock finished.

United Kingdom

Advanced Biofuel Solutions Ltd (ABSL), Swindon site

Commercail demo for production of 20-25 GWH/y of bio SNG

Status Nov. 2020

- Construction complete
- Cold commissioning finished
- Hot commissioning in January 2021
- Waste processing planed Feb./March 2021

https://www.linkedin.com/company/advanced-biofuel-solutions-ltd/

Project Bright

- Similar technologies to ABSL Swindon plant
- Larger scale 320 GWJ/y of bio SNG
- Located near centre of HyNet projects – CCS infrastructure should be available 2025

USA

Fulcrum Bioenergy/Sierra Biofuels

Under construction

Gasification/FT under construction

- MSW feedstock/ TRI indirectly heated fluid bed steam reforming gasifier
- Input: 175 kt/y prepared MSW
- Johnson Matthey DAVY™/BP fixed-bed FT
- Start-up in Q1 2021
- Recently pivoted from jet fuel to FT wax
- Plant is ‘full scale’; scale up (3X) planned with parallel trains
- 12 new projects currently planned/underway

USA

Red Rock Biofuels Lakeview, OR: Aerial view on September 4, 2020, looking SW

Red Rock Bio (Lakeview, Oregon)

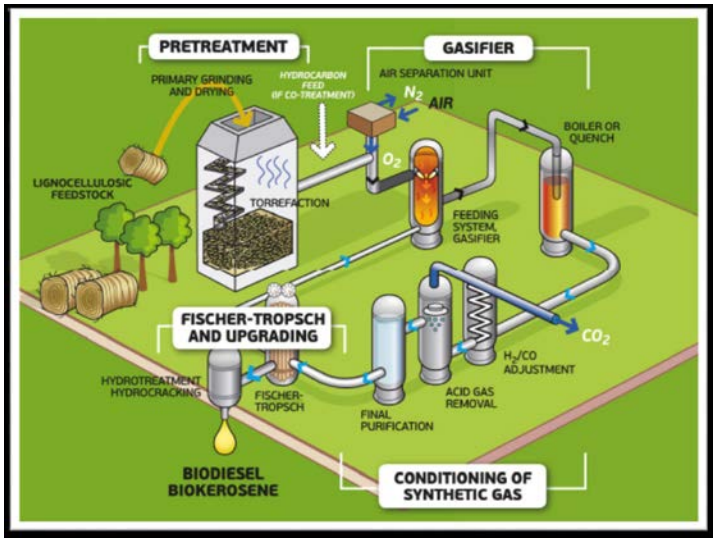
Under construction

- Pathway: gasification to Fischer-Tropsch
- Technology providers
- Gasification: TCG Global steam reforming
- FT technology: Velocys and Emerging Fuels Technology
- Feedstock: forest residue (136,000 tons per year)
- Products: cellulosic renewable jet, diesel, and naphtha fuels
- Offtakes: Southwest Airlines, FedEx Express
- Capacity: 15 MGY
- Anticipated construction completion: Q1 2021

France

Objective: develop, demonstrate and commercialize a full B-XtL chain

- Process chain validated and optimized on a wide range of biomass
- End to end solution: From R&D to market / From biomass to final products



Status November 2020:

- ✓ Commissioning and start up completed
- ✓ Ongoing technology optimisation
- ✓ Commercialization: 1st contacts
  - Axens (on behalf of consortium): single licensor for the complete B-XtL chain
  - A performance guarantee for the complete chain:
    - For processes and catalysts
    - From biomass to final products
  - A full scope of services from studies to unit start-up and follow-up

https://www.ifpenergiesnouvelles.com/innovation-and-industry/our-expertise/renewable-energies/biofuels/our-solutions
https://www.total.com/energy-expertise/projects/bioenergies/biotfuel-converting-plant-wastes-into-fuel

France

Objective: Demonstrate the feasibility of the production of 2nd generation bioCH4

- A 10-year R&D program
- Demonstration platform covering the entire production chain

Feedstock:

- woody biomass
- non-recyclable waste (Solid Recovered Fuel)

Output:

- biomethane 0,4 MW (demo)

Status december 2020:

- ✓ Oct. 2017: platform inauguration
- ✓ Nov. 2018: 1st production of purified synthesis gas from biomass
- ✓ Nov.2019: 1st production of biomethane from woody biomass
- ✓ Nov. 2020: 1st production of biomethane from SRF

France / Belgium

NOTAR® Reactor

A MULTI-STAGE DOWNDRAFT GASIFIER

ADVANTAGES

- CLEAN GAS (99,95% TARS DESTROYED)
- COMPACT GASIFICATION UNIT
- SIMPLE AND COST EFFECTIVE GAS CONDITIONING UNIT

SYNGAS — NO TAR, NO HEAVY METAL, NO POLLUTANT

TECHNOLOGICAL ADVANTAGE

Accurate control of operating parameters:

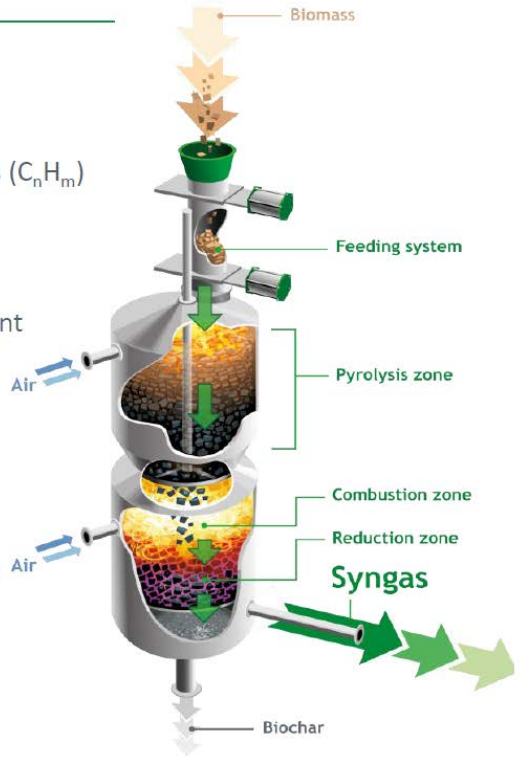
- ✓ Tar Free Char (C)
- ✓ Light Pyrolysis Gases (CH_p)
- ✓ Primary Tar concentrated in pyrolysis gases (C_nH_m)

Combustion in gaseous phase:

- ✓ Destruction of Pyrolysis Tar
- ✓ Conversion of biomass with high ash content
- ✓ Power range from 0.1 to 2 MW

Reduction is fed withs Tar Free products:

- ✓ Production of a Tar Free syngas
- ✓ Maximum Gas Temperature of 750°C
- ✓ Metallic Compounds condensed in biochar

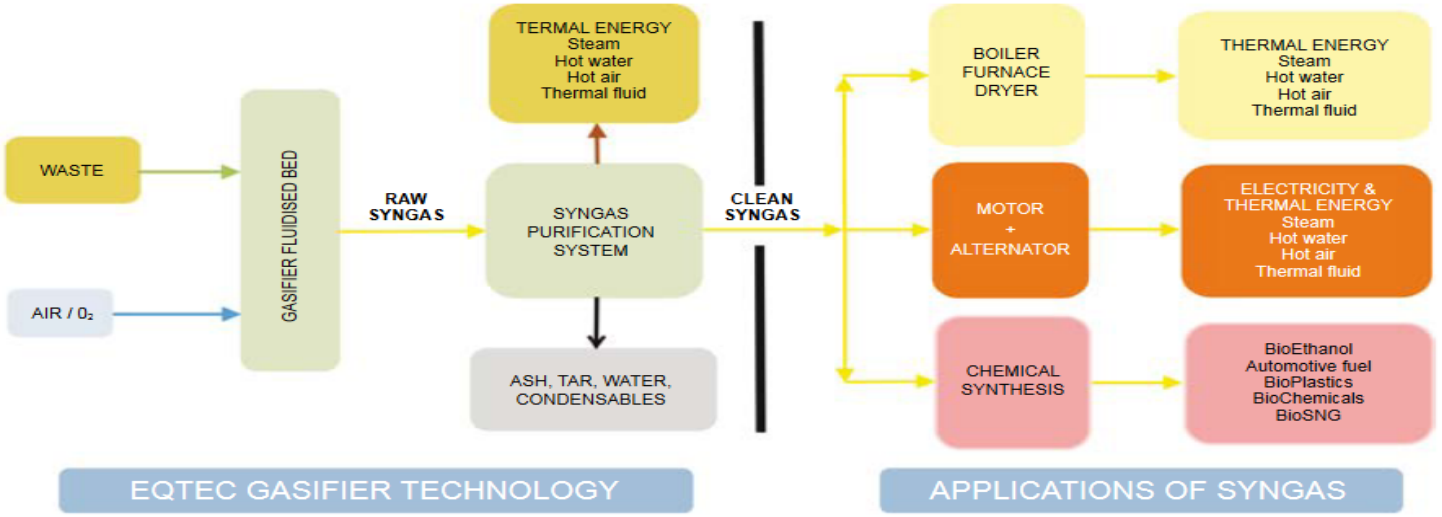


Biochar as a valuable by-product

	Unit	Dry base
Humidity	%	0
Mineral materials rate	%	15 – 20
Volatile matter rate	%	< 5
Fixed carbon rate	%	75 – 80
LHV	kJ/kg	25 000 – 28 000

XYLOWATT sa

Spain



EQTEC

Location	Cuidad Real, Spain
Description	5,9 MWe IBGPP
Electrical efficiency	28%
Total efficiency (electrical + thermal)	64%
Feedstock	Olive Mill Pomace
Feedstock throughput	4 ton/h
Engine	3 x GE Jenbacher 620
Operating temperature range	720-750 ºC
Operating hours	**111,000+ (third party certificates available)**

IEA Bioenergy

Spain

Bubbling fluidized bed technology
Feestock: wood chips, meat and bones meal

Reactor	Bubbling Fludised Bed
Thermal power	7,4 MWth (2 MWe)
Application	**CHP** Electricity production 1,6 Mwe (GE Jenbacher JMS – 320 (x3)) **Heat used for drying in briquettes manufacturing (variable heat required)**
Gasifying agent	Air
Operation Pressure / Temperature	0,3 barg / 800ºC
Biomass load	45 t/day
Start up date	2012
Biomass	Wood chips
Location	Ejea de los Caballeros (Zaragoza)

Reactor	Bubbling Fludised Bed
Thermal Heat	**10 MWth**
Use	12 T/h saturated steam 10 bar
Gasifying agent	Air
Operation Pressure / Temperature	0,3 barg / 800ºC
Start up date	2013
Biomass	Meat and bone meal (MBM) Cat01
Location	Aldeaseca de la Frontera (Salamanca)

Reactor	Bubbling Fludised Bed
Thermal Heat	**16 MWth**
Use	20 T/h saturated steam 10 bar
Gasifying agent	Air
Operation Pressure / Temperature	0,3 barg / 800ºC
Start up date	2014
Biomass	Meat and bone meal (MBM)
Location	Sao João da Madeira (Porto, Portugal)

Spain

neoelectra

Plant in Santa Perpetua de la Mogoda, Barcelona	
Application	Steam generation for industrial processes
Feedstock	Forest biomass, plastics, RDF, waste biomass
Output	25 t/h of steam
Start up	2018
Output/Capacity	20 MWth

Plant in Villacañas, Toledo	
Application	Power generation through steam turbine 8 MWel
Feedstock	Forest biomass
Technology	Wood gasification, syngas combustion
Start up	2010
Steam boiler output	44 tons/h 460°C, 40 bar

IEA Bioenergy Task 33

Status reports

To be published

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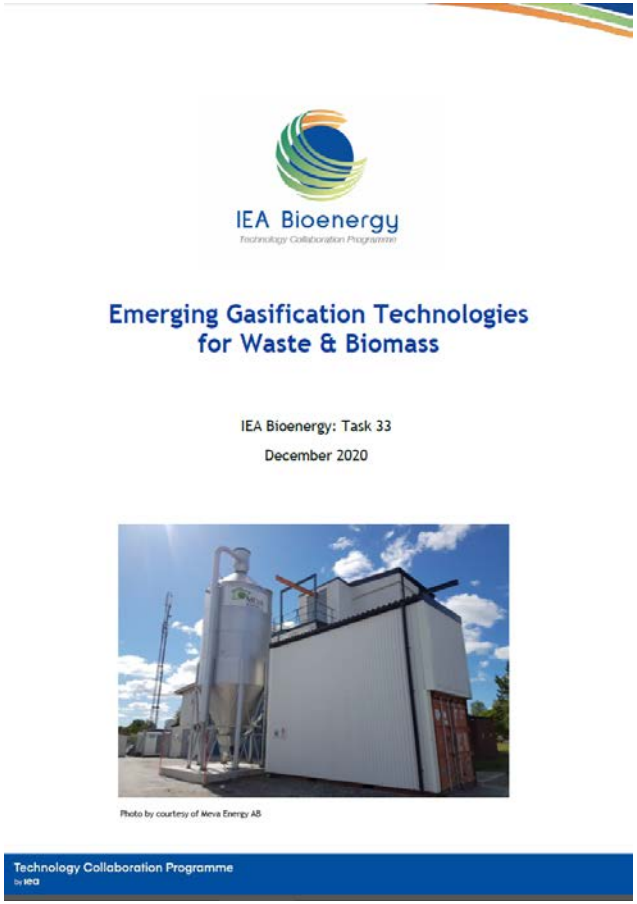
Special report on emerging gasification technologies



Will be published on Friday 26. February 2021

At the Task 33 website in section „Task projects“

Conclusions

Thermal gasification makes sense!

- Variety of feedstock can be utilized and waste disposed
- Different gasification technologies available in commercial scale
- Variety of possible products
  - Syngas for CHP
  - Biofuels
  - Biochemicals
  - Biochar (CCS) – negative CO2 footprint
  - …
- Integration/combination of gasification with other technologies

Conclusions

What is needed now?

To recognize that:

- gasification based on biomass and waste

can be sustainable technology saving our environment.

- the combination of gasification with other technologies makes it much more attractive.

Clear and stable political frame, supporting renewable energy and products to encourage investors and implementation of know how on gasification!

Thank you!

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Technology Collaboration Programme

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