Webinar Task 33
The past, present and future of gasification

Speakers: Berend Vreugdenhil and Jitka Hrbek
Moderator: Luc Pelkmans
Outline

- Past – Presenter Vreugdenhil –

- Present – Presenter Hrbek –

- Future – Presenter Vreugdenhil –

- Concluding remarks

- Questions – Pelkmans moderator –
Goal of the webinar

1. To show the long history of gasification and the versatility of its applications
2. To show the current applications and developments using gasification
3. To show a possible future for gasification and to set some boundary conditions for this to happen
Gasification

Partial combustion of a feedstock, with the goal to generate heat that converts the remaining feedstock into gas.

Divisions can be made on:
Low – Medium – High temperature → strong effect on composition of the gas

Fixed bed – Fluid Bed – Entrained flow → determines the technology

Direct vs. Indirect → strong effect on the quality of the gas
# Gasification past

<table>
<thead>
<tr>
<th>Application</th>
<th>Pre-industrial</th>
<th>1900-2000</th>
<th>2001 - today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal to gas</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Coal to liquid</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Crude oil to liquid</td>
<td>-</td>
<td>Few</td>
<td>Yes</td>
</tr>
<tr>
<td>CHP IGCC with NG/Coal</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Small scale biomass CHP</td>
<td>No</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Large scale biomass CHP</td>
<td>-</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Co firing biomass</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MSW</td>
<td>No</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Biomass to syngas</td>
<td>Yes, for food preservation</td>
<td>Yes, short time mobile application</td>
<td>Yes</td>
</tr>
<tr>
<td>Biomass to liquid</td>
<td>Yes, for tars and chemicals</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Biomass CHP with IGCC</td>
<td>-</td>
<td>Demonstrated</td>
<td>No</td>
</tr>
<tr>
<td>Biomass to SNG</td>
<td>-</td>
<td>No</td>
<td>Demonstrated</td>
</tr>
</tbody>
</table>
Some of its more unusual applications

Charcoal bus, Japan (Author KY Metro)

Town gas (Westergasfabriek Amsterdam)

Kitchen application, Indonesia (Author Djoewito Atmowidjojo)
Gasification growth
Gasification – large scale applications

Gasification is dominated by fossil based technologies. Gasification is developed towards a variety of products.
Gasification – small scale applications

Small scale gasification excels in biomass gasifiers. Typical products are heat and/or power
Large scale deployment
Great plains synfuel plant

1972 – Decision taken to build a coal gasification flagship

1980 – Construction finally started
1984 – Getting online
1985 – Nearly abandoned → DoE took ownership
1988 – Basin Electric obtained ownership and formed the Dakota Gasification Company

https://www.dakotagas.com/about-us/history
Dakota Gasification Company

Started as a coal to synthetic natural gas project
1984 – Anhydrous ammonia
1984 – Sulphur
1985 – Light oils as wood preservatives
1990 – Phenol
1990 – Krypton / Xenon
1993 – Cresylic acid
1994 – Fertilizer
1997 – CO$_2$ for EOR
2014 – Urea / Ammonium sulfate
2014 – Tar oil
2014 – Liquified CO$_2$
2017 – Diesel exhaust fluid

And the list is incomplete
Learnings so far

- Gasification has been around for centuries
- Gasification has been successfully applied for a long list of products (some temporary)
- The early applications were actually high value products (chemicals)
- Percentage installed capacity for biomass gasification is small
- Number biomass gasifiers is actually quite large
- Gasification has the opportunity to develop from single product to refinery unit
- Gasification is flexible towards the desired output
Present status of gasification - Jitka Hrbek
Content

- **Status of thermal gasification** of biomass and waste in IEA Bioenergy Task 33 **member countries** (Triennium 2016-18)

<table>
<thead>
<tr>
<th>Austria</th>
<th>Norway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>Sweden</td>
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<tr>
<td>Germany</td>
<td>Switzerland</td>
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<tr>
<td>Italy</td>
<td>USA</td>
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<tr>
<td>The Netherlands</td>
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</tr>
</tbody>
</table>

- **Overview and description of reference facilities**

- **Conclusions of actual status**
Austria

In comparison with the past time, the boom of small scale gasification facilities can be observed

- Urbas (https://www.urbas.at/)
- Syncraft (http://www.syncraft.at/index.php/)
- Glock-ökoenergie (https://www.glock-oeko.com/)
- Hargassner (https://www.glock-oeko.com/)
- Fröling (https://www.froeling.com/at.html)

Contrary to this, all large scale facilities e.g. Güssing, Oberwart are on hold

R&D focuses on waste material feedstock characterisation and usage as well as product gas applications

Waste gasification facility will be build near Vienna (project Waste 2 value)
Austria
Waste 2 value project

Construction begins this year, 2020
Commissioning with beginning 2021
## Denmark operational plants

<table>
<thead>
<tr>
<th>Project name/ location</th>
<th>Technology</th>
<th>Input/ Feedstock</th>
<th>Output/ El./Th.</th>
<th>Usage/ Product</th>
<th>Start up/ Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harboøre CHP plant</td>
<td>Fixed bed - updraft</td>
<td>3,5 MW /forest wood chips</td>
<td>1 MW electric 1,9 MJ/s heat</td>
<td>CHP generation</td>
<td>1993 (CHP in 2000) /operational</td>
</tr>
<tr>
<td>/Harboøre, DEN</td>
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<td></td>
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</tr>
<tr>
<td>Sindal CHP plant</td>
<td>Staged updraft</td>
<td>5.5 MW /wood residues</td>
<td>0.8 MW electric 5 MJ/s heat</td>
<td>CHP generation</td>
<td>2018 /operational</td>
</tr>
<tr>
<td>/Sindal, DEN</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Skive CHP plant</td>
<td>Bubbling fluidised bed</td>
<td>20 MW /wood pellets</td>
<td>6 MW electric 11,5 MJ/s heat</td>
<td>CHP generation</td>
<td>2008 /operational</td>
</tr>
<tr>
<td>/Skive, DEN</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
Denmark
Skive plant

- BFB gasifier for CHP, woody biomass (input 20 MW) as feedstock, three engines (6 Mwel), heat (11.5 MWth) consumed in local district heating network and electricity sold to the grid.
- In operation since 2008, owned by Skive Fjernvarme
Denmark
other plants

▪ Pyroneer plant, Kalundborg co-firing
  CFB, 6 MWth, commissioning in 2011
  Feedstock: straw, manure fibres
  Cofiring in coal fired unit
  Planned upscaling up to 60 MWth, but technology not sold
  2015 mothballed, now at DTU, research ongoing

▪ Viking gasifier, Hillerød CHP, Weiss
  Staged gasifier, 500 kWel, heat for district heating
  Feedstock: wood chips
  Plant never came into commercial operation, dismantled in 2016
  Research still ongoing at DTU

▪ Hillerød CHP, Biosynergi
  Staged down draft gasifier developed and patented by DTU, Scale-up by Weiss and DTU, licensed by COWI
  In operation in 2017
  Minor technical challenges in combination with lack of further funding forced the company to cease activities in the last part of 2017, the plant has been dismantled in 2018
Germany
large scale gasifiers

**Bioliq pilot plant** *(extra slide following)*
Developed at KIT, aims the production of synthetic biofuels and chemicals, TRL 6
Technology is based on two staged process (decentr. pyrolysis, centralized gasification)
Feedstock: straw and other materials (0.5 t/h)
2 MW fast pyrolysis for biosyncrude, 5 MWth gasification (EF up to 8 Mpa)
Product: DME (608 t/y), final gasoline synthesis (360 t/y)
In operation since 2010,
DME and gasoline synthesis since 2014

**Blue Energy Wood-CHP Senden**
Technology based on FICB (as was in Güssing)
Feedstock: wood chiops
Output: 4.55 MWel, 15.1 MWth
Start up 2011, in operation till 2018, now on hold
Germany bioliq plant
Germany
other gasifiers

Entrained flow gasifiers
- AirLiquide EC (https://www.engineering-airliquide.com/de/syntesegas)

Fluidized bed gasifiers
- Sülze Kopf SynGas (www.kopf-syngas.de) – gasification for sewage sludge application (drying)
- Burkhardt GmbH (output: 50, 165, 180 kWel/wood pellets) – more than 240 plants
- Stadtwerke Rosenheim, staged gasification (http://www.swro.de/kraftwerke/holzvergaser.html)

Fixed bed gasifiers
- LiPRO energy GmbH&CO.KG - output 30-50 kWel, 60-100 kWth (Web: www.lipro-energy.de)
- Spanner RE2 GmbH, output 2-9 kWel, 3-22 kWth (http://www.holz-kraft.com) – over 700 plants
- REGAWATT GmbH, output 300-2000 kWel, 600-4300 kWth – 6 plants in operation
- Biotech Energietechnik GmbH – multi-staged gasification, output 25 kWel./75 kWth (https://www.biotech-heizung.com)
Italy

<table>
<thead>
<tr>
<th>Geographical area</th>
<th>Nº Plants</th>
<th>%</th>
<th>kWel.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Italy</td>
<td>140</td>
<td>64.2</td>
<td>32,141</td>
<td>73.8</td>
</tr>
<tr>
<td>Central Italy</td>
<td>51</td>
<td>23.4</td>
<td>7,141</td>
<td>16.4</td>
</tr>
<tr>
<td>Southern Italy and islands</td>
<td>27</td>
<td>12.4</td>
<td>4244</td>
<td>9.8</td>
</tr>
<tr>
<td>Total</td>
<td>218</td>
<td>100.0</td>
<td>43,526</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Distribution by electrical output

- 800-1000 kWel.
- 250-500 kWel.
- 160-200 kWel.
- 90-150 kWel.
- 20-70 kWel.

n° of plants

IEA Bioenergy www.ieabioenergy.com
Italy
fixed bed gasification

- downdraft gasifier, output up to 20 kWel./40 kWth
- feedstock: forest residues, urban waste wood, mushroom manure, olive waste, sawdust, rice husk, shells, etc.

ESPE SRL (http://www.espegroup.com/en/biomass/cogenerator/)
- output 49 kWel/110 kWth

RESET s.r.l. (www.reset-energy.com)
- fully automatic plants, output 50-200 kWel
- high grade biochar
The Netherlands 1/3

Bio Energy Netherlands (BEN) (https://bioenergynetherlands.nl/)

- modular plants for CHP production, but in the future will use this platform to produce biogas, hydrogen and CO2
- in Nov. 2017 construction started, plant designed for 15 MWh of CHP and hydrogen

Essent / RWE (www.rwe.com)

- waste wood gasifier (Geertruidenberg) connected to a 600 MWe coal-fired power station
- CFB (Lurgi technology), capacity 85 MWth

ESKA (www.eska.com)

- CFB 12 MWth, paper reject, product gas as a feed to a boiler (steam production)
- technology supplied by Leroux & Lotz, implemented in 2016

ECN part of TNO

- ECN part of TNO has developed a technical route to convert biomass into substitute natural gas. This technology is based on the MILENA indirect gasifier combined with the first gas cleaning OLGA. This technology is commercialized through a joint venture between ECN part of TNO and Dahlman Renewable Technology (part of Synova)
The Netherlands 2/3


- turn-key technology, down-draft fixed bed
- feedstock: different manures and sludges
- product gas combusted directly after gasifier and usage of the heat
- Ecochar production to be sold

**Synova** ([www.synovapower.com](http://www.synovapower.com))

- waste-to-energy company
  - developed standardized modular unit based on MILENA ans OLGA of approx. 6 MW input, this so-called SMM can be used to couple to a power block to make circa 1.5 MWe electricity
  - The first SMM to power will be in Thailand, North-East from Bangkok. Synova will own and operate the plant.

**Synvalor** ([www.synvalor.com](http://www.synvalor.com))

- new multi-staged vortex reactor for difficult fuels producing low-tar gas for e.g. gas engines
  - test facility 50 kWel was built
  - currently commissioning of gasifier in Gerbera grower, results expected
The Netherlands 3/3

Torrgas ([http://torrgas.nl](http://torrgas.nl))

- aim is to be a leading provider of value chain solutions for plant scale (10-100 MW) syngas from torrefied biomass

- Torrgas has successfully commissioned their first demonstration plant at DNV-GL at 0.7 MWth and finished the Basic Engineering of 25 MWth (2*12.5 MW) gasification plant in Delfzijl. The syngas produced in the Delfzijl project will be converted into SNG. This project is together with Gasunie, Pörner, and DBI. The Delfzijl project is intended to start construction in 2019.

SCW ([www.scwsystems.com](http://www.scwsystems.com))

- young company focusing on supercritical waster gasification (T>375°C, p>221 bar)

- A first demonstration plant is constructed in Alkmaar and the commissioning started in the second half of 2018. This installation has been connected to the high pressure transport grid round December 2018.

- Gasunie New Energy is directly involved in this development. Expected Green Gas production in 2019

Host ([www.host.nl](http://www.host.nl))

- one of the largest suppliers of bioenergy systems in Europe, focuses on the technological development of the processing of biomass and waste streams and the supply of systems for renewable energy from biomass and waste.

- Their CFB technology has been proven on various feedstock and their offers are in the range of a standard installation of 1-5 t/h or specialty plants of >5 t/h.
Norway

Small scale gasification
- Volter, started operation in 2016

In Norway, the prices of energy are relatively low, thus CHP production based on gasification is too expensive in comparison with other energy sources.

Other projects

Quantafuel - The plant in Skive will source plastic from local suppliers and produce local, environmentally friendly, high-quality fuel, an initial capacity of 60 metric tonnes of plastic waste per day, and will convert approximately 18 000 tons of plastic waste per year. Output more than 15 mill. L of high quality recycled fuel.

- Preliminary capacity targets for full scale facilities are around 7 million litres of jet-fuel/year.

BioFuel - focuses on sustainable economic production of aviation biofuel from household waste
Sweden 1/4

Small scale gasification
- Emåmejeriet, Hultsfred (www.bkvab.se, energikontorsydost.se)
- output 40 kWel/100 kWth

Large scale
- GoBiGas (extra slide)
- LTU Green Fuels AB
  - project ended in 2013

400 t of DME for Volvo trucks was produced, trucks operated for over 80 000 km
Official start-up of phase 1 in October 28, 2013
After 1 800 oper. hours, the plant was shut down and mothballed in May 2018

The reasons for shut down:
- the sales value of the bio-methane had not followed the projections

The second phase with output of 80-100 MW of biomethane was planned but this decision was canceled in November 2015
Cortus Energy AB (www.cortus.com) – developed the WoodRoll Technology

After testing with the three stages operating off-line, a fully integrated unit has been constructed and was mechanically complete in early 2015. It has been reported that the gasifier has been operated over 5,000 hours in September 2018, and the dryer and pyrolyzer over 2,000 hours each.

In late 2018, Cortus was also awarded a grant from the Swedish Sustainable Aviation fuel program to study the integration of the WoodRoll system with a FT system producing aviation fuel.

Cortus cooperates with Japanese Forest Energy, California Energy Commissioning, Engie, Infinite Fuels GmbH
MEVA Energy (www.mevaenergy.com)

- Cyclone gasification technology- VIPP (Vortex Intensive power process)
- Pilot plant at ETC (input 500 kWth crushed pellets, gas cleaning, engine with 100 kWel output; op.h 800, dismantled 2017)
- Scale up (5 MWth input, 1,2 MWel/2,4 MWth), commissioning 2014-15, rebuilt in 2016, since 2017 as R&D, over 2000 operating hours
## Switzerland

<table>
<thead>
<tr>
<th>Gasifier</th>
<th>RE Puidoux</th>
<th>AEW Rheinfelden</th>
<th>Käser Gasel I+II</th>
<th>J. Bucher AG Escholz. I+II</th>
<th>A. Steiner + Cie. AG</th>
<th>Holzstrom in Stans I+II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volter Fi</td>
<td>Regawatt</td>
<td>Burkhard</td>
<td>Ligento</td>
<td>Wegscheid</td>
<td>Spanner</td>
<td>2 units each 4 gassifier Pyroforce/BR</td>
</tr>
<tr>
<td>downdraft</td>
<td>updraft</td>
<td>downdraft</td>
<td>downdraft</td>
<td>downdraft</td>
<td>downdraft</td>
<td>2-zone downdraft</td>
</tr>
<tr>
<td>40 kW el</td>
<td>Jennbacher+ ORC; Total = 890 kWel</td>
<td>165 kW</td>
<td>2 x 140 kW el</td>
<td>2 x 133 kW el</td>
<td>45 kW el</td>
<td>2 x 690 kW el Jennbacher</td>
</tr>
<tr>
<td>district heating</td>
<td>district heating</td>
<td>district heating</td>
<td>for BM drying</td>
<td>drying wood chips</td>
<td>district heating</td>
<td>1,2 MW for district heating</td>
</tr>
<tr>
<td>-</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>Yes</td>
<td>yes</td>
<td>1,6 MW BM 1,7 MW oil</td>
</tr>
<tr>
<td>Dry clean wood chips</td>
<td>clean wood chips</td>
<td>Pellets</td>
<td>Dry clean wood chips G 30-100</td>
<td>Dry waste wood chips</td>
<td>Dry waste wood chips</td>
<td>demolition wood/scrap wood chips</td>
</tr>
</tbody>
</table>

(Status Nov. 2018)
**USA**

**Red Rock Biofuels** ([www.redrockbio.com](http://www.redrockbio.com))
- Construction of Biofuels production plant in Lakeview, Oregon
- Conversion of 136 000 t of woody biomass into 15 mill gall/year of biofuels (jet fuel, diesel)
- Under construction, start up 2020?

**Aematis/Lanzatech** ([www.inentec.com](http://www.inentec.com), [www.lanzatech.com](http://www.lanzatech.com))
- Agricultural waste, syngas fermentation to ethanol – InEnTec plasma-assisted gasifier
- Construction scheduled to start in 2020

**Fulcrum Bioenergy**
- Conversion of 200 000 t/y of MSW into 10 mill.gall of syncrude oil
- Fluidized bed steam reformer ([www.tri-inc.net/steam-reforming-gasification](http://www.tri-inc.net/steam-reforming-gasification))
- Now under construction, operational with the end of 2020
Welcome

Task 33 is a working group of international experts with the aim to promote the commercialization of efficient, economical and environmentally preferable thermal biomass gasification processes.

Latest Updates

2019-12-02 | Events
IEA Bioenergy Task 44 Workshop on Flexible Bioenergy
24. January 2020, Graz, Austria

2019-10-07 | Events
10. Internationale Anwenderkonferenz Biomassevergasung
10.12. 2019, MCI Innsbruck, Austria
The conference will be held in German language.

IEA BIOENERGY TASK 33 REPORTS

<table>
<thead>
<tr>
<th>Date</th>
<th>Publication</th>
<th>Annex</th>
</tr>
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<tbody>
<tr>
<td>10/2019</td>
<td>Status report on thermal gasification of biomass and waste 2019</td>
<td>Annex 1 - CHP operational facilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annex 2 - CHP non operational facilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annex 3 - Fuel synthesis operational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annex 4 - Fuel synthesis non operational</td>
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<tr>
<td></td>
<td></td>
<td>Annex 5 - Other gasif. technology operational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annex 6 - Other gasif. technology non operational</td>
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<td>08/2019</td>
<td>Lessons learned about thermal biomass gasification</td>
<td>Historical documents</td>
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<td>02/2019</td>
<td>Biomass pre-treatment for bioenergy, Case study 3: Pretreatment of MSW for gasification</td>
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<td>12/2018</td>
<td>Gasification of waste for energy carriers</td>
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<td>12/2018</td>
<td>Hydrogen from biomass gasification</td>
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<td>11/2018</td>
<td>Valoration of by-products from small scale thermal gasification</td>
<td>Annex 1 - Market for carbon and charcoal</td>
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<td>Annex 2 - Analytics</td>
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<tr>
<td></td>
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<td>Annex 3 - Charcoal</td>
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<tr>
<td></td>
<td></td>
<td>Annex 4 - Dust, ash</td>
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<tr>
<td>10/2018</td>
<td>Thermal gasification based hybrid systems</td>
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<td>09/2018</td>
<td>Gas analysis guideline report - part I and part II</td>
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<tr>
<td>07/2018</td>
<td>Implementation of bio-CCS in biofuels production</td>
<td></td>
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</tbody>
</table>
Welcome

Task 33 is a working group of international experts with the aim to promote the commercialization of efficient, economical and environmentally preferable thermal biomass gasification processes.

Latest Updates

2019-12-02 | Events
IEA Bioenergy Task 44 Workshop on Flexible Bioenergy
24. January 2020, Graz, Austria

Read more
Summary of the current status

- **Boom of small scale gasification for CHP** applications can be observed in Europe during the past 5 years (over 1500 facilities in operation)

- **Large scale gasification** facilities are mostly **closed for economic reasons** (e.g. Güssing, GoBiGas, Senden, ...)

- **Feedstock** for gasification moves from clean wood to **waste and other difficult materials** (e.g. chicken manure, sewage sludge, RDF, etc.)

- Synthesis gas from gasification can be used in different ways, e.g. **biofuels production** (FT kerosene) seems to be a promising way for the future

- **Combination** of thermal gasification with other renewables e.g. wind power or PV **offers new possibilities** for electrical grid balancing and/or energy storage

- **Bioenergy is one of the essential sources for energy supply in the world without fossils**
Future of gasification – Berend Vreugdenhil
Gasification future

SRIA’s of ETIP Bioenergy and EERA Bioenergy

- Major role for gasification-based value chains in accordance with the SET plan and the Action 8 Implementation Plan
- Main R&D needs identified

www.etipbioenergy.eu

www.eera-bioenergy.eu
Upcoming developments

Gasification can be used for:

- Waste management
- Biofuel production with CCS
- Hydrogen production
- Refinery integration
- Steel industry
- ...

IEA Bioenergy
Refinery application

Gasification as a supplement to pyrolysis processes. Providing input to refinery processes

Graphic: Chalmers University

Gasification of beech wood

Source: TNO

Gasification of DKR310

Source: TNO

IEA Bioenergy

www.ieabioenergy.com
Höganäs AB – Steel industry

- At Höganäs AB a 14 (m) high gasifier is used to produce a gas from forest residues to replace natural gas.

- Technology used is from Cortus Energy. The 6 MW Woodroll

Photo: Cortus Energy
How will this develop

Examples:
- BioTFuel
- ENGIE - Gaya
- Sungas Renewables
- Enerkem

Examples:
- Mavitec
- Torrgas
- Syncraft
- Synova
- Many others

Examples:
- RWE Furec
Conclusions

▪ Currently biofuels offer the possibility for gasification to grow; not in numbers, but in scale!
▪ Co-production is important in developing sound business cases (Dakota Gasification company)
▪ Gasification holds the key in unlocking the combination of a biobased economy and a circular economy
Warning!

- Gasification has so much potential to be applied in different fields of industry. On the one hand this will raise the expectations, whereas on the other hand people forget that the development pathways to these applications is not easy.

- This mismatch has led to good projects being stopped, not for technical reasons but mostly financial reasons.

- Gasification has the flexibility to change over time from one application to another. This strength can also be perceived as weakness, because it affects credibility.
Questions

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