

## IEA Bioenergy Task 33

Gasification of biomass and waste



Photo: SYNCRAFT@Werk Beta / Mierschach / South Tyrol / Italy

Dr. Jitka Hrbek

University of Natural Resources and Life Sciences Vienna  
(BOKU)

6. CEBC, 24.1.2020, Graz



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# Content

- IEA Bioenergy Task 33 “Gasification of Biomass and Waste”
- Task activities in last Triennium
- Outlook

# IEA Bioenergy Task 33

## „Gasification of Biomass and Waste“

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

TRIENNIUM 2019-2021

### Member countries

- Austria
- Germany
- Italy
- Netherlands
- Sweden
- UK
- USA

### Task Leader:

Berend Vreugdenhil, TNO

### Task Co-Leader:

Dr. Jitka Hrbek, BOKU

### Austrian representatives

Dr. Jitka Hrbek  
Prof. Christoph Pfeifer,  
BOKU Vienna

DATE	COUNTRY	AUTHOR	LAST UPDATE
2018	<a href="#">Austria</a> (pdf 2,8 MB)	J. Hrbek, <i>BOKU</i>	25.11.2019
2019	<a href="#">Denmark</a> (pdf 2,1 MB)	M. T. Hansen, Ea Energy Analyses	
2008	<a href="#">Finland</a> (pdf 876 KB)	I. Hannula, <i>VTT</i>	25.11.2019
2019	<a href="#">Germany</a> (pdf 3,2 MB)	T.Kolb, M. Eberhard, <i>KIT</i>	25.11.2019
2019	<a href="#">Italy</a> (pdf 6,8 MB)	Donatella Barisano, <i>ENEA</i>	25.11.2019
2012	<a href="#">Japan</a> (pdf 612 KB)	M. Morita, <i>NEDO</i> ; T. Ogi, <i>AIST</i>	
2013	<a href="#">The Netherlands</a> (pdf 2,1 MB)	B. Van der Drift, B. Vreugdenhil, <i>ECN</i>	25.11.2019
2012	<a href="#">New Zealand</a> (pdf 611 KB)	Shu-sheng Pang, <i>Univ. of Canterbury</i>	
2015	<a href="#">Norway</a> (pdf 230 KB)	R. Khalil, J. Sandquist, <i>SINTEF</i>	
	<a href="#">Sweden</a> (pdf 4.3 MB)		
2019	<a href="#">Annex Report (1997-2009)</a> (pdf 1.6 MB)	L. Waldheim, <i>WAC</i>	25.11.2019
2015	<a href="#">Switzerland</a> (pdf 197 KB)	M. Rueegsegger, <i>ETECA GmbH (Ltd)</i>	
2006	<a href="#">United Kingdom</a> (pdf 322 KB)	Nick Barker, <i>Future Energy Solutions</i>	25.11.2019
2011	<a href="#">Turkey</a> (pdf 124 KB)	S. Gul, H. Karatas, <i>TUBITAK</i>	
2019	<a href="#">USA</a> (pdf 7.83 MB)	K. Whitty, <i>University of Utah</i> , B. Baldwin, <i>NREL</i>	25.11.2019

WV

## Task33

Gasification of Biomass and Waste



### 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.

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# IEA Bioenergy WELCOME www.task33.iea.org

## Task33

### Gasification of Biomass and Waste



[Gasification explained](#)

[Task 33 Description](#)

[Participants and Country Reports](#)

[Task Meetings and CR updates](#)

[Workshops and Events](#)

[Task 33 Projects](#)

### 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**  
24. January 2020, Graz, Austria

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Date, Location	Workshop topic	Files (pdf)
26. November 2019 Birmingham UK	Waste gasification	Workshop presentations
06. June 2019 Karlsruhe Germany	Gas cleaning, experiences, new developments, analytics and diagnostics	Workshop presentations WS - Report
06.-09. November 2018 San Francisco USA	ABLCL Global Conference 2018	Conference
08. May 2018 Petten the Netherlands	Waste gasification	Workshop presentations WS - Report
24. October 2017 Skive Denmark	Fluidized bed conversion of biomass and waste	Workshop presentations WS - Report Site visits presentations
03. May 2017 Innsbruck Austria	Small scale gasification for CHP	Workshop presentations WS - Report
26. October 2016 Lucerne Switzerland	Gas Sampling, Measurement and Analysis (GSMA) in Thermal Gasification Processes	Workshop presentations WS - Report
25. May 2016 Trondheim Norway	Aviation Biofuels through Biomass Gasification	Workshop presentations WS - Report
27.-29. October 2015 Berlin Germany	IEA Bioenergy Conference 2015	Conference proceedings
11 - 13 May 2015 Ponferrada Spain	Symposium on Renewable Energy and Products from Biomass and Waste	Workshop (Symposium presentations) Poster proceedings
03 - 05 November 2014 Karlsruhe Germany	"Liquid biofuels"	Workshop WS - Report



- Gasification explained
- Task 33 Description
- Participants and Country Reports
- Task Meetings and CR updates
- Workshops and Events
- Task 33 Projects
- Other Publications and Reports
- Newsletter

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2019-12-02 | Events  
**IEA Bioenergy Task 44 Workshop on Flexible Bioenergy**

24. January 2020, Graz, Austria

[»» Read more](#)

2019-10-07 | Events  
**10. Internationale Anwenderkonferenz Biomassevergasung**

10.12. 2019, MCI Innsbruck, Austria

The conference will be held in German language.

[»» Read more](#)

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### IEA BIOENERGY TASK 33 REPORTS

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

# IEA Bioenergy Task 33

[www.task33.ieabioenergy.com](http://www.task33.ieabioenergy.com)

Task33

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# IEA Bioenergy Task 33

## Gasification of biomass and waste

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Filter Projects

Type

- TRL 1-3 Research
- TRL 4-5 Pilot
- TRL 6-7 Demonstration
- TRL 8 First-of-a-kind commercial
- TRL 9 Commercial

Technology

- Power and Heat via Gasification (VC3)
- Gasification
- Fuel Gas (Heat)
- Power / CHP
- Fuel Synthesis
- Other Gasification Technology

Status

- no status
- planned
- under construction
- erection
- commissioning
- operational
- non operational
- historical (project cancelled before 2012)
- cancelled
- stopped while under construction
- deconstructed
- idle
- on hold

Raw Material

- agricultural residues
- biomass / biomass coal blends
- biomass syngas
- forest residues
- lignocellulosics
- oilcrops, oils and fats
- organic residues and waste streams
- other
- unknown

Submit



operational | under construction | planned | non operational | no status

Leaflet | Map data © OpenStreetMap Tiles © Esri

Babcock&Wilcox Volund	CHP B&W Harboore	Denmark	<a href="#">Info</a>
Babcock&Wilcox Volund	CHP Updraft gasifier Daio	Japan	<a href="#">Info</a>
Bioenergie Schnellingen	Bioenergie Schnellingen	Germany	<a href="#">Info</a>
bioenergy 2020+	One Barrel per Day Pilot Plant	Austria	<a href="#">Info</a>
Biomasse Energie GmbH	FICFB Villach	Austria	<a href="#">Info</a>
Biomass Engineering Ltd.	CHP Biomass Engineering Cumbria	United Kingdom	<a href="#">Info</a>





# IEA Bioenergy Task 33

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## Last Triennium Task projects (selection)

- Status report 2019
- Gasification based hybrid systems
- Gasification of waste for energy carriers
- Valorization of by-products from small scale thermal gasification

# Status report 2019



Implementation of gasification projects in Task 33 member countries (last Triennium)

Countries included:

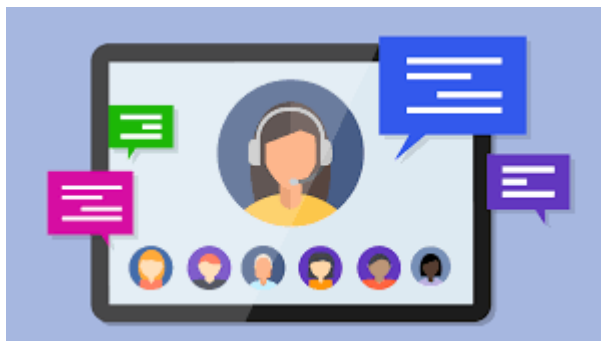
- Austria
- Denmark
- Germany
- Italy
- The Netherlands
- Norway
- Sweden
- Switzerland
- USA

# IEA Bioenergy Webinar

Connect to the webinar at: <https://meet80114613.adobeconnect.com/rim08cdsh89u/>

Date: 30. January 2020

Time: 4-5 pm (Centr.Europ.time)



## IEA Bioenergy WEBINAR SERIES

### The past, present and future for biomass gasification

January 30, 2020

4:00 pm - 5:00 pm Central European Time  
10:00 am - 11:00 am North American Eastern Standard Time  
3:00 pm - 4:00 pm Greenwich Mean Time



Moderator  
Luc Pelkmans  
IEA Bioenergy  
Technical Coordinator



Presenter  
Dr. Jitka Hirbek  
University of Natural Resources  
and Life Sciences Vienna  
Senior Scientist, Institute for Chemical  
and Energy Engineering



Presenter  
Berend Vreugdenhil  
TNO Energy Transition  
Innovation Manager Gasification,  
Gas Cleaning and Upgrading

#### Presentation Summary

Gasification has a long history with ups and downs regarding successes. An important factor in the success perception of gasification is related to the expectations of gasification. In this webinar we will show that gasification is a versatile technology with many possible outlets and that there are many success stories to be told. We will also discuss some of the learnings from the past decades to illustrate how sometimes a technology fails to be successful. All in all, the future of gasification is looking bright and this we will also elaborate upon. However, with a warning that we must remain realistic about what is needed to reach success!

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Tel. +39 055 5002280

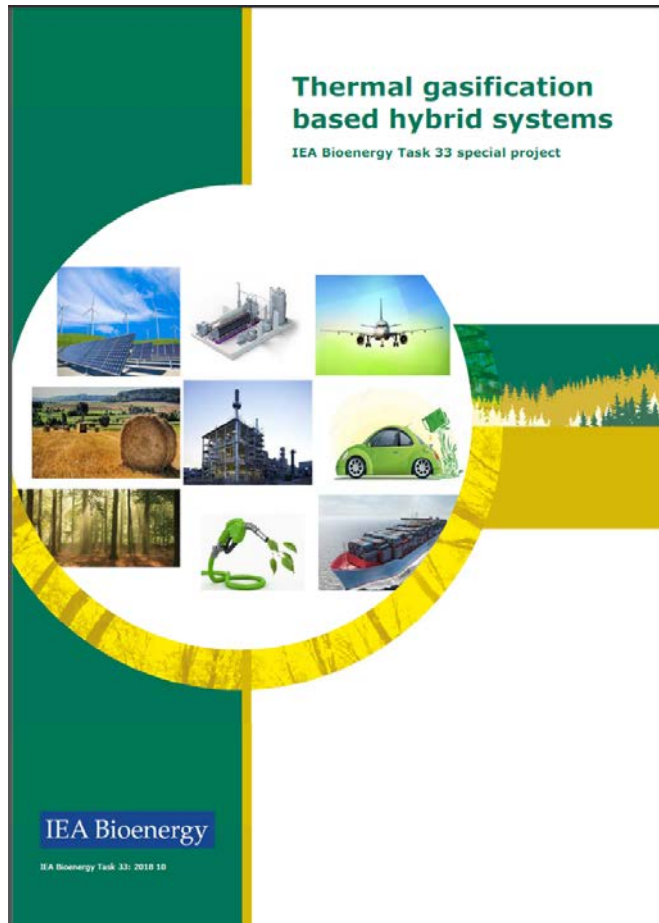
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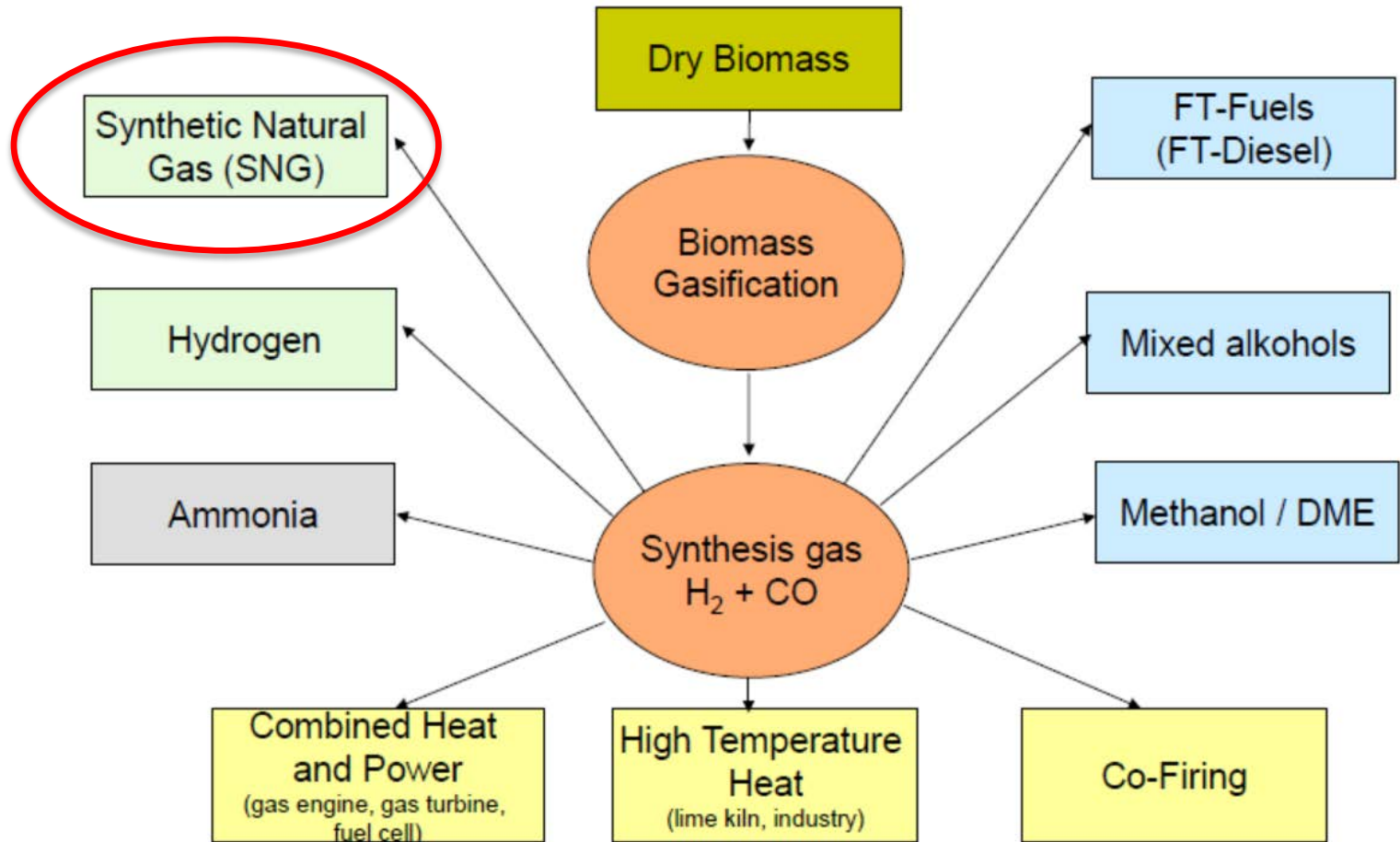
[www.ieabioenergy.com](http://www.ieabioenergy.com)

# Gasification based hybrid systems PtG & PtL

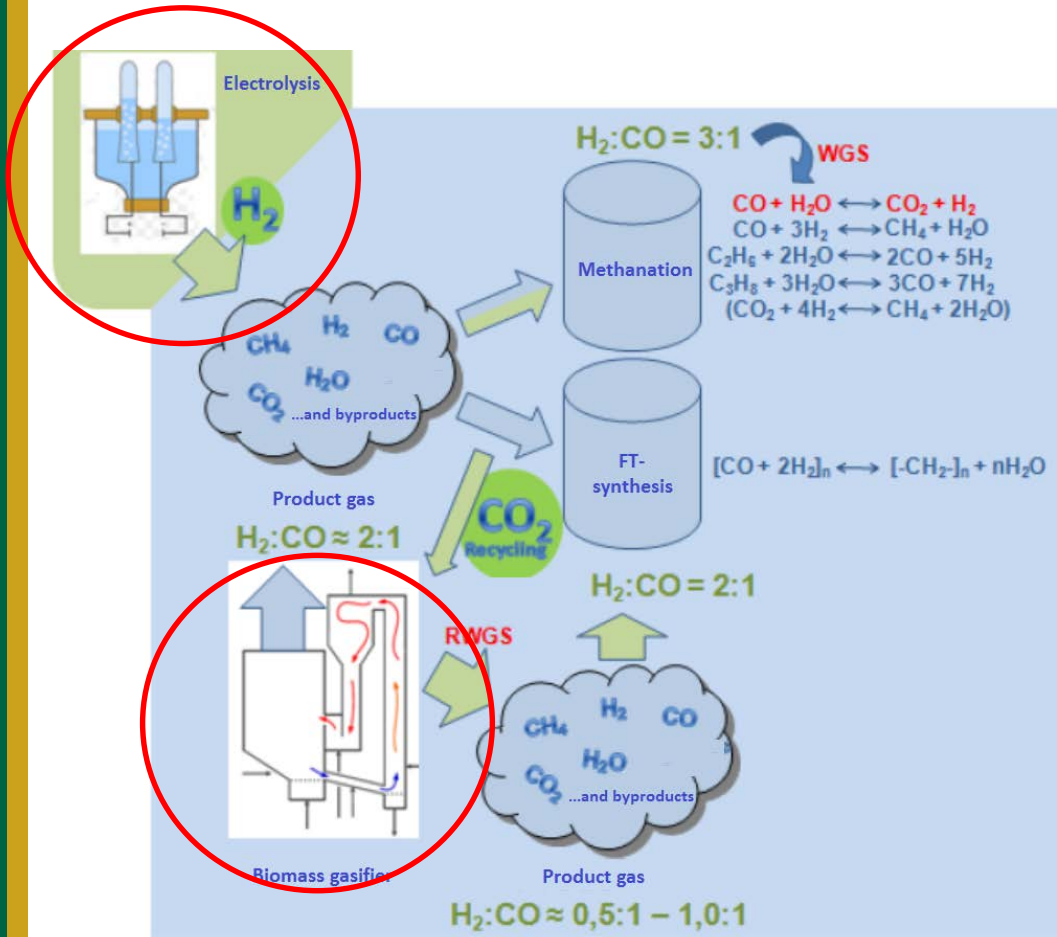


1. Energy Strategy 2020, 2030, 2050
2. Future potential of biomass
3. Thermal gasification explanation
4. Solar and wind power energy
5. Storage of fluctuating energy
  - Power to Gas
    - explanation+economics
    - projects
  - Power to Liquids
    - explanation+advantages
    - projects

# Power to Gas



# PtG



A system consists of double-bed steam gasifier and electrolyser for production of methane (PtG)

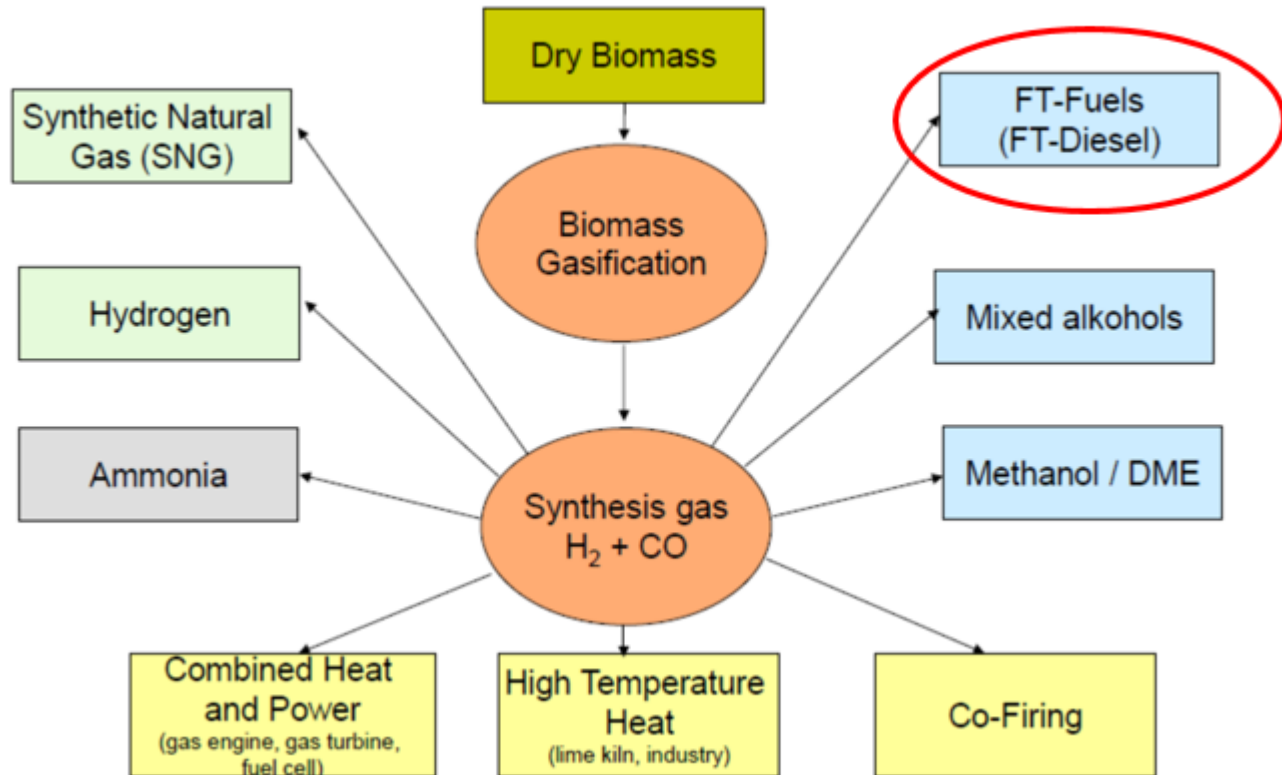
During the steam gasification a gas with  $H_2 : CO = 2$  ratio is produced, but for methanation a gas with ratio  $H_2 : CO = 3$  is necessary, it means further hydrogen from electrolyser is needed.

**Advantage:**  
Coupling the thermal gasification of biomass with hydrogen from electrolysis can doubled the production of renewable fuels in comparison if only product gas from gasification is used.

# Advantages of gasification integration into PtG systems

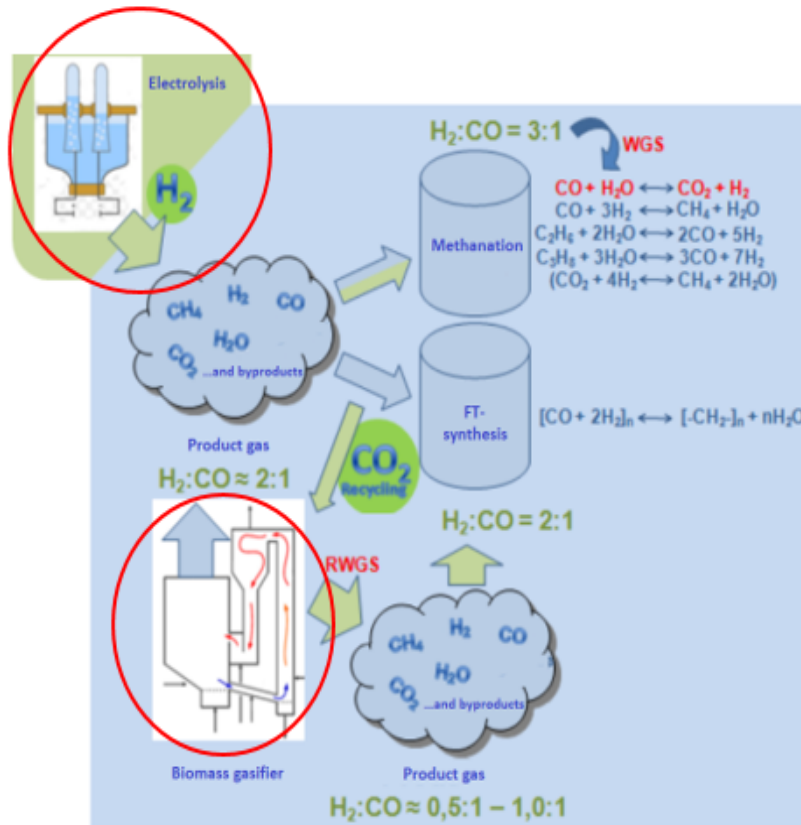
- Total carbon exploitation from biomass can be more than doubled
- Higher overall process efficiency (larger product yield and possibility of heat integration)
- O<sub>2</sub> from electrolysis can be used for gasification
- By adding hydrogen from electrolysis, the use of the water-gas shift reaction can be avoided
- Large H<sub>2</sub> storage can be avoided
- By non-available surplus electricity, the methanation can be operated with synthesis gas from gasification only

# Power to Liquids





# PtL (FT products)



Compound		Air gasification	Oxygen gasification	Steam gasification
		Fixed bed	Entrained flow	Fluidized bed
CO	Vol. %	13-18	45-55	25-30
CO <sub>2</sub>	Vol. %	12-16	10-15	20-25
H <sub>2</sub>	Vol. %	11-16	23-28	35-40
CH <sub>4</sub>	Vol. %	2-6	0-1	9-11
N <sub>2</sub>	Vol. %	45-60	0-1	0-5
Calorific value	MJ/Nm <sup>3</sup>	4-6	10-12	12-14

Source: A.V. Bridgwater, H. Hofbauer, S. van Loo: Thermal Biomass Conversion, 2009, ISBN 978-1-872691-53-4

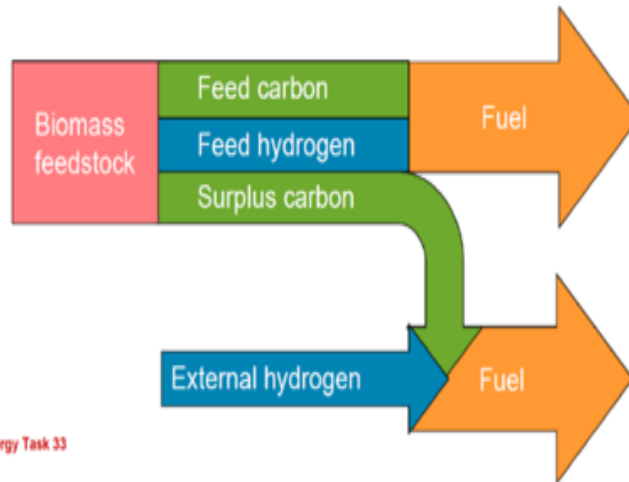
A system consists of two bed steam gasifier and electrolyser for production of methane (PtG) or FT-products (PtL).

During the steam gasification a gas with  $\text{H}_2 : \text{CO} = 2$  ratio is produced, which is optimal for FT-synthesis.

By FT synthesis is the usage of additional hydrogen from electrolyser a little bit different. The principle is based on  $\text{CO}_2$  recycling, it means, the inert  $\text{CO}_2$  will not be released to the atmosphere, but it will serve as an additional fluidizing agent in the gasification unit as a carbon source for further reactions with hydrogen from electrolysis.

# Advantages

Using of additional (external) hydrogen the FT products amount could be doubled



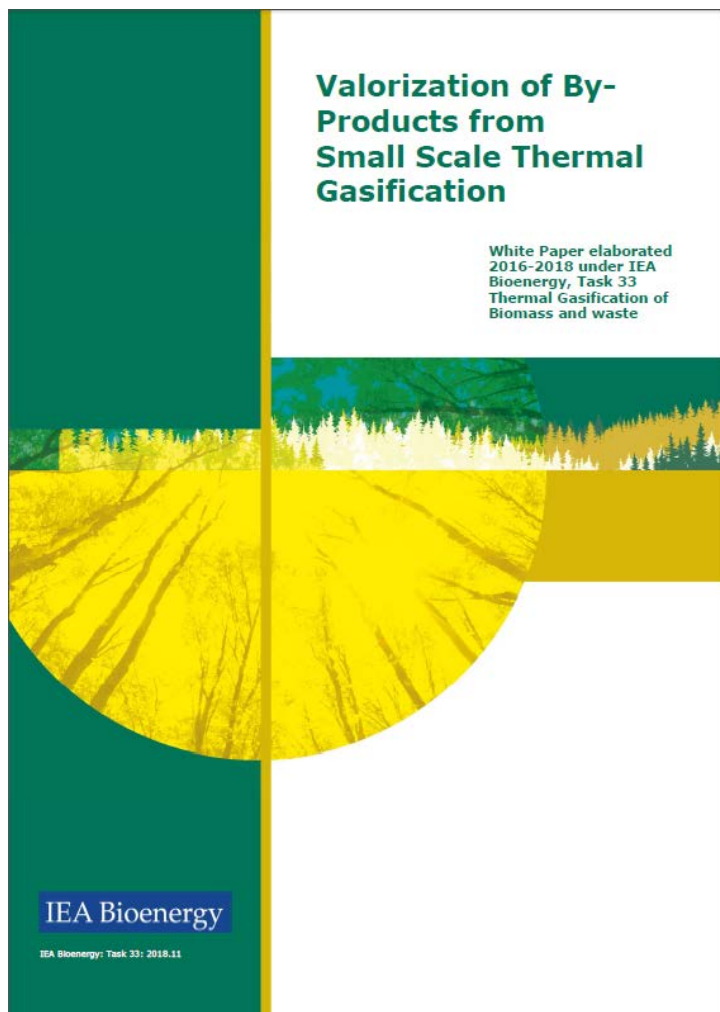
Workshop IEA Bioenergy Task 33  
26. October 2016  
HSLU Lucerne University of Applied Sciences  
Dr Ilkka Hannula



Advantages:

- Conversion of surplus electricity and surplus carbon to high valuable products
- Higher carbon utilization
- Biomass acts as base load (8000 oph/y possible), no start-stop operation, only load change

# Byproducts from thermal gasification



## Annex 1

October 2018

### Market for Carbon, Charcoal activated Coal

Valorization of by-products from small scale gasification

## Annex 2

Analytic, Checks, Tests and Examples of Coal containing residues and by-products out of small-scale thermo-chemical wood gasification CHP plants

## Annex 3

CHP small-scale CHP Unit examples build for charcoal production

October 2018

## Annex 4

### Research Activities

Valorization of by-products from small scale CHP thermal gasification

## Charcoal market

Carbon utilization	Production by	Coming from	Raw material	General expretions	Brand names
<b>Filter absorber</b>	gasification pyrolyze	biomass	wood	Activated carbon	Donaucarbon Silcarbon
<b>Agriculture Gardening Soil improvement</b>	gasification pyrolyze lignite grinded	biomass «Biochar»  fossil		(Pflanzenkohle) <b>BIOCHAR*</b>	Verora Egos
<b>BBQ</b>	gasification pyrolyze lignite grinded and pressed		wood  fossil coal	BBQ coal charcoal	
<b>Metal production</b>	gasification pyrolyze lignite grinded	biomass fossil	Wood Coal lignite	Lignite Carbon	
<b>Energy</b>	gasification lignite	fossil biomass	biomass all type of carbon Lignite	Biomass Coal	
<b>Animal food</b>	pyrolyze	biomass			
<b>Medical human</b>	pyrolyze	biomass			

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# Waste gasification for energy carriers



## Comprehensive review

- Waste as a feedstock (Charakterisation and Standards)
- Waste in EU, Japan, USA - overview
- Waste policy (EU, Japan, USA)
- Gasification technologies
- Gas cleaning
- Facilities examples
- Products from waste gasification

# Waste gasification – new ways?

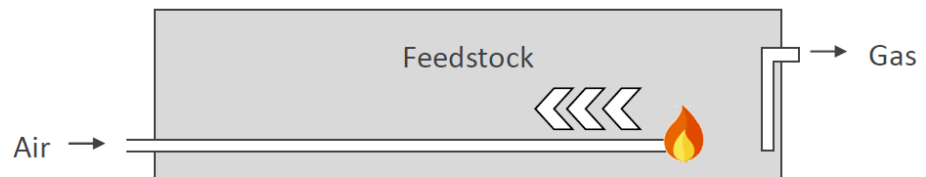
## MIHG: A New Concept



➤ MIHG is fundamentally different to all existing designs

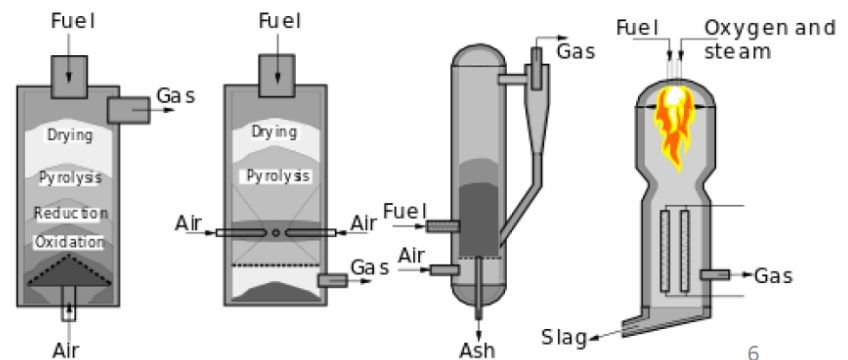
### Moving Injection Horizontal Gasification (MIHG)

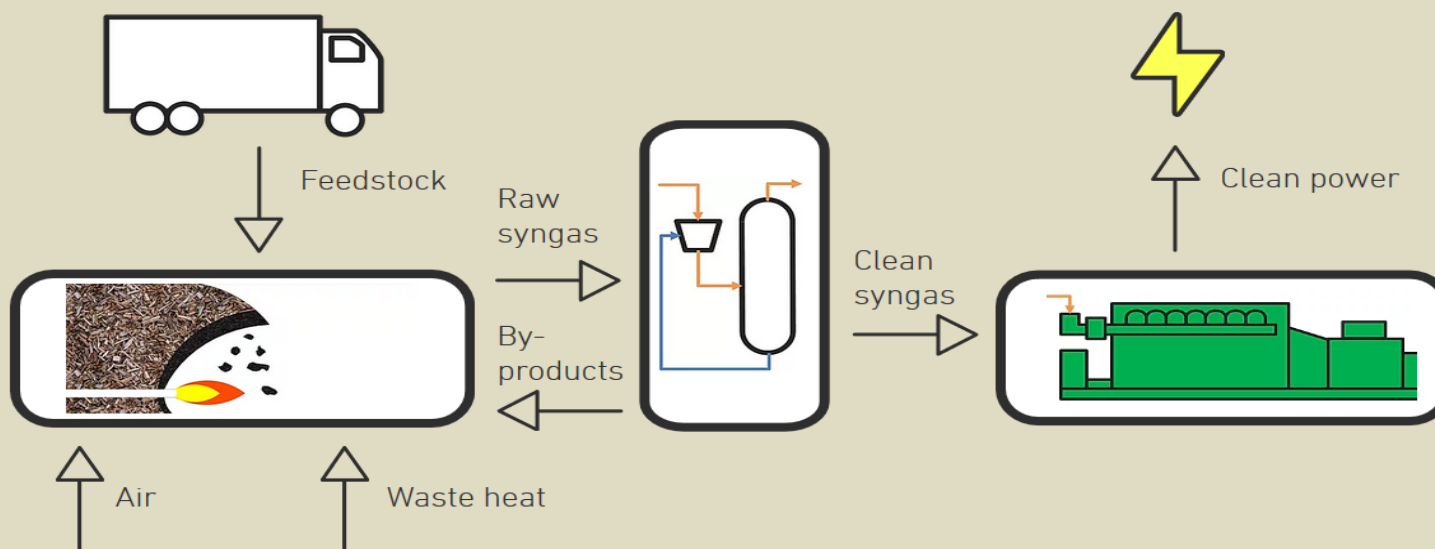
- ❑ Move the Air to the Feedstock



### Existing Gasification Technologies

- ❑ Move the Feedstock to the Air





### MIHG Reactor

- Feedstock is loaded
- Reactor is closed
- Feedstock is ignited
- Air injection point is slowly retracted to gasify the fuel
- Reactor is opened and reloaded

### Gas Cleanup

- Raw syngas is cleaned using proven technology
- By-products are recycled to MIHG reactor

### Gas Engine

- Clean syngas is converted to power using proven gas engine technology
- Renewable baseload power is supplied to customer or grid
- Optional cogeneration of heat and power or production of hydrogen and biofuels

# MIHG: 2 MWe Plant





# Benefits of MIHG

(moving injection horizontal gasification)



- No feedstock pre-treatment
  - Batch loading avoids the need for pre-treatment
  - Attractive to waste management operators
- Reliable operation
  - Batch loading eliminates problematic feeding and ash removal systems
  - Long run time between batch changeover
  - Moving injection provides stable, high efficiency gasification
- Reduced costs
  - Simple construction using low cost materials
  - Combined storage, drying and gasification in the MIHG reactor
  - Moving injection enables recycling of byproducts

# Outlook

## Planned Task projects for actual Triennium 2019-21

- **Emerging technologies for biomass and waste**  
(molten bath gasification, reforming gasification, thermal plasma, etc.)
  - Sweden leading
- **Status Report**  
update of the Report 2019, also non-member countries incl.
  - Austria leading
- **Bioenergy for high temperature heat in industry**  
Intertask Projekt mit T 32, 34, 36, 40  
Case study on ESKA gasifier
- **Gasification for the application in biorefineries**

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  - Austria leading

# Gasification for the application in biorefineries

(actual Task 33 project)

## Content

- Overview on biorefinery scenarios
- Definition of feedstock streams available
- Definition of gasification concepts
- Techno-economic assessment of most promising scenarios
- Decision making tool available – a clear overview
- Definition of open questions and interfaces to other IEA Bioenergy Tasks (e.g. Task 42)

# Conclusions

- Gasification of waste became more important, but research in this field is still needed
- Byproducts from gasification e.g. charcoal offer great benefits
- The combination of gasification with other technologies (e.g. PV, wind power) could be the way for the future



*Thank you!*

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**Contact Details**

Dr. Jitka Hrbek

[Jitka.Hrbek@boku.ac.at](mailto:Jitka.Hrbek@boku.ac.at)

Prof. Christoph Pfeifer

[Christoph.Pfeifer@boku.ac.at](mailto:Christoph.Pfeifer@boku.ac.at)