IEA Bioenergy Task 32, 33, 36 & ERFO Workshop

”Production and utilisation options for Solid Recovered Fuels”

Copenhagen, Denmark 2018-05-17

Waste gasification; beyond two-stage incineration

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IEA Bioenergy Task 33
Thermal Gasification of Biomass and Wastes

1996 study available on the Task 33 website

IEA Biomass Agreement

TASK X. BIOMASS UTILIZATION
BIOMASS THERMAL GASIFICATION AND GAS TURBINES ACTIVITY

Sub-task 6 - Gasification of Waste

Summary and Conclusions of Twenty-five Years of Development

Erik Rensfelt, TPS Termiska Processer AB
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Recent interest in waste gasification, new study in 2017

- **Regulatory considerations**
- **Waste as a gasifier fuel, gasifiers and gas cleaning,**
- **Use of the product gas, market, technical requirements and barriers**
- **Waste gasification developers, plants and projects (listing of > 70 developers, > 250 plants and projects**

*MSW, IW etc. but not special or hazardous wastes

Gasification

Definition

The transformation of a combustible solid or a liquid to a gaseous form

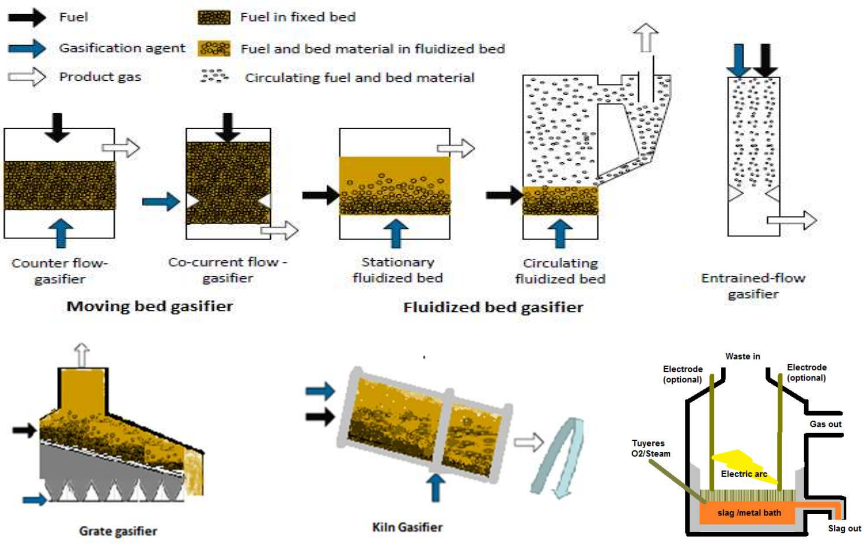
General purposes

- To provide a more flexible use of the original fuel
- To allow separation of combustible components from inorganics/ash
- To allow cleaning from certain contaminants
- To access certain chemical building blocks e.g. hydrogen

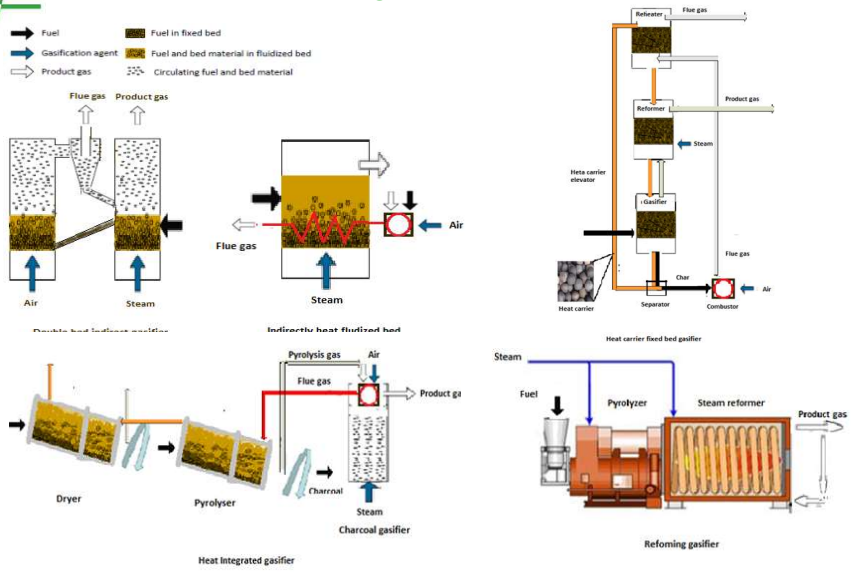
Waste-specific purposes

- To accomplish ash vitrification w/o external energy input, metal recovery
- To accomplish pre-combustion cleaning of smaller gas volume
- To thereby fulfill end-of-waste criteria for downstream uses of gas

Direct Gasifiers



Indirect, Multi-stage Indirect Gasifiers



Incinerator definition, end-of-waste

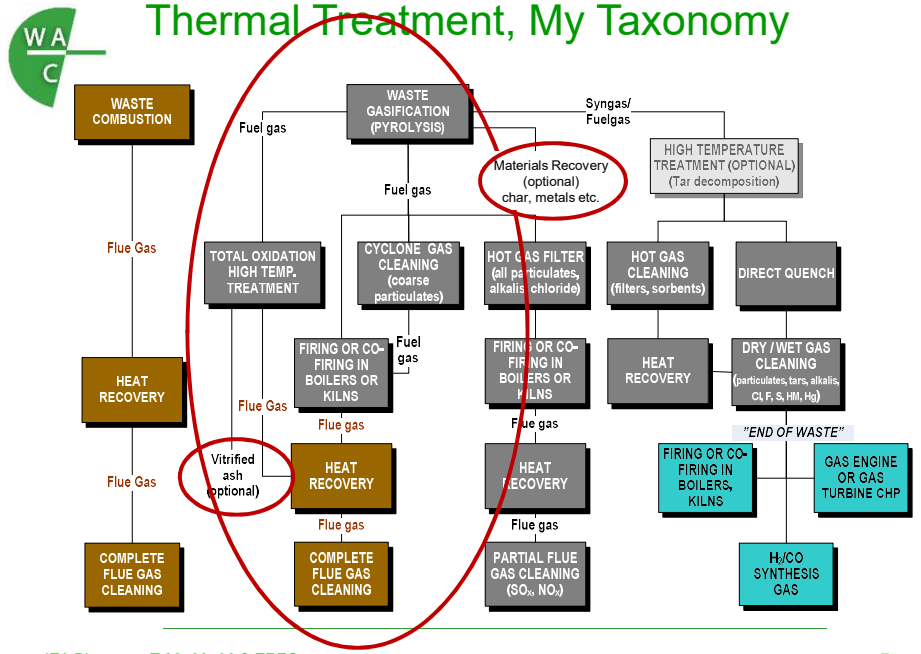
Industrial Emissions Directive 2010/75/EC.

"'waste incineration plant' means any …… technical unit and equipment dedicated to the thermal treatment of waste, with or without recovery of the … heat generated, through the incineration by oxidation of waste as well as other thermal treatment processes, such as pyrolysis, gasification or plasma process, if the substances resulting .... are subsequently incinerated;"

'waste co-incineration plant' …..main purpose is the generation of energy or production of material products and which uses waste as a regular or additional fuel or in which waste is thermally treated for the purpose of disposal…….

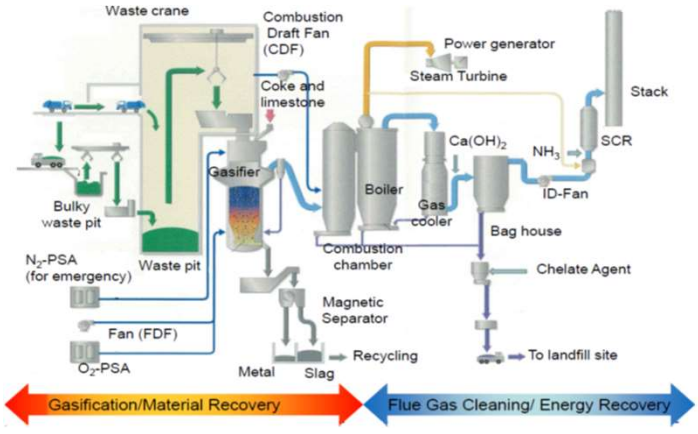
End-of-waste condition for waste gasification product gas: gases "are purified to such an extent that… they can cause emissions no higher than those resulting from the burning of natural gas"

Thermal Treatment, My Taxonomy



Example; Japanese Waste Gasification

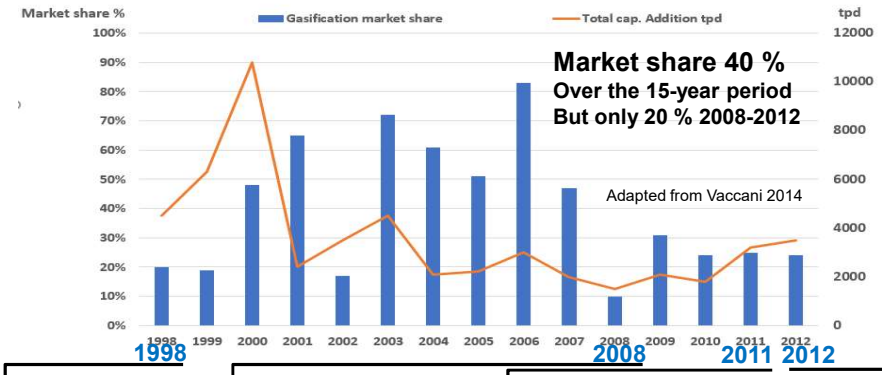
Nippon Steel & Sumikin Engineering Co. Ltd Shaft Furnace



Ash melting: Ebara, Hitachi, IHI, JFE, Kawasaki, Kobelco, MHI, Mitsui, Takuma etc.

Metal recovery: Corenso (Al from carton waste), Chinook Sciences (metals from ELVs)

Japan MSW Incinerator/gasifier Market



1998

Ash melting required for all new incinerators Investment subsidy of 30-50 %.

2008

Ash melting no longer required, but has 50 % inv. subsidy, (30 % w/o melting)

2011

Post- Fukushima. Promotion of energy generation. Inv. subsidy 33-50 % based on energy performance.

2012

FiT. 0.15 €/kWh 20 years (2014)

Gasifier/ Two-Stage Incinerator Examples

ENERGOS, NO, UK

Eight "gasifier" plants,10-80 kton/year, 3-40 MW_{th} some CHP < $5MW_e$
Mainly NO, also DE and UK.
Bankrupt 2016.

Other grate type technologies

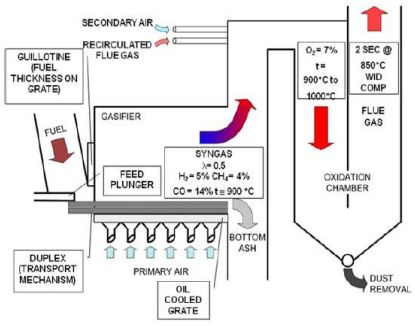
Biomass Power, Michaelis, Covanta etc.

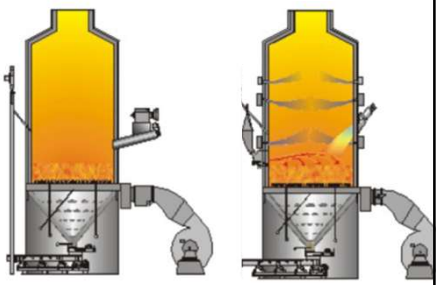
OUTOTEC, USA/FI

Several FB bed plants in operation and construction in USA and the UK

Other FB type technologies

EQTEC, Kobelco, Ebara, Mitsubishi Kawasaki etc.





Gasifier **Advanced Gasifier**

Two-Stage Incinerator/Gasifiers

"Gasifiers"/"two-stage" incinerators vs. modern incinerators

- **lower or at best similar efficiency to power**
  - **partially due to smaller scale**
  - **partially for process reasons**
- **similar air pollution control (APC) technology i.e. similar environmental performance**

Drivers

- **claimed cost benefit at small scale**
- **potential for ash vitrification w/o external energy (Japan)**
- **UK Renewable Obligation system promoted gasification technology in the past**
  - **2 MJ/Nm^3, 1 ROC/MWh, 4 MJ/Nm^3, 2 ROCs/MWh**
  - **Waste incinerators w/o CHP 0 ROCs**
- **new UK CfD system R1 "Advanced Conversion Technology"**
  - **spark price 114 £/MWh 2014**
  - **decreased to 74 £/MWh 2017**

Waste Framework Directive 2008/98/EC

R1: Energy recovery

$$\text{Energy efficiency} = \frac{(GWh_e * 2.6 + GWh_{th} * 1.1 - GWh_{f+i})}{0{,}97 * (GWh_w + GWh_f)} > 0.65$$

R1 Waste Incinerator (WI) power, heat and CHP technologies	Power prod. (% energy)	Heat prod. (% energy)	"Energy Efficiency"
Limiting WI, power only	**26**	0	0.65
Limiting WI, heat only	**0**	57	0.65
Typical WI with some CHP	**15-20**	22-10	0,65
Typical WI CHP, w/o flue gas cond.	**25**	60	1.35
Typical WI CHP, with flue gas cond.	**25**	65	1.41
Lahti-type waste gasific. power only	**34**	0	0.83
Lahti-type waste gasification CHP	**31**	56	1.47

Prevention
Re-use
Recycling
Recovery
Disposal

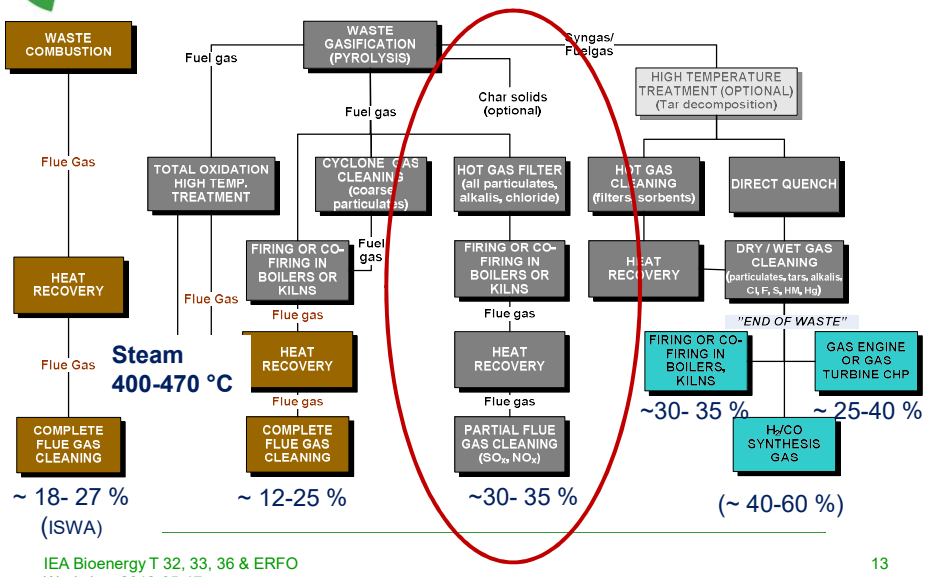
R3: Recycling/reclamation of org. substances which are not used as solvents (incl. composting & other biological transformation processes).

Includes gasification & pyrolysis using the components as chemicals.

But no quantitative criteria on the expected recovery efficiency

Technologies, applications

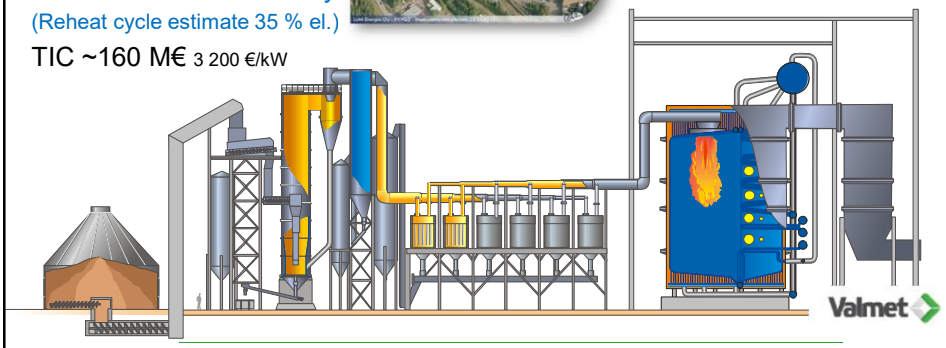
Efficiency to electric energy (biofuels)



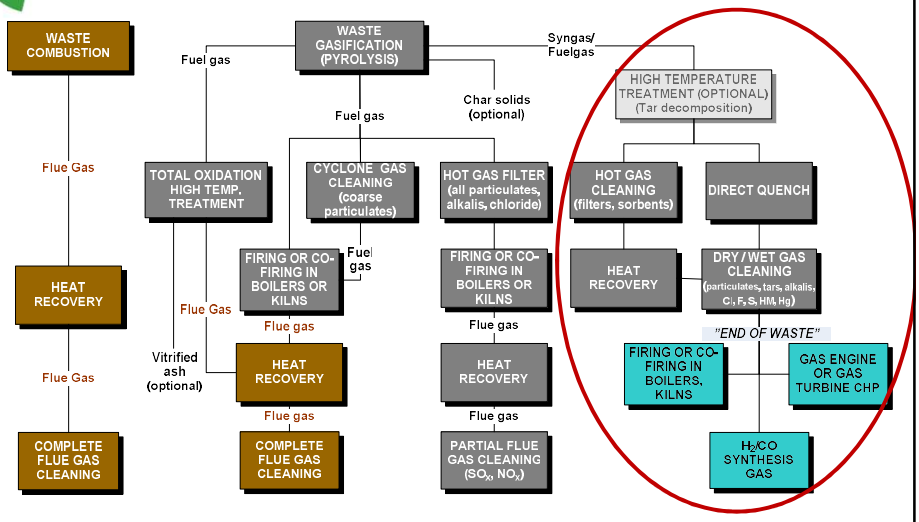
Kymijärvi II, Lahti, Finland

Fuel 2*80 MW SRF etc.
250 000 ton SRF / year
120 bar/ 540 °C
50 MW_e / 90 MW_{th}
31 % / 88 tot. % efficiency
(Reheat cycle estimate 35 % el.)
TIC ~160 M€ 3 200 €/kW

30 000 op. hrs 2012 to 2016
Fuel quality an issue.
Gas filter new feature, maintenance, learning.
Gas firing, emissions OK, no corrosion in boiler or gas cooler



Technologies, applications



Air Products, Ineos

Teesside, UK

2 *350 000 ton/year waste
Each 49 MW_e gross, 37 MW_e net.
AlterNRG atm. Plasma gasifiction,
2*Solar Titan GT-CC per unit
Ext. pre-combustion gas cleaning
Investment 500 million $ per unit
Commissioning in 2014.
Both projects stopped in 2016

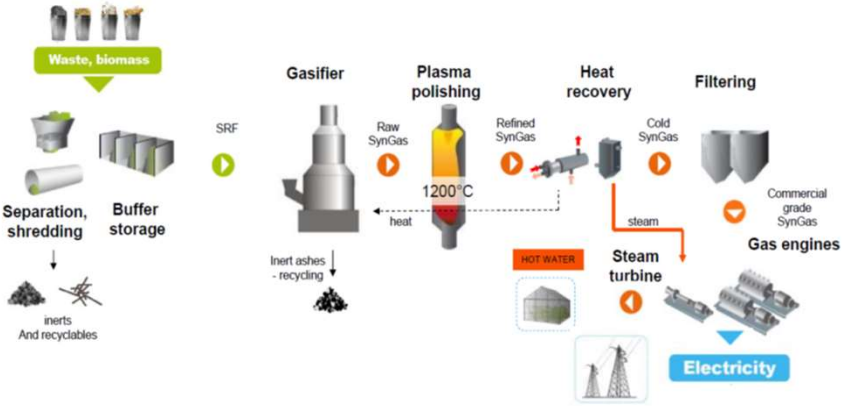
Vero Beach, FL

Biomass waste, MSW
Syngas fermentation
30 000 m^3 of ethanol, 6 MW_e gross
Oxygen-blown two-stage gasifier
130 million $.
Commissioning late 2012,
reengineering in 2014 and restart.
Ineos stopped activities in 2016.

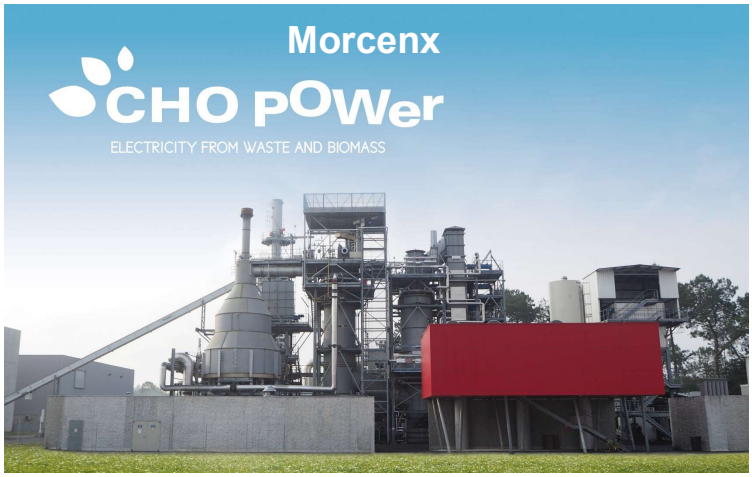
CHO Power (Europlasma), France

Morcenx

40 000 tpa MSW producing 10 MW_e+18 MW_{th}
PRME fixed bed gasifier, plasma gas cleaning system,
Start 2012, insolvency + refinancing + re-enginering in 2013
Passed acceptance tests mid-2017.



CHO Power (Europlasma), France



Several projects in development in France (Thouars, Locminé, others)

Other developments, France and UK

LLT, Villers-sous-Montrond

CFB gasifier + thermal tar reactor + gas cleaning system + motors, 7 MW_e + 10 $MW_{th.}$

In construction to start in 2018

SynTech Bioenergy Centre, Wednesbury

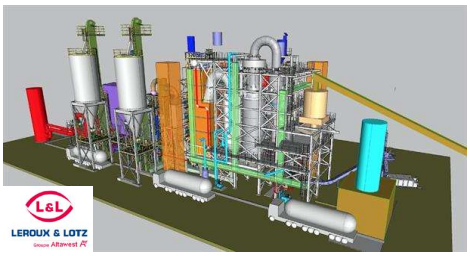
Parent of **Frontline Bioenergy** LLC.

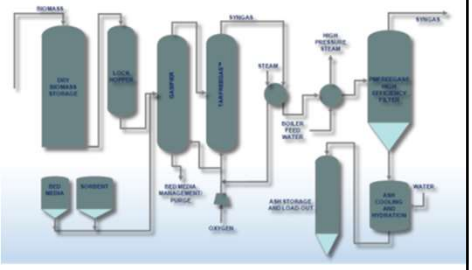
40 ton/day RDF, 1.5 MWe, some CHP

Press. O2-blown FB, thermal reformer, gas cleaning to "end-of-waste", high-efficiency engine

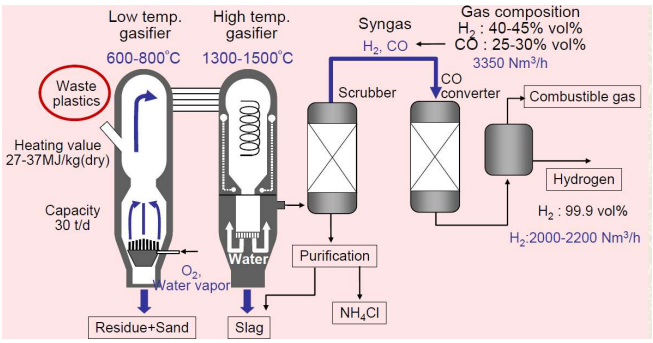
10 million £ cost, 50 % from ETI

Mechanical completion end of 2017





Ebara-Ube



Showa Denko K.K

EUP technology. Start-up 2003.

65 kton/y plastic waste. Syngas for hydrogen and ammonia, 30 % of need

Expansion of the plant in 2015 to make 65 % of the hydrogen required for ammonia production (200 kton/year total)

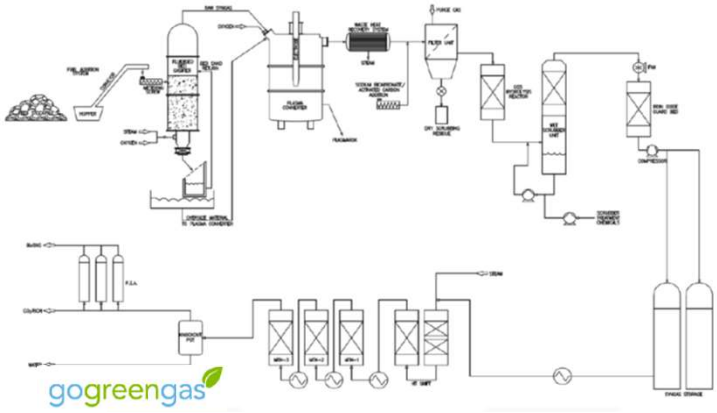
Enerkem, Edmonton, Kanada

100 000 ton per year RDF plant. Product 38 000 m^3 of methanol/ethanol
Commissioning initiated 2013, installed ethanol step 2016.
Ramping up production in 2018.

Plans for 220 000 m^3 methanol in Rotterdam for plastic wastes

GoGreenGas

4.4 MW SNG Demo in construction in Swindon to start 2018.
27 M£, Support 11M£ Dep. Of Transport, 5 M£ Ofgem
Partners Cadent (8.7 M£), APP, Carbotech, Progressive Energy
APP gasification (Outotec oxygen-blown FB gasifier, plasma reformer)
AMEC Foster Wheeler gas conditioning, synthesis



Thermal treatment/gasification aspects

– General therm. treatment factors +
Gasification-related factors

Waste available for thermal treatment

Waste reduction schemes	Land fill bans
Recycling targets	Special wastes, recycling
Conv. treatment overcapacity	Waste sorting practices

Economics of thermal treatment, other aspects

General decline in power prices	Land fill bans and disposal cost
Lower heat demand, heat pumps etc.	R3 recovery chemicals, (bio)fuels
Lower heat demand, heat pumps etc.	Biofuels incentives?
Carbon pricing for fossil part	*Future changes to R1 value??*
Investment costs to meet BAT	
Public acceptance	
Risk, new technology introduction barriers	
Acceptance of waste-derived fuels?	

Thank you for your attention

Gasification news available at
IEA Bioenergy Task 33 Thermal Gasification web page

task33.ieabioenergy.com/