

# **Trends in Thermochemical Conversion of Waste and Biomass**

#### A brief overview

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### **Outline of presentation**

Background

Waste as a resource

A little bit about thermochemical conversion of solid fuels!

Waste-to-Energy (WtE) systems

Where are we going?

Summary





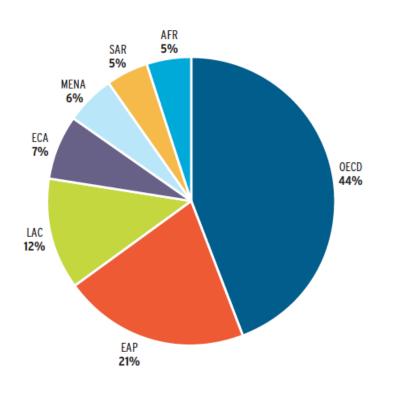
# **Background**

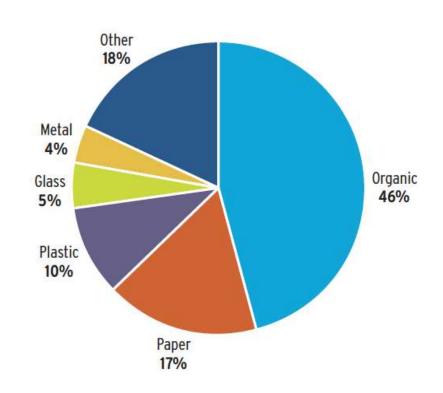




### **Background**

In 2012, the total generation of waste in the world was estimated to 1.3 billion tonnes.





MENA: Middle East and North Africa LAC: Latin America and the Caribbean ECA: Eastern and Central Asia

EAP: East Asia and the Pacific Region

AFR: sub-Saharan Africa SAR: South Asian Region OECD: OECD countries





# **Background**

### Two examples of waste disposal 2012

	AFR		OECD	
	Mtonnes	%	Mtonnes	%
Dumps	2.3	44	-	-
Landfills	2.6	50	242	42
Compost	0.05	1	66	12
Recycled	0.14	3	125	22
Incineration	0.05	1	120	21
Other	0.11	2	20	3
Total	5.25	100	573	100





# Waste as a resource?





### Waste as a resource



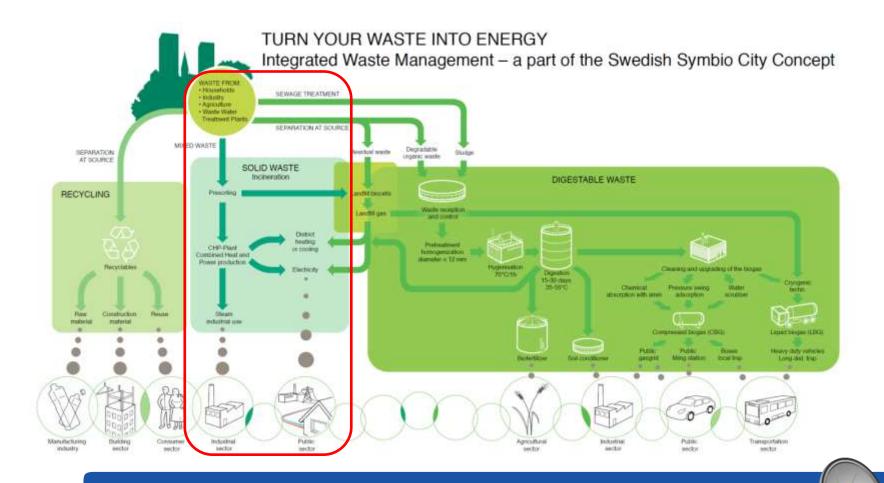
Thermal treatment is an "integrated" part of any waste management system and will very likely be so also in the future!





### Waste as a resource

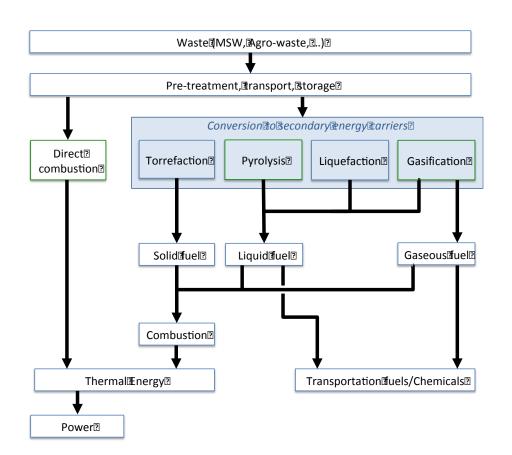
An example: Waste management in Sweden





### Waste as a resource

### Products from thermochemical conversion systems



Type of thermochemical technology depends on:

- Feedstock
- Desired and possible product(s)
- Economic incitements
- Available technology
- Geographic population
- Societal infrastructure

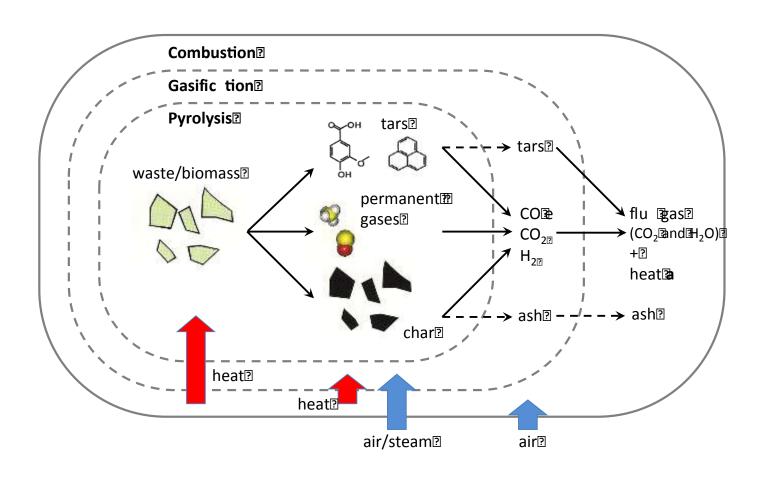




# A little bit about thermochemical conversion of solid fuels!







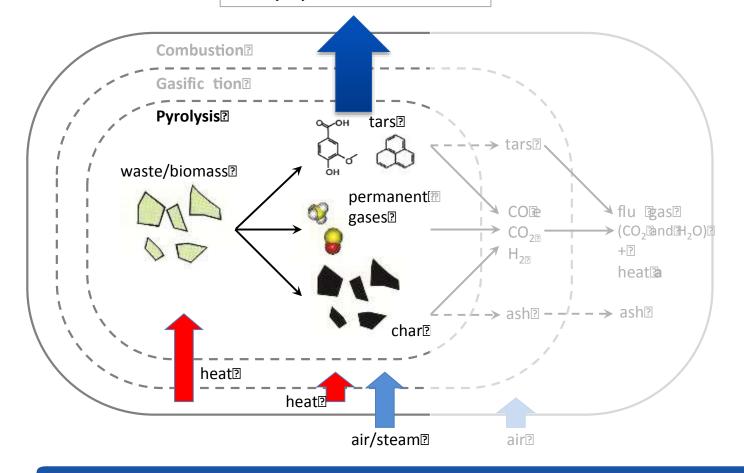




Products
Char
Product gas
Tars/Pyrolysis oil

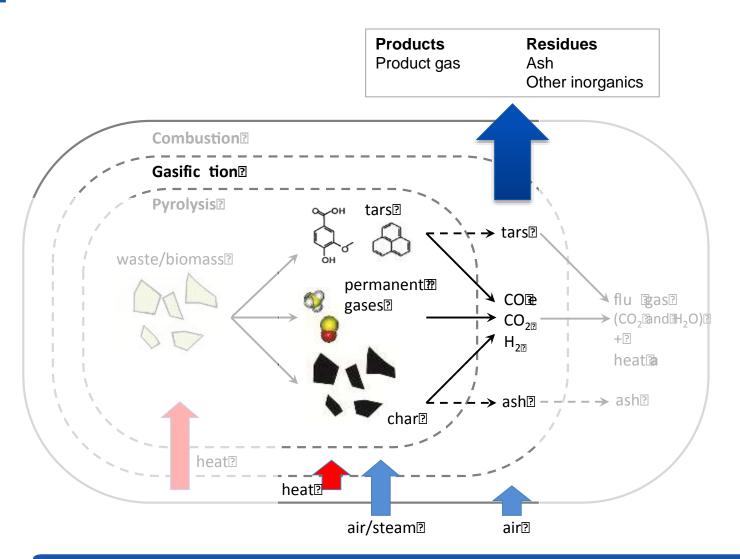
Residues

"After further upgrading"



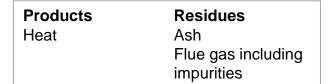


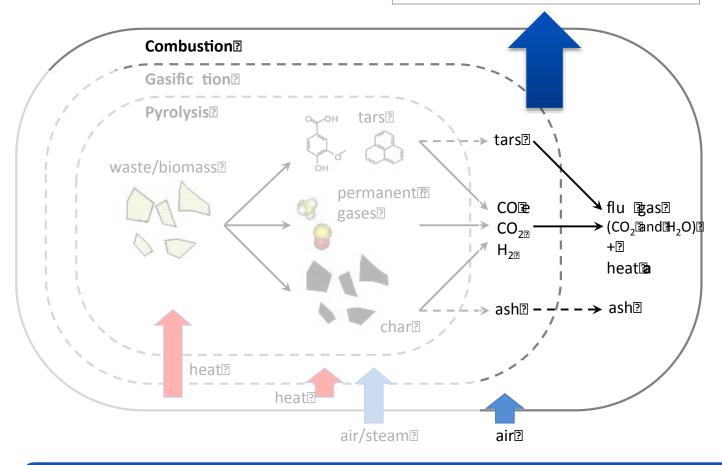










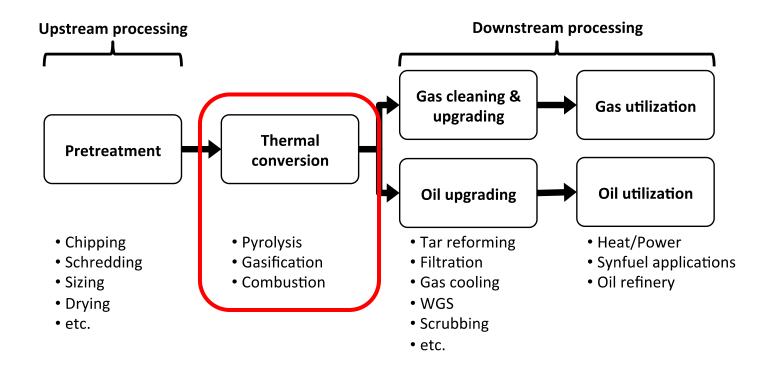










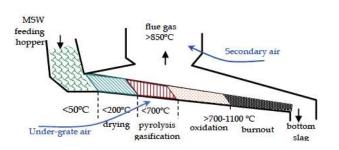




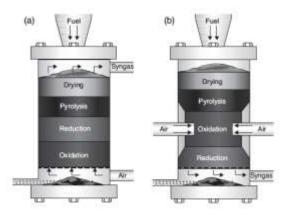


Examples of thermal conversion technologies

### **Grate furnace**

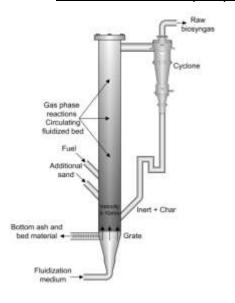


#### Fixed bed



"Downdraft"

#### Fluidised bed (FB)

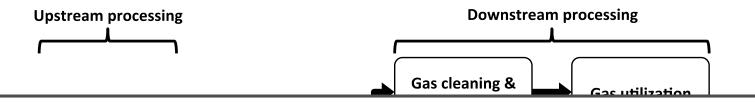


"Circulating FB - CFB"
"Bubbling FB – BFB"



"Updraft"





# What about a complete system?

- Schredding
- Sizing
- Drying
- etc.

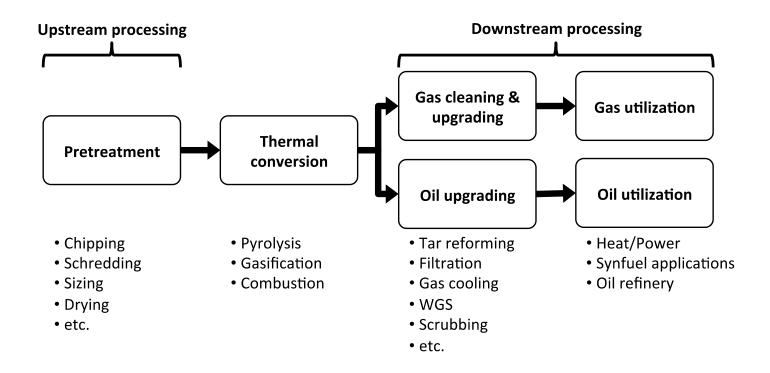
- Gasification
- Combustion

- Filtration
- Gas cooling
- WGS
- Scrubbing
- etc.

- Synfuel applications
- Oil refinery







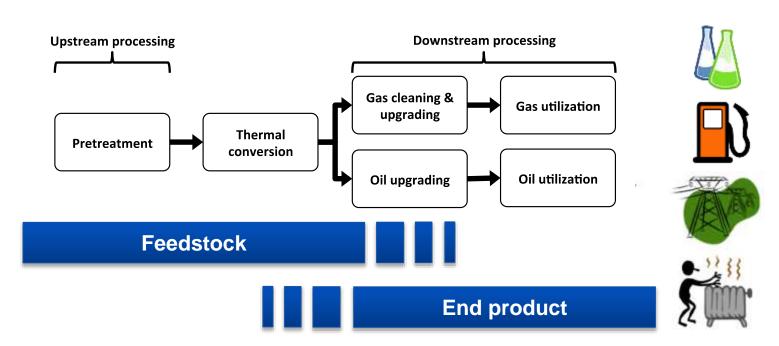
There is a vast number of possible process configurations depending on feedstock and utilization





Factors influencing choice of process configuration



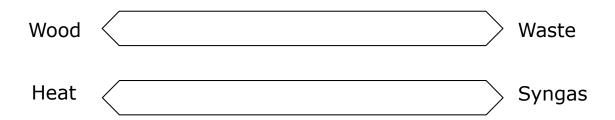






Factors influencing choice of process configuration

### **Process complexity**



# Cost efficiency

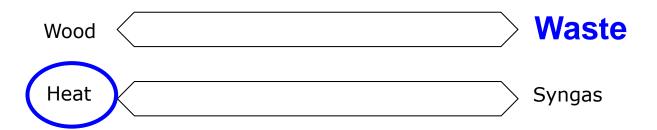
Small scale \times Large scale





Factors influencing choice of process configuration

### **Process complexity**



# Small scale Large scale





### Technologies generally utilized!

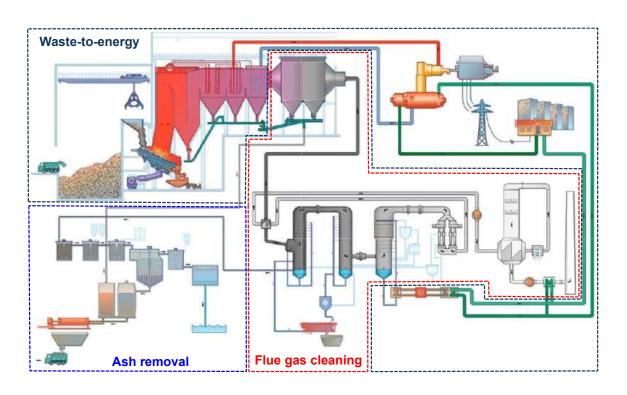
Technique	Untreated MSW	Pretreated MSW and RDF	
Combustion			
Grate	Widely applied	Widely applied	
Rotary kiln	Not normally applied	Applied	
Fluid bed - bubbling	Rarely applied	Applied	
Fluid bed - circulating	Rarely applied	Applied	
Fluid bed - rotating	Applied	Applied	
Pyrolysis	Rarely applied	Rarely applied	
Gasification	Rarely applied	Rarely applied	





Direct combustion: A modern waste incineration plant – an example

- Waste incineration CHP is mainly carried out in grate fired boilers for fuel flexibility
- Examples using rotary kiln and and circulating fluidised bed (CFB) also exist



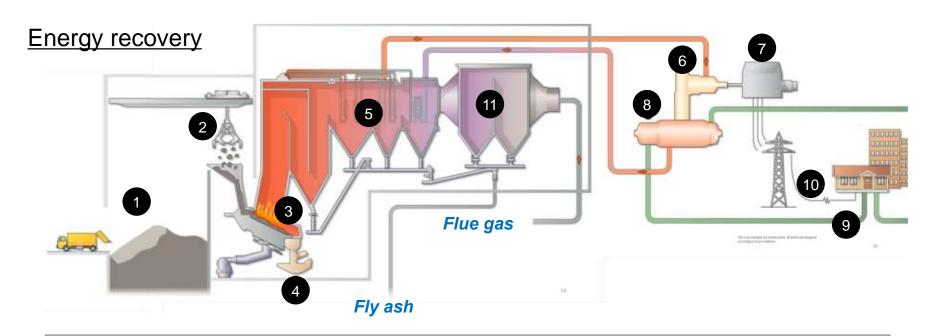
Mainly three parts:

- Energy recovery
- Flue gas cleaning
- Ash removal (recovery)





Direct combustion: A modern waste incineration plant – an example



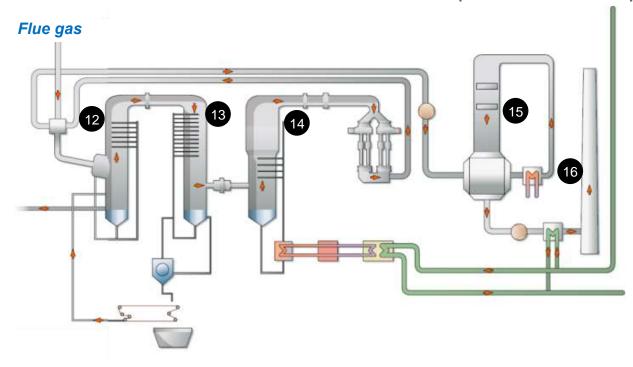
- 1. Waste bunker
- 2. Fuel feeding
- 3. Furnace, 1000 °C
- 4. Slag to water filled trough
- 5. Heat exchangers, steam data typically T = 400 ° C, P = 40 bar
- 6. Steam turbine

- 7. Generator
- B. Heat exchanger district heating
- 9. District heating  $T = 70 120^{\circ}$  C
- 10. Electricity
- 11. Gas cleaning with electrostatic precipitator



Direct combustion: A modern waste incineration plant – an example

Flue gas cleaning



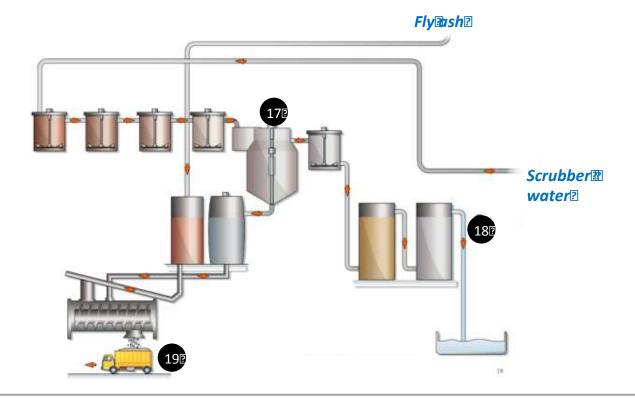
- 12-14. Water scrubbing with water containg various substances eg lime
- 12. Removal of heavy metals and acidic componds
- 13. Removal of SO2
- 14. Condensor condensing remaining moisture and heat pump extracting heat
- 15. SCR catalytic convertor for Nox
- 16. Chimney





Direct combustion: A modern waste incineration plant – an example

### Ash removal

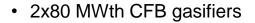


- 17. Cleaning of scrubber water. Precipitation of heavy metals using chemicals. Precipitated sludge is drained.
- 18. pH adjustment and release of water
- 19. Sludge and fly ash is stored



Gasification: Combined heat and power CFB plant

### Lathi Energia Gasification Power Plant by Metso



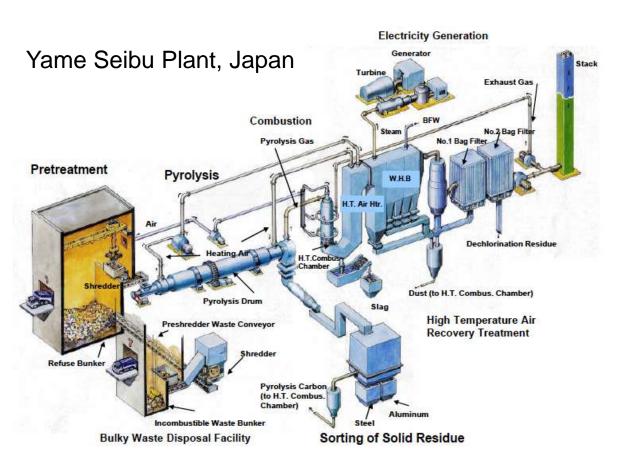
- Waste derived fuel
- 50 MW<sub>el</sub> and 90 MW<sub>heat</sub>
- Supported by the Finish authorities
- Total investment 157 M€
- Start-up 2012
- Fuel handling
- 2. Gasifier
- Gas cooling
- 4. Gas filter
- 5. Gas boiler and flue gas cleaning



Source: IEE task 33



Pyrolysis: Power production in a rotary kiln pyrolysis plant



- Pyrolysis of MSW is a rotary drum at 450 ° C.
- Producing an oil rich pyrolysis gas, char as well as ferrous and nonferrous metals.
- Pyrolysis gas directly combusted in a HT combustor connected to a boiler producing steam for power generation.
- Char combusted in HT combustor.
- Residual ash in form of fused ashes is sent to landfill.



Source: IEE task 32



"A guess on possible trends!"





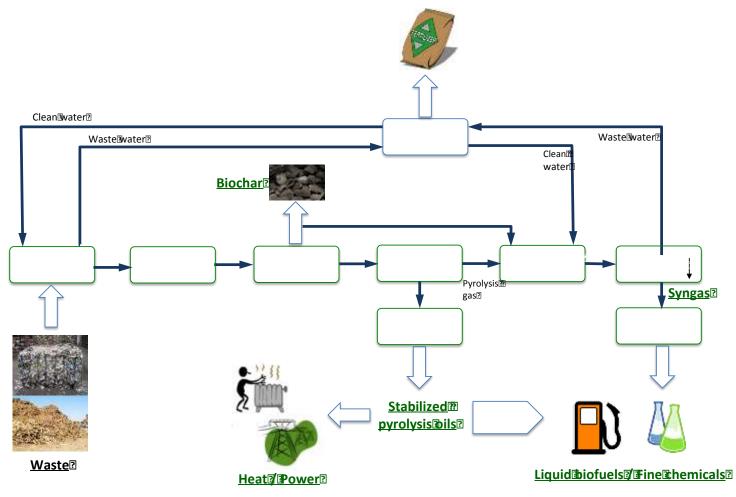
### A few examples!

- Diversified production of multiple products
- Integration in the society
- Small scale processes





Flexible production of multiple products

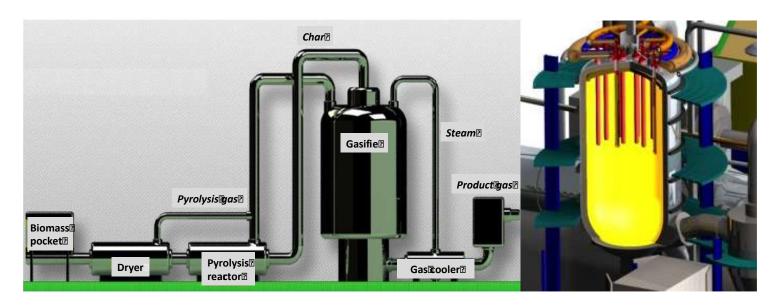






Flexible production of multiple products

An example: The WoodRoll® process by Cortus Energy AB



- Next to commercial three stage gasifier with separate steps dryer, pyrolyser and gasifier
- Indirect heating by radiation heaters fuelled by pyrolysis gas
- High temperature gasification (~ 1100 ° C) using steam no tar formation
- Development of cost efficient gas cleaning and upgrading a challange



### Flexible production of multiple products

Another example: Plasma gasification



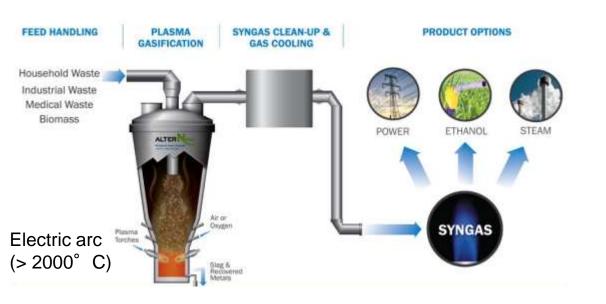
- The plasma decomposes the organic components to a product gas.
- A relatively clean gas free from tar
- A vitrified slag is produced In case of gasification

Source: Alter NRG



### Flexible production of multiple products

Another example: Plasma gasification



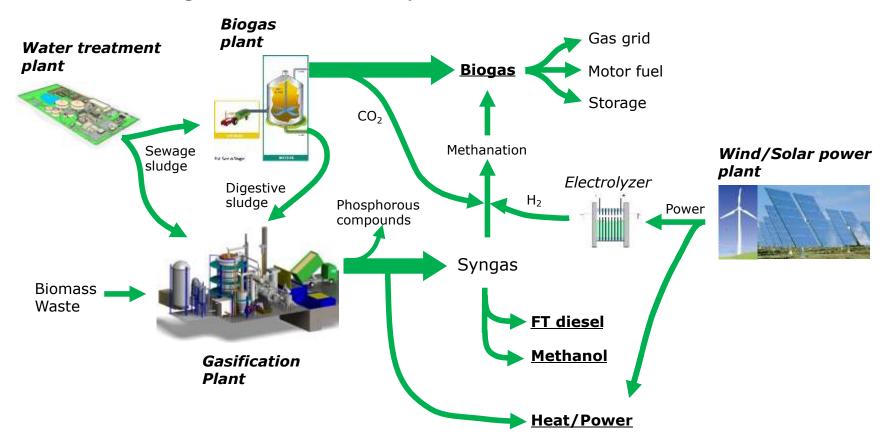
- The plasma decomposes the organic components to a product gas.
- A relatively clean gas free from tar
- A vitrified slag is produced In case of gasification

"Commercial plasma gasification has taken a hefty setback recently when the project erecting two WtE plants in Tee Valley, UK (50 MW electricity, 350 ktonnes waste / year) were halted after completing the first of the plants due to technical problem during commission;"

Source: Alter NRG



Integration in the urban system

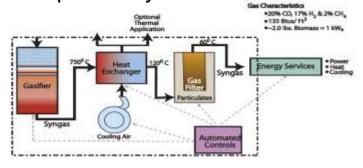


"Several components in the society integrated for efficient energy recovery"



### Small scale WtE processes

# BioMax®100 Gen2 Modular Biopower System





- Waste treatment at a local level, close to the waste source
- An interesting option for rural areas with sparse population and poor infrastructure
- Preferably enable production of enable production of power
- Mobile to allow for use at the site where the feedstock is available

- Downdraft gasifier → lower tar formation
- A simplified gas cleaning system.





# **Summary**





## **Summary**

- Thermochemical conversion technology has been around for a long time but still large efforts are made to develop new techniques for treatment of waste and other residual materials.
- A major driving force is the continue need for treatment of nonrecyclable waste.
- Other important aspects are feasible techniques for
  - Local treatment of waste in regions with small communities
  - Societies with poor infrastructure
  - Need to for system facilitating multi-product production, especially in form of high value energy carriers and chemicals.
- Todays, technologies are generally either developed for largescale applications or not suitable for a waste feedstock, such as MSW or RDF.





### **Summary**

 Trends in R&D to meet the societal needs are development of thermochemical waste conversion processes for diversified multi-product production, where different approaches are considered depending on feedstock type and plant scale.







# Thank you for your attention!

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