Future district heating plant integrated with sustainable hydrogen production

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4DH
4th Generation District Heating Technologies and Systems

University of Agder

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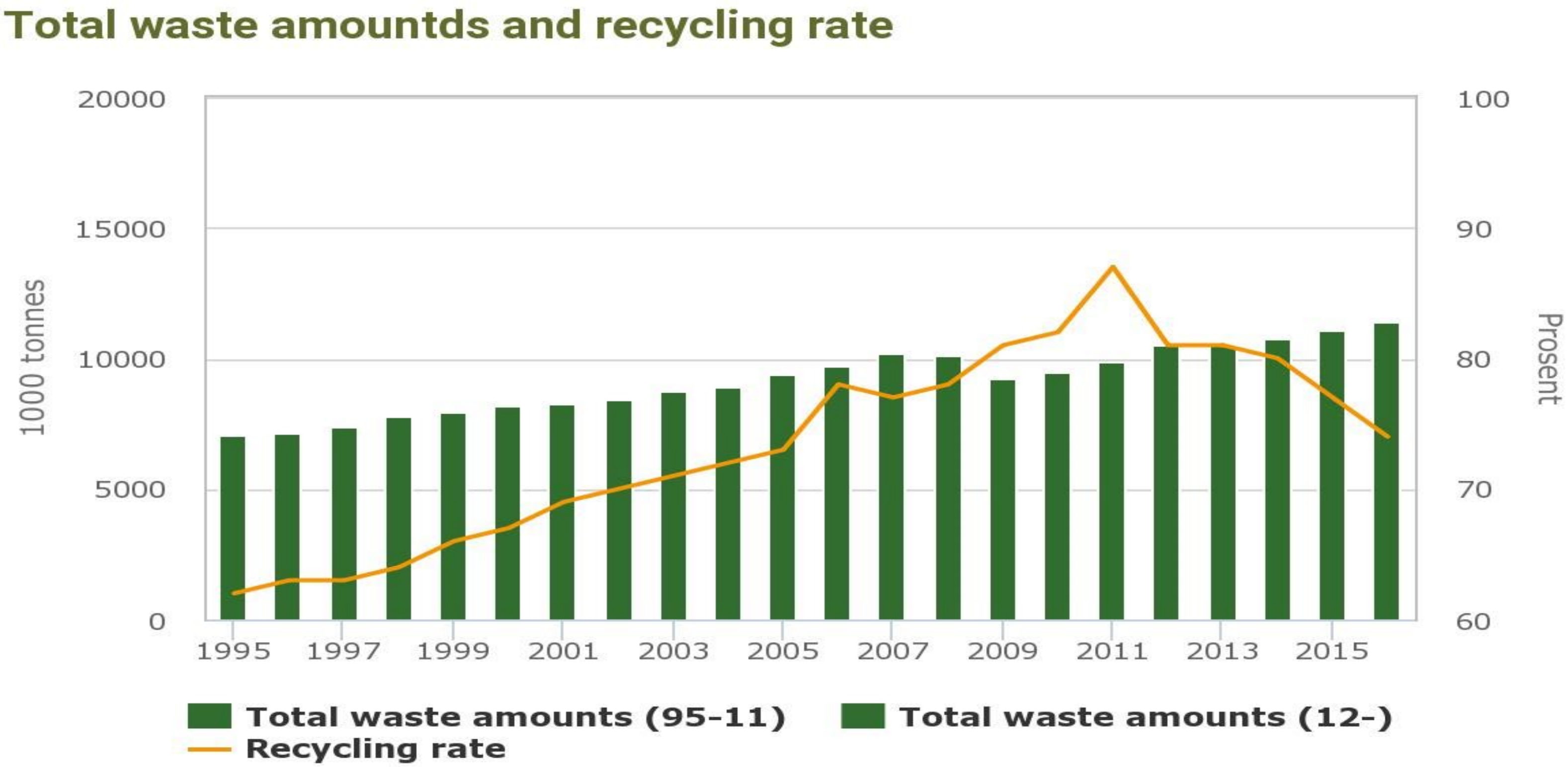
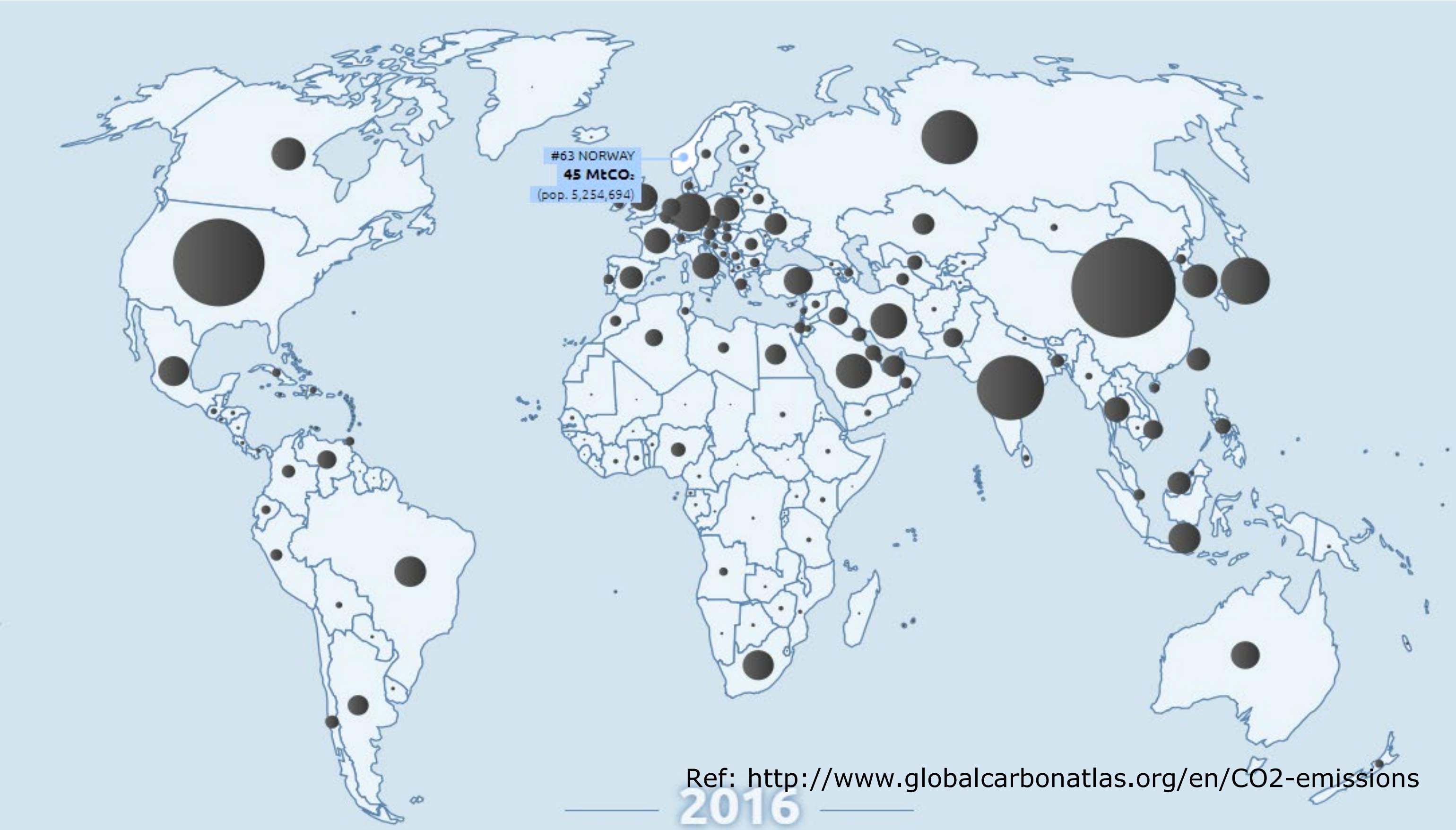
Introduction



Source: Statistics Norway (SSB) Licence: NLOD

Global CO_2 emissions in 2016



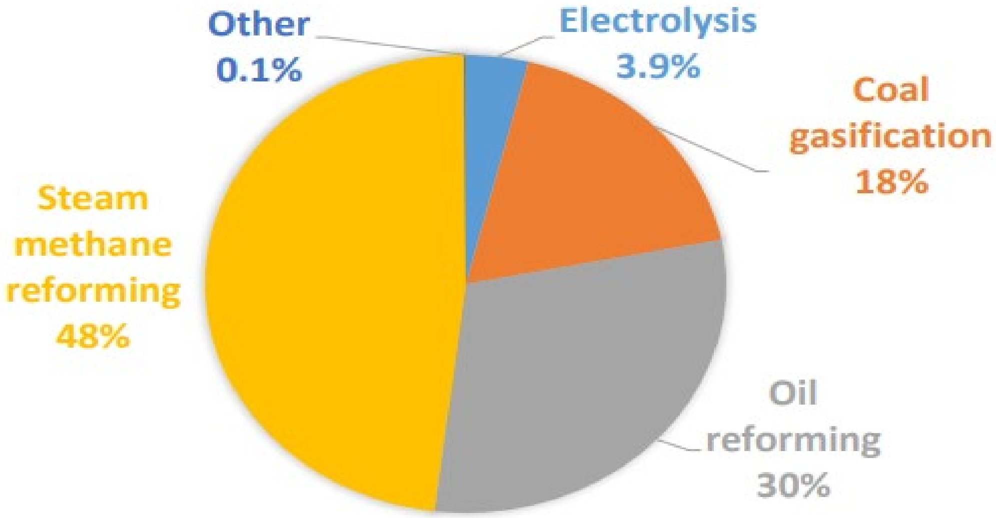
Ref: http://www.globalcarbonatlas.org/en/CO2-emissions

Norway: 0.12% (43 million tonne CO2)

Rest of the World: 99.88% (36140 million tonne CO2)

Status of Hydrogen genertion

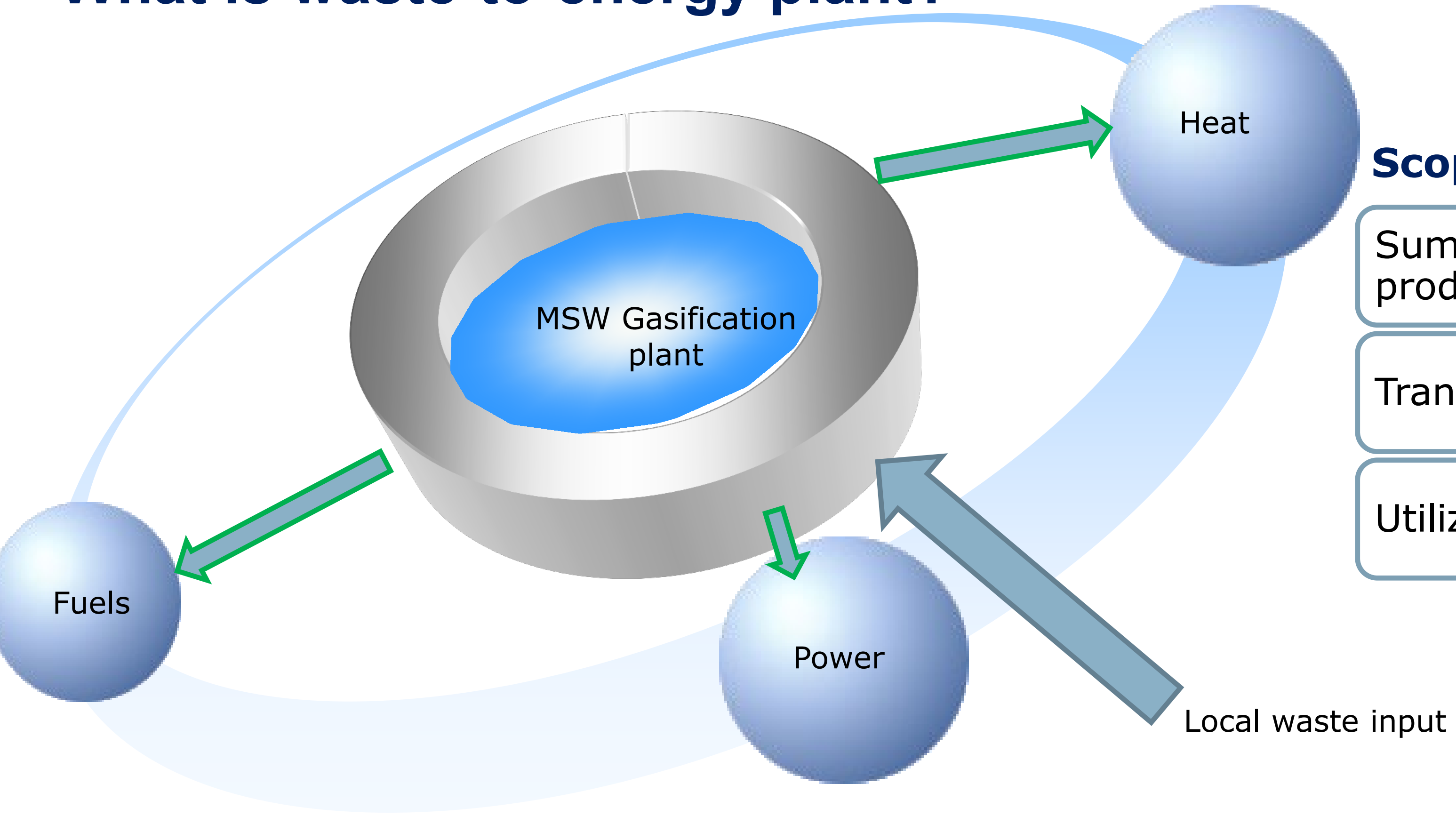
Contribution of different methods to worldwide hydrogen production.



How can hydrogen be produced from local, non-fossil resources available in Southeren Norway with minimum use of primary energy?

Ref: https://www.uib.no/sites/w3.uib.no/files/attachments/20180515_-_hydrogen-from-waste_-_lummen_-_public.pdf

What is waste-to-energy plant?

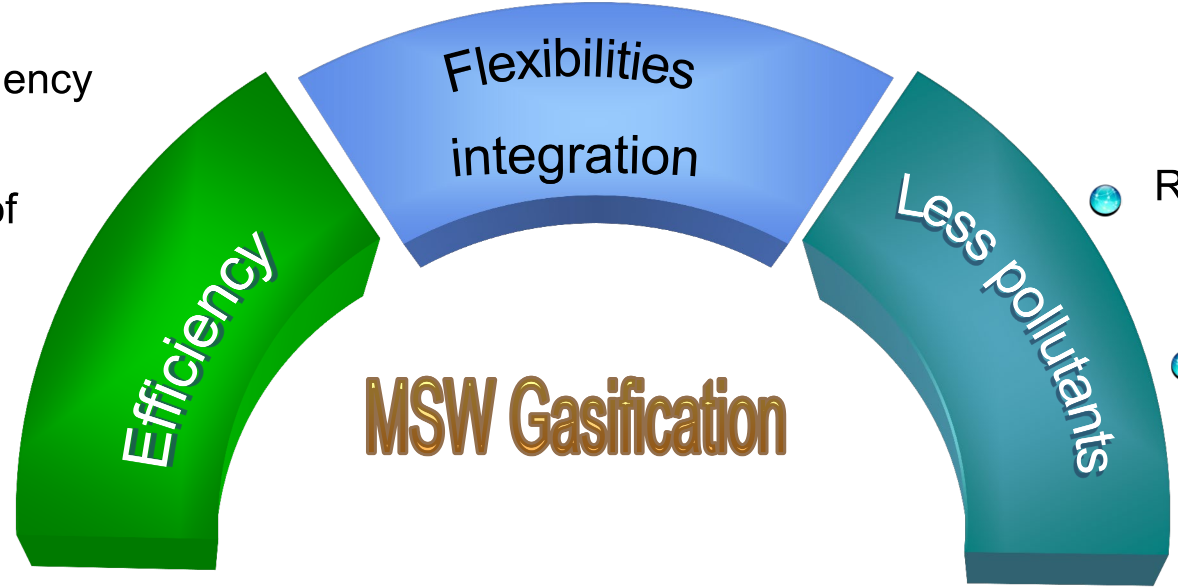


Scope of this study

- Summer mode H2 production
- Transportation fuel
- Utilizing local waste

- Flexible to produce different products
- Integrated with existing CHP/DH plants
- Handle a diverse type of waste

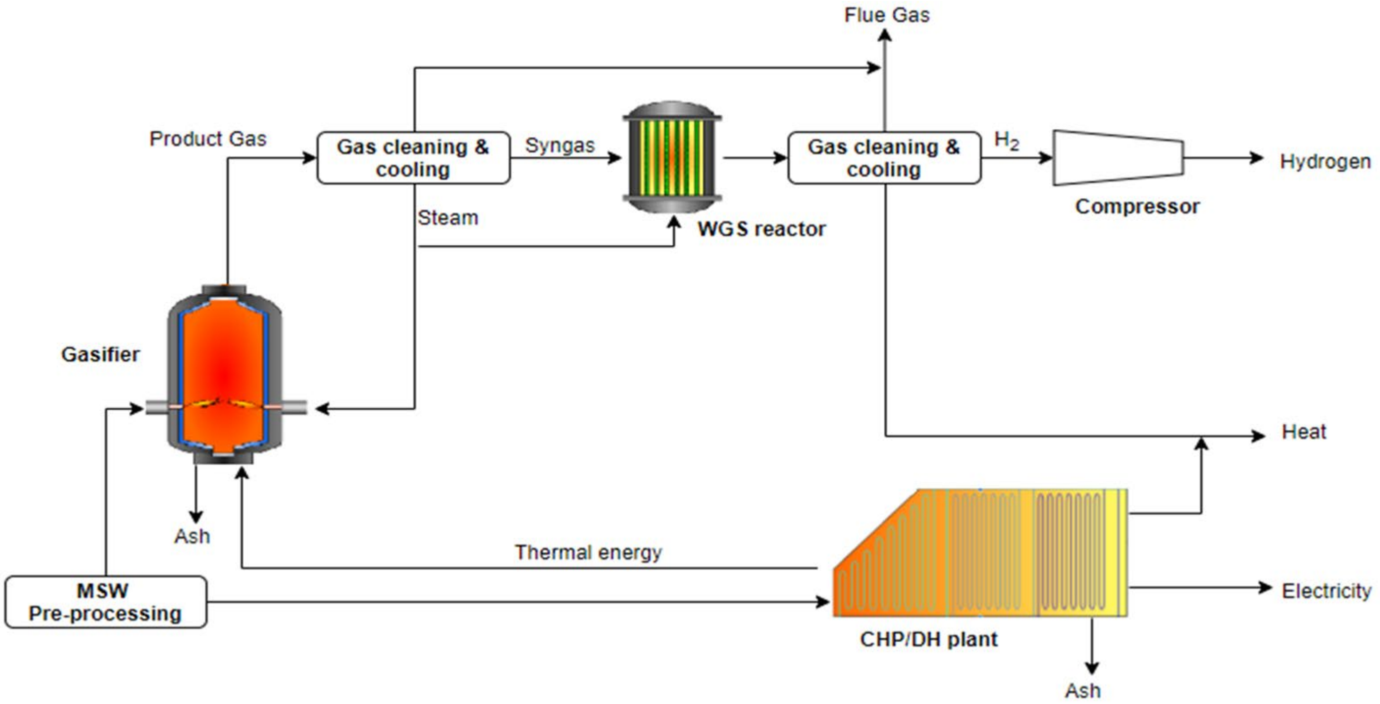
- Improve efficiency
- Minimization of energy loss



- Reducing emission
- 100 % local waste energy systems

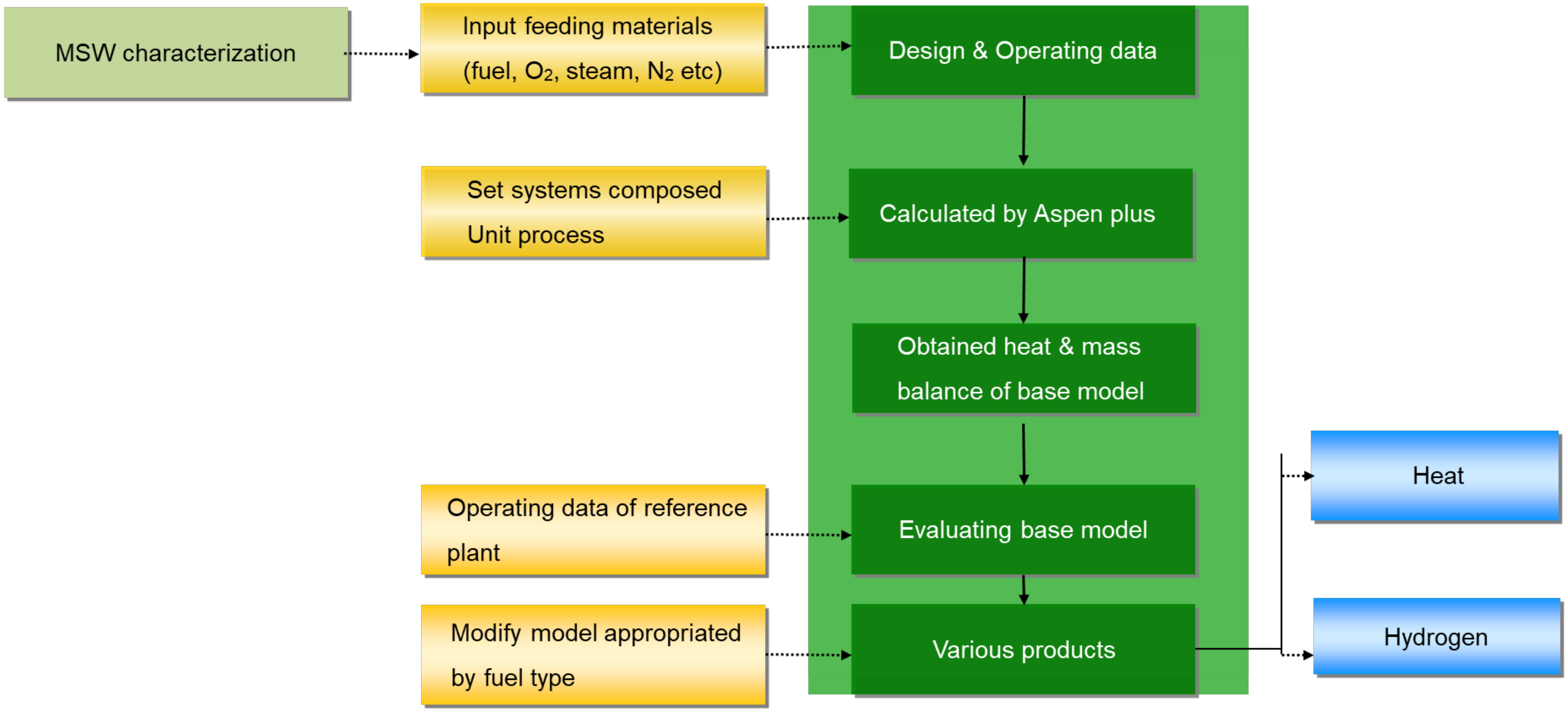
Design and simulation

Process flowsheet

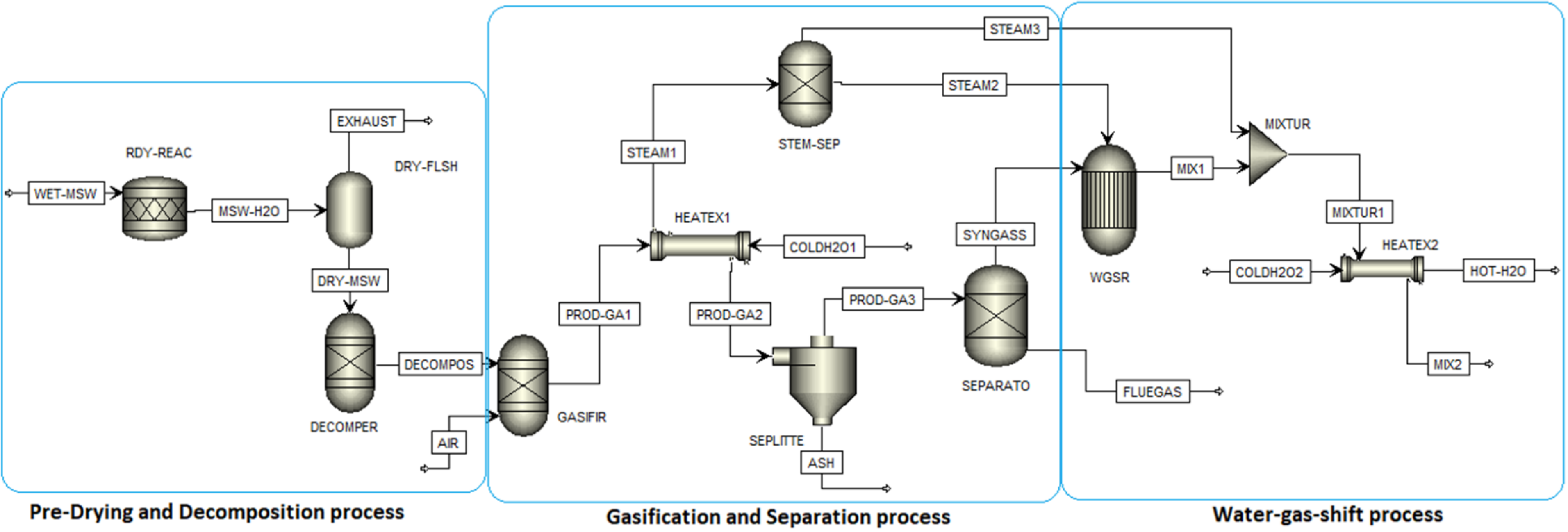


Simplified scheme of the proposed hydrogen production system in direct gasification

Design and optimization



Aspen Plus Simulations



Process flowsheet of direct gasification system with air as a gasifying agent

Results

Characterization of MSW

Proximate Analysis

Parameters	Present result	Measured [*]	Calculated [*]
Moisture (%wb)	6.3	N/A	N/A
Volatile matter (%db)	78.6	77.4	78.4
Fixed carbon (%db)	9.0	15.1	14.5
Ash (%db)	12.4	7.6	7.2

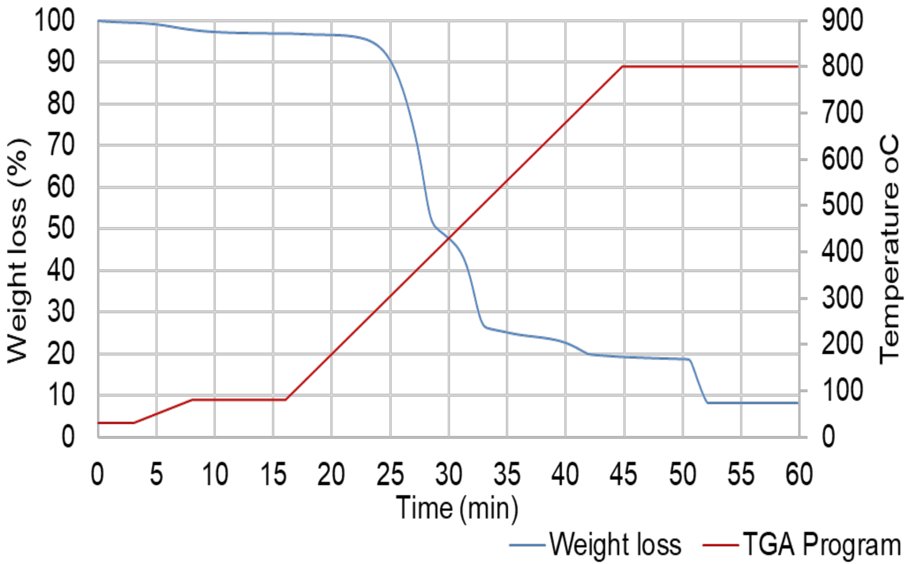
Ultimate Analysis

Element	C (%db)	H(%db)	N(%db)	O(%db)	S(%db)	Ash(%db)
Present sample	51.6	6.3	0.8	28.7	(0.2)	12.4
Measurement [*]	52.8	6.4	1.29	31	0.18	7.6

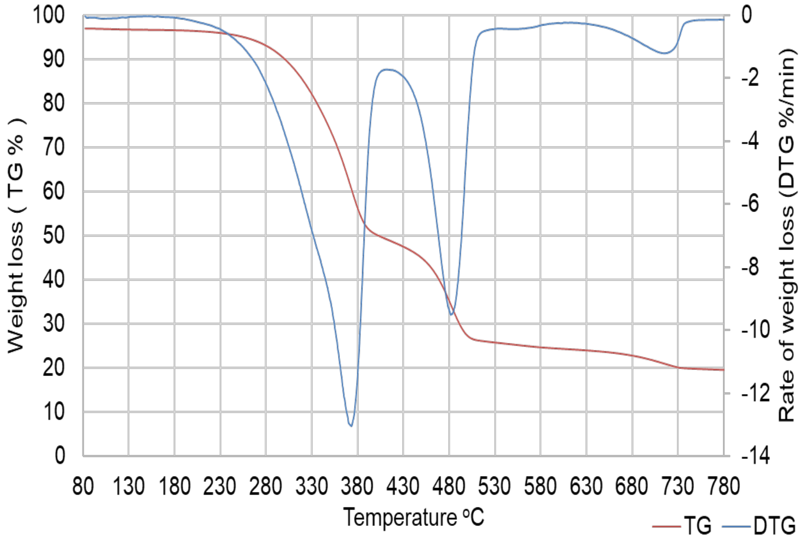
Formula	Boie	Dulong	Reed	Average
HHV_{db}(MJ/kg)	22.3	21.3	21.7	21.8
HHV_{db} from literature				
Literature	[9]	[11]	[12]	[13]
HHV_{db}(MJ/kg)	22.5	22.2	18.97	21.2

* S. S. Hla and D. Roberts, “Characterisation of chemical composition and energy content of green waste and municipal solid waste from Greater Brisbane, Australia,” *Waste Manag.*, vol. 41, pp. 12–19, Jul. 2015

Characterization of MSW

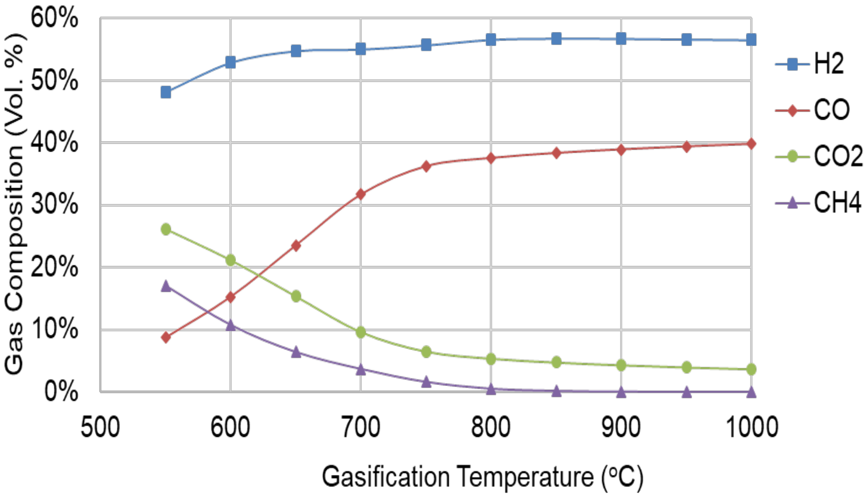


TGA weight loss characteristics of the sample

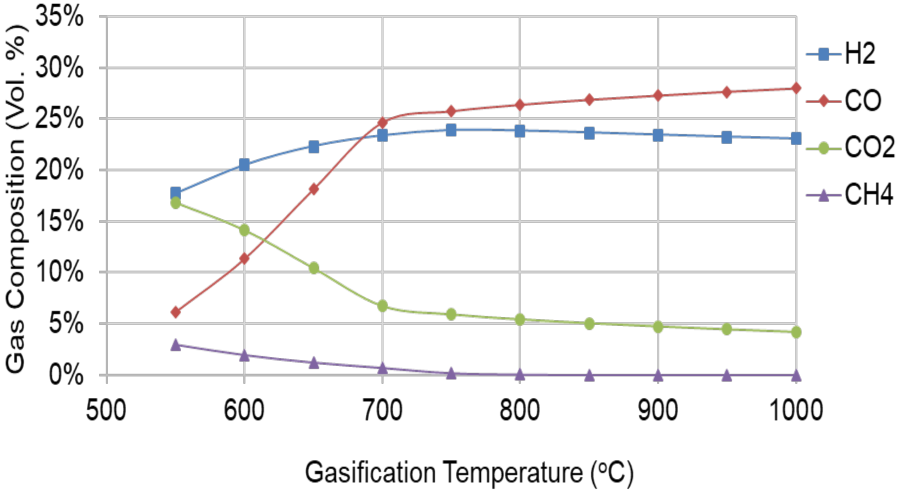


TG and DTG characteristics of the sample

Simulation Results

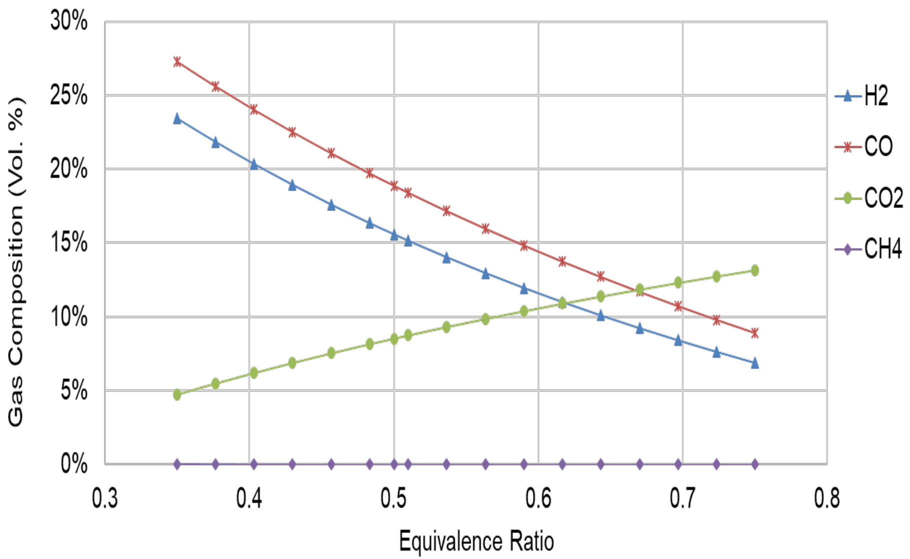


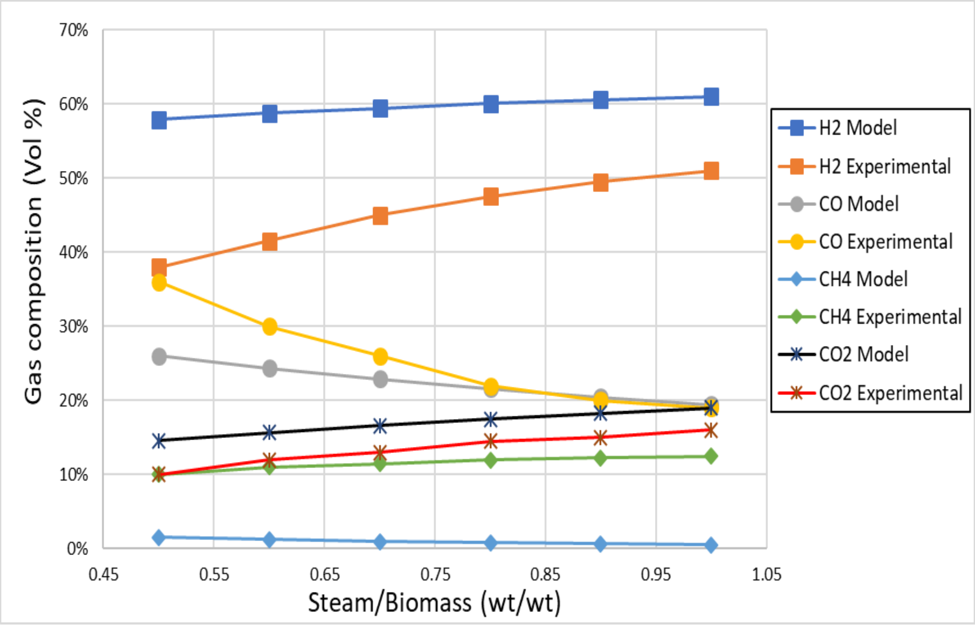
Effect of gasification temperature with steam



Effect of gasification temperature with air

Simulation Results

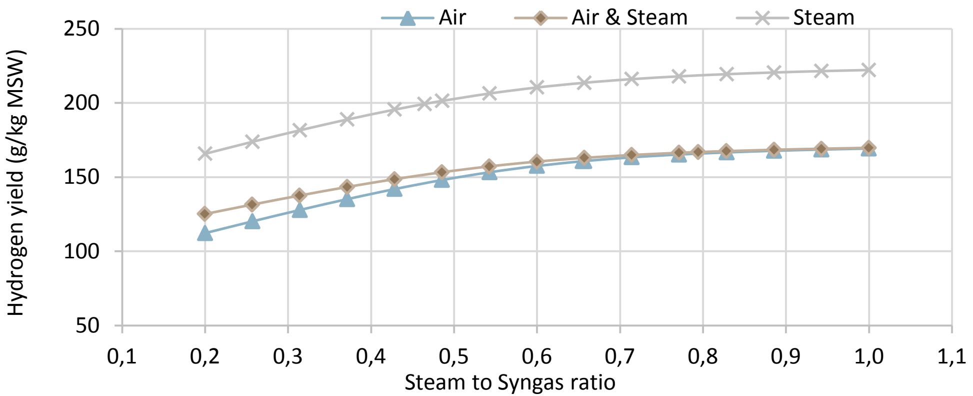




S. Fremaux, S.-M. Beheshti, H. Ghassemi, and R. Shahsavan-Markadeh, “An experimental study on hydrogen-rich gas production via steam gasification of biomass in a research-scale fluidized bed,” *Energy Convers. Manag.*, vol. 91, pp. 427–432, Feb. 2015

Comparison of different setups

	Gasification Reactor				WGS Reactor	
Setups	Gasification Agent	ER	Steam to MSW Ratio	Temp. (°C)	Temp. (°C)	Steam to Syngas Ratio
1	Air	0.25	-	1000	300	0.2-1
2	Air & Steam	0.25	0.5	930	300	0.2-1
3	Steam	-	0.5	1000	300	0.2-1



Conclusions

The characterization of MSW performed on the main constituents of the MSW using statistical data was well representative of the actual MSW from incineration plants.

The highest hydrogen yield potential attained out of the three setups was in the steam gasification which was 222 g H2/kg of dry ash free MSW, representing 94% of the MSWs maximum theoretical hydrogen yield.

At optimized condition, the hydrogen and heat produced in steam gasification per one kg of MSW were 199.6g of hydrogen, and the excess thermal energy heated up 4 liters of water to 100 oC.

The indirect gasification with steam as gasifying medium showed the highest hydrogen production potential while the direct gasification was the lowest.

Takk!!

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