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Biomass Gasification

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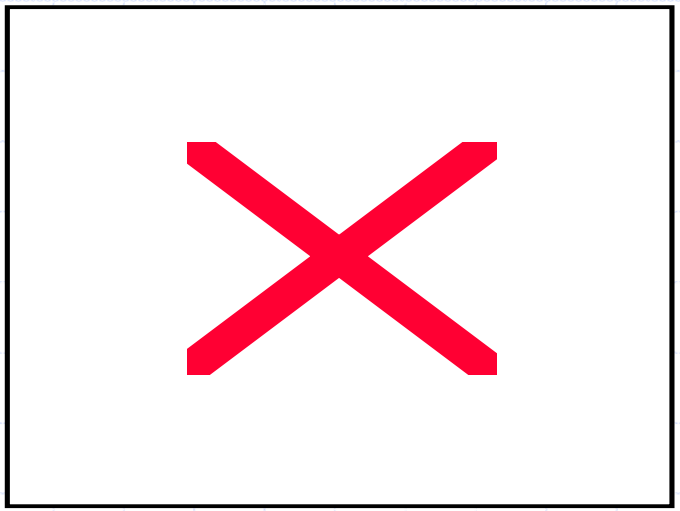
1 INTRODUCTION

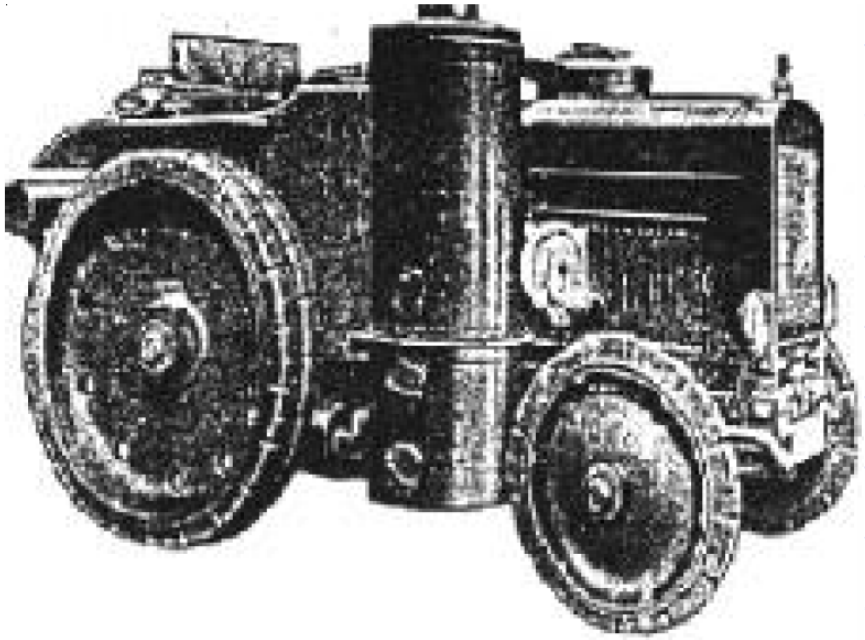
1.1 Benefits from renewables (Biomass)

- Abundantly availability
- Energy security
- Employment/economic opportunities
- Their use does not result into net greenhouse gases in the atmosphere
- Are capable to mitigate effects of greenhouse gases



1.2 Gasification is and Old Technology

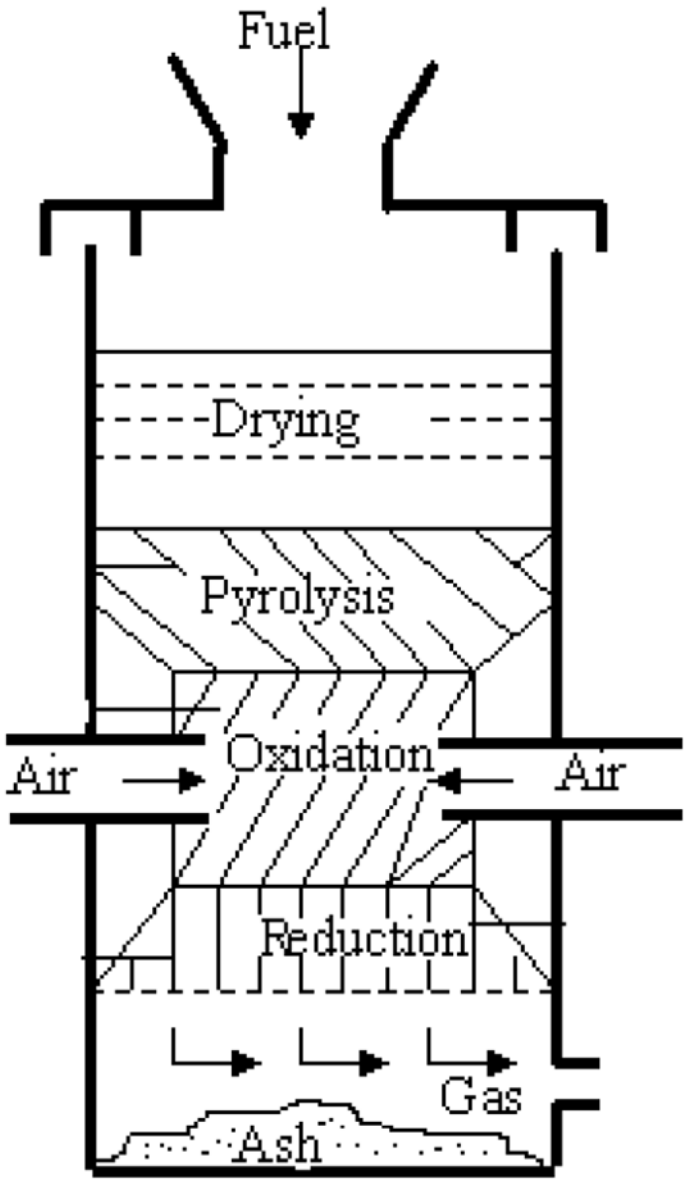
- Biomass gasification originated from the old coal gasification technology
- In England: Murdock for room lighting in 1792; Dowson introduced gas producer-engine systems in 1872, and J. W. Parker operated a gas producer-passenger vehicle between 1901 and 1905
- Since World War II producer-engine research for commercial trucks/tractors by the National Machine Testing Institute in Sweden



2 BIOMASS GASIFICATION

2.1 The Technology

- A combustible gas (syngas or producer gas) is produced by blowing a limited amount of air into a bed of carbonaceous fuel such as: coal, wood, charcoal, densified biomass or crop residue
- The combustible gases are carbon monoxide (CO), hydrogen (H_2) and methane (CH_4).



$$C_xH_yO_z + j(0.21O_2 + 0.79N_2) + \alpha H_2O \rightarrow aCO + bCO_2 + cH_2 + dH_2O + eCH_4 + fC + gN_2$$

2.2 Main Gasification Reactions

Combustion zone

$CH_aO_b + O2 \Rightarrow CO + H_2 + CO_2 + H_2O$

$C + O_2 \Rightarrow CO_2$

$H_2 + O_2 \Rightarrow H_2O$

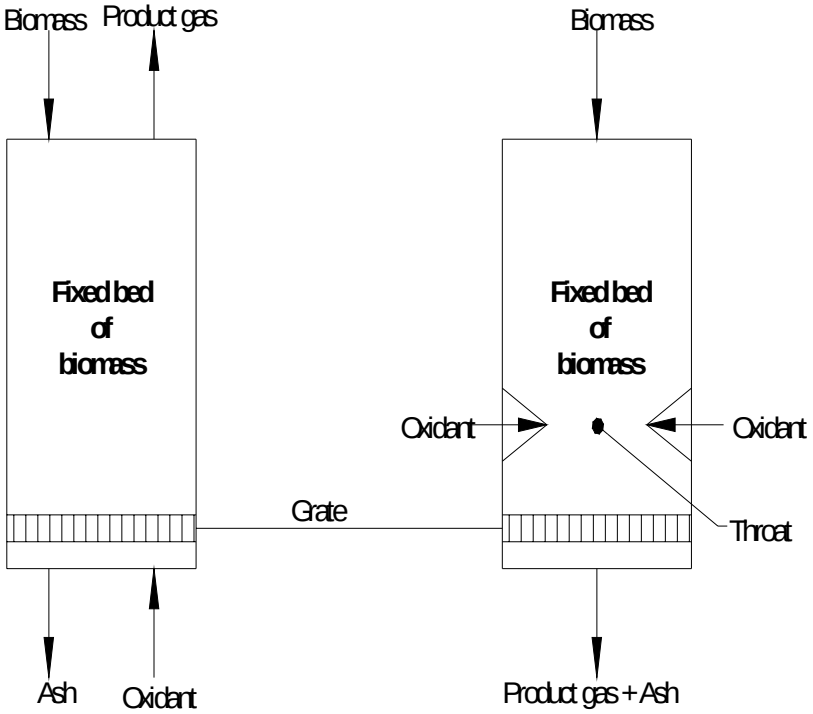
Pyrolysis reaction

Biomass ⇨ char + tar + gases (CO, CO_2, H_2 ,H_2O, CH_4, C_mH_n)

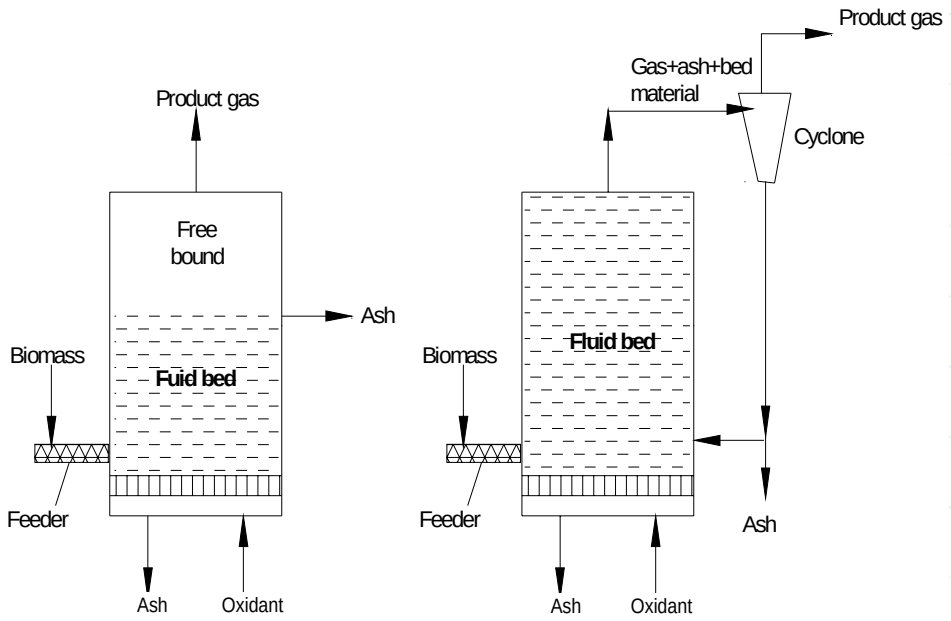
Heterogeneous reactions

$C + CO_2 \Rightarrow CO$	(Boudouard reaction)
$CO + H_2O \Rightarrow CO_2 + H_2$	(Water-gas shift reaction)
$C + H_2O \Rightarrow CO + H_2$	(Primary water-gas reaction)
$C_xH_y + Xh2o \Rightarrow (x+y/2)H_2 + xCO$	(Steam reforming of tars)
$Tar \Rightarrow CH_4 + H_2O + C_mH_n + H_2$	(Cracking of tars)
$C_xH_y + xCO_2 \Rightarrow (y/2)H_2 + 2xCO$	(Dry reforming of tars)

2.3 Main Gasifier Schemes



(a) Updraft, and (b) downdraft gasifiers



(c) and (d) fluidized bed gasifiers

2.4 Generalized Technical Comparizon

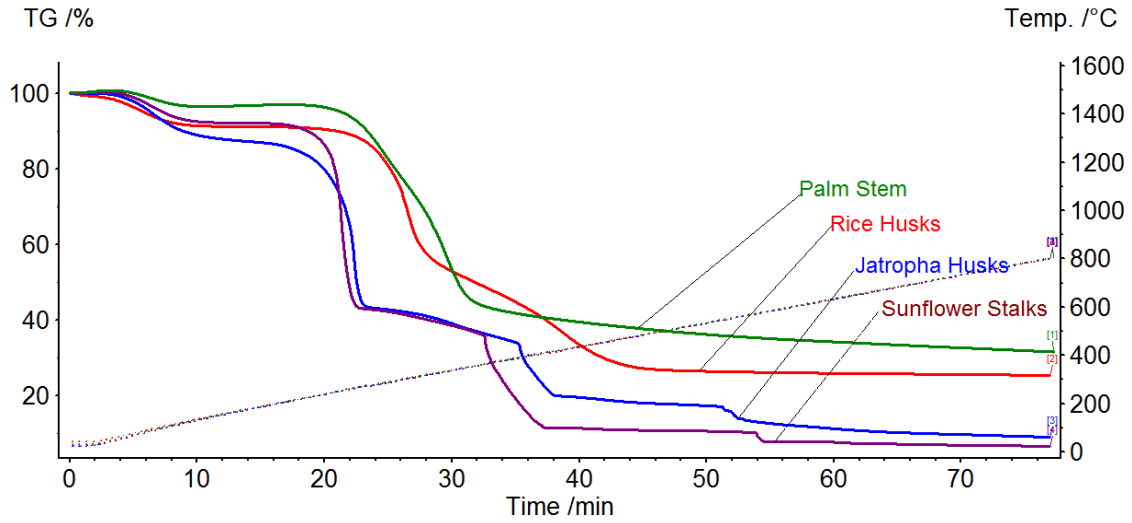
GASIFIER TYPE		TEMPERATURE		TARS	PARTICULATES	SCALE-UP	Mw_e	
		REACTION	EXIT GAS			ABILITY	MIN.	MAX.
Fixed bed	Downdraft	1000	800	v. low	moderate	poor	0.1	1
	Updraft	1000	250	v. high	moderate	good	1	10
Fluid bed	Single reactor	850	800	fair	high	good	1	20
	Fast fluid bed	850	850	low	v. high	v. good	2	50
	Circulating bed	850	850	low	v. high	v. good	2	100

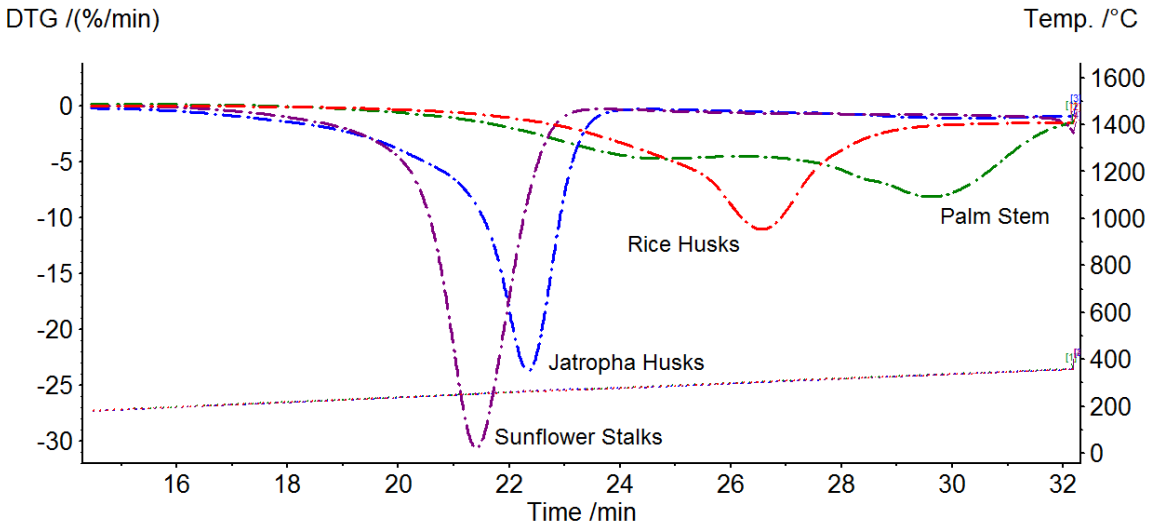
IGCC Värnamo, Sweden

- World demo plant built in year 1996
- By Sydkraft AB and Foster Energy Inc.
- 18 MW fuel
- 6 MW_e
- 9 MW_{th} – heating

2.5 Gasification Controlling Parameters

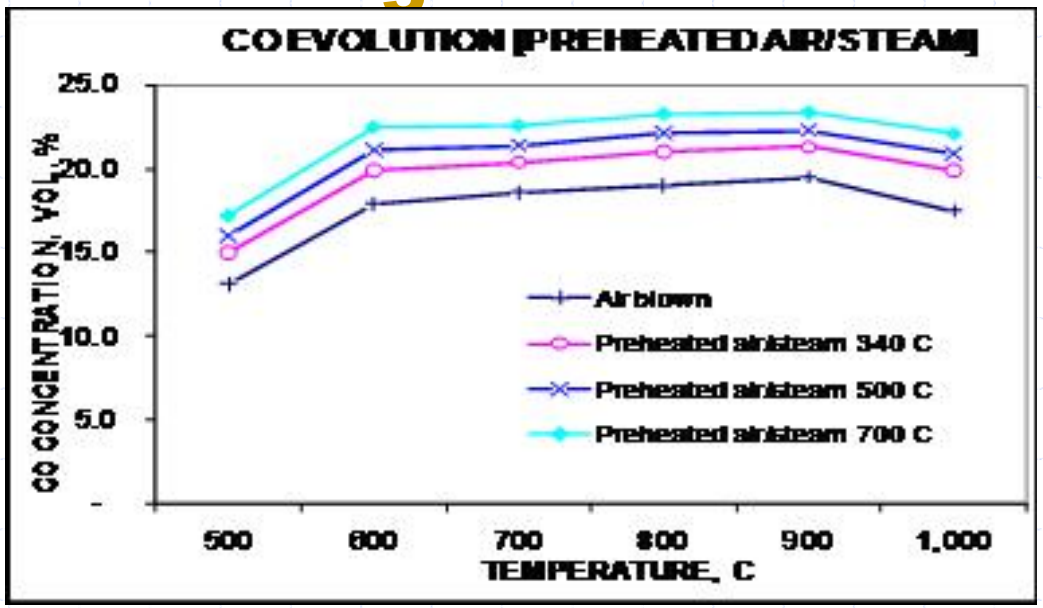
(a) Material ($C_xH_yO_z$)



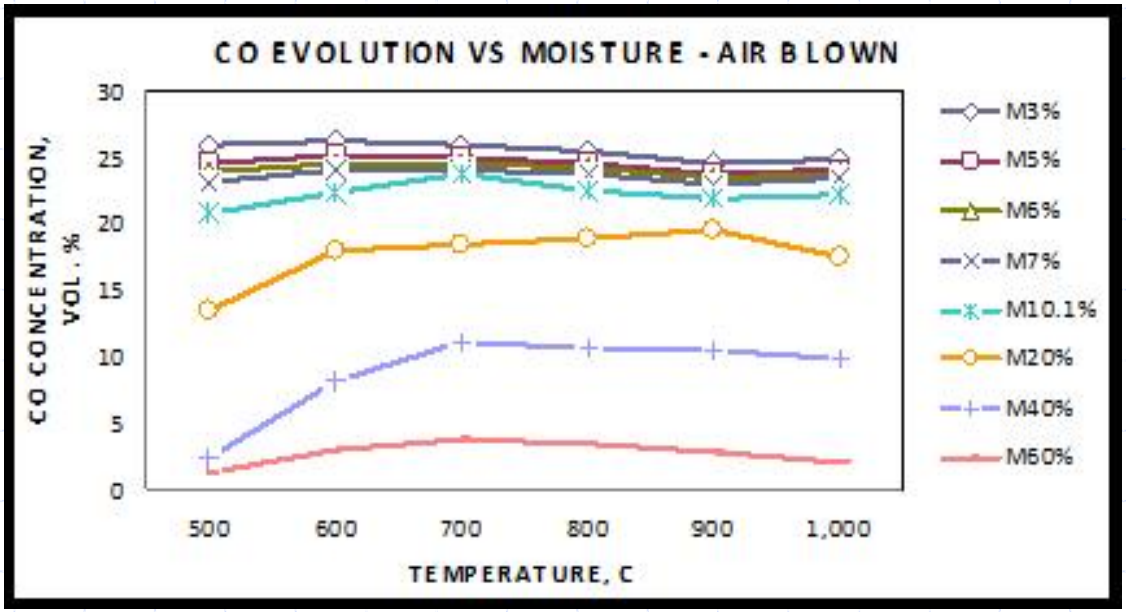


… / Gasification Controlling Parameters

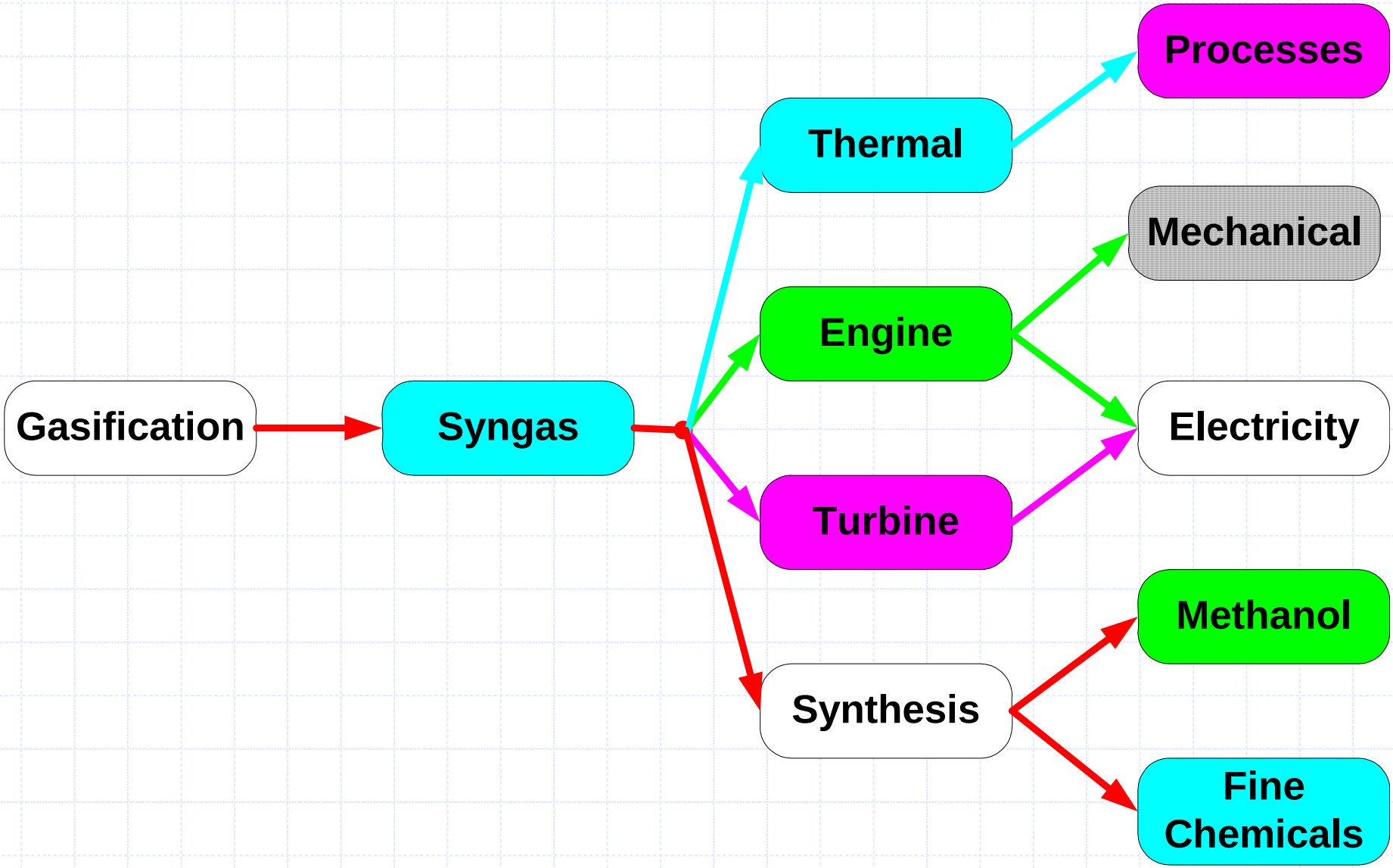
(b) Temperature



(c) Moisture

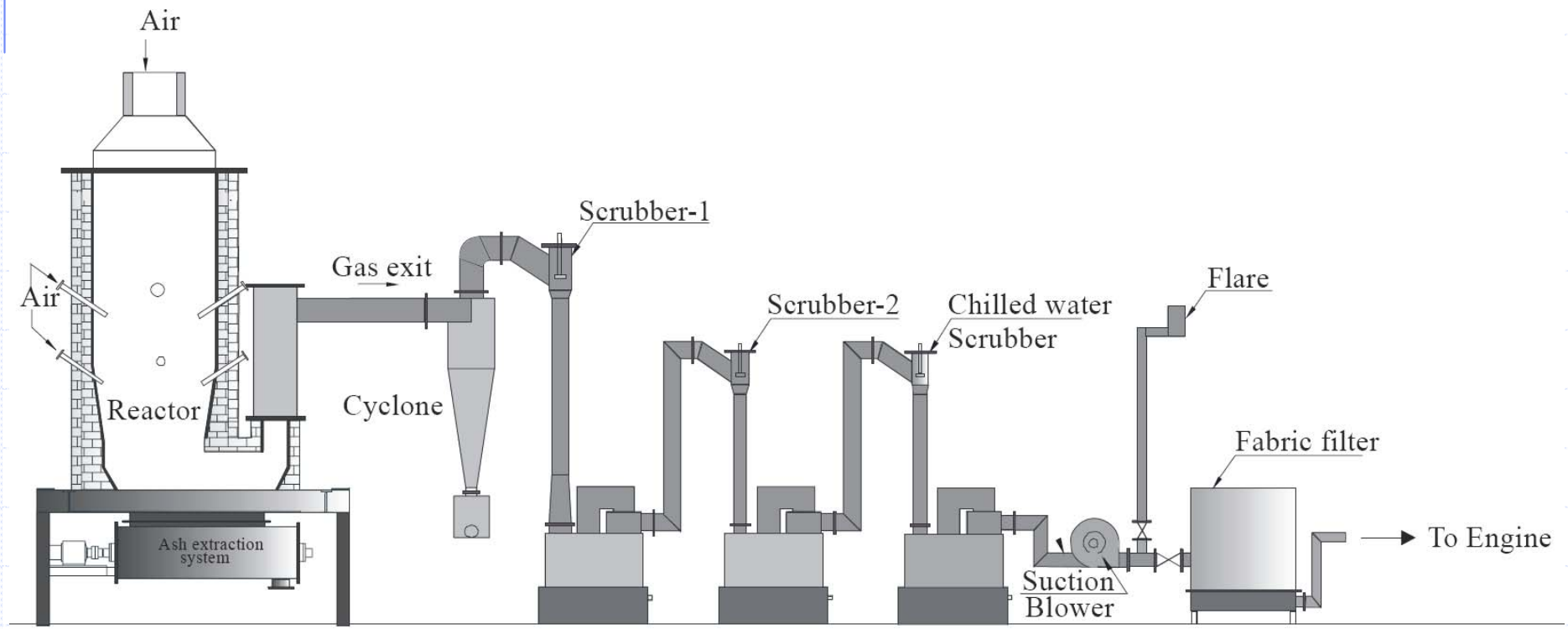


2.6 Gasifier Applications



2.7 Typical System Arrangement for Small/Medium-Scale Applications

Decentralized electrical/mechanical systems utilizing small/medium-scale biomass gasifiers (5 – 50 kW) coupled to run internal combustion engines are ideal



3 CONCLUSION

- Renewable biomass is abundant in Africa
- Its sustainable harnessing has a potential to alleviate existing commercial energy scarcity
- Biomass gasification is an efficient and versatile biomass-to-energy conversion process
- The application of decentralized small/medium-scale biomass gasifiers coupled to run internal combustion engines are ideal
- A dedicated demonstration is vital for realizing their effectiveness