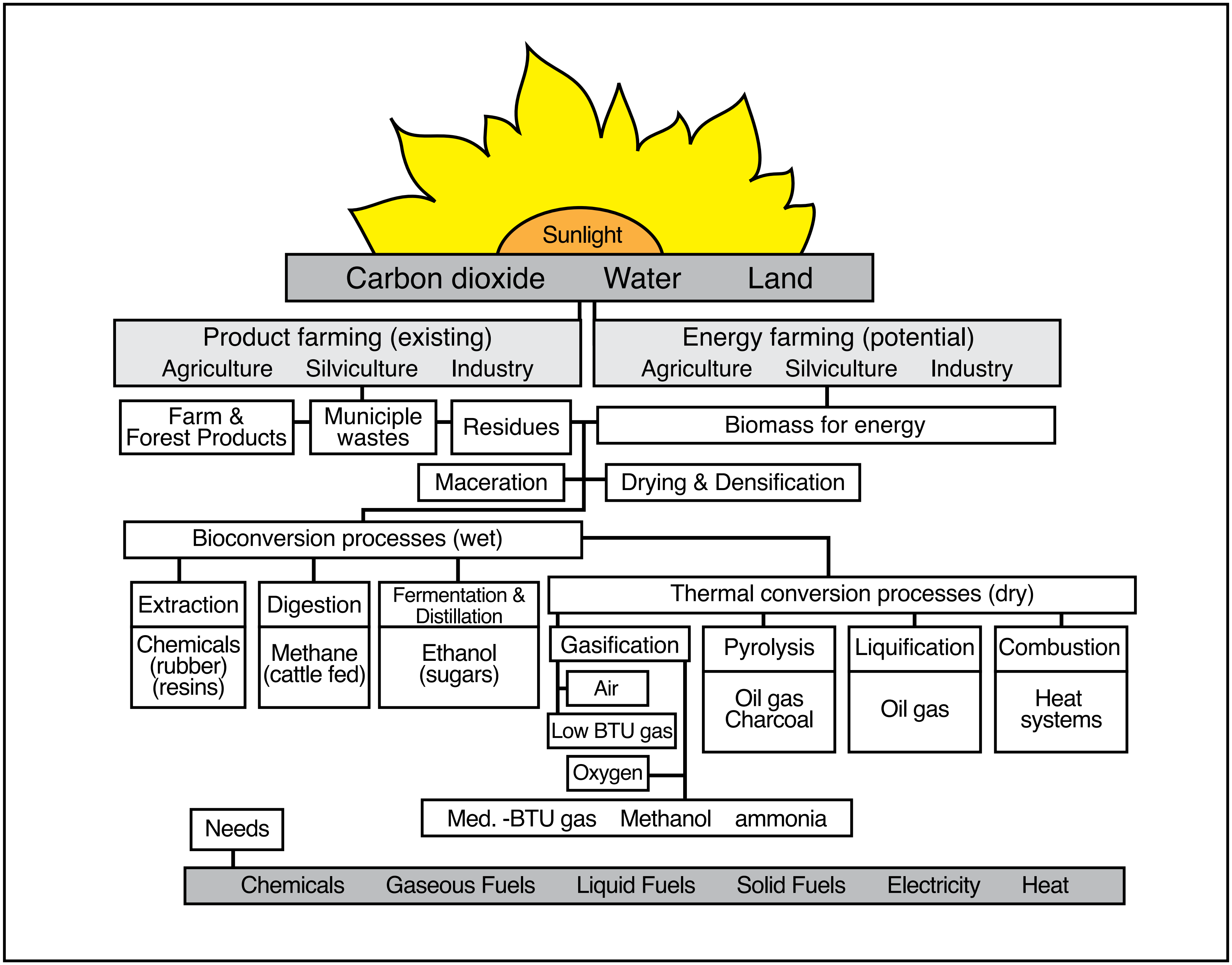
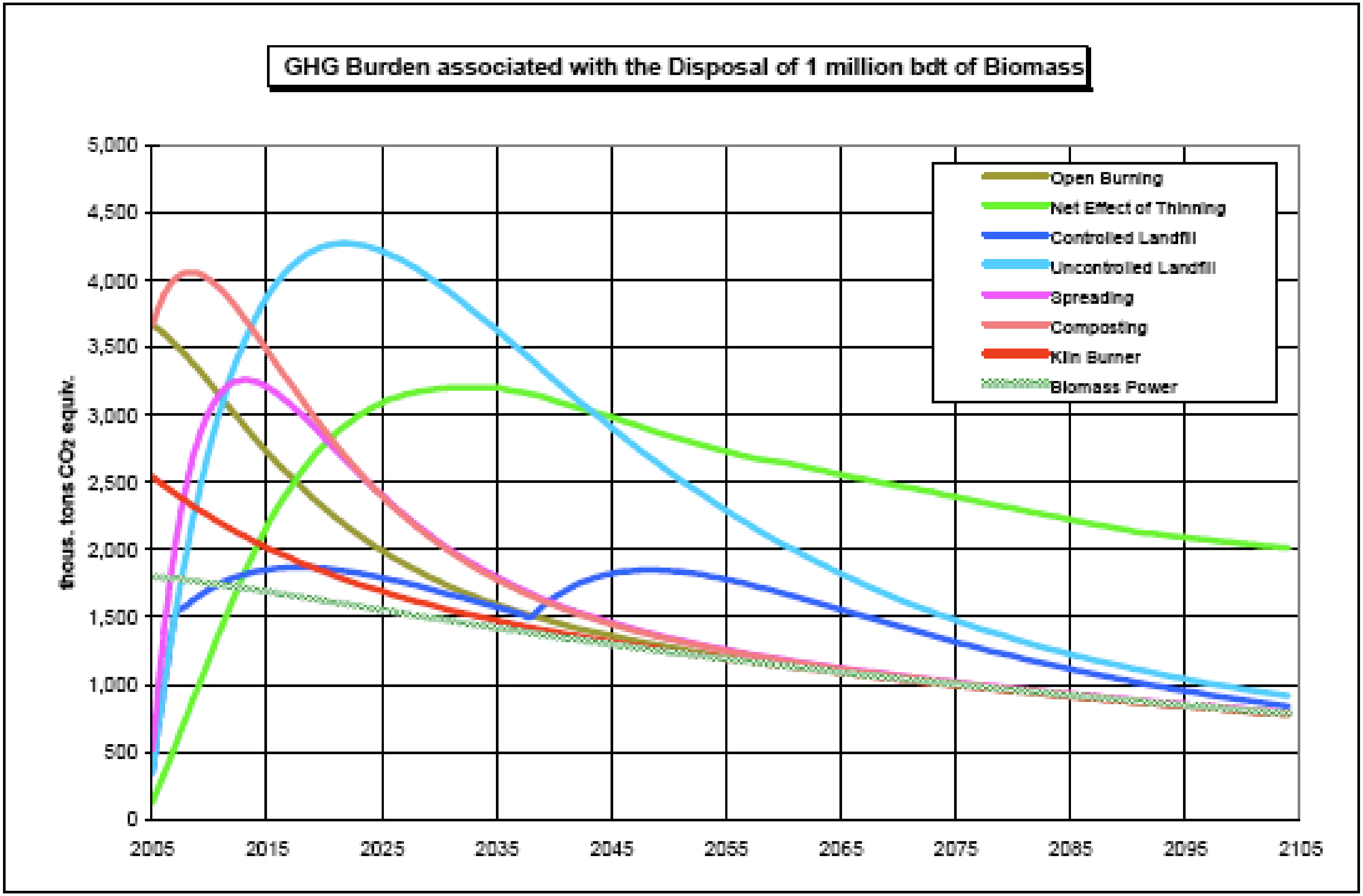
ALL POWER LABS
GASIFIER EXPERIMENTERS KIT

Gasification Basics

Pathways of Biomass Energy

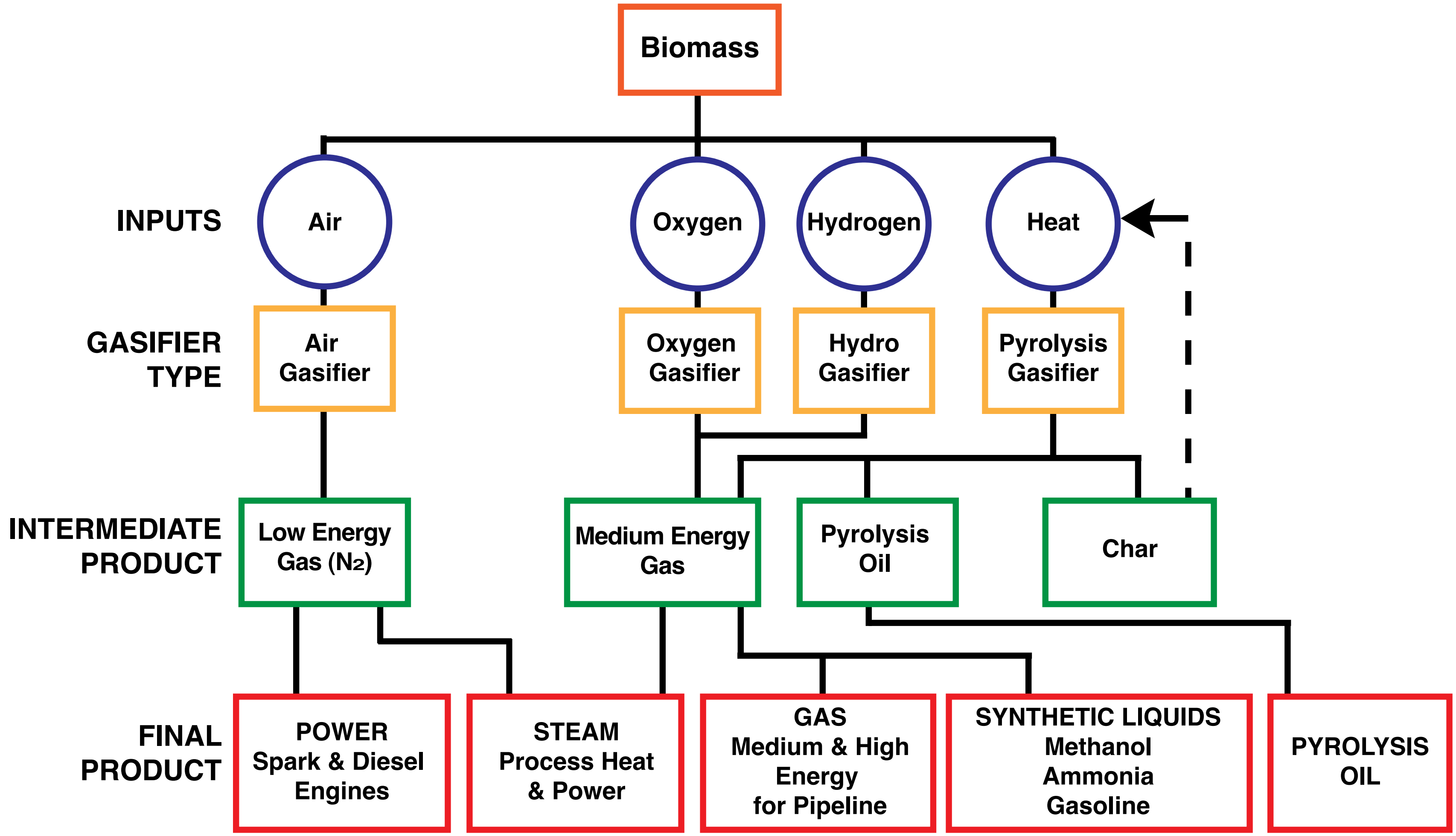


Source: Tom Reed 1978



GHG Burden associated with the Disposal of 1 million bdt of Biomass
thous. tons CO2 equiv.
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
Open Burning
Net Effect of Thinning
Controlled Landfill
Uncontrolled Landfill
Spreading
Composting
Kiln Burner
Biomass Power

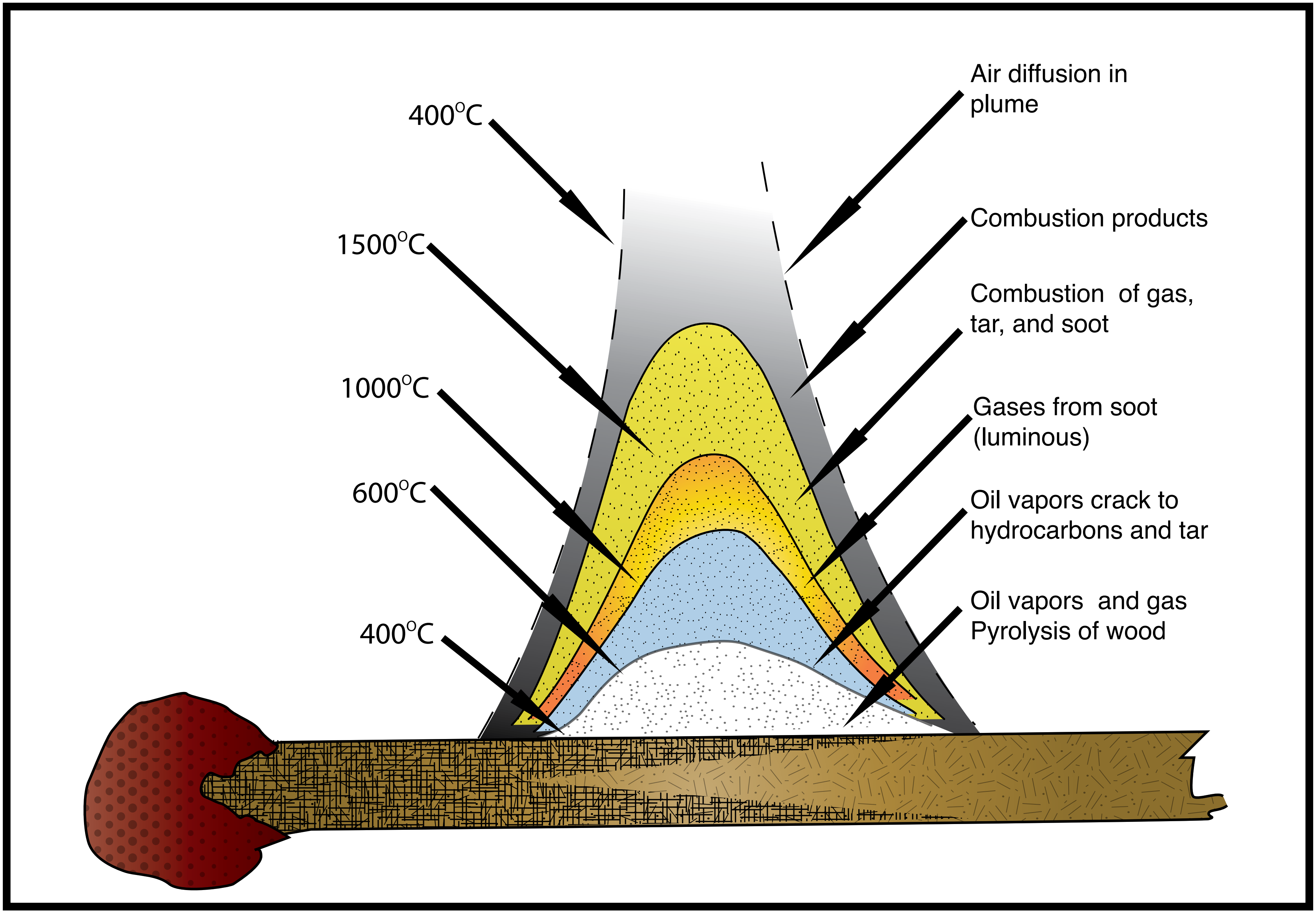
Pathways of Biomass Energy



Gasification Processes and Their Products

Adapted from Tom Reed

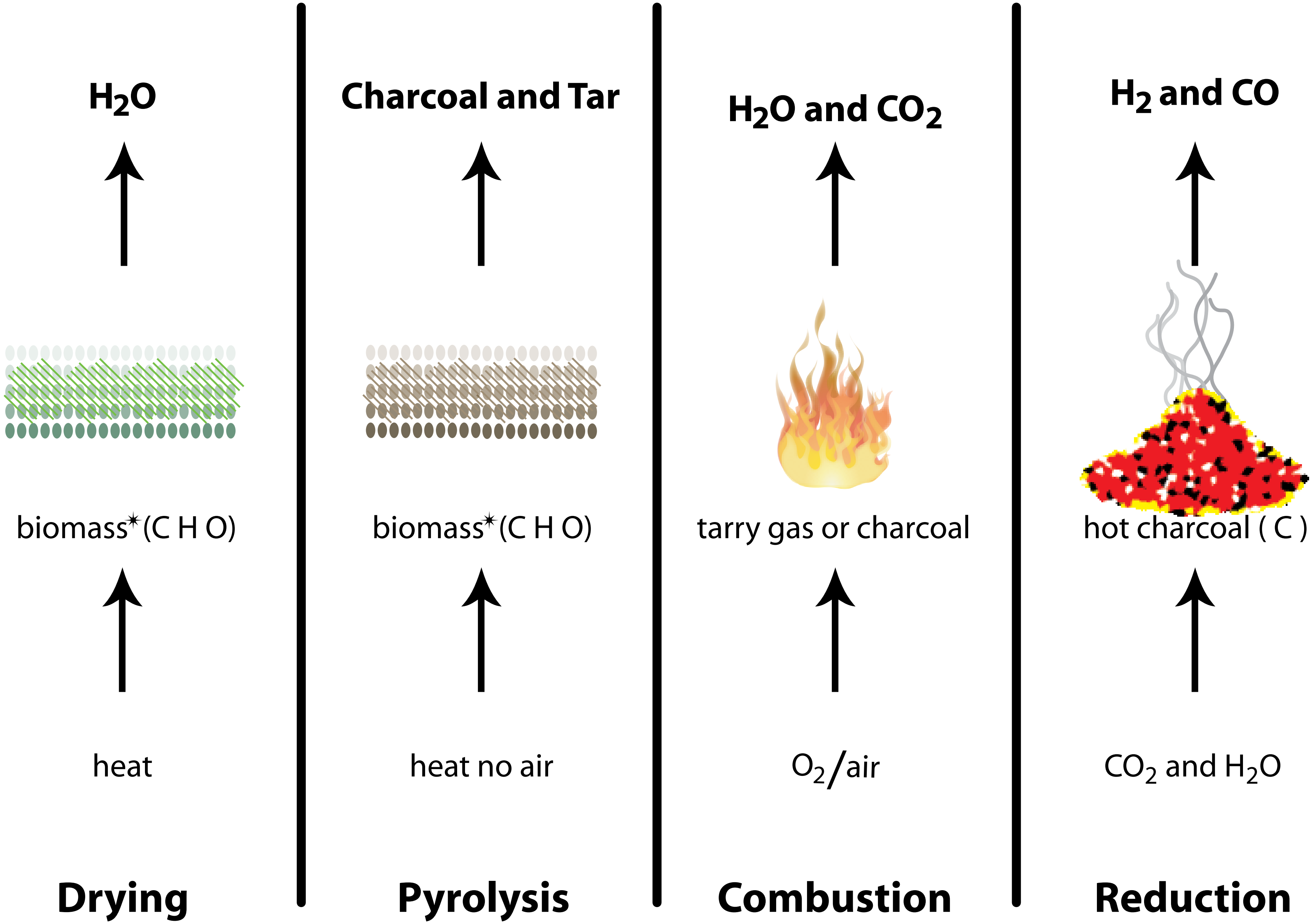
Pyrolysis, Gasification and Combustion in a Flaming Match



Adapted from Tom Reed

4 Processes in Gasification

not necessarily in order



* Biomass is a combination of C, H, and O ($C\ H_{1.4}O_{0.6}$)

Temperature and Yield Profile for Biomass Pyrolysis

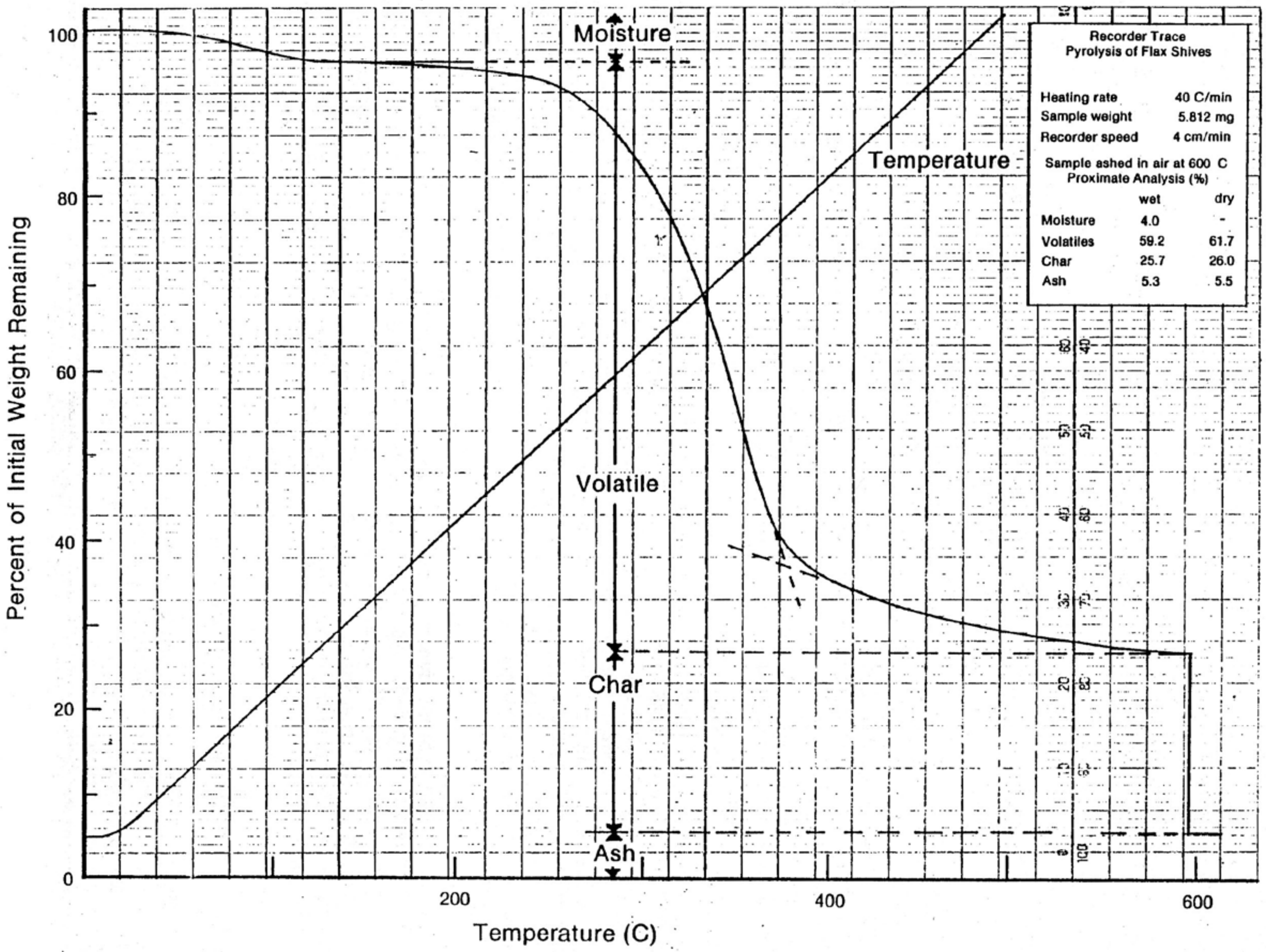


Figure 5-2. A Typical Dynamic TGA Result Obtained with Flax Shives and Showing Moisture, Volatile Matter, Char, and Ash Content

Source: T. Milne 1979

The Reduction Reactions

The Heart of Gasification

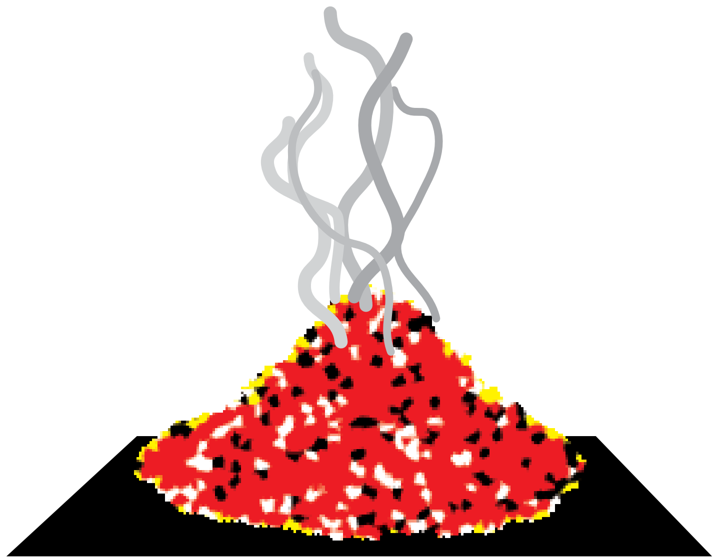
C
carbon

INPUT

$CO_2 + H_2O$
carbon dioxide + water vapor

OUTPUT

$H_2 + CO$
hydrogen + carbon monoxide



Red Hot Charcoal Bed

REACTIONS

$$CO_2 + C = 2CO$$

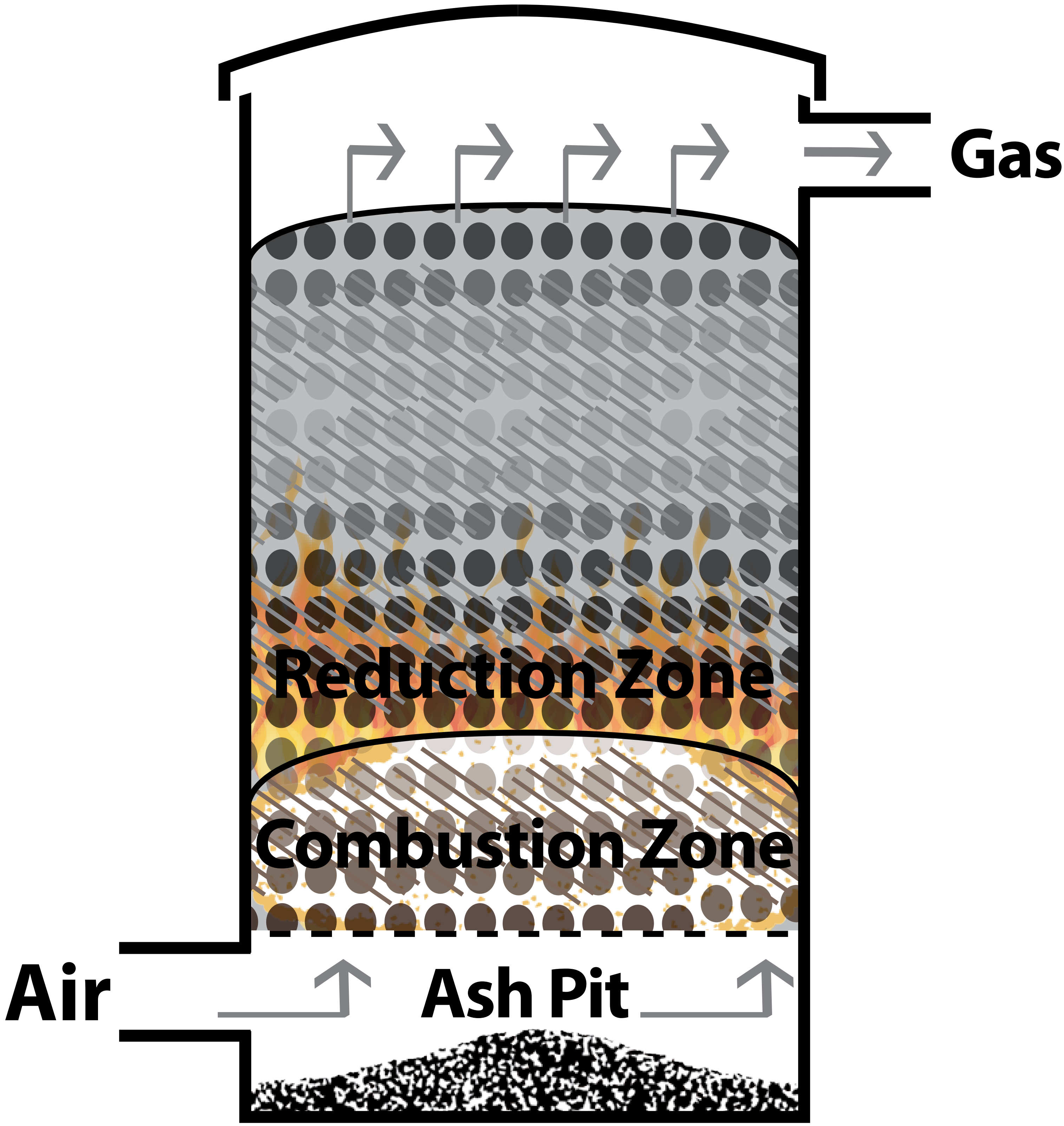
carbon dioxide + carbon = carbon monoxide

$$H_2O + C = H_2 + CO$$

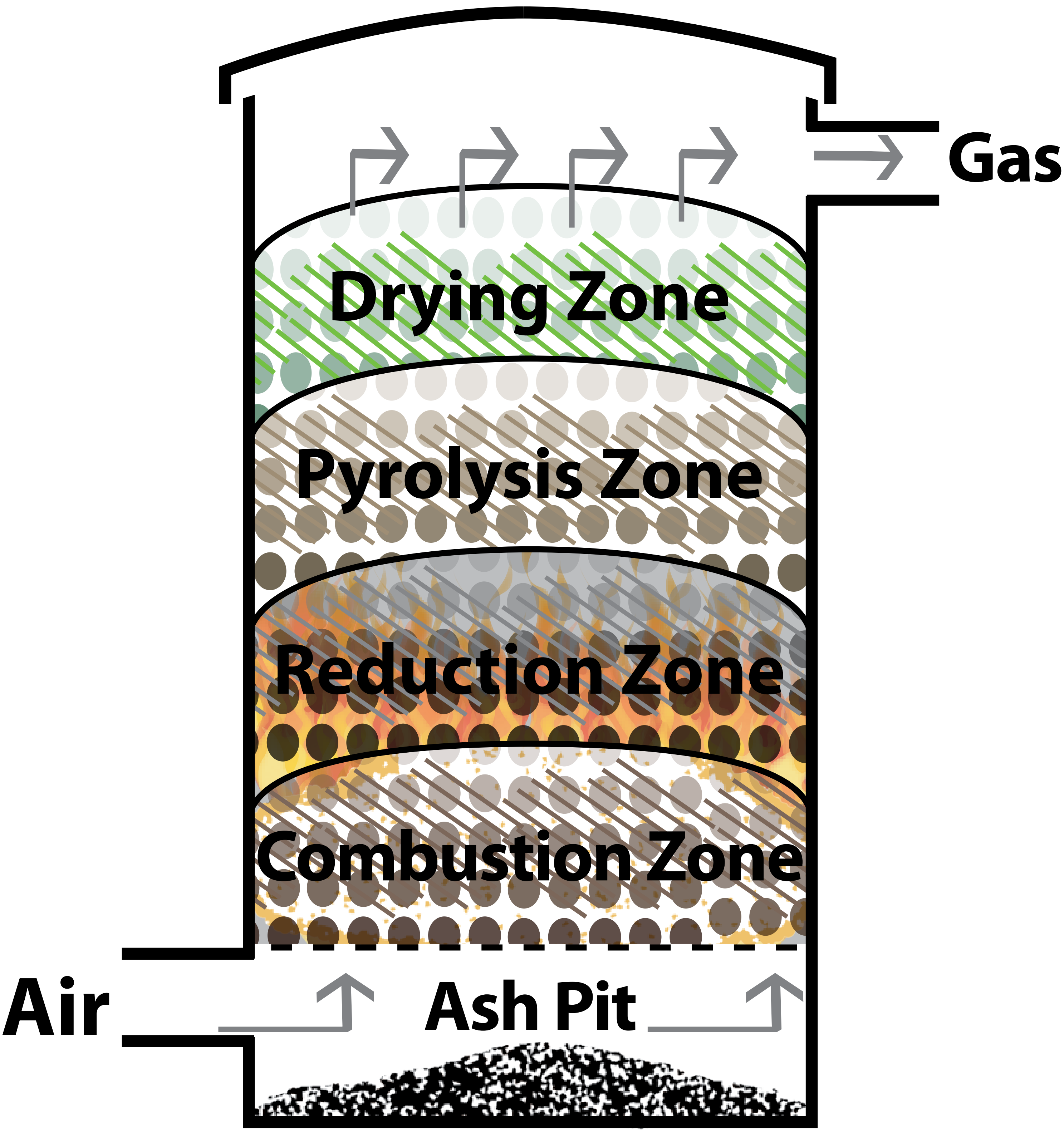
water vapor + carbon = hydrogen + carbon monoxide

Updraft Gasifier

Charcoal Only

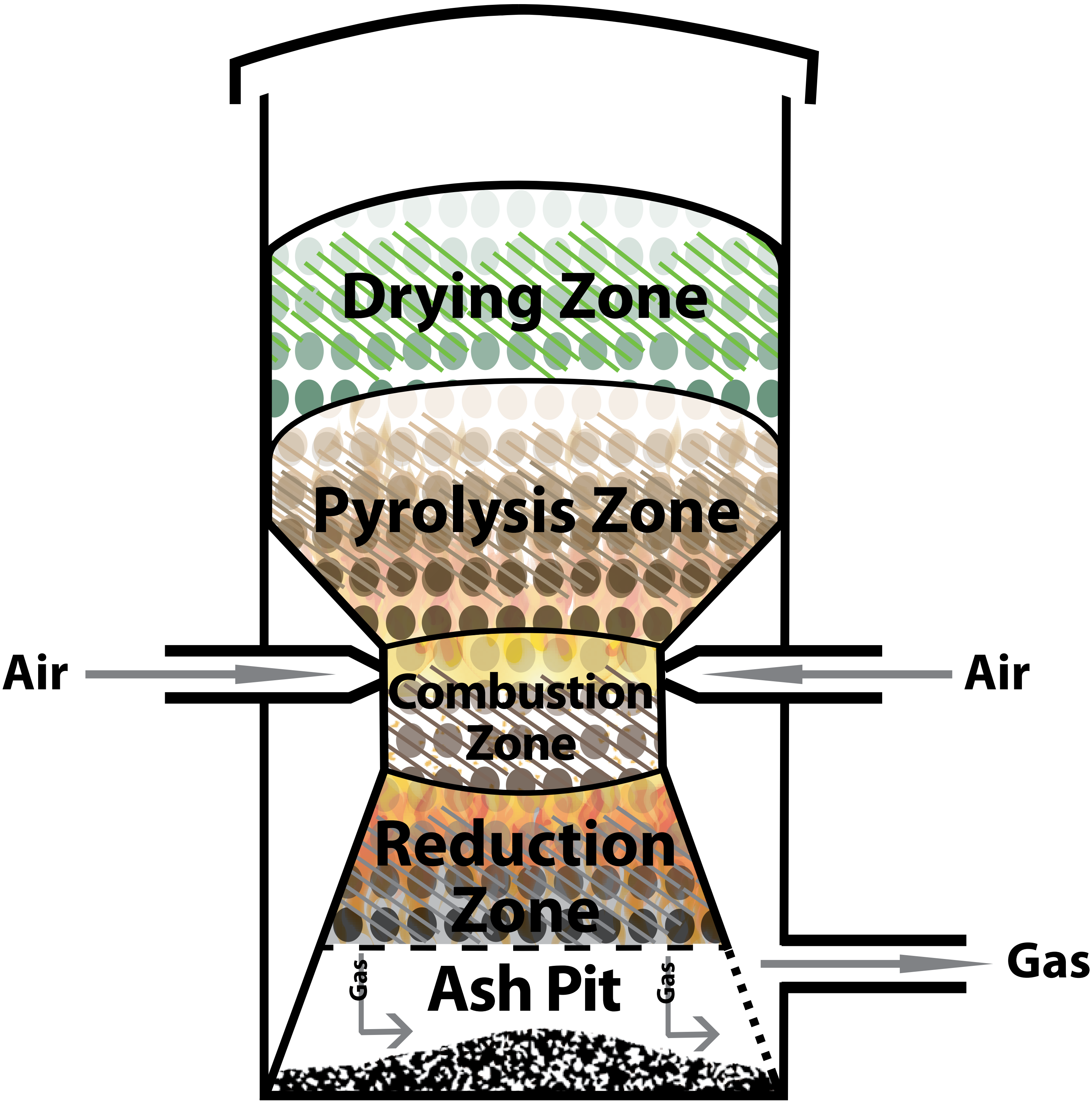


Updraft Gasifier

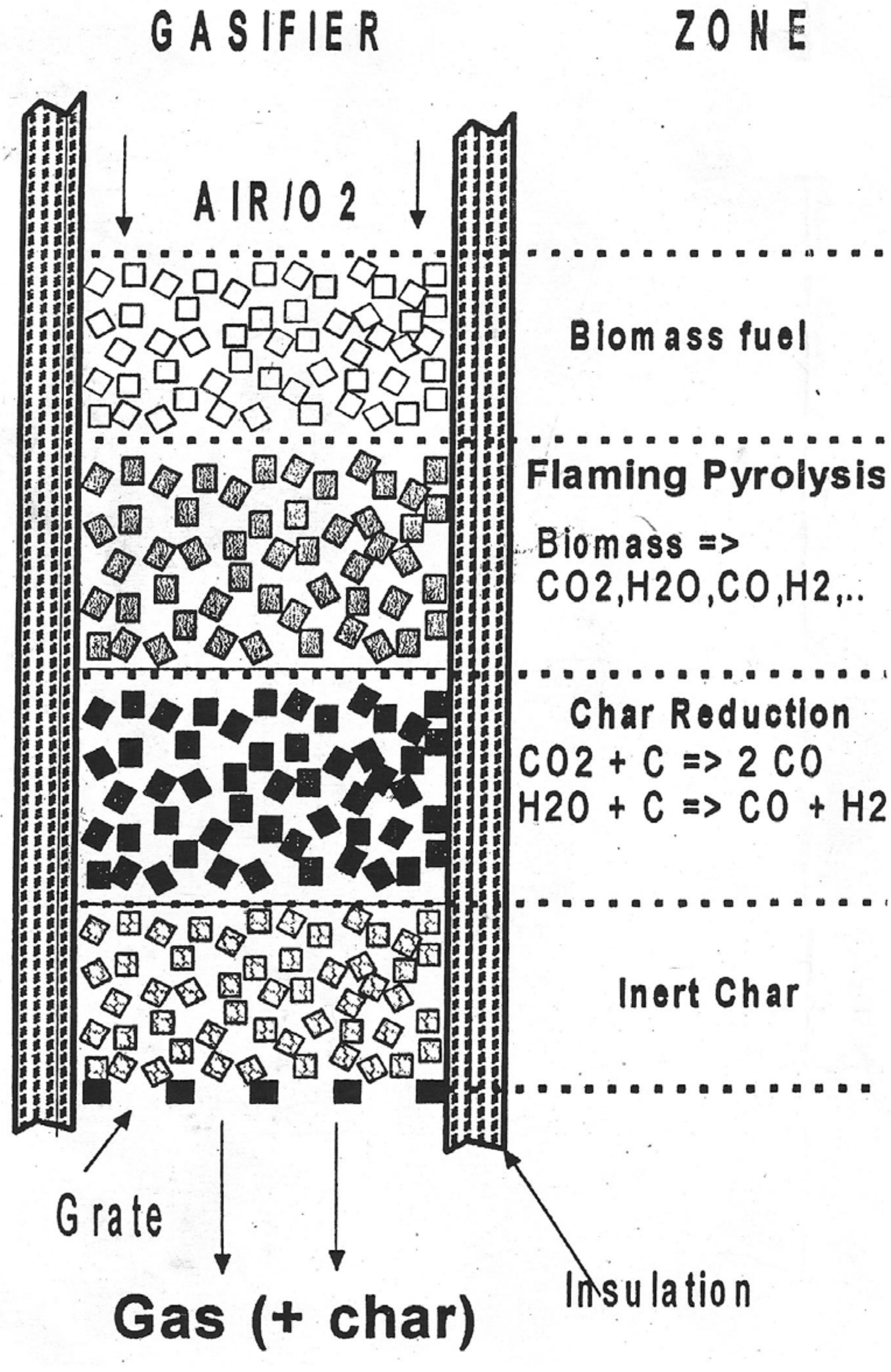


Downdraft Gasifier

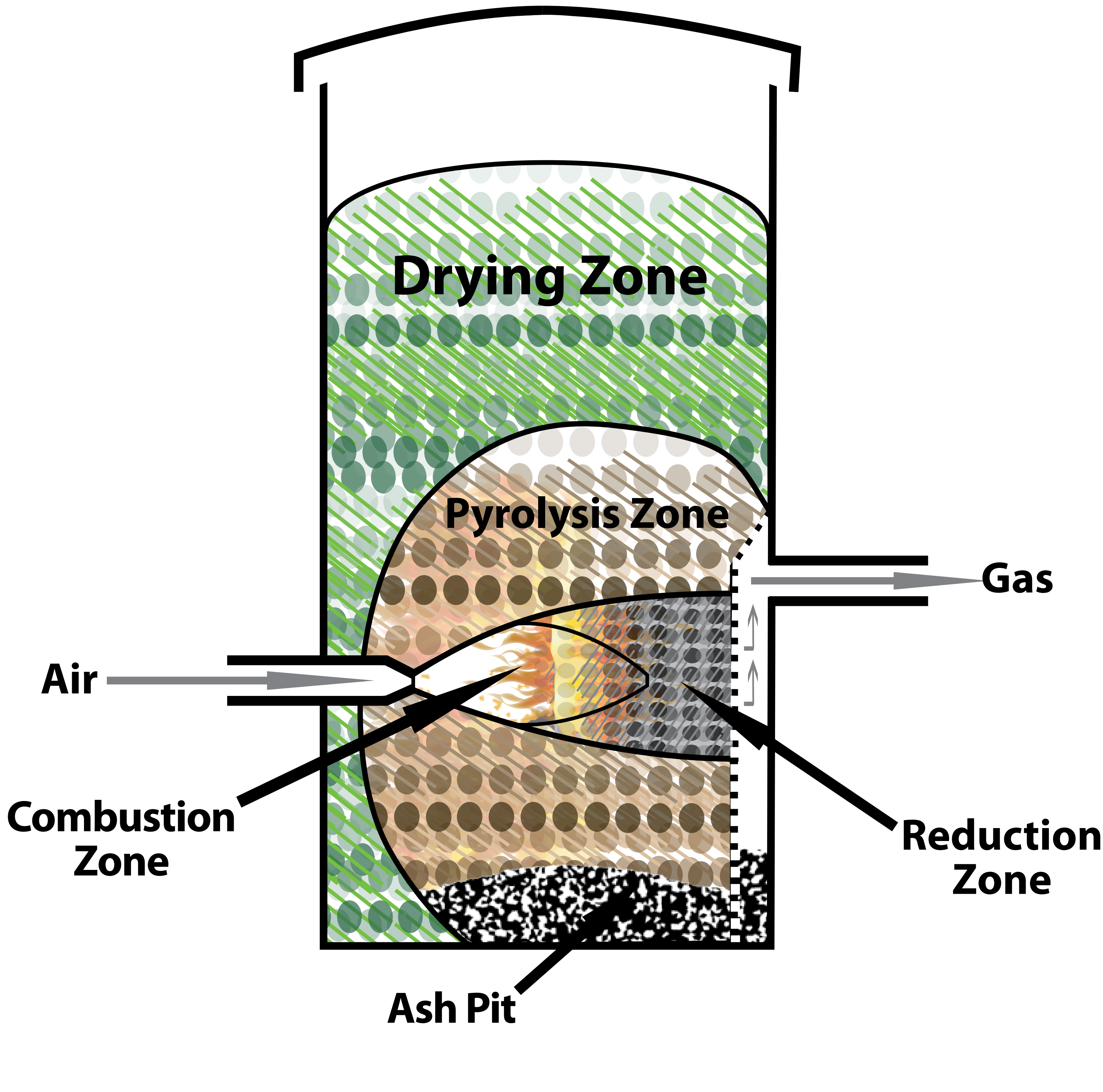
Nozzle and constriction (Imbert)



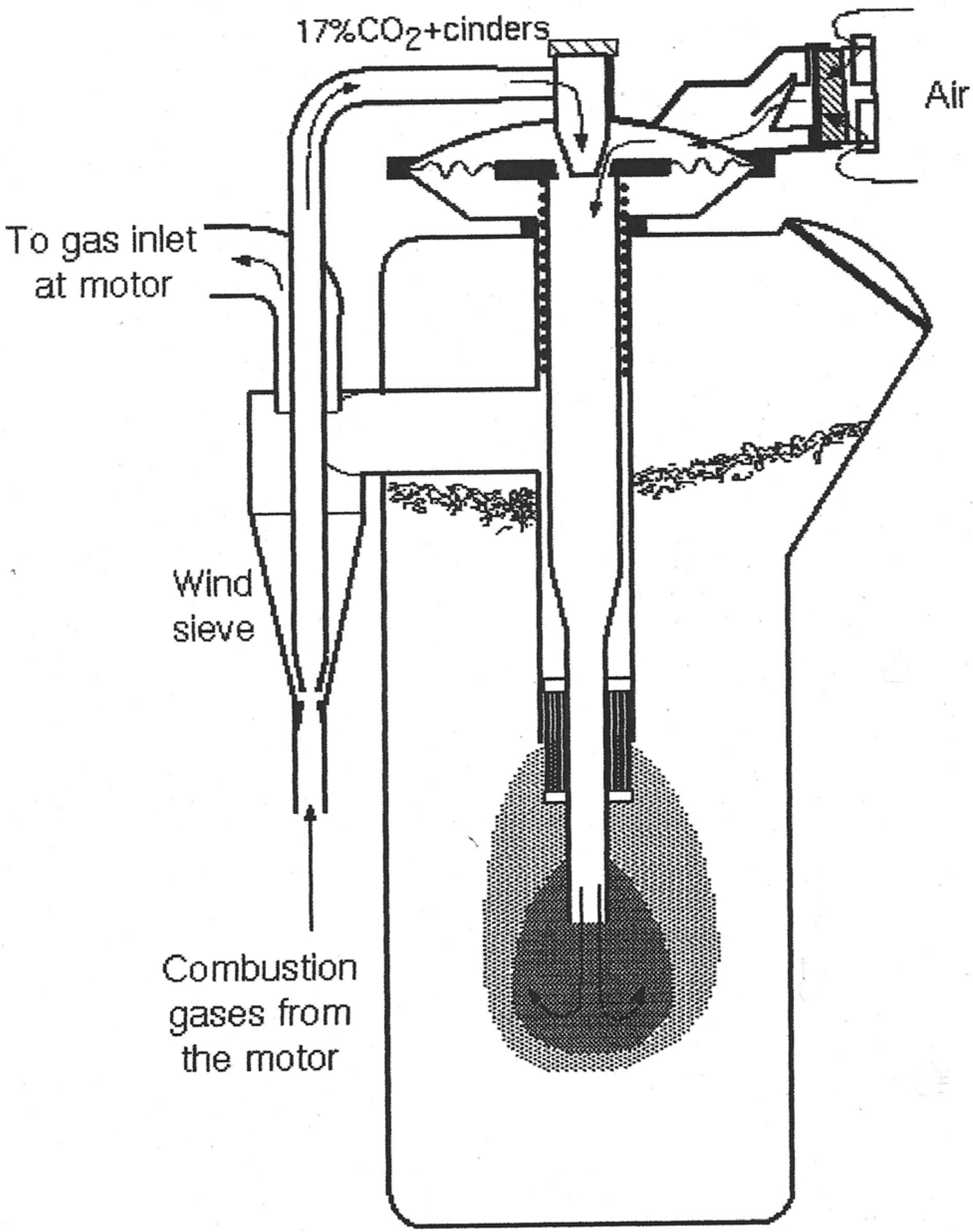
Stratified Downdraft / Open Core



Crossdraft Gasifier

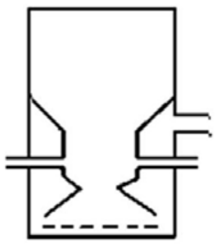


The Kalle Gasifier

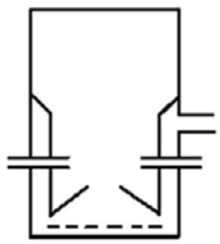


Downdraft Gasifier Types

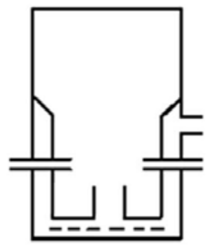
Nozzzle and Constriction Closed Top Designs (aka: Imbert type)



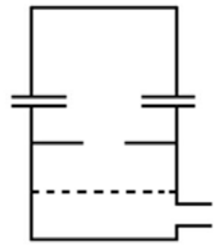
Imbert Hourglass
(double throat)



Inverted V Hearth
(Sweedish origin)



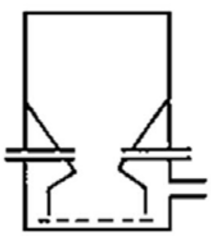
Straight Reduction Tube



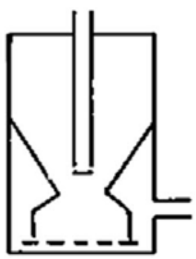
Constriction Plate

Air Inlet Variations

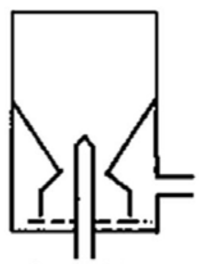
(shown with Imbert Hourglass single throat type)



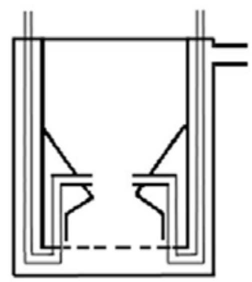
Side Inlets



Central Inlet
(down from top)

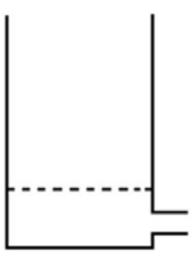


Central Inlet
(up from bottom)

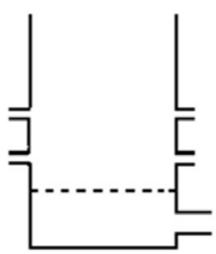


J tube
(air preheating)

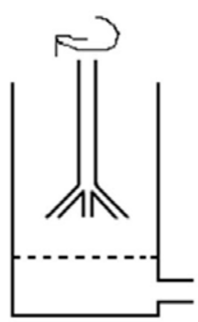
Open Core Designs



Stratified Downdraft
(Tom Reed, FEMA)



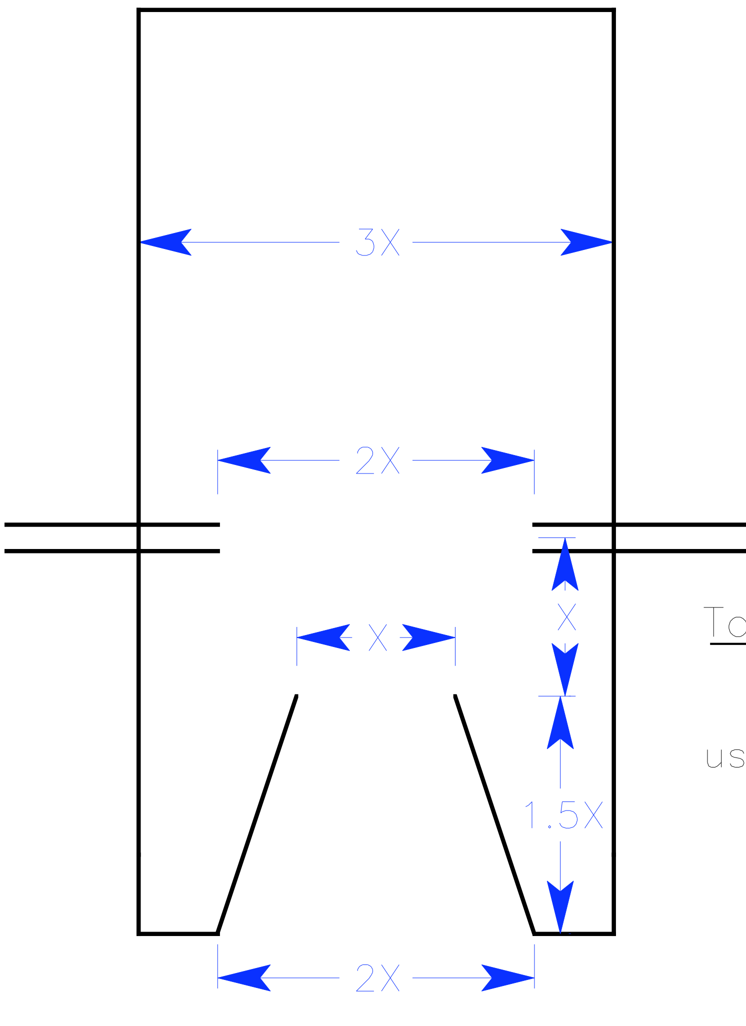
Multi-point Air Injection
(Mukunda, CPC)



Buck Rogers

General Proportions for Inverted V Hearth Downdraft Gasifier

(see charts for more detailed dimensions and variations)



$$\frac{\text{Total area of nozzles}}{(X)} = .05$$

use odd number of nozzles

ALL Power Labs June 16, 2008

Table 5-2. Imbert Nozzle and Hearth Diameters

d_r/d_h	d_h mm	d_r mm	$d_{r'}$ mm	h mm	H mm	R mm	A No.	d_m mm	$\frac{A_m \times 100}{A_h}$	$\frac{d_r}{d_h}$	$\frac{h}{d_h}$	Range of Gas Output max. Nm^3/h	min. Nm^3/h	Maximum Wood Consumption kg/h	Air Blast Velocity Vm m/s
268/60	60	268	150	80	256	100	5	7.5	7.8	4.5	1.33	30	4	14	22.4
268/80	80	268	176	95	256	100	5	9.0	6.4	3.3	1.19	44	5	21	23.0
268/100	100	268	202	100	256	100	5	10.5	5.5	2.7	1.00	63	8	30	24.2
268/120	120	268	216	110	256	100	5	12.0	5.0	2.2	0.92	90	12	42	26.0
300/100	100	300	208	100	275	115	5	10.5	5.5	3.0	1.00	77	10	36	29.4
300/115	115	300	228	105	275	115	5	11.5	5.0	2.6	0.92	95	12	45	30.3
300/130	130	300	248	110	275	115	5	12.5	4.6	2.3	0.85	115	15	55	31.5
300/150	150	300	258	120	275	115	5	14.0	4.4	2.0	0.80	140	18	67	30.0
400/130	130	400	258	110	370	155	7	10.5	4.6	3.1	0.85	120	17	57	32.6
400/150	135	400	258	120	370	155	7	12.0	4.5	2.7	0.80	150	21	71	32.6
400/175	175	400	308	130	370	155	7	13.5	4.2	2.3	0.74	190	26	90	31.4
400/200	200	400	318	145	370	153	7	16.0	3.9	2.0	0.73	230	33	110	31.2

Variables not given in figure are defined as follows:

d_m = inner diameter of the tuyere.

A_m = sum of cross sectional areas of the air jet openings in the tuyeres.

A_h = cross sectional area of the throat.

A = number of tuyeres.

Source: Kaupp 1984a, Table 5; Fig. 75.