

Heating Boilers

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- **Boilers generate heat from combustion of fuel and transfer to hot water or steam for distribution**

Energy Transfer Media

- **Air**

specific heat capacity 1.012 kJ/kg/K

density 1.205 kg/m³

- **Water**

specific heat capacity 4.186 kJ/kg/K

density 1000 kg/m³

- **Steam**

refer to steam tables for particular cond.

Fuel Selection

- **Availability**
- **Cost**
- **Cost of installation**
- **Carbon emissions**
- **Long term security of supply**

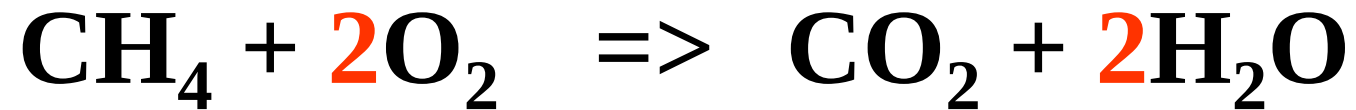
Common Fuel Types

- **Natural Gas/Hydrogen?**
- **Liquid Petroleum Gases**
- **Oil**
- **Coal**
- **Bio-mass**
- **Electricity**

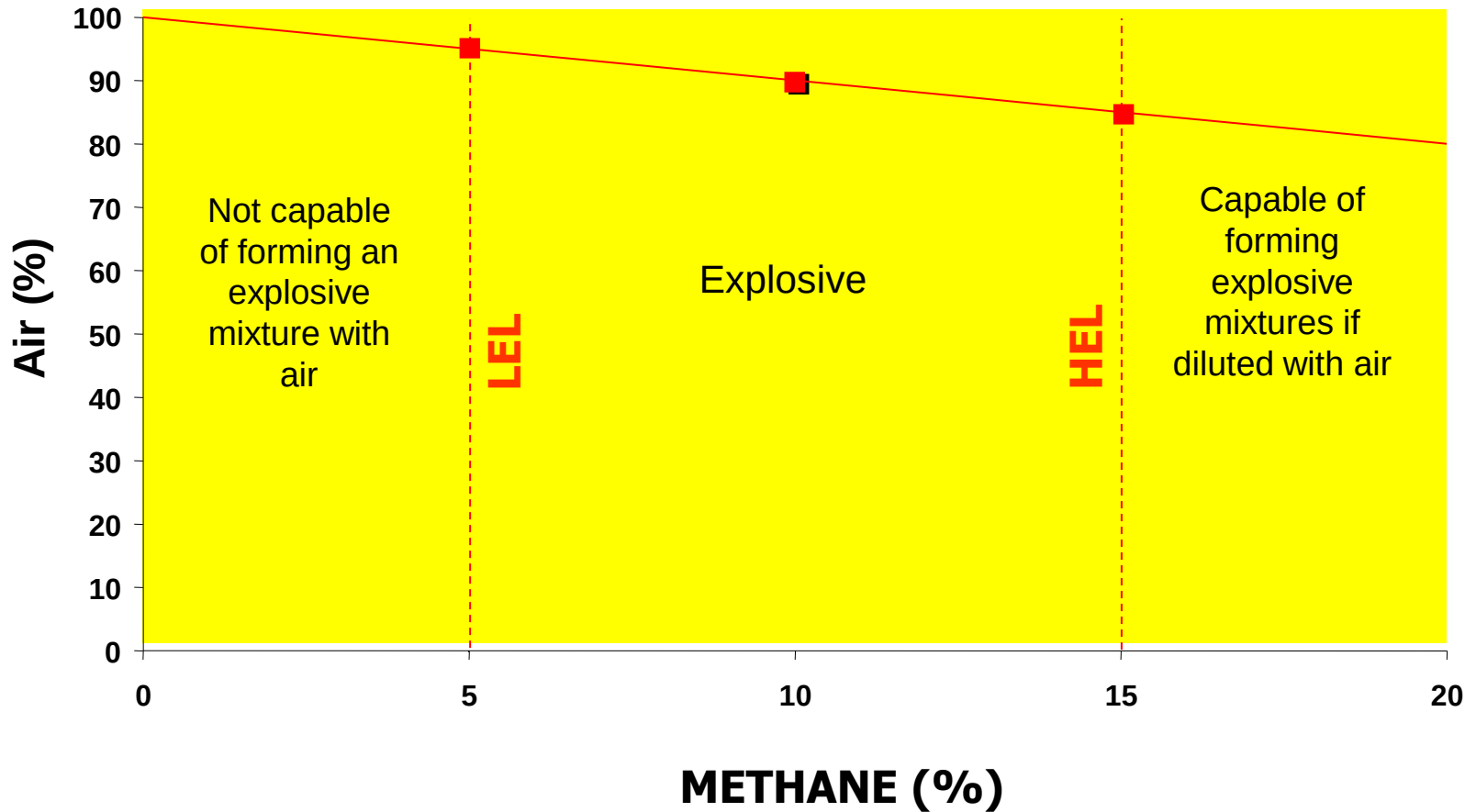
Typical Composition of Natural Gas

<i>Constituent</i>	<i>Formulae</i>	<i>% by volume</i>
Methane	CH_4	90%
Ethane	C_2H_6	5.3%
Nitrogen	N_2	2.7%
Propane	C_3H_8	1.0%
Carbon dioxide	CO_2	0.6%
Butane	C_4H_{10}	0.4%

Simplified combustion equation



Explosive mixture – gas in air (G.I.A.)



CO₂ Emission Factors

Approved Document L2A Table 2

Fuel	kg CO ₂ /kWh
Natural Gas	0.194
LPG	0.234
Oil	0.265
Coal	0.291
Biomass	0.025
Grid Supplied Electricity	0.422

CO₂ Concentration in air (%)	Effect
1 - 2	Continuous exposure upsets the electrolytic balance in the body.
2	After several hours exposure, headaches and mild exhaustion develop, together with shortness of breath
3	Severe headaches, sweating, shortness of breath
5	Mental depression
6	Visual impairment, tremors develop
10	Unconsciousness

CO Concentration in air (%)	Effect
0.005	Shortness of breath on moderate exertion
0.020	Slight headache within 2-3 hours
0.040	Frontal headache within 1-2 hours becoming widespread in 3 hours
0.080	Dizziness, nausea, convulsion within 45 minutes. Unconscious in 2 hours.
0.160	Headache, dizziness, nausea within 20 minutes. Death in 2 hours.
0.640	Headache, dizziness in 1-2 minutes. Death in 10-15 minutes
1.280	Death in 1-3 minutes.

Factors affecting presence of carbon monoxide

- Incorrect installation of appliance and flue
- Inadequate ventilation
- No proper maintenance

Calorific Value (CV)

- **Calorific Value is the heat energy contained in any given unit of mass or volume of a fuel e.g. MJ/m³**

CALORIFIC VALUES

Fuel	Energy Content (GJ/tonne)	Energy Content (GJ/m ³)
Wood (dried to 20% moisture)	15	10
Paper (stacked newspaper)	17	9
Dung (dried)	16	4
Straw (baled)	14	1.4
Sugar Cane (air dried stalks)	9	10
Domestic refuse (as collected)	16	1.5
Commercial wastes (UK average)	4	Varies wildly
Grass (fresh cut)	4	3
Oil (petroleum)	42	34
Coal (UK average)	28	50
Natural Gas	55	0.04

Boiler Efficiency

$$\text{Efficiency \%} = \frac{\text{Output (kW)}}{\text{Input (kW)}} \times 100$$

Boiler Efficiency

Boiler efficiency is influenced by three factors, namely:

- good combustion of the fuel**
- good heat transfer to the hot water**
- low standing losses**

Boiler Efficiency

- **Gross Efficiency based on Gross CV, i.e. including latent heat produced.**
- **Net Efficiency based on Net CV, i.e. less latent heat produced. Used for european boiler tests.**
- **Seasonal boiler efficiency is a “weighted” average of the efficiencies of the boiler at 15%, 30% and 100% as quoted by the manufacturer.**
- **For comparison purposes use factors listed in DCLG Non-Domestic Heating, Cooling and Ventilation Compliance Guide.**

Non-Domestic Heating, Cooling and Ventilation Compliance Guide

Table 40 Factors for converting efficiencies

Fuel Type	Conversion factor
Natural gas	0.901
Liquified petroleum gas (LPG)	0.921
Oil	0.937

NB:

To convert from net efficiency to gross, multiply

To convert from gross efficiency to net, divide

Boiler Types

Atmospheric or natural draught

Forced/induced draught

Heavyweight (sectional, welded, shell & tube) - constructed from cast iron or steel

Lightweight (low content) – constructed from Copper, aluminium stainless steel

Multiple or modular

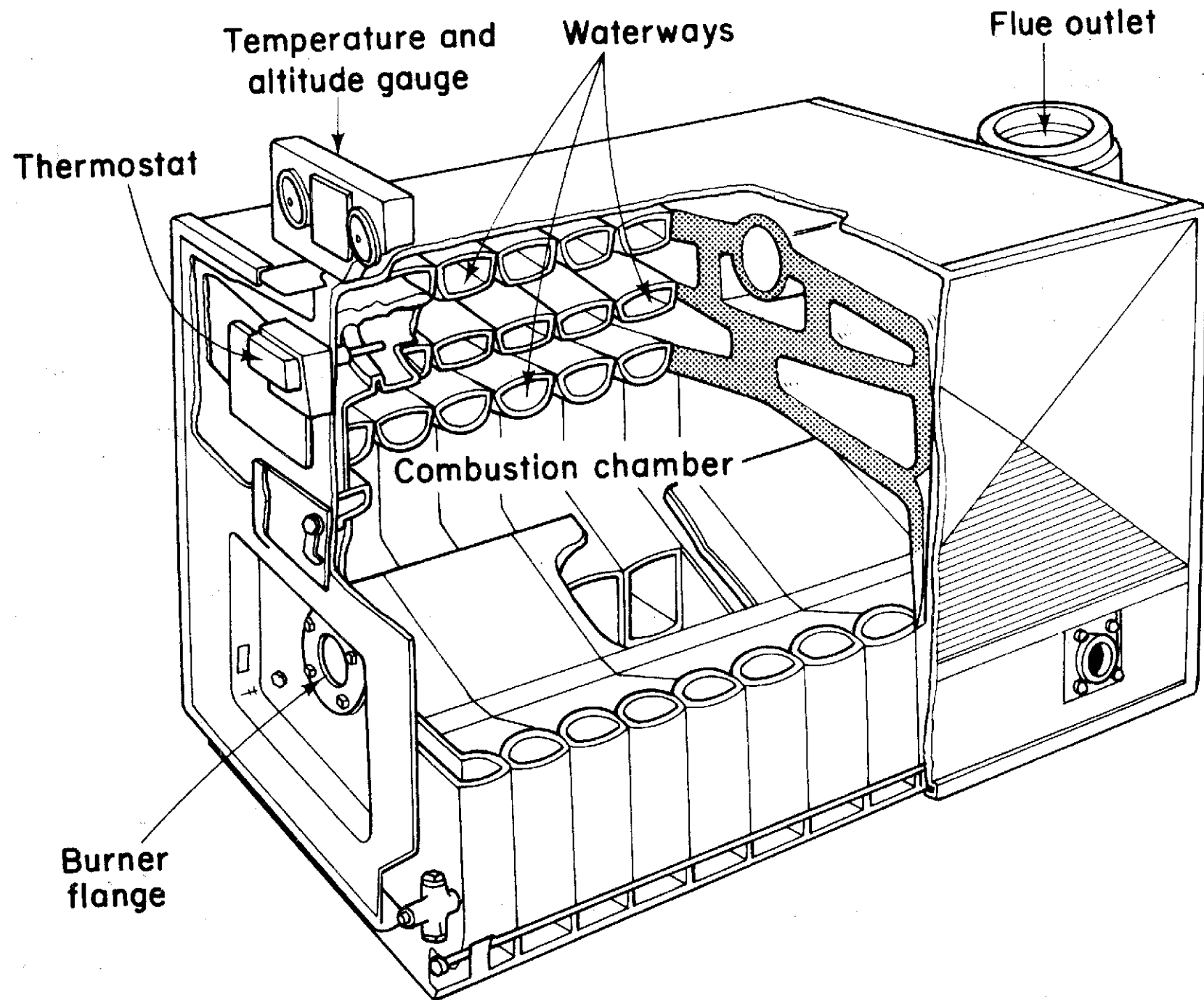
Dual-fuel



Example of a modular atmospheric gas boiler installation.

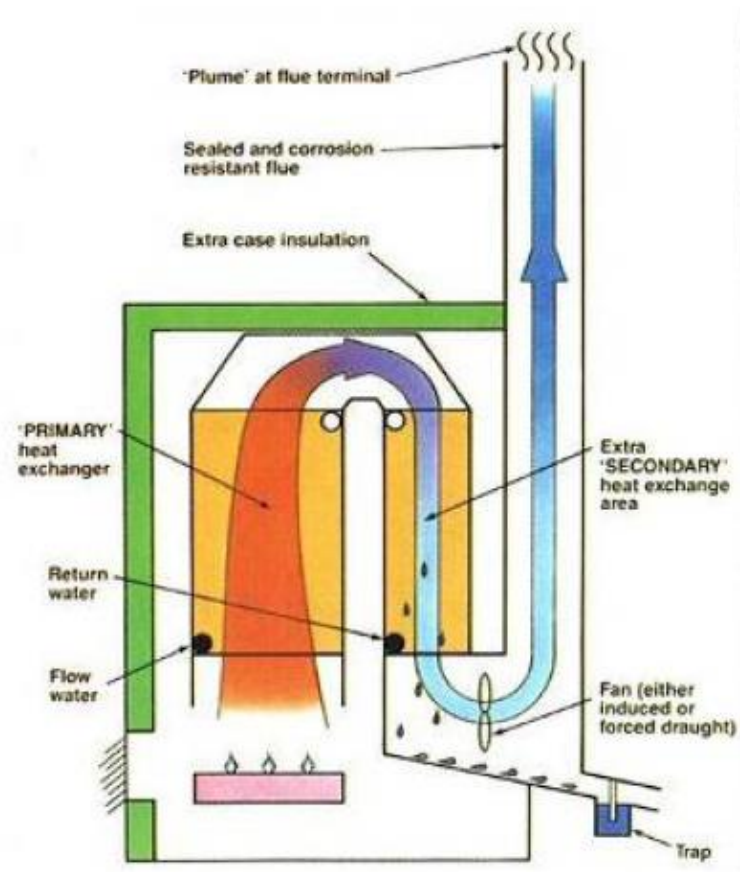


Example of forced-draught gas boilers.



Condensing Boilers

- **Have more efficient heat exchangers**
- **Resulting in lower flue gas temperatures and recovery of latent heat**
- **Causing condensation of water vapour within P of C**
- **Formation of condensate requires provision for condense drain and use of corrosion resistant materials hence higher capital costs**
- **But overall efficiency of 90-95% means lower running costs**



A basic cross-sectional view of a condensing boiler

Condensing Boilers

To maximise efficiency, heating return temperatures need to be as Low as possible.

Direct weather compensation and under-floor heating are beneficial applications.

Typical Boiler Schematic

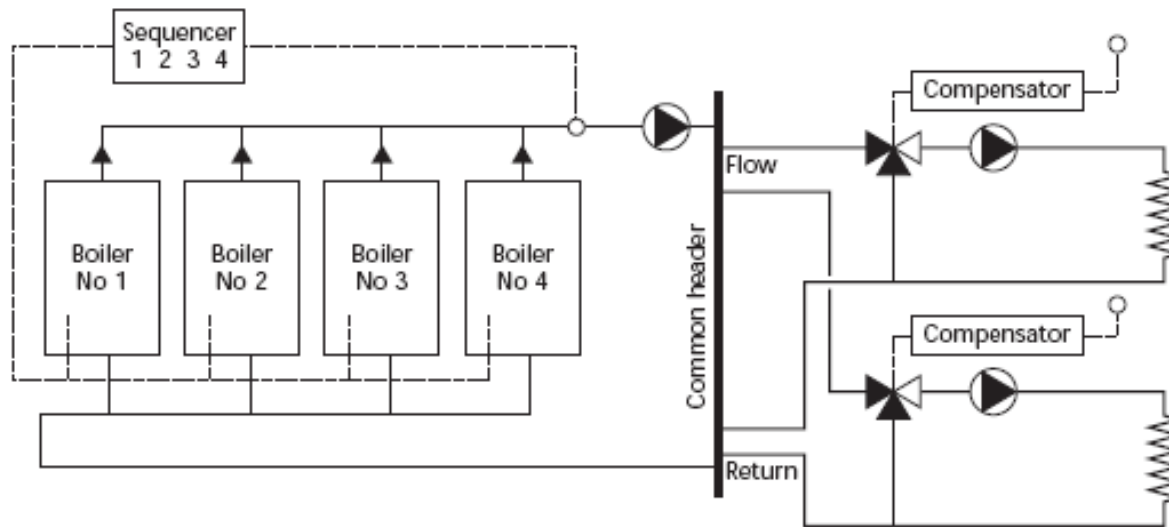


Figure 1.10 Multiple boiler circuit with header and reverse return circulation through boilers (courtesy of Hamworthy Heating Ltd)

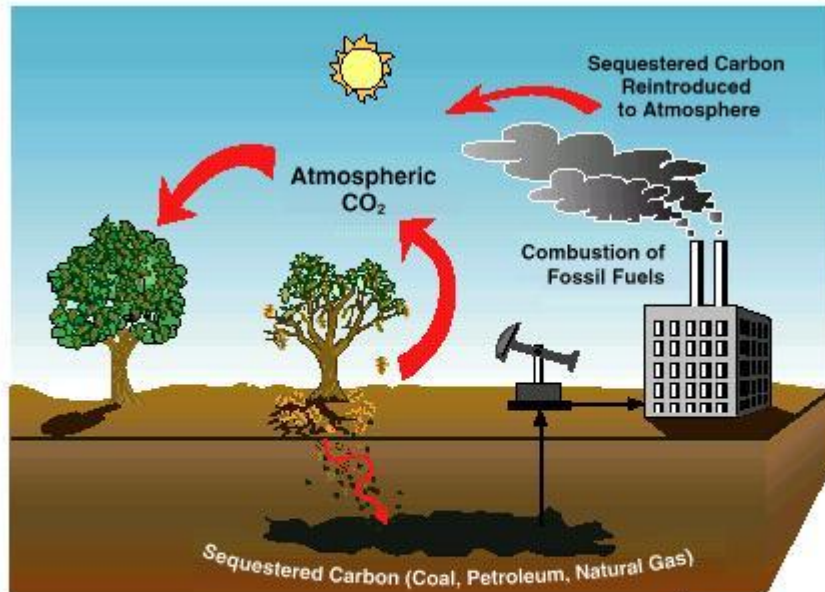
Source: CIBSE Guide B

Low Carbon Boilers

“Biomass produces very large quantities of CO₂ per unit of energy when burned – more than gas or oil – and any notion that the fuel is low carbon depends entirely on re-uptake of CO₂ through subsequent biomass growth.”

Source: CIBSE Journal February 2012

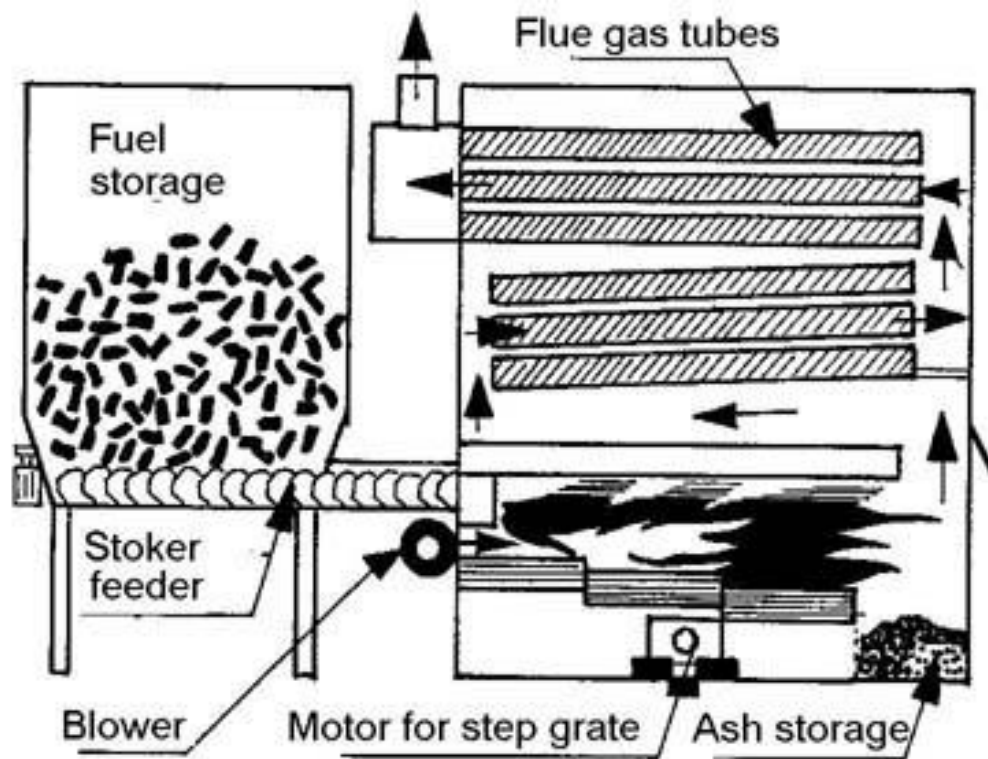
THE CARBON CYCLE



CO₂ from the atmosphere and water from the earth combined during photosynthesis to produce carbohydrates (sugars)

Simplified carbon cycle. *Unlike fossil fuels, biomass does not increase atmospheric green house gases when burned.*

Biomass Boiler



2.5MW WOODCHIP OR PELLET INSTALLATION



HOW MUCH WOOD WILL I NEED?

Output kW	Cons. kg/hr	Cons. m ³ /annum
18	4	10
25	6	15
32	7	20
50	13	30
80	18	50

BIOMASS DESIGN CONSIDERATIONS

Economics – most favourable when comparing to oil-fired plant (consider Renewable Heat Incentive income).

Maintenance – greater than for conventional natural gas plant.

Sizing/control – need to carefully consider matching to heat profile.

Storage/delivery – balance also need to consider effect of adverse weather on delivery.

Availability – standby plant? Implications of power failure?

Emissions – CO₂ will be lower but other emissions may be less favourable NO_x/SO_x.

Useful References

- CIBSE Guide B: Heating, ventilating, air conditioning and refrigeration