CONVENTIONAL SOURCES OF CO_2

INTRODUCTION

This is part one of a two part update, in which we revisit the conventional sources of CO_2 supply and discuss the influence of factors, such as heat requirement and electricity price on the cost attributed to CO_2 supply. Conventional sources includes: flue gas from the 'back of the gas boiler', LPG or kerosene direct-fired heaters, CHP units or pure CO_2 delivered to site.

Part two examines whether the supply of CO_2 from alternative sources, such as biomass, is any more practical now than they have been in the past, as well as discussing the supply of CO_2 from anaerobic digesters.

RECENT CHANGES

Since the last CO_2 Technical Update in August 2014, factors influencing CO_2 systems and economics have changed. Most significantly from the way glasshouses are heated and notably with the uptake of biomass boilers in the protected ornamentals sector. Growers of protected edibles have also embraced biomass heating and some have taken advantage of generous renewables subsidies to fund installations of anaerobic digestion (AD) plants.

Next Generation Growing (NGG) techniques have also led to a rethink of how CO_2 is used, as they require changes in ventilation methods; for example, by keeping vents closed for longer the CO_2 levels within the glasshouse environment are altered.

NATURAL GAS BOILERS, CHP AND AIR HEATERS

Considering CO_2 supply from a gas boiler, gas CHP engine and air heaters, the table below shows how much CO_2 is available from 1 kWh of gas burnt and from 1 kWh of heat energy supplied.

Energy source	Efficiency of source % (heat output/fuel input)	Quantity of CO_2 per kWh fuel input	Quantity of CO_2 per kWh heat output	Heat supplied (kWh) for 1 tonne of CO_2	Fuel required (kWh) for 1 tonne of CO_2
Gas boiler	85	204 g	240 g	4,167	4,902
	70		291 g	3,431	
Gas CHP	45	204 g	453 g	2,206	4,902
	35		583 g	1,716	
LPG air heater	98	230 g	235 g	4,261	4,348
Kerosene air heater	98	258 g	263 g	3,798	3,876

As the table shows, the quantity of CO_2 per kWh of fuel input changes little with the source or the heat producing equipment. The biggest change comes from how the heat is produced and how efficiently the equipment functions. Perversely, maximising CO_2 production per unit of heat produced is a result of having low efficiency equipment. This means the cost of the heat is higher than it needs to be.

CO_2 that is obtained as a by-product of burning fuels for heat is difficult to put a cost on and is frequently regarded as being 'free', because heating for temperature or humidity control is the primary reason for burning the fuel. This is not true in all cases as some boilers will require modification, or a CHP plant will require gas-cleaning equipment to ensure the flue gases are clean and cool enough to enter the glasshouse. This is a cost that has to be factored in to derive the true price of the CO_2. Using CHP as the CO_2 source is further complicated by the value attributable to the electricity production.

If gas has to be burnt for CO_2 production alone, with all of the heat being 'thrown away', its cost is related to the full fuel price. This is shown in the table below:

Cost of natural gas		Cost of CO_2
Pence per Therm	Pence per kWh	£ per tonne
30	1.02	£50.19
40	1.37	£66.92
50	1.71	£83.65
60	2.05	£100.38
70	2.39	£117.11
80	2.73	£133.84
90	3.07	£150.57

PURE CO_2 SUPPLY

Pure CO_2 is produced and used by many industrial processes. As a result, there is an established market and infrastructure for pure CO_2. Typical costs for pure CO_2 are around £80 - £150 per tonne delivered. However, it is worth bearing in mind that there are additional costs involved:

- Tank rental and maintenance from the supplier, probably £2,000 - £3,000 per annum.
- Vaporising the liquid (typically done by re-heating), £2/tonne at today's market price.
- Keeping the tank cool, around £1,500 per annum.

If a boiler-based CO_2 distribution system is already in place, then this can also be used to distribute pure CO_2. If not, then a dedicated high-pressure distribution system will be more suited to pure CO_2 supply. However, a subsequent move from pure CO_2 to boiler based CO_2 cannot be accommodated easily, as the system will not be suitable for flue gas supply.

CO_2 BURNERS

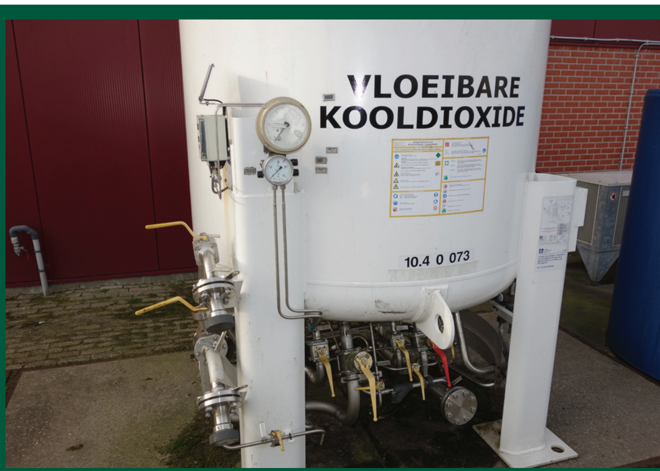
CO_2 burners combust LPG, natural gas or kerosene and are suspended, above the crop, within the glasshouse. The use of LPG or kerosene is more costly than natural gas, which in turn makes the CO_2 more expensive. As well as generating CO_2, burners produce water vapour, which can raise glasshouse humidity. They also produce heat, which will offset glasshouse-heating costs in winter, but may be undesired in summer. Regular maintenance is essential, to prevent incomplete combustion and incorrect flame temperature, since this results in the production of aerial pollutants. It may be necessary, in well-sealed glasshouses, to provide the burners with their own outside air supply. CO_2 burners tend to be either on or off, giving little or no control. Their placement in the glasshouse can lead to uneven distribution and gradients of CO_2. A comparison of the costs of CO_2 production from different fuels is given in the table below:

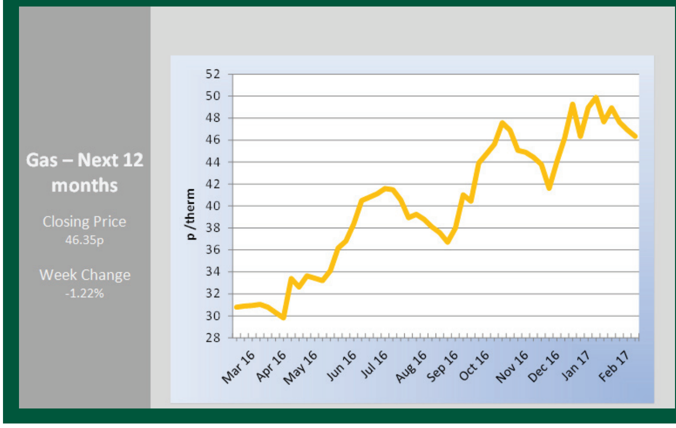
Fuel	kg-CO_2/kWh	Fuel Cost (p/kWh)	Cost of CO_2 (£/t)
LPG	0.24	8.3	£346
Natural Gas	0.23	1.7	£74
Kerosene	0.26	3.8	£148

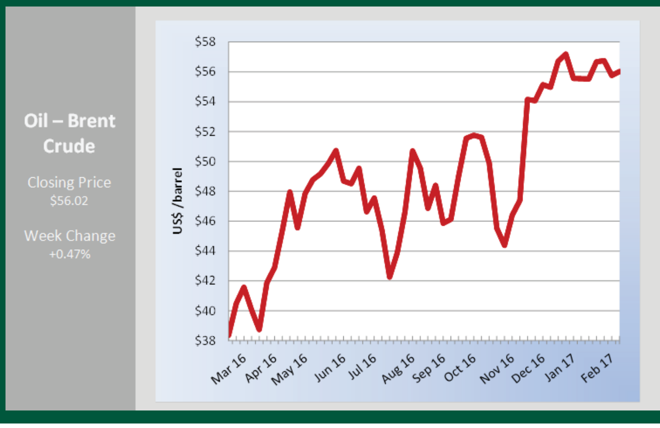
As can be seen from the table, the amount of CO_2 produced per kWh is similar for each fuel type. However, the relative cost of production varies greatly, due to the market price of the fuel.

CONCLUSIONS

Whilst it is very easy to cost CO_2 per tonne from pure sources, it is not so easy to quantify the running costs of the equipment needed. Similarly, the cost of CO_2 from heating sources can be difficult to calculate accurately, as this is tied in to the value of the heat supplied. However, as can be seen from the figures used here, burning fuel for CO_2 alone is not always particularly cost effective. As fuel prices increase, the option of buying in pure CO_2 could become more attractive. Developments in carbon capture and utilisation (CCU) technology could also be a factor. CO_2 produced through industrial processes can be captured for use in manufacturing and agriculture. Since CO_2 is often an undesirable by-product of many industries, there could be a plentiful supply, although the costs are still an unknown quantity.







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