CO_2 — its current status in horticulture

Introduction

Two major developments in greenhouse heating and environmental control are now affecting the availability of CO_2 for green house atmosphere enrichment.

Firstly, the efficiency of energy use for heating is getting better. Thermal screens, controls and better structures are reducing heating fuel use; and the consequence is that less CO_2 is available for enrichment.

Secondly, there is a small but growing shift away from fossil fuel-fired boilers towards renewable heat sources as a result of government subsidies for biomass systems. Because biomass boilers do not produce a clean exhaust gas, it's not cheap or easy to derive CO_2 from this source.

As a result there's a push is for greater efficiency and better utilisation of CO_2 and for more innovative CO_2 sources.

Current cost status

At the moment, the only growers who know the true cost of CO_2 are those using 'pure' CO_2. Here, the cost per tonne is clearly set by the supplier and this, plus the cost of storage, is the true total cost.

In contrast, CO_2 that is obtained from burning natural gas is difficult to cost; it is usually derived as a by-product of heating and, as such, is generally regarded as being 'free'.

However, if gas has to be burnt for CO_2 production with all of the heat being 'thrown away', its cost is related to the gas price. This is shown in the table to the right.

Cost of natural gas		Cost of CO_2
Pence per Therm	Pence per kWh	£ per tonne
30	1.02	55.65
40	1.37	74.19
50	1.71	92.74
60	2.05	111.29
70	2.39	129.84
80	2.73	148.39
90	3.07	166.94

Biomass boiler CO_2

When comparing biomass with gas, it is possible to derive a notional saving per tonne of CO_2 produced, and show how much a grower could afford to spend on exhaust gas clean up, whilst still producing CO_2 at a competitive price.

This changes with the Renewable Heat Incentive (RHI) rates, the cost of renewable fuel and the price of boiler equipment — so it's quite a volatile area of costing at the moment.

The current position is that, with an attractive RHI payment, significant investment can be justified for gas cleaning.

The main problem gases for biomass boilers are NO_x, SO_x and ethylene. Current thinking on cleaning these gases is shown in the table to the right.

Issues	Solutions
Particulates	A high standard of particulate removal is recommended. Bag or ceramic filters are best suited to this.
NO_x	A good quality wood chip boiler might deliver acceptable NO_x levels. A straw boiler will not. Ceramic filters impregnated with a selective catalytic reduction catalyst are a possible solution.
SO_x	SO_x removal is advisable. Dry scrubbing with sodium bicarbonate is possible.
Ethylene	The worst case ethylene concentration is borderline acceptable, so should be checked.
Tars & other volatile compounds	Detailed flue gas analysis is required to determine if these are likely to be a problem. A flue gas condenser may provide sufficient removal.

See these HDC projects for more information on CO_2 research:

- **HDC Project PE 003: CO2 enrichment in the future: a technical and economic analysis of alternative CO_2 sources**
  - http://www.hdc.org.uk/project/co2-enrichment-future-technical-and-economic-analysis-alternative-co2-sources-7
- **HDC Project PC 287: An investigation into the effects of fluegas quality on the performance of greenhouse crops**
  - http://www.hdc.org.uk/project/investigation-effects-fluegas-quality-performance-greenhouse-crops-5

Developments

Exploratory work is being carried out in Europe on biomass boiler gas cleaning, and there is one known commercial system running on a greenhouse in Canada using a CO_2 absorption system.

CO_2 absorption involves a liquid solvent being used to absorb CO_2 from the flue gas. The CO_2 is then released by applying heating. In this way, all the other products of combustion are exhausted with the flue gas, leaving clean CO_2. Data presented at the Tomato Growers' Association Conference in 2012 showed that the CO_2 absorption technique would, in fact, produce cleaner flue gas than from a natural gas boiler. It is also worth noting that a biomass boiler gives twice the amount of CO_2 per megawatt-hour of heat delivered than a natural gas boiler.

One major financial challenge to biomass development in North America has been the introduction of cheap gas from fracking. Although wood for combustion is abundant and relatively cheap, it still cannot compete with cheap gas in a non-subsidised market. As such, financing and developing gas-cleaning technology is difficult to justify. It appears that heat demands of at least 6 megawatts are required to make an installation viable.

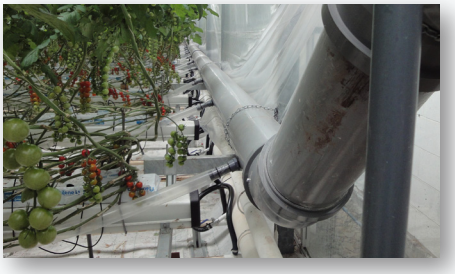
In the UK, with the introduction of RHI support and with higher gas prices, conditions are better for developing this type of technology. However, we still await a mainstream commercial product.

A biomass boiler bag filter for removing particulates from flue gas

CO_2 from air

One area of work that is being explored at the moment is the extraction of CO_2 from air. Recent laboratory-scale trials (backed by Technology Strategy Board funding) evaluated a wet scrubbing CO_2 extraction technology. This evalutation appears to show that, although not particularly useful for global decarbonisation, the technology could work on a greenhouse scale.

The process itself is relatively simple, but scaling to commercial levels might be a problem — mainly because of cost. The absence of any pollutants at all is a major plus point, and the technology deserves some more investigation. Work proceeds in this area today.



CO_2 distribution pipes

CO_2 optimisation

In addition to CO_2 generation, growers need to be mindful of best control and utilisation. Firstly, obvious management issues — like the calibration of sensors, the maintenance of burners and the correct setting of the climate control computer — need to be considered. Beyond that, questions about the rational use of CO_2 have to be asked.

In the past, with cheap energy and plentiful CO_2 resources, optimum levels have not been so much of an issue. But with high costs and limited supply, optimisation has become more important.

Trials at the Improvement Centre in Holland are looking at the optimum use of CO_2 with respect to production. These promise to produce better guidance on CO_2 targets in relation to season temperature, crop levels and light levels.

A gas meter

For more information on ...

- **Dutch R&D into efficient CO_2 use and alternative CO_2 sources**:
  - http://www.greenq.nl/en/component/content/article/2-news/331-rapport-het-nieuwe-belichten-tomaat
  - http://www.energiek2020.nu/efficienter-fossiel/co2/

  Note that some of this information is in Dutch — however, if you use the Chrome web browser with the translate function turned on, the text will be in English.
- **The CO_2 from biomass system that is in commercial use in North America**:
  - http://gc6.ca/
  - http://www.greenhousecanada.com/content/view/3268/63