CHP at NMR Nurseries, Denmark

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Nursery details
The nursery is located near Borup, around 30 minutes from Copenhagen, and just off the main motorway network. There are around 4ha of glass, forming one single block, all of which was erected in the 1980's. The glass is all 8m from gutter to gutter, with an adjoining packhouse and boiler house. In common with other Danish growers Peter has adopted a policy of emphasising the quality, and especially flavour, of Danish tomatoes in the market place, trying to differentiate domestic production from imports. Planting dates are similar to the UK, but temperatures and winter light levels are worse. One of the most noticeable elements of the organisation of the nursery is the strong and apparently successful emphasis on team working, and involvement for all members of staff. Peter's view is that with labour costs in Denmark being high it is important that staff are fully involved in business operation and development.

The electricity supply situation is quite different from the de-regulated one in the UK, and this combined with government incentives for more environmentally friendly power generation offers opportunities for CHP on holdings. Prices received by the nursery are in 3 tariff bands, at 6.6p, 4.5p and 2.7p per kW.h. These combined with an additional 30% installation grant meant that the nursery has funded the installation (and reaps the rewards) entirely on its own, without third party financing which is more necessary in the UK (*Growers in the UK should be aware that for installations of less than 1MW(e) there is the possibility of a 25% grant from the CHPA*).

One of the most remarkable aspects of the installation at the NMR nursery is the background preparation and management put into the design and planning by Peter - a position which seems to have paid dividends. Planning budgets for the scheme were prepared at the outset, and each month the operation, maintenance and financial returns for the system are examined from the computer records to ensure that all is on track. Peter informed us that a survey of CHP in Danish horticulture last year showed an average utilisation of just below 70% - the NMR installation has to date operated at around 86%. Availability ((i.e. amount of time the unit is actually operating during the periods when you want it to be) is around 98%. Peter investigated many sites with CHP with particular reference to engine sets and his installation is unusual in that he has three smaller engines rather than one single large one. His opinion, based on other growers' experiences, is that the reliability of the smaller engines, and particularly the unit he chose, was significantly greater than that of the bigger ones, and although the capital costs were slightly higher this was more than compensated for by output and running

costs.

Installation details

CHP units:	3 off Caterpillar 3516 spark ignition gas engines, 1MW electrical output, 1.3MW thermal output
CO2 scrubbers:	2 off Steuler ECO_2PRO systems
Heat store:	2000m3 purpose built steel tank on asphalt base, 300mm rockwool insulation with plastic coated steel cladding.
Controls:	Priva Integro with "In Touch" link software to generator controls, CO2 scrubber controls by Steuler with modem link to factory for routine inspection and analysis.

The three engines are each installed in separate 200mm reinforced concrete block engine rooms with 50mm of acoustic insulation, all located inside a large portal framed building. Each engine has a separate floor slab to ensure that the vibration is not transmitted to the main building - particularly important in the event of engine problems. The CO2 scrubbers are mounted on the roof of each, with the flue gases then taken down to a heat exchanger from the main hot water heating circuit. The urea tanks are located beside the main control panels for the scrubbers, along with the demineralised water for automatically washing out the jets on shut down. The gases are cooled further by two secondary heat exchangers comprising glass tubes in a silicone manifold with external air used as the cooling medium (4kW fan each) which remove a further 200kW of heat. There are 2 CO2 system fans, each of 15kW, which supply the gases to the distribution network to the houses. This is fairly conventional, with PVC mains and PE layflat tubes, 1 per row. A layout of this can be seen in the drawing below - 'Outline of CO2 production and heat exchangers'.

Waste heat is recovered from the units with a combined circuit in the engine house 'cooling' the intercooler, engine block (including oil cooler), pre-cooler and economiser (exhaust gases - only down to 430^{o}C as the CO2 scrubbers require a high temperature to operate), and can be seen below - 'Layout of water side heat exchangers'. This circuit is separate from the main heating circuit in order to isolate the two in the events of any problems.

Control of the heat output is an elegant solution utilising variable speed pumps rather than the more typical arrangement of mixing valves (see drawing below - 'Schematic of heating system'). This arrangement works by allowing more or less of the flow from the CHP to go into the greenhouse circuits according to the speed of the mixing set pumps. By default the remainder of the flow will go into the heat store. 2 port isolating valves prevent water being drawn through the CHP units when heat is being pulled from the heat store, with any additional heat being provided by the main boiler. Pressurisation of the system is provided by means of two heater elements in the top of the heat store, these providing a head of steam in the top 0.5m freeboard.

After the installation it was necessary to fit an additional 4th row of SCR catalysts in order to keep the NOx levels low enough. In achieving the low NOx levels required the air inlet and intercooler temperatures can be quite critical with conventional fuel control, but Caterpillar are now offering an engine management system which should reduce these levels considerably, and this is an upgrade

being considered. Further upgrades include new spark plugs claimed to give a 0.25% increase in electrical efficiency and a 20^{o}C drop in engine temperature.

Control of the CO_2 scrubbers is by the Steuler control panel, with on line sensing of CO, CO_2, NO, NO_2 and O_2, and the unit is set to shut down under various fault scenarios.

Installation Costs
An approximate breakdown of costs is given below.

CHP units	£530,000
Exhaust systems	£57,000
CO_2 scrubbers	£200,000
Chimney	£35,000
Heat store	£150,000
Heating system alterations	£170,000
Pipe insulation	£40,000
High voltage and electrical work	£125,000
Grid connection	£85,000
Civil works and building	£150,000

Maintenance and running costs
The engine units are maintained under a contract with the local Caterpillar agent; the CO2 scrubbers are on a contract with Steuler. Other general running costs are mainly as below.

Urea - 3 - 4l/hour per engine, with urea at around 23p/l
Engine oil - 6l per day per engine

A urea solution of 35% is used - this is fairly normal and although higher concentrations can be employed the lower ones give less freezing problems. The nursery has not taken out additional crop protection insurance for potential damage caused by the exhaust gases.

Benefits
The CO2 output of the 2 units fitted with CO2 scrubbers peaks at around 460 tonnes per month in June / July. To date the units have run for around 5600 hours each (first year) and produced 17.6 million kW.h of electricity.

According to the computer the efficiency of the unit was 34% electrical (gcv) and 48.2% thermal, although this electrical efficiency is actually slightly higher than that claimed by Caterpillar!

Overall the system seems to have been integrated into the nursery remarkably well, and has performed in excess of the budget predictions made by Peter at the outset. Unusual though it may seem the running times have been greater and maintenance costs lower - an ideal outcome!