Co-generation or combined heat & power (CHP)

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Co-generation or combined heat-and-power production (CHP) on a greenhouse property is the superb way of making maximum use of natural gas. A CHP produces heat, electricity and CO2. A greenhouse needs heat and CO2, and a tiny bit of electricity; the surplus electricity is available for other users. 'Local' generation of electricity avoids transport loss. In the Netherlands there are hundreds of CHPs in operation at greenhouse properties, and some other countries have got them as well. Their governments recognise the benefits of CHP and provide subsidies for growers investing in CHP. Moreover, these countries have the infra-structure and a sophisticated market system for buying & selling electricity. A CHP installation requires a enormous investment. At present it is not economically feasible in NZ, but that can change. This article is just meant to show that CHP is a reality that works. Perhaps in the future someone will introduce it into the NZ greenhouse industry.

What is Co-generation (CHP)?
A combined heat-and-power (CHP) or co-generator produces heat, electricity and CO2. It consists of a gas-fired engine, generator, heat exchanger and safety devices. The engine, with ignition and cylinders, drives a generator, which produces electricity. The heat produced by gas combustion is largely retrieved by the heat exchanger. This heat can be used for heating a greenhouse, or temporarily stored in a buffer. Overseas, the electricity is sometimes used for artificial lighting, but often it is sold to the grid. There are internet-based exchange markets where the electricity producer (the grower) can sell his power instantaneously. The flue gases can be prepared for CO2 for enrichment. A CHP enables utilising natural gas to the full.

Possible addition: flue gas condensor
A CHP be combined with a flue gas condensor and a flue gas purification system. The condensor is similar to a condensor behind a boiler. Its function is cooling down the flue gases and thereby retrieving energy that otherwise would disappear through the chimney. It also condensates the water vapour in the flue gas, which retrieves an extra amount of energy. A condensor is only useful when it is connected to a stream of cold water, e.g. low-temperature return water. Ideally a condensor is connected to a special heating net that runs at a low temperature, e.g. 35-45 °C.

Possible addition: flue gas purifier
The flue gases of a gas-fired <u>boiler</u> are very clean and can be used directly for CO2 enrichment. In contrast, the flue gases of a CHP (which is a gas-fired <u>engine)</u> are contaminated by motor oil, particles, and high levels of noxious gases including NO_x, CO and C_xH_y. To make the flue gases of a CHP suitable for CO2 enrichment, they need to go through a thorough purification process. They first need to be cooled down to below 500 ^oC. A flue gas condensor can perfectly do this. Most flue gas purification systems used in horticulture are based on two steps: a so-called SCR that removes NO_x-gases, and an oxidation catalyst that removes carbon monoxide and unsaturated hydrocarbons. The first step uses injection of a urea solution. Flue gas purification is expensive.

Capacity
The electrical capacity is expressed in kilo-Watt-electric (kW_e or kW-e). This is the instantaneous electricity production, in energy per second, at a given moment. The amount of electricity produced over a longer period of time is expressed in kilo-Watt-hour-electric (kWh_e or kWh-e). Similarly, the capacity of heat production is expressed in kW_{th}, or kW-th, with 'th' for 'thermal', etc.

The capacity of the CHP is limited by the amount of gas combusted in the engine. The electricity generator must have a larger capacity than the engine, e.g. the generator may be 200 kW-e, but the engine limits the CHP to 165 kW-e. Most CHP installations on greenhouse properties are 1 to 2 MW-e each. The total capacity of CHP on greenhouse properties in the Netherlands is over 1000 MW-e, and increasing.

Efficiency
The efficiency of a CHP is given by the electrical and thermal efficiency. The electrical efficiency depends on the mechanical efficiency of the engine, which is often 35-40%. The thermal efficiency is in the order of 55%, but can be 65% if a condensor is used in combination with a low-temperature heating net.

Number of hours in operation
A performance indicator of a CHP is the number of hours in a year that the CHP is in operation. In a greenhouse environment, the operation time of a CHP is limited by the number of hours with heat demand and/or CO_2 demand. This depends on the climate, the crop and preferences of the grower. In greenhouses for tomato and capsicum in the Netherlands, a CHP operates around 4500 hours per year, or 51% of the time. For tropical pot plants it can be 6000 hours, or 68% of the time. If a heat buffer is used, another 500 hours (or 6%) can be added. The number of operational hours will probably be lower in NZ than in colder climates elsewhere. However, it can be similar if a somewhat smaller CHP is used.

Set-up
A CHP is part of a larger set-up for greenhouse heating. Sometimes there is also a boiler that is used for CO_2 production. The CHP will then make less hours, which makes the investment less profitable. The reason to keep the boiler is to avoid investment in an (expensive!) flue gas purification system for the CHP, and to have back-up heat supply. A CHP can be placed parallel or in series with the boiler. Ideally there is also a heat buffer in the circuit. This allows producing electricity when the prices are high, and storing the heat for later use.

Ownership and control
There are many variants of ownership, financing, control and price structures. The CHP can be owned by the grower or by a power company. If owned by the grower, he controls it for heating the greenhouse and CO_2 enrichment. He uses the electricity for artificial lighting (overseas), or sells it, or a combination of both. A possible construction is that the power company does all the investments, and that the grower buys the heat (and CO_2) of the power company.
A good computer-based control programme is essential to make optimal use of all the heating equipment. The control can be done by the grower or by the power company. Power company *Westland Energy* in the Netherlands is commissioned to do remote control of the energy plants on many greenhouse properties, even as far away as in other continents.

Future
Co-generation, or combined heat-and-power production (CHP) on a greenhouse property is not for the faint-hearted grower. CHP is a world in itself. CHP and the associated power supply to third parties requires a lot of specialised technology. The user needs to do meticulous preparation and to learn a new vocabulary of jargon. Moreover, it is an enormous investment.
Despite the costs, CHP is being used overseas in large numbers, and still on the increase. CHP is no reality yet in NZ. But given the turmoil in NZ about electricity production at present, and given the benefits and successes of CHP overseas, it may arrive at a greenhouse property in NZ one day.