CHP, co-generation, renewable energy and CO2

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Published in the Grower 63(6), 2008, p. 30-31

CHP (combined heat and power) also known as co-generation is the future for greenhouse heating. A CHP installation produces heat and electricity, and possibly CO2 for enrichment. Surplus electricity that is not needed in the greenhouse is sold to the grid. This way of local electricity production ('spark spread') can be beneficial for the grower, the power company, the community and the environment. CHP on natural gas is common practice overseas for many years. The flue gases from gas-fired CHPs are purified and used for CO2 enrichment. A new development is a CHP installation that uses renewable energy such as waste wood. Taking CO2 from a wood-fired CHP is not possible yet, but methods for flue gas purification are being sought.

Gas-fired CHP

Combined Heat Power (CHP) installations on natural gas are common practice for greenhouse heating in the Netherlands since the late 1990s. Most CHP installations are equipped with a flue gas purification installation to allow CO2 enrichment. At a seminar earlier this year, Erik Koolwijk from 'Cogen Projects' presented some figures. The total capacity of CHP for greenhouse heating in the Netherlands is now 2,500 MegaWatt. (For comparison: this is about double the total capacity of the three generators together in the Huntly Power Plant). It is expected to grow to 3,000 MW by 2012. The heat from a CHP is used for greenhouse heating, while the electricity is used partly for devices in the greenhouse, but mainly sold to the grid. By using the heat and the electricity, the natural gas is used in the most efficient way, even close to 100%. The policy of 'spark spread' (localised electricity generation) has proven to be very profitable for all involved. Obviously the profitability and the break-even point of a CHP depend on the price of the fuel (gas) and the product (electricity). CHP is very popular on large, medium and 'clustered' greenhouse complexes in the Netherlands. Small greenhouse don't have the economy of scale to afford the high investments of a CHP. The speaker predicted that natural gas for CHP will be replaced by renewable energy.

Renewable energy

CHP is very energy efficient, but the conventional CHPs still use natural gas. Natural gas is a non-renewable fuel, like coal and oil, and is therefore not good for the environment. Non-renewable fuels are taken from the earth crust, and by digging them up and burning them, the are introduced in the carbon cycle. In contrast, renewable energy comes from material that is found on the surface of the earth, so it was already part of the carbon cycle. Renewable energy does not add 'extra carbon' to the atmosphere and is therefore less damaging for the environment. Renewable energy includes wood fire, waste wood, oil from animal or plant products, gas from landfills, gas from algae ponds, etc. Waste wood and other bio-masse and bio-fuels are being used for greenhouse heating in many places, but so far this was always in boilers. One of the largest wood chip boilers for greenhouse heating in Europe is found in Sweden, which has a large forestry industry. Also in Canada waste wood is used in large scale projects. But there were no wood-fired CHP installations yet, until last year.

Vink Sion in the Netherlands

The first CHP on waste wood for greenhouse heating started operating in November 2007 in Beetgum (near Berlikum) in the north of the Netherlands. Grower Jaap Vink of Vink Sion produces capsicums in a 7.5 ha glasshouse. He used to have a conventional gas-fired boiler, but wanted to escape the spiralling gas costs. So last year he converted to a CHP on waste wood. This installation heats his own 7.5 ha glasshouse plus a neighbouring 4 ha glasshouse (when there is surplus heat). Jaap Vink saves about 3 million cubic meters (Mm3) of natural gas, and his neighbour about 1.5 Mm3 gas per year. The surplus electricity produced by the CHP is sold to the grid. The investment was huge: 4.5 million Euros (ca 9 million NZ$), but it was partly covered by government subsidy for energy-saving innovations. The grower expects a pay-back time of about six years, but it depends on price developments of waste wood (the fuel used now) and natural gas (the standard fuel to compare with).

CHP on waste wood

The CHP installation at Vink Sion is made by HoSt & Imtech-Vonk and has a capacity of 5 MegaWatt (thermal). The fuel is wood chips from pruning bushes and shelterbelts. It is trucked in and dumped into a bunker in the huge boiler house (20 x 30 m and 11 m high). Per hour an amount of 160 m3 wood chips is conveyed into the fire. Heat of 450 oC goes into a steam boiler where pressure builds up to 55 bar. This high pressure results in a relatively high electricity output. The steam flows through a steam condensor, where the heat is transferred to water for the pipe heating systems of the two glasshouse complexes. The flue gases of the CHP meet the strict environmental requirements for discharging, but CO2 enrichment from this installation is still in the development stage.

CO2 from gas-fired CHP

Combined Heat Power installations are engines and not burners. Therefore the flue gases from co-generation are dirty (even from a gas-fired CHP), and cannot be used safely for direct CO2 enrichment. The dirty flue gases from a gas-fired CHP can be purified though, albeit at a high cost. The flue gas purification equipment is only cost-effective for large scale glasshouses. The first flue gas purification equipment for the greenhouse industry was CodiNOx exhaust gas purifier, made by Hug Engineering and marketed by Hanwel. There are now more than 800 systems in operation (www.codinox.com/xE-home.html). Later Steuler came on the market with the ECO2-PRO purification systems. This is also used for boilers on bio-gas and bio-oil (not coal or wood though) and removes methane too (www.steuler.de/sab/html/en-steuler_eco2-pro-system.html). Nowadays there is a third supplier of flue gas purification systems, Knook Energy Solutions, who developed the SQ2 based on other principles (www.kesi.nl). Perhaps more about flue gas purification in a future issue.

CO2 from CHP on waste wood?

As discussed above, the newest development is that a CHP installation burns waste wood instead of natural gas. While flue gases from a gas-fired CHP can be purified with the right equipment, the flue gases from the new wood-fired CHP cannot be made pure enough yet. Actually, more in general, so far it seems not feasible to purify the flue gases from wood-fired or coal-fired burners (let alone CHPs). This is mostly due to fact that particles (smoke) have to be removed, besides many gaseous components. So there are technical challenges to overcome before flue gas from wood, coal etc can be used safely for CO2 enrichment. It involves several steps and will be very expensive.

CO2 enrichment dilemma

Growers value the effect of CO2 and want to do everything to have 'cheap' CO2 in huge amounts, also in summer. Waste wood (in boilers and CHPs) and also waste heat, geothermal heat and some other alternatives do not have the associated bonus of clean CO2 for enrichment. Growers find this a disadvantage of these technologies. We think that CO2 enrichment is sometimes over-rated, and that alternatives are sometimes rejected for the wrong reason. It is important to consider the real value and real costs of CO2, and we can help with that. The options are buying 'pure' (liquid, bulk) CO2 in tanks, or doing without CO2 enrichment. After all, it requires a lot of extra production to earn back the hundreds of thousands of dollars (possibly more) for a flue gas purification system plus the costs of the CO2 enrichment system plus the running costs of producing CO2. Moreover, there is still a risk of impurities in the enrichment gas, and the disadvantage of possibly excessive CO2 production and emission.

Sources: www.weekbladgroentenenfruit.nl; www.kasalsenergiebron.nl; www.energiek2020.nl