Page 1

Energy transition & decarbonisation in greenhouses – update from the Netherlands

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This text accompanies a Powerpoint presentation. Numbers [P2] refer to pages in the presentation.

INTRODUCTION

Greenhouse growers worldwide face rising costs for heating and are compelled to decarbonise and switch to sustainable forms of energy. This presentation provides information from the Netherlands (abbreviated as NL), especially seen at the Greentech trade fair in Amsterdam in June 2023. NL is at the forefront of greenhouse technology developments, and many

greenhouse growers in New Zealand receive their materials, services and advice from NL.

The price of natural gas, electricity and CO2 emission in the Netherlands (NL) showed huge price increases of the past five years, with enormous peaks around August 2022. [P2].

The Dutch greenhouse industry continuously strives to improve their energy efficiency already since the energy crisis of 1973. A recent breakthrough was the adoption of '*The new way of growing*' aka '*Growing by Plant Empowerment*', which includes new approaches to climate control. Currently (2023) we see the large-scale transition to new energy sources. [P3].

ENERGY TRANSITION

The Dutch greenhouse industry relied for nearly 100% on natural gas. Natural gas-fired cogenerators (CHPs = combined heat and power installations) produce heat, electricity and CO2. The power produced by CHPs is largely sold to the grid. But growers are encouraged to move to more sustainable energy sources. By 2021, already 30% of energy need was covered by geothermal heat, industrial waste heat and biofuels.

The projection for 2040 is that fossil fuel will make up only 4% of the energy use for greenhouse climate control. The main energy sources will be geothermal, waste heat, and solar heat captured in glasshouses and transferred to the aquifer for seasonal storage. Hydrogen may account for 10%, while bio-fuel will be only 3% (in the Netherlands). [P5].

Electrification is huge, accomplished by super-scale solar and wind projects, as well as thousands of existing co-generators (CHPs). The electricity supply & demand is a complicated balancing act. Greenhouse growers receive money for using electricity in hours of oversupply of wind and/or solar power. Therefore growers now invest in (additional) electric boilers to produce heat when power is cheap. The heat is stored in the aquifer for later use. [P6].



Electrification often involves the use of heat pumps. The most efficient way is heat transfer from (warm or lukewarm) source water to water in the heating system, or to air heating. The (luke)warm water comes from the aquifer storage, or from factories, dams or canals. [P7].

Heat storage in an underground water layer (aquifer) is common practice in NL. In summer, cool ground water is pumped up, and used for cooling (in a separate loop). Thereby the heat is transferred to the ground water, which goes back into the aquifer. In winter, the then tepid ground water is pumped up. The heat is extracted by a heat-pump, and used for heating. [P8].

GREENHOUSE CLUSTERS

Modern greenhouse complexes are generally very large (10-50+ ha each). Nowadays they are often combined in huge 'clusters', covering hundreds of hectares of glasshouses. One example ('NEXTgarden' in Lingewaard, NL) comprises 735 ha of glasshouses and some enormous energy plants using sun, wind and bio waste for greenhouse heating. [P9].

This greenhouse cluster has a solar park with over 6,000 solar panels, generating 13 MegaWatt. The panels float on the communal water pond. The combined energy installations not only supply 735 ha of glasshouses, but also 600 homes. [P10].

This cluster also has a biomass-fired co-generator that produces heat, electricity and clean CO2. [P11]. A schematic drawing and some metrics are presented. [P12].



A variety of energy sources can be used, depending on the scale of the glasshouse complex. Large clusters (covering many hundreds of hectares) can afford the enormous investments in a geothermal plant. They use other large installations in addition for peak heating demand and for CO2 supply. Stand-alone glasshouses (although some are large) are too small for geothermal energy. They are entitled to use biomass. In NL, there is not enough biomass compared to the potential demand, and is therefore biomass is reserved for stand-alone greenhouses. [P13].

When divesting from natural gas, growers often opt for a combination of energy sources, to cover the baseload, medium-load and peakload. The base-load (that stays stable in winter and summer) is suitable to be filled by industrial waste



Page 3

heat, because a factory prefers a steady year-round heat uptake. Geothermal heat can be used for the base-load in very large-scale greenhouse projects. The medium demand can be covered by a boiler, while peaks are covered by heat pumps or electric boilers [P16].

BOILERS

A wide range of new boilers for a wide range of fuels is now available. Powerful electric boilers are a new phenomenon, with one brand offering 20 models ranging from 375 to 1200 kiloWatt (1.2 MegaWatt). [P17]. Modern gas boilers and oil boilers (efficient and low-NOx) are now available from as small as 65 kiloWatt. [P18, 19]. Larger boilers (1-20 MW) can be fired with combinations of natural gas, biogas, oil, bio-oil. [P20].

Glasshouse clusters (covering hundreds of hectares) are heated by huge communal central energy installations, each with a capacity of up to 25 MegaWatt (built by HoSt). Their new super-scale technology includes co-generation plants, biomass boilers, anaerobic digesters, fluidized gasifiers, biogas generators, as well as flue gas cleaning technology for CO2 enrichment. [P21].

GREENHOUSE CLIMATE CONTROL (VENTILATION, DEHUMIDIFICATION)

A huge reduction in energy use has been achieved by improving humidity control. This is especially important in mild conditions, where generally a major part of heating is for humidity control rather than for raising the temperature. Old methods (including minimum pipe, minimum venting, pulse venting, and gapping the screen) wasted a lot of energy.

New methods of energyefficient humidity control include: mechanical ventilation, air treatment, latent heat recovery, air movement. It helps keeping CO2 inside. [P23]. New technology is widely adopted, as demonstrated in some photos [P24, 25].



Air Treatment Units (ATU's) contain a strong fan, a cooling coil (for drying) and a heating coil, and optionally more devices (heat exchanger, heat pump, latent heat recovery, fogging, CO2 enrichment). ATU's draw in greenhouse air or outside air or a mix, and treat it. They produce warm dry air and blow that into the greenhouse, often via large tubes (sleeves). [P26]. Several companies have made their own variation of ATU's based on these principles. [P27, 28].

A special Air Treatment Unit (branded 'DryGair') has a huge drying capacity. It draws in greenhouse air only [P29]. There are many other dehumidifiers [P30]. And there are special fans that draw air from above a thermal screen (where it is cold and dry). With these fans in use, the thermal screen can be closed much longer, so it is more effective in saving energy. [P31].

The use of mechanical ventilation, active dehumidification and Air Treatment Units (ATU's) is now common practice in Dutch glasshouse, and improved the energy efficiency. [P32].

LATENT HEAT RECOVERY (CONDENSATION)

Humidity control requires a lot of energy. In mild climates, the temperature is often close to optimal, but heating is needed to drive the water vapour (moisture) out of the greenhouse. [P34]. Moisture in the greenhouse air contains a lot of energy, called latent heat energy. This energy can be regained by condensation. [P35]. This principle is well known from the flue gas condenser, which recovers latent heat from flue gases from a natural gas boiler. [P36].

Recovering latent heat energy is done by creating condensation, basically on a cold pipe. The cold pipe absorbs the heat that is released by condensation. The pipe is made cold by a flow of cold air or cold water, that is created by a compressor and evaporator (a small fridge). [P37]. A number of ATU's with heat recovery capacity are shown. [P38].

Energy for humidity control can be drastically reduced by allowing a higher humidity level, so not aiming for a very low humidity. This can only be done safely when the temperature is evenly distributed, so there are no cold spots in the greenhouse. P39]. An overview shows the various methods of humidity control, from wasteful to sustainable. [P40].

CO2 & MORE

Growers wish to use CO2 enrichment to boost the production. Unfortunately, there is no CO2 available from sustainable energy sources such as geothermal heat, waste heat, hydrogen, solar or wind energy, electric, hydrogen. A solution for the CO2 issue is part of the fuel transition strategy in the Netherlands. Most glasshouses receive CO2 via a pipeline. [P42].

There is a wide range of other new developments aiming at decarbonisation and energy transition, for instance: using thermal screens (2 or even 3); cooling by adsorption (using heat); CO2 capturing from the air; smart CO2 strategies; improving the efficiency of an air-to-water heat pump; LED lighting; new roof cladding materials; improved control, better sensors, 'autonomous' growing, data-driven control and the use of Artificial Intelligence. [P43]. **To conclude,** this is a summary of learnings gathered from attending Greentech June 2023, on the decarbonisation situation for the greenhouse industry in the Netherlands, and should be read in conjunction with the accompanying presentation.

