tle with the produce to avoid bruising and with the plant to avoid damage. Abundant Robotics has developed an early version apple picking robot that is gentle and precise. Another company, Energid, has a similar solution for picking oranges. Neither of these solutions is ready for primetime and the complexity of a real orchard. Time will tell if they turn into a viable, cost effective solution to a difficult problem.

Every year, automation technology gets more sophisticated. What was cutting edge just a few years ago (guidance, drive-by-wire, continuously variable transmissions, remote sensors) has now become relatively commonplace and cost effective. Technological development toward full automation will only continue to accelerate as sensing, weather performance, terrain responsiveness and proactive autonomous decision making become more sophisticated.

It's not outside the realm of possibility that the coming decades could see farms managed from afar, with less need for human manual labor and more emphasis on human intuition, management and decision making. However, it's still clear that the human element of managing a farm is critical for the foreseeable future. Automation will enable farmers to scale their operations and be more efficient, but with all the complexities of weather and growing, it still takes human instincts and decision-making to run a modern farm.

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COGENERATION: ENERGY SOLUTION FOR GREENHOUSES

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Abstract. The article tells us about the newest approach to combine heat and power and on-site electric generation that also utilizes the byproduct heat for climate control in the greenhouse.

Keywords: CHP, carbon dioxide, greenhouse, newest approach, product freshness, greenhouse environment, tanks, cylinders, composting beds or bins, electric generation systems, SCR system, CodiNOX system, CHP-CO_2 System.

Commercial greenhouse production requires energy for lighting, heating and ventilation. Often the best solution is combined heat and power (CHP) – on-site electric generation that also utilizes the byproduct heat for climate control in the greenhouse. And now there's a bonus: captured CO_2 from the engine or turbine exhaust stimulates plant growth, making crop yields bigger, plumper, and best of all, faster to market. CHP with CO_2 fertilization is now being employed in commercial greenhouses in the U.S. and Canada. Companies including General Electric, Caterpillar and Cummins are actively developing this market in North America.

The goal is to make growth process both more efficient and greener.

Therefore, CHP makes that. In addition, that includes CO_2 as benefits of carbon dioxide supplementation on plant growth and production within the greenhouse environment have been well understood for many years.

A factsheet published by the Ontario Ministry of Agriculture, Food and Rural Affairs describes the key role played by CO_2. «Carbon dioxide is an essential component of photosynthesis. Photosynthesis is a chemical process that uses light energy to convert CO_2 and water into sugars in green plants. These sugars are then used for growth within the plant, through respiration».

The factsheet goes on to explain that the normal atmospheric levels of CO_2 are about 340 ppm by volume. It notes that for many years, plant scientists have known that by increasing ambient levels of CO_2 in greenhouses to levels up to 1,000 ppm, plant growth and production can be dramatically increased for many, but not all, plant species. The publication points out that various methods have been used to increase CO_2 levels in commercial greenhouses.

One of the most basic is to use tanks or cylinders of compressed CO_2 to release gas through a perforated tube network in the greenhouse. Another method is to maintain composting beds or bins in or near the greenhouse that will release CO_2 as vegetable material decays. A third method is to capture and treat the exhaust from dedicated burners or from natural gas-fired boilers that are also used for greenhouse heating as a source.

The most recent innovation is to capture engine or turbine exhaust from on-site electric generation systems, separate the CO_2, and distribute it at appropriate levels in the greenhouse. Engine generation is widely used in combined heat and power (CHP) systems that also use byproduct heat on the same site. In commercial greenhouse operations, the byproduct heat is usually used for greenhouse heating.

The concept of using the CO_2 byproduct as a plant stimulant was pioneered in northern Europe. These CHP + CO_2 greenhouses produce tomatoes, peppers, cucumbers, lettuce, cut flowers, ornamental plants and other products. It is estimated that raising CO_2 levels will bring plants to maturity 10–15 % faster and will increase crop yield and quality. According to Stefan De Wit from Cummins, operators in Europe are seeing total production increases of up to 40%. This more than justifies the additional capital expense of these sophisticated systems.

This energy application is more established in Europe than in North America, but it is being pioneered here in several areas, ranging from Quebec to Southern California. In some cases, a key to success is being able to market surplus electric power to regional electric utilities. Daylight hours when the need for artificial lighting is minimal may coincide with periods of utility peak demand. Prices paid to operators for this energy vary from region to region, thus in planning such a facility, it is important to work with the electric utility.

When used as a CO_2 nutrient source for greenhouses, the engine exhaust must be treated. According to De Wit, a system that is commonly used in Europe is the CodiNOX™ system developed by the European firm Hug Engineering for scrubbing the exhaust gas using a selective catalytic reduction (SCR) system. These units are being used in many greenhouse operations, coupled with engines from various manufacturers. The COdiNOX system is sold as a package and is used by different engine packagers.

One of the leaders in promoting greenhouse CHP applications is GE-Jenbacher. According GE spokesperson Matt Falso, there is growing enthusiasm for this solution. «Today, more than 1,000 Jenbacher cogeneration units are deployed around the world, with a capacity of 2.3 gigawatts (GW). More than 60 % have been installed with CO_2 fertilization». Falso adds, «Today's greenhouses can simultaneously increase crop production and effectively control CO_2 emissions».

Falso indicates that GE offers standardized greenhouse cogeneration technology; the Jenbacher gas engine and generator, catalytic converter, heat exchanger and all balance-of-plant equipment and controls. He adds, «The compact, modular design of our CHP system creates a smaller footprint and can be scaled to fit unique requirements. The standardized package makes service easier since the generators and all other installations can be removed at the same time».

He notes that GE offers a digital solution, myPlant Asset Performance Management™, for Jenbacher gas engines which can help the greenhouse cogeneration plant run more efficiently to improve growing conditions and lower operating costs. He explains, «In North America, GE sales and services providers for Jenbacher gas engines are helping to engineer cogeneration plants to meet customer requirements. To accommodate our horticulture customers' changing business needs, GE provides flexible lease, loan and tax-exempt financing solutions for CHP operations for new installations, replacement and overhauls, and for implementation and maintenance».

Because greenhouse horticulture is a capital-intensive business, it is important to maximize plant production and to shorten growth cycles. Growers have learned to optimize lighting, greenhouse temperature and CO_2 levels. Thus, at certain times of day and seasons of the year, surplus generating capacity is available. Falso points out that in some situations, a useful option is to sell surplus electric energy to local or regional utilities, particularly at time when renewable sources such as solar or wind generation are not available or adequate. In this way, cogeneration units can continue to operate at optimum levels. He notes that GE Jenbacher engines are well suited to load-following or frequent start-stop operations, allowing them to be gainfully used in commercial greenhouses or other applications.

And in conclusion, for optimal greenhouse plant growth and production, there are numerous variables, including plant species, air temperature, moisture supply, light levels and duration, soils or hydroponic nutrient levels, and CO_2 levels. Temperature, light levels and duration and CO_2 levels can all be controlled by a CHP-CO_2 system. Individual owners must consider the cost of optimizing growing conditions, but today many are including these systems in their evaluations. It may be your time to look into investing for a more productive greenhouse.

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OPERATING COSTS OF AGRICULTURAL MACHINERY

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Abstract. The article deals with the basic concepts necessary to determine the operating costs of agricultural machinery. A lot of attention is paid to the costs of used machinery.