Combined Heat and Power (CHP) Systems Add Food Resiliency to the Menu

By Tom Bourgeois Director U.S. Department of Energy's New York New Jersey Combined Heat and Power Technical Assistance Partnership (NY/NJ CHP TAP)[1]. June 16, 2022

In this article, we turn our attention to CHP systems role in adding "Food Resiliency" to the menu of CHP benefits. Recent events including the disruptions caused by the COVID-19 pandemic, and now supply chain issues, have highlighted the tenuous nature of the world's food supply. These occurrences, whether man-made or natural, can disrupt world food supplies and inventories.

In the same way that decentralized energy systems can decouple from the risks that threaten centralized energy generation and transmission approaches, localization of food production enhances the resiliency of a region's food supplies. CHP is a critical enabling technology to support high efficiency, low emission and economically viable, local food production while also providing support to the electric grid.

The Dutch, who are recognized world leaders in Controlled Environment Agriculture (CEA) have nearly 4,000 MWs of CHP systems operating at greenhouses across the country. In 2020 the production of electricity using natural gas fired CHP in greenhouse horticulture in the Netherlands was 10.3 billion kWh.[2] By deploying CHP in greenhouse horticulture, the Dutch have reduced total CO_2 emissions by approximately 1.76 million tons.[3]

The US Department of Energy's CHP Technical Assistance Partnership (CHP TAP) Program has been investigating CEA as an important and impactful market sector what can significantly benefit by the inclusion of CHP. Greenhouses and vertical farms are an ideal application for CHP as they demand year-round substantial heat and power. CHP systems generating on-site electricity, heat, cooling, dehumidification, and CO_2 are well suited to match CEA's load profile. In addition, CHP at CEA can also be used to support the local power grid. CHP-connected sites are used widely in Europe and Canada to, not only control and optimize the growing environment, but to also provide support to the electric grid.

As the electric power grid decarbonizes and incorporates ever greater levels of intermittent renewable energy resources, there will be a growing need for investment in distributed dispatchable resources. In fact, the New York Independent System Operator (NYISO) anticipates a multiplicity of new grid products and services necessary to provide grid stability with increasing renewable penetration. CHP applied to modern 'High Tech' greenhouses as well as vertical agriculture may well possess an additional attractive attribute, adding to the menu of benefits that locally grown food with CHP brings to the table.

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[2] Energiemonitor van de Nederlandse glastuinbouw 2020. Wageningen Economic Research Rapport 2021-127 | Projectcode 2282200621. October 2021. Page 10.

[3] Ibid., page 10

At a recent NY/NJ CHP TAP sponsored event, Mike Swider, Senior Market Design Specialist at NYISO provided an illuminating presentation describing several NYISO Market Initiatives with potential implications for CHP[4]. Mr. Swider pointed out that, *to the extent that a Combined Heat Power resource can follow a NYISO dispatch signal, it can participate [in the market] by selling energy, reserves and capacity to the grid*[5]*.* This potentially engenders a set of new market initiatives that will likely create revenue opportunities in the future for CHP.

Ideal candidates to serve as dynamic grid assets are those where production process control variables can be time or intensity shifted, with little to no impact on the quality or the quantity of the output. CEA possesses this attribute as lighting and CO_2 injection can be interrupted for periods without negatively impacting crop yields or quality. For some vegetables lights can be strategically turned up or down as long as the total amount of light over a 24- to 36- hour period is maintained[6], and the levels of CO_2 can be adjusted in tandem with lighting levels to temporarily reduce site power and energy consumption while maintaining production integrity.

Thermal storage which is a component of these modern CEA facilities allows for continued heating through periods where CHP power may be dispatched to the grid to support during low grid production. [7]In addition, when carbon-free grid power is plentiful and cheap, lighting can be turned on to assist in maintaining grid stability. While there are limitations to CEA's flexibility to adjust a range of equipment schedules[8], initial research indicates that there is sufficient flexibility to allow for multi-hour grid support which will have increasing importance and value as we move to much higher penetrations of wind and solar power generation on the grid as is the plan in New York.

This ability to time shift power loads together with the availability of sophisticated controls and optimization algorithms that typically exist in modern CEA facilities, makes the high-tech greenhouse or plant factory well positioned to operate as a dynamic asset serving the grid. Appropriately designed CEA systems with CHP sit in an ideal spot to provide important societal benefits across several important functions if the incremental expenses of adding this functionality to automation & control systems for greenhouses being small.

It was in part the ability to earn revenues in both the energy business and the horticultural business, which created a boom in CHP at greenhouses in the Netherlands. Here in New York State, NYISO tells us that dynamic grid assets will become ever more valuable as the New York grid decarbonizes. Potentially CEA yields and local power grid resiliency needs might be balanced in a manner that drives important new business models leading to more incentives for inclusion of CHP in the CEA industry. Stay tuned for

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[4] Grid in Transition: DEFRs and Dispatchability. Mike Swider Senior Market Specialist, NYISO. Prepared for joint US DOE's NY/NJ CHP TAP and Northeast CHP Initiative (NECHPI) Webinar CHP's Role in Decarbonization. January 27, 2022 https://www.dropbox.com/s/pkxkk6e9mgwoj57/NYISO_GIT_DEFR_CHP_Final.pdf?dl=0

[5] Ibid., page

[6] Only Extreme Fluctuations in Light Levels Reduce Lettuce Growth Under Sole Source Lighting. Ruqayah Bhuiyan* and Marc W. van Iersel. Frontiers Plant Science, 28 January 2021 | https://doi.org/10.3389/fpls.2021.619973

[7] Thermeleon makes greenhouse horticulture more sustainable with smart thermal battery". By Roelant Frijns. January 22, 2022. Innovations Origin. Source: https://innovationorigins.com/en/thermeleon-makes-greenhouse-horticulture-more-sustainable-with-smart-thermal-battery/

[8] Round Table Discussions - Dr. Greenhouse - Kelley Nicholson. Polygreens Podcast. Mar 4, 2022. Episode 063. https://podcasts.google.com/feed/aHR0cHM6Ly9mZWVkcy5idXp6c3Byb3V0LmNvbS8xMjg4Mzg1LnJzcw/episode/QnV6enNwcm91dC0xMDE4OTkyMQ?hl=en&ved=2ahUKEwjl45D8_Nf2AhVekokEHbbMBzsQjrkEegQIAhAF&ep=6

more details as we investigate the validity and the robustness of our hypothesis that local food production (food resiliency) with CHP is positioned well to provide the co-benefit of grid support (energy resiliency) and, perhaps will be well compensated for doing so!