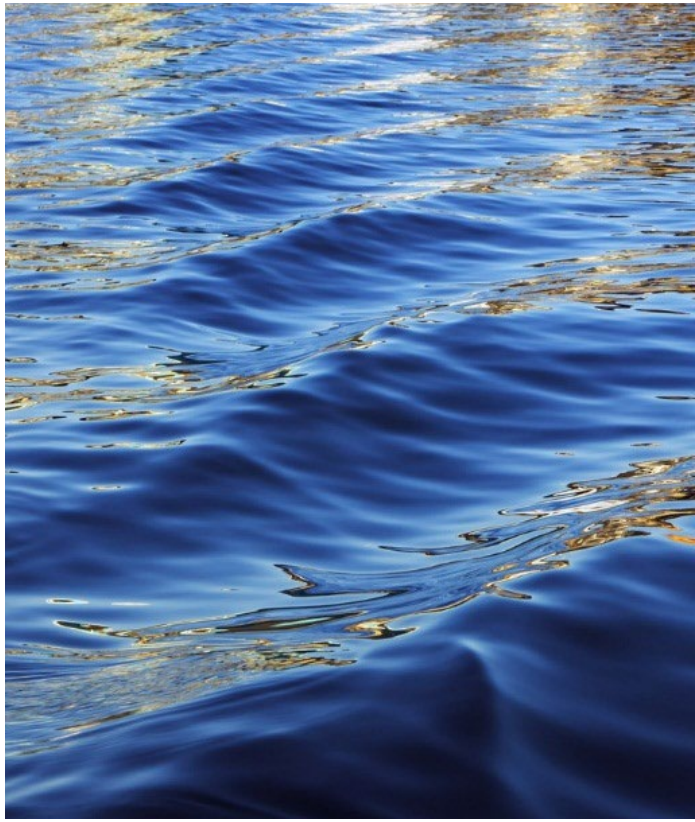
Energy / Water /Food / Environment Nexus:

Conjoining Local Food Resiliency with Energy / Grid Resiliency

IEEE Smart Village (ISV) Webinar
Food Security:Climate Change, Mitigation Technologies 10/17/2023



This Presentation Will Address

- Socializing the idea (Need and Purpose)
- Context and Objective
- Key Stakeholders and Involved Parties
- Skills Required to do the Work
- Implementation and Opportunities to Effect Change

Need and Purpose: Food Resiliency

- According to an often cited FAO report the world will require a 60% increase in production by 2050 over 2010 levels[1]
- The potential fragility of conventional farming and the world food supply chain has been recently exposed by world pandemics like COVID-19 and the Russian invasion of Ukraine.
- Current agriculture practices are water intensive, utilize an abundance of chemical inputs affecting ecosystems and are a major source of greenhouse gas emissions (GHG), sustainable solutions are critical

1. A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. By Michiel van Dijk, Tom Morley, Marie Luise Rau, Yashar Saghai. Nature Food | VOL 2 | July 2021. page 496

Need and Purpose: Energy / Grid Resiliency

- Many US States have set ambitious decarbonization goals
- NY has passed a sweeping Climate Act (CLCPA) requiring a 70% renewable grid by 2030 and a 100% renewable grid
- The Final Climate Act Scoping Plan analysis and current studies show that the 100x40 goal requires 15 GW to 45 GW of electricity from zero-emission, dispatchable resources in 2040 to meet demand and maintain reliability[2]
- With electrification of heating and the expected shift to a winter peak in 2032, more buildings, in particular multifamily public and LMI housing, may become "Critical Infrastructure" sites requiring heat resiliency backup

2. New York State Climate Action Council. 2022. "New York State Climate Action Council Scoping Plan." climate.ny.gov/ScopingPlan. pg. 13, Executive Summary

CHP and CEA: *<u>Conjoining*</u> Food & Energy for Resilient and Sustainable Communities

- Locally grown healthy food
- CHP for site energy resiliency, redundancy, & reliability
- Thermal storage for peak shaving
- Heat recovery for greenhouse, carbon sequestration from engine feeds plants
- Goodwill toward community
- Educational program opportunities

Context and Objective

- Our hypothesis is that appropriately designed, configured, controlled and operated CEA systems can simultaneously address

  * Societal needs for greater food output with markedly lower environmental footprint

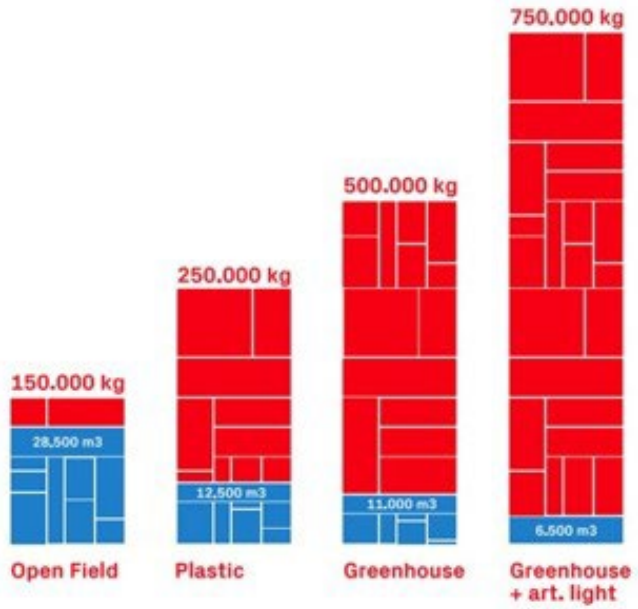
  * Societal need to address water, energy, environment waste mgmt

  * The pressing imperative of developing (**NY as "exemplar")** 15 to 45 GW's of DEFRs, a requirement for safe/reliable functioning of the 100% renewable grid

Energy, Water, Food Nexus

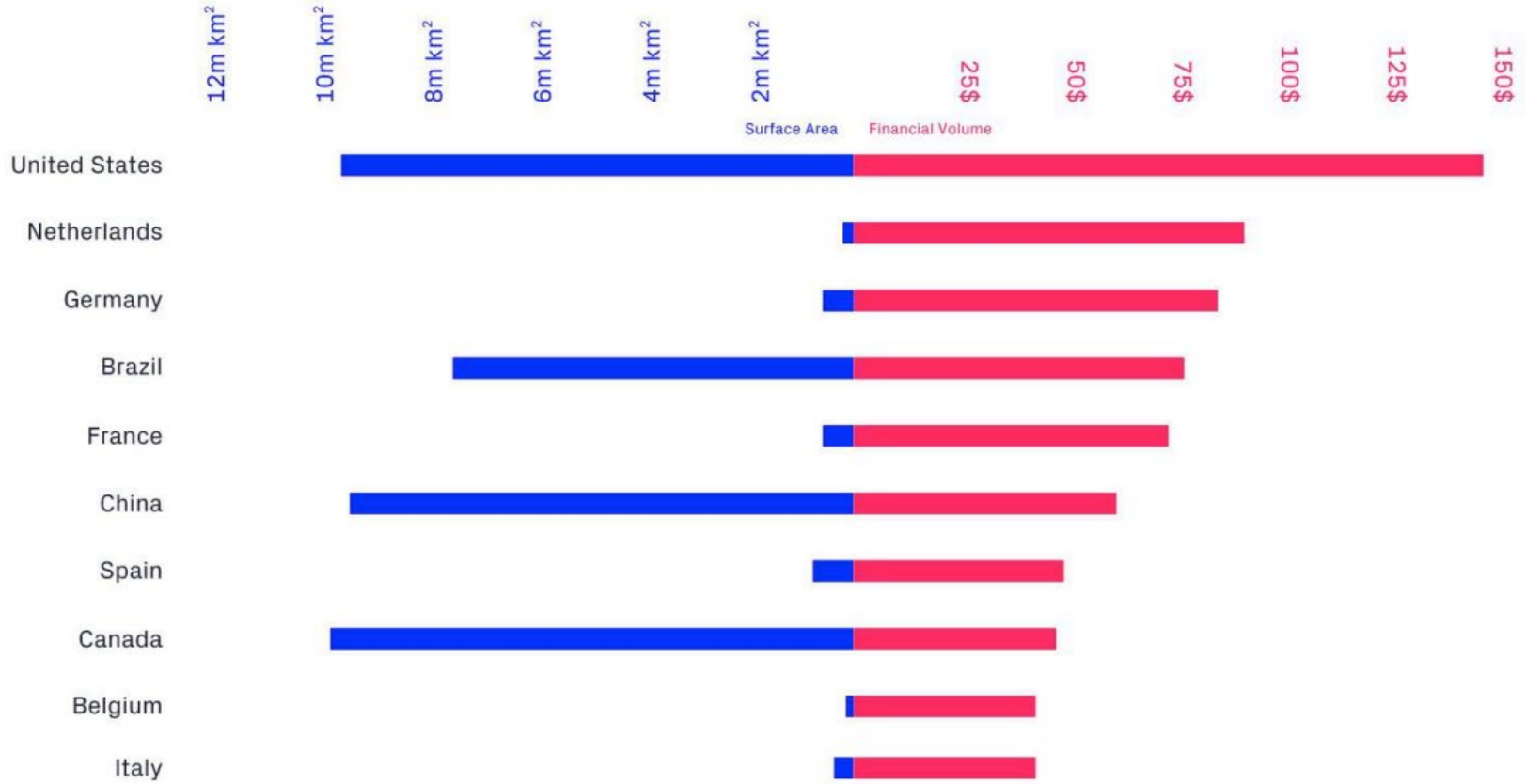
It can be done, it has been done

The high-tech greenhouse delivers 5 times the output while consuming nearly 78% less water.



Tomato production on one hectare vs. water consumption (Dutch Greenhouse Delta 2021).

Success of CEA in the Netherlands



Country Food Production in Dollars by Land Area. (Dutch Greenhouse Delta 2021)

CEA – Flexible Loads

Lighting	LED lighting can be ramped more easily than HPS lighting. Plants can tolerate variations in lighting amount and schedule. Alternating red and blue light with tomatoes to reduce peak demand.
Ventilation and Fans	Horizontal and vertical fans are utilized to create different crop zones in the same greenhouse. The use of variable flow drive fans allows flexible usage. Vertical fans that provide boundary separation in lettuce crops can be flexibly timed.
Thermal Energy	Thermal batteries allow decoupling greenhouse thermal generation and utilization allowing flexible timing of cogenerated heat and power.

Source: Afzali et al. 2021; Bhuiyan and van Iersel 2021; Frijns 2022; Hao 2021; Nicholson et al. 2022.

Study Objectives

CEA – High tech greenhouses and indoor vertical farms are energy intensive operations

Generally, **onsite** energy systems (Combined Heat and Power 'CHP') at CEA sites are operated with natural gas

Government, academia, the CEA industry[3] are all seeking solutions, one being Renewable Natural Gas (RNG) powered CEA

Using NYS as the laboratory we examine regulatory structures, market frameworks, feedstock supplies, and current to near term industry technical capabilities to support RNG fueled CEA complexes

3. USDA, US DOE have ambitious programs supporting reducing the environmental footprint of CEA. For example, Pace has partnered with UC-Davis , Cornell University, Texas A&M Schools of Agriculture to respond to USDA's SAS grant on Climate-Smart Solutions for Sustainable Food Production in Indoor Vertical Farming

Integration of CHP w/ CEA – Renewable Power & Heat

HoSt's 2020 State-of-Art Biomass CHP Plant:
Produces 15 MW thermal + 3.4 MW electrical power

- Biomass-fired combined-heat-and-power (CHP) plant recently commissioned in Andijk, Netherlands
- Produces of heat and electricity from ***prunings***, providing renewable heat to six greenhouse companies.
- Independently conducted emission measurements, certified by a public authority, certify this biomass plant's NOx emission reduction >99%. Achieved using HoSt's ultra low-NOx innovative combustion technology, precise combustion temperature control, and highly automated control.
- CO_2 from flue gases can be captured for use in greenhouses for crop growth, for sales, or storage in liquid or gaseous form.
- Excess heat and electricity can be supplied to district thermal or electric microgrids.

Source: Biomass Magazine, June 26, 2020
Courtesy: David Van Holde, PE, CEM, Director US DOE Northwest CHP TAP

Foothill Greenhouse LLC

- Foothill Greenhouse is a third-generation family owned/operated business, Ontario
- Onsite power with 20kW of PV and 3.2 MW CHP system. The site captures and recirculate 100% of their irrigation water to use fertilizer efficiently[1]
- Wood-waste and CO2 Recycling, consumed by plants in the greenhouse[1]
- This 15 acre farm can produce about 2400 tons of cucumbers, ~ 8 times more than field grown cucumbers

NOTE: Feb 6th 2023 this site received unanimous approval from Town to build new 1.2 MW CHP to serve as Grid Asset in Ontario. See Source: https://www.jenniferanstey.ca/post/king-township-council-meeting-february-6-2023

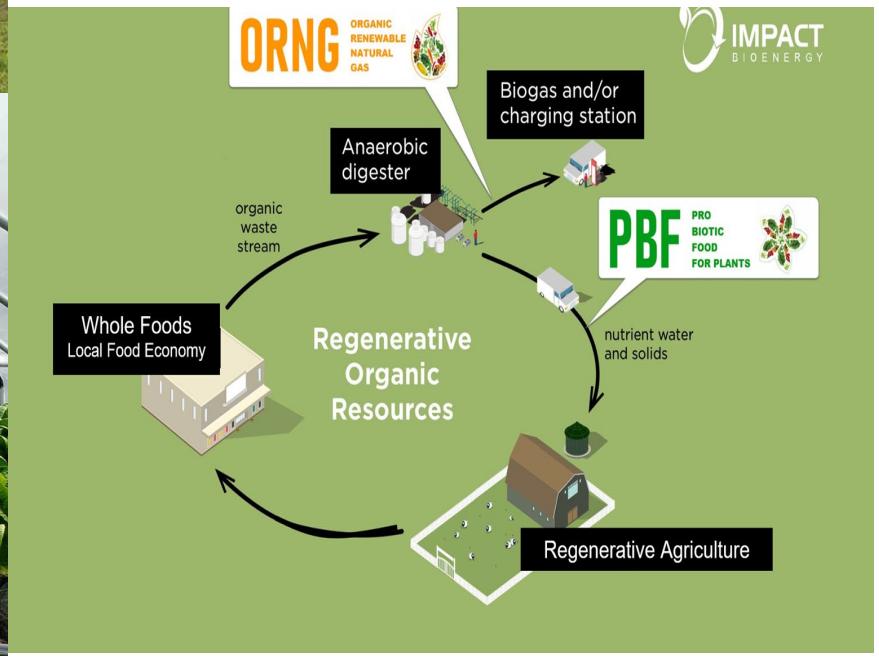
1. https://www.foothillgreenhouses.com/eco-initiatives.php

CHP → CEA: At small scale to village scale

***Impact Bioenergy's Vashon Island, WA Bioenergy Farm*:**

- **Food wastes →**
- **Biogas as Fuel +**
- **Greenhouse nutrients and heat**
- **CHP option**

Village Scale: This site uses a cottage industry's food production waste to produce biogas for heat and renewable natural gas for sale, as well as plant nutrients. A greenhouse is integrated on top of the biogas digester.



Images and Graphics Courtesy of Impact Bioenergy

Innovations : Hybrid Applications, Efficiency, Decarbonized Solutions

AGR Chear Farm Glass house, Cambridgeshire U.K. that supplements CHP heat with water source heat pump heat.

- 33MWth Heat Pump System
- 9 MW CHP, 3 high efficiency engines with CO2 recovery
- Will qualify for the Renewable Heat Incentive (RHI)

Varegro, a horticultural company in Ootrozebeke, West Flanders.

- 40,000m2 site. The (Cummins) HSK78G supplies the site with 2MW of power
- Electricity for lighting, the heat produced for heating and the exhaust gasses cleaned and used for CO2 fertilization.
- The heat buffer allows Varegro to influence the variable energy market and support the grid network. The electricity is sold back to the grid in a flexible manner which offers greater fuel savings for Varegro.

Seacliff Energy Corporation (Seacliff) anaerobic digestion (AD) facility in Leamington, Ontario, Canada

- First privately-owned, commercial-scale anaerobic digestion (AD) plant in Canada.
- Integrated with an adjacent 300,000 square foot commercial organic greenhouse
- Exports green electricity to the Ontario utility grid, produces renewable heat for greenhouse and anaerobic digester operations, and fertilizer as a by-product for local organic farming operations in a sustainable, closed-loop, system.
- Permitted capacity of up to 110,000 tons per year of source-separated organics (SSO), industrial, commercial, and institutional (ICI), and liquid waste streams.

CEA Integration in Districts

- Q-Scale data center with Greenhouse utilizing residual Heat Lévis, Que. the company claims that it will "produce 2,800 tonnes of small fruit and more than 80,000 tonnes of tomatoes per year" in greenhouses to be constructed adjacent to the facility.[1]
- Toundra Greenhouse, Resolute Paper Mill, CO2 Solutions Partnership – Phase one of a $100 million, 34 hectare, agrothermic industrial park has been completed. Heat and CO_2 produced from the Resolute pulp mill are used to heat and supplement greenhouse CO_2 in a 8.5 hectare greenhouse. CHP is under consideration to serve electric loads and provide heating for upcoming industrial tenants.
- Sweden: An agreement between Agtira and Greenfood $27.8 million ($US) has been signed for a cucumber cultivation plant in Boden. The facility will be one of eventually a total of ten around the country.
  "The potential to recover residual heat from data centers and other industries is a huge and often unused resource,"[2]
  - Pontus Lamberg, operations manager at Agtira (Data center). Source:

[1] https://www.greenhousecanada.com/waste-heat-tapped-by-major-quebec-grower-31899/
[2] https://www.hortidaily.com/article/9516261/sweden-cucumbers-grown-on-residual-data-facility-heat/ date: Mon 3 Apr 2023

Circular Economy: Grow local food, use wasted heat from Data Centers, industries, businesses

- Circular economy and "shared resources" way of thinking
- several homes, businesses, greenhouses or farms create a communal district (district energy)
- the "waste" from one source (heat in data center) is a resource for another (greenhouse)

Decarbonization / Energy Markets /Grid Reliability

- Short term reliability margin are "thinning" to 2026 [1]
  - NYC reliability margin narrows to 50 MW in 2025
  - *"even the slightest deviations from expected conditions, load forecasts, or project delays could trigger future reliability needs" - NYISO*
- Total Installed Capacity must Triple (95 GWs) to meet the 2040 Goal[2]
  - New York currently has 37 GWs of generating capacity
  - Roughly 7 years from now, an estimated 20 GW's of additional renewable generation needed
  - 12.9 GWs of new generation have been developed since 1999

[1] *2022-RNA-Datasheet.Pdf*
[2] *NYISO 2021-2040-Outlook-Datasheet.Pdf*

DEFRs are Critical for a Reliable Grid

- Dispatchable Emission-Free Resources (DEFRs) must be developed and added at scale to reliably serve demand when intermittent generation is unavailable [1]
  - 25 GWs to 42 GWs of DEFRs required in 2040 Policy Scenarios
  - DEFRs must be developed and deployed at scale well before 2040
  - *"There will be a great need for DEFRs to meet the flexibility and energy supply needs of the future system" – NYISO*
- *CHP is a proven DEFR when operated on zero (low) carbon fuels.*
- *CEA's flexible load characteristics can serve the same purpose as DEFR's by reducing grid load.*

[1] *NYISO 2021-2040-Outlook-Datasheet.Pdf*

Ontario IESO: CEA & CHP as Grid Solution

- Challenge: Significant grid congestion in SW Ontario due to high concentration of industrial facilities and high energy users. Ontario requires an additional 4,000 MW of electricity supply between 2025 and 2027.

- Solution: Long term generation procurement (ELT1 / LT1) RFP Released by IESO in 2022.
- Procurement target of 4,000 MW of new efficient, dispatchable, year-round resources including hybrid electricity generation and storage facilities > 1 MW that can provide > 4 hrs of continuous output.
- IESO is looking to procure a diverse portfolio: 2,500 MW of storage, contributions from other non-emitting resources such as hybrids and biofuel resources, and up to 1,500 MW of natural gas to relieve grid congestion
- Open to variety of dispatchable generation technologies with largest carveout for BESS with significant portion for CHP
- Program provides reserve payment to participate in program and for response to demand event calls (15-year contracts)

E LT-1 RFP: Example Greenhouse Resources

Under Sun Acres Green Energy – Plant 2, The expansion (1) additional natural gas fired CHP engine with an electrical output of up to 3.3 MW. The engine. Efficiency of ~90% or greater where the waste heat from the engine is recovered and utilized to heat Under Sun Acres' production greenhouse.

Soave Hydroponics Company ("Soave Cogeneration") intends to participate in the IESO's E-LT1 RFP to expand our existing cogeneration facility by 6.6 megawatts (MW). This will help support increased reliability to the Kingsville area. The IESO has identified Kingsville as a priority location for new projects in Ontario. https://soave-cogeneration.com/assets/documents/CommunityAndIndigenousEngagement.pdf

Foothill Greenhouses intends to seek a new contract with the IESO under the E-LT1 program to install an additional 1.4MW Natural Gas fueled Cogeneration plant;

https://www.foothillcogen2.ca/

[1] https://undersunacres.com/cogen-exp/

Key Stakeholders and Involved Parties

- Energy Regulators and Policy Makers
- Grid Operators and Utilities
- Community organizations and Environmental Justice concerns
- State / Local Agencies managing spectrum of waste initiatives
- Affected industries and trade associations

  Greenhouse Lighting and Systems Engineering Consortium – GLASE

  Onsite power companies and RNG industry

  Farms - food waste generators – waste management enterprises

Skills required to conduct the work

An exceptional opportunity for multidisciplinary collaborations

- High level feedstock characterizations
  - GIS, distance / cost mapping available, recoverable energy from wastes
- Impact analysis of state, local, national policy drivers
- Develop and execute remote interviews to ascertain opportunities, barriers and mitigating measures from a variety of perspectives
- Forge cooperative relations with network of academic institutions, embedded community organizations, environmental and utility regulators-market actors, CEA Industry and others

Implementation and Opportunities to Effect Change

CEA with CHP can be designed to create Multiplicative Benefits

conjoining local food (food resiliency) local generation (energy resiliency)

District Energy further augments benefits

actively managing, across property lines, broad portfolios of energy demands / supplies

Urgency in developing local / dispatchable / appropriate generation

(e.g. NY) will require dispatchable emission free generation / load flexibility

Regions facing local grid challenges are valuing CEA/CHP like resources

(e.g. several greenhouses expect to participate in Ontario IESO newly required markets

In the words of the NYISO the scale of the need is "unprecedented"

This work is important, impactful, widely applicable and *actionable* !

We urge your consideration because…

This work leverages a significant pre-existing research base: published papers, newsletters, delivered presentations and ***demonstrable*** market success

It addresses a broad scope of matters of immediate and pressing concern (water/climate/energy/environment/land use/food/ resiliency

New ground must be broken in resource characterization, GIS, developing a land use, roadmaps/ matrix of policy drivers – there is no redundancy here

This research is highly replicable and relevant to urban/rural, rich/poor

as regions facing local grid challenges benefit from valuing CEA/CHP like resources

Industry participants, agencies and authorities having jurisdiction, academic thought leaders have encouraged knowledge, experience advancements

.. E.g Sept 28th 2023 US DOE's Industrial Efficiency & Decarbonization Office announces a CEA Accelerator

IEDO's New CEA Accelerator Will Help Develop New Models for Low-Emission American Agriculture

We invite you to please, share your thoughts, advice, guidance and experiences

Tom Bourgeois Pace Land Use Law Center