JISEA Joint Institute for Strategic Energy Analysis

2022 Annual Meeting: Agricultural Energy & Efficiency Table Topic

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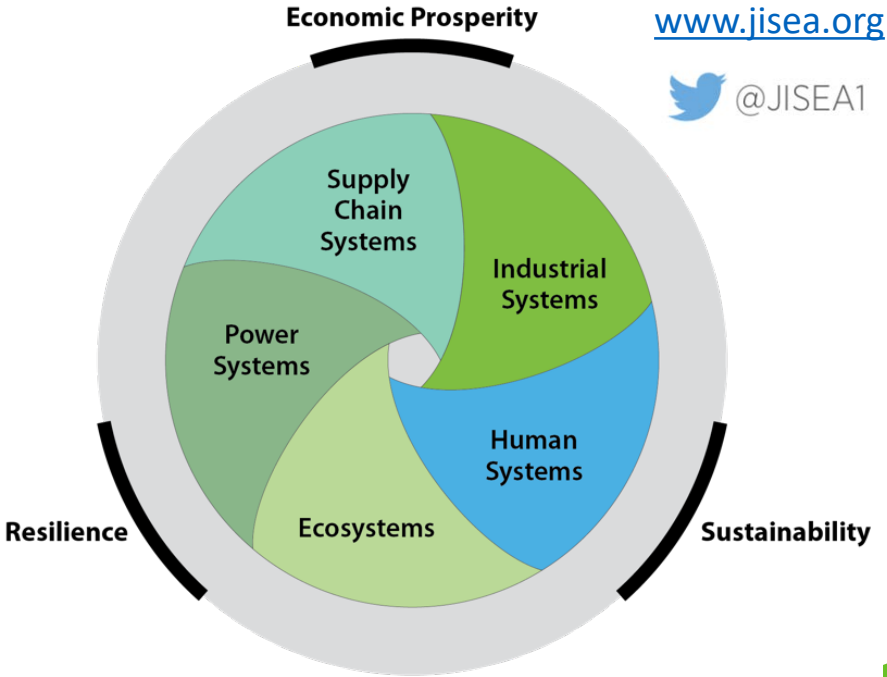
JISEA 2022 Annual Meeting – Agricultural Energy & Efficiency

Connecting technologies, economic sectors, and continents to catalyze the transition to the 21st century energy economy.

"JISEA is researching ways to reduce the cost of energy in food systems, reduce emissions, assess new energy sources for agriculture, and increase food resilience."

- Jill Engel-Cox, JISEA

Energy, food, and water are connected throughout the food supply chain.



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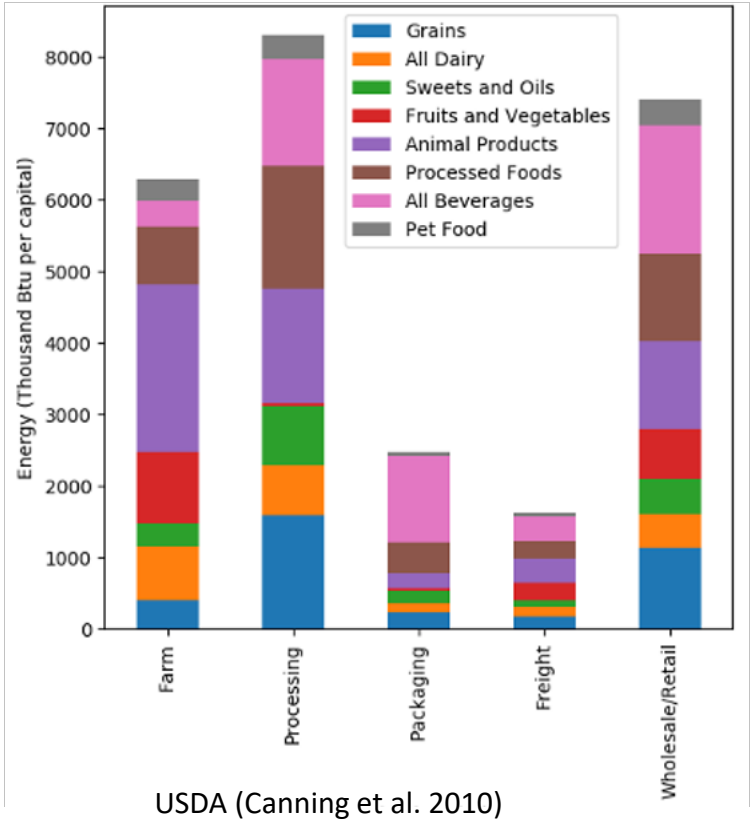
JISEA FY22 Annual Meeting – Agricultural Energy & Efficiency

Food-related energy use accounted for an estimated 15.7 percent of the national energy budget in 2007

USDA (Canning et al. 2010)

- How is energy use related to land and water use?
- How can renewable energy be generated & used within the food system?
- How does food loss and waste contribute to energy use?
- Where in the food supply chain would efficiency improvements be the most impactful?
- How can increasing demand for food be met in a sustainable way?



USDA (Canning et al. 2010)

Generate renewable biogas while addressing environmental concerns at a Colorado dairy

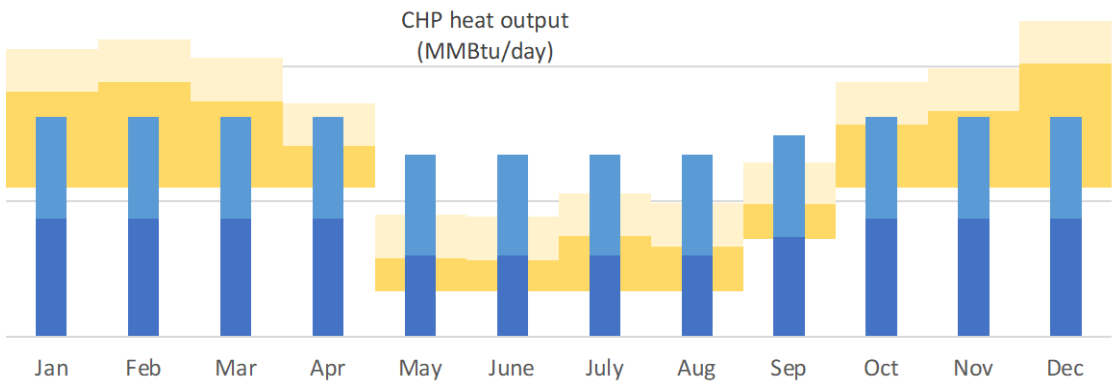
Save and generate energy by incorporating solar technologies in greenhouse design

JISEA energy and agriculture case studies focus on connecting resilience, economic, and sustainability goals

Two case studies funded by the Colorado Department of Agriculture and the Colorado Energy Office highlight the diversity of approaches to saving energy, reducing environmental impact, and improving the energy economics for Colorado farms.

Anaerobic digestion implementation at dairies in Colorado

Darlene Steward, Elizabeth Weber, Laura Supple



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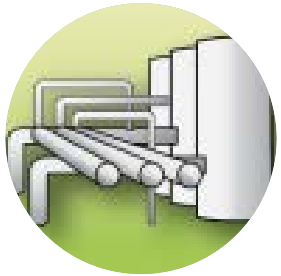


Electricity

Supply the dairies' electricity (including digesters) +
1.1 – 1.9 MW excess to the grid

CHP Heat

Supply the dairies' heat and hot water needs and heat the digesters

RNG

After upgrading, over 170,000 MMBtu renewable natural gas produced per year

Milk Trucks

Less than 7% of the upgraded RNG would supply the milk truck fleet.

Digestate

Over 90% of pathogens are destroyed, resulting in many beneficial uses

Generate Electricity or Upgrade to Renewable Natural Gas (RNG)?

Electricity generation should be considered if:

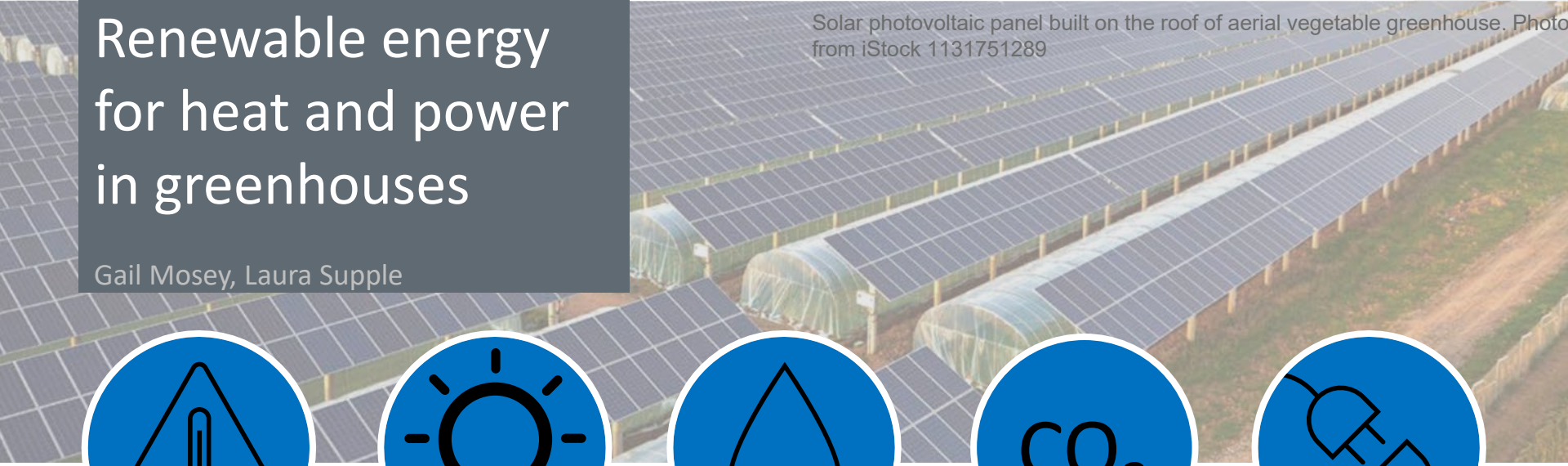
- Electricity is large fraction of farm expenses or is unreliable, and/or
- The farm can take advantage of an incentive for using or producing renewable electricity, and/or
- The waste heat from electricity generation can be used onsite to replace fossil fuel heating.

Upgrading to RNG should be considered if:

- There is a nearby connecting point to a natural gas pipeline.
- Or there is a nearby CNG station or there is demand for a CNG station.
- The farm is unable to take advantage of incentives for renewable electricity generation.

Renewable energy for heat and power in greenhouses

Gail Mosey, Laura Supple



Solar photovoltaic panel built on the roof of aerial vegetable greenhouse. Photo from iStock 1131751289

Temperature

Maintaining the temperature accounts for most of the energy demand in typical greenhouse construction.

Light

Different crops require different amounts of photosynthetically active radiation (PAR, 400-700 nm).

Humidity

Maintaining proper humidity is a critical function of heating, ventilation, and air conditioning equipment.

CO_2 concentration

CO_2 concentration directly influences plants' photosynthetic rates.

Mechanical

Energy is used for pumps, sprayers, mechanical harvesters, vents, curtains and other control equipment.

Solar Technologies and Greenhouse Lighting Needs

The type and configuration of solar panels can be selected to provide the right amount of shading

- Semitransparent bifacial panels reduce shading from panels.
- Organic PV cells can be designed to use non-PAR wavelengths for electricity generation, allowing PAR wavelengths through (new technology).
- Dynamic PV shading controls move PV panels to increase or decrease shading.
- Checkerboard configuration provides more even lighting for crops.

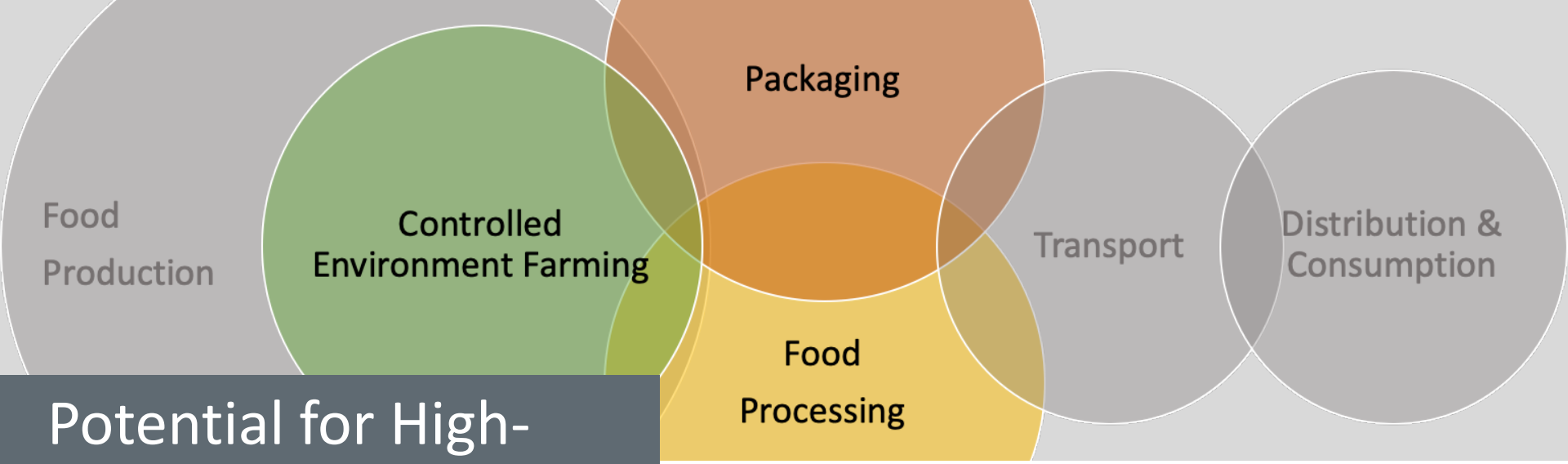
Photovoltaic solar panels installed on a greenhouse. Photo from iStock 1207270991

Key Considerations

The specific requirements of crops, cultivation, and climate should be the starting point for evaluating solar technologies and strategies.

- Thermal regulation typically accounts for the majority of energy demand. Hybrid systems can improve thermal and electrical efficiency.
- Passive technologies are most easily implemented in the design phase.
- Newer technologies such as organic PV cells require further development to be economically competitive.

Greenhouse interior. Photo from iStock 950588546



Potential for High-Impact Analysis?

- Integrate energy systems to maximize efficiency, use of waste heat and opportunities for renewables
- Valorize benefits/ disbenefits such as water use, waste disposal, resilience, and animal welfare
- Consider novel strategies such as on-site processing and smart sensors to capture energy benefits

NREL/PR-6A50-82583

For more information on this work, see our reports:

- Anaerobic Digestion Implementation at Dairies in Colorado, https://www.nrel.gov/docs/fy21osti/80381.pdf
- Renewable Energy for Heat and Power Generation and Energy Storage in Greenhouses, https://www.nrel.gov/docs/fy21osti/80382.pdf

Thank You

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