Energy for Future Food Systems: Controlled Environment Agriculture

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The American Council for an Energy-Efficient Economy is a nonprofit 501(c)(3) founded in 1980. We act as a catalyst to advance energy efficiency policies, programs, technologies, investments, & behaviors.

Our research explores economic impacts, financing options, behavior changes, program design, and utility planning, as well as US national, state, & local policy.

Our work is made possible by foundation funding, contracts, government grants, and conference revenue.
Controlled environment agriculture (CEA)

"is production of plants and their products, such as vegetables and flowers, inside structures such as greenhouses. By using CEA, we can produce high value crops at maximum productivity in an efficient and environmentally friendly way."

University of Arizona, Controlled Environment Agriculture Center
Drivers of CEA Industry Growth
Market Preferences

- Consumers
  - Year-round produce availability
  - Quality
  - Food safety
  - Organic and local food movements
- Retailers
  - Increased quality and variety of products
  - Longer shelf-life in store → fridge-life in home
- Restaurants
  - Local, farm-to-table
  - Specialty produce: custom herbs, microgreens, delicate produce
Changing Business Models

- Overcome limitations of climate and seasonality
- Improve product quality, consistency, yields
- Meet demand for specialty produce
- Expand value-added product offerings
- Reduce acreage
- Minimize risks common to food production
  - pests
  - drought
  - product safety
Urban farms
- Equity and sustainability in economic development
- Job creation
- Equity and fresh food access
- Revitalization and brownfield redevelopment

Technology advances
- LED lighting
- Variable speed, integrated HVAC & dehumidification
- Sensors & controls
- Robotics
- Artificial intelligence
Energy Use in CEA: Opportunities and Challenges
Energy use data is limited

- EPRI study estimates
  - Container farm: 45 MWh/yr
  - Vertical farms: 8,700 to 70,000 MWh/yr
- Estimated 10-60% of facility costs

Energy use intensity (kWh/sf/yr)

- Outdoor
- Conventional Greenhouse
- Greenhouse w/ night dehumidification
- Air-conditioned greenhouse
- Warehouse

10-70
100-200
160-500
200-800

Source: Dr. Greenhouse 2020
Reducing energy impacts

- Lighting
  - DOE estimates 40% savings nationally from LED adoption (2.3 TWh/yr)
  - Case studies validate savings
  - Efficiency differentiation among LED products emerging

- HVAC and dehumidification
  - Integrated systems for large facilities
  - Fans, shading and other techniques
  - Best practices emerging

- Distributed energy resources
- Flexibility in time of use
- Facility level energy management
- Energy use benchmarking
Comparing CEA to conventional agriculture

• CEA makes sense for a limited set of crops: higher value, specialty, delicate
• Energy intensity of CEA is a challenge, energy efficiency and DERs present significant opportunities to reduce impact
• CEA offers opportunities for significant reductions in water, pesticide, land use
• Rural communities: economic development through diversification of farming and expansion into processed/value-added agricultural products
• Urban communities: CEA for economic development and increasing access to healthy food in underserved communities
• Robotics and automation in CEA may limit job opportunities
• CEA may reduce energy use associated with long-distance freight movement: transportation fuel, food storage, added packaging

It’s an emerging market and we have a lot to learn!
Thank You!

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