EPRI ELECTRIC POWER RESEARCH INSTITUTE

ELECTRICITY REINVENTING AGRICULTURE

Insights from EPRI's Ongoing Research Into Indoor Agriculture

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Today, the world's population is approximately 7.5 billion and is estimated to reach 9.6 billion by 2050, with approximately 80% of that population living in urban areas. As the population increases, there are challenges associated with land constraints and resource availability. These population growth challenges coupled with the diminishing availability of additional usable farmland in the world today, shed light on the need for new and innovative means of producing and delivering food using traditional agriculture or indoor agriculture.

Indoor agriculture facilities could potentially provide a reliable means of producing crops near the point of consumption. When successful, indoor agriculture facilities can deliver fresh, high-quality produce to local/regional consumers while reducing the logistics of produce delivery and dramatically lowering the amount of water used per plant.

It is possible to produce a wide range of crops indoors using indoor agriculture. Currently, however, the economics of indoor food production does not lend itself to long shelf lives or low cost per pound value crops. As a result, most attention and research related to indoor agriculture is focused on niche high-value crops while field farming will continue to produce fresh produce, grains, and long shelf life products for the foreseeable future. Thus, indoor agriculture can augment outdoor production in some cases.

Though the indoor agriculture industry primarily focuses on specific crops today, it is expanding. Based on some estimates, the indoor agriculture marketplace is expected to increase fourfold in the next few years worldwide. Much of this increase in indoor agriculture market share is likely to be driven by an increased focus on sustainability and customer demand for local produce.

Currently, there are several types of indoor agriculture facilities in use, with the most common emerging forms being :

- Augmented greenhouses: greenhouses that use electric lighting to augment daylight
- Container farms/pod farms: converted 320-square-foot shipping containers that use electric lighting, HVAC, and other systems to create a microclimate for plant growth
- Vertical farms: converted warehouses or custom buildings with lighting, HVAC, and associated technologies that create stacked growing environments for plant growth

Regardless of indoor agriculture facility type, a range of technologies including electric lighting, modern building management systems, advanced thermal and pumping systems, and innovative water delivery and recovery systems can be used to create a microclimate to maximize crop production. Advances in these technologies, driven by non-agricultural applications, also supports their use in indoor agriculture where the technology innovations can help improve the yield of a variety of fresh crops.

INDOOR AGRICULTURE BENEFITS INCLUDE:

- Controlled, optimal growing environments that maximize the use of interior space (horizontal and vertical), allowing for additional annual crop cycles and increased yield per square foot of production, regardless of climate and location.
- Opportunity for drastically reduced water use per plant by recovering and recycling water runoff. Depending on the type of crop and facility, water savings associated with indoor agriculture may be between 70% and 90%, over field-based agriculture.
- Reduction or elimination of herbicides and pesticides used in crop production, also reducing water waste chemical discharge.
- Economic development through local jobs creation and utilization of empty land or under-utilized buildings—in rural, suburban, or urban areas.

These elements of indoor agriculture limit the potential introduction or imbalance of harmful insects and diseases within the production facility. Note, though indoor agriculture reduces the risk of foodborne diseases due to its controlled nature, all produce should still be washed before preparation and/or consumption.

Challenges in indoor agriculture include the cost of production (including high startup costs, energy costs, labor costs, and others), access to food distribution networks, lack of trained farmers, and lack of consumer education regarding the benefits of indoor food production. These factors combine to result in a high failure rate for indoor agriculture facilities in many cases.

The complexity, variety, and emerging nature of the indoor agriculture industry results in numerous knowledge gaps, questions, and challenges for the R&D community to address. As a collaborative research institute focused on electric sector research issues with a public benefit charter, the Electric Power Research Institute (EPRI) is uniquely positioned to address these challenges. As such, EPRI has assembled an internal team of expert researchers from the electrification, energy efficiency/end use, sustainability, water, and environmental programs and engaged with leading industry experts to address a range of topics related to indoor agriculture. Through market surveys, research partnerships, and scouting activities, along with lab research and collection of field data from operational indoor agriculture facilities, the team's primary areas of indoor agriculture research are:

- Operational nature and characteristics of indoor agriculture technologies
- Facility (and associated technologies) energy use and load profile
- Overall industry and facility sustainability
- Facility siting considerations
- Facility and industry water use and water discharge characteristics
- Environmental impact
- Economic development opportunities—local jobs
- Plant biology considerations

This ongoing research effort is laying the groundwork to fully understand the operational nature, challenges, potential impact, and opportunities of the emerging indoor agriculture industry.

Figure 1. Leafy greens with vertical LED lights in a container farm

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