In The Field

Powering a Sprouting Industry

Indoor Agriculture May Offer an Efficient Solution for Future Global Food Needs

By Chris Warren

An indoor agriculture facility.

In the foreseeable future, farming may move indoors.

Agriculture's traditional reliance on more acreage for more products may not be adequate for much longer. By 2050, the United Nations estimates that the global population will reach 9.8 billion—up from 7.6 billion in 2017. Providing food for the additional 2.2 billion people could strain natural resources. According to the World Bank, agriculture uses 70% of freshwater resources in most of the regions of the world, and a University of Sheffield study reports that available land suitable for growing crops has decreased by 30% over the past 40 years. The drive to increase production per acre has made the use of fertilizers, pesticides, and herbicides in field agriculture a growing contributor to freshwater contamination.

The emerging indoor agriculture industry uses electric lighting to augment natural light or provide all light necessary for crop growth. Greenhouses, old

warehouses, shipping containers, new construction, and other indoor facilities are typically equipped with lighting; heating, ventilation, and air conditioning (HVAC) equipment; electric pumps; and building controls. Through recycling they reduce water use and discharge. They eliminate fossil-fuel-powered farm equipment and reduce the risk of polluting rivers, streams, lakes, and oceans from fertilizer and pesticide runoff. Their controlled environments also can help prevent plant diseases. Most indoor facilities grow vegetables and fruits in coconut husks, cloth, or other growth media, reducing or eliminating the use of soil.

Field-grown lettuce can travel hundreds or even thousands of miles from farm to table. Indoor farms close to consumers in or near urban centers reduce fossil fuel emissions for transport, potentially increasing freshness and shelf life. "If lettuce is picked the day before you buy it, it can taste fresher, have a longer shelf life, and is less likely to be thrown out," said EPRI Senior Technical Leader Frank Sharp, who leads EPRI research on indoor agriculture and its implications for the electric power industry.

Some countries have already scaled up indoor agriculture. Although The Netherlands is only 41,543 square kilometers compared with the United States' 9,833,517 square kilometers, it is the world's second-largest food exporter, driven by its advanced greenhouse industry. After the Fukushima-Daiichi nuclear accident contaminated significant farmland, Japan aggressively repurposed factories and warehouses as indoor farms. EPRI estimates that in the United States today, there are fewer than 50 vertical farms greater than 10,000 square feet. This number is expected to increase significantly in the near future.

CULTIVATING U.S. INDOOR FARMING

Different plants grow best when exposed to specific light spectra, including non-visible spectra. Since 2012, EPRI has been examining aspects of horticultural lighting technologies, such as spectral output, potential effectiveness at enabling crop growth, and energy consumption.

New EPRI Whitepaper

Indoor Agriculture: A Utility, Water, Sustainability, Technology and Market Overview

"In recent years, we have measured visible and non-visible spectra of lights potentially used in indoor agriculture, including high-intensity discharge, induction, light-emitting plasma, LED, and fluorescent. We have gained insights on how certain light sources may impact plant production," said Sharp. "Plants need ultraviolet and infrared light,

though the optimal lighting requirements vary from one plant species to another."

Indoor farms may have large electric loads such as lighting, pumps, heating, cooling, environmental sensors and controls, and (potentially in the future) crop-picking robots. EPRI is examining how utilities can engage effectively with these facilities, municipalities, and local organizations to support indoor farming operations.

"EPRI is working to inform utilities on how best to work with farms, communities, economic development agencies, and other stakeholders on issues such as siting, grid impacts, load profiles, and grid infrastructure," said Sharp. "Utilities need to understand the scale and power consumption of indoor agriculture. In some cases, there may be a need to build new substations or other grid infrastructure, or there may be an opportunity to convert an inactive industrial site to an indoor farm because it already has the necessary infrastructure."

A recent EPRI study on indoor agriculture examined crop yields, sustainability, energy and water consumption, the economics of various fruits and vegetables, and potential opportunities for load shifting . "For indoor farms today, it can make economic sense to grow leafy greens, strawberries, herbs, tomatoes, and other high-value crops that can be stacked or grown vertically and that have a short shelf life," said Sharp. "Though corn, wheat, and other row crops can be grown indoors, it is not economically viable to do so today because they have a low price per pound, have a long shelf life, and their production cannot be easily stacked."

According to Sharp, both indoor and outdoor agriculture are essential to future food production. "The model that appears to be developing is indoor cultivation of high-value, short-shelf-life crops and outdoor cultivation of low-price-per-pound, long-shelf-life crops," he said. "This is likely to continue for the foreseeable future."

Recently, EPRI launched a project to gather energy data on U.S. indoor agriculture facilities. Through site audits and smart meter monitoring, researchers plan to evaluate how energy loads, water use, and sustainability vary across different crops, facilities, and locations.

Another new EPRI project will evaluate how climate affects indoor farms' energy consumption, water use, sustainability, temperature and humidity, and other key operational parameters. "On most days, an Eastern Tennessee indoor farm will operate differently from one in the Southwest, as a result of different climates. However, in a given year, both climates bring to bear high- and low-temperature days and high- and low-humidity days," said Sharp. "By collecting data from farms throughout the United States, this study will help utilities understand how daily differences in outdoor temperature and humidity affect farm operations. This can help utilities to forecast load and assess the potential for load flexibility."

This research also will examine the facilities' incoming and outgoing water and carbon dioxide (CO_2) levels. "To drive higher yields, many farms maintain higher-than-normal CO_2 levels by burning propane or using bottled CO_2," said Sharp. "If the outside air is already high in CO_2, they may need to produce or purchase less CO_2 for the farm, which means lower costs."

Indoor farms offer significant potential to reduce agricultural water use, benefiting society and the environment. "Water is going to be a key driver in future discussions about energy and sustainability in many communities around the world," said Sharp. "Indoor agriculture offers a tool that can enable communities and society to use water more effectively and efficiently."

Short term, Sharp expects continued growth in the indoor agriculture industry. Long term, he sees potential for indoor agriculture to augment outdoor production of fresh produce and help feed growing populations.

"Our role is to provide objective analysis," said Sharp. "We are informing utilities about various aspects and potential impacts of indoor agriculture, enabling them to partner effectively with this growing industry."

KEY EPRI TECHNICAL EXPERTS

Frank Sharp