Organic certification for indoor vertical farms

by

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Abstract

The indoor vertical farming industry is growing globally. The proponents for acceptance of indoor vertical farming by organic certifying bodies say producers follow the current guidelines and should receive certification. Opponents believe the lack of a soil environment and the natural light that accompanies it makes indoor vertical farming outside the spirit of the organic guidelines. An alternative to certification could be to create new classifications for indoor vertical farms.

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Introduction

The indoor vertical farming industry in the context of what constitutes organic methods of production is currently in a state of limbo. Indoor vertical farming as it is currently widely practiced, takes place indoors exclusively but is possible outdoors as well. Vertical farming is defined as a method of production involving vertically stacked layers of plants in various structures. (Federman, 2021) The most popular modern methods also involve growing indoors, soilless media such as hydroponics or aeroponics, and climate control. For the remainder of this document, we will call this method of production indoor vertical farming.

Organic farming has a set of requirements put forth by certifying bodies and the USDA. Please see Table 1 below for more detail on the requirements of the USDA for organic crop production. An indoor vertical farm operation may want to gain organic certification as the profit margin for organic products is frequently higher than conventionally produced crops (Oberholtzer & Greene, 2012). The USDA organic requirements, which differ from conventional farming regulations, generally hold that chemicals should be restricted to a USDA approved list, no genetically modified seeds or plants can be used, and that the land being used for organic production has not been used for conventional production for at least three years (McEvoy, 2022). Conventional farming, as opposed to organic farming, does not restrict any method of production if the methods employed are within the bounds of federal and state law governing land use and chemical use ("Summary of the Federal Insecticide, Fungicide, and Rodenticide Act | US EPA", 2022). Indoor vertical farming can make certain requirements irrelevant. Some examples of this are ecology requirements and soil health. Indoor vertical farming typically does not use soil and the ecology of the indoor portion of a building is nonexistent. Proponents of indoor vertical farming acceptance by organic certifying bodies say indoor vertical farms follow the current organic guidelines and should receive certification without any issue (Moore, 2019; Organic Production and Handling Standards, 2022). Opponents believe the lack of a soil environment and the life that accompanies it put indoor vertical farming outside the spirit of the organic guidelines. Both indoor vertical farms and consumers need clarity on these guidelines to make the choice that fits their desires and ideals (Moore, 2019). A solution could be to create an organic classification for indoor vertical farms. The objective of this creative component is to educate and inform students, consumers, and industry about the status of indoor vertical farming in the USA and other countries.

Differences and Regulation in Indoor and Conventional Farming

The largest differences between indoor and conventional farming are that the sun, soil, weather, and competing flora and fauna are not present (Garg, 2014). Natural pollinators, in the traditional organic paradigm, are missing in indoor vertical farming. However, this will be irrelevant since artificial solutions can be employed for crops that require cross pollination. Examples of natural pollinators are bees and other insects.

Supporters of organic agriculture would say that bees alone are essential to our survival as a species and should therefore be included in the requirements for organic certification. Those on the other side of this argument would say crops typically grown by the industry, such as lettuce and other greens, do not rely on pollinators since they are harvested before flowering.

In indoor farming, soil is not typically present and the plants are grown in a hydroponic solution. (Beacham et al., 2019) The industry is generally in favor of approving hydroponic systems as the National Organic Standards Board voted not to ban these methods from certification (Gilmour et. al., 2019). Hydroponics is the cultivation of plants in media other than soil using a nutrient solution, and usually takes place indoors. Examples of these alternative media are expanded clay, peat, and gravel. A nutrient solution is mostly a blend of nutrients in water. This method is often used by those studying nutrient deficiencies as one can easily change the nutrient solution ratios during mixing and blending.

Light sources are another point of contention as the Sun's rays are replaced by LED bulbs and the light spectrum required by plants is replicated and optimized. There are no cloudy days in an indoor facility therefore weather is not a variable factor indoors. Weeds and insects, both beneficial and harmful, are significantly less of a problem with the indoor vertical farm system during ideal operation. (Roberts et al., 2020) Many organic traditionalists argue that the absence of these factors justifies why indoor vertical farms should not be called or certified organic even though as the rules and laws currently read, all requirements are technically met by indoor vertical farms.

The primary issue that opponents have is that indoor vertical farms do not have a soil environment to contend with, foster, and manage. The question of whether this is a problem should be resolved for the producer's clarity in the parameters of their operation. The objectives of most advocates of organic farming are to produce safe, nutritious, and sometimes genetically specific products. These can all be achieved with indoor vertical farming. The requirement that an organic producer must have soil is one that does not make a product safer or more nutritious. See Figures 1 and 2 for a basic visual of an indoor vertical farming operation.

Figure 1. Shelf configuration for lettuce in an indoor vertical farm (Photo courtesy of Benke & Tomkins; Sky Greens 2017).

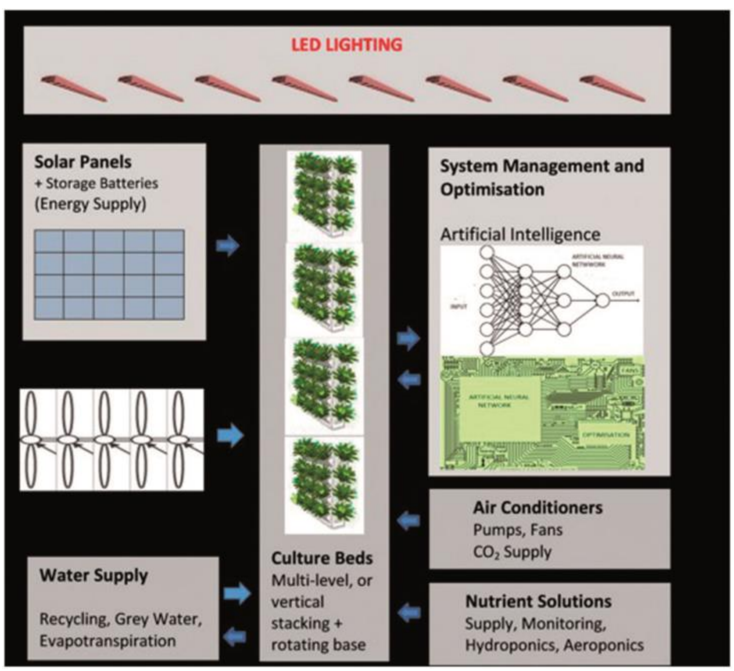

Figure 2. Layout for an indoor vertical farm. (Photo courtesy of Benke & Tomkins, 2017)

State of the Industry

The indoor farming industry is growing each year and new companies have formed totaling an estimated $250 million in market share (Grand View Research, 2021). Some companies claim to produce 400 times more than conventional farms and these statements are not fully substantiated but the operations are without a doubt more space efficient. (Malewar, 2021) Many of these companies have gone through serious growing pains like pathogen outbreaks and lighting adjustments to match the required spectrum so the plants can grow properly. These companies have experienced issues with pathogens and culture, many of which are related to a lack of ventilation, proper lighting, and contamination/sanitation problems. Poor ventilation causes the plants to develop improperly as a certain amount of stress is required for plants to grow as expected. Gibberellic acid is released under this stress and moves to different parts of the plant regulating elongation in the stem and other parts of the plant. (Gupta & Chakrabarty, 2013)

Plants may become elongated or weakened without artificial ventilation providing this beneficial stress. Ventilation also reduces humidity/standing water which are potential catalysts for disease. Plants require certain wavelengths of light to develop and it is easy to replicate without regard for power consumption. LEDs allow the reproduction of the important wavelengths with little waste of power and at high intensity (Perez, 2014), or mimicking and manipulating such wavelengths for improved plant growth and development. Red (660 nm) and blue (440 nm) wavelengths are most important and optimum levels of each change slightly based on what is being grown (Coić et. al., 2017, Darko et. al. 2014). Sanitation and contamination have been a concern especially when the nutrient and light needs of the plant are not completely met. As ventilation and lighting have been optimized, sanitation has also improved and the plants can handle more outward stressors. Some companies have worked through these challenges and are beginning to produce.

Hub and spoke indoor vertical farm operations

Plenty is an Amazon backed company that has been working to expand into the greens market. The company uses large towers with tiers of troughs for the plants. There is a network of lights and plumbing for the plants. Plenty uses a hub warehouse model to distribute their products which include kale, arugula, mizuna mix, and lettuce. They have relocated and shut down locations at least twice, closing a hub in Kent, Washington and opening another in Compton, California. Their other location is in the Bay Area near San Francisco, California (Plenty, 2021).

Kalera is an Orlando, Florida based company that uses automation in a multi-tiered, climate-controlled environment to produce lettuce and herbs. Produce is distributed from hubs to grocers. This company is working on using data to drive further improvement in their process (Kalera, 2021).

AppHarvest is a Kentucky-based company that grows greens and vegetables. They utilize data, recovered rainwater and a multi-tiered climate-controlled production method. The location was chosen due to its proximity to major population centers. It operates as a large hub in a rural environment which ships to large cities (AppHarvest, 2021). In the US, indoor vertical farming has grown in popularity two-fold in the last two years. Many companies are not more than two to three years old.

Bowery Farming is based in New York and operates in both New Jersey and New York. It was founded in 2015 and follows a hub and spoke distribution model. The plants are grown in racks and shelves and moved around by conveyors with human assistance. This company is selling in large box stores like Walmart and Albertsons. Bowery Farming's products include lettuce mixes and other herbs (Bowery Farming, 2021).

CropOne is a United Arab Emirates based company that uses a multi-tiered method of climate controlled growth. This company focuses on using data (light spectrum optimization, solution levels, and growth performance) they gather on plant development to continue improving the operation in terms of seed to head production and input efficiency. There is a facility in Massachusetts that produces lettuce for the local area. They use a hub and spoke distribution method for their product (CropOne, 2021).

Unique Approaches

Infarm takes a different approach to growing their product in that the growing areas are highly decentralized and maintained by outside technicians in grocery stores. These stores include Whole Foods, Marks & Spencer, Aldi, and Kroger. The company began in 2013, and management is based in Berlin, Germany. Infarm grows starter plants at warehouses and then distributes the young plants to the display cases in grocery stores. The plants, which include a range of herbs like basil and oregano, continue to develop in modules with proper lighting and nutrient solution in the store's display and development cases (Infarm, 2021).

Aerofarms was founded in 2004 in Newark, New Jersey and utilizes an aeroponic system to grow plants in large shelf racks with lights on each tier. Aerofarms also employs a warehouse-style distribution. Aeroponics is the growth of plants by keeping a routine spray of nutrient solution on the roots of the plant. In this case, the plants are anchored by foam. Aerofarm's products are found in Whole Foods, Walmart, and Amazon Fresh among others in the New York and New Jersey area (Aerofarms, 2021).

Gotham Greens takes a unique approach to vertical farming in that they build on top of existing buildings and have single tier for production. These greenhouses reclaim areas like rooftops that would not otherwise be used for any other purpose. The power is provided by wind and solar. These facilities provide produce in an urban food desert and fresher options for urban dwellers at a lower cost. This company is based in the New York City area (Gotham Greens, 2021).

Government and Regulatory Status

The major point of contention for those against the certification of indoor vertical farms is that there is no soil or the soil is sterile (Perez, 2014; Moore 2019). Sterile soil or media has little or no bacteria or life in the soil or media to help or hinder plant growth. Organic proponents hold that the soil in an organic farm must have and foster life. This advantage is directly at odds with some of the ideals of organic farming (Perez, 2014). Greenhouses, which can receive organic certification use natural and supplemental light while indoor vertical farms use only artificial light. Some organic advocates argue that natural light is an implied condition for an organic operation. Indoor farms are not part of the ecosystem. They are completely contained and do not interact with the environment. Certifying bodies are approving facilities as of this writing (Primus Labs, 2021). These facilities have plants growing in containers in large well-lit warehouses using inputs from stock tanks indoors. Certifying bodies such as Primus is a very popular agency and has grown in recent years with the organic farm industry. Table 1 below displays a breakdown of the USDA requirements of an organic operation and how an indoor vertical farm can meet them all. Note that this is only what the USDA requires. Most certifying agencies have more requirements which vary between each company. Based on this table, a greenhouse operation can be certified organic and an indoor vertical farm can meet the same requirements that a greenhouse does.

Table 1. Requirements for an organic operation. (Organic Production and Handling Standards, 2022)

Organic greenhouse operation requirements	**Indoor vertical farm methods to satisfy organic requirements**
Prohibited substances may not have been used within 3 years of harvest of an organic crop.	This requirement is satisfied since the land is not used to produce the crop.
Only animal and crop waste, with some permitted synthetic materials may be used as fertilizer.	Most of this requirement does not apply. The fertilizers used can be sourced within the bounds of this regulation.
Pest and weed control must adhere to a national list which includes physical, mechanical, biological, and botanical, as well as approved synthetic substances.	Control of pathogens and pests should not be an issue if the operation is running properly. If there is an issue, the methods and chemicals employed would be in line with the regulations.
Limit plant material to organic seeds and other available planting stock.	Indoor vertical farms can use organically produced seeds.
Technologies that can alter DNA, such as genetic engineering, and ionizing radiation, and sewage, must not be used.	Indoor operations can avoid these methods.

Potential Solutions to Certification

Potential solutions to certifying indoor vertical farms as organic could include a separate certification. However, the USDA already voted on the question of organic certification for vertical farms and recommended that hydroponic farms not be banned from organic certification. The result of this vote does not exclude indoor vertical farms but does not include in any way either. This ambiguity leaves room for opportunity as well as problems since it does not define or codify any rules or guidelines for organic certification and leaves open the possibility that in the future this question can be further explored and debated (Gilmour et. al., 2019). This issue was not listed as an open item or to be discussed/voted on in the USDA National Organic Standards Board Meeting Agenda as of 2020 (USDA 2020). Currently, there is no public information on efforts to clarify, define, or codify the issue further now and this leads to legal gray areas and opens companies up to potential litigation.

Industry Perspective

Several indoor vertical farming operations in the industry addressed the question of organic certification of indoor vertical farming, by responding to questions as detailed in examples below. Aerofarms, to the question "Is your product organic?" that illustrates the inconclusive nature of an organic certification for indoor vertical farming now and how private industry is handling the situation:

Is your product organic?

"Not yet. The United States Department of Agriculture (USDA), the government body that oversees organic certifications, has been inconsistent in its evaluation of soilless methods of farming. We meet all criteria for organic certification. In fact, we go further by being more land

and water efficient, and by using methods that do not contribute to any kind of dangerous run off." (Aerofarms, 2021)

Infarm and Plenty avoid addressing organic certification outright but, Infarm alludes to organic certification in their FAQ on its website with the following.

Q. What about pesticides, herbicides and GMO?

"At Infarm, we never use treated or genetically modified (GMO) seeds. And we don't apply any chemical pesticides, fungicides herbicides or growth hormones to our plants at any point. We always use untreated seeds and when available, organic seeds to deliver our plants." Both responses from these two companies show the desire of the private indoor vertical farming sector to use an organic certification. The nuances of this can be exploited since a producer could grow a crop using all organic methods with seed that is not necessarily an organically produced seed, but from a transgenic variety." (Infarm, 2021)

Consumer Perspective

Proponents of indoor vertical farming maintain the primary benefits are that supply chains and logistics are made shorter and have less waste. A supply chain is the series of touchpoints a product must go through to reach consumers. Logistics are the methods the supply chain utilizes to move goods to the consumer. The reduced use of shipping lines and logistics lowers carbon footprint and financial impact for a company moving products. An indoor vertical farm in an urban area is the best example of this reduction in transit time and distance. The consumer also benefits from a fresher and higher quality product. The size of an indoor vertical farm is also an advantage because the product per acre has the potential to be much higher since the form factor is compact and built upward rather than outward and sprawling. Current supply chains sometimes involve thousands of miles and many modes of transportation. A shorter and more local solution is good for the producer because they will be able to fetch higher prices as assumed waste will fall. The consumer will receive higher quality and fresher product and ideally, produce less waste as they buy only what is necessary. (Jürkenbeck et al., 2019)

Benefits to Society

The planet will benefit the most from reduced transit and carbon release which benefits all. In places like California, many popular vegetables are grown relatively nearby yet shipped in from other locations. The most striking example is grapes with a locally grown distance of 134 miles from the urban market area and the option to buy grapes that are grown an average distance of 2,143 miles away (Anonymous, 2021 https://cuesa.org/learn/how-far-does-your-food-travel-get-your-plate). A great deal of resources has been expended on moving those grapes to the market. It is estimated that we put ten calories of fossil fuel energy to produce and deliver one calorie of food. The carbon that is released to move these grapes is not necessary. On average, a meal travels 1500 miles from the field to the table. Importing produce is a necessity for some countries but nearly every country has some sort of market for commodity trading and large-scale brokers for produce. (Federman, 2021) In the short term, this is good business to exploit these inefficiencies but long term, this is crippling our future and making weaker economies worse due to these artificial market forces (Anonymous, 2021 https://cuesa.org/learn/how-far-does-your-food-travel-get-your-plate). Caribbean countries like Jamaica can produce their own food but the local farmers cannot compete with the proximity, volume, and price of, for example, US-produced chicken. Crop subsidies and other market forces allow US producers to market a chicken at a much lower price than a Jamaican farmer. Local indoor vertical farms have the potential to alleviate all the above problems. Once infrastructure is established, indoor vertical farms can provide the local population with higher quality produce and some of the minimal food waste can be used for small scale livestock rearing or compost. (Jürkenbeck et al., 2019) Figure 3 below shows why minimal food waste and maximum land use is important.

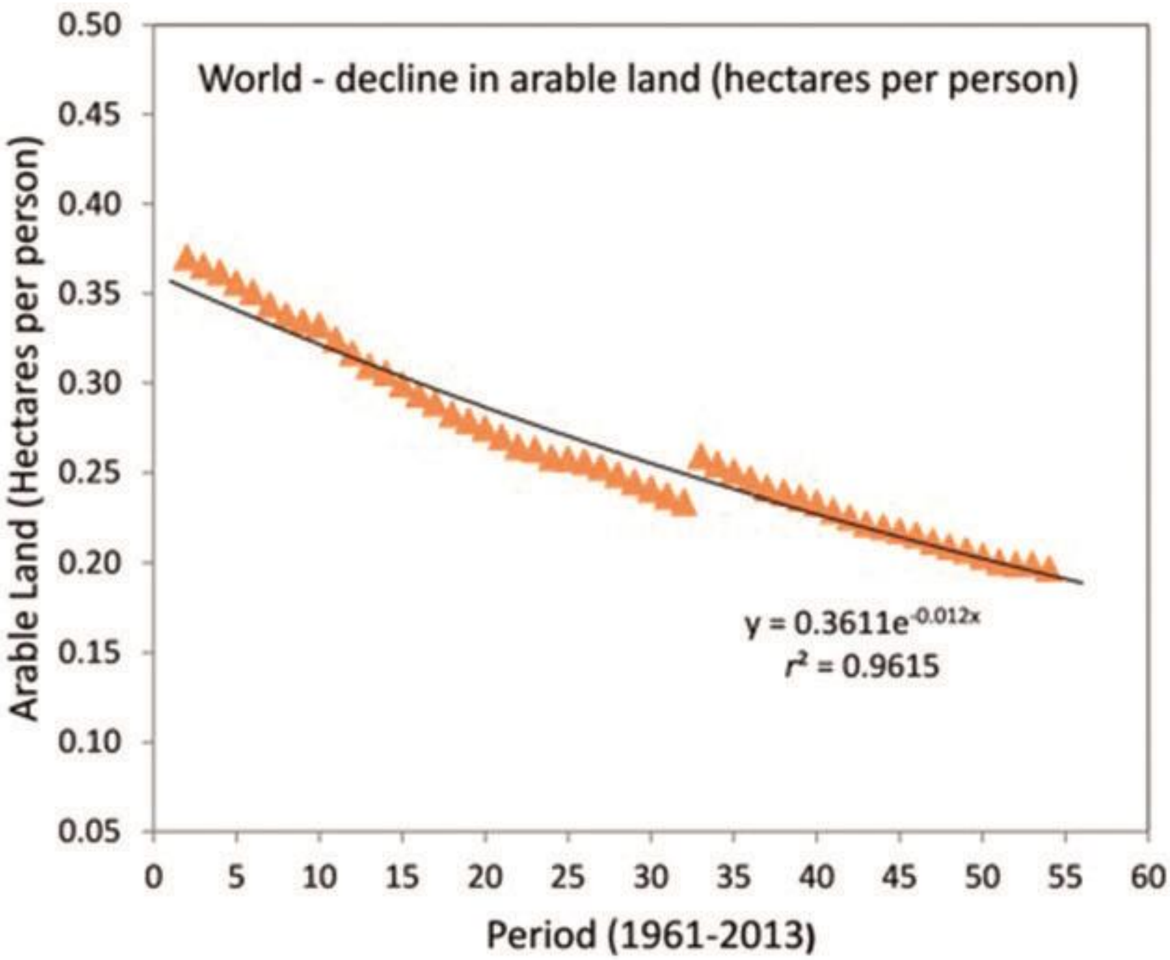

Figure 3. Decline of stocks of arable land in the world over the period 1961–2013. Indicative trend line calculated using data from the United Nations Food and Agriculture Organization (FAO 2016; Chart courtesy of Benke & Tomkins, 2017).

Applications of Indoor Vertical Farming

As indoor vertical farming technology continues to mature, many applications on and off planet exist. Space travel and life in space, the moon, mars and other planets, and the asteroid belt will rely on the work that is being done on Earth today. Many designs will be tested and put forward but the most efficient and productive will be used off planet. Indoor vertical farming systems will likely be relied upon not only for food but for CO_2 scrubbing, waste treatment and reclamation, and potentially composite building materials. CO_2 scrubbing, which is the method used to process CO_2 into O_2 for breathing gas, would likely be handled by algae or kelp as they are some of the most efficient for converting CO_2. A plant like papyrus may be resurrected from ancient times as a useful composite in building with lunar regolith which is the dust and rock on the surface of the moon. The wastes from all life will need to be reclaimed as life off planet requires a certain level of resourcefulness and conservatism. Waste treatment would be performed though both natural and chemical means. Fungi and bacteria would help us process these wastes into components that indoor vertical farms would be able to utilize (NASA, 2018). Fungi could also be exploited for food in low or no light areas with proper conditions on a spacecraft. Indoor vertical farms will help fresh low cost produce reach urban areas with shorter field to plate distances. (Federman, 2021) (Kalantari et al., 2018)

Conclusion

Indoor vertical farms are going to become more commonplace in the coming years in the commercial sector. The ability of some producers to market their products as organic is also going to be in high demand due to the public's current general perception of organic being superior (Economic Research Service, USDA 2012), and willing to pay a much higher price than non-organic products, one of, if not the main motivation for indoor vertical farming organic certification. The producer can sometimes make a larger profit margin from an organic product. From a financial perspective, it is in the best interest of large certifying bodies to find a way to allow indoor vertical farming producers to market with the organic label. The certification process is paid for by the operations and this revenue stream is not going to be abandoned by most certifying organizations. Regulators would get involved when certifying bodies or consumers allege malfeasance. It is likely that organic farmers using soil would market their products as more “pure” or “natural” to distinguish themselves from indoor vertical farms and attempt to garner a premium due to this distinction (Moore 2019).

Greenhouses can be certified as an organic operation and this may be an avenue to acceptance for indoor vertical farms as they share many similar attributes. The major distinction remaining between a greenhouse and an indoor vertical farm would be the sterility of the soil and air. Based on this, many operations are being certified as of this writing (Moore 2019). Based on the USDA guidance on what constitutes an organic operation, there is no difference between indoor vertical farms and greenhouses.

The indoor vertical farming industry is moving forward with complying with and soliciting certifications from various certifying bodies. The concerned parties appear to be standard organic producers who are concerned about losing their market share (Gómez Tovar et al., 2005). Consumers appear to be unconcerned with certification as many are generally uneducated on the requirements for certification (Gilmour et al., 2019). There does not appear to be any premium for products produced through indoor methods at this time (Economic Research Service, USDA 2012).

The future for indoor vertical farming is uncertain. It will continue to exist in one form or another but what form factor/design methodology the industry will take is in dispute and in the test stages. The goal for many in indoor vertical farming is to be a part of city planning and supplement grocery stores in urban environments. Integrating indoor vertical farms into everyday life would be an incredible benefit to society if the difficulties of sourcing clean power, creating public awareness and acceptance, and breeding and developing optimized cultivars can be overcome.

Sourcing clean power is a challenge that varies depending on geographical location. Clean power is defined as power that produces no carbon and does not affect the ecology of the area where it is produced in an irreparable way. Washington and Hawaii have hydroelectric and solar, respectively, but Missouri does not in the same abundance. Solar in Hawaii is an excellent option once the upfront cost is undertaken, otherwise, the public power utility in Hawaii has the highest rate in the US (Jansky 2019). Sourcing power is the largest hurdle to getting indoor vertical farms in the mainstream. Public acceptance has not been an issue at the consumer level and some grocery stores are embracing these companies, with Infarm and the grocery chain QFC in the northwest are prime examples.

Breeding cultivars specifically for use in indoor vertical farms is exciting and presents many challenges. Cultivars are varieties that have been developed for farmers. Since plants will not have to face inclement weather, one could breed for reduced cellulose and stem length to save energy for the more edible parts. Examples of this are wheat, soybean, and corn. The conventional farming industry is moving toward short stature corn. The indoor vertical farming industry can do the same and breed for a reduction in cellulose content in the stalk. Cellulose is what gives some plants their structure. There are many more exciting possibilities for breeders and their teams. (Federman, 2021)

The indoor vertical farming is a budding industry with great potential to society now and in the future if we can overcome the obstacles both real, such as production and design issues, and regulatory.

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