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IndoorÂ AgÂ and Advanced Wastewaterâ€“ request for information

Please find attached response to RFI 19-ERDD-01 from Resource Innovation Institute. Resource Innovation Institute (RII) is a non-profit organization whose mission is to advance resource efficiency to cultivate a better agricultural future. Founded in 2016 to address the resource impacts of indoor cultivation, RII is extending its services to a broader array of energy-intensive horticultural sectors. Its PowerScore resource benchmarking platform represents the worldâ€™s largest dataset on indoor agriculture energy use. Cannabis PowerScore uses specialized key performance indicators to measure and rank facilities by weighing performance metrics for energy efficiency and productivity. We are developing similar KPIs for other crops as part of our USDA project.

RIIâ€™s Technical Advisory Council is the leading multi-disciplinary body assessing the environmental impacts and best practices associated with cultivation resource issues. RIIâ€™s Board of Directors includes the American Council for an Energy-Efficient Economy (ACEEE) and a former board member of the US Green Building Council. RII is funded by governments, utilities, foundations and industry leaders.

Additional submitted attachment is included below.

To help us in the development of the solicitation, CEC staff would appreciate your responses to the following questions:

Area A: Advanced energy efficiency and load shifting in indoor farms

Indoor farm is defined here as a facility for growing crops under controlled environment twenty-four hours a day, seven days a week – lighting, nutrients, water delivery and heating/cooling. Unlike a greenhouse, an indoor farm uses artificial lighting as a primary source of light. Indoor farms include vertical farms.

The following will help us align our future solicitations with needs of disadvantaged communities:

a. Can indoor farms help solve some problems, such as food security, in low income or disadvantaged communities? What are the barriers that should be addressed to better address these problems?

Indoor farms have the potential to help solve food security and other challenges facing low income and disadvantaged communities in markets where there are disruptions in the supply chain caused by climate change and other issues affecting open-field agricultural practices. The main barrier to be addressed is cost of production, which is greatly influenced by energy expenses.

b. What technological advancements in indoor farms are needed to improve the availability of affordable fresh produce in LI/DAC communities and provide additional benefits-like jobs?

In general, indoor farming could benefit from research related to optimization of both resources (e.g., energy, water, etc.) and quality (e.g., aroma, taste, nutritional value). For example, there is targeted research being done by a small number of universities that are studying the impacts of LED lighting on terpenes and other plant expressions.

c. How could disadvantaged communities and private companies develop mutually beneficial partnerships? For instance, could it be viable for a private company that develops a technology platform for indoor farming to provide it at a discount to local communities? In exchange, these communities would train workforce for the platform and participate in testing new crops and technologies?

These types of partnerships are always possible. It is likely there are technology providers who are interested in contributing. What it takes for these efforts to succeed is a project manager who can facilitate shared objectives, hold participants accountable, and track/report overall project outcomes.

The following will help us target our specific research:

a. What is the typical breakdown of electric and natural gas use in indoor farms? How important is reducing energy costs relative to other costs?

The breakdown of energy sources used in indoor facilities varies by the location of the operation. Facilities located in areas with natural gas service may use gas to serve the building's HVAC system, while others with ample electrical service may choose to use electrically powered HVAC solutions. Some may elect to install combined heat and power systems if they are constrained in their electric service but have ample natural gas capacity available at their site.

In a study of cannabis cultivation facilities in Boulder, Colorado, natural gas made up as little as 2% of indoor facilities' annual energy use. In a study in Massachusetts, indoor cannabis operations' natural gas use for HVAC loads made up closer to 20% of annual energy use. Massachusetts facilities benchmarked in Cannabis PowerScore with complete electric and non-electric energy use data show natural gas usage accounting for 15% - 70% of total facility Btu; this variation is in part due to some facilities using hydronic HVAC systems with gas-fired chillers, with others using electric direct expansion equipment for cooling loads.

With energy comprising anywhere from a third to over half of operational expenses for indoor cultivation facilities, it is crucial for producers to reduce energy costs relative to other business expenses so that they can be more competitive while lessening their environmental impact. While reducing other business costs such as labor or materials may be important for operational resilience, reducing energy costs may create the most positive change for a cultivator due to the non-financial benefits that come with reducing energy costs. The efficient equipment and processes employed to reduce energy costs can better maintain target environmental conditions for plants and achieve greater yields.

b. What systems of indoor farms have technical potential for improvements in energy efficiency over the currently available best-in-class equipment? What is preventing growers from deploying these improvements?

- **Horticultural lighting systems**
- **Lighting controls systems (dimming, spectral tuning, integrated with HVAC controls)**
- **Split, packaged, and centralized cooling systems**
- **Standalone and centralized dehumidification systems**
- **Central plant equipment: boilers, chillers, heat exchangers, heat pipes**
- **Free cooling equipment like dry coolers**
- **Variable frequency drives for pumps and fans**
- **HVAC controllers**
- **Environmental sensing & monitoring equipment**
- **Environmental control strategies: temperature, humidity, airflow**
- **Building automation system infrastructure and software programming**
- **Integrated HVACD and lighting systems with automation**

- **Efficient industrial processes: drying/curing, conditioned storage, processing/extraction, packaging**

There are a variety of factors affecting growers, and some growers have multiple barriers to surmount:

1. **Some growers need restorative justice to enable them to access financing and business support programs that elevate cultivators of color and communities most impacted by cannabis prohibition.**
2. **Growers need available capital to invest in efficient equipment and navigate the learning curve, as their product is at stake when any cultivation process equipment is replaced, or any standard operating procedure is altered. Increased support from utility and efficiency programs are essential to buy down the first cost of high-performance systems, and a greater variety of financing options like on-bill financing and energy saver loans will increase grower participation.**
3. **Growers need education that meets them where they are via specialized curriculum delivered in diverse ways to allow for quick and easy access to programming to help them improve their operations, understand who can assist, and how to get help.**
4. **Growers respond well to recognition for achieving excellence in energy performance and productivity so the risks they take by adopting new and emerging technologies are rewarded with business benefits to brand identity and associated public relations, marketing, and sales.**

c. Is there an interest and feasibility of shifting the electrical load to be flexible to the electric grid, such as increasing electricity use when renewable energy is plentiful and decreasing when renewable energy is not available?

Most growers do not necessarily have an innate interest in load shifting or load flattening unless it will significantly impact their bottom line. While some producers are concerned about the carbon emissions associated with their energy, many do not understand the ways the fuel mix of the grid changes over the course of the day or year, and focus more on their operations' fuel mix at the facility level.

Load flattening can be feasible for growers, while load shifting can be less attractive depending on how often and for how long they are being asked to shift the load. Load flattening strategies like using energy efficient equipment and reducing coincident peak loads are reasonable for growers to incorporate into their business plans and Standard Operating Procedures.

Attitudes toward load shifting vary by approach; how a utility plans on growers decreasing their electricity use when renewable energy is not available would very much impact the feasibility of the request as perceived by the grower. For instance, if growers are asked to increase temperature setpoints or decrease light levels in cultivation areas, it will not be as reasonable of a request as asking for non-cultivation areas to have setpoints adjusted. In summary, temperature setbacks and lighting controls in cultivation areas are not feasible for mission-critical growing operations.

Flexible demand management approaches that allow utilities to directly control lighting or cooling equipment in facilities via building automation systems for demand response events are also not feasible for most growers, though some operators may be convinced with attractive economics.

Feasible load shifting opportunities in indoor facilities:

- **Lighting flowering rooms during off-peak hours (requires multiple labor shifts)**
- **Balancing flowering rooms (half the rooms are off when other rooms are on)**
- **Temperature setbacks in non-cultivation areas**
- **Lighting controls in non-cultivation areas**

d. Is there interest in developing, designing and operating zero carbon indoor farms? If so, are there examples of zero carbon indoor farms?

There is some interest in the architect/engineer/construction and supply chain/manufacturer communities in designing and constructing high performance indoor cultivation operations, but growers themselves are more concerned with other aspects of their business. Some of these aspects include whether their crops are grown using organic approaches, the productivity of their plants, and the harvest they get per square foot of their facility.

In order for zero carbon farms to be a goal of growers themselves, they must be shown what is in it for them apart from feeling more sustainable. Growers want to be able to be able to charge more for a zero-carbon crop, and in order to do so, certification systems need to exist to qualify and verify operations and their performance so operations can access the business benefits of being zero carbon.

RII is not aware of any zero-carbon indoor operations in North America. If there are examples of zero carbon indoor farms, how are any of them being proven to be so? What metrics would they use to demonstrate 'zero carbon' and where does the carbon assessment begin and end (limited to the site, or accounting for embodied carbon and carbon associated with the electricity they use from the grid)? What third party is recognizing zero carbon farms? If there is no third party, unverified claims could flood the market, much like 'greenwashed' cleaning products in the 2000s.

e. What technological research and demonstration activities are necessary to make indoor farming a cost-effective option?

Knowledge sharing is not yet common amongst indoor growers of both cannabis and non-cannabis crops, as production processes are intellectual property and some producers do not want to demonstrate their activities for fear of exposing their 'secret sauce'.

To assuage these concerns, funded studies of pilot projects using high performance equipment and strategies in indoor farms are necessary to show how cost-effective key performance indicators for efficiency and productivity can be achieved.

Funded studies that demonstrate emerging technologies like LED lighting and test the validity of energy savings claims and illustrate non-energy benefits are imperative to gaining grower trust and increasing adoption of cost-effective indoor farming equipment and techniques.

f. What are some crops that could be cost-effectively grown using indoor farms beyond "traditional" leafy greens, cannabis and tomatoes? What are current and future prospects of using controlled environments to grow high-value crops with fine-tuned taste and aroma like coffee, for instance?

Some crops are proving to be cost-effective to cultivate indoors, especially:

- **Hemp for seed, fiber, flower, and extracts**
- **Fruits like cucumbers and strawberries**
- **Culinary foods like heirloom varieties of produce and edible mushrooms**
- **Spices like saffron**
- **Off-season fruits and vegetables**
- **Seed starts and propagations of some varieties of retail plants**

g. Please recommend some past or current indoor farming projects and related publications, proceedings, or reports that you believe would assist us in properly targeting a future solicitation.

IAES conference proceedings: Farms of the Future I and II panels

Indoor AgTech Innovation Summit
Other similar and emerging conferences

The following will help us establish performance metrics for energy efficiency research on indoor farming:

The following metrics could be used to describe effectiveness of advanced indoor farm operations when comparing potential technologies for deployment:

- Annual energy use and water consumption per square foot of indoor farm
- Annual energy use and water consumption per pound produced
- Net annual cost of production per pound produced

Cannabis PowerScore uses specialized key performance indicators to measure and rank facilities benchmarked:

- **Facility Energy Efficiency in kBtu/sq ft of flowering canopy per year**
  - **Electric Facility Energy Efficiency in electric kBtu/sq ft flowering canopy (converted from kWh)**
  - **Non-Electric Facility Energy Efficiency in kBtu/sq ft flowering canopy for non-electric fuels**
- **Facility Energy Productivity in grams per kBtu per year**
  - **Electric Facility Energy Productivity in grams per electric kBtu**
  - **Non-Electric Facility Energy Productivity in grams per kBtu for non-electric fuels**

We are developing similar KPIs for other crops as part of our USDA project.