

Increasing Equity for Growers through Strategic Energy Management

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ABSTRACT

The United States cannabis industry offers a new and rapidly growing opportunity for efficiency programs as more states legalize methods of indoor cannabis production. This segment, which has been largely underserved by utility efficiency programs, also struggles with limited access to capital and other barriers leading to a limited pool of growers that are able to participate. As more states legalize methods of cannabis production, utilities can design, implement, and evaluate efficiency programs in ways that resonate with growers' diverse needs. Our research investigated how to grow a Midwest's Utility's indoor agricultural program to better serve diverse growers.

Strategic energy management (SEM) programs can engage a diversity of customers with persistent and verified energy savings, connect utilities to underserved customers, and build capacity for future energy efficiency strategies. Research on controlled environment agriculture (CEA) and benchmarks from a variety of crops suggest that the CEA sector is well suited for SEM. A cohort design could address equity issues within the CEA industry, as many smaller growers struggle to compete. Grouping similar businesses can help lower program costs and increase decision-maker support. Forming a cohort of businesses that move through programs together allows for peer-to-peer support and collaboration for incorporating energy efficiency into business plans. This paper discusses lessons learned through the development of these programs in a niche market, which can also be applied to help growers of all backgrounds, facility sizes, and diverse crop types to become more efficient and improve the production of our food supply.

Introduction

The agricultural community throughout the United States has responded to the loosening of legal restrictions by increasing the production of cannabis to support both the medical and recreational markets. Consequently, utilities are seeing an increase in the energy loads from the burgeoning cannabis industry, while the sales price that growers receive is often variable. These controlled environmental agricultural (CEA) facilities represent a critical opportunity for energy efficiency programs to address extensive energy needs as well as to apply lessons learned from other agricultural, commercial, and industrial sectors. CEA facilities require constant monitoring, maintenance, refinement, and continual and cyclical flow of nutrients, atmospheric conditions, and circadian lighting patterns to optimize the growing cycle. Additionally, as external climate and pest-pressures expand, and demands on quality increase, growers of all crops have responded by moving their production from fields to greenhouses and indoor facilities to mitigate these pressures. These CEA facilities encapsulate characteristics similar to those of process manufacturing environments such as chemicals, plastics, and refined metals for whom a

more collaborative, whole system, SEM program design has been an effective approach for utility-sponsored programs to engage with customers.

In this paper, we discuss how the production and energy needs of the CEA sector align well with SEM program design, particularly for smaller growers, whose needs are not addressed by conventional prescriptive or custom resource-based program designs. Lessons learned through the development of these programs in a niche market, can also be applied to help growers of all backgrounds, facility sizes, and diverse crop types to become more efficient and improve the production of our food supply. Utilities that leverage SEM design elements can augment a diversity of CEA producers' internal abilities to assess projects and prioritize future measures.

TRC Companies (TRC) conducted this research in conjunction with a major Midwest utility, who sees the looming increase in consumption and demand expected from the cannabis industry as a challenge and opportunity to better support CEA producers by providing more holistic, comprehensive energy efficiency solutions. To that end, TRC investigated best practices for engaging with a diverse mix of growers, and leveraged additional research conducted by Resource Innovation Institute (RII) to understand how to help the utility program achieve deeper savings.¹

Research Objectives

The objective of this research was to investigate whether an SEM program design would effectively meet the needs of a diverse array of CEA producers. To achieve this goal, the objectives of this research were to:

- Investigate the potential energy impacts of a range of measures beyond lighting
- Examine outreach strategies that could help move the cannabis and broader CEA sector beyond single measure lighting upgrades
- Assess whether an SEM program design offers an effective alternative to traditional resource-based programs for addressing the needs of CEA facilities

Methodology

To meet these objectives, TRC performed a review of secondary sources. Our research team leveraged secondary sources from over 30 utility programs covering over 130 measures, more than 15 case studies, as well as a variety of reports and regulatory filings from the United States and Canada. We focused our research on utilities with robust indoor agriculture offerings, industry organizations that work closely with utilities' indoor agriculture offerings, and government agencies that work with growers to encourage the implementation of energy efficient measures. We reviewed each of these sources for the following:

- Energy, production, and behavioral needs of CEA facilities
- Program approaches to addressing needs of CEA facilities
- Effectiveness of various approaches at providing comprehensive solutions to meet needs of CEA facilities

In the sections that follow, we discuss the CEA sector's extensive need for program support, focusing on a whole-building and continuous improvement approach to energy efficiency (EE) measures. First documenting the end-use, production, and cultural needs of CEA facilities with particular emphasis on cannabis facilities. Next, we review program characteristics

¹ RII is a non-profit market transformation organization celebrating efficiency in greenhouses and indoor farms.

of various program design strategies. Finally, we discuss synergies between CEA sector needs and SEM program design.

CEA Sector End Uses

Our research determined there is no single technology that will drive efficiency, rather we identified a host of measures to increase efficiency in CEA facilities. As these facilities also operate in a continuous production environment in which the product output (or crop yield) is highly sensitive to the intensity, timing, and continuity of lighting, temperature, humidity, air-quality, as well as with measured and timely flow of irrigation and nutrients, the CEA sector needs extensive program support including a whole system approach to EE measures and integrated controls. In this section, we discuss the need for a whole-buildings type approach instead of standalone measures. Further, CEA production requirements create added need for continual monitoring, adaptation, and adjustment and refinement of operating conditions and EE solutions, which underscores the need for retro- and re-commissioning program offerings. Utilities must shift their program strategy to a whole-buildings approach instead of standalone measures while simultaneously finding ways to provide the right support to augment producers' internal abilities to assess projects, make decisions, and prioritize future projects.

Buildings and their environmental control systems are generally optimized to serve humans, not plants. However, optimal plant growth requires finer control over lighting intensity, temperature gradients, and humidity swings than is delivered from commonly installed systems in new and existing buildings. Conflicting systems not only lead to wasted energy but can also impact plant health through spikes in temperature and/or humidity. Rather than rely on distinct prescriptive measures, these findings suggest the most effective strategy is to pursue a mix of measures. Lighting measures, particularly those with integrated controls to optimize lumens and light color mirror optimal circadian rhythms. Moreover, non-lighting measures with the most potential for energy savings include bundled heating, ventilation, and air conditioning (HVAC) systems, integrated environmental controls, and building envelope improvements (ERS 2020; Posterity Group 2019). The following paragraphs document the extensive non-lighting measure needs of CEA facilities.

Re-commissioning and Retro-commissioning

Re-commissioning and retro-commissioning of old commercial and industrial properties, such as warehouses, is a common strategy for many CEA producers. As growers convert existing buildings into CEA facilities, they often need to recommission the existing lighting, HVAC, and dehumidification systems that are designed to serve humans rather than to optimally serve plants. Typical building lighting, HVAC, and dehumidification systems are often not correctly sized to serve plants, nor are their environmental controls integrated to speak to each other. Consequently, the most commonly installed equipment does not optimally maintain environmental set points. A similar pitfall exists for producers pursuing new construction. Commissioning of new buildings must factor in the unique needs of plants to optimize the environment and their production.

HVAC

HVAC equipment poses the greatest opportunity for electric and gas program savings, particularly greenhouses often use more fuel than indoor operations due to facility construction and HVAC system choice. Two 2021 market characterization reports on cannabis and non-cannabis CEA operations by Southern California Edison identified HVAC as a source of energy efficiency program savings. In food and floriculture facilities, HVAC accounted for 56% of the electricity use (30% ventilation, 21% air conditioning, and 5% heating) of indoor CEA operations (ETCC 2021a). For cannabis facilities, lighting systems can contribute 38% to 75% of energy use but HVAC systems can be the secondary source of energy demand (Emerging Products 2021). Growers using environmental control systems not sized or configured to maintain target conditions may experience crop degradation and crop loss as a result (Schimelpfenig 2021b). Given bundled HVAC and humidity management systems are a paradigm shift from standalone systems, producers can reference best practice guides and trainings for growers to properly deploy efficient technologies (RII 2022a). As mentioned previously, integrated environmental controls can further optimize the efficiency of plant-centric systems as well as influence yield and quality.

Integrated controls

Controlling temperature and humidity is a key concern for growers (Schimelpfenig, 2021c). Optimal crop production requires timely delivery of water and nutrients, environmental factors such as temperature, humidity, air quality, and pressure. Many producers are located in variable climates, ranging from hot and humid summers to cold and dry winters, so environmental control has a major impact on their energy consumption and product quality. Integrated environmental controls can reduce on-farm labor requirements, increase yields, maximize resource efficiency, and mitigate risks of crop damage or loss (Schimelpfenig 2021d). Integrated environmental controls can further optimize the efficiency of systems and influence yield and quality. Integrated environmental controls can be used in concert with multiple technologies (i.e., HVAC+D, lighting, and fertigation). Having a more integrated system allows for a better user experience than manual controls, as customers can analyze and visualize their data (Schimelpfenig 2021d). This can promote higher yield and quality by protecting against rapid fluctuations of temperature and humidity.

Thermal Curtains

The greenhouse sector also presents opportunities for efficiencies in natural gas and electric use primarily through the use of thermal curtains (Schimelpfenig 2021e). Greenhouses can use more fuel than indoor farms due to facility construction and HVAC system choice. Many facilities use hydronic heating systems and unit heaters to keep cultivation spaces warm at night, when lights are off, or to overcome heat loss during colder weather. These heating systems run on natural gas and propane and require electricity to run associated pumps and fans. Thermal curtains are described using their function (thermal/energy, shade/blackout), and some greenhouses employ multiple curtain systems at different elevations to stage and use simultaneously. Greenhouse curtains can achieve energy savings of 40 to 50% in both colder and warmer climates (Sanford 2019).

While our research identified a host of measures to increase efficiency in CEA facilities, the findings suggest the most effective strategy is to pursue a variety of measures; there is no single technology that will drive efficiency. Instead, a whole-building approach that incorporates a mixture of measures is most likely to keep up with the rapidly evolving industry. Utilities that offer a custom incentive structure increase the flexibility of their program offerings to implement emerging technologies. Conversely, utilities that provide a prescriptive incentive structure reduce customer evaluation risks and utility program costs. However, neither program structure overcomes the need for growers to access community-based forums for information sharing and collaboration. Utilities' programs would benefit from finding ways to provide the right support to augment producers' internal abilities to assess projects, as well as how to prioritize future projects.

Need for a Continuous Improvement Approach

As the novel CEA industry evolves, growers can benefit from the availability of flexible incentives but more importantly from open communication with cohort growers, as well as an understanding of the flexible and adaptive processes and solutions which can be fine-tuned to provide the highest yield. Together, these facts suggest program support should include education and training elements, including support for detailed information sharing on the benefits of specific energy efficiency strategies, as well as to include flexible technologies and incentive structures to allow for the most effective practices to evolve. In addition to identifying the most promising non-lighting measures, we also explored outreach strategies to support producers looking to adopt non-lighting measures. Specifically, we were focused on how to move producers from a single-measure mindset to a continuous improvement culture.

To initiate the shift away from single-measure projects, utilities are providing educational programming for CEA growers to improve their understanding of the value and benefits of investing in energy efficiency projects. CEA producers have unique barriers to widespread adoption of energy efficiency technologies and practices. Recent research has identified factors such as upfront cost of emerging technologies, access to capital and financing, a lack of knowledge of efficient technologies, and skepticism of product performance (Schimelpfenig 2021a) as key barriers faced by growers entering the market. Barriers specific to emerging technologies are also prevalent and affect new construction and retrofit projects differently. These projects can suffer from low producer awareness and trust. Providing access to training like RII's Efficient Yields workshop series, which offers education to cultivators on the supply chain and emerging technologies, can help raise awareness and increase trust. (RII 2022b). Midwestern efficiency programs have funded two RII delivered workshop series, Efficient Yields, for CEA growers in 2020 and 2022. These types of community-based platforms for information sharing allow growers to collaborate to promote optimal yield and minimal cost.

Our research, previously and for this study, underscored the fact that growers are far more likely to try something they know worked for another grower. Energy-use modeling can more clearly demonstrate opportunities and their potential impact for a specific facility. Additionally, peer utilities that publish case studies can more clearly demonstrate the energy savings and non-energy benefits related to the installation of energy-efficient technologies. Impacts of equipment upgrades can include both energy and non-energy-related impacts including canopy productivity. Communicating the benefits of energy-efficient equipment is best done through portfolio reporting comparing robust datasets like RII's PowerScore specialized for CEA facilities with crop-specific ranked data sets (RII 2022c). Benchmarking the energy- and

non-energy impacts of facility and system choices and savings from efficiency projects is crucial for ongoing support and outreach of CEA SEM programs.

CEA customers benefit from proactive engagement and comprehensive services from program staff. Indoor agriculture customers require program staff with specialized knowledge to meet customers' unique circumstances. Given that lighting, HVAC, and dehumidification have significant impacts on the quality of growers' products, and their profits, growers must feel confident they can trust expertise from their utility. Auditing for skills gaps among outreach staff can ensure utilities have in-house knowledge of plant production, emerging technologies, and how they interact with other systems in the facility. In addition, growers have limited capacity and lower priority to engage with efficiency programs. Branding energy efficiency offerings to the CEA industry as a SEM program fosters a culture of continuous improvement by building producer capacity throughout their production system and efficiency journey.

Current Program Offerings

Since 2008, efficiency programs across North America have launched programs designed for CEA cultivators. Legalization of commercial cannabis has expanded since 2013, and efficiency programs have responded by offering efficiency measures like horticultural LED lighting and dehumidification equipment. Energy efficiency programs supporting greenhouses and indoor farms have proliferated, and as of 2022, there are 19 states with dedicated programs for CEA businesses (including producers of cannabis and hemp) (Schimelpfenig 2021f). The Midwest utility's indoor agriculture initiative was developed in 2019 as a sub-component of their Agriculture Core Services offering. The goal of the initiative is to target indoor growers, primarily cannabis growers, with prescriptive and custom rebates for energy-efficient equipment. Growers can utilize the extensive prescriptive rebate catalog offered by the utility, but most of the projects currently being claimed through the program come from energy-efficient lighting. While more traditional forms of plant and animal agriculture already had a robust utility program offering, not all measures were directly transferable to indoor growers, and the utility recognized the opportunity to incorporate measures that are meaningful in other growing environments.

While programs have grown in number, many still rely on custom savings approaches for incentives, which take more time for producers to receive financial support for expensive heating, ventilation, and air conditioning and lighting equipment. Utilities that offer both custom and prescriptive offerings provide the best platform for meeting diverse customer needs and rapidly changing technologies, however, both custom and prescriptive offerings have limitations in addressing the CEA market:

- **Custom programs** - increase the flexibility of program offerings to implement emerging technologies, however, custom programs often include cumbersome measurement and verification processes and time-consuming administrative barriers that limit the ability of smaller, or specialized growers, to take advantage of these offerings.
- **Prescriptive programs** - reduce the burden of participating and reduce utilities' program costs and overall evaluation risks, however, lack the agility to quickly incorporate new technologies. Prescriptive programs also aid in transforming the up- and midstream supply chains that service the emerging technologies in the dynamic CEA sector.

While there are pros and cons to both a custom and prescriptive approach, neither program design offers growers the necessary support and information to assess projects on multiple factors, for example allowing for optimal yield at minimal cost. Given this, utilities

need to find ways to provide the right support and level of information to augment producers' internal abilities to assess projects and make energy-related decisions.

Case for Strategic Energy Management (SEM)

Facilities that implement SEM practices use energy resources more efficiently over time through a systematic continuous improvement approach (CEE 2014). SEM fosters a culture change by focusing on business practices and organizational culture. Originally employed by the manufacturing sector to improve performance over time, many SEM approaches rely on a familiar cycle of systematic performance measurement and regular reassessment of metrics and goals (i.e., plan-do-check-act). Demand side management program administrators offer SEM programs that aim to build customer capacity to sustain holistic improvements, unlike other resource acquisition program designs that solely address equipment performance, but they typically only direct their programs to a small proportion of their commercial and industrial portfolio.

While initially focused on more traditional industrial customers, SEM offers an opportunity for improving business competitiveness and delivering cost-effective energy savings to programs across a range of sub-sectors and business sizes including CEA. A 2021 study from the North American SEM Collaborative of an analysis of the SEM program landscape showed that 100% of programs reported to be cost-effective. As seen in Figure 1, programs that reported specific cost-effectiveness values range mostly from 1.1 to 2.4, with an outlier at 8.5 (Therkelsen et al. 2021).

These results should be taken in context of the specific portfolio of each program but, the overall trend aligns, SEM programs are capable of operating at comparable levels of cost-effectiveness to broader portfolios and in several cases even greater cost-effectiveness. These cost-effectiveness findings were in line with a 2021 SEM program evaluation and peer utility benchmark TRC performed for Xcel Energy Minnesota (TRC, 2022), as well as a 2014 Consortium for Energy Efficiency report (CEE 2014). SEM programs can increase the program access for diverse growers as well as deliver cost-effective solutions for utility programs

As a proven program method, utilities are searching for other C&I sectors to apply SEM to next, as well as how to increase access to SEM programs for smaller customers. We believe utilities can apply SEM strategies, such as coaches, organizational commitments, energy champions, benchmarking, energy modeling, peer-to-peer learning via cohorts, treasure hunts, workshops, and incentives to CEA businesses, with some adjustments. Given their similarities to other industrial customers, many CEA producers are well-suited candidates for SEM programs, depending on the size and type of their facilities. Savings results for CEA SEM programs stack up against conventional SEM participants according to RII Utility Working Group members.

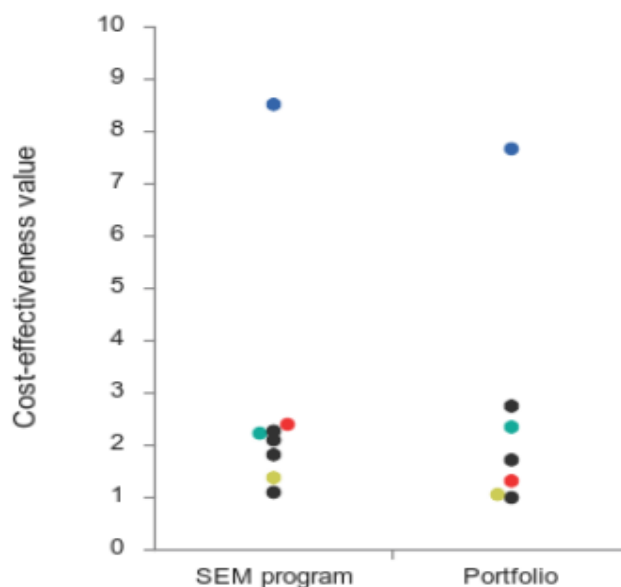


Figure 1 Reported SEM program and portfolio cost-effectiveness values (Therkelsen et al. 2021)

Program and utility engagement with the CEA market commonly occurs at several points throughout business development. An SEM approach is capable of encouraging more frequent projects that may yield higher energy efficient opportunities. Wraparound services may help utilities build customer capacity to identify and implement whole-building projects with higher energy efficiency opportunities than one-off projects. Utilities should continue to develop proactive strategies to engage producers with energy efficient offerings, such as engagement blitzes, educational programming, case studies, as well as cohort and self-guided program design that include smaller facilities. Program outreach staff could also use RII's PowerScore as a tool to introduce customers to energy efficient opportunities. Specialized tools like RII's PowerScore can be supportive for CEA SEM programs that seek to integrate data from customer energy management systems, generate standardized key performance indicators for CEA facilities that can be used in regression analysis, and offer competitive performance rankings to gamify the benchmarking experience and encourage participants to continuously improve.

CEA customers need program outreach staff with technical knowledge to instill confidence that their recommendations will deliver results. An SEM approach could combat this by maintaining specialized program staff and subject matter experts with dedicated time and technical education specific to the cannabis and CEA market. In-depth knowledge of plant production and interactions within grow environments are crucial for accurately forecasting the performance measures and yields. Utilities can use resources like RII's *Harvesting Savings* workshop series to develop subject matter expertise in-house or bring in external subject matter experts to aid program development and implementation. In 2020 and 2022, RII worked with Midwest utilities to host a *Harvesting Savings* workshop series to train their own staff on CEA, increase collaboration between departments, and claim more savings by connecting with customers earlier in their design phase or business development plan.

Additional Opportunity

The worldwide CEA industry has seen rapid growth over the past decade. Crops are grouped into three major categories: food, floriculture, and cannabis.² The 2017 U.S. Department of Agriculture (USDA) Census of Specialty Crops tracked nearly 50,000 operations and valued the United States nursery, greenhouse, and floriculture market at \$20 billion (USDA 2017). The 2021 Cannabis Water Report co-authored by RII and New Frontier Data forecasted the legal cannabis market to grow by 102% between 2020 and 2025 (RII, 2021). These trends underscore the need for considering alternative program designs to circumvent the growing demand for resources by this sector.

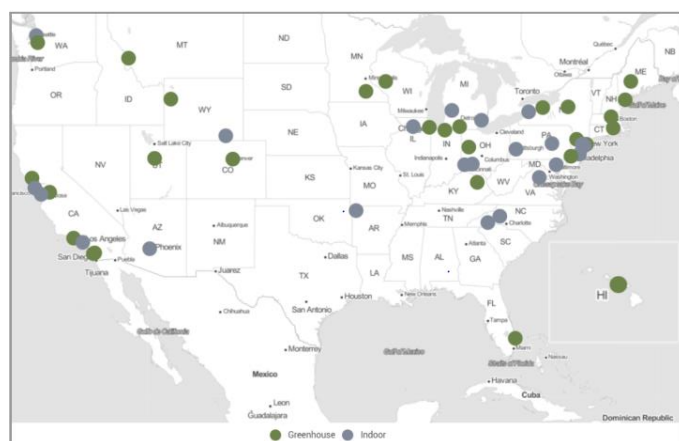
As utilities develop energy efficiency offerings to keep pace with the complex needs of these fast-growing industries, they can seize the opportunity to address issues of equity both within the CEA industry and the pool of customers who participate in utility programs. Given that only a fraction of C&I customers ever participate in a utility energy efficiency program, this underscores the fact that many C&I customers are not leveraging a service they typically support through the energy efficiency surcharge on their bill. While at the same time, small-scale, craft growers that helped establish the cannabis and other CEA industries are being pushed out by more well-funded, larger, and typically less diverse businesses. Utilities should consider the

² The food category includes vegetables and herbs like peppers and leafy greens, berries, mushrooms, and vine crops like cucumbers and tomatoes. The floriculture category includes nursery crops, bedding plants, and seeds.

different types and sizes of growers and tailor the modes of engagement necessary to meet those growers where they are in their business development.

Developing more comprehensive offerings could help to break down the unintentional barriers that have resulted from standard rebate program design. When programs are designed around offering individual rebates, the goal is typically to target larger customers with bigger savings (e.g., number of light bulbs) per project. This unintentionally makes smaller customers less of a priority. Similarly, these programs target single measures, that, beyond lighting, typically involve larger and more costly equipment with longer return on investment; thus, rendering these opportunities simply impractical for any small-scale company. Leveraging an SEM cohort-based, or self-directed design could provide smaller growers with more comprehensive and cost-effective solutions.

CEA producers are also lending to the regional economic development. CEA operators growing food and floriculture crops generate thousands of well-paying jobs in regions needing quality employment for communities (WTVQ, 2021). Figure 2 shows a map of CEA producers, their cultivation approach, and their major crop type. While this map of the CEA landscape is skewed to larger, high-tech companies serving more urban environments, it shows the potential for this market to increase in scale (Schimpelphenig and Smith 2021). For context on what



potential growth might look like, the cannabis industry was forecasted to add \$92 billion into the U.S. economy in 2021 and \$160 billion in 2025 (MJ Biz Daily, 2021). In Midwestern states where TRC evaluates efficiency programs, the number of cannabis operations outnumber many other crop categories like food and floriculture operations: there are 906 cannabis operations generating \$511 million in annual sales, compared to the 727 greenhouses producing bedding and garden plants worth \$458 million a year.

Figure 2 Locations and Types of U.S. CEA Facilities (Indoor and Greenhouse), 2021

Concluding Thoughts

With a rise in extreme weather conditions such as, droughts, fires, and pests, all CEA sectors have begun to shift outdoor and greenhouse food production to more controlled growing environments. To meet this rise and prepare for an increase of non-cannabis growing applications, utilities should combine lessons learned from the cannabis industry and general agriculture to develop a targeted offering toward CEA food and floriculture producers. Utilities that provide flexible offerings will be more prepared to capture savings from emerging technologies. Utilities should be prepared to target small-scale producers, such as stand-alone shipping container grow operations in urban areas and protected agriculture operations in rural

areas. Including small-scale and non-traditional production facilities will increase accessibility and improve equity.

There is a demand from growers to develop services that increase producers' confidence of the savings, performance, and payback periods of proposed upgrades. Due to the potential to impact yield and quality, as well as potential financing limitations, many CEA customers require higher levels of confidence that proposed upgrades will deliver results (both in terms of energy savings, and non-energy benefits). Therefore, programs that investigate ways to incorporate facility modeling into their existing CEA offering could more holistically demonstrate the potential impacts. Potential options to increase modeling capabilities include collaborating with trade allies or promoting capabilities within utility programs. While the efficiency side of that equation is becoming better understood, there is still work to be done to model non-energy benefits with more certainty. Utilities that partner with the supply chain to demonstrate the potential of new technologies will be better suited to fill this gap. Producers want to improve efficiency and realize non-energy benefits, but they need help implementing new systems and processes.

As federal and state governments commit to carbon neutrality and utilities and energy efficiency programs implement decarbonization strategies, these actors can thoughtfully engage with CEA producers to accomplish policy and program goals while equitably supporting businesses to be more competitive. SEM for CEA presents many avenues for decarbonization, flexible demand management, connecting with diverse customers, shifting to a whole-building approach, and bringing equity to the forefront of climate solutions. Learning to apply lessons from more established C&I SEM programs in meaningful ways in other subsectors beyond traditional industrial manufacturing will help to increase access to efficiency programs. CEA producers are a logical next step to spread SEM practices because of their high proportion of energy costs relative to their total production costs, in addition to a desire to interact with utility programs, but they often lack capacity to maintain their savings over time. SEM can support behavioral change by offering program engagement opportunities every year, throughout the year, whereas measures can only reach growers at times of upgrades, retrofits, and new construction. In addition to energy savings, unlocking this potential in CEA producers' is a promising strategy to decarbonize the food and crop production process, as well as reduce a significant portion of global greenhouse gasses.

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