Market Characterization of Indoor Cannabis Cultivation

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EXECUTIVE SUMMARY

This report outlines the findings of a market study and technology assessment on Indoor Cannabis Agriculture (ICA) in Southern California. The report findings are based on a combination of literature review and stakeholder interviews. This study was commissioned by Southern California Edison (SCE) to examine impacts of increased demand and investigate a potential offering within its energy efficiency (EE) incentive programs. Interviews were conducted with various stakeholders including Investor Own Utilities (IOU), growers, associations, and vendors to document the current industry practices and existing market barriers in adopting EE techniques in Southern California. By understanding how and why industry stakeholders make decisions, the existing barriers are more distinctly defined, and solutions developed. The intent of this report is to assess the market to determine savings potential, how utility intervention strategies can help achieve that potential, and recommend a course of action.

The scope of this study involved the following components:

- Literature review to research market forces, economic drivers, and regulatory factors
- Interviews with industry stakeholders: cultivators, growers, IOUs, vendors, and associations
- Analyses of industry norms, energy savings potentials, greenhouse gas reduction (GHG), and energy reduction potentials
- Recommendations of proposed incentive design
- Proposed next steps for increasing ICA participation in IOU Incentive Programs

Based on the findings from the literature review and interviews, it was found that the cannabis market in California will continue to expand and experience changes in industry transparency, facility types, equipment used, and operations. Being several years into legalization, a shift to more mainstream and corporate proliferation has initiated, and the trend is expected to continue. This has resulted in a change in the types of stakeholders involved, the investment capital available, and the facility types that are being constructed. Future years will see a continual transition from "underground" and/or illicit operations to more mainstream and amalgamated businesses. There will be a combination of existing facility renovations and new construction to establish indoor cannabis grow facilities. Both scenarios will present challenges related to grid impacts, infrastructure updates, and significant opportunity for demand side management.

Interviews with key stakeholders uncovered various market barriers for ICA facilities participating and receiving utility incentives. Some of the key barriers identified include lack of capital available for EE technologies, lack of trust to share data with utilities, and frustrations with the custom incentive process due to timelines and data required. Stakeholders also shared their perspective on potential solutions such as streamlining the incentive process, providing education and training to growers, and tailoring incentives for the ICA market. This report summarizes the state of the industry, interview results, future outlook, and recommended next steps.

ABBREVIATIONS AND ACRONYMS

AUMA	Adult Use of Marijuana Act
BCEIOF	Boulder County Energy Impact Offset Fund
BMS	Building Management System
CASE	Codes and Standards Enhancements
CDFA	California Department of Food and Agriculture
CEA	Controlled Environment Agriculture
CHP	Combined Heat and Power
CPUC	California Public Utilities Commission
CRI	Color Rendering Index
DLC	Design Lights Consortium
DLI	Daily Light Integral
DX	Direct Expansion
EE	Energy Efficiency
EER	Energy Efficiency Ratio
EMS	Energy Management System
ERI	Energy Resource Integration
GHG	Greenhouse Gas
HID	High Intensity Discharge
HMI	Human-Machine Interface
HVLS	High Volume Low Speed
HPS	High Pressure Sodium
HVAC	Heating, Ventilation, and Air Conditioning
ICA	Indoor Cannabis Agriculture
ISP	Industry Standard Practice
IoT	Internet of Things
IOU	Investor-Owned Utility
J	Joule
MAUCRSA	Medicinal and Adult Use Cannabis Regulation and Safety Act
MH	Metal Halide
M&V	Measurement and Verification
NMEC	Normalized Meter Energy Consumption
OBF	On-Bill Financing
PAR	Photosynthetically Active Radiation
PG&E	Pacific Gas and Electric
PPE	Photosynthetic Photon Efficacy
PPF	Photosynthetic Photon Flux
PPFD	Photosynthetic Photon Flux Density
RTU	Rooftop Units
SB	Senate Bill

SCE	Southern California Edison
SEP	Statement of Energy Performance
SMUD	Sacramento Municipal Utility District
THC	Tetrahydrocannabinol
TRC	Total Resource Cost

INTRODUCTION

The benefits of growing agriculture indoors are becoming more recognizable by both consumers and investors. Primary benefits include improved product quality, increased production per plant, and less water consumption. Among the many potential crops that can be grown indoors (such as greens, flowers, berries, etc.), cannabis has been a growing market in the USA and particularly in California over the past several years.

There are several types of Indoor Cannabis Agriculture (ICA) growing techniques available. Some use traditional methods with soil but many use soilless growing mediums such as artificial media like rockwool, shredded coconut husk, water, and/or air. The three primary soilless growing techniques available are aeroponics, hydroponics, and aquaponics. With any of the ICA methods, growers face challenges balancing cost, technology, and production. All ICA facilities require specialized equipment for cloning, growing, harvesting, and processing of the cannabis they grow.

Additionally, ICA growers are historically secretive of their activities because there is a tainted legacy/stigma/image associated with the business operation. Therefore, quantifying and comparing electricity use and associated production amounts of all indoor cannabis cultivation facilities are difficult. The clandestine nature of ICA results in barriers in sharing information on energy demand, which leads to inefficient energy consumption, leaving utility companies with insufficient data on the energy needs for indoor cannabis operations or what future energy needs may be required.

Preliminary information indicates that the primary energy input for most ICA production facilities is lighting, typically accounting for 38% to 75% of energy usage in ICA facilities. LED fixtures have been gaining traction in recent years but have low market share when compared to other technologies in the cannabis space in Southern California. This is primarily due to the high up-front cost of LEDs. In addition to higher cost, LED fixtures face a negative perception within the industry. Several early experiments with LED fixtures in indoor agriculture were conducted when LED technology performance was unable to meet growers' expectations. Thus, many in the industry still consider LEDs to be inferior to traditional lighting technologies, despite advances in light quality made in the LED space. However, modern horticultural LED fixtures have efficacies in the range of two times that of single-ended HPS fixtures. The energy savings potential for adopting LED fixtures would mean reduced electricity consumption and reduced load on the HVAC system.

The cannabis market in California will continue to expand and experience changes in industry transparency, facility types, equipment used, and operations. Being several years into legalization, a shift to more mainstream and corporate proliferation has initiated, and the trend is expected to continue. This has resulted in a change in the types of stakeholders involved, the investment capital available, and the facility types that are being constructed. There will be a combination of existing facility renovations and new construction to establish indoor cannabis grow facilities. Both scenarios will present challenges related to grid impacts, infrastructure updates, and significant opportunity for demand side management.

BACKGROUND

INDOOR AGRICULTURE

Indoor Agriculture, also called Controlled Environment Agriculture (CEA) or Indoor Farming, is the practice of growing crops or plants entirely indoors. It can be applied in many forms, some of which are detailed in this paper. Among the many potential crops that can be grown indoors (such as greens, flowers, berries, etc.), cannabis has been a growing market in the USA and particularly in California over the past several years. Many of the techniques and technologies applied in Indoor Agriculture are shared and utilized in the indoor cultivation of cannabis. However, specific set points and data points described in this paper relate only to Indoor Cannabis Agriculture (ICA). Additionally, the size and growth of the cannabis market places it in a separate category from a utility programmatic perspective.

INDOOR CANNABIS HISTORY

Cannabis is a fast growing, easy to cultivate crop and was used as an herbal medicine as far back as 500 B.C. (or earlier). Hashish, a purified form of cannabis smoked with a pipe, was widely used in the Middle East and parts of Asia after 800 B.C. In the Americas, colonists were required to grow cannabis most in the form of hemp. The hemp fiber is commonly used in textiles, paper, and rope manufacturing.

In the 1830s, cannabis extracts were used for medical purposes, such as to treat stomachaches and vomiting. The mind-altering chemical tetrahydrocannabinol (THC) was also used for religious practices and healing ceremonies. Synthetic THC has been found to lessen nausea and promote hunger, a chemical benefit used for cancer and AIDS patients, in pill form - Marinol and Syndros.

In the early 1900s, the recreational use of cannabis was introduced from South America but later criminalized in the 1930s in the Marijuana Tax Act of 1937 and further controlled in the Controlled Substances Act of 1970. These legislations also controlled hemp production. However, the 2018 Farm Bill allows for the production of industrialized hemp, but the hemp cannot contain more than 0.3 percent THC. [1] Federally, cannabis containing greater than 0.3 percent THC is still listed as a Schedule I substance under the Controlled Substances Act.

While cannabis remained illegal at a federal level in the early 1970s, several states began decriminalizing cannabis, reducing criminal penalties, and reducing enforcement for certain cannabis-related crimes generally limited to personal possession of small amounts. The California State Legislature passed Senate Bill 95 (SB 95) in 1975, which reduced the penalty for possession to a misdemeanor punishable by a $100 fine.

In 1996, California became the first state to legalize cannabis for medicinal purposes with the passing of Proposition 215. In 2016, California voters passed Proposition 64, which legalized cannabis for recreational adult use.

In June 2017, the California State Legislature passed SB 94, which integrated the Medical Cannabis Regulation and Safety Act (MCRSA, 2015) with the Adult Use of Marijuana Act (AUMA, 2016) to create the Medicinal and Adult Use Cannabis Regulation and Safety Act (MAUCRSA). MAUCRSA combines the two regulations into one single regulatory system to govern the medicinal and adult-use cannabis industry in California.

MAUCRSA creates a dual licensing structure in which both the state and local governments participate in setting guidelines and public health and safety standards for the cannabis industry. The state sets minimum requirements that all licensees must follow, and local governments set additional requirements to regulate commercial cannabis activities in their respective jurisdictions. Pre-2018 under MCRSA, the state required indoor and mixed light grow facilities to utilize 42% renewable energy. After MAUCRSA, the regulatory burden was relaxed and only requires that cultivators meet the average electricity greenhouse gas emissions intensity required of their local utility program[1].

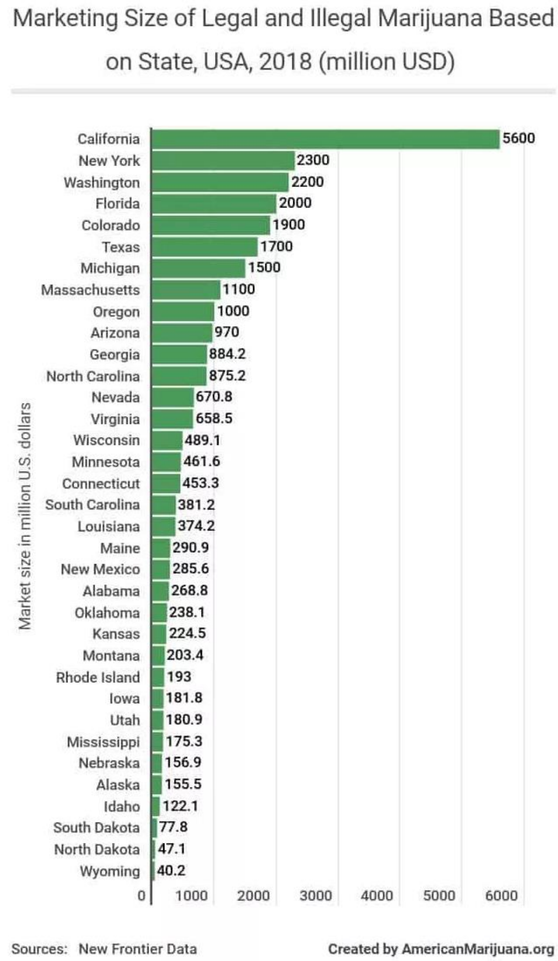

FIGURE 1: MARKETING SIZE OF LEGAL AND ILLEGAL BASED MARIJUANA BASED ON STATE, USA, 2018

As cannabis is crop in the eyes of the California Department of Agriculture, a division was opened called CalCannabis that was created for the purposes of licensing and regulating commercial cannabis cultivators. This division is developed for consumer safety as they monitor and regulate the policy around cultivation and cannabis related products to consumers in California. CalCannabis also provides licenses to eligible growers based on the growing canopy size and customer end use (adult/medicinal)[2]. As of 2018, 14.7% of licensed cultivators are classified as indoor growers of the 9,249 issued licenses[3].

[1] https://scholarworks.sjsu.edu/cgi/viewcontent.cgi?article=1946&context=etd_projects
[2] See Section 5.2 for a summary of CalCannabis licenses types for cultivators
[3] https://static.cdfa.ca.gov/MCCP/document/CalCannabis--2018%20by%20the%20Numbers_12.31.18.pdf

STAGES OF CANNABIS GROWTH

Cannabis has three growing stages that follow germination: seedling, vegetative, and flowering.

SEEDLING STAGE

In the seedling cycle, growers typically use LED, metal halide (MH), or T5 high output (T5HO) fluorescent lighting because they can be placed close to the plant and stacked vertically with limited heat and light intensity, reducing the chance of damaging the seedlings. The amount of lighting exposed to seedlings vary between 16 to 24 hours per day based on the grower's preference. The seedling growing phase can either start from germinating seeds or a clone from another plant. During this two to three-week phase, the plant will grow vertically and develop leaves until it develops five (5) to seven (7) blades per each leaf[4]. Once this is achieved, the plant is ready for vegetative growth.

VEGETATIVE STAGE

In the vegetative cycle, 600W or 1000W metal halide (MH) high intensity discharge (HID) fixtures are typically preferred since their light spectra contains more blue wavelengths. For vegetative growth, the plants are exposed to light for 18 to 24 hours per day. During the growth of the cannabis plant, the indoor CO_2 levels are often raised to four (4) times natural levels to boost plant growth. The plants require additional watering and nutrients as the plants grow vertically and produce more leaves. During this phase, the sex of the plants can be determined and is common practice to remove male plants to avoid pollination as the female plants contain more cannabinoids and other desirables traits. After 3 to 16 weeks of vegetative growth, the cannabis plants can be transitioned to its flowering stage. The larger range in the vegetative growth is based on several factors such as the plant's height, strain, growing method, and source of the plant (seed versus clone)[5]. After the completion of the vegetative phase, the plants will begin to grow flowers (buds) that will be harvested in 8 to 11 weeks.

FLOWERING STAGE

Although high pressure sodium (HPS) fixtures are frequently used for vegetative and flowering growth, they are preferred for the flowering stage since they deliver more lighting energy in the yellow and red range of the light spectra. The lights are typically used at their maximum output for 12 hours per day to promote flowering. After the plant's flowers have reached the desired quality, the entire plant is cultivated for drying and processing into various cannabis products.

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[4] https://www.leafly.com/learn/growing/marijuana-growth-stages

[5] https://www.royalqueenseeds.com/blog-when-to-switch-your-cannabis-grow-from-vegetative-to-flowering-n1074

Benefits of Growing Indoors

Primary Benefits

The benefits of growing agriculture indoors are becoming more recognizable by both consumers and investors. Primary benefits include improved product quality, increased production per plant, and less water consumption.

Isolation from Common Contaminants

Since the crops are grown indoors in a closed-loop system, the cannabis is isolated from common contaminants that negatively affect outdoor crops. For example, indoor agriculture farms typically require little or no pesticides or herbicides to manage pests and weeds.

Growing indoors also helps to prevent indirect contact with fecal matter from nearby farmlands, as well as cross contamination from pesticides or pollen from nearby farms by air or water run-off. This type of contamination is much less likely when crops are grown indoors where nutrient-rich water is usually recirculated within the building, and the buildings are often located in or near urban areas.

With the help of production automation systems, there is even less risk of cross contamination due to human contact. Consumers are now accustomed to and demand an extraordinarily high-quality product which can only be produced in these carefully balanced indoor conditions.

Increased Production and Reduced Water Use

Increased production and reduced water usage are lesser but still significant benefits as compared to quality. An indoor grower can yield multiple harvests up to five to eight times more; therefore, producing higher crop yields per year. This is made possible since indoor agriculture is not dependent on seasonal weather, nor subject to hostile or changing climates. This independence from outside conditions allows for year-round production.

In addition, water conservation is being increasingly more critical across the agriculture sector with drought conditions tending to persist for longer durations. For cannabis cultivation, which is not a water intensive crop, it is estimated 16 plants require 10-25 gallons per week[6]. In comparison to outdoor growing, which requires approximately 0.12 to 0.20 gallons of water per square foot during flowering, indoor growing has the potential to use less water with between 0.096 to 0.16 gallons of water per square foot during flowering[7]. For ICA, factors that influence water consumption include temperature, lighting density, lighting technology, and growing techniques (hydroponics for example).

[6] https://www.rand.org/content/dam/rand/pubs/working_papers/2010/RAND_WR764.pdf
[7] https://www.green-technology.org/gcsummit18/images/Water-Cannabis.pdf

REDUCED TRANSPORTATION CARBON FOOTPRINT

Due to the potential to locate ICA facilities in or around urban or suburban areas, the harvested cannabis can be transported to local processing plants and dispensaries within shorter distances. The cost and energy used by gasoline or diesel equipment needed for transporting cannabis from a local indoor facility is dramatically reduced. Additionally, ICA uses about one-tenth of the land that is typically used for outdoor agriculture for the same or equivalent production amount (depending on the farming techniques applied). This reduces damage to outdoor fields due to soil erosion or nutrient depletion.

TECHNOLOGIES AND FARMING TECHNIQUES

FARMING TECHNIQUES

There are several types of ICA growing techniques available. Some use traditional methods with soil but many use soilless growing mediums such as artificial media like rockwool, shredded coconut husk, water, and/or air. The three primary soilless growing techniques available are aeroponics, hydroponics, and aquaponics.

AEROPONICS

Aeroponics techniques involve growing crops by suspending the plant roots in air and the roots are misted with nutrient filled solution.

HYDROPONICS

Hydroponics by far being the most common for indoor cannabis production so far. Plants in a hydroponic system have their roots planted in pots filled with a soilless grow medium and placed on a water trough shared between rows of plants. Fertigation is a process where plant nutrients are released in the water which feed the roots. Some indoor facilities also use soil for cannabis crop production, but it is becoming more common to use hydroponics or other soilless growing medias.

AQUAPONICS

Aquaponics involves the use of fish to supply nutrients to cultivated plants. But this method is rarely used in commercial cannabis production.

GROWING CONFIGURATION

In any of the techniques described above, the plants may be organized on a single layer (or on a flat-bed configuration) or vertically (i.e., stacked, or non-stacked). Flatbed growers typically use a warehouse growing approach, in which electric light fixtures are mounted above the plant canopy at the celling or suspended below the cannabis. Traditionally, light is provided by a grid of HID fixtures.

Single Layer or Flat Bed Configuration

The single-level growing approach is intended to maximize the HID lighting effectiveness[8]. Due to these large mounting heights, it is impractical to stack canopies vertically when using HID lighting. But with the use of LEDs, fixture-mounting heights can be reduced, and this opens up the potential for vertical cannabis production.

Vertical Configuration

Growing crops vertically (stacked/layered above each row, two or more layers high) maximize the benefits described above such as a higher production volume per square foot compared to outdoor field crops or flatbeds. This growing method is modeled after vertical indoor agriculture growing facilities.

In this configuration, the ICA will likely use some LED lighting given the racked vertical growing arrangements are easier with LED fixtures due to proximity to the plants[8]. Vertical growing maximizes facility space efficiency, which is measured in grams of dried flower produced per square foot of the facility's floor area. It also enables growers to make better use of heating, ventilation, and air condition (HVAC) and dehumidification equipment relative to the plant productivity per volume of space that must be conditioned.

Building Types and Constructions

There are different types of Indoor Cannabis Agriculture or Controlled Environment Agriculture (CEA), also called Indoor Farming.

Greenhouses

The most common type of indoor farming facilities are greenhouses. Greenhouses are typically structures made of glass or other translucent material that allow for natural light to transmit inside but traps some heat from re-radiating and protests crops from the elements, pests, etc. Plants may be laid on flatbeds in soil or soilless set-ups.

While greenhouses make use of natural sunlight for plant production, many also use technology such as artificial lights to facilitate increased crop productivity. Depending on the local climate, greenhouses may use various types of equipment to create an artificial environment inside the structure including HVAC, dehumidification, and artificial lighting to simulate longer growing days even in both fall and winter seasons. Greenhouses are typically located in rural and agricultural areas where there is available land in which an outdoor farm might also be managed.

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[8] LED lighting For Cannabis Cultivation & Controlled Environment Agriculture. Resource Innovation Institute. Dec 2019

Existing or New Construction Nonresidential Buildings

Other ICA farms are constructed in buildings or warehouses typically in urban and suburban locations. The building may be of a completely new construction built for ICA or a renovation of an existing commercial or industrial property. Facilities built within existing buildings can often be described as a shell-within-a-shell construction type. Buildings can vary in size from a small, single-story warehouse to a commercial warehouse several football fields wide or multiple stories tall. The size and configuration can be endless depending on the land and structure availability in the given locale. This paper focuses on these fully enclosed, 100% artificial light-reliant commercial businesses. Due to land-use restrictions by local and city governments, indoor production of cannabis is preferred, and most localities have banned outdoor cultivation[1].

Growing Setup Business Economic Factors

Purchase or Lease of Buildings

When growers are looking for facilities, the cost to purchase or lease a building is a key factor in the business economics. Consequently, some companies are exploring alternative indoor growing setups such as repurposed shipping containers.

Repurposed Shipping Containers

The start-up cost, for these compact repurposed shipping container units, is typically less than growing indoors within an ICA building. Ready to use containers start at $59,000[9]. The units are pre-built and modified with light boxes, growing racks and irrigation system for ICA, and all the necessary equipment is self-contained in the converted shipping freight containers. The containers can be mobilized to just about anywhere and have a compact footprint in which the farm is ready to go upon arrival. Although the start-up cost is less than an ICA building, the operational costs can be higher when balanced with the production volume possible in such a small square footage.

Specialized Equipment in Different Growing Setups

With any of the ICA methods described above, growers face challenges balancing cost, technology, and production. All ICA facilities require specialized equipment for cloning, growing, harvesting, and processing of the cannabis they grow. However, greenhouses use much less artificial light than fully enclosed ICA buildings, since they can use sunlight through the glazing. The tradeoff is that greenhouses tend to use more heating energy in the cooler months relative to warehouse environments. Freight containers and warehouses use the most equipment because they are fully reliant on artificial light and require some form of mechanical

[9] https://growboxco.com/grow-boxes/

cooling. The energy usage or draw, on the local electrical grid to operate the indoor microenvironment and lighting, is all managed and artificially provided by some or all of the technologies listed in **Table 1.**

TABLE 1: DESCRIPTION OF EQUIPMENT AND TECHNOLOGY USED FOR INDOOR AGRICULTURE EQUIPMENT

TECHNOLOGY TYPE	DESCRIPTION AND KEY FACTORS
Sensors	To monitor the climate, sensors such as temperature, humidity, soil moisture, and many others are deployed. If not performed automatically with a controller, these measurements are performed manually by the grower.
Cameras	Primarily used for security, the cameras provide the growers the ability to view and monitor the crop remotely.
Hygrometers	To monitor the humidity levels in the growing room(s).
HVAC systems	• Technologies used vary from Heat Pumps, Direct Expansion (DX) package units, DX Mini-Splits, and Hydronic Chiller Systems. • Dehumidification is typically achieved through portable dehumidifiers or at the air distribution level if available. • Due to improper sizing, facilities experience high loading and long run times.[29] • With an air filtration of MERV 14 or greater, outside air can be used without introducing outside contaminants.[10] As a rule of thumb, cannabis grows best in 70°F to 80°F temperature ranges. ICA facilities are commonly closed-ventilation systems employing HID lights and the grow rooms are cooling-dominated environments.**Error! Bookmark not defined.**
Internet of things (IoT)	• Using artificial intelligence, machine learning, and other advanced algorithms to assist growers in their operations. • Mobile device control capabilities. • In the future could employ grid connectivity at the equipment level and enable responsiveness to regional grid impact events.
Environmental Controllers (Hardware and Software)	• These controllers use input data from sensors and cameras to modulate the HVAC, Lighting, water, and other systems. • ICA facilities may develop homemade/customized

[10] https://www.aceee.org/files/proceedings/2017/data/polopoly_fs/1.3687880.1501159058!/fileserver/file/790266/filename/0036_0053_000046.pdf

TECHNOLOGY TYPE	DESCRIPTION AND KEY FACTORS
	systems, work with a controls vendor, or develop proprietary sensor and controls systems in partnership with universities.[11]
Automation	• Used for cloning, growing, harvesting, production and to replace human labor/contact.
Artificial Lighting	• Historically incandescent, fluorescent, and high-intensity discharge (HID) lamps such as high-pressure sodium (HPS) lamps were used. • Commonly the blue-shifted Metal Halide (MH) spectrum is used for the vegetative phase and the orange-red High Pressure Sodium (HPS) spectrum is used for the flowering phase[12]. • A photoperiod is the number of hours per 24-hour day in which cannabis plants are exposed to light. Cannabis plants in vegetative growth stages typically require 18-hour photoperiods and in flowering stages need shorter photoperiods of approximately 12 hours**Error! Bookmark not defined.** • Recently ICA are converting to LED since the LED technology has improved in efficiency and the light spectrum required for cannabis growth.
CO^2 generation	• Growers increase the CO^2 concentration in their rooms to improve their yields. Most indoor growers maintain a range of 800 to 2,000 PPM, depending on the plants' growth stage. Levels above 2,000 PPM can damage plants, and anything above 3,000 PPM is dangerous to humans.[13] • CO^2 is commonly added through compressed gas tanks since they are readily available, easy to set up, and do not add any extra heat to the grow room unlike CO^2 generators do**Error! Bookmark not defined.**.
Electric Generators	• When the market was historically illicit, the use of electrical generators was used in remote areas used to avoid conspicuous utility bills. • Used today as a backup system for larger grow facilities.
Noise and Odor Suppression	Techniques such as ozone generators, air purifier, carbon filters and inline fans are used for this purpose.

[11] https://www.researchgate.net/publication/254408509_The_carbon_footprint_of_indoor_Cannabis_production
[12] LED lighting For Cannabis Cultivation & Controlled Environment Agriculture. RII, Dec 2019.
[13] https://weedmaps.com/learn/the-plant/growing-cannabis-indoors-intro/

MARKET CHARACTERIZATION STUDY OBJECTIVES

The scope of this market characterization study involved the following objectives:

- Performing a literature review to research market forces, economic drivers, and regulatory factors.
- Conducting interviews with industry stakeholders: cultivators, growers, IOUs, vendors, and associations
- Analyze industry norms, energy savings potentials, greenhouse gas reduction (GHG), and energy reduction potentials.
- Provide recommendations of proposed incentive design.
- Outline proposed next steps for increasing ICA participation in IOU Incentive Programs
- Identify barriers, solutions, and provide recommendations to improve the participating of ICA customers in SCE territory.

TECHNOLOGY/PRODUCT EVALUATION

INDOOR AGRICULTURE LIGHTING TECHNOLOGY

The primary energy input for most ICA production facilities is lighting, typically accounting for 38% to 75% of energy usage in ICA facilities[14]. When discussing and comparing lighting fixtures for ICA facilities, it requires an understanding of lighting technology concepts specific to horticultural lighting.

LIGHTING DEFINITIONS AND METRICS

A foundational metric, for indoor lighting system design and operation, is daily light integral (DLI), which is a measure of the amount of photosynthetically active radiation (PAR) received by the crop per day, measured in moles/m^2/day. PAR light is usually defined as light with a wavelength of approximately 400nm to 700nm and is fundamental to measuring the output and efficacy of horticultural light fixtures. PAR output of horticultural lights is reported in terms of photosynthetic photon flux (PPF), which is measured in micromoles of light output per second (μmol/s).

To achieve optimal illumination for plant health, horticultural light intensity is also measured at the canopy level in terms of photosynthetic photon flux density (PPFD), which is a measure of instantaneous PAR on a square meter basis generally reported as μmol/s/m^2. Finally, horticultural lighting efficiency is measured in terms of photosynthetic photon efficacy (PPE or PE), which is a measure of PAR output per Joule (J) of input energy, reported as μmol/J.

HIGH INTENSITY DISCHARGE

High Intensity Discharge (HID) fixtures are the industry standard with HPS, or MH fixtures being chosen depending on the light spectra required by the plants. MH produces more blue light while HPS produces more red and yellow light. High-wattage HID are common, with 600-1000W fixtures seeing frequent use. These high-wattage fixtures produce large quantities of waste heat, which must then be cooled by the HVAC system.

Double-ended HPS fixtures have been gaining popularity since they have higher efficacy than single-ended fixtures but are generally still considered a "known quantity" by growers. Double-ended HPS fixtures generally have similar high wattages as single-ended fixtures (600-1000W). The output of traditional single-ended HPS fixtures is 1.02 μMol/sec while the output of DE grow fixtures is 1.66 to 1.70 μMol/sec. Each DE 1000W HPS fixture can typically serve a 4'×4' area of plant canopy which contains two to four flowering plants. A constant

[14] Based on various studies and surveys of customers, the variation of operating hours and lighting technology have significant impacts on the percentage of total energy consumption within an ICA facility.

output 1000W HPS grow light fixture is available from $200 to $300. DE 1000W HPS fixtures with dimmable or specialized output are $400 to $600**Error! Bookmark not defined.**.

T5HO Linear Fluorescent

T5HO linear fluorescent fixtures are occasionally used for seedling/clone growth. T5HO horticultural fixtures consist of panels that contain between four (4) and twelve (12) T5HO linear fluorescent lamps. Fluorescent fixtures do not produce the same desirable light spectra when compared to HID and generally have lower efficacies as well. However, TH50 fixtures are typically lower wattage than available HID fixtures and produce less heat. This reduces HVAC load, and allows for lamps to be placed closer to plants, allowing for vertical stacking.

LED Lighting

Lighting Efficacy

LED fixtures have been gaining traction in recent years but have low market share when compared to other technologies in the cannabis space in Southern California. This is primarily due to the high up-front cost of LEDs. An LED fixture producing similar light output to a 1000W HPS fixture can cost three to four times as much as the HPS fixture. LEDs do have the benefit of higher efficacy. Modern horticultural LED fixtures have efficacies in the range of two times that of single-ended HPS fixtures. This means reduced electricity consumption, and reduced load on the HVAC system.

Heat Output and Heat Load

Additionally, the reduced heat output allows fixtures to be placed closer to the plants, allowing for vertical stacking, similar to T5HO fixtures. Water-cooled LED fixtures have also been developed, which reject heat to a fluid loop to be moved outside the growing space, further reducing HVAC load. However, at the time of this study, there are few water-cooled LED manufacturers that service the California market.

Adoption Market Barriers

In addition to higher cost, LED fixtures face a negative perception within the industry. Several early experiments with LED fixtures in indoor agriculture were conducted when LED technology performance was unable to meet growers' expectations. As a result, many in the industry still consider LEDs to be inferior to traditional lighting technologies, despite advances in light quality made in the LED space. Current LED horticultural fixtures can produce adequate PPFD, and many can be tuned to a variety of different light spectra depending on needs of the grower and strain. Some LED fixtures can produce multiple light spectra with a single fixture.

Table 2: Typical Grow Lights Used in ICA

Light Type	Cannabis plant cycle	Details	Fixture PPE	Light Type
T5HO fluorescents	Seedling	1. Can be placed close to the plant and stacked vertically, 2. Limited heat and light intensity reduce the chance of damaging the seedlings. 3. 4 ft, 220W fixture, approx. $100-200 4. Run time – 24 hours per day	Can be placed close to the plant and stacked vertically,	T5HO fluorescents
600 W or 1000 W metal halide (MH) HID	Vegetative	1. Spectra contains more blue light 2. Lighting is typically used for 18 to 24 hours per day 3. Fixture cost is Approx. $200	Spectra contains more blue light	600 W or 1000 W metal halide (MH) HID
Single ended (SE)		1. Spectra contain more yellow/red 2. Preferred for flowering, but also used for full growing cycles with a single fixture.	Single ended (SE)	
double-ended (DE) HPS	Flowering	1. Significantly more output light than single-ended 2. Fixture cost is Approx. $400-500 3. Run time – 12 hours per day		double-ended (DE) HPS
LED	Seedling	1. Marketed as 40% reduction in power and energy use over traditional HID fixtures 2. Capable of being dimmable 3. Variable color spectrum available 4. Less heat emission 5. 600W Fixture is approx. $1,500		LED

HIGH PRESSURE SODIUM

During the flowering cycle, the most common lighting technology used are HPS or other HID lamps. This is primarily due to 1) lower cost compared to other lighting technologies, 2) grower's preference of the light spectrum, and 3) historical use within Southern California. Other common lighting technologies used for the flowering stage include metal halides and fluorescents, with LED lighting still emerging in the market. For vegetative growth, high pressure sodium fixtures are again the most common. The major difference between the lighting approach used in the vegetative versus flowering stage is the quantity of hours per day under the lights.

During the seedling cycle, the most common lighting technology used are also HPS fixtures. Many growers choose to use other technologies such as T5 fluorescents, LEDs, or metal halides based on the space available or opinions on the impacts to the seedlings. Based on various interviews, the only common technology not used for growing seedlings was LEDs due to the growers' concern of affecting the quality of the plants. While using LEDs for seedlings is possible, if positioned properly at the appropriate height and configuration, HPS fixtures are the most common. Not all indoor growers develop their plants from seeds to seedling, as some choose to purchase them from a third party.

HVAC TECHNOLOGY

Creating a suitable environment for growing plants indoors requires complex HVAC systems that must meet very different requirements from human comfort. Growing plants add a huge amount of latent load to a space, both through the evaporation of water from the plant surfaces, and the exhalation of water vapor as part of photosynthesis. Several of the unique HVAC needs that must be met are detailed below.

COOLING

ICA facilities typically have substantial heat loads produced by intensive lighting systems. To maintain the optimal conditions for plant growth, mechanical cooling systems are often (though not always) necessary. The most common cooling systems in ICA facilities include direct expansion (DX) units, and the more uncommon chilled-water systems. Common DX cooling systems include split, mini-split, and roof-top units (RTUs), which are the most widely used and commercially available.

While DX cooling systems are the most common cooling solution found in ICA facilities, they have several disadvantages. Most DX solutions are not designed for intensive year-round use, which can result in early failure and higher operation and maintenance during their useful life. Additionally, DX systems typically do not have the ability to control humidity, resulting in the need for stand-alone dehumidifiers.

Chilled water systems achieve higher efficiencies than refrigerant-based DX systems, and have several distinct advantages including longevity. Chilled water systems utilize air handling systems which operate independently of compressors, which allows the IA facility to operate multiple rooms without comingling air. Chilled water systems are more expensive and complex than DX systems, but offer greater air handling capabilities and reduced operating costs. It is more common to see chilled water-based HVAC systems in large commercial or warehouse buildings.

HEATING

Heating systems are not always found in ICA facilities due to the considerable heat created by the lighting system and other equipment. However, larger ICA facilities often use boiler systems to distribute heat via hydronic distribution systems. Smaller ICA facilities use natural gas heaters within the grower rooms to provide both heat and CO_2 as a byproduct of the gas combustion.

MECHANICAL VENTILATION

Mechanical ventilation various in its energy impacts for indoor facilities based on the size and HVAC technology used[15]. Ventilation is used to circulate air within the growing area and is typically separate from the fans used for heating and cooling systems. The primary function of ventilation is to mitigate stagnant air pockets and create a more homogenous climate through air circulation. Depending on the configuration of the ICA facility, ventilation systems are either horizontally mounted fans or multiple wall mounted fans. Although uncommon, ICA facilities may make use of exhaust and/or intake fans to replenish air within the facility. Another less common ventilation technology is high volume low speed (HVLS) fans, which is also used for thermal destratification.

The use of ventilation for cannabis also has multiple benefits for the plant's health. The airflow provides movement to the plants that helps strengthen the plant to allow for increased height, and consequently increased product. The airflow also distributes any CO_2 pockets that are developed which helps nearby plants receive the CO_2 necessary for growth.

DEHUMIDIFICATION

Humidity is another important factor which must be controlled to prevent mold growth. While air conditioning units can be used to dehumidify, dedicated dehumidification units (either desiccant or direct expansion) are commonly used. These are more efficient at dehumidification and allow air conditioners to operate more efficiently as well.

CO2 PRODUCTION

Additionally, indoor CO_2 levels are often raised to four times natural levels to boost plant growth. Several companies produce agriculture-specific unitized units which combine temperature, humidity, and CO_2 control into a single packaged unit.

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[15] https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9121311

ADVANCED CONTROLS

Advanced climate control systems that integrate and coordinate the components of HVAC systems are becoming increasingly common and sophisticated. The most common form of HVAC controls are programmable thermostats that allow the growers to vary their setpoints and schedules. To provide more functionality, more advanced controls connect multiple systems that enable growers to remotely monitor and automate HVAC systems via cloud-based interfaces. These systems typically rely on internet-of-things (IoT) sensors to feed real-time data to the control software, which can then be used for remote monitoring and/or remote control of HVAC equipment. This technology is in early stages of commercialization for ICA facilities, but is likely to rapidly gain in popularity due to the advantages it offers in terms of EE and demand management.

CODES, STANDARDS, AND POLICY

CALIFORNIA

On January 16, 2019, the California Department of Food and Agriculture adopted final regulations for state cannabis cultivation licensing, which are contained in Title 3 of the California Code of Regulations. The regulations modified the types of carbon-offset sources available to the license to cover excess emissions from the previous annual-license period for energy consumption by indoor cultivation. Applicants for indoor cannabis cultivation licenses must submit a lighting diagram with the application that includes the aggregate wattage per square foot of each canopy, location of all lights in the canopy area(s), and maximum wattage of each light[16].

Additionally, under §8305 of Title 3 of the California Code of Regulations, the state enacted renewable energy requirements beginning January 1, 2023 (3 CCR §8305). This new requirement will require cannabis producers and nurseries with tier 2 mixed-light, to ensure that all electrical power used for commercial cannabis activity meets the average electricity greenhouse gas (GHG) emissions intensity required by their local utility provider pursuant to 3 CCR § 8305)[17].

In a survey of 19 California cities that permitted commercial cannabis activity, only 11 cities (or 57%) established some type of requirement to address indoor cannabis cultivation and its high electricity-based energy use including its associated carbon impacts. **Table 3** summarizes the cities in California the have cannabis energy or reporting requirements.

[16] http://humboldt-dspace.calstate.edu/bitstream/handle/2148/1461/Arnold_Jessica_M_Sp2013-r.pdf?sequence=4
[17] NEED A REFERENCE HERE…

TABLE 3 CALIFORNIA LOCAL JURISDICTION REQUIREMENTS

CALIFORNIA CITY	ENERGY EFFICIENCY REQUIREMENTS	RENEWABLE ENERGY REQUIREMENTS	ANNUAL REPORTING REQUIREMENTS	MINIMAL
Sacramento	Yes			
Long Beach	Yes		Yes	
Oakland	Yes	Yes	Yes	
Hayward	Yes			
Berkeley	Yes	Yes	Yes	
San Francisco		Yes	Yes	
Moreno Valley		Yes		
Chula Vista			Yes	
San Bernardino				Yes
Modesto				Yes
Salinas				Yes

The cities of Berkeley and Oakland were among the 11 cities that had the most progressive programs, as they had multiple types of requirements such as local requirements for EE, renewable energy usage, mandatory reporting, as well as offering options to purchase carbon offsets.

Additionally, commercial cannabis businesses in their city are required to demonstrate that 100% of their electricity is derived from renewable or carbon-free sources. Although some cities can ban commercial cannabis cultivation in their jurisdictions, California state law permits adults to grow up to six plants for personal cultivation on their private property (i.e., non-commercial cultivation)[18].

OREGON

California utilities can emulate policies of other western states to supplement and address their local EE management for cannabis facilities. For example, in Oregon, Energy Trust of Oregon offers licensed cannabis growers free technical services and cash incentives for the installation of EE equipment at new and existing grow operations. Incentives are available for indoor, outdoor, and greenhouse grow operations. Energy Trust of Oregon also offers free technical services and cash incentives of $0.25 per kWh of electricity saved and $2.00 per therm of natural gas saved for new and existing grow facilities. Incentives are calculated based on operating hours and usage (Energy Trust of Oregon, 2019)[19].

Since the California Bureau of Cannabis Control does not require growers to report data on energy use until 2022, nor require statewide standards for renewable energy until 2023, some

[18] NEED A REFERENCE HERE…

[19] NEED A REFERENCE HERE… Energy Trust of Oregon, 2019).

California cities have enacted local laws to support regulatory activity that will either prohibit or limit the use of fossil-fuel-generated-energy as they develop local regulations and local cannabis programs[20].

COLORADO

Within Colorado, Boulder County promotes sustainable energy use practices through the Boulder County Energy Impact Offset Fund. This promotes cannabis industry use of renewable energy, educates cultivators on efficient cultivation practices, and funds carbon offset and renewable energy projects. The Board of County Commissioners of Boulder County also adopted Resolution No. 2014-41, entitled "A Resolution Creating the Boulder County Energy Impact Offset Fund," (BCEIOF) on August 5, 2014 to reduce greenhouse gas emissions of the local cannabis industry.

The offset fees collected from the BCEIOF are used to establish the technical infrastructure of the program, such as eGauge electricity monitors and the software code to aggregate and analyze the electricity-usage data that they produce. Boulder County collects energy consumption data through eGauge electricity monitors which collect electrical energy use data, anonymize the data, and make the anonymized data available to the general public[21].

Boulder Municipal Code §§6-14-8(i) and 6-16-8(i) requires licensed medical cannabis and recreational cannabis cultivation facilities to offset 100% of their electricity consumption and to keep monthly records of their energy use and compliance with renewable energy requirements[22]. As a revenue source, Colorado's Boulder County has a surcharge of $0.022/kWh for cannabis grow facilities. A similar tax was enacted in Arcata, California, in which the city has collected more than $300,000 annually (a.k.a. excessive energy use tax[23].)

BARRIERS TO COMPLIANCE

Along with the benefits detailed earlier, challenges remain that keep ICA from fully benefiting from the agriculture economy. If cannabis was not faced with the State and Federal conundrum, growers would have more options such as hiring migrant workers, sourcing experienced growers, and available capital from external sources. Capital funding opportunities would be more available since investors and financial institutions could participate in funding ICA without fear of Federal repercussions.

When compared to other agricultural commodities in California, the cannabis industry has not benefited from publicly funded agricultural research to better optimize production in various cultivation settings. It is common for growers to have minimal experience in facility management which can lead to poor HVAC and lighting design choices. If ICA facilities had

[20] NEED A REFERENCE HERE…
[21] NEED A REFERENCE HERE…
[22] NEED A REFERENCE HERE…
[23] http://www.cavendish-e.com/uploads/7/5/7/3/75738781/puf-0317_1.pdf

more access to traditional funding, they would be incentivized to utilize mainstream designers or technical experts in the EE field to improve their performance.

An approximate capital expenditure for a new cannabis facility is six to seven figures, with energy representing 30 to 60% of the operational expense of indoor facilities. A snapshot of the cost to start and operate an ICA of 350 lbs. of cannabis per year from about 1,000 plants and eight workers follow[24].

TABLE 4 APPROXIMATE CANNABIS FACILITY CAPITAL EXPENDITURES

COST DESCRIPTION	COST
Space Rental	$50,000
Structures	$60,000
Equipment	$150,000
Lighting Structures and Related	$120,000
Security System	$45,000
Legal Fees	$55,000

The energy cost per year is about $55,000 as shown in **Table 5**.

TABLE 5: ADDITIONAL CANNABIS FACILITY OPERATIONAL COSTS

COST DESCRIPTION	COST
Water	$700
Labor Costs	$50,000
Packaging Costs	$3,000
Fertilizer and Related	$7,000
Cloning	$1,500
Quality Control and Lab Work	$5,250
Light Bulbs	$1,500
Miscellaneous Supplies	$1,750
Taxes	$55,000

[24] https://www.lender420.com/the-cost-of-setting-up-an-indoor-cannabis-farmthe-cost-of-setting-up-an-indoor-cannabis-farm

Conflicts of Law

As of 2013, Federal prohibition of cannabis significantly hinders local and state regulation in this industry, which keeps black market prices high and reduces the motivation for growers to comply with environmental standards. During cannabis prohibition, Humboldt County's Sheriff's Office Drug Enforcement Agency stated that it is difficult to quantify exact amounts of electricity consumption related to this clandestine industry. Record keeping does not conform with secret operations[16]. Quantifying and comparing electricity use and associated production amounts of all indoor cannabis cultivation facilities is difficult. The clandestine nature of ICA results in barriers in sharing information on energy demand, which leads to inefficient energy consumption, leaving utility companies with insufficient data on the energy needs for indoor cannabis operations or what future energy needs may be required[25].

In short, ICA growers have a tainted legacy/stigma/image and are associated with illegal outdoor cannabis growers' environmental destruction caused by their trespassing and illegal grows during prohibition. Therefore, growers are historically secretive of their activities. For now, cannabis production profits currently far outweigh costs of doing business[23]. A pound of medical cannabis sells for about $2,000.00 on the wholesale market. But production costs are only $600 per pound, resulting in low motivation to conform to legal requirements, taxation, or energy conservation. As more competition enters the market both in California, which is currently the largest source of cannabis on the market and among other legalized states and the profit margin dwindles, incentives to conform to regulations or local policies may play a greater role in incentivizing growers to become more energy efficient.

[25] NEED A REFERENCE…

MARKET CHARACTERIZATION APPROACH

INTERVIEWS

QUESTIONNAIRE DEVELOPMENT

With California's booming supply of cannabis, indoor farming has become a popular alternative for growers. Utilities have shown increased interest in the demand-side energy impacts of indoor cannabis, its current market status, future growth, and environmental impact.

The survey and interviews conducted in this study are intended to gain insight from different stakeholders including their points of view, concerns, and various facets of the indoor cannabis market. The results help provide an overview of the market and a holistic picture of the indoor cannabis industry as it relates to energy usage. This also provides information to assess the market for greenhouse gas reduction potentials. The survey led to a deeper understanding of the energy challenges as well as the opportunities to be considered.

To get a representative sampling of industry stakeholders, short survey questions were developed and targeted towards Indoor cannabis growers, equipment vendors, designers, or engineers, associations, and policy makers (the "stakeholders"). Questions for the stakeholders included both closed and open-ended questions. The open-ended questions were intended to create a deeper conversation and to adapt the questions based on the stakeholders' responses or feedbacks. Statistical data collection was not the primary goal in the questionnaire but intended to get an overview of the industry itself. The targeted questions were intended to gain industry insights and to identify barriers in market adoption of EE techniques in growing facilities.

STAKEHOLDER OUTREACH

Outreach to stakeholders was performed by email and telephone calls. A quick explanation for the survey intent and requests for scheduling a time to complete the survey were scheduled and completed with willing stakeholders. The surveys were later compiled to compare with research data: assessing commonalities and differences. Outreach to various stakeholders resulted in responses and subsequent interviews with eight indoor growers, three industry associations, two IAC designers, three HVAC & Controls vendors, ten incentive program staff from various IOUs, and three lighting vendors. Interviews with vendors included conversations with both sales staff, and design/engineering staff.

The surveyed stakeholders each have an interest in the success of the indoor cannabis industry. Indoor cannabis growers are obviously interested in the success of their business for economic reasons. These open conversations with growers provide insight on their technical knowledge, energy-related efforts and challenges, and their current equipment infrastructure. The reasons for making equipment choices and doubts regarding technical advances gives us more insight to possible solutions that may be implemented.

Indoor cannabis equipment vendors were surveyed to determine the driving forces behind growers' equipment selection. Although growers may desire to buy certain technologies to run their facility, the manufacturers and equipment dealers have insight into the investment path as illustrated by the actual sales. Additionally, the vendors can confirm if sales were made directly to growers or to third party consultants or designers/engineers.

The discussions with designers/engineers reinforced the frame of mind that growers operate their business based on their product quality. The designers work to influence the growers to bridge the gap between the business minded growers and tech skills to get the growers' vision implemented. This sometimes results in less EE options implemented due to the limitations of the grower.

Association roles are mainly as advocates for the growers. They provide community connections, and a sounding board for growers to express their trials, tribulations, and successes in the indoor cannabis community with like-minded persons. They were open to discuss most topics especially with the intent to improve the growers' community (re. cost, energy, licensing, production, etc.) and were an open source of information, although they did not have readily available tangible data.

MARKET CHARACTERIZATION RESULTS

INTERVIEW FINDINGS

LIGHTING

During the initial outreach of growers, a large number cited they used LEDs in their facilities during at least one stage of the plant's lifecycle. Six out of seven surveyed indoor cannabis growers used LED, two of which also used other fixture types such as HPS as well. Some growers preferred other fixtures such as HPS because they can provide more lumens of light and within the required range on the spectrum. Surveyed lighting vendors dealt with a variety of lighting fixtures including LEDs, HPS and ceramic metal halide (CMH). Unlike the growers interviewed, they view a lot of growers note that HPS and CMH lighting are historically the "go-to" for the indoor cannabis industry.

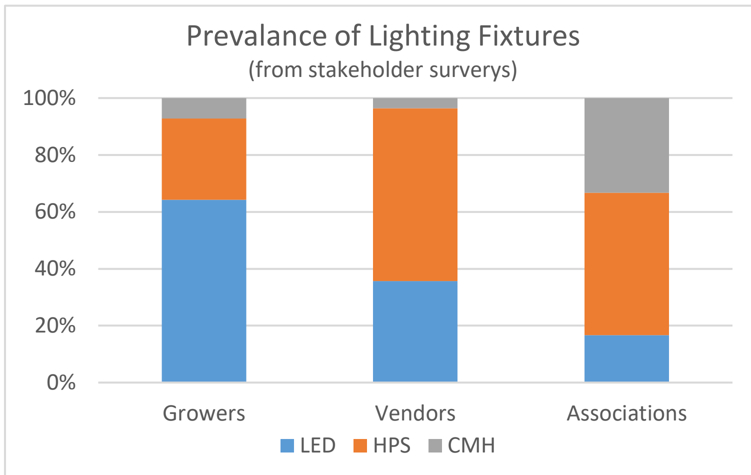

FIGURE 2: INTERVIEW SURVEY RESULTS ON GROWERS' PREVALENT LIGHTING FIXTURE TYPES

They also suggest that policies, energy savings, and incentives have increased the overall popularity of LEDs for indoor cannabis. All surveyed parties noted that the higher efficiency and reduced heat output of LED fixtures were important factors for the wide proliferation of LEDs. The reduced heat output is especially important in vertical farming since the stacked racks of plants and lighting necessitate close placement of plants to lighting fixtures.

The flexibility of LED fixtures was cited by vendors and growers as another major factor for their popularity in the indoor cannabis space. Different strands will often require different lighting power densities, and/or lighting spectra. While traditional lighting technologies would require different lamps or even entirely different fixtures to be installed to meet these requirements, LED technologies can be tuned to meet different power density or spectra requirements. This makes LEDs extremely attractive to growers who want to produce multiple strands of cannabis in the same facility.

HVAC

Based on survey results, cooling requirements are met with a variety of technologies, including split-systems, packaged units, and hydronic boiler/chiller systems. According to one vendor, the technology used depends largely on the size of the customer, with large growers generally using a hydronic system for heating and cooling, and smaller growers generally using split systems or DX packaged units. Information gathered from surveyed growers, associations, and other vendors, tended to align with this.

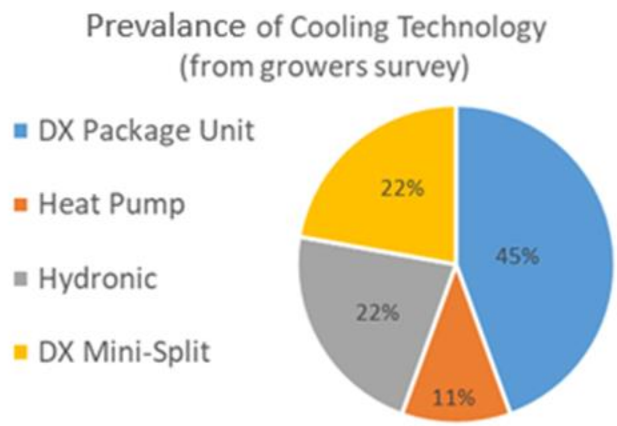

FIGURE 3: INTERVIEW SURVEY RESULTS ON GROWERS' PREVALENT HVAC SYSTEMS

Surveyed growers had a large range of canopy areas, from as small as 600 ft^2 up to 110,000 ft^2 and used a variety of systems such as packaged DX, split units, hydronic cooling, and even absorption chillers for space cooling. Five out of seven of the surveyed growers did not use any type of space heating, whereas the other two used natural gas boilers to heat the growing area.

During the interviews with growers, it was found that all California indoor facilities use an HVAC system for cooling. A range of technologies are used that vary based on the age of the building, canopy size, and cost. The most common HVAC technology across all facility sizes is a DX mini-split configuration. This primarily due to their lower capital cost, availability to purchase off the shelf, and history of use in the illicit California market.

Other common systems used include packaged DX RTUs and heat pumps. But these are less common than DX mini splits. Chilled water HVAC systems are rare but are typically used within buildings that were renovated for indoor cannabis growing and not new construction.

Some advantages of chilled water-based systems include improved overall efficiency and the ability to use water cooled LEDs. The more energy efficient option is replacing the mini-split DX units with high efficiency package units that exceed the Title 24 requirements for their tonnage. The highest efficiency option, which is less common, is a chiller-based system with distributed air handlers. This system configuration is the most efficient and allows for additional upgrades such as waterside economizing, chilled water reset, variable speed chillers, and more.

DECISION DRIVERS AND BARRIERS TO ADOPTION

One factor that all stakeholders agreed on is that there is more control of product quality by growing cannabis indoors. This was a main driver for many of them to go indoors, in addition to factors such as proximity to markets, growing space, water efficiency, and crop resiliency. Growers cited concerns around electrical energy costs, and training required to operate the indoor equipment.

Associations and HVAC vendors noted that there is currently a lack of established best practices with regards to HVAC for indoor cannabis. Based on vendor responses, growers tend to choose the lowest-cost system that can meet the temperature and humidity requirements of their crops.

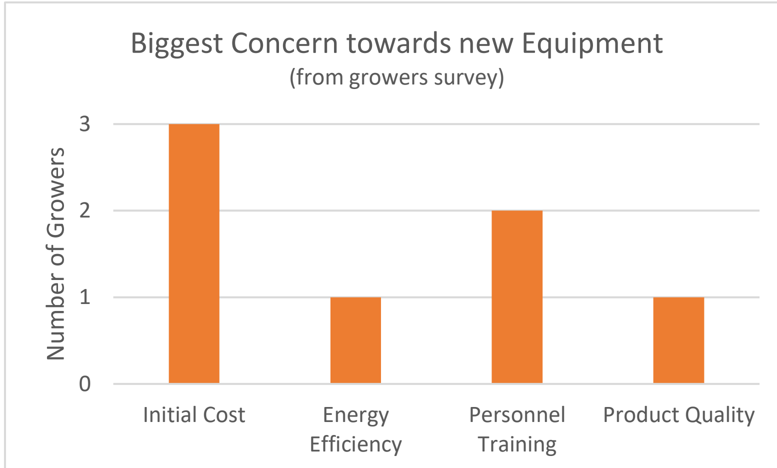

Figure 4: Interview Survey Results on Growers' Biggest Concerns Towards New Equipment

While some larger indoor growers have the background knowledge to consider efficiency and ongoing operating cost, smaller growers are primarily concerned with up-front cost. Design engineers have the knowledge to spec out a system based on provided design points, but generally do not have the background knowledge in cannabis cultivation to determine whether the points they are given are realistic or necessary. Establishment of HVAC best practices for indoor cannabis would be helpful for both growers and vendors in seeking out and developing more efficient indoor cannabis HVAC systems.

One of the main concerns with incentive programs for indoor cannabis is that cannabis is considered illegal on the federal level; hence, they cannot take advantage of federal incentive programs during their transition towards EE equipment. Therefore, incentives will have to be issued by state utilities for them to be accessible to indoor cannabis growers. In addition, current incentive programs tend to focus on like-for-like equipment replacement. As a result, growers will look at equipment that provides the maximum possible incentive rather than equipment that best meets the needs of the facility. Some growers stated the programs do not align with their facility need on either a financial or technical level.

There was a wide range of opinions among growers on the effectiveness and use of EE technologies. Some growers are not convinced that replacing existing HPS with LED lighting fixtures will yield significant energy savings. Others have either installed or are familiar with the concept. In general, all growers have a basic level of knowledge of the technologies that exist in the current market.

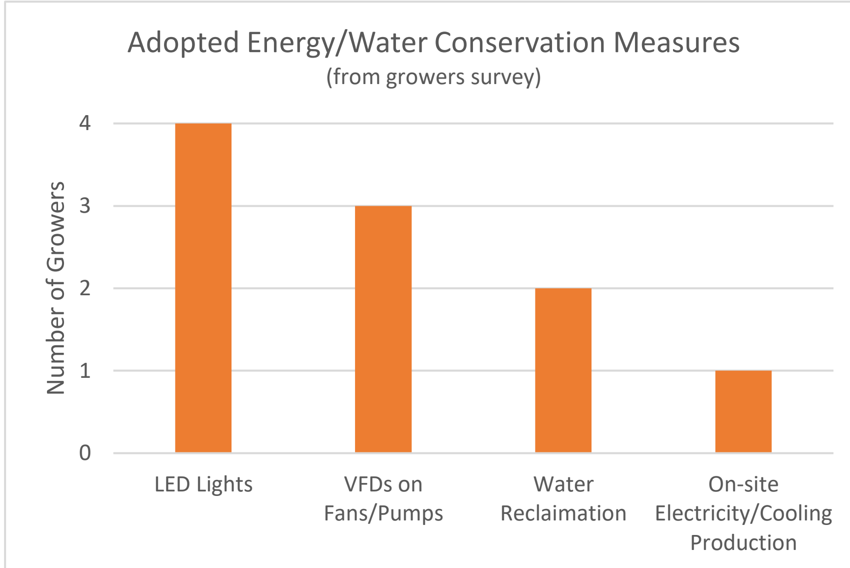

FIGURE 5: INTERVIEW SURVEY RESULTS ON GROWERS' ADOPTED ENERGY/WATER CONSERVATION MEASURES

One grower interviewed has adopted all available EE technologies including a combined heat and power (CHP) system to generate electricity on-site. The system produces electricity for the lights and pumps used for growing and captures waste heat to use in a series of absorption chillers to cool the entire growing facility. Additionally, dew water is collected from the chillers and is used to water the crops. Such a grower whose focus is self-sustainability and environmental preservation, can set an example for others that adopting EE technologies is cost effective and reduces operational costs. Shining light on EE through workshops, associations and utility programs can increase grower awareness and inclination towards EE equipment integration into their facilities.

IOU STAKEHOLDER FEEDBACK AND ASSOCIATED IMPACTS

Various utility stakeholders with direct indoor cannabis experience were interviewed to discuss their programs, incentive processes, and industry standard practice. They also provided insight into the economic and industrial barriers that indoor growers are facing and potential solutions to enhance EE within the industry.

IOU FEEDBACK ON LIGHTING

A total of 12 utility representatives from SCE, Pacific Gas and Electric (PG&E), Sacramento Municipal Utility District (SMUD), and others around the U.S. were interviewed and their experiences are shared in this section. The general consensus was that HPS lighting was the most common for indoor growing facilities followed by MH fixtures. While the interviewed stakeholders varied by geographic location, the market share of LEDs has not surpassed more common HID style lamps. HPS lights are especially popular for growing flowers (including cannabis), whereas MH are more frequent for vegetative growth.

IOU Feedback on LED Lighting Market Barriers

As the cost of LEDs are declining, and their popularity for new construction is increasing, there is still a lag in the industry adoption of LED technology. Based on IOU interviews, this is due to a combination of higher capital costs and misconceptions on the impacts on crop quality. A large majority of new cannabis growers depend on capital investments, and the lower up-front capital HID fixtures are an easy way to start operation and meet their budgets.

Within the cannabis industry, obtaining loans or securing other formal forms of financing their investments is difficult due to restrictions at the Federal level. This leads them towards lower initial cost alternatives rather than EE ones such as LED lights. From a functionality standpoint, some growers argue that LEDs do not provide the full spectrum of light needed for photosynthesis and that the heat released by HPS lights can be desirable for plant growth especially in colder climate zones. Although there is some reluctance towards LEDs, they have become more acceptable by growers recently as the technology has improved to expand the lighting spectrum. The energy savings and long life of LEDs are also catching the attention of growers, which gives reason to believe they will become more widespread in the industry in the near future. LEDs are by far the most incentivized EE technology that the utilities have reported.

IOU Feedback on HVAC

HVAC systems adopted by indoor growers consist primarily of packaged and split units, mainly due to their lower initial costs. These units can be purchased off the shelf with easy installation. Larger growers may lean towards a hydronic (chilled water-based) HVAC system throughout the facility or use existing equipment if the infrastructure was pre-existing.

Standalone dehumidifiers are commonly used to counter the effects of evapotranspiration, removing moisture from the air that the crops produce during growth. CO_2 monitoring is also abundant to help ensure optimum environmental conditions in the canopy area. However, most monitoring is performed manually with adjustments made by either purchasing CO_2 or producing the gas through combustions. Very little consideration is taken towards EE when it comes to environmental control, mainly due to the initial costs and lack of awareness by growers.

For existing indoor growing facilities in California, the systems and equipment have been constructed/set-up relatively recently due to the legalization of recreational cannabis in 2016. Customers are cautious about upgrading systems and equipment that still has large amounts of life remaining in their use. Ultimately this leads to growers being less interested in capital upgrades with higher payback periods for HVAC opportunities due to the sunk costs of their existing infrastructure.

IOU Feedback on HVAC Control Systems

To improve the control of the environmental conditions in the canopy area, some technology focused growers have adopted environment management systems (EMS). Temperature, humidity, lighting density and CO_2 levels can all be monitored and adjusted using the EMS, hence have gained traction to improve crop yield and in some cases energy efficiency. Larger growers tend to have more intricate environmental control and can afford such systems, therefore are more common among them.

Based on various interviews, EMS integration is largely tied to the size of the facility, where growers under 10,000 ft^2 are only 20% likely to use an EMS of some sort, about 30-40% of growers between 10,000 and 50,000 ft^2 have an EMS, and growers larger than 50,000 ft^2 in canopy area are likely to have an EMS in 60% of cases. One of the largest perks to having a comprehensive EMS system onsite is the ability to track energy consumption by area, equipment, or process. With this, growers can understand which equipment is operating inefficiently and may require retrofitting.

IOU Feedback on Current Incentive Process Barriers

Although EE equipment is encouraged by utilities, they remain the expensive alternative and often vary their return on investment between two to five years, or greater. Growers, especially indoor cannabis, need to be cash flow positive early on and simply cannot afford to wait that long for their return. Although year-round harvest is one of biggest advantages of indoor farming, their product demand is not always consistent. This results in short fluctuations in available capital when growers can implement EE technologies. Indoor growers usually cannot handle long term losses, let alone afford expensive technologies to enhance energy efficiency.

Within California, the custom incentive process often results in a long timeline before approval (4 to 8 weeks) which deters customers from participating. Since a lot of indoor agricultural facilities are relatively new and indoor cannabis growers have only recently legalized, they were not able to take advantage of EE incentives the way other industries have and will continue to lag behind until clear energy standards are established in the industry and/or impactful incentives are readily available.

IOU Feedback on Overcoming Adoption Barriers

California Utilities and other stakeholders such as vendors and the growers themselves are working on overcoming the barriers to achieve widespread EE in indoor growing, but it all starts with spreading knowledge and awareness according to multiple experts who were interviewed. Indoor agriculture is a 'word of mouth' community amongst growers, so it is important to educate and provide relevant customer examples and case studies. It is important to growers understand the benefits of energy savings and how they can be achieved without compromising the quality of their product. Some of the utility representatives discussed crop testing with EE alternatives such as LED lights in comparison to typical HPS or MH fixtures, to demonstrate that they do not have adverse effects on yield or crop quality.

There are a significant number of growers who are aware of such technologies; however, find them unattainable either due to their initial cost or because of the long process associated with the application for financial incentives. An idea, from a few of the interviewees, was to develop a sub-sector for indoor growing with incentives tailored to their upgrades. This would help address eligibility issues and perhaps accelerate the incentive application process, which the utility representatives highlighted as key for indoor growers' confidence in the system.

The overall message was to increase awareness, demonstrate proof of product quality and energy savings, and provide uncomplicated incentives that will help improve the payback period of EE technologies.

MARKET ANALYSIS DISCUSSION

POTENTIAL MARKET SAVINGS

As seen in the previous years, the ICA market is continuously rising with growth estimates ranging from 3% to 15% over the next few years [26]. With this growth there will be a significant increase in new facilities to meet the demand with new constructions, renovated warehouses, and expansions on existing facilities. The increased growth requires that utility companies assess their resources for the new load on the grid to account for ay infrastructure modifications to support it. To mitigate expensive modifications to the grid, looking at other cost-effective resources such as EE can help address this concern.

For this study, the potential is limited to the impacts on the Southern California cannabis market. The following sections will review the market savings potential for several technologies and their potential to reduce load from the grid.

LIGHTING

Lighting of indoor cannabis facilities is served by a variety of different lighting technologies. While LEDs have been gaining popularity, especially in stacked applications, HPS lighting is still widely considered the industry standard, with MH fixtures also being used for particular growing applications. The challenge when comparing different types of fixtures is using an appropriate metric to avoid comparing apples to oranges.

The metric used to determine level of service for horticultural lighting is Photosynthetic Photon Flux (PPF), which is a measure of the number of photons produced by a fixture that are usable for photosynthesis. Photosynthetic Photon Efficacy (PPE) is a related measure of how efficiently a given fixture can produce PPF. While there are other measures of lighting performance, such as color rendering index (CRI), a measure of how accurately colors appear under a fixture), and lumen output (a measure of the visible brightness of a fixture), these metrics are not generally applicable to cannabis growth or other types of horticulture. The table below summarizes the PPE ranges of various lighting technologies.

TABLE 6:LIGHTING TECHNOLOGY AND PPE RANGES AND COST PER WATT

LIGHTING TECHNOLOGY	PPE RANGE	LIGHTING TECHNOLOGY
Metal Halide HID	1.0-1.5	$0.24/W
Single Ended High-Pressure Sodium HID	1.3-1.7	$0.23/W
Double Ended High Pressure Sodium HID	1.7-2.0	$0.28/W
LED	2.0-3.0	$1.50/W

[26] https://newfrontierdata.com/cannabis-insights/california-cannabis-sales-gather-momentum/

California Title 24 Proposed Codes and Standards Efficiency Impacts to New Construction

With the upcoming changes to Title 24 in California for Controlled Environment Horticulture, the efficiency required for new construction buildings will naturally reduce load on the grid. The most recent California Codes and Standards Enhancements (CASE) study is proposing a PPE of 2.1 µMol/J as the code minimum for loads exceeding 40 kW for indoor growing of cannabis during the entire life cycle. This proposed PPE is reflective of 92% of Design Light Consortium (DLC) approved fixtures having a PPE of 2.1 or greater[27]. Other agencies such as IECC are proposing a PPE of 1.6 µMol/J as a recommended standard. The current average PPE on the DLC is 2.48[28].

While these proposed efficacies will affect new construction or code triggering modifications, they do not have impacts on existing facilities using lower efficient technologies. Based on interviews with various stakeholders, there is currently a low interest to retrofit to LED or other EE technologies. The identified barriers are implementing LEDs are attributed to upfront capital, education on LED light impacts on quality, and no interest to change based on historical norms. Through natural attrition, a very large portion of existing facilities will eventually transition to LED fixtures with a minority staying with HID or other technologies. HVAC

Space Cooling

Space cooling needs are met by a variety of technologies. Generally, HVAC systems are sized by either BTU/hr. output, or tons (1 ton = 12,000 BTU/hr.), and efficiency is expressed as the Energy Efficiency Ratio (EER). For small and medium facilities, DX packaged units are the most common. These are available a wide variety of sizes (generally 1-10 tons for small facilities) and efficiencies (9.7-11.2 EER). Split-system heat pumps are another available technology which have very similar efficiencies to DX package units with improved efficiency when in heating mode. Within Southern California, there is limited number of heating days in comparison to the cooling load required, and therefore little efficiency gain between heat pumps and DX units.

As facilities increase in size, packaged units are still often used which are available in sizes upwards of 100 tons. Hydronic chiller systems see occasional use in larger facilities which can greatly exceed package unit efficiencies and equate to an EER range from 12 to 15. Chiller based cooling systems are more expensive than package units and require water piping loops, pumps, and potentially cooling towers to support them. Some other benefits of a chiller-based systems include the ability to have tighter temperature control, improved humidity control, and the ability to use water cooled LEDs.

Horticulture-specific packaged units are available but are relatively recent and do not have much market penetration. These units generally have an EER comparable to standard

[27] https://title24stakeholders.com/wp-content/uploads/2020/10/2022-T24-NR-CEH-Final-CASE-Report.pdf

[28] The average PPE of 2.48 is based on 208 fixtures that are approved as of 12/1/2020 on the DLC. https://www.designlights.org/

packaged units, but have the benefit of including a dedicated dehumidifier, and generally are packaged with a horticulture-focused control system.

Mechanical Ventilation

Ventilation fans are frequently used within growing spaces to maintain consistent temperature and humidity conditions throughout the space. These fans vary in sizes ranging from ¼ HP to 5 HP based on their configuration and quantity. While EE options are available for fan motors of this size, due to the small motor size and relatively small gains in efficiency between standard and high efficiency models, the magnitude of available savings is limited. There are potential savings for upgrading horizonal fans to higher efficiency models that will improve air circulation and temperature regulation but should be assessed individually.

Dehumidification

As a result of indoor growing, humidity within the growing area needs to be dehumidified to meet the desired levels in the air. The most common type of dehumidifier are portable dehumidifiers you can purchase online or from a local retailer. The dehumidifiers come in various designs, sizes, and capacities which is specified as pints (or liters) of water removed per day.

Energy Star has designated an energy performance standard for portable dehumidifiers which is designated by Liters per kWh based on three different capacity bins. During the interviews with growers, there was not a lot of information known on the make or model of dehumidifiers used in the growing area. Based on Energy Star, a standard dehumidifier uses 15% more energy than efficient unit[29].

Southern California Market Potential

ICA facilities have a wide variation in energy density per square foot ranging from 150 to 400 kWh/ft^2. This variation is based on a collection of grower-based decisions on lighting hours, temperature control, lighting technology, lighting density, and many other plant specific requirements. There are estimates that show cannabis production requires 1,200 kWh/lbs.[30] of dried product and various surveys that have been performed which have an average production of 39.5 grams per square foot[31]. As an example, a 5,000 square foot facility that harvest three times a year will produce approximately 1,300 pounds of product and use approximately 1,560,000 kWh per year. For this example, it should be noted that the energy consumption of an ICA facility is directly tied to the efficacy of their lights, number of harvests per year, and other energy consuming systems onsite which will impact the kWh per pound metric.

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[29] https://www.energystar.gov/products/appliances/dehumidifiers

[30] https://www.swenergy.org/data/sites/1/media/documents/publications/documents/A%20Budding%20Opportunity%20%20Energy%20efficiency%20best%20practices%20for%20cannabis%20grow%20operations.pdf

[31] https://www.cannabisbusinesstimes.com/article/measuring-yield/

COMMERCIAL ICA FACILITY CARBON FOOTPRINT

In addition to electrical energy, various fuels (such as Natural gas or Propane) l in a commercial ICA facility are used for several purposes, such as a CO_2 source and as a substitute electrical source. The CO_2 injected into grow rooms is produced industrially (from tanks) or by burning propane or natural gas within the grow room contributing about 1–2% to the carbon footprint and represents a yearly U.S. expenditure of $100 Million.

Off-grid diesel- and gasoline-fueled electric generators have per-kilowatt-hour emissions burdens that are three to four times those of average California electricity grids. Vehicle use associated with production and distribution contributes about 15% of total emissions and represents a yearly expenditure of $1 billion.

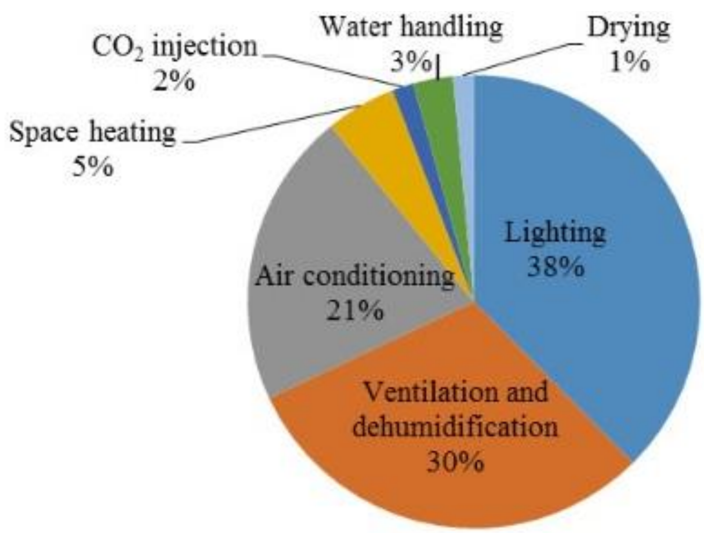

FIGURE 6: ELECTRIC END USE EMISSIONS

ICA EE SAVINGS POTENTIAL ESTIMATES

There is a lack of detailed information on California's total energy usage for indoor cannabis production that is publicly available. Some sources try to use large assumptions and estimates based on production rates which result in a wide range of potential market share. Fortunately, CalCannabis Cultivation Licensing, a division of the California Department of Food and Agriculture (CDFA), keeps public records on active licenses for cultivating cannabis within the State.

Depending on the use, canopy size, and growing location (indoor, outdoor, etc.), this licensing information can be used to determine a low and high estimate on the total square footage of indoor cannabis production in California. Based on the interviews of growers on the current technologies used, it is estimated that a full implementation of EE technologies across all ICA end uses would result in approximately 101.8 GWh reduction when compared to existing standard practices[32]. While this value is unlikely to be achieved, it does provide insight on the total savings that can be achieved. The ICA market has been growing rapidly, and new growth has to potential to increase this savings potential.

2022 California Title 24 Codes and Standards Efficiency Proposal

Conversely, the 2022 Title 24 CASE Report on Controlled Environment Horticulture proposed minimum efficiency requirements for both lighting and dehumidification. In particular, the CASE report proposed a minimum efficacy requirement of 2.1 µMol/J for indoor horticulture, including ICA. The results of this code enforcement will naturally drive the market to adopt LEDs (as the most efficient HID fixture is ~2.0 µMol/J) for new construction and major renovations of ICA facilities.

100% EE Technologies Implementation Emission Reductions Savings Potential

Based on the above kWh savings potential, 100% implementation of EE technologies in the indoor cannabis sector would result in an 18.32 MT of CO_2 reduction in GHG emissions when compared to baseline. It should be noted that the energy use intensity for indoor horticulture is significantly greater than the traditional outdoor farming, resulting in increased GHG emissions. Some of this energy use may be offset by reduced GHG emissions produced by transportation, since ICA facilities can be located closer to retail locations than outdoor farms. Water pumping is also an end-use that has a lower energy requirement for indoor horticulture when compared to outdoor. However, these amounts are dwarfed by the additional energy required by lighting and HVAC for a fully enclosed ICA facility.

Indoor Cannabis Market Barriers for Growers

Financial Barriers

For growers, the primary barrier to EE implementation is financial. The cannabis industry lacks access to traditional banking and loans to raise capital, so equipment purchasing decisions are frequently driven by financial interests, resulting in the least first cost option being purchased. Of the growers interviewed, a majority stated a two-year or shorter payback requirement to consider any higher-cost, higher-efficiency equipment, such as LED lighting fixtures or high-efficiency HVAC. Four out of seven growers stated a 1-year payback requirement. Due to this, financial incentives for EE technologies would have a significant impact on technology adoption if they can reduce payback periods to meet grower requirements.

Educational Barriers

Education is another barrier to EE. Many cannabis growers have been working in the industry for a long time, and frequently have experience in the illicit market using legacy technologies such as HPS lighting. These growers know that the legacy technologies work for their needs

[32] See Section 5 for a summary of the market savings potential assumptions

and are reluctant to change for a variety of reasons, particularly due to concerns that any changes will negatively impact their product quality. This tends to hold true, even when the grower's needs change and the legacy technologies are no longer optimal (for example moving from a garage-scale operation to a warehouse-scale operation).

Due to the insular and still semi-illicit nature of the industry, growers do not receive as much exposure to new technologies and are frequently not receptive to input coming from outside the cannabis industry. For example, one interviewed grower was under the impression that the difference in efficiency between double-ended HPS fixtures and LED fixtures was marginal. Increased availability of educational opportunities for growers, particularly case studies of successful EE projects within the cannabis industry, will be beneficial for helping growers make informed decisions regarding energy consuming equipment.

REGULATORY REQUIREMENT BARRIERS

Regulatory requirements are another barrier to EE, though this is less specific to the indoor market and more with regards to the cannabis industry overall. State and local regulations tend to push growers towards indoor growing and away from greenhouses and outdoor growing, which are naturally less energy intensive. While the scope of this study is primarily concerned with EE in the indoor cannabis market, it is still important to note that expanding the legality of growing cannabis in greenhouses or outdoors would improve EE in the overall cannabis growing market.

INDOOR CANNABIS MARKET BARRIERS FOR VENDORS

EDUCATIONAL BARRIERS

For vendors, the primary barrier is educational. ICA is still a developing industry, particularly when looking at large scale operations. Because of the novelty of the industry, vendors, and designers can spec out systems to meet the stated needs of growers, but do not have the background knowledge required to determine whether the growers stated needs are realistic. Establishment of best practices for indoor cannabis growing, and availability of case studies will allow vendors and designers to help growers design efficient systems that meet the growers' needs and give them the background knowledge to push back when growers have unreasonable expectations.

Additionally, regulatory hurdles, and particularly the semi-illicit nature of the cannabis industry may prevent some vendors from working directly with cannabis growers, especially for larger vendors with a national presence. While cannabis is increasingly becoming legal for medical and recreational use at the state level, it is still illegal at the federal level, and larger vendors with a national presence may be reluctant to work directly with the industry.

Stakeholder Feedback on Indoor Cannabis Market Barriers

Frustration with IOU Custom Incentive Programs

There are multiple IOUs that provide incentives in various capacities to ICA facilities. These programs have varied in success based on their market, technology saturation, code, and effort put forth by the IOU. Multiple stakeholders, who worked with IOU incentive programs across the USA, were interviewed to determine the common barriers that impact the performance of growers' program participation.

In California, the most common barrier is the customers' frustration with the custom incentive program. This was echoed through multiple interviews due to the length of the approval process, required documentation, influence hurdles, and restrictions on when the customer can purchase and implement their project. From the programmatic perspective, lighting has historically been classified as a simpler measure to implement where a deemed/prescriptive offering has served the market. The project developers who work with ICA customers have a hard time developing engagement due to these factors of participating in the existing program framework.

Legal Ramifications Based on Conflicts of Law

Other barriers identified stem from engaging with customers specifically in California due to the previous illicit nature of market. Some customers are not eager to work with or share any details with the IOUs in fear of potential legal concerns at a federal level or regarding state licensing. This hinders project development work and limits the data necessary for developing a complete custom incentive project.

In relation to this barrier, the ICA community in California is very "word of mouth" based where they do share some insights that mutually benefit the community. As IOUs are viewed as public agencies, penetrating this community has historically been challenging as there is a lack of trust on how the information collected and is shared.

Customer Educational Barriers and Uncertainty

One of the larger barriers after engagement with a customer is gaining customer interest in using EE technologies due to education on the product and the capital required. There is still a large portion of growers who believe that technologies such as LEDs will reduce their operating costs but are unsure on their impacts to their product quality. While there are resources and available literature to show the impacts of LED lights on cannabis production, each cannabis grower makes their own independent decision for their facility. This impacts the IOUs as there are very few educated on ICA and therefore do not know how to appropriately service the market.

RECOMMENDATIONS

ERI has compiled various studies, datasets, interviews, and publications to arrive at the following recommendations and next steps for SCE. It is important to note, that multiple standard practice documents and studies were reviewed and found variations from common practices, market adoption, and barriers that were not reflective of the interviews performed of California stakeholders. The following technology practices are based on interviews with stakeholders and available data for Southern California.

SYSTEM STANDARDS AND EFFICIENT TECHNOLOGY

The following sections will outline baseline recommendations for various technologies used within ICA facilities. These recommendations were selected using current market trends and interviewed stakeholders to arrive at these conclusions. While the market is under constant evolution, these recommendations are what is most common and standard practice for existing ICA facilities in Southern California. It is also recommended to perform a detailed customer survey for each technology to determine the current market shares for a formal Industry standard practice determination.

INDOOR HORTICULTURE LIGHTING

During the interviews performed in this study, there was a clear distinction made that the lighting for each phase of the plant’s life cycle may change based on the grower’s preferences. **Table 7** summarizes the most common fixture based on the growth cycle.

TABLE 7: CANNABIS GROWTH CYCLE AND BASELINE FIXTURE RECOMMENDATIONS

CANNABIS GROWTH CYCLE	BASELINE RECOMMENDED FIXTURE
Seedling/Clone	High Pressure Sodium, Ceramic Metal Halides, T8 or T5 Fluorescents
Vegetative	High Pressure Sodium, Metal Halides
Flowering	High Pressure Sodium

All lighting systems are typically controlled with a simple or centralized controller that dictate the timing of the lights. Based on the literature review, there are known optimal lighting hours per day based on the stage of the plant’s life. Due to these requirements, it is common practice to use a timer in the form of a centralized controller or simple electro-mechanical switch.

As technology advances LEDs design for indoor horticulture, the efficacy of these fixtures will increase and overall average PPE within the industry will rise. The average PPE on the Design Light Consortium (DLC) for LED fixtures is currently at 2.48 μmol/J which is significantly greater than the industry standard of Double Ended HPS fixtures at 1.7 to 2.0 μmol/J. It is not recommended to use PPE as standard practice or a baseline due to technology limitation and gap between LEDs and Double-Ended HPS fixtures.

HVAC and Dehumidification

When growing cannabis indoors, keeping the plants at their optimal temperature for growth is imperative for quality and maximum production. In addition to temperature control, indoor facilities are typically humidity controlled to ensure to ensure plant health and reduce the likelihood of mildew.

The most common form of humidity control is a portable dehumidifier that can be purchased at most cannabis supply stores. It is important to size the dehumidification system, typically by pints of water removed per day, to ensure there is no vapor pressure deficit between the plants and air.

Energy Star provides certifications to portable dehumidifiers using a metric of Liters per kWh which varies based on the number of Pints per day of water removed. **Figure 7** summarizes the energy star standard for dehumidification.

Energy Star Certification for Portable Dehumidification [33]

Equipment	Specification	
	Product Capacity (pints/day)	Integrated Energy Factor Under Test Conditions[1] (L/kWh)
Portable Dehumidifiers	≤ 25.00	≥ 1.57
	25.01 to 50	≥ 1.80
	≥ 50	≥ 3.30

Figure 7: Energy Star Certification for Portable Dehumidification

Due to a wide range of dehumidification brands used, a more detailed assessment of Southern California growers' selection of dehumidification needs to be performed to determine the amounts that are Energy Star Certified.

Horticulture Controls

For indoor cannabis production, a centralized controller or energy management system (EMS) is used to integrate all systems from lighting, HVAC, CO_2, humidity, water, and plant sensor data. The control allows for scheduling, setpoint adjustment, automation, and monitoring of the plant's health or performance. Based on interviews with various stakeholders, a centralized building management system (BMS) is very uncommon for all growers in Southern

33 https://www.energystar.gov/products/appliances/dehumidifiers/key_efficiency_criteria

California with only a small portion of larger growers utilizing them. This is due to their higher capital cost to install, experience needed to use effectively, and excessive number of data points in the eyes of the growers. Regarding EE, a centralized BMS allows for the ability implement various strategies to reduce energy consumption for lighting, HVAC, and water consumption.

The most common type of controller (>90% of growers) is a simple human-machine interface (HMI) to control lighting schedules and HVAC setpoints. Either in separate or a single controller, this provides the grower the easiest and cheapest method for adjusting and monitoring their systems operation. While a majority of the HMIs is touch screens, there are some customers who use electromechanical timers due to the reduced costs.

MARKET ADOPTION STRATEGIES

As more states move to legalize medical and recreational cannabis, there is a following market trend to improve the efficiency of indoor ICA facilities. This results in growers and IOUs seeking technologies and methods to reduce energy consumption without impacting the grower’s product quality and quantity.

Depending on their geographic location and number years the state has legalized cannabis growing, there is an observed difference in standards, practices, and codes that are impacting the markets. For example, within California the climate allows for cannabis production outdoors while more northern states can only produce cannabis indoors or with greenhouses. This in turn drives the market to adopt more innovative and efficient technologies as the market is primarily dependent on indoor production.

As outlined in previous sections, there are multiple barriers by all stakeholders that are hindering EE adoption into the market. While some of these barriers have simple solutions, others are more complex and require acute attention to solve. The follow sections will outline a collection of potential recommendations based on conservations with growers, vendors, and IOU representatives with experience in ICA programs. Not all recommendations will be ideal for Southern California Edison but will provide a holistic look at the increasing the adoption of EE for indoor Cannabis customers.

EDUCATION & MARKETING

The cannabis market has many challenges when new growers are starting to renovate an existing facility or begin new construction. While it is easiest to implement EE technologies during the construction of a facility, implementing upgrades at an existing ICA facility has many barriers such as impacts on production schedules, additional costs for removing old equipment and concerns from growers on the impacts to quality and quantity. Within Southern California, this is heavily driven by the previously illicit market using the same practices and standards after legalization.

Multiple discussions with growers, vendors, and IOUs that offer cannabis incentive programs have identified that the primary reason for not adopting different technology is education.

Growers are aware of the various technologies but have fears about their impacts on the quality of their product. The following are recommended solutions:

- **Case Studies** – Producing case studies by real growers in Southern California territory will allow growers to see how others are using various technologies and their effects on product. It is recommended to select well known growers in the industry to reflect different technologies and experiences. This will empower other growers to adopt technologies such as LED lighting and detailed controls.
- **Open Houses & Workshops** – For other IOUs, providing growers the opportunities to come view the technologies at a customer site was shown to be beneficial. Due to California's previous illicit market, some current growers need to see the technology working in person to feel comfortable investing their capital. Introducing workshops during these customer open houses can help answer technical concerns, introduce incentive programs, and develop IOU influence.
- **Technical Documents & Marketing** – Based on grower interviews and IOU discussions, marketing to cannabis growers on the IOU website has an impact on program participation. Out of state IOUs received this feedback from growers that the direct marketing to Cannabis growers increased their participation. By having directed marketing documents, technical papers, and websites, cannabis growers feel the IOUs are directly serving the market and the incentives provided will materialize and not be rejected due to federal restrictions.

Incentives and Funding

Cannabis growers are typically very limited on capital, resulting in using the lowest cost option that will not negatively affect the plants. This was verified through growers selecting HPS fixtures as standard practice due to their low fixture and up-front cost. It was also found that nearly all growers required a near instant return on their investment to consider retrofitting to LED fixtures. The growers' largest concern is that capital for projects such as lighting retrofits needs to be saved in cash and traditional banks (at the time of this study) do not allow cannabis growers to deposit funds. Due to these factors, financing or funding upgrades for cannabis growers is viewed as the primary way to influence participation in IOU programs.

Financing EE Projects

There are multiple methods and ways to finance IOU customers to implement EE projects: Rebates, Custom Incentives, and On-Bill Financing. During interviews with growers, on-bill financing (OBF) gained the most interest to help solve their upfront capital short coming. Currently, there are no California IOUs that are providing OBF due to the issue with federal compliance.

The second most popular option is deemed/prescriptive rebates as they are easier to submit and require a less time-intensive process for approval. The least preferred option is custom incentives due to a variety of hurdles, timelines, and limitations of eligible LED fixtures. Based on the above, the following are the recommend solutions:

- **Cannabis OBF** – Providing cannabis growers easy access to capital to invest in EE will influence capital tight growers. The major hurdles to overcome include federal loan requirements and approval from IOUs.
- **Rebates Targeted at Cannabis Growers** – While LED lighting in California for commercial uses is approaching full industry standard practice (ISP) for both exterior and interior, LED lighting for non-vertical indoor growing is still in early adoption. While it may be challenging to get a workpaper approved (as LEDs for indoor growing can be complex based on canopy size and wattages), it would provide growers an easier method of participating IOU programs. The challenges associated with getting LED workpapers approved include collecting sufficient customer data and meeting the DEER requirements for lighting set by the CPUC. A secondary option from a deemed approach would be a simplified or hybrid process that uses tools to calculate the incentive and savings. This would provide improved accuracy of savings with only minor additional inputs over the deemed approach.
- **Streamline the Custom Incentive Process** – During interviews with various IOUs, one of the major hurdles for engaging customers to participate in California incentive programs are the timelines and documentation required. Cannabis being a cash business means they need to be agile and make quick decisions on projects and upgrades. As they are an agricultural customer, revenue generation is directly tied to their crop and therefore the amount and quality are their largest concerns. Interviewed growers stated that the incentive program can take too long which results in reduced participation or withdrawal from projects. A more streamlined incentive process would line up with the customers implementation speed and improve overall satisfaction with the programs.
- **Normalized Metered Energy Consumption (NMEC) Program** – One of the most common challenges with Cannabis incentive projects is developing a measurement & verification (M&V) plan for verifying lighting project savings. Depending on the customers control system, this varies from challenging to simple. But most of the time collecting logged data on the operating hours requires large numbers of loggers distributed throughout the growing area. During logging there are other challenges such as blocked sensors, relocated sensors, or changing of lighting levels that the loggers do not detect. An incentive program designed around the NMEC platform would make M&V quicker, simpler, and faster for customers to participate in the programs. Some challenges associated with NMEC would be model accuracy if the customer changes lighting schedules significantly.
- **Cannabis Specific Incentive Rates** – Based on various grower interviews regarding investment criteria, more than 90% stated a simple payback approaching one year is needed to invest in energy efficiency. Due to the capital constraints of the market, without any incentive or other non-energy benefits, most growers would elect not to implement any EE projects. Based on historic cannabis projects observed in California, typical indoor LED projects have a payback ranged between three to five years with incentives lowering the payback from one to three years. It is recommended to increase incentive rates for cannabis customers to a limit of a one-year simple payback. This can be justified based on higher realization rates and net to gross values for indoor cannabis projects. As an additional recommendation, the IOUs could require a commitment letter by the customer to reduce the number of withdrawn projects.

- **ICA Facility Classification and Benchmarking** – During the literature review, it was identified that every ICA facility operates differently based on their license, lighting type, lighting density, strain of cannabis, and growers' preferences. These factors directly influence the energy consumption of the facility and therefore skew the benchmarking (kWh/ft^2) for similar facilities with differences in grow techniques or lighting density. It is recommended to implement a form of facility classification and benchmarking to allow for easier tracking and assessment of ICA facilities. This would allow SCE to better target high potential ICA facilities and observe industry trends towards EE over time. While there are benchmarking platforms for cannabis such as Power Score[34] by RII, performing benchmarking at the IOU level provides a more simplified approach that is less rigorous to perform.
- **ICA Growing Technique** – It has become clear that different growing methods have their benefits when it comes to energy usage, product yields, and operational costs. The facilities choice in growing technique

EMERGING TECHNOLOGIES

The Indoor cannabis market is under constant innovation and adoption of various growing strategies, cultivation techniques, and other facets to improve their profitability. As a result, there are many emerging technologies that propose to revolutionize the industry through product quality or energy efficiency. The following technologies have been identified as potential key players in the future of indoor cannabis production.

LIQUID COOLED LEDS

In comparison to HPS fixtures, LEDs put out significantly less energy to heat which results in energy savings at a higher cost per fixture. However, air cooled LEDs still generate heat at the fixture that imparts extra load into growing area that needs to be conditioned by the HVAC system. Liquid cooled LEDs provide cooling to the components of the fixture which rejects the heat out of the growing area. The collected heat can be used for space conditioning, boiler pre-heating, radiant floor heating, and more. The resulting design has the capability to be more efficient than an air-cooled LED system but requires additional capital for the liquid infrastructure.

FIGURE 8: LIQUID COOL LED FIXTURES

[34] https://cannabispowerscore.org/

VERTICAL/STACKED FARMING

As described in previous sections, most growers' main focus is to cultivate a cost-effective product in the space or building they have. The most common cannabis growing techniques used are hydroponics and soil in pot methods with suspended lighting. Within the indoor agriculture market for vegetables and leafy greens, the newest and cost-effective growing technique emerging is vertical or stacked growing. The benefit of vertical farming is the ability to produce more product per square foot in comparison to traditional indoor techniques. When adopting vertical farming techniques to cannabis, there are multiple challenges that need to be overcoming such as vertical height constraints, requirements of different cannabis strains, and sufficient air flow.

Some factors that are slowing the adoption to indoor growing is the requirement to use LEDs as HPS or HID fixtures cannot be placed very close to the plant. Additionally, the infrastructure cost for the initial setup is greater than a more traditional hydroponic or soil in pot method which makes renovating existing facilities less cost effective.

FIGURE 9: VERTICAL OR STACKED FARMING

INDOOR AGRICULTURE AUTOMATION

Unlike traditional outdoor agriculture, indoor cannabis production provides the ability to control almost every element of the plant's growth from light, water, and nutrients. This allows the grower to fine tune the growth of the crop through manual adjustments my taking various measurements within the growing area. A new type of smart horticulture control is allowing growers to use distributed sensors throughout the growing area to automate the adjustments to the system. The controller allows for automatic control of heating, cooling, lighting, water, nutrients, humidity, and CO_2. The automated controls allow the grower to increase their production without having to increase their growing area.

CONCLUSION

The goal of this study was to identified barriers, solutions, and provide recommendations to improve the participating of ICA customers in SCE territory. As summarized in this section, there are multiple potential solutions, emerging technologies, and methods that SCE can adopt to improve their relationship, participation, and overall energy savings from ICA customers.

ICA OPERATIONAL GRID IMPACTS AND ELECTRICAL INFRASTRUCTURE NEEDS

Utility stakeholders have expressed the importance of assessing grid impacts on substations and distribution networks for ICA facilities. Unlike industrial customers who require existing infrastructure or grid impact assessments, indoor growing facilities can exist in commercial or residential centers which may overload the pre-existing grid. For example, a 25,000 square foot commercial space converted to growing cannabis would see an increase in energy usage by over 500,000 kWh per year[35].

While there are solutions to this problem such as substation upgrades, they are costly and typically funded by the utility. It is recommended to explore various options such as zoning cannabis growers, microgrids, or targeted demand side management to avoid costly upgrades. The following steps are the recommended actions for SCE to implement that have been shown through this paper's research to be the most beneficial the IOU.

1. **Program and Measure Development** – The challenges to the ICA industry identified through the research, surveys, and interviews in this study show that existing utility programs can be helpful in very specific circumstances for a very particular customer type. Existing programs help large customers with straightforward scope. There are savings left on the table for the small to medium sized customers and facilities. Significant potential also exists for more complex holistic projects that analyze systems comprehensively to identify, implement, and incentivize a truly beneficial solution. By ensuring that the energy consuming systems complement rather than contradict each other, utility interventions can provide a range of offerings that achieve energy savings with the side effect of better functioning operations.

2. **Marketing Documentation** – Update SCE's marketing documentation to directly target ICA facilities. This update will provide confidence to the growers that the incentive programs are for them to utilize and help dispel any pre-conceived notions that data is shared with the California licensing board or Federal agency. It is also recommended to also update website and online marketing to include ICA facilities.

[35] 36 kWh/sq. ft for an average indoor cannabis facility. https://aeenewengland.starchapter.com/images/Cannabis_Energy_DOER_to_AEENE_Dec_2018_Web.pdf. 13.10 kWh/ft^2 for small office (<30ksf). California Commercial End Use Survey. https://planning.lacity.org/eir/CrossroadsHwd/deir/files/references/C19.pdf

3. **Customer Education** – Provide publicly available studies and documents on SCE website for ICA facilities to review on EE and impacts on Cannabis production. Agencies, such as SMUD[36], provide a good example of different case studies and information regarding Cannabis producers in their territory for review. This information gives confidence that growers they can reach out to have knowing growers who implemented projects and received utility incentives. The education documentation can also dispel myths in the market such as LEDs providing negative impacts on cannabis growth. There is also opportunity for utilities to learn from growers to understand their facilities and provide programs that are tailored to their specific needs.

4. **Utility and Implementer Training** – Perform various training to utility staff and implementers who work directly and indirectly with cannabis projects. This training will ensure all personnel have a clear understanding of the market, technologies, terminologies, and barriers that ICA customers face in the Southern California market. With an educated team with marketing materials, SCE will be better suited to help ICA customers participate in the program and received utility incentives for equipment upgrades.

5. **Simplify ICA Incentive Process** – There are many methods summarized above for simplifying the incentive process for ICA projects. For lighting projects, it is recommended to pursue a simplified or deemed calculation approach to improve the program participation. As most ICA projects are centered around lighting, developing a workpaper or hybrid tool would be achievable with the aid of multiple standards such as the fixtures being on the DLC and baseline fixtures being HPS. If a deemed offering or hybrid tool are not feasible, it is recommended to implement a simple customized approach for ICA lighting projects to reduce turnaround time, meet customizers expectations, and provide flexibility around implementation schedules. This can be achieved but the use of a custom calculation tool, documentation checklists, and streamlined reports.

6. **Modify ICA Incentive Rates** – It is recommended to customize the incentives provided for ICA lighting projects which will result in increased program interest while remaining cost effective. Due to the nature of lighting projects have a simple calculation methodology, the resulting realization rate for this measure type will be higher on average to improve the net-to-gross ration. When customized incentives are paired with streamlined calculation approach, the utility can provide more resources to their customers to implement projects while maintaining a positive Total Resource Cost (TRC) for the program.

[36] https://www.smud.org/en/Corporate/Landing/Cannabis-Operations

APPENDICES

SUMMARY OF CALIFORNIA CITY CANNABIS POLICIES

San Francisco - Commercial cannabis businesses are required to ensure that electrical power is procured from sources that meet the city's minimum requirements for renewable energy. The minimum renewable energy requirements are set by the Director of the Department of the Environment and are consistent with the amount of renewable energy contained in CleanPower SF's Green Service. Commercial cannabis businesses are also required to provide to the Director and the Department of the Environment an annual report documenting the amount and source of energy consumed by the business in the prior 12 months (SFPC Section 6-1618-8(c)).

Sacramento - Applicants are required contact Sacramento Municipal Utility District (SMUD) for their estimated power usage and find EE options for their business. Applicants are required to submit an EE plan with their business operating permit application (City of Sacramento, 2019).

Long Beach - HVAC systems of all structures shall be designed and installed for efficient utilization of energy. Commercial cannabis businesses are required to collect energy usage data and submit annual reports of energy usage. Cultivation shall always be conducted in accordance with state and local laws and regulations related to cultivation, zoning, grading, electricity, water usage, water quality, fish and wildlife habitat protection, wastewater discharges, pesticides, and fertilizers, handling and storage of gases, and employee safety (LBMC, Section 5.92.1010).

Oakland - Indoor cultivators are required to demonstrate that 100% of their electricity is derived from renewable or carbon free sources. This can be done by enrolling in East Bay Community Energy's Brilliant 100 program's renewable content option for electricity or equivalent. Applicants are required to submit Statement of Energy Performance (SEP) and Emissions Performance Reports to the City Administrator's Office (OMC, 5.81.050). The City of Oakland's Green Building compliance standards requires that new residential, commercial, including commercial cannabis businesses, and retrofitted buildings are designed to achieve high levels of EE and green performance (City of Oakland, 2019).

Chula Vista - Commercial cannabis businesses are required to collect energy usage data and submit annual reports of energy usage.

San Bernardino - Commercial cannabis business applicants are required to submit sustainable businesses practices as part of their supplemental evaluation criteria in their application (City of San Bernardino, 2019).

Modesto - Use of renewable resources for indoor cultivation and mixed-light operations is encouraged. The City of Modesto's Commercial Cannabis permit application procedures may award credit for use of renewable resources (MMC§10-3.707(g)).

Moreno Valley - Commercial cannabis businesses are required to use electrical power from municipality's minimum requirements for renewable energy.

Hayward - Applicants are required to submit a Sustainability Plan that mitigates electric and water use. Plans are required to be prepared by an environmental engineer and reviewed by the Environmental Services Department.

Salinas - Applicants are required to describe how their business would practice EE in their application.

Berkeley - Commercial cannabis businesses are required to collect energy usage data and submit annual reports of energy usage. Indoor cultivators are required to demonstrate that 100% of their electricity is derived from renewable or carbon free sources. Cultivators must mitigate the carbon dioxide emissions caused by the generation of electrical energy delivered to its Facility by participating in East Bay Community Energy's 100% renewable content option for electricity or equivalent. Alternatively, the offset can be achieved through purchase of renewable energy certificates certified by the Center for Resource Solutions.

CAL CANNABIS CULTIVATION LICENSE NOMENCLATURE

The following table summarizes the square footage and license categories used when issued to California Growers by Canopy Area.

Category	Outdoor	Indoor	Mixed-Light
Specialty Cottage	Up to 25 mature plants	Up to 500 sq ft	Up to 2,500 sq ft
Specialty	Up to 5,000 sq ft or up to 50 mature plants	Up to 5,000 sq ft	Up to 5,000 sq ft
Small	5,001-10,000 sq ft	5,001-10,000 sq ft	5,001-10,000 sq ft
Medium (limited)	10,001 sq ft to 1 acre	10,001- 22,000 sq ft	10,001- 22,000 sq ft
Large (Not issued until 2023)	Greater than 1 acre	Greater than 22,000 sq ft	Greater than 22,000 sq ft
Nursery	No size limit defined in statute (no canopy)		
Processor	Conducts only trimming, drying, curing, grading, or packaging of cannabis and nonmanufactured cannabis products		

FIGURE 10: CANOPY AREAS BY CALIFORNIA GROWER TYPE

Source:
https://static.cdfa.ca.gov/MCCP/document/2017%201206%20Cannabis%20Cultivation%20Regulations%20Update.pdf

MARKET POTENTIAL ASSUMPTIONS

			Notes
Current Standard PPE	1.85	umol/J	Average for Double Ended HPS which is most common standard
Proposed PPE for LED	2.48	umol/J	Average from DLC LED Lights
Photons Received by Plants	85%		Estimated
Target PPFD	700	µmol/(m2*s)	Recommend an average PPFD for photosynthesis
CA Min Sq Ft for Licenses	1,950,412	Square Feet	From CalCannabis License
CA Max Sq Ft for Licences	5,080,500	Square Feet	From CalCannabis License
Ave Lighting Hours	5201.25	Hours per year	From 2022-NR-COV-PROC4-Final for T24 dated October 2020
Conversion 1	10.7639	Sq Ft per a Sq Meter	
Percent of ICA in Southern California	53%		Estimated from License Data by # of licenses per County
Baseline Demand Low Estimate	42.8	MW	kW = PPFD * SqFt / C1 /PPE/1,000,000/Photons Received * % of SCE
Baseline Demand High Estimate	111.4	MW	kW = PPFD * SqFt / C1 /PPE/1,000,000/Photons Received * % of SCE
Baseline Energy Low Estimate	222	GWh	kW = MW*Hours/1000
Baseline Energy High Estimate	579	GWh	kW = MW*Hours/1000
Proposed Demand Low Estimate	31.9	MW	kW = PPFD * SqFt / C1 /PPE/1,000,000/Photons Received * % of SCE
Proposed Demand High Estimate	83.1	MW	kW = PPFD * SqFt / C1 /PPE/1,000,000/Photons Received * % of SCE
Proposed Energy Low Estimate	166	GWh	kW = MW*Hours/1000
Proposed Energy High Estimate	432	GWh	kW = MW*Hours/1000

Demand Savings Low	10.9	MW
Demand Savings High	28.3	MW
Demand Savings Average	19.6	MW
Energy Savings Low	56.5	GWh
Energy Savings High	147.1	GWh
Energy Savings Average	101.8	GWh

FIGURE 11: ICA MARKET POTENTIAL ASSUMPTIONS

SUMMARY OF INTERVIEW QUESTIONS

INDOOR AGRICULTURE SURVEY FOR INDUSTRY ASSOCIATION

Thank you for taking the time to answer a few questions regarding Indoor Agriculture in California. The results from this survey will be used by utilities to develop incentives and programs to improve the adoption of high efficiency technologies. If you have any questions, please email Ethan.Clifford@Eripacific.com

Please answer the following questions to best of your knowledge:

1) Approximately what percentage of cannabis production occurs in an indoor environment, vs in a greenhouse or outdoor? Is this generally increasing, decreasing, or remaining steady?

2) What are the primary reasons for growers choosing indoor growing over outdoor/greenhouse?

3) What do you think are the primary reasons for any industry-wide trends towards or away from indoor growing?

4) From highest (1) to lowest (4), rank the prevalence of each lighting technology in indoor cannabis growing facilities.

   ___ Incandescent

   ___ Fluorescent
   ___ LED
   ___ HPS
   ___ MH

5) Why do growers typically choose traditional lighting technologies over LEDs?

6) From highest (1) to lowest (4), rank how common each cooling system technology is among indoor cannabis growers.

   ___ DX Package Units
   ___ Water-source heat pump
   ___ Split system AC/heat pump
   ___ Hydronic (chiller) system

7) What are the primary drivers behind cooling system choice?

8) Besides Lighting, HVAC (including circulation fans), and water pumping, is any other major energy using equipment common at cannabis cultivation sites?

9) Are there any formal guides or classes regarding indoor growing best practices (with regards to lighting, cooling, heating, water use, etc.)?

10) What, in your opinion, are the primary barriers to the adoption of energy efficient technologies (i.e. LED lighting, high efficiency HVAC, motor VFDs) in indoor cannabis growing?

11) What, in your opinion, could be done to increase the prevalence of energy efficient technologies in indoor cannabis growing?

INDOOR CANNABIS SURVEY FOR CULTIVATORS

Thank you for taking the time to answer a few questions regarding Indoor Cannabis in California. The results from this survey will be used by utilities to develop incentives and programs to improve the adoption of high efficiency technologies. If you have any questions, please email Ethan.Clifford@Eripacific.com

Please answer the following questions to best of your knowledge:

1) Could you provide an estimate of how much cannabis is produced by the indoor farm annually (lbs/ft^2)?

2) What percent of facilities were in each size range?

<10,000 Ft^2 10,000 to 50,000 Ft^2 >50,000 Ft^2

3) From most common (1) to least common (4) rank the prevalence of the following cannabis horticulture set-ups.

___ Soil

___ Hydroponics

___ Aeroponics

___ Vertical Farming

___ Other ____________________

4) From most common (1) to least common (6) rank the prevalence of HVAC System set-ups in the indoor cannabis facilities being cultivated.
    ___ Packaged DX Units
    ___ Evaporative Cooling
    ___ Natural Ventilation
    ___ Split AC
    ___ Hydronic Systems
    ___ Heat Pumps

5) From most common (1) to least common (4) rank the prevalence of lighting fixture set-ups.
    ___ Incandescent
    ___ Fluorescent
    ___ LED
    ___ HPS
    ___ CMH
    ___ Other ____________________

6) What is the typical lighting density for crop growth in indoor cannabis facilities (fixtures/ft^2)?

7) Has there been an increased demand in indoor cannabis cultivation in recent years? How much and what is the main reason for its growth?

8) What are the biggest barriers that you have observed when it comes to adopting energy efficiency in lighting, HVAC systems, and other equipment used in indoor cannabis farming?

INDOOR CANNABIS SURVEY FOR GROWERS

Thank you for taking the time to answer a few questions regarding Indoor Cannabis in California. The results from this survey will be used by utilities to develop incentives and programs to improve the adoption of high efficiency technologies. If you have any questions, please email Ethan.Clifford@Eripacific.com

Please answer the following questions to best of your knowledge:

1) What is the total area of the facility that is dedicated to growing (ft2)?

2) Was the facility a new construction or a renovated existing facility?

☐ New Construction
☐ Renovated Facility

3) What kind of horticulture is used to nourish the cannabis?

☐ Soil
☐ Hydroponics
☐ Aeroponics
☐ Vertical Farming
☐ Other

4) How much cannabis does the facility produce annually (lbs./year)?

5) What type of lighting does the farm use for cannabis photosynthesis?

☐ Incandescent
☐ Fluorescent
☐ LED
☐ HPS
☐ CMH
☐ Other

6) What is the wattage and how many lighting fixtures are used for growing in the facility?

7) How much water does the facility consume annually (gallons/year)?

Indoor Cannabis Survey for Lighting Vendors

Thank you for taking the time to answer a few questions regarding Indoor Cannabis in California. The results from this survey will be used by utilities to develop incentives and programs to improve the adoption of high efficiency technologies. If you have any questions, please email Ethan.Clifford@Eripacific.com

Please answer the following questions to best of your knowledge:

1) Where are most of your clients located in California? Outside California?

   California (north, central, south, etc.,): ________________________________

   Locations Outside CA (East, south, etc.): _________________________________

2) In terms of indoor farm area, approximately what percent of customers were in each range (ft^2)?

   ___% <10,000 Ft^2

   ___% 10,000 to 50,000 Ft^2

   ___% >50,000 Ft^2

3) What percentage (%) of your customers purchase for new builds, retrofit, or to upgrade?

   ___ % New build

   ___ % Retrofit

   ___ % Upgrade

4) What kind of horticulture do your customers purchase lights for?

   ☐ Soil

   ☐ Hydroponics

   ☐ Aeroponics

   ☐ Vertical Farming

   ☐ Other ________________________

5) For Indoor Cannabis customers, which fixture is purchased the most (1) to least (6).

   ___ Incandescent

   ___ Fluorescent

   ___ LED

   ___ HPS

___ CMH

___ Other __________________

6) What is the main driver(s) for growers' selection of lighting, racks, and control systems?
   - ☐ Price
   - ☐ Ease of use
   - ☐ Specific crop requirements
   - ☐ Electricity consumption
   - ☐ Other ____________________

7) Which types on Indoor Cannabis set-up is the most dependent on light levels? (Rank from most to least)
   - ___ Soil
   - ___ Hydroponics
   - ___ Aeroponics
   - ___ Other ______________________

8) What is the average lighting density (lamps/square feet) or (lumens/square feet) or photosynthetic photon flux density (PPFD) purchased by Indoor Cannabis customers?

9) What types of controls are Indoor Cannabis customers purchasing with their lights (i.e. manual On/Off, timer, photosensor, light spectrum controls, etc.)?

10) In the last five years, how has the use of lighting in Indoor Cannabis been trending (i.e. type of lights used, number of fixtures, type, or expertise of customers, etc.)?

11) What are the barriers to customers selecting LED tech and controls in their facilities either for new builds or retrofit/upgrade?

12) What can be done within your industry to increase adoption by your customer base of energy efficient tech?

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