RESOURCE INNOVATION INSTITUTE

Efficient Yields
Best practices on energy, water efficiency, and productivity

Sungrown Efficiency - Optimizing the Energy-Water Nexus

In partnership with

3C-REN
TRI-COUNTY REGIONAL ENERGY NETWORK
SAN LUIS OBISPO • SANTA BARBARA • VENTURA

April 7, 2022

Agenda

About RII	1:30	pm
Best Practices for Hardy Starts	1:40	
Water Sources	1:50	
Jurisdictional Expectations, Oversight, Regulations	2:00	
Energy Sources and Utility Bills	2:10	
Efficient Water Management	2:25	
Cannabis Water Benchmarks for California	2:35	
Resource Benchmarking for Water Efficiency and Productivity	2:50	
Efficiency Program Examples	3:00	
Q&A	3:15	

SECTION 01

WELCOME & ABOUT RII

ABOUT US

About RII

- Objective, data-driven non-profit
- Founded 2016 in Portland, Oregon
- Expertise in climate policy, utility programs, green building certification, sustainable business, construction & indoor cultivation
- In 2020, received 3-year grant from USDA to develop KPIs, standards & building rating system for CEA

ABOUT RII

What We Do / Our Mission

We measure, verify & celebrate the world's most efficient agricultural ideas.

Measure

Efficiency & Productivity

- Key Performance Indicators
- Benchmarks
- Baselines

Verify

Best Practices & Standards

- Training
- Policies
- Utility Programs

Celebrate

Leadership Recognition

- Verification
- Case Studies
- Certification

ABOUT RII

Our Network

INPUT from industry leaders and partners

RESOURCE INNOVATION INSTITUTE

EDUCATION and advocacy about best practices for growers

ABOUT RII

Technical Advisory Council

Multi-disciplinary body who aggregates knowledge to support producers and other stakeholders with objective and peer-reviewed data and curriculum on benchmarking resource efficiency

- **Guides** development of standards
- **Shapes** tools and resources to support best practices
- **Advocates** for informed policies, incentives and regulations

HVAC - Lighting - Utility - Water
Policy - Data - Controls - Emissions
Facility Design & Construction

ABOUT RII

PowerScore Benchmarking

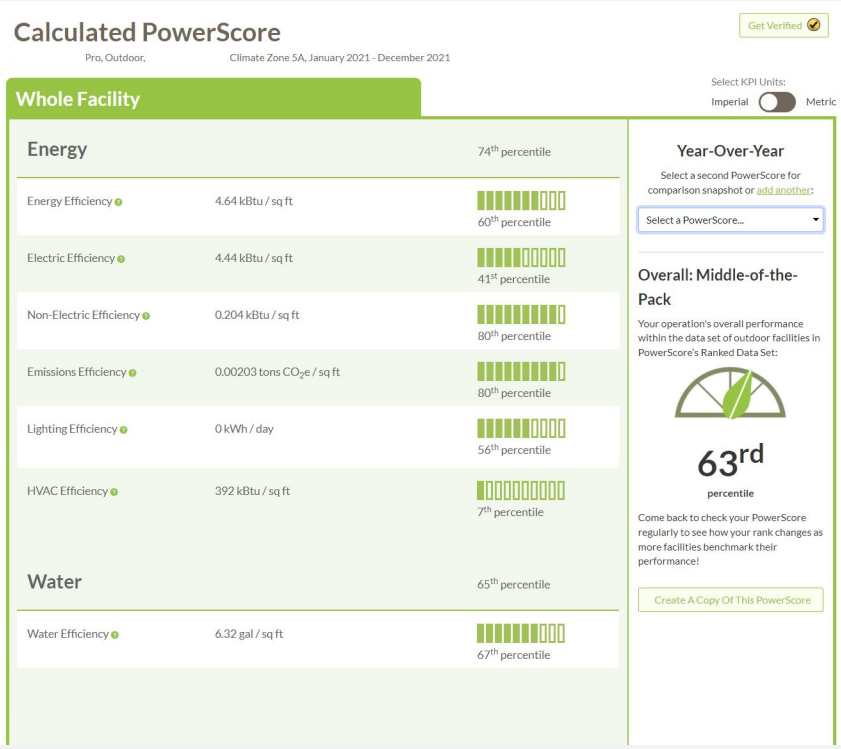
Specialized Key Performance Indicators

- Performance Snapshots
  - Year-over-year energy, water, and emissions rankings
  - Third-party data verification
- PowerScore Comply in select jurisdictions
- Access PowerScore Pro as an RII member
  - Enhanced portfolio management
  - Dashboard reports
  - Filters
  - Access Ranked Data Set

Competitive business insights

- Get ahead of compliance
- Assess portfolios of facilities to continuously improve
- Prioritize capital projects
- Forecast KPIs for new facilities and retrofits

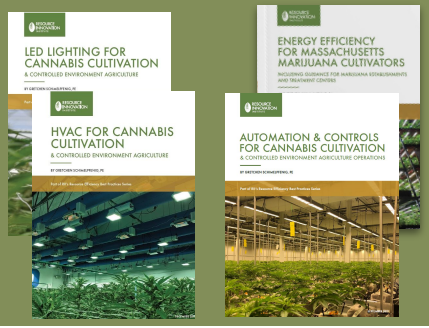
PowerScore



ABOUT RII

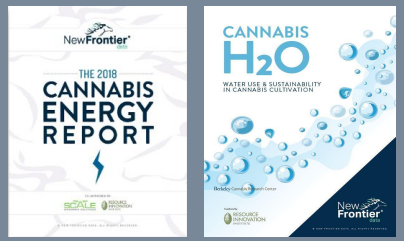
Informing Audiences with Peer-Reviewed Publications

Best Practices Guides
for Producers



Primers
for Governments & Utilities

Collaborative Reports
on Resource Usage

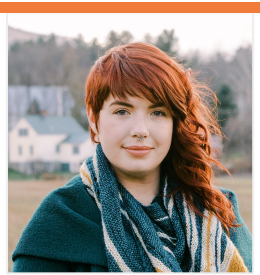


Intelligence Insights
for Members

SECTION 02

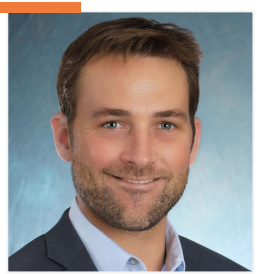
INTRODUCTIONS & PURPOSE

Today's Speakers



Gretchen Schimelpfenig

RESOURCE INNOVATION INSTITUTE



Kyle Lisabeth

Silver Bullet WATER TREATMENT

Chris Burd

CENTRAL COAST AGRICULTURE

Chris Dillis

Berkeley Cannabis Research Center

Daniel Putnam

UC DAVIS UNIVERSITY OF CALIFORNIA

3C-REN: Tri-County Regional Energy Network

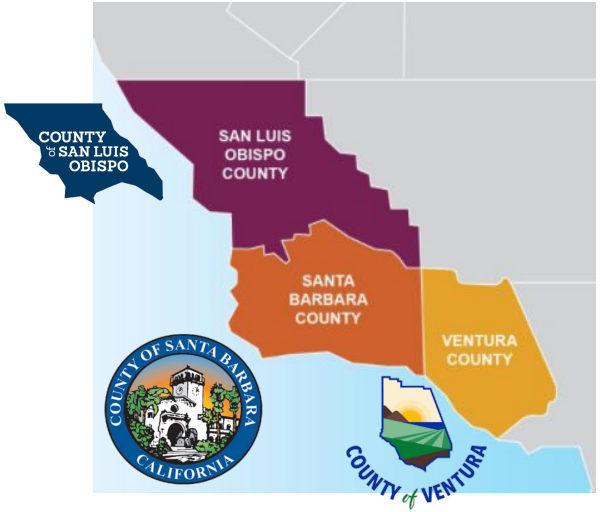
Three counties working together to improve energy efficiency in the region with free programs:

- Energy Code Connect
  - Industry Trainings and Forums
  - Energy Code Coach: Title 24 Compliance Support Hotline (805) 220-9991
- Building Performance Training
  - Training & certification for current and prospective building professionals
  - Helps workers thrive in an evolving industry
- Home Energy Savings
  - Improves home comfort and safety
  - Owners & Renters; Multifamily & Single Family
- Upcoming Courses

3C REN

TRI-COUNTY REGIONAL ENERGY NETWORK

SAN LUIS OBISPO • SANTA BARBARA • VENTURA



Purpose of Today's Workshop

- Help cannabis producers improve the efficiency of their operations with environmental control systems
- Convey scientific insights directly to producers and finding the best ways to translate them in the context of a local ecosystem
- Help government agencies and energy efficiency programs achieve their climate goals through knowledge sharing
- Encourage cultivators to take advantage of 3C-REN resources to support compliance with County energy conservation plans

3C-REN

TRI-COUNTY REGIONAL ENERGY NETWORK

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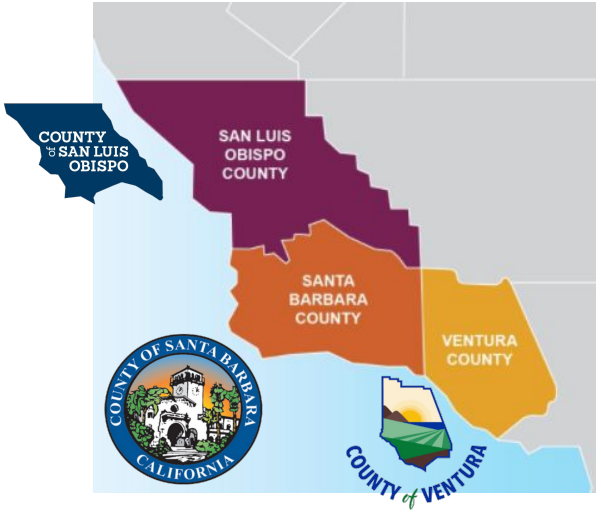


Access Your Tri-County Virtual Classroom

Access the virtual classroom to continue learning

Free guidance on efficient cannabis cultivation

All live workshops are available for on-demand viewing!

- Recordings of live workshops
- Tip Clips
- Downloadable resources
- 3C-REN tools

Create an account at
ResourceInnovation.org/Tri-County

Stream Recorded Workshops

Access the virtual classroom to continue learning

Free guidance on efficient cannabis cultivation

All live workshops are available for on-demand viewing!

- Automation & Controls Best Practices for All Cultivation Environments
- Greenhouse Optimization - Aligning Your Systems with Your Surroundings
- Indoor Optimization - HVAC & Lighting Best Practices

Product Type

ON DEMAND

Efficient Yields Tri-County: Automation & Controls Best Practices for All Cultivation Environments

Faculty: Kyle Booth | Jon Crozier | Ian Logan | Thomas Lor | Gretchen Schimelpfenig | Autumn Shelton | Jan Westra
Duration: 1:50
Format: Audio and Video
Original Program Date: Oct 14, 2021
Price: $0.00 - Non-Members Rate

More info » Save for Later Register

Product Type

ON DEMAND

Efficient Yields Tri-County: Greenhouse Optimization - Aligning Your Systems with Your Surroundings

Faculty: Kyle Clark | Kyle Edmiston | Josh Holleb | Marc Paynter | Gretchen Schimelpfenig
Duration: 2 hours
Format: Audio and Video
Original Program Date: Dec 02, 2021
Price: $0.00 - 3C-REN

More info » Save for Later Add to Cart »

Product Type

ON DEMAND

Efficient Yields Tri-County: Indoor Optimization - HVAC & Lighting Best Practices

Faculty: Dario Boyce | Eric Noller | Anders Peterson | Gretchen Schimelpfenig | Neda Vaseghi | Corinne Wilder
Duration: 2 Hours
Format: Audio and Video
Original Program Date: Feb 03, 2022
Price: $0.00 - Non-Members Rate

More info » Save for Later Register

SECTION 03

BEST PRACTICES FOR HARDY STARTS

Optimize Propagation

- Nursery Clones or Starter Plants - quarantine and review test results
- Cuttings/Clones - need a head house for your stock plants
- Tissue Culture - need a head house for your stock plants
- Starting from seeds - ensure enough time

- Have good environmental controls & biosecurity in head house
- Having variety of genetics so combat unexpected outdoor variables
- Testing source water a fertigation infrastructure before transplanting spring crops

Water as a Performance Tool - Crop Steering

Faster Growth Rate

By maximizing the watering cycles, drybacks, and moisture levels within a plant's medium can increase the growth rates

- Expedite vegatative process
- Average 12-14 day veg time
- Manipulate water viscosity to affect plant stalk/stem development.
- Larger stalk/stem allows for greater nutrient uptake and growth
- Less veg space needed

Faster growth rate within the same space and equal watering amounts = Greater Efficiency

Water as a Performance Tool - Crop Steering

Increased Yields

By maximizing the watering cycles, drybacks, and moisture levels within a plant's medium can increase the growth rates and positively impact yield

- Increase yield rates by 20-50%
- Increase terpene production
- Grow more biomass in the same amount of footprint space

Higher yields within the same space and equal watering amounts = Greater Efficiency

Ensuring Hardy Cannabis Starts

Proper Propagation

- Tissue culture is used widely in ag and has genetic and disease related advantages
- Quarantine your starts at intake, no matter what stage of growth they come in at
- If tissue culture starts are available to you
    - Ask for disease testing
    - Inspect stock
- If tissue culture not available
    - Consider starting in house
- Don’t delay nutrient solution supply for starts

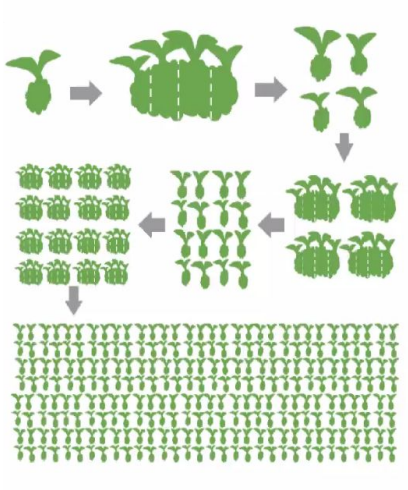


Figure credit: Dr. Hope Jones “Hemp in CEA” presentation

Water as a Performance Tool

Light + Co2 + WATER

Water is one of the critical elements for plant growth and performance

Water quality, quantity, frequency, and timing all affect how a plant grow. And these factors can be manipulated to adjust growth rates and quality

Watering Methodology/Equipment Determines

- When you can water
- How much you can water
- Nutrients that can be controlled
- Water sterility and quality
- Water waste and run-off

Lighting Effects on Crop Growth & Development

Photomorphogenesis: the physical effect of light on plants

- Structure, shape, appearance, color, aroma, leaf size
- Color can affect phytochemicals and nutritional content

Phytochemicals: various biologically active compounds found in plants

Secondary metabolites: can be broken down into two basic families of compounds:

- Cannabinoids, of which THC and CBD are just two of more than a hundred; and
- Terpenes, a large family of compounds associated with aroma and taste

Yield: Production of desired biomass (leaves, flowers, roots, stems)

Research Findings on Spectral Treatments

Blue (450 – 485 nm) has the greatest effect on quality traits and ***suppresses stretch***

"Sometimes, anecdotally, I feel like I get too much blue stretch suppression in early part of growth (develop a canopy that is too compact), so I have to lower PPFD to increase stretch."

Red (625 – 700 nm) drives photosynthesis and biomass production (yield)

Far red (700 – 750 nm) ***positively influences morphology*** but impacts quality more adversely

"Far-red light can increase leaf expansion or stretching which may be beneficial (or not) in achieving a desired effect."

Red (640 nm)

Blue (450 nm)

Amber (595 nm)

Red, Blue, Amber

Supplemental Lighting for Hardy Starts

Enhance plant structure with the right light

"Raise a great child, you are more likely to end up with a great adult."

1. Manage your photoperiod with a lighting schedule
2. Modulate your light intensity by moving lights or dimming
3. Select light recipe to optimize R:B and R:FR
    a. Blue suppresses stretch (compact plants)
    b. Far red encourages stretch (expanded canopy)
4. Monitor your lighting system with metering
    a. Light meter for PPFD
    b. Environmental conditions including temperature & RH

Hardy Start for a Hardy Finish

Figure credit: Chris Burd

High Density Outdoor Plantings prior to Harvest

Figure credit: Chris Burd

SECTION 03

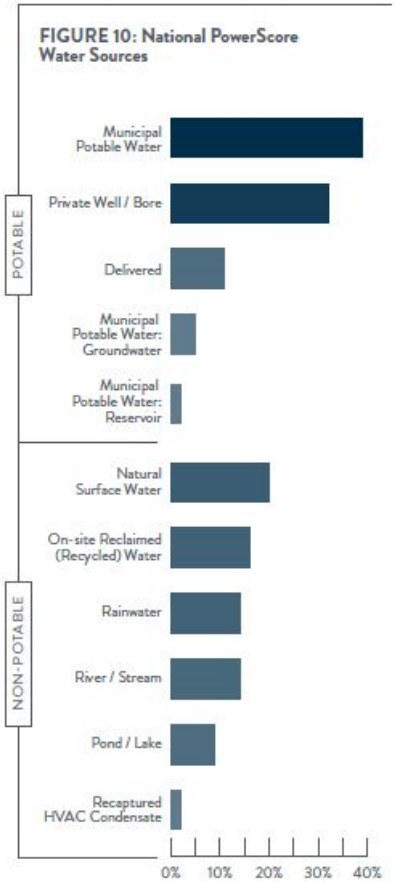
WATER SOURCES

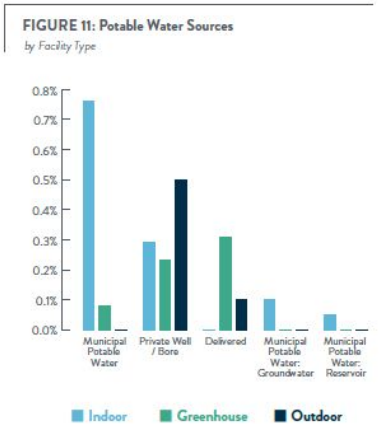
Sourcing Water

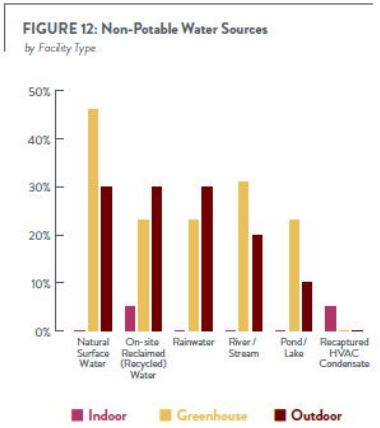
Evaluate Source Water Quality

What water, from where?

- Natural source?
- Municipal source? Private source?
- Delivered?
- Potable?
- Recirculated water?
- Constant? Seasonal?







Treating Water

Consider Treatment Options

What type of system to improve water quality?

- Physical?
- Chemical?
- Biological?

1 **Pre-Treatment/Pre-filtration:** Removing organic and organic debris, including plant material, sediment, and algae.

2 **Sanitation:** A purification process which removes potentially harmful contaminants including microbiological organisms, heavy metals, and residual chemicals.

Treatment solutions can include physical, chemical, and biological systems, as summarized below. The systems are often used in combination to achieve optimal results.

PHYSICAL

Eliminate contaminants either by passing them through the treatment system, or by killing organisms in the water without removing them. Treatment methods generally do not have a residual effect on the irrigation system itself, and generally have no phytotoxic effects. Physical treatment generally does not prevent biofilm buildup or prevent clogging.

- Filtration – from sand separators to reverse osmosis
- Rapid media filtration (rapid sand, greensand, activated carbon)
- Ultraviolet irradiation
- Heat treatment (pasteurization)

CHEMICAL

Chemical treatment systems function by damaging cell membranes and/or internal cell organs, causing organism death. Chemical treatment can also prevent biofilm buildup in an irrigation system.

- Oxidizing agents
  - Chlorine & Bromine – oxidation to destroy organisms such as algae, fungi, and bacteria
    - *Bromine*
    - *Calcium hypochlorite (solid); 60-70% available Cl*
    - *Chlorine dioxide*
    - *Chlorine gas*
    - *Electro-Chemical Activation (ECA)*
    - *Sodium hypochlorite (liquid; bleach)*
  - Hydrogen Peroxide, Peroxyacetic acid
  - Ozone
- Combined Physical and/or Chemical: Advanced Oxidation
- Copper and Silver
  - Copper ionization
  - Copper salts
  - Copper / spin-out fabric liner
  - Silver

BIOLOGICAL

Biological treatment systems generally combine a number of treatment processes: physical separation, competition by other organisms, or creating an unfavorable environment for pathogens. These systems can often provide nutrient removal, and manage water that cannot be recirculated.

- Slow media filters and fluidized beds
- Constructed wetlands
- Wood chip denitrification bioreactors
- Hybrid treatment systems
- Bioswales
- Vegetated filter strips
- Land application

NOTE: Biological systems are often implemented outdoors, and are responsive to temperature. Design consideration should be given to temperature management in regions which experience extreme fluctuations during the year.

Source: Adapted from Water Treatment Guide for Greenhouses & Nurseries, West, J., Huber, A., Carlow, C., April 9, 2018

Ongoing Monitoring & Seasonality

How to be proactive

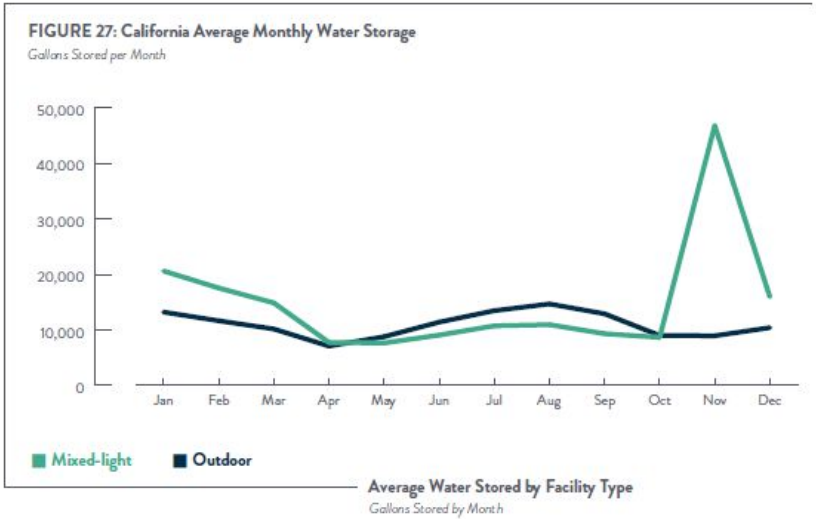
- Ongoing water testing
- Source, Fertigation, End of Line
- Fluctuations in well water quality and depth
- Changes in municipal treatment process.
- Seasonal changes in municipal water source
- Changes in water rates, rights, or reuse requirements

Storing Water

Storage Affects Demand

Store water to save for peak irrigation periods

- What sort of system serves your needs?



Fertigating

Irrigation + Nutrients = Fertigation

Consider substrate and leach percentage

Runoff wastes nutrients and a natural resource

Substrate Options for Hemp

- Soil mix including
  - Coconut coir
  - Peat
  - And amendments like perlite, sand, sawdust, vermiculite, diatomaceous earth
- Rock Wool
- Water Culture
  - Deep Water Culture
  - Aeroponics

WATER MANAGEMENT APPROACH AFFECTS SUBSTRATE & LEACH PERCENTAGE

- **Hydroponic**
  - Deep water
  - Aeroponics
  - Recirculating (no leach) approaches such as deep water culture, aeroponics, top feed drip reclaim, or ebb-and-flow
- **Rock wool**
  - Drain to waste
  - Recirculating (i.e., with no leach)
- **Coir**
  - Minimal leach
  - Leach (10% to 25 %)
- **Peat**
  - No or minimal leach
  - Leach (10% to 15 % range)

Wastewater

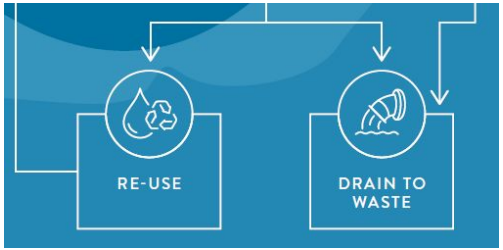
Irrigation Approaches Affect Runoff

Hose watering

Drip irrigation

Micro-pulse irrigation

Recapture, treatment, and reuse



> Depending on watering techniques, 25% or more of applied water drains as runoff.

Water Savings from Drip Irrigation

Compared to using a hose to irrigate the plants, or to a flood-and-drain technique which is highly water-intensive, the precise targeting of drip irrigation can reduce water consumption by 30% to 70%, and improve water productivity by 20% to 90%.

Water Savings from Sensor-Based Irrigation

One agricultural researcher reported that a self-built, microsensor-based system used up to 20 times less water than hose-based irrigation, with equal to better crop yields.

SECTION 04

JURISDICTION EXPECTATIONS, OVERSIGHT & REGULATIONS

Upcoming Code Changes: HVAC

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Read the Final CASE Report

Dehumidification Equipment Standards

Dehumidification equipment shall be one of the following:

1. Stand-alone dehumidifiers that meet minimum integrated energy factors:
    - Minimum integrated energy factor of 1.77 L/kWh for product case volumes of 8.0 ft^3 or less
    - Minimum integrated energy factor of 2.41 L/kWh for product case volumes greater than 8.0 ft^3
2. Integrated HVAC system with on-site heat recovery designed to fulfill at least 75% of the annual energy for dehumidification reheat
3. Chilled water system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat
4. Solid or liquid desiccant dehumidification system for system designs that require dewpoint of 50°F or less

Upcoming Code Changes: Lighting

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Read the Final CASE Report

Indoor Growing, Horticultural Lighting

In a building with CEH spaces and with more than 40 kW of aggregate horticultural lighting load, the electric lighting systems used for plant growth and plant maintenance shall meet the following requirements:

1. Luminaires shall have a photosynthetic photon efficacy of at least ***1.9 micromoles per joule*** rated in accordance with ANSI / ASABE S640 for wavelengths from 400 to 700 nanometers.

2. Time-switch lighting controls shall be installed and comply with Section 110.9(b)1, Section 130.4(a)4, and applicable sections of NA7.6.2.

3. Multilevel lighting controls shall be installed and comply with Section 130.1(b).

Horticultural Lighting Options – Fixture Choices

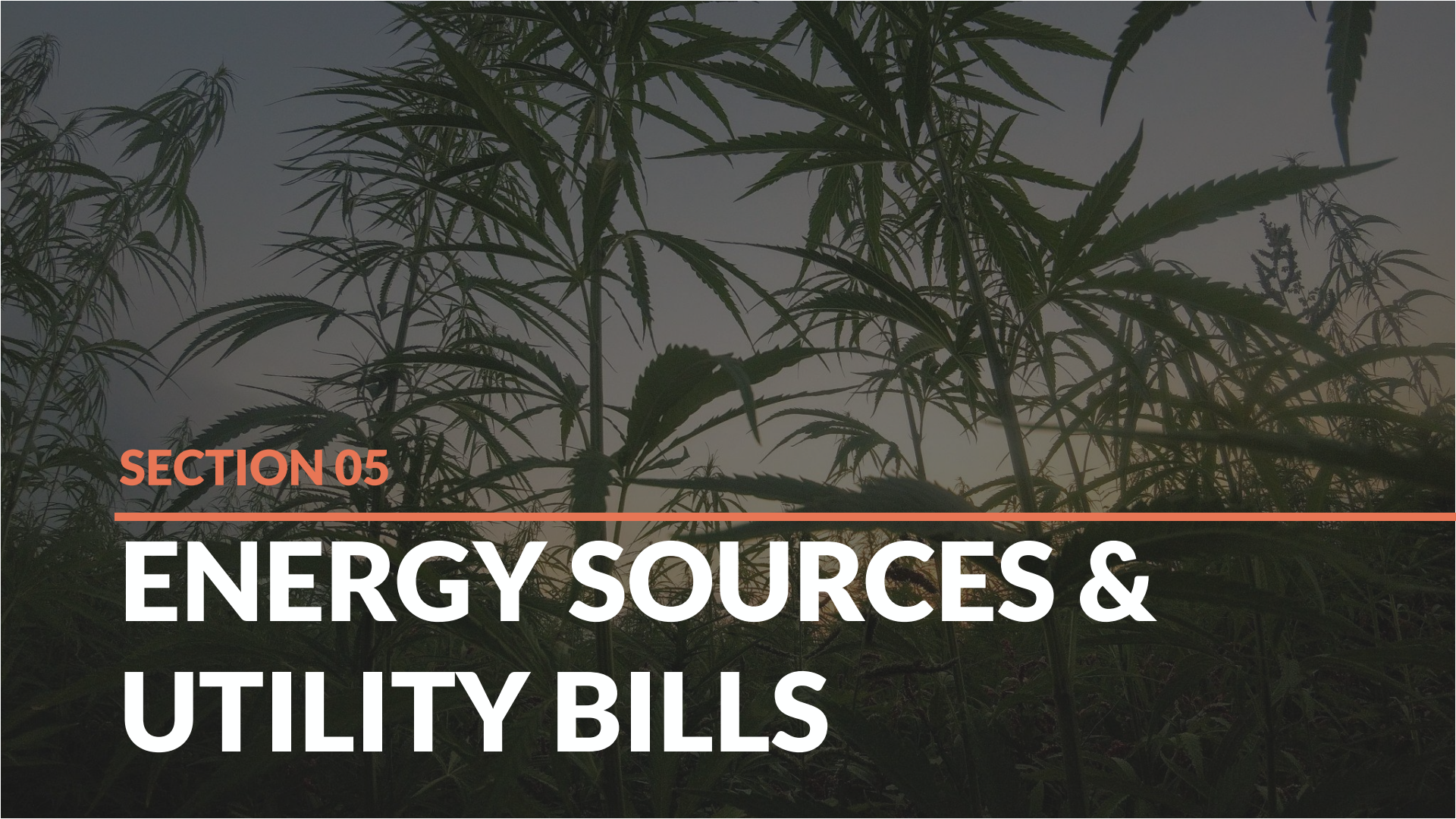
	FLUORESCENTS		HIGH-INTENSITY DISCHARGE (HID)			LEDs
	T8 *Linear, Tube*	T5 *Linear, Tub*	DE HPS *High Pressure Sodium*	MH *Metal Halide*	CMH *Ceramic Metal Halide*	LED *Light-Emitting Diode*
Spectrum	Balanced	Well Balanced	Warm (Yellow-Red)	Cool (Blue-Green)	Well Balanced	Custom (Balanced)
Initial Cost	Low	Medium	Medium	Medium	Medium-High	Low - High
Power Draw	Low / 32W	Medium / 54W	Med / 400-1000W	Med / 400-1000W	Med / 400-1000W	Low-High / 100-800W
Efficiency	Low	Low-Good	Better	Better	Best	Good - Best
µmol/j	0.8 - 1.0	0.9 - 1.2	1.9 - 2.1	1.7 - 1.8	1.6-1.9	1.8 - 3.7
Lifetime (hrs)	12,000	12,000	5,000 - 10,000	6,000-12,000	5,000	≥36,000

Image credit: Fluence by OSRAM

Code: Water Resources

ORDER WQ 2019-0001-DWQ

GENERAL WASTE DISCHARGE REQUIREMENTS AND WAIVER OF WASTE DISCHARGE REQUIREMENTS FOR DISCHARGES OF WASTE ASSOCIATED WITH CANNABIS CULTIVATION ACTIVITIES



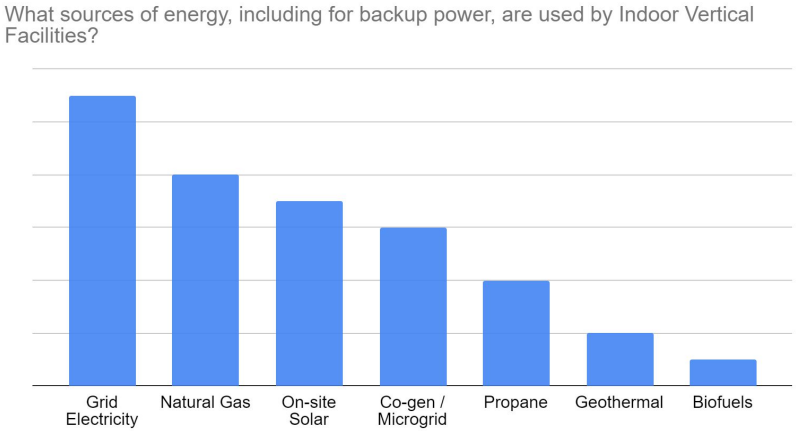
SECTION 05

ENERGY SOURCES & UTILITY BILLS

Energy Choice - Suppliers

Choosing Energy Suppliers

1. Electricity
2. Fuels
   a. Natural gas
   b. Delivered fuels (ex propane)
3. Back-up generation
   a. Delivered fuels (ex gasoline or diesel)
4. On-site energy generation
   a. Solar
   b. Other renewables
5. Energy storage
   a. Battery backup



Energy Choice - Considerations

Major Considerations

- Cost
- Lead time
- Reliability
- CapEx
- OpEx
- Estimating Rates
- Rate stability
- Environmental Considerations
- Opportunity Fuels
- Availability

On-Site Energy Generation - Interconnections

Designing Effective Interconnections

- Types
  - In front of the meter
  - Behind the meter
- Project lead times
- Costs associated
- Process separate from service supply

Lead Times & Supply Chain Considerations

System Type	Order When	Lead Time
Electrical Infrastructure (Switchgears)	Supply chain issues affect this infrastructure so pick a supplier at 30% design to understand electrical loads and bring in vendors. Design to what products are available.	Typical: 18 weeks Today: 32 - 38 weeks Future: 48 - 52 weeks
Energy Infrastructure (Renewable Energy)	If your facility will incorporate technology like solar panels, account for both material delivery and interconnection with your utility.	Today: 1-12+ months (microchip supply) Interconnections can be local issues, dependent on distribution system, and can take up to 12 months.

SECTION 06

EFFICIENT WATER MANAGEMENT

Fuel Sources: Water Pumping for Cultivation

Optimize Operation and Maintenance

- Fuel types (diesel, gas, electric)
- Fuel costs (current & future), availability, and efficiency
- Operating expense
- Environmental impact of energy use for water pumping
- Runtime strategy
- Strategy for a power outage or equipment failure
- Operations and maintenance plan
- Solar powered pumping stations

Service & Maintenance: Water Pumping for Cultivation

Plan Ahead

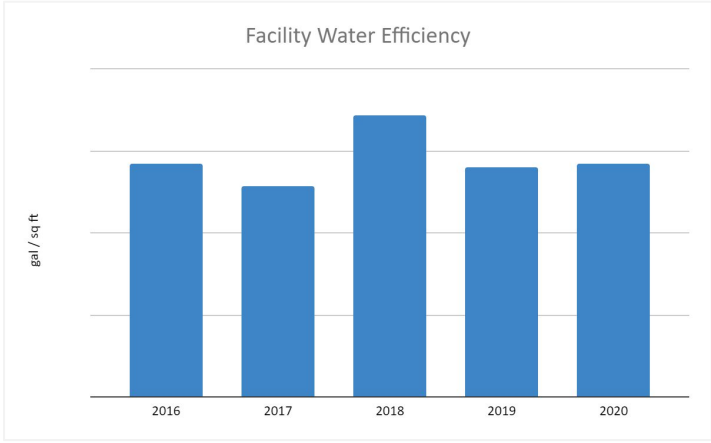
- Backups for
  - Planned maintenance
  - Scheduled downtime
  - Unscheduled downtime
- Seasonal considerations
  - Summer vs winter needs
  - Fuel availability
  - Schedule maintenance around low pumping seasons

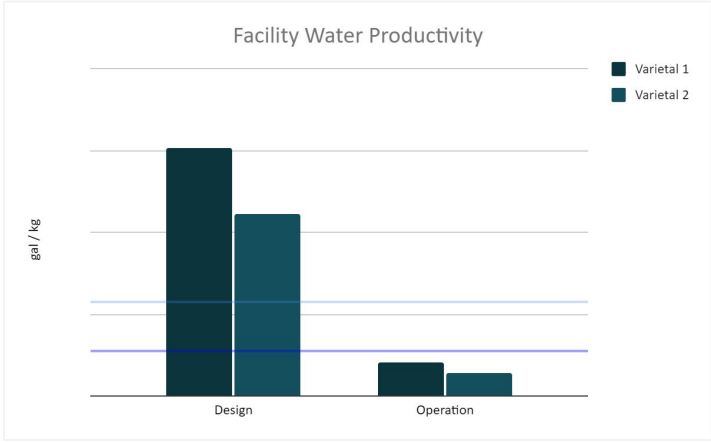
Emerging Water KPIs for Cannabis

Whole Facility

Energy

Electric Efficiency	3,412 kBtu / sq ft	17% better
Emissions Efficiency	0.698 tons CO_2e / sq ft	17% better
Lighting Efficiency	585 kWh / day	10% better
HVAC Efficiency	263 kBtu / sq ft	0% change





Creating Calculation Methodology for Water Circularity

Prescribing Water Savings of Facilities

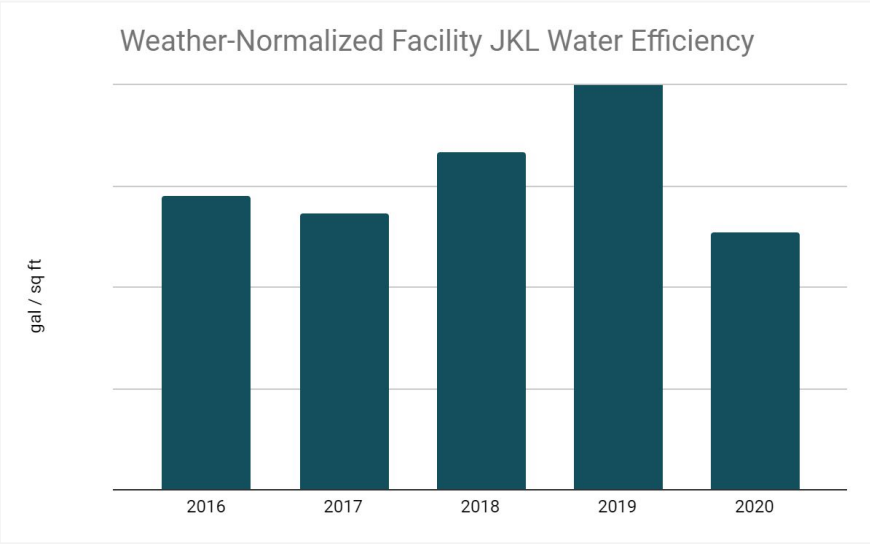
DWG review of calculation methodology

- A grower benchmarks and says they recapture and reuse 55% of the water used by their facility

Actual Water Efficiency KPI = annual consumption per square foot of canopy

Water Circularity % = amount of water recaptured and reused annually

Water Circularity KPI = Water Efficiency * Water Circularity %



Water Controls: Value Proposition

Design and operate for recapture and reuse

- Treat irrigation runoff and HVAC condensate

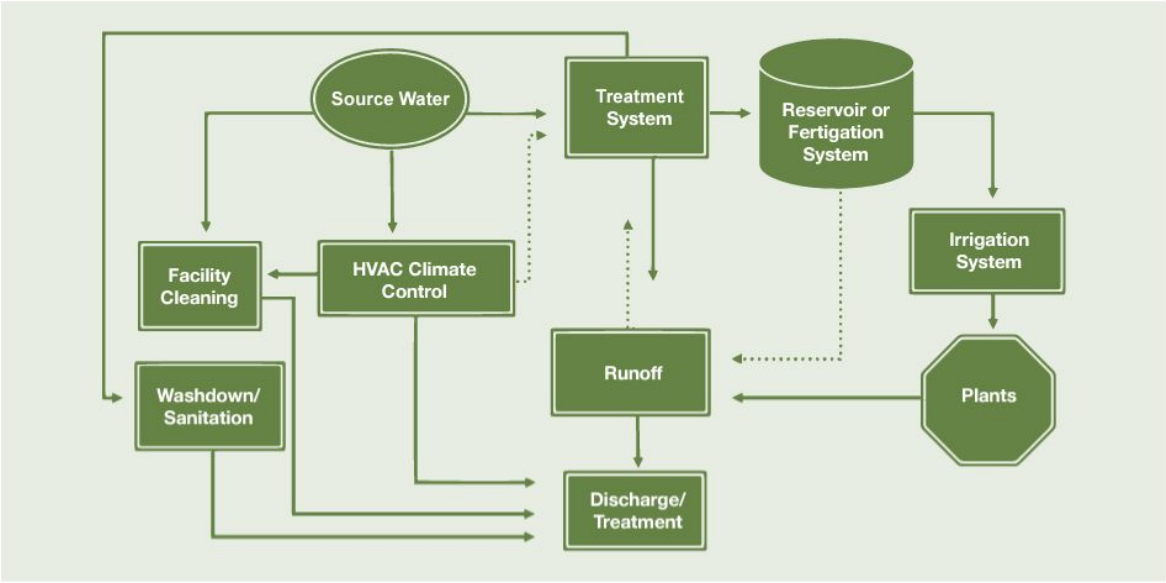


Figure credit: Silver Bullet Water Treatment and Priva

Water Controls: Irrigation Measures

Reduce pumping energy while managing water quality

- Choose substrates with lower leach percentage to manage less runoff
    - Lower leach may be achieved with water culture approaches that recirculate irrigated water
- Understand watering and drainage rates
    - Watering events can range from 1 - 20 per day depending on your choice of substrate
- Employ drip irrigation controls

Precise targeting of drip irrigation can reduce water consumption by 30% to 70%, and improve water productivity by 20% to 90%

Table 8: Water Controls Parameters Measured by Cannabis Cultivators

Water Data Collected	Percentage of Growers Collecting, 2020
Nutrient solution pH	76%
Substrate pH	54%
Nutrient solution electrical conductivity (EC)	51%
Media EC	38%
Root zone temperature	21%

Figure data source: Cannabis Business Times

Water Controls: Recipes for Cannabis Steering

Table 9: Water Controls for Cannabis Steering by Stage of Plant Growth

Watering Controls	Vegetative	Flowering	Ranges of Controls Values
EC Growing Medium	Decrease	Increase	1.8 - 4.5 EC
EC Irrigation Water	Decrease	Increase	2 - 2.8 EC
Substrate Water Content	Increase	Decrease	45 - 65%
Day-Night Water Content Decrease	Decrease	Increase	2 - 10% (5 - 15% with rock wool)
Irrigation Cycle Length and Frequency	Short & Higher	Long & Lower	50 - 150 ml per dripper
Start Time First Irrigation	Earlier	Later	1-3 hours after sunrise/lights on
Stop Time Last Irrigation	Later	Earlier	3-5 hours before sunset/lights off

Figure data source: Signify

Irrigation Studies

2020-2021

- What are the water requirements?
- Does ‘Deficit’ Irrigation improve or detract from CBD production
- Fresno, CA, Davis, CA; Hermiston, OR, Klamath, OR, Ontario, OR, Colorado

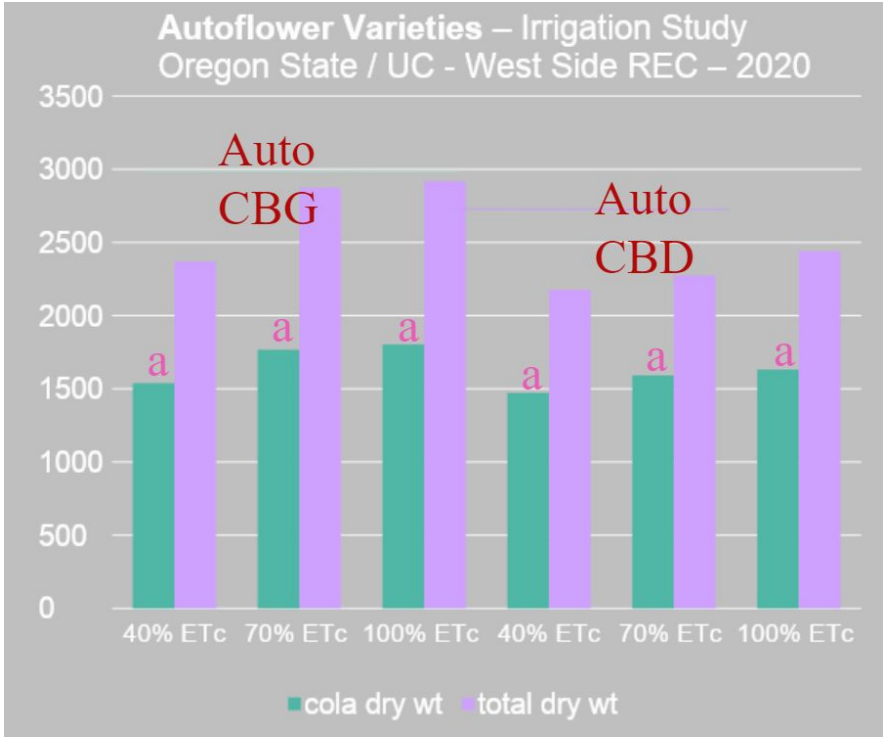


Figure credit: D.H. Putnam et al. ; UC Davis

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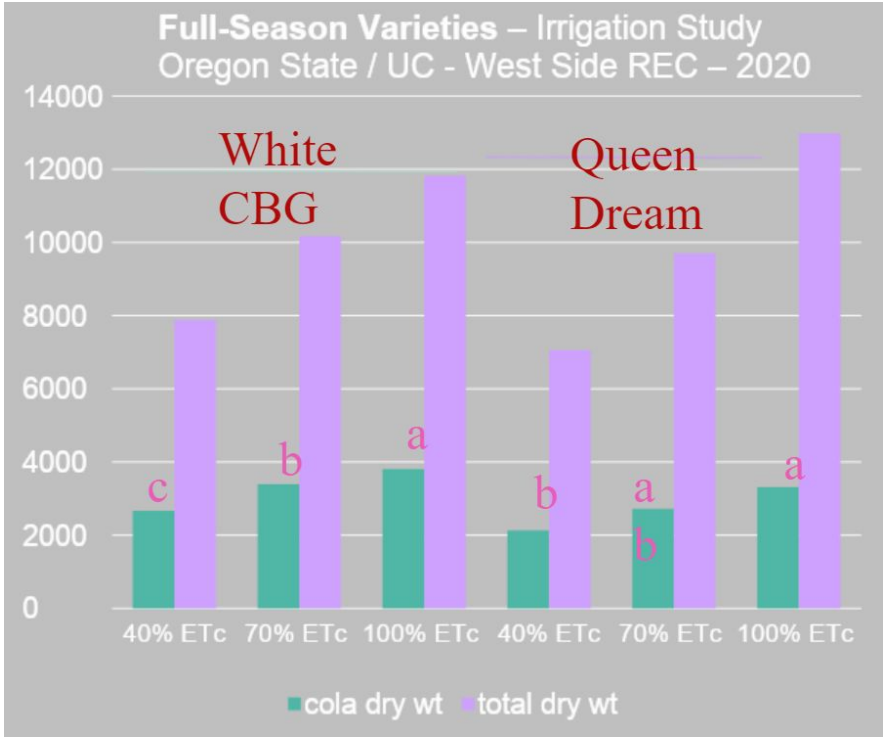


Figure credit: D.H. Putnam et al. ; UC Davis

Applied SDI Irrigations

Industrial Hemp Irrigation Trial – autoflower vs. full-season

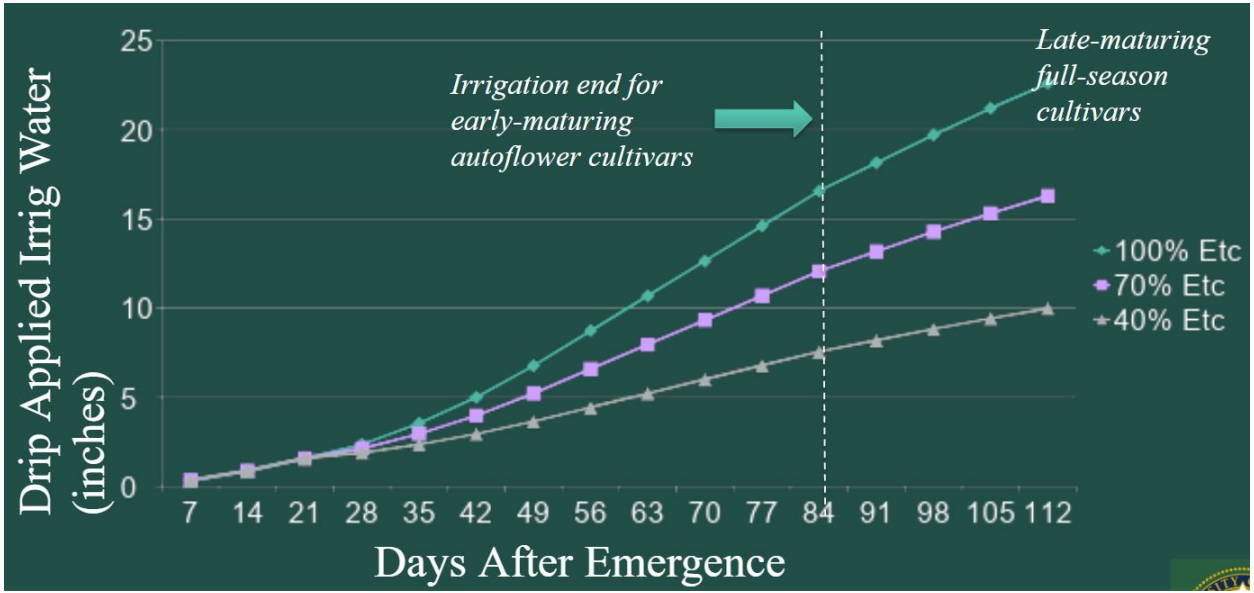


Figure credit: D.H. Putnam et al. ; UC Davis

Nitrogen Studies: (Davis, Fresno)

- 5 N rates
- 4 varieties
- Autoflower vs. Full

Figure credit: D.H. Putnam et al. ; UC Davis

N response '21 (Autoflower)

Trial Site	Cultivar name	Cola yields (all colas larger than 3" length on main stem and branches) (lbs/acre)				
		Within growing season N application level				
UCD		T1 (0 lbs/ac)	T2 (15 lbs/ac)	T3 (50 lbs/ac)	T4 (75 lbs/ac)	T5 (110 lbs/ac)
	Maverick	1399	1395	1595	1561	1507
	Alpha Nebula	1166	1144	1099	954	1137
WSREC		T1 (0 lbs/ac)	T2 (30 lbs/ac)	T3 (60 lbs/ac)	T4 (90 lbs/ac)	T5 (120 lbs/ac)
	Maverick	1676	1899	2186	2344	2407
	Alpha Nebula	1532	1682	1971	2126	2034

Figure credit: D.H. Putnam et al. ; UC Davis

N response '21 (Full Season)

Trial Site	Cultivar name	Cola yields (all colas larger than 3" length on main stem and branches) (lbs/acre)				
		Within growing season N application level				
UCD		T1 (0 lbs/ac)	T2 (45 lbs/ac)	T3 (85 lbs/ac)	T4 (135 lbs/ac)	T5 (170 lbs/ac)
	The Wife	975	1192	1469	1818	1896
	Scarlett	1536	2102	2018	2104	2142
WSREC		T1 (12 lbs/ac)	T2 (55 lbs/ac)	T3 (110 lbs/ac)	T4 (165 lbs/ac)	T5 (220 lbs/ac)
	The Wife	885	1230	1589	1812	1762
	Scarlett	712	860	1075	1179	1269

Figure credit: D.H. Putnam et al. ; UC Davis

Pest Issues

- Weed Management
- Insect Pressure
- Some diseases

Figure credit: D.H. Putnam et al. ; UC Davis

Pest Issues

Corn Ear Worm

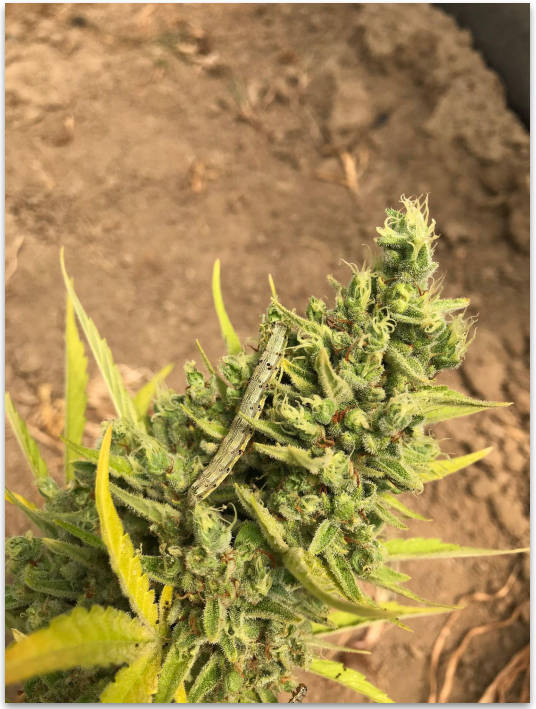


Figure credit: Chris Burd

Pest Issues

Two Spotted Spider Mite

Figure credit: Chris Burd

Pest Issues

Rice Root Aphid

Figure credit: Chris Burd

Pathogen Issues

Beet Curly Top Virus

Figure credit: Chris Burd

Pathogen Issues

Botrytis; Grey Mold

Powdery Mildew

Figure credit: Chris Burd

Research Conclusions

- Full Season Types:
    - Low density, transplant, higher biomass, low Harvest index, high plant residues, long season, higher water use (20-30”), Hand harvest? higher N requirement.
- Autoflower Types:
    - High density, direct seeded, low biomass, high harvest index, little plant residue, short season, low water use (11-15”), lower N use, whole plant mechanical harvest?

Figure credit: D.H. Putnam et al. ; UC Davis

Dive Deeper into Irrigation Controls

Rooting for Recapture and Reuse

READ MORE

Substrate Selection Can Lead to Improved Greenhouse Water Reuse

READ MORE

Articles co-authored by RII with members of our Technical Advisory Council Working Groups

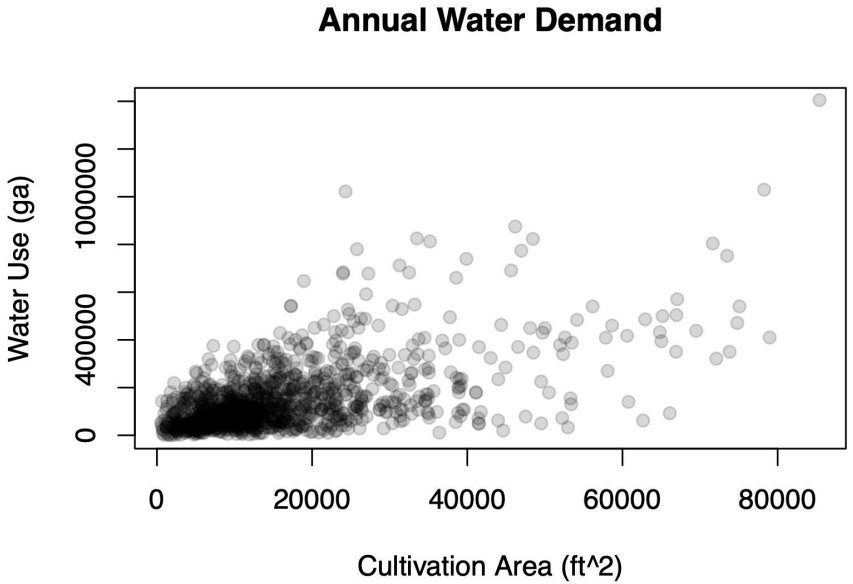
SECTION 08

CANNABIS WATER BENCHMARKS FOR CA

Northern California Data

Variation in Water Use Efficiency

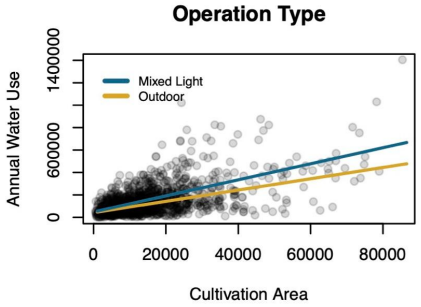
- Data from licensed outdoor (and mixed light) farms in the North Coast Region
- Remarkable spread in the relationship between cultivation area size and annual water use
- Significant variation in growing practices among farms

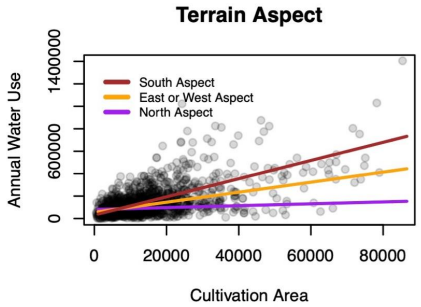


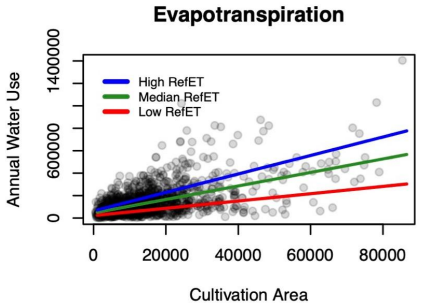
Northern California Data

Variation in Water Use Efficiency

- Spread can be partially explained by
  - **Operation Type** (mixed light or full outdoor), which in this dataset largely reflects planting density
  - **Reference Evapotranspiration** and other broad climatic variables, such as ambient temperature, wind, etc.
  - Local variables like **Terrain Aspect** of the site (i.e. direction of hillslope)



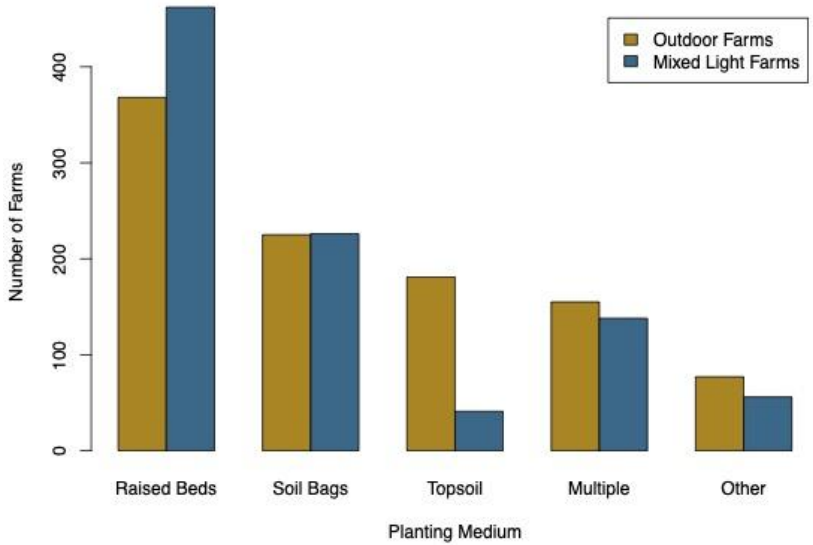




Northern California Data

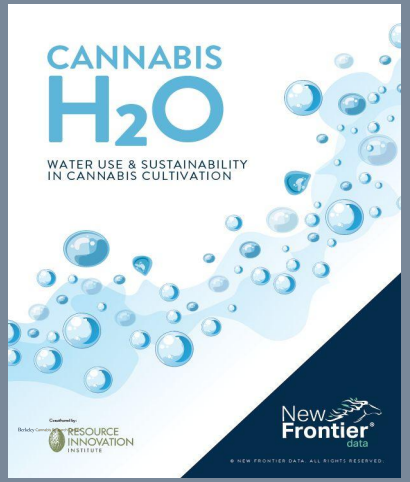
Variation in Water Use Efficiency

- There is also notable variation among farms in planting medium
- Other potential causes of inefficiencies
  - Leaking delivery systems
  - Unsecured water storage
  - Overwatering
- A lot of potential for improving water use efficiency



Resource Usage Reports

Collaborative Reports with New Frontier Data



Peer reviewed

Brand-agnostic

+50 contributors

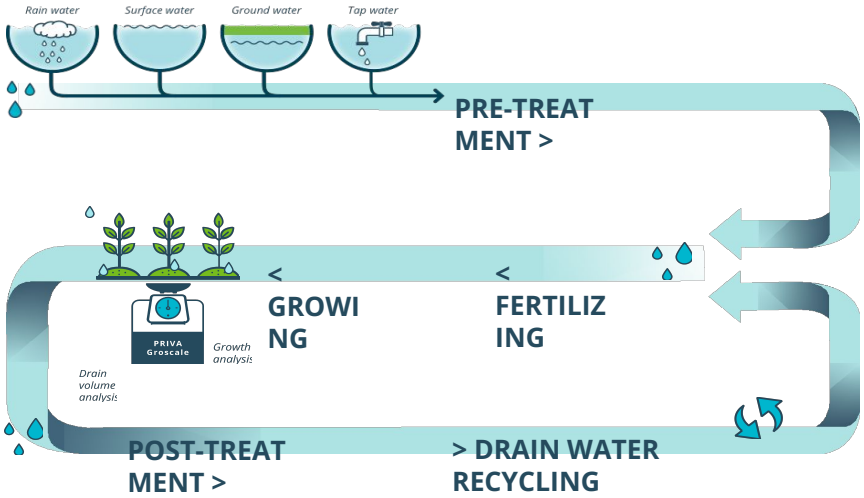
Available through New Frontier Data at resourceinnovation.org/resources

Water Management Processes

Benchmarks for Performance Evaluation

Capture the complexity of cultivation operations

Water Efficiency	***gallons / flowering canopy sq ft***
Water Productivity	***grams / gallon***
Water Demand	***gallons / year, month***



Water Management Systems and Applications

- Irrigation
- *Cooling*
- *Cleaning*
- *Fogging for Pest Control or Humidification*

Recapture and reuse for efficiency

Figure credit: Priva

Cannabis Water Benchmarks

Rethinking Cannabis Water-Use Benchmarks

A recent report on cannabis cultivation water use and sustainability suggests a shift in the way growers should think about and measure water usage.

Doing away with gallons per plant

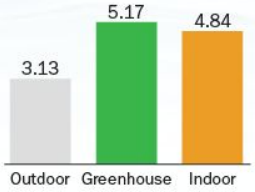
Early efforts to quantify facility water use focused on gallons per plant, but that model didn't take into account the variability in plant density, size and cultivation period.

New performance benchmarks and example usage

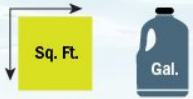
Three measures for tracking water use with examples from self-reported cultivation water data collected by the Resource Innovation Institute's Cannabis PowerScore platform.

Productivity
Measures cannabis flower output relative to water input.

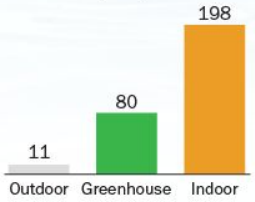
Grams of flower per gallon



Efficiency
Describes how water is used per unit of cultivation area.

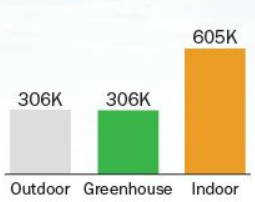


Gallons per square foot



Demand*
Shows how much water is used as the cannabis is produced.

Gallons per year



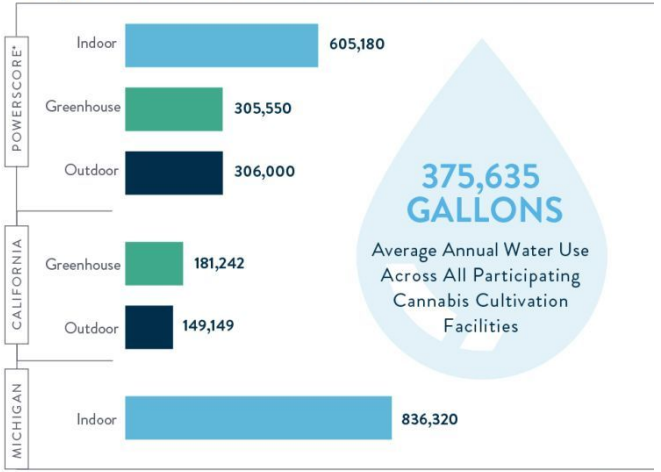
Source: Resource Innovation Institute, Berkeley Cannabis Research Center, New Frontier Data

* Water storage is another demand metric.

CannaBit – EST. 2014 –

AVERAGE ANNUAL WATER USE VARIES WIDELY ACROSS FACILITY TYPES AND REGIONS

Average Annual Water Use of Cannabis Cultivation Facilities *Gallons/Year*



For More Insights Like This,Visit: **NewFrontierData.com**

New Frontier data

* PowerScore Data is comprised of primarily indoor and greenhouse facilities in OR, CA and MA.

Download at
https://info.newfrontierdata.com/cannabis-h2o

Cannabis Water Benchmarks

FIGURE 41: Water Use by Market Type

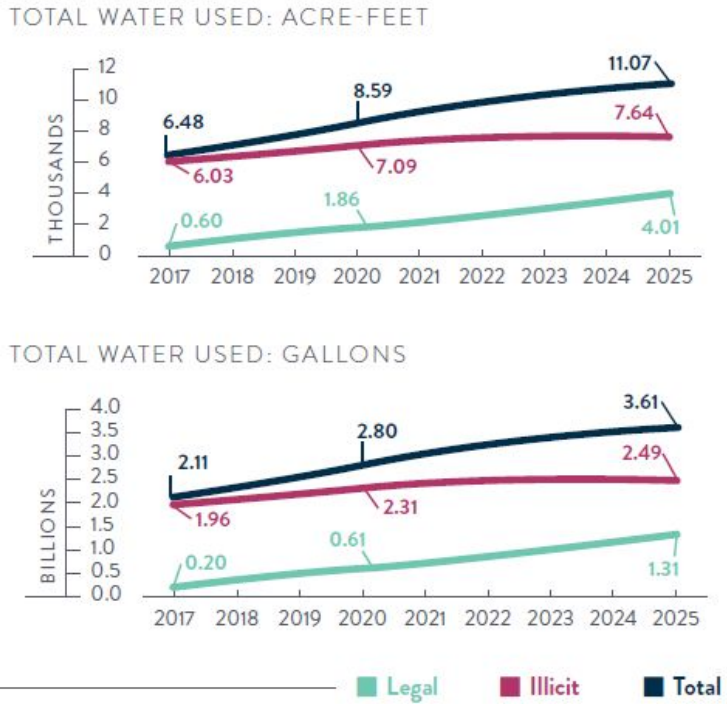


FIGURE 30: U.S. Total Cannabis Cultivation

by Facility Type, 2017-2025

FIGURE 20: PowerScore Water Productivity

Grams/Gallon

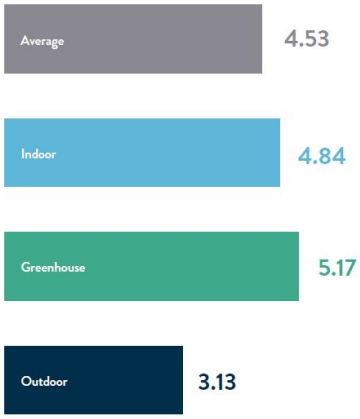
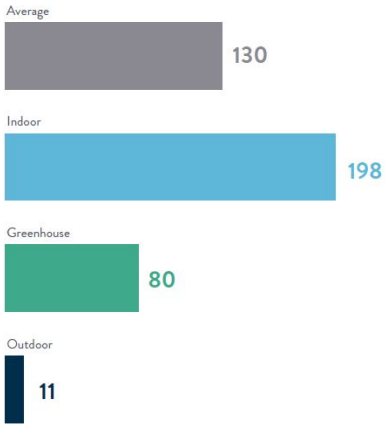


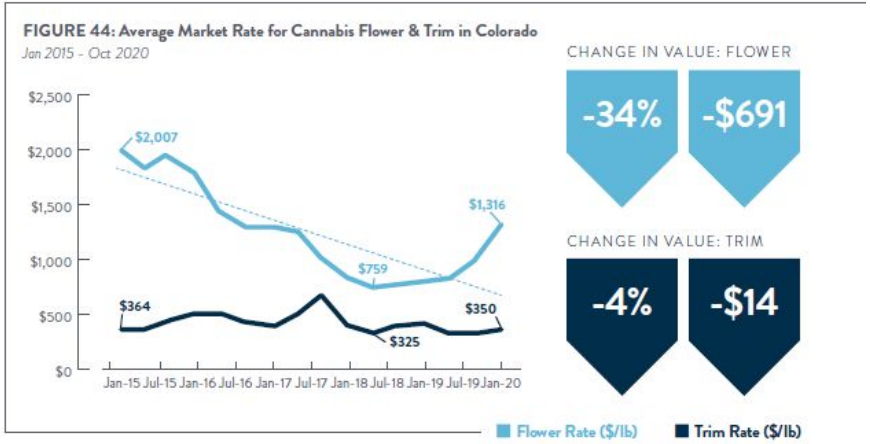
FIGURE 21: PowerScore Water Efficiency

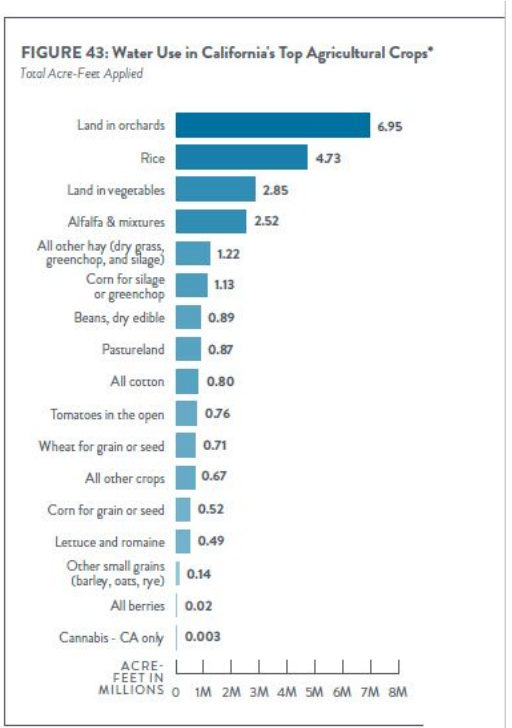
Gallons/sq. ft.



Cannabis Water Benchmarks

A competitive and resilient hemp market demands water efficiency





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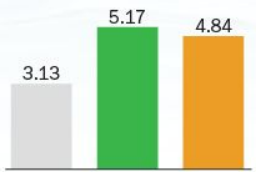

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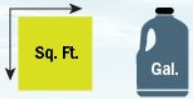
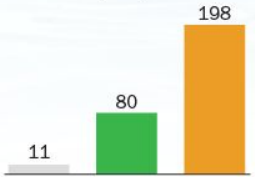
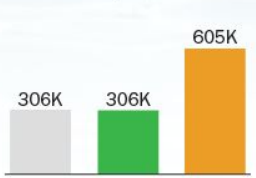


Gallons per square foot



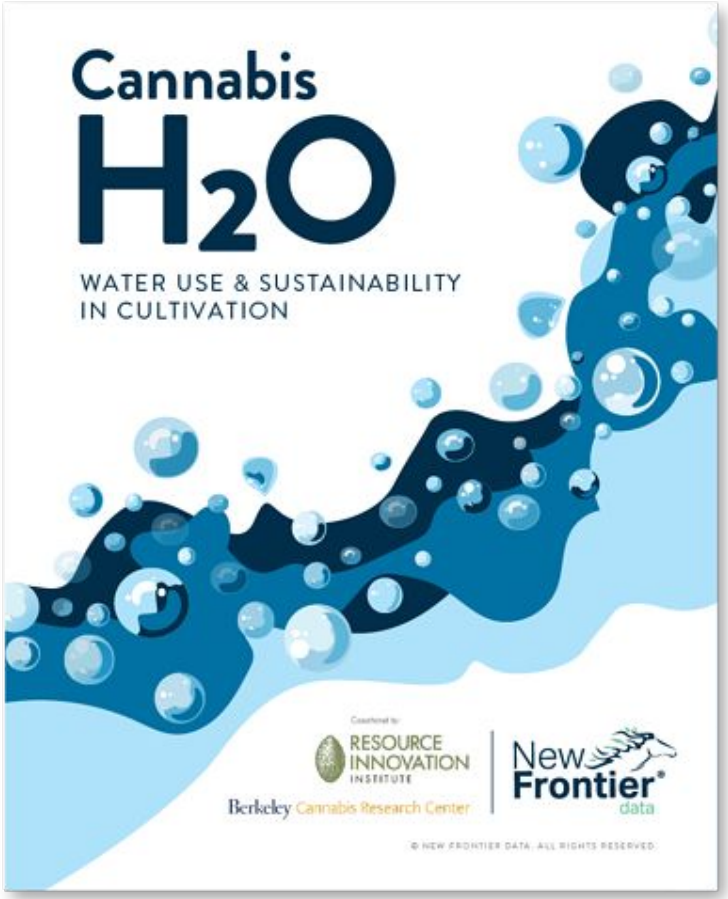
Demand*
Shows how much water is used as the cannabis is produced.

Gallons per year



Source: Resource Innovation Institute, Berkeley Cannabis Research Center, New Frontier Data

* Water storage is another demand metric.



SECTION 09

RESOURCE BENCHMARKING

Facility Performance Snapshots

Key Performance Indicators for CEA

Quantify performance of CEA facilities using specialized key performance indicators for:

- Efficiency
- Productivity

Understand how water system operation affects both water and energy KPIs

- Gallons per day → annual facility energy use

Observe changes in canopy productivity

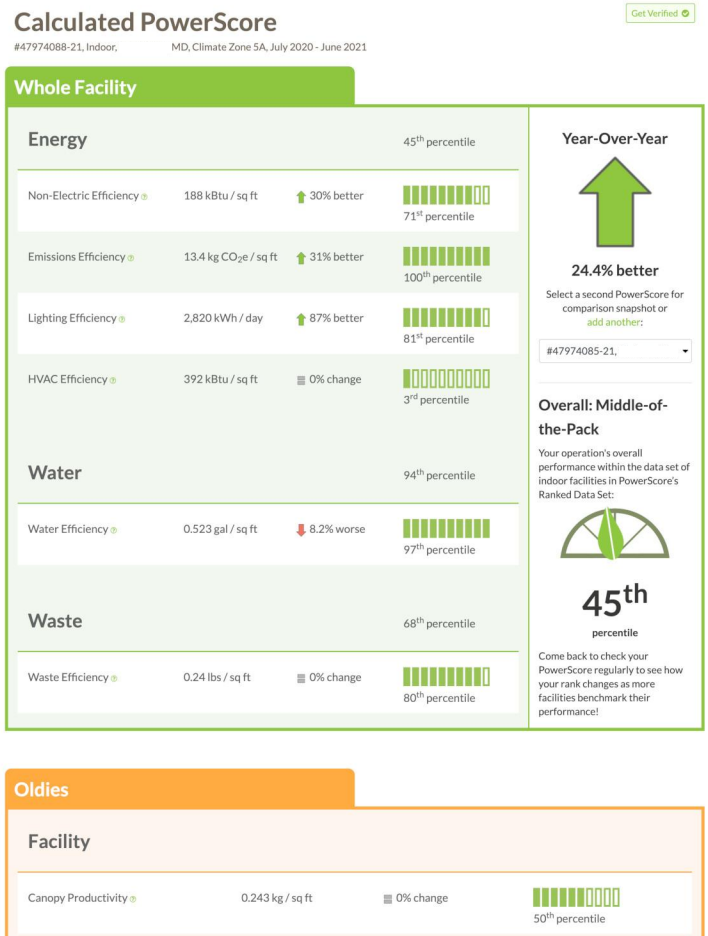


Figure credit: RII, PowerScore

Verify KPIs

Third-Party Verification for Certification

Get Verified KPIs with PowerScore

Share utility bills for RII data check

Use Verified KPIs for environmental reporting

Use data integrations for easy system reports

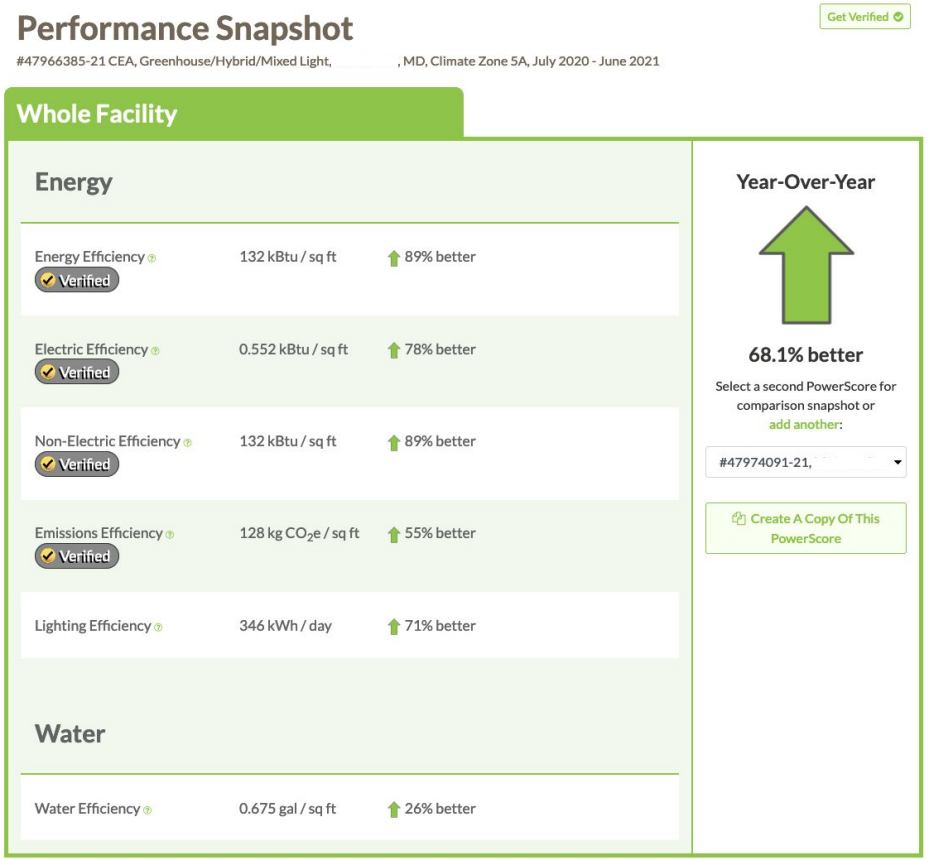


Figure credit: RII, PowerScore

SECTION 10

EFFICIENCY PROGRAM ROUNDUP

Efficiency Utilities Serving Tri-County

Three Regional Utilities with Efficiency Programs

- Utility service territories determine eligibility
- Growers in Tri-County region can benefit from technical assistance and financial incentives
- Incentives reduce the first cost of high-performance technology

PG&E Pacific Gas and Electric Company®

SOUTHERN CALIFORNIA EDISON®

SoCalGas

PG&E Program for Producers

Agriculture Energy Savings Action Plan (AESAP)

Retrofit Program

Visit AgEnergySavings.com

- Cash incentives for energy-saving retrofit projects
  - Installation of new, high-efficiency equipment or systems.
  - Incentives structured to achieve customer's simple payback requirements
- Financing options available
  - On-bill financing
  - Go Green financing

SoCalGas Programs for Producers

Energy Efficiency Programs

- **Agriculture Energy Efficiency Program (AgEE)**
  - New program implemented by ICF, EnSave, and ERI Pacific
  - Financial incentives of up to 50% of the project cost
  - Projects must be installed by the end of 2023
  - Incentives for some projects are available back to June 7th, 2021
  - SoCalGas customers can contact Karl from EnSave at karlj@ensave.com
  - Send general program emails to AgEE@CAEnergyPrograms.com
  - Call 844-523-9981

Visit https://caenergyprograms.com/AgEE

SoCal Program for Producers

Agriculture Energy Efficiency (AgEE)
Retrofit Program

Visit caenergyprograms.com/AgEE

- SoCalGas program currently active
- SCE program projected to launch mid-2022
- Rebates and custom incentives available for retrofit projects


Q & A

CONTACT US

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carmen@resourceinnovation.org

Innovative Water Methods and Equipment

Increased Efficiency and Performance

Drip Irrigation

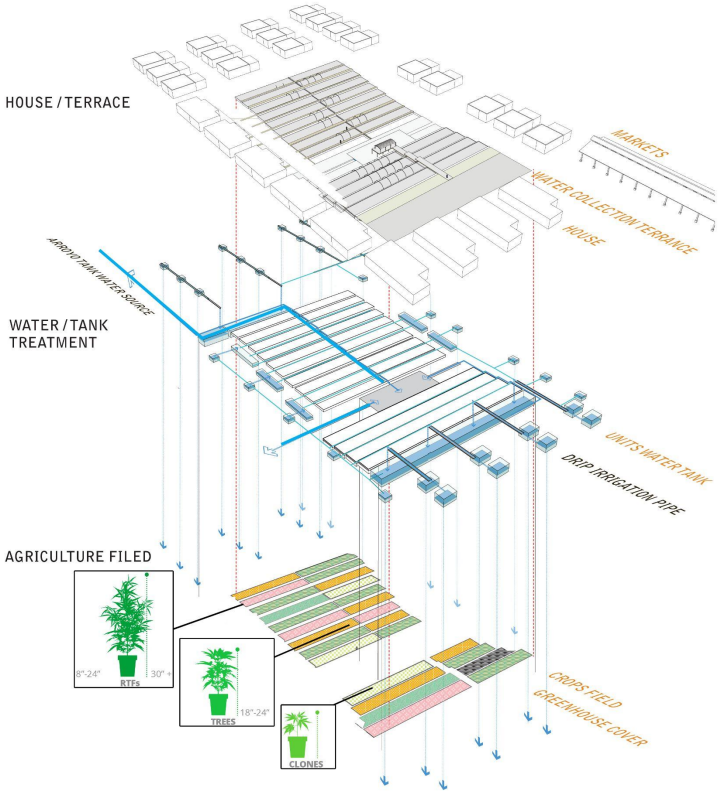
Deep Water Culture (DWC)

Nutrient Film Technique (NFT)

Aquaponics

Benefits of Controlled Watering Systems

- Less water usage
- Greater control of water frequency & quantity
- Fine tune nutrient dosages
- Reduced labor and operational burden
- Opportunities for recapture and reuse
- Less run-off and loss



Case Study Comparison - Waste Water and Reclamation

In addition to how much water is used, it is important to consider how much water is wasted

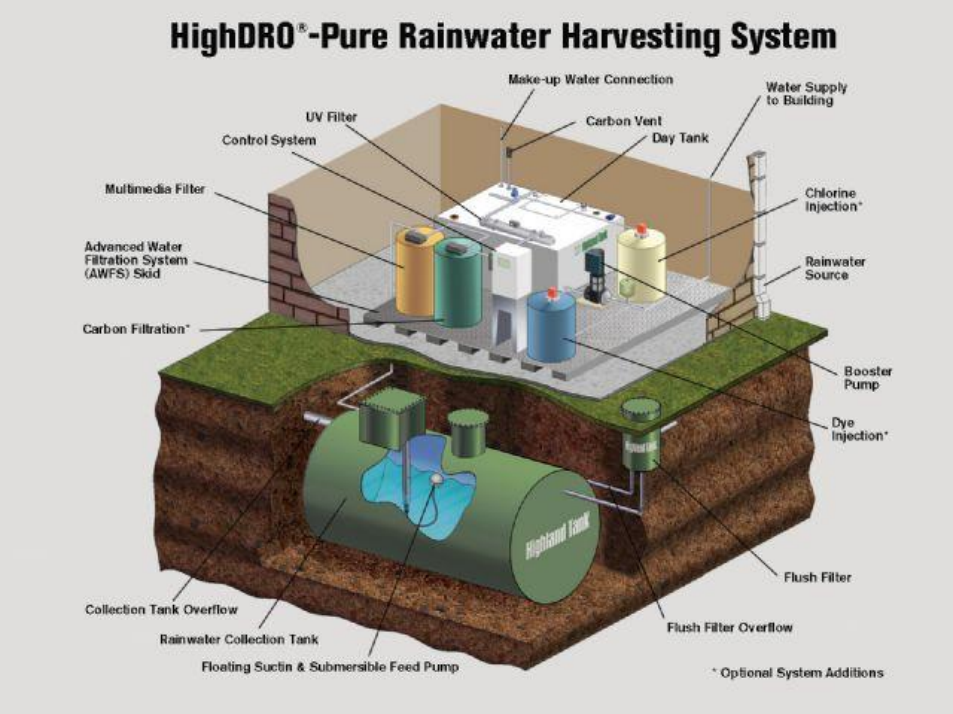
There are many other factors to consider that influence water waste and reclamation:

Reclamation:

- Site collection - Rainwater capture, infrastructure run-off, etc
- Equipment condensate reuse - HVAC
- Irrigation system recirculation

Waste:

- Run-off amount (ie, hydro = 20%, Soil bed = 0%)
- Affluent discharge
- Utility sanitary sewer credits



Water as a Performance Tool - Crop Steering

Light + CO_2 + WATER

Crop steering is a plant growth management practice that manipulates the environment (light, climate, irrigation) to encourage plants to grow a certain way. Next to light intensity, water irrigation is the most important tactic you can use to manipulate yield.

- Uses a series of sensors and tools to maximize the control of the environment
- Through the detailed control of the irrigation factors the cultivator is able to manipulate the plant's growth and performance
- Yield, harvest cycles, terpene amount, and cannabinoid profiles can all be significantly affected