

State of the Market: Liquid Cooled LED Lighting

October 29, 2020

Presented by:

RESOURCE INNOVATION INSTITUTE

In cooperation with:

DLC Energy · Quality · Controllability℠

ASABE

Moderated by:

lighting design lab

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@RIInstitute

@resourceinnovation

We advance resource efficiency to cultivate a better cannabis future

Energy | Water | Waste | Carbon Emissions

RESOURCE INNOVATION INSTITUTE

Objective | Non-profit | Data-driven

We bring stakeholders together to:

Measure and report resource efficiency

- Benchmarks
- Baselines

Inform governments, utilities & industry

- Best practices & standards
- Policies
- Programs

Validate cultivation approaches

- Technologies
- Techniques



Trusted by Programs, Cultivators, Supply Chain, & Governments

Technical Advisory Council

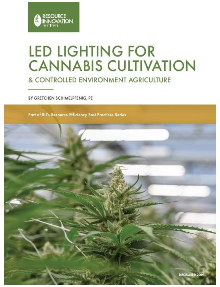
Multi-disciplinary body facilitated by RII to aggregate knowledge and data to support cultivators, governments, utilities, standards bodies and other stakeholders with objective, peer-reviewed information on cultivation resource use and quantification of performance

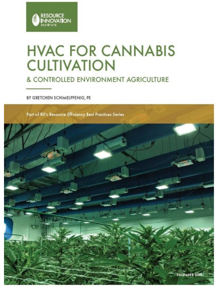
1. Provides guidance on development of standards
2. Shapes tools and resources to support best practices
3. Informs advocacy on policies, incentives and regulations

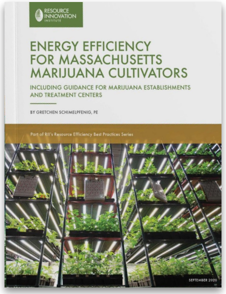
Technical Advisory Council Working Groups

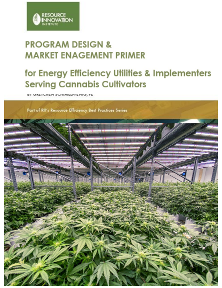
2019	Q1 2020	Q2 - Q4 2020	2021
Lighting	Utility	Water	*Controls*
HVAC		Massachusetts	*Design & Construction*
		Policy	
		Data	

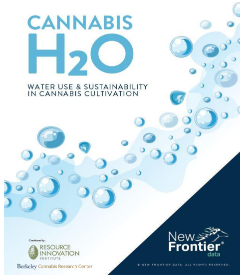
IAES'20
Indoor Agriculture Energy Solutions











Best Practices Guides

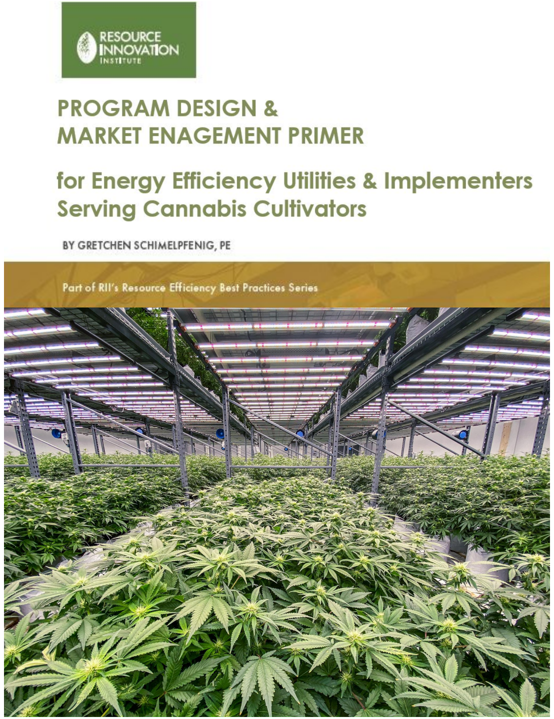
- **60+ contributors & peer reviewers**, including cultivators, architects, engineers, manufacturers
- Defines key terms
- Recommends KPIs
- Meets all growers where they are
- State-specific guidance for Massachusetts

Free downloads at
ResourceInnovation.org/Resources

Support for utilities and implementers

- **Educational curriculum**
  Cultivators, utility staff, trade allies
- **Utility Working Group**
- **Best practices guidance**
  Peer-reviewed, brand-agnostic
- **Grower outreach**
  Marketing toolkit
- **Project planning & verification platform**
  M&V guidelines
  PowerScore for portfolios

Efficient yields
CULTIVATION WORKSHOPS
Best practices on energy. Grower led. No sales pitches.



Cannabis PowerScore

Benchmark operational efficiency with Cannabis PowerScore

Competitive

- **KPIs** benchmark facility resource efficiency:
  - Energy: **kBtu/sq ft**
    grams / kBtu
  - Water: **gallons / sq ft**
    grams/gallon
- **Ranks** competitive position relative to other facilities

Trusted

- Used by **300+ cultivators & facilities**
- Metrics **peer-reviewed** by Technical Advisory Council
- **Specified by governments** including Massachusetts

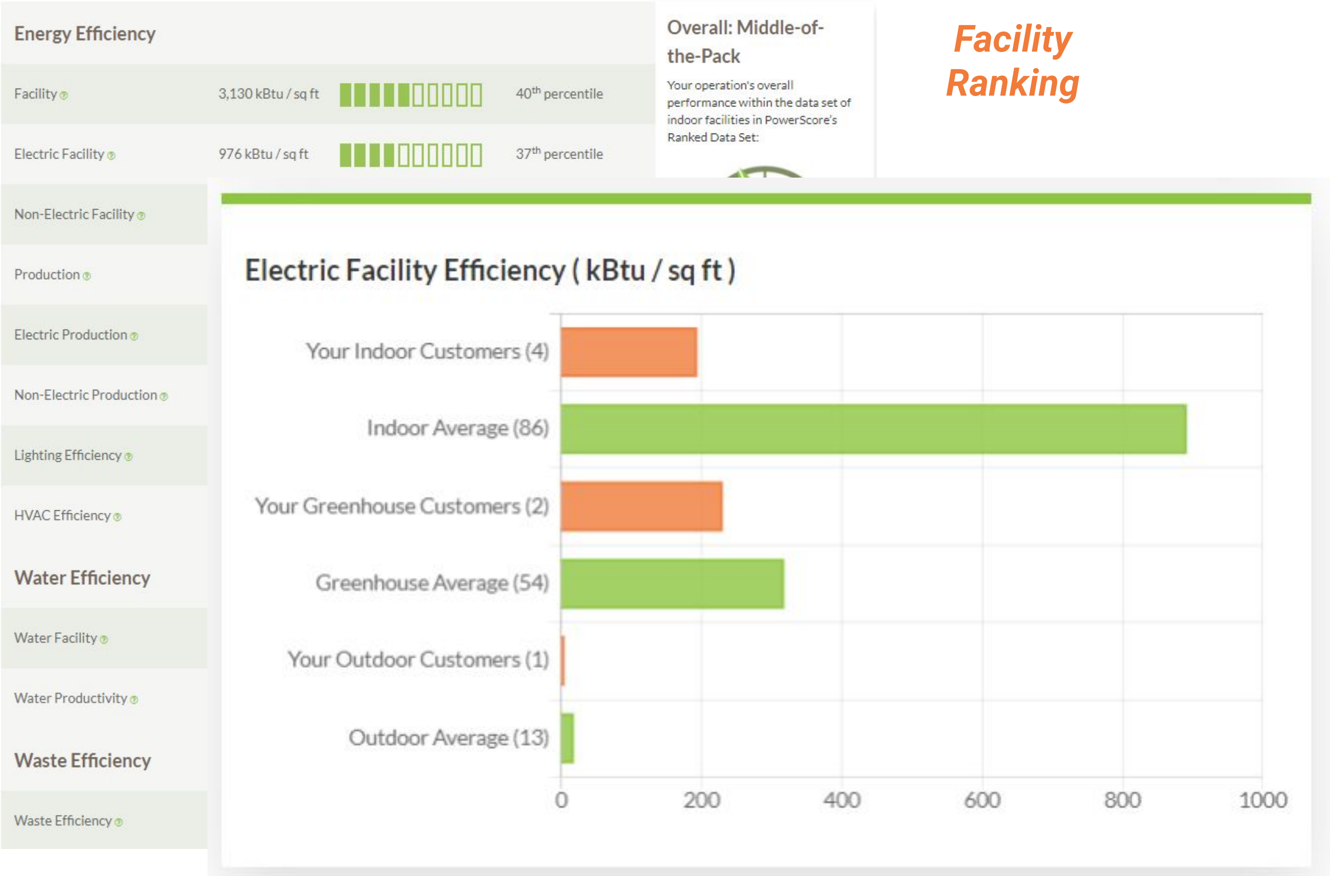
Confidential

- Maintained by a **non-profit**
- **Confidential** survey
- **Protected** individual farm data
- **Free** to cultivators

RESOURCE INNOVATION INSTITUTE

PowerScore Performance Benchmarks

KPIs



Facility Ranking

PowerScore Analysis of Facilities Using LED Lighting Systems

Figure 2. Average Electric Facility Efficiency of Indoor Cannabis Operations in PowerScore's Ranked Data Set

PowerScore Analysis of Facilities Using LED Lighting Systems

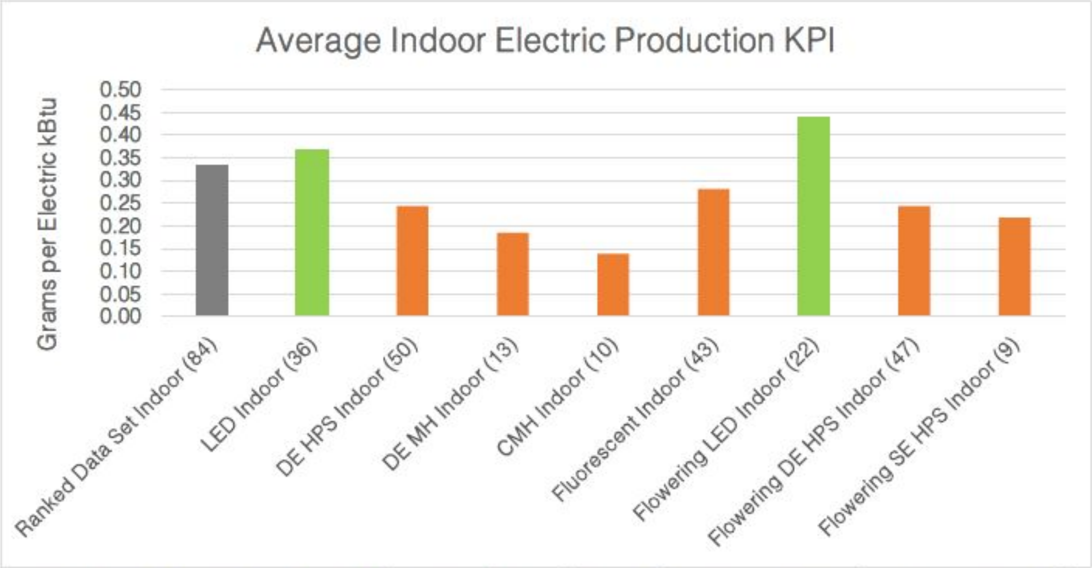


Figure 3. Average Electric Production Efficiency of Indoor Cannabis Operations in PowerScore's Ranked Data Set

Purpose of Today's Workshop

Aligning with our mission to:

- Inform governments, utilities, & operators
- Improve utility & efficiency programs
- Develop industry standards
- Influence policies & regulations
- Facilitate best practices for efficiency
- Educate with expert curriculum and virtual workshops
- Report out market intelligence

Purpose of Today’s Workshop

Validating emerging technology matters to RII because:

- **Markets need additional efficient technology options** supported by utilities and understood by design & construction professionals, especially in states with energy regulations
- Evaluation starts with sharing how things work and **establishing standardized terminology to describe performance across manufacturers and models**
- **Transparent reporting across diverse examples of the technology** is necessary so labs can create testing protocols, standards organizations can certify equipment, and efficiency programs supporting projects can verify actual energy savings
- Collaboration **accelerates market transformation**

Our Moderator

John Arthur Wilson

- Lighting Design Lab = Seattle City Light
- Emerging tech demonstration and education focus
- Electrification, Energy Efficiency, and so much more...
- Regional footprint, Pacific Northwest

lighting® design lab

Powered By

Seattle City Light

Agenda

1:10 - 1:20 pm ET	Facilitator introductions
1:20 - 1:45 pm	Technical overview and Q&A
1:45 - 2:25 pm	Voices from Industry and Q&A
2:25 - 2:30 pm	Conclusion and Transition to Breakout Rooms
2:30 - 3:00 pm	Breakout Sessions

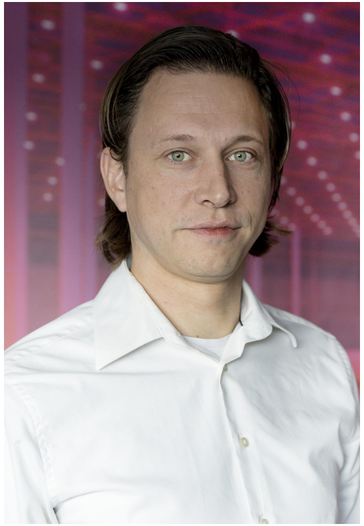
- ***Data:*** Developing a collaborative open source data access plan to enable consistent and defensible custom incentive calculations
- ***Landscape:*** Identifying complementary policy and customer engagement approaches
- ***Technology:*** Deeper understanding of technology

Our Speakers

Twan Mennink

Ken Bouquillon

Jordan Miles



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LED. LIGHT. GROW.

GS
THERMAL
SOLUTIONS

Agnetix

Our Speakers

Kasey Holland

DLC
Energy · Quality · Controllability℠

Carl Bloomfield

intertek

Bob Gunn

SEINERGY LLC

Data Transparency Pledge

As manufacturers of liquid-cooled horticultural LED lighting solutions, we commit to work together by providing transparent and standardized data to enable utilities and stakeholders to better understand how liquid-cooled lighting equipment operates and how it can save energy.

THERMAL SOLUTIONS

oreon LED. LIGHT. GROW.

Agnetix

Technology Overview - Reducing Heat Load

An indoor growing facility wants to grow cannabis under a light level of 800 umol/s/m^2. With a PPE of 2.7 umol/J this will require approximately 300W electrical power per m^2.

This 300W is divided in:

- 150W/m^2 of light
- **150 W/m^2 is heat produced inside the fixture**

Liquid cooling transfers this heat out of the cultivation environment, reducing heat load in grow environments by 50%.

The heat from the water-cooled fixtures can be expelled to the outside air using dry coolers. These coolers consume approximately 0.5% - 1% of the electrical energy consumption of the fixtures itself.

Technology Overview - Energy Savings

The water-cooled system has less heat to be removed, but adds 1% of dry-cooler power.

Water-cooled:

150W/m^2 divide by COP of 3.5 = 42.9 W/m^2 HVAC energy + 3 W/m^2 dry cooler

Air-cooled:
300W/m^2 divide by COP of 3.5 = 85.7W/m^2 HVAC energy

Energy savings:

Water-cooled:	300W/m^2+42.9W/m^2+1.5W/m^2	= 345.9W/m^2
Air-cooled:	300W/m^2+85.7W/m^2	= 385.7W/m^2

Energy savings: = 39.8W/m^2
= **0.0398kW/m^2**

Technology Overview - OpEx Savings

Electricity rates can range between \$0.05 - \$0.30/kWh. Using a blended electricity price of \$0.10/kWh, and 5000 lighting hours per year, the use of water cooling will result in:

Total energy cost saving of: **0.0398 kW/m^2** * 5000 * \$0.10/kWh

Total energy cost savings of liquid cooled LED lighting = **\$19.90 USD/m^2 per year**

This can work out to **\$67 per fixture per year** in OpEx savings.

Technology Overview - CapEx & Total Cost Savings

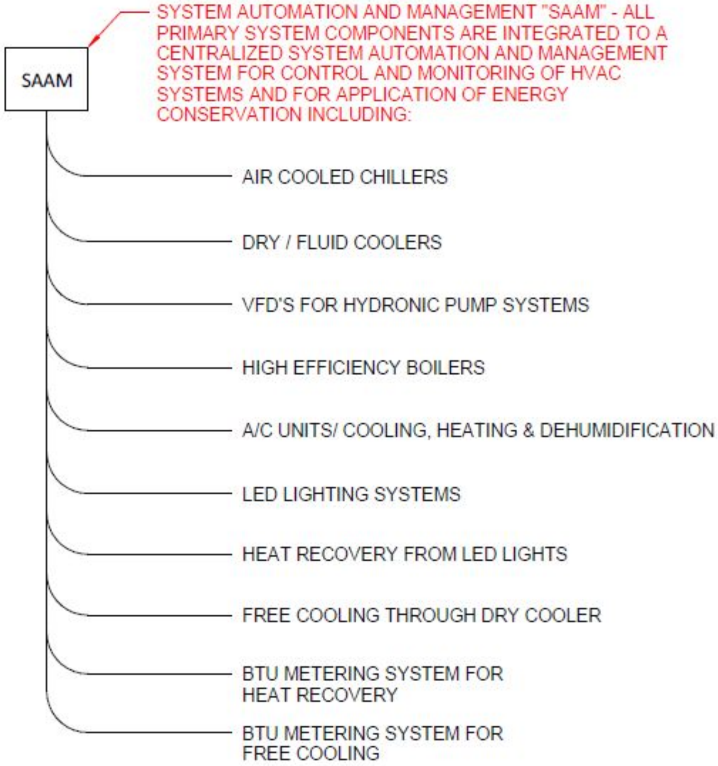
Less heat in the room results in less HVAC capacity necessary. The investment cost per ton of refrigeration is somewhere between 700 USD and 2500 USD. For this example, we calculate with $1,200/ton.

Water-cooled:	150W = 0.0426 ton of refrigeration/m^2 = \$55.44/m^2
Air-cooled:	300W = 0.0852 ton of refrigeration/m^2 = \$110.12/m^2
Savings:	**\$55.44/m^2**

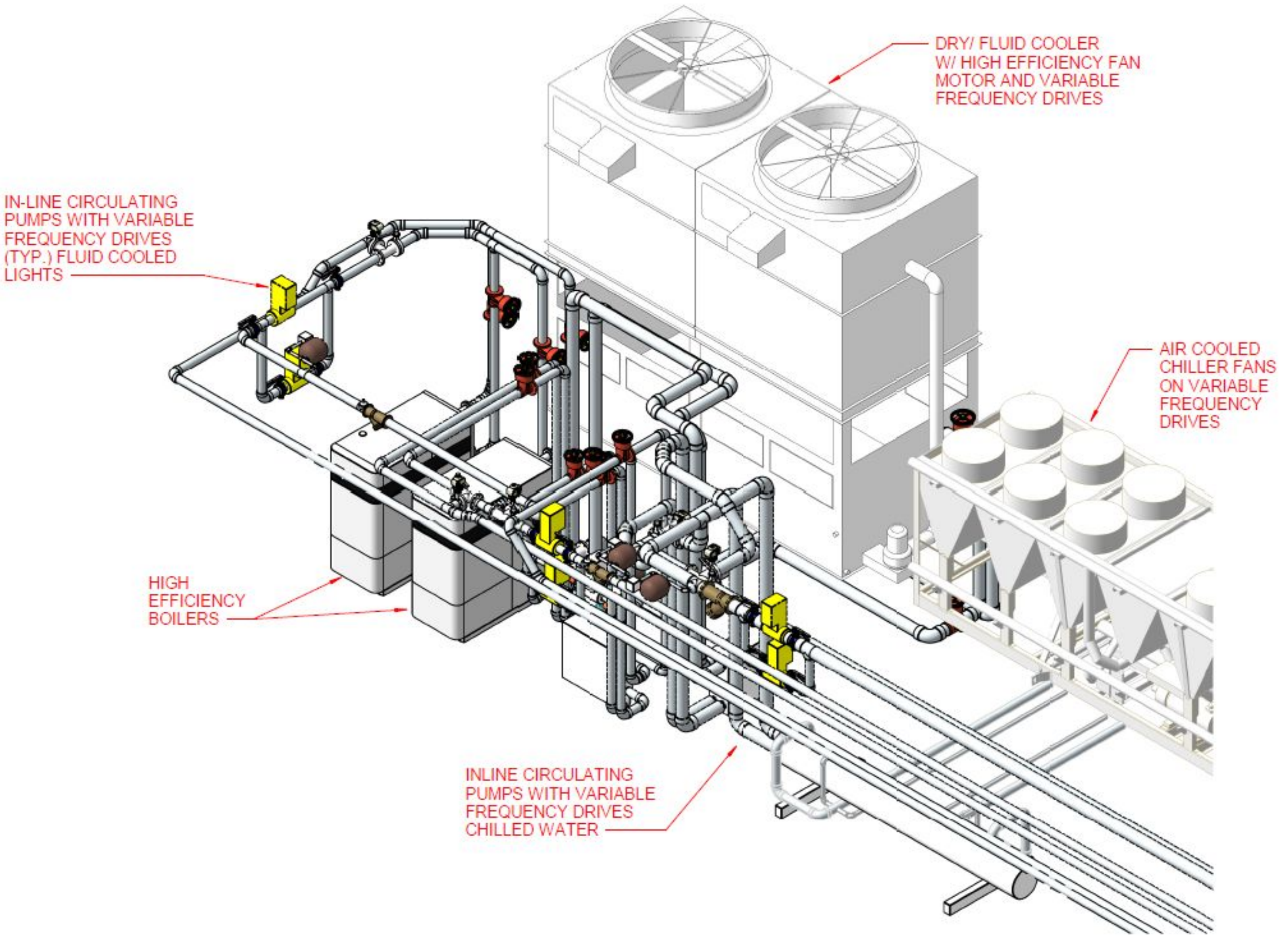
This can work out to **$187 per fixture** in on-time CapEx savings.
Using 10 year amortisation of HVAC CapEx, we can calculate annual savings.

Annual total HVAC energy savings per fixture:
OpEx + CapEx = $67 + $19 = **$86/fixture/year**
(and more than 10% of total energy savings)

Liquid Cooled Lighting Building System



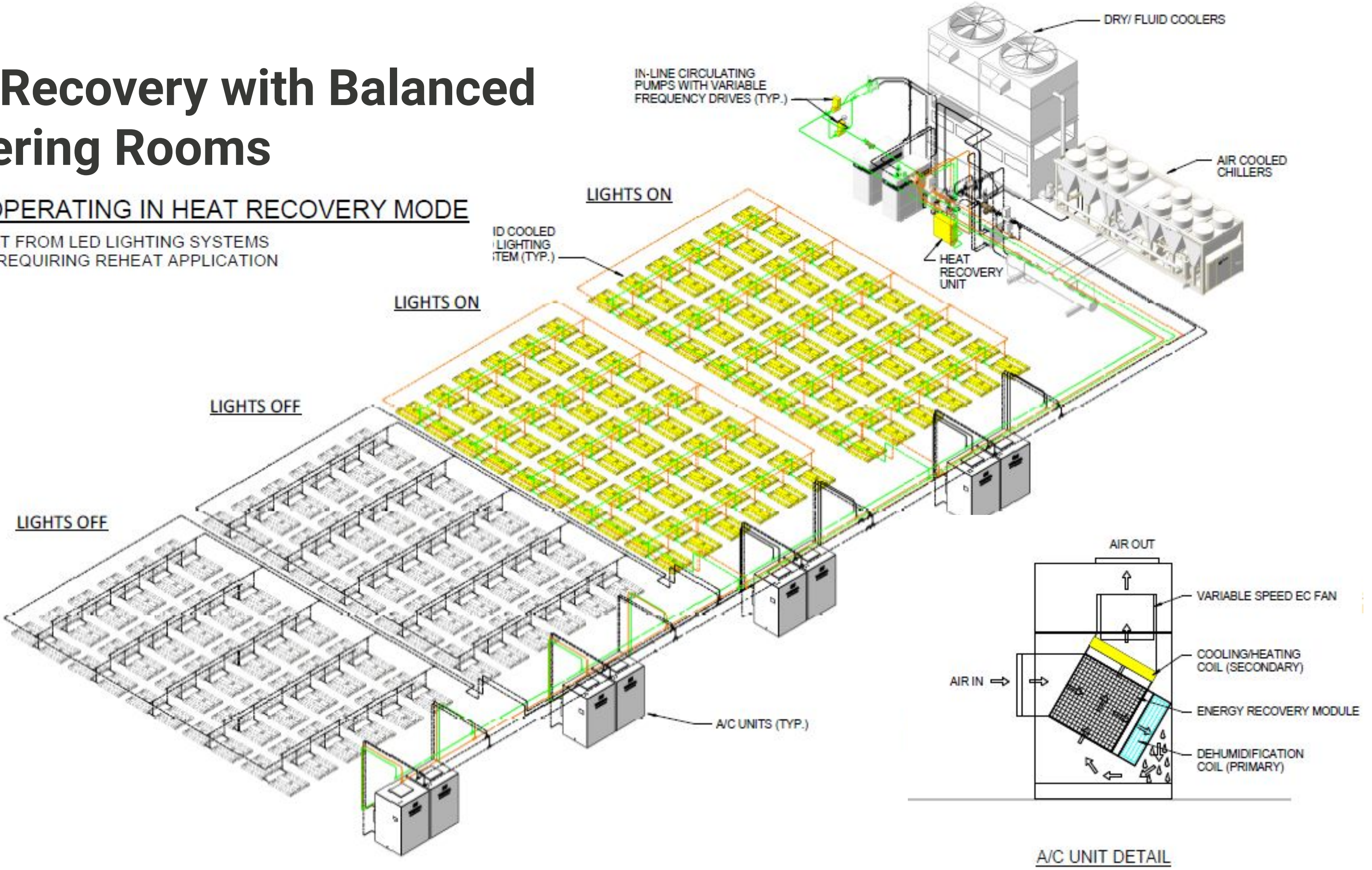
SYSTEM AUTOMATION AND MANAGEMENT


DRY/ FLUID COOLER W/ HIGH EFFICIENCY FAN MOTOR AND VARIABLE FREQUENCY DRIVES
IN-LINE CIRCULATING PUMPS WITH VARIABLE FREQUENCY DRIVES (TYP.) FLUID COOLED LIGHTS
AIR COOLED CHILLER FANS ON VARIABLE FREQUENCY DRIVES
HIGH EFFICIENCY BOILERS
INLINE CIRCULATING PUMPS WITH VARIABLE FREQUENCY DRIVES CHILLED WATER

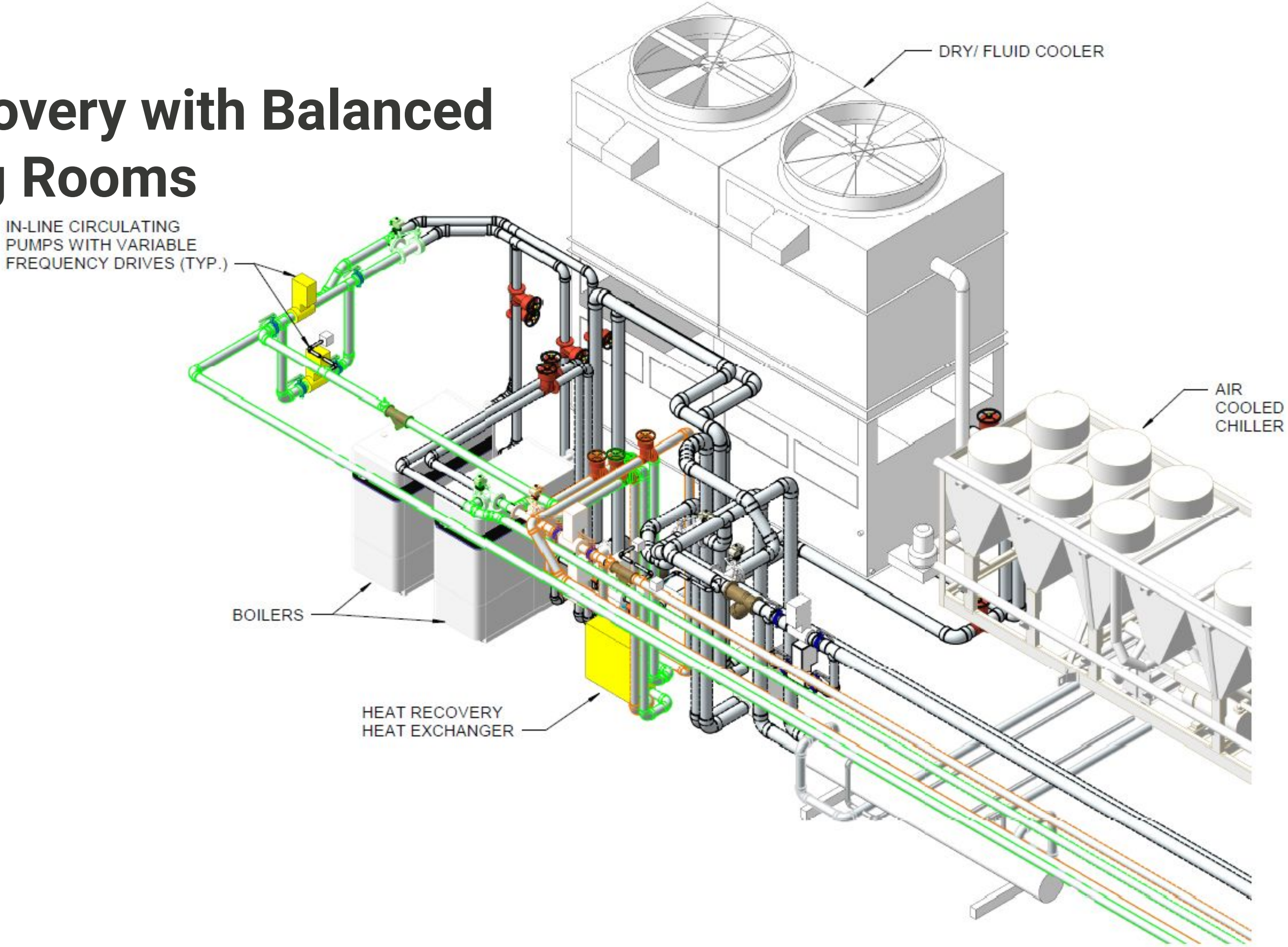
Heat Recovery with Balanced Flowering Rooms

SYSTEM OPERATING IN HEAT RECOVERY MODE

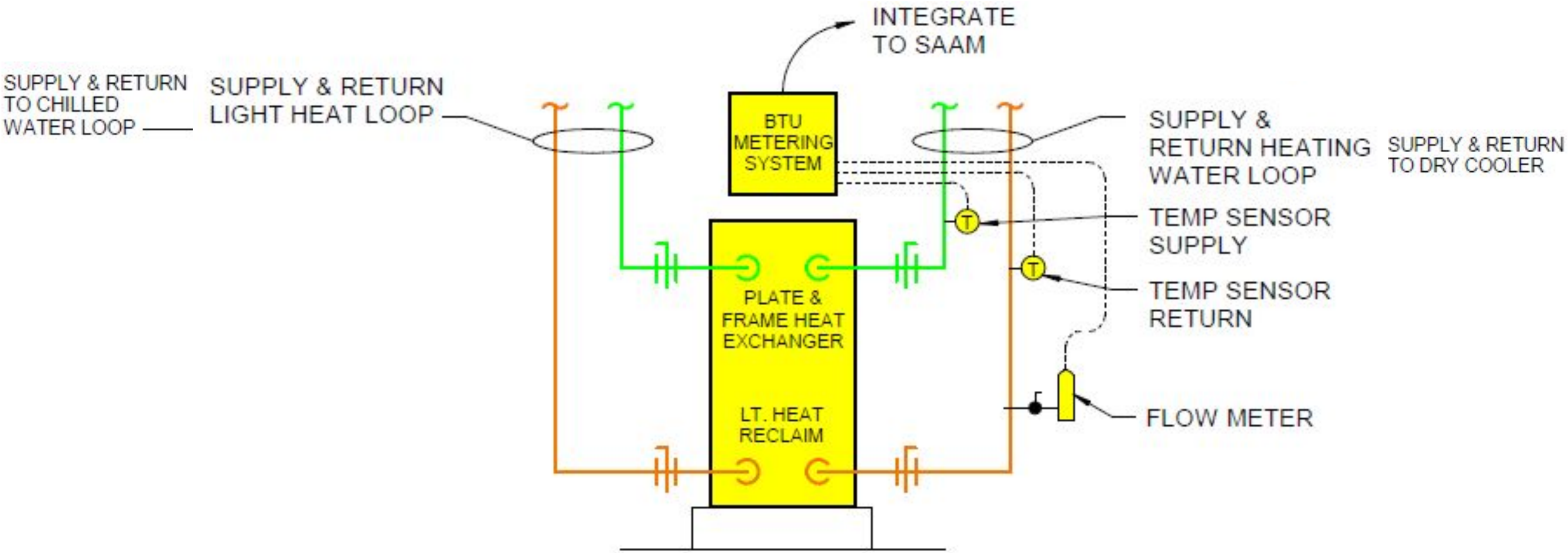
RECLAIMS HEAT FROM LED LIGHTING SYSTEMS
TO A/C UNITS REQUIRING REHEAT APPLICATION



Heat Recovery with Balanced Flowering Rooms



BTU METERING FOR HEAT RECOVERY AND FREE COOLING APPLICATIONS

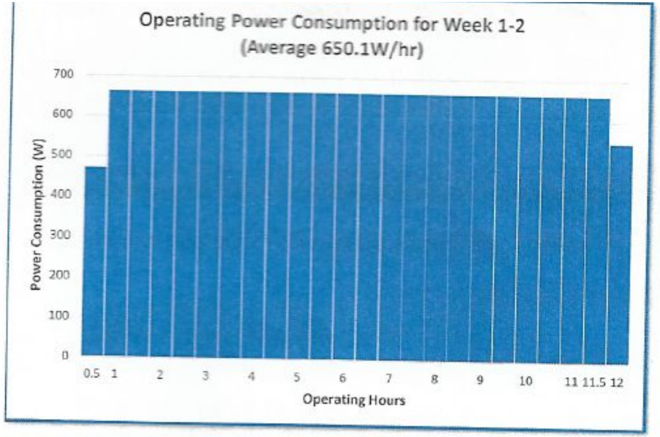


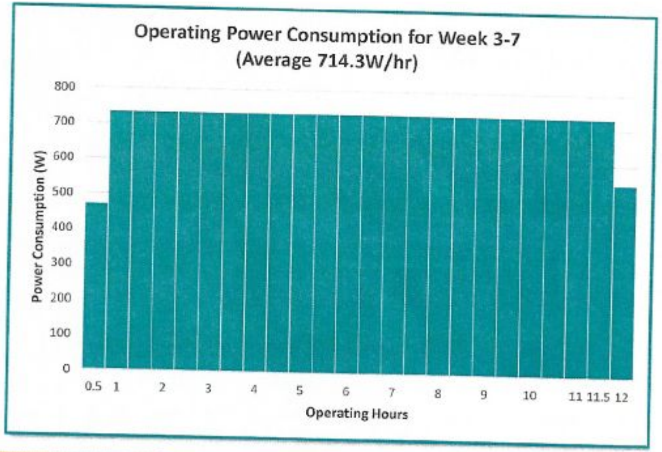
<u>LIGHT HEAT RECLAIM HEAT EXCHANGER</u>

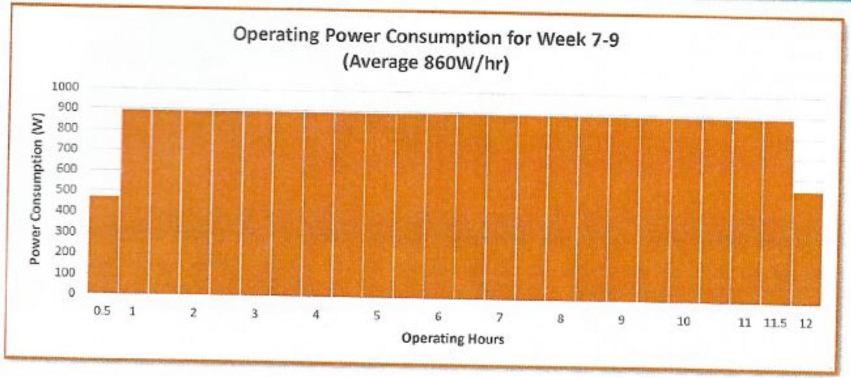
Light Recipe and Operating Schedule

	Operating		Light Setting				Power Consumption (W)			PUD Ltg hrs	No. of Fixtures
		Hr	White	Blue	Red	Deep Red	Power Consumption (W)	Average Power Consumption (W)	Average Power Consumption in Flower/Veg Stage (W)	Hrs per year	48
Flower Light (25ft² Coverage Area)	Week 1-2	0.5	70	100	0	0	470	650.1	732.4	973	
		11	80	40	60	60	663				
		0.5	50	25	60	60	546				
	14 days										30,372
	Week 3-7	0.5	70	100	0	0	470	714.3		2433	
		11	70	40	80	80	733				
		0.5	50	25	60	60	546				
	35 days										83,424
	Week 8-9	0.5	70	100	0	0	470	860.0		973	
		11	70	40	80	80	892				
		0.5	50	25	60	60	546				
	14 Days										40,179
Veg. Light (25ft² Coverage Area)	Veg.	18	80	90	30	30	610		610	6570	32,062

Adjustable Spectrum







Grow Room HVACD Trends

Trended data needed to validate estimated energy savings

SunnyDayz Data	SnoPUD Trend 1											
Nov 1 - 15, 2019	Dehu 2 Dmd	Dehu 1 Dmd	Lights Rm 2 Dmd	Lights Rm 1 Dmd	OA Humidity	OA Temp	Rm 2 CO2	Rm 1 CO2	Rm 2 Humidity	Rm 1 Humidity	Rm 2 Temp	Rm 1 Temp
	kW	kW	kW	kW	% RH	°F	ppm	ppm	% RH	% RH	°F	°F
11/1/19 12:00 AM	1.83	1.74	8.84	12.58	65.4	40.4	1232	1264	49.6	50.3	76.7	74.4
11/1/19 12:05 AM	1.83	1.74	0.00	15.23	65.6	40.4	1212	1262	50.6	50.3	76	74.8
11/1/19 12:10 AM	1.83	1.74	0.00	15.23	66.3	40.2	1207	1239	50.6	51.4	75	75.4
11/1/19												
11/1/19												
11/1/19												
11/1/19												

SunnyDayz Data	SnoPUD Trend 2													
Nov 1 - 15, 2019	Dehu 2 Mode	Dehu 1 Mode	Dehu 2 Pri Coil	Dehu 1 Pri Coil	Dehu 2 RAH	Dehu 1 RAH	Dehu 2 RAT	Dehu 1 RAT	Dehu 2 Sec Coil	Dehu 1 Sec Coil	Rm 2 Grow Cycle	Rm 1 Grow Cycle	Rm 2 VPd	Rm 1 VPd
	Heat, 2=Co	Heat, 2=Co	%	%	% RH	% RH	°F	°F	%	%	See last column for mode		Pa	Pa
11/1/19 12:00 AM	1	1	56.9	64.8	49.6	50.3	76.7	74.4	52.3	100	1	8	1.37	1.21
11/1/19 12:05 AM	1	1	74.4	47.1	50.6	50.3	76	74.8	38	100	1	8	1.19	1.31
11/1/19 12:10 AM	1	1	74.6	49.7	50.6	51.4	75	75.4	38	100	1	8	1.19	1.27
11/1/19 12:15 AM	1	1	74.7	51.6	50.7	51.5	74.2	75.7	44.5	100	1	9	1.18	1.25
11/1/19 12:20 AM	1	1	73.2	46.3	50.9	50.8	73.5	76.1	56.8	100	1	9	1.21	1.32
11/1/19 12:25 AM	1	1	69.6	58.6	51.2	52.2	73.5	76.3	70.5	100	1	9	1.19	1.27
11/1/19 12:30 AM	1	1	68	48.8	49.7	51.4	73.7	76.3	81.9	100	1	9	1.22	1.37

Central Plant Trends

Trended data needed to validate estimated energy savings

SunnyDayz Data	SnoPUD Trend 3													
Nov 1 - 15, 2019	CHW P1 VFD	CHW P2 VFD	CHWR Temp	CHWS Temp	DC Fan Dmd	Chiller Dmd	Dry Cool P1 VFD	Dry Cool P2 VFD	Dry Cool Supply Temp	Light Loop Return Temp	CHW P2 Dmd	DC P1 Dmd	DC P2 Dmd	CHW P1 Dmd
	%	%	°F	°F	kW	kW	%	%	°F	°F	Watts	Watts	Watts	Watts (est)
11/1/19 12:00 AM	0	56.6	53.5	45	0.0	17.2	61.5	0		88.8	412	180	0	0
11/1/19 12:05 AM	0	55	52.7	45.3	0.0	17.2	61.1	0		87.5	467	180	0	0
11/1/19 12:10 AM	0	59	55.3	44.1	0.0	17.2	61.3	0		86.4	457	182	0	0
11/1/19 12:15 AM	0	56.2	52.5	50.6	0.0	17.2	61.2	0		85.4	407	181	0	0
11/1/19 12:20 AM	0	54.8	52.1	44.5	0.0	16.8	61.4	0		86.5	464	180	0	0
11/1/19 12:25 AM	0	56.1	55.6	44.4	0.0	17.2	61.6	0		87.6	408	180	0	0
11/1/19 12:30 AM	0	53.9	52.8	50.7	0.0	17.2	61.9	0		88.2	442	180	0	0

Utility Incentive Overview

Customer product cost for upgrades = $255,350
Utility incentive @ *$0.25/kWh* = **$139,675** (54.7%)

Annual energy savings estimated = **328,300 kWh/year** *$0.43/kWh*

Baseline Lighting Energy Consumption

New Install? or Retrofit?	Space Type	# of Existing Fixtures	Existing Watts / Fixture	Area[6] (in ft²)	Existing Watts / ft²	Industry Standard Watts / ft²	Baseline Hours / Year	Baseline kW	Baseline kWh/yr
New	Flowering Room (New)			816		69.00	4,380	56.3	246,612
New	Vegitation Room (New)			816		50.00	4,380	40.8	178,704
New	Vegitation Room (New)			271		50.00	6,570	13.6	89,024
			Total:	1,903 ft²				111 kW	514,339 kWh

Utility Incentive Overview

Customer project cost for upgrades = $255,350
Utility incentive = **$139,675** (54.7%)

Annual energy savings estimated = **328,300 kWh/year** *$0.43/kWh*

Proposed Lighting Energy Consumption

Location / Area	Space Type	# of Proposed Fixtures	Proposed Watts / Fixture	Fixture Description	Eligible[4] Tech? (Yes/No)	Proposed Hours / Year	Proposed kW	Proposed kWh/yr
Flower Room 1	Flowering Room (New)	24	732.4	GS Thermal Solutions GSTS 1000	Yes	4,380	17.6	76,990
Flower Room 2	Flowering Room (New)	24	732.4	GS Thermal Solutions GSTS 1000	Yes	4,380	17.6	76,990
Veg Room	Vegitation Room (New)	8	610.0	GS Thermal Solutions GSTS 1000	Yes	6,570	4.9	32,062
							40 kW	186,041 kWh

Notes:

732.4 is average wattage of flower room 63 day grow cycle. Two flower rooms to alternate hours to distribute and reduce load on HVAC/dehu loads. 610 is average wattage of Veg room lighting. See Light Recipe tab for calculations

Utility Incentive Overview

Room Type: Vegetative Room

Inputs:	Baseline	Proposed
Canopy (ft^2)	271	271
Lighting Load[1,2] (W/ft^2)	50.00	18.01
HVAC Type	Heat Pump	Heat Pump
Efficiency (SEER)	13.7	13.7
Cooling Capacity (BTUh)	4,512	4,512
No. of units	1	1
Total Cooling available (BTUh)	4,512	4,512
Average Evaporative Rate[3]	16%	16%
Dehumidifier Efficiency (L/kWh)	2.8	2.9
Grow Lights On (hrs/day)	18	18
Growing Production (days/yr)	360	360
Annual Grow Light Operation (hrs/yr)	6,480	6,480

Sensible	Baseline	Proposed
Grow Lighting Load	46,233 BTUh	16,651 BTUh
Less Evaporative Cooling from Pla	- *7,397* BTUh	- *2,664* BTUh
Sensible HVAC Load[5]	38,835 BTUh	13,986 BTUh
Annual Sensible HVAC Load	251,653,288 BTU	90,632,328 BTU
Annual HVAC Energy	18,369 kWh/yr	6,615 kWh/yr
Sensible Energy savings		**11,753 kWh/yr**

Latent	Baseline	Proposed
Evaporative Cooling from Plants	7,397 BTUh	2,664 BTUh
Dehumidification Load[6] (1,060 BTU/lb_{H2O}-hr)	7.0 lb_{H2O}	2.5 lb_{H2O}
H_2O Conversion - lbs to liters	3.1 $liters_{H2O}$ #	1.1 $liters_{H2O}$
Dehumidifier Power	1.1 kW	0.4 kW
Annual Latent Load	8,640 hrs/yr	8,640 hrs/yr
Annual Dehumidifier Energy	9,690 kWh/yr	3,370 kWh/yr
Dehumidifier Energy Savings		**6,321 kWh/yr**
Total HVAC Savings		**18,074 kWh**

Utility Incentive Overview

Room Type: Flower/Budding Room

Inputs:	Baseline	Proposed
Canopy (ft^2)	1,632	1,632
Lighting Load[1,2] (W/ft^2)	69.00	21.54
HVAC Type	Heat Pump	Heat Pump
Efficiency (SEER)	13.7	13.7
Cooling Capacity (BTUh)	97,879	97,879
No. of units	1	1
Total Cooling available (BTUh)	97,879	97,879
Average Evaporative Rate[3]	47%	47%
Dehumidifier Efficiency[4] (L/kWh)	2.8	2.9
Grow Lights On (hrs/day)	12	12
Growing Production (days/yr)	3	
Annual Grow Light Operation (hrs/yr)	4,	

Sensible	Baseline		Proposed	
Grow Lighting Load	384,218	BTUh	119,950	BTUh
Less Evaporative Cooling from Pla	- *180,583*	BTUh	- *56,376*	BTUh
Sensible HVAC Load[5]	203,636	BTUh	63,573	BTUh
Annual Sensible HVAC Load	891,924,817	BTU	278,450,868	BTU
Annual HVAC Energy	65,104	kWh/yr	20,325	kWh/yr
Sensible Energy savings			**44,779**	**kWh/yr**

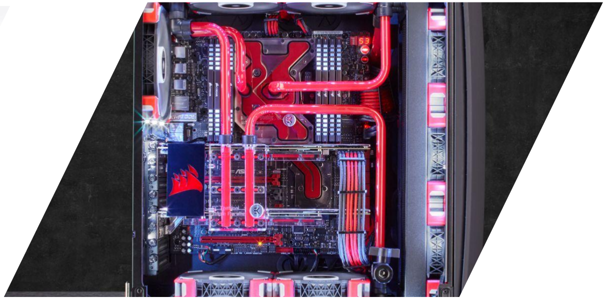
Latent	Baseline	Proposed
Evaporative Cooling from Plants	180,583 BTUh	56,376 BTUh
Dehumidification Load[6] (1,060 BTU/lb_{H2O}-hr)	170.4 lb_{H2O}	53.2 lb_{H2O}
H_2O Conversion - lbs to liters	76.7 $liters_{H2O}$ #	23.9 $liters_{H2O}$
Dehumidifier Power	27.4 kW	8.3 kW
Annual Latent Load	8,760 hrs/yr	8,760 hrs/yr
Annual Dehumidifier Energy	239,844 kWh/yr	72,295 kWh/yr

	Baseline	Proposed
HVAC Load:	28.5 kW	8.6 kW
HVAC Load Reduction:		19.9 kW
Annual HVAC Energy Use:	333,007 kWh/yr	102,605 kWh/yr
HVAC Energy Use Savings:		230,402 kWh/yr
SnoPUD Incentive:	@ $0.25 /kWh	$57,600.48

Veg + Flower HVACD Savings = 70% of total

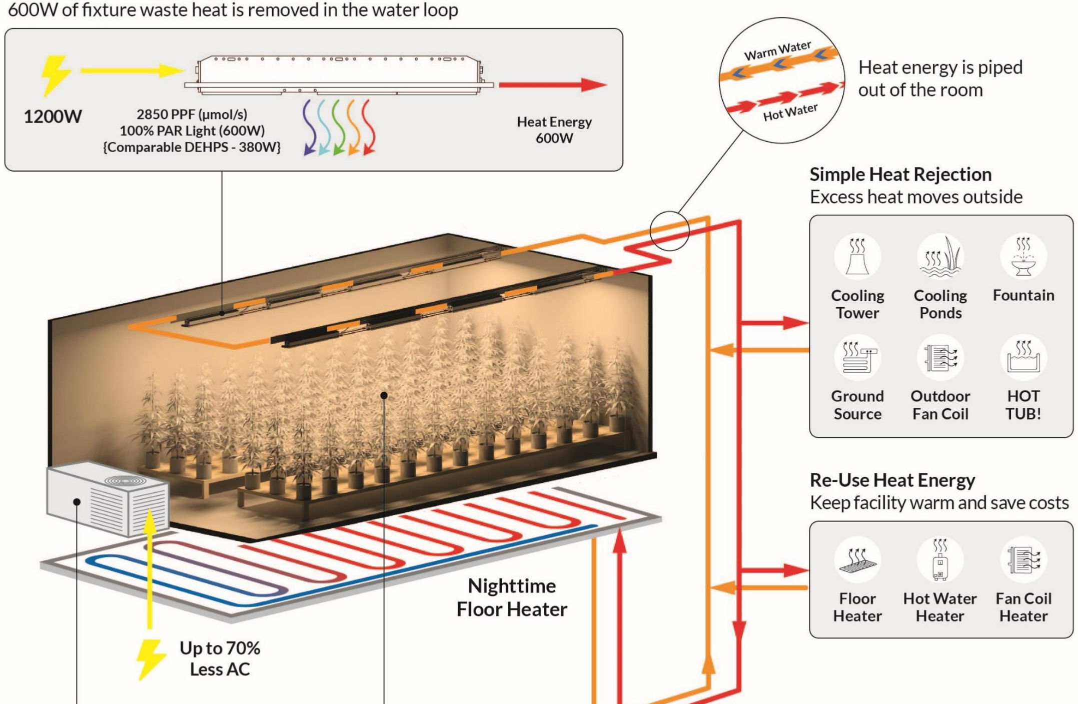
Data Centers

Porsche / Tesla EV



Virtual Reality / Gaming

WATER-COOLED LIGHTING – EVERYTHING IS EASIER WHEN THE FIXTURE WASTE HEAT IS REMOVED FROM THE CHAMBER



Reduce HVAC
Less heat inside reduces equipment size and power usage, ideal for traditional split HVAC or more efficient alternatives

Traditional HVAC	Hydronic Heat Pump	Desiccant Systems

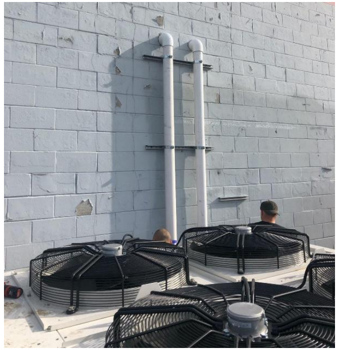
Grow More
High-output, full spectrum light for great growth at any light intensity level

Super Fast Growth	Precision Dimming	Use Less Power
High light levels 1500+ PPFD	Built in, 1% steps, get the right levels for all stages of growth	Efficacies up to 2.8 µmol/J when dimmed

Dry Cooler

Pump Station/Chamber Manifold

Mini Cooling Tower



Energy Savings Opportunities with Facilities Using Liquid Cooled Lighting

- Liquid cooled LED horticultural lighting
- Efficient central plant
  - VFDs for pumps and fans
  - Integrated HVACD and lighting systems
  - High efficiency electric and gas chillers
  - High efficiency boilers
- Energy recovery systems
  - Heat pipe, plate, wheel
  - Free cooling heat exchangers
- Co-generation

Q&A

Our Speakers

Carl Bloomfield

intertek

Kasey Holland

DLC
Energy · Quality · Controllability℠

Bob Gunn

SEINERGY LLC

Energy · Quality · Controllability℠

Active Cooling: DLC's Proposed Process and Timeline

- Date

Agenda

- DLC Overview and Specification Development Process
- V2.0 Technical Requirements (Brief Review)
- Proposed Considerations in V2.1 Draft 1

DLC Overview

Energy. Quality. Controllability.

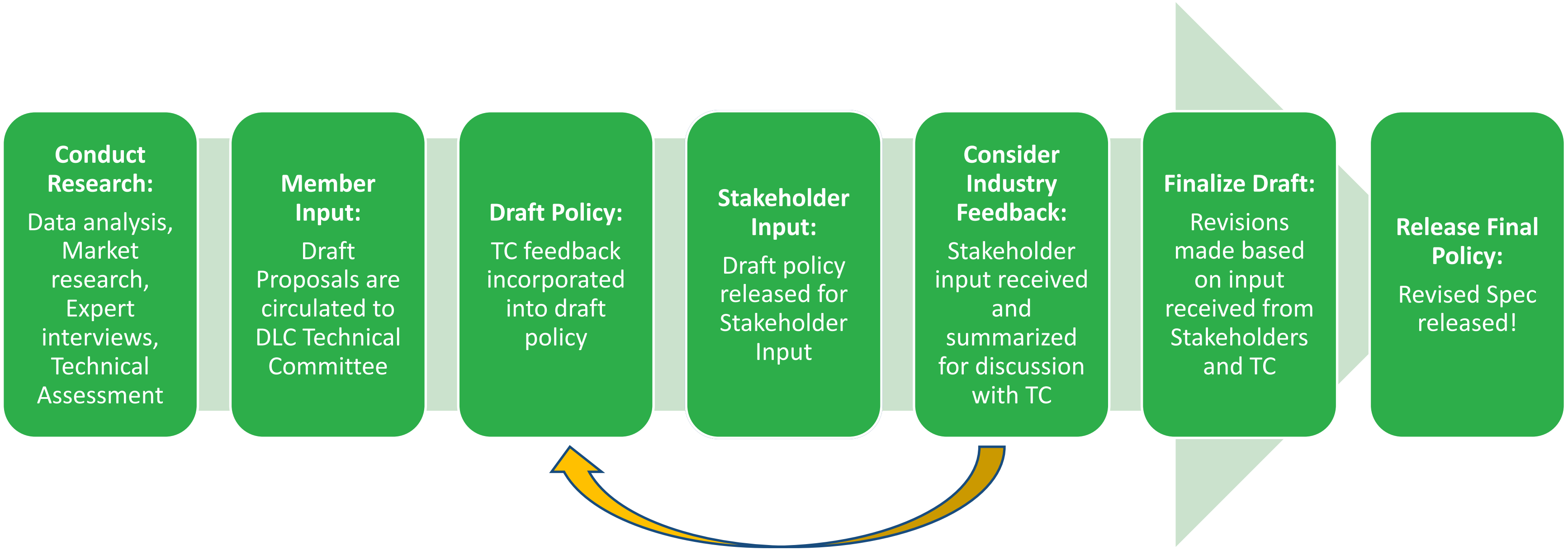
Non-profit organization

Creates performance specifications

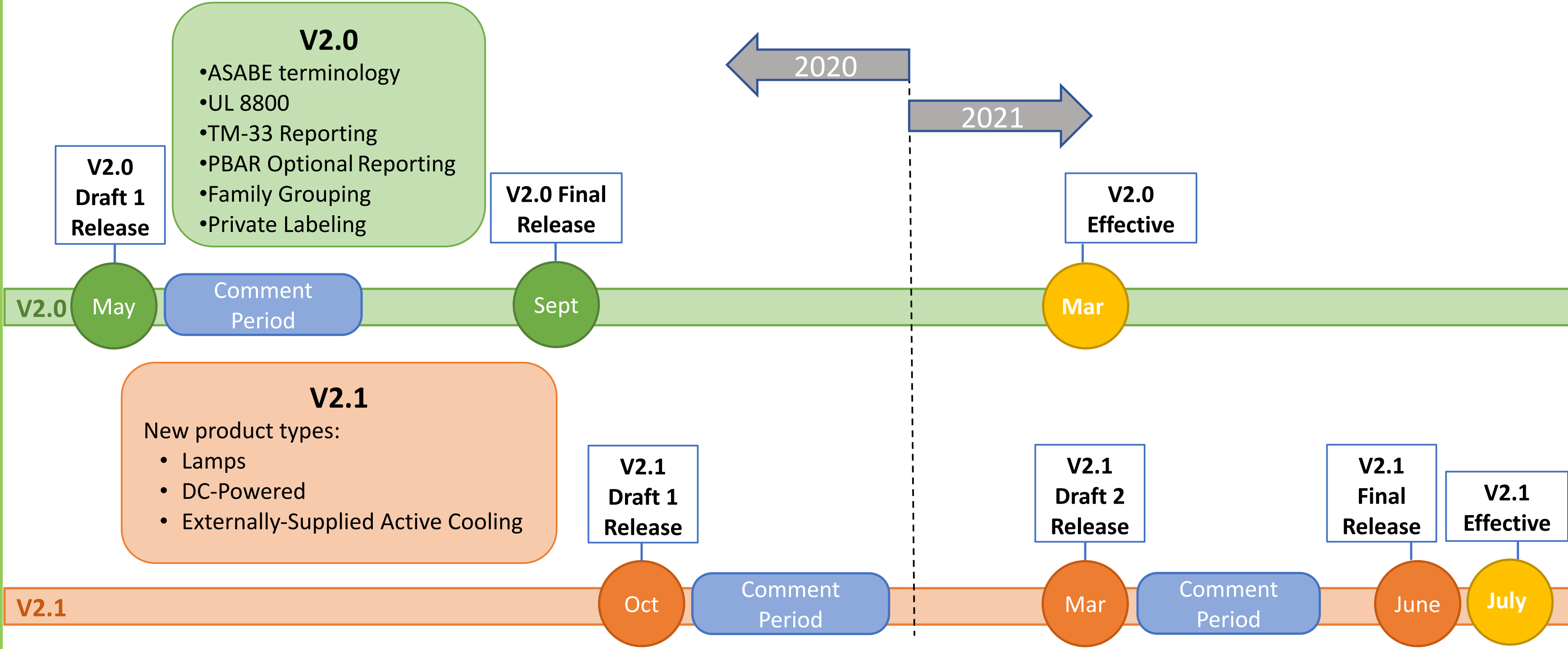
Provides tools, information, & expertise

Accelerates adoption of efficient commercial lighting

Stakeholder Input Is Critical



Hort Version 2 Timeline



V2.0 Technical Requirements

V2.0 Technical Requirements

- Requirement Type
  - Reported vs. Required/Threshold
- Required/Threshold
  - Efficacy (PPE)
  - Flux Maintenance (Q90)

Parameter/Attribute/Metric	Requirement	Requirement Type	Method of Measurement/Evaluation
Photosynthetic Photon Flux (Φ_P or PPF) ($\mu mol \times s^{-1}$)	n/a	Reported	(ANSI/IES LM-79) 400-700nm range, with 400-500nm, 500-600nm, and 600-700nm bins reported alongside the total
Far-Red Photon Flux ($\Phi_{P,fr}$ or PF_{FR}) ($\mu mol \times s^{-1}$)	n/a	Reported	(ANSI/IES LM-79) 700-800nm range
Photon Flux (PF_{PBAR}) ($\mu mol \times s^{-1}$)	n/a	Reported (Optional)	(ANSI/IES LM-79) 280-800nm range
Spectral Quantum Distribution (SQD) ($\mu mol \times s^{-1} \times nm^{-1}$)	n/a	Reported	(ANSI/IES LM-79) (ANSI/IES TM-33-18) 400-800nm range
Photosynthetic Photon Intensity Distribution (I_P or PPID) ($\mu mol \times s^{-1} \times sr^{-1}$)	n/a	Reported	(ANSI/IES LM-79) (ANSI/IES TM-33-18) 400-700nm range
Photosynthetic Photon Efficacy (K_P or PPE) ($\mu mol \times J^{-1}$)	$\geq$1.90 $\mu mol \times J^{-1}$	Required/Threshold	(ANSI/IES LM-79) 400-700nm range
Photon Efficacy (PE_{PBAR}) ($\mu mol \times J^{-1}$)	n/a	Reported (Optional)	(ANSI/IES LM-79) 280-800nm range
Photon Flux Maintenance, Photosynthetic (PFM_P)	Q_{90} $\geq$36,000 hours	Required/Threshold	(ANSI/IES LM-80 / IES TM-21 or IES LM-84 / IES TM-28) 400-700nm range, fixture technical specification sheet, and *In-Situ Temperature Measurement Test* (ISTMT)

Energy · Quality · Controllability℠

V2.0 Technical Requirements

- Requirement Type
  - Reported vs. Required/Threshold
- Required/Threshold
  - Component Lifetime
  - Warranty
  - Power Quality (PF and THDi)
  - Safety Certification

Parameter/Attribute/Metric	Requirement	Requirement Type	Method of Measurement/Evaluation
Driver Lifetime	≥50,000 hours	Required/Threshold	Driver technical specification sheet, fixture technical specification sheet, and *In-Situ Temperature Measurement Test* (ISTMT)
Fan Lifetime	≥50,000 hours	Required/Threshold	Fan technical specification sheet, fixture technical specification sheet
Warranty	5 years	Required/Threshold	Legal warranty terms & conditions
Power Factor (PF)	≥0.9	Required/Threshold	Benchtop electrical testing or ANSI/IES LM-79
Total Harmonic Distortion, Current (THDi)	≤20%	Required/Threshold	Benchtop electrical testing or ANSI/IES LM-79
Safety Certification	Horticultural Lighting designation by OSHA NRTL or SCC-recognized body	Required/Threshold	ANSI/UL 8800 (ANSI/CAN/UL 8800)

V2.1 Draft 1 Proposal (Active Cooling)

Draft 1: Externally-Supplied Actively Cooled Fixtures

- LED horticulture fixtures that employ **externally-supplied circulating liquid to actively cool are eligible**
  - Products in which liquid, often water or a water/glycol solution, flows through input and output ports of each fixture in the system, being channeled through a cooling plate or other heat exchanger within the fixture
- Externally-supplied **ducted forced-air are not eligible** at this time
- ***All V2.0 Horticultural Lighting Technical Requirements must be met***

Draft 1: Externally-Supplied Actively Cooled Fixtures

- Manufacturers must specify the range of allowable operating conditions that should be supplied to or affect the LED product performance, including:
  - Solution type/concentration
  - Flow rate
  - Inlet fluid temperature
- The threshold-qualifying state to be tested must be the manufacturer designated state with the *worst-case* operating conditions for inlet fluid temperature, flow rate, and solution concentration.
  - Average and highest inlet fluid temperature, measured at the manufacturer specified Test Measurement Location (TML), must be measured and reported during ISTMT and LM-79 testing.
  - ISTMT reports must report the operating temperature(s) at the fixture's highest rated ambient temperature.
- Inlet fluid temperature must also be measured and reported during benchtop electrical testing.

Draft 1: Externally-Supplied Actively Cooled Fixtures

- LM-79 gonioradiometer testing with methods or equipment from other gonioradiometer types in addition to Type C.
  - All *externally*-supplied circulating-liquid cooled horticultural fixtures seeking qualification by the DLC must test the fixture per ANSI/IES LM-79, while employing active cooling.
- Electrical testing must be provided on the cooling system
  - document the maximum input power and input voltage to the externally-supplied cooling mechanism when operating at the highest voltage in an "All On" (i.e. max flow rate, highest fluid temperature, etc.) state.
  - In-house (i.e. non-accredited lab) benchtop electrical testing is sufficient.
- Additionally, applicants must provide documentation describing the *externally*-supplied cooling mechanism with the following reporting and threshold requirements:
  - Rated lifetime of the cooling system must be a minimum of 10 years, as stated on the cooling mechanism manufacturer's specification sheet.
  - Range of acceptable inlet and outlet fluid temperature, flow rate, and solution type/concentration must be defined.

Draft 1: Externally-Supplied Actively Cooled Fixtures

- In addition to the existing fields, *externally*-supplied actively cooled fixtures will have the following information listed on the QPL:
  - Product Category
    - ***“Externally*-Supplied circulating-liquid horticultural fixture”**
  - Per ISTMT and LM-79 test results
    - **“Maximum”** and **“Average Tested Inlet Fluid Temperature”**
  - Allowable operating conditions supplied to fixture including:
    - **“Solution Concentration”**
    - **“Flow Rate Range”**
    - **“Inlet Fluid Temperature Range”**
  - Per cooling mechanism in-house benchtop electrical test report:
    - **“Maximum Input Voltage”**
    - **“Maximum Input Power”**
    - **“Power Factor”**
    - **“Total Harmonic Distortion (current)”**

intertek
Total Quality. Assured.

STATE OF THE MARKET: LIQUID COOLED LED LIGHTING

Carl Bloomfield
Global Director of Commercial Infrastructure Products

October 29, 2020

INTERTEK SERVICES FOR THE LIGHTING INDUSTRY

North American Certification
(cETLus)

International Evaluations
(CB, CE, NOM, KTC, CCC, BSMIA, and others)

Photometrics
(LM 79, LM 80, LM 84, CIE S 025, ASABE S642 and others)

Energy Efficiency
(ENERGY STAR®, NRCAN, CEC, DLC, ErP)

Performance
(HALT, EMC, Vibration, Transient, IP, DALI®, Zhaga)

Environmental
(RoHS, Reach, WEEE, California Prop 65, and other Chemicals)

Data Acceptance Program
(SATELLITE)

Global Market Access
(SASO, Kuwait, Singapore, Russia, and others)

Advisory Services
(Consulting, Cyber Security, Software Testing, Training)

ABOUT ASABE

- Who is ASABE?
  - ASABE is the American Society of Agricultural and Biological Engineers
    - is an educational and scientific organization dedicated to the advancement of engineering applicable to agricultural, food, and biological systems
    - founded in 1907 and headquartered in St. Joseph, MI
    - more information at www.asabe.org

ABOUT ASABE

- Multiple committees within ASABE but two are focused on lighting
  - ES-310 – Addresses application of agricultural lighting systems
  - ES-311 – Lead and coordinate the activities of ASABE in matters related to LEDs and other electromagnetic radiation source applications for plant growth and development

NOTE: ES-310 and ES-311 are in process of being combined into one committee

ASABE ES-311 HORTICULTURAL LIGHTING STANDARDS

- **Metrics Task Force – Standard ANSI/ASABE S640 – Published July 2017**
  - Title: Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms)
  - Scope: Provides definitions and descriptions of metrics used for radiation measurements for plant (photosynthetic organisms) growth, development, and production. This document does not cover display aspects and human visualization

- **Testing Task Force – Standard ANSI/ASABE S642 – Published September 2018**
  - Title: Recommended Methods of Measurements and Testing of LED Products for Plant Growth and Development
  - Scope: This document describes methods for measurement and testing of LED packages and arrays or modules, LED lamps, and any other LED optical radiation devices, with a spectral range between 280 nm and 800 nm, used for plant growth and development. These methods are necessary to obtain information about device characteristics

- **Performance Task Force – DRAFT Standard ASABE X644**
  - Title: Performance Measures of Electromagnetic Radiation Systems for Plants
  - Scope: Provides guidance on measures for reporting electromagnetic output and efficacy of individual luminaires used for plant lighting applications (not for bare lamp measurements)

Summary Lighting Facts, Horticultural Applications

Brand	Valoya
Model	R150 NS1
Lamp type	LED
Voltage (VAC)	120
Current (A)	1.11
Power (W)	133.3
PSS (-)	0.83

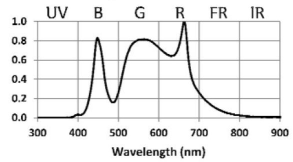
Photon flux (at 61 cm mounting height):

Waveband (nm)	Photon flux (μmol/(m²s))
300-399	0.7
400-499	35.1
500-599	77.9
600-699	70.4
700-799	11.2
800-900	1.3
300-900	196.6

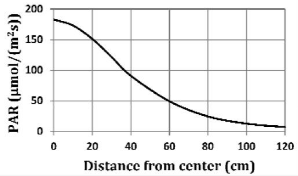
Measurements performed according to IESNA LM-79-08: *Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products*

PAR flux (μmol/s)	191.4
PAR efficacy (μmol/J)	1.44
PAR efficacy (mol/kWh)	5.17
PAR conversion efficiency (%)	31
Luminous flux (lm)	12,480
CCT (K)	4,949
CRI (R_a)	80.0
Case temperature (°C)	55.0

Normalized photon flux:



PAR intensity (at 61 cm mounting height):



Label is from a paper by Both, Bugbee, Kubota, Lopez, Mitchel, Runkle, and Wallace

ASABE ES-311 S642 WORKING GROUP OVERVIEW

- **Working Group Members consists of:**
  - Academia
  - Manufacturers (LEDs, Lamps, or Luminaires)
  - Testing laboratories
  - Users / growers
  - ASABE Staff

- **Recurring Calls**
  - Biweekly calls to review recommended changes to the document
  - Goal is to have consensus on the document before sending it off to the full committee or to the external industry for voting
  - Challenges exist due to the differing opinions on the applications and the technology

ANSI/ASABE S642 SEP2018 OVERVIEW

- **<u>Current Published Version:</u>**
  - Focused on laboratory level testing of LED Packages and Arrays or Modules, LED Lamps, any other LED radiation device
  - Covers measurements of Spectral Radiant Flux, Spectral Photon Flux, Radiant and Photon Intensity
  - Covers initial product performance and long-term performance changes
  - Does not address testing of actively cooled products

KEY FACTORS IN DEVELOPMENT OF THE ANSI/ASABE S642

- Supports the development of test methods/procedures for parameters identified in ANSI/ASABE S640 and the pending S644 document
- Prioritizes the referencing of existing industry standards and where applicable provide deviations due to Horticultural environment application
- Focusses on repeatability of measurements for both field and laboratory measurements
- Focuses on common testing practices and instruments

DIFFERENT PARAMETERS BETWEEN GENERAL LIGHTING AND HORTICULTURAL LIGHTING APPLICATIONS

Typical Parameters for General Lighting	Typical Parameters for Horticultural Lighting
• Luminous Flux (lm) • Luminous Efficacy (lm/W) • Correlated Color Temperature (CCT) • Color Rendering Index (CRI)	• Photosynthetically Active Radiation (PAR) • Photosynthetic Photon Flux (PPF) • Photosynthetic Photon Flux Density (PPFD) • Plant Biologically-Active Radiation (PBR) • Daily Light Integral (DLI) • Photon Flux Efficacy • Phytochrome Photoequilibrum Value (PSS)

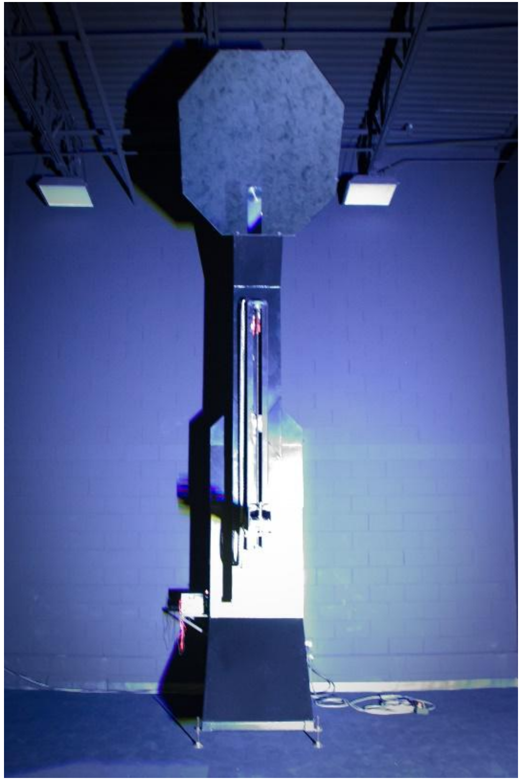
DIFFERENT STANDARDS BETWEEN GENERAL LIGHTING AND HORTICULTURAL LIGHTING APPLICATIONS

Typical Standards Used For Testing SSL General Lighting	Typical Standards Used for Testing SSL Horticultural Lighting
IES LM-79	IES LM-79
IES LM-80	IES LM-80
IES LM-82	IES LM-84
IES LM-84	IES LM-85
IES LM-85	ASABE S640
IES TM-21	ASABE S642
IES TM-28	IES TM-21
	IES TM-28

PERFORMANCE TESTING – DISTRIBUTION MEASUREMENTS

Typical Report includes:

- IES Files
- Luminaire Efficacy, Minimum Light Output, Zonal Lumen Density
- Color Measurements (Chromaticity) and Electrical Measurements
- Spectral Distribution over visible wavelengths (mW/nm)
- Photosynthetic Photon Intensity distribution (umol/s/sr)
- Absolutely Intensity Candlepower (cd) Summary table
- Isocandela Plot
- Luminance Summary table
- Illuminance – Cone of Light
- Illuminance – Isofootcandle Plot



PERFORMANCE TESTING – COLOR (SPHERE) MEASUREMENTS

Typical report includes

- Color Characteristics
- Power and Power Factor
- Spectral data
- Photosynthetically Active Radiation (PAR)
- Photosynthetic Photon Flux (PPF)
- Photosynthetic Photon Flux Density (PPFD)
- Plant Biologically-Active Radiation (PBR)
- Photon Flux Efficacy
- Phytochrome Photoequilibrum Value (PSS)

CHALLENGES IN TESTING ACTIVELY COOLED PRODUCTS

•Laboratory concerns:

- Getting the actively cooling method (e.g. water plumbing or HVAC ducting) into the defined laboratory environment
- Impact actively cooling method can have on equipment (e.g. leaks or moisture impact on sphere coating)
- Some cities/states can have their own/additional requirements

•Testing Challenges

- Repeatability of measurements are dependent on product stabilization which is dependent on setup
- Variation in actively cooling methods vary product to product or manufacturer to manufacturer. Flexibility needed
- Distribution test requires rotation of the DUT and the mirror
- Defining a “Tc” location for testing

ANSI/ASABE S642 SEP2018 – NEXT STEPS

Latest revision out for Committee ballot:

- Address measurements of actively (by external means) cooled products
- Provide methods of measurement for field application

Future revisions to include:

- Near field irradiance measurements. Currently waiting on an IES test method to be developed
- Supporting testing/calculation beyond currently defined PAR

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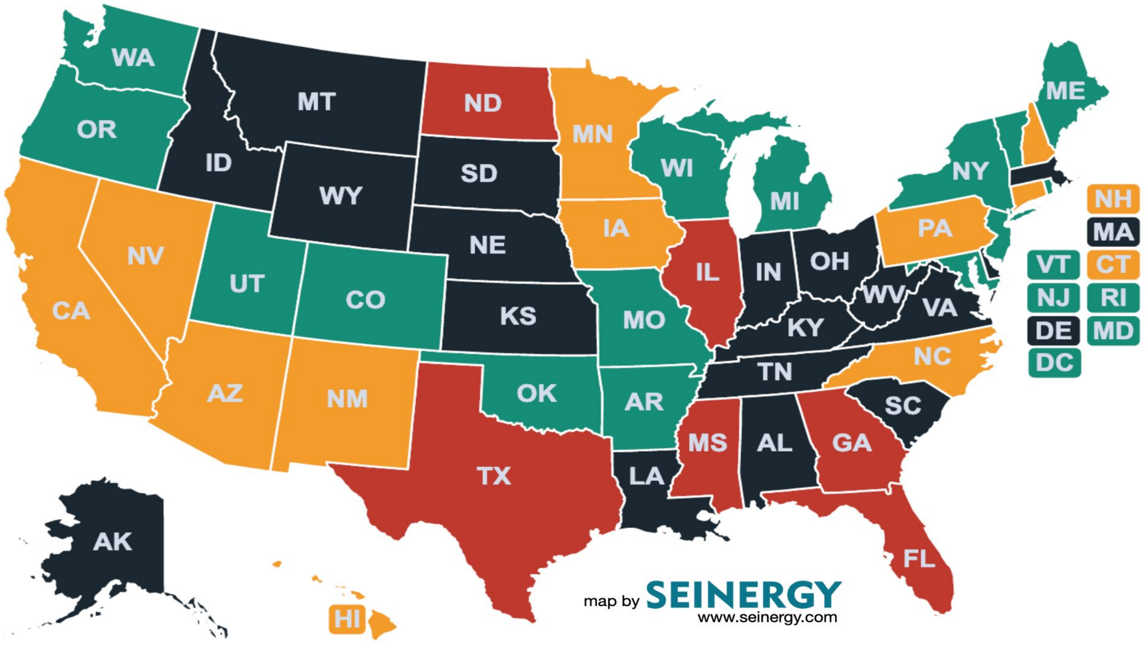
National Utility Rebate Expertise, for Growers



SEINERGY

Innovating Energy Efficiency

Bob Gunn, CEO
www.seinergy.com

Utility & Efficiency Program Incentive Process

1. You have the tools you need <u>today</u>.
2. Leverage custom. Don’t create a <u>P</u>rogram. (It’s still too early!)
3. Savings methodology may be easier than you think

Production Efficiency* =

Labor, facility, nutrients, air quality, genetics, skill, secret sauce, value added processes, marketing, energy inputs → **umol/J**

———————————————

Revenue (output x price)

umol/J

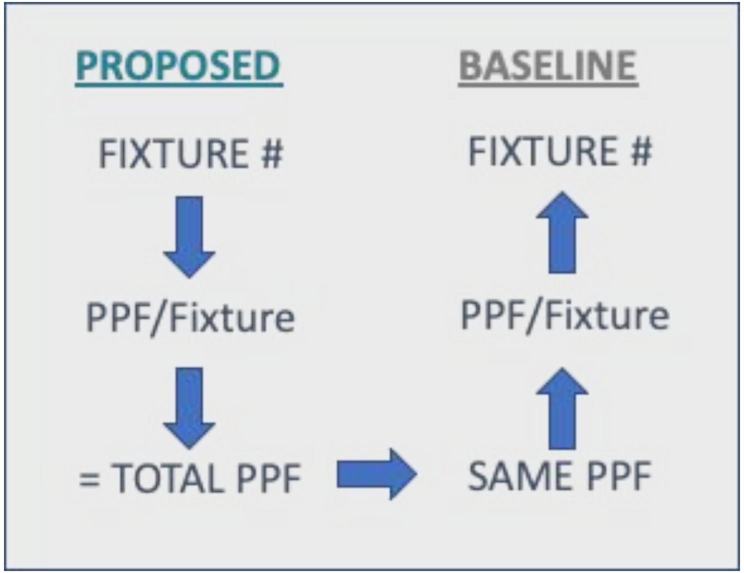
**differs by audience*

SEINERGY

Savings Methodology I - Two Step PPF Parity

1. **Start with proposed**

2. **Back into the baseline**



Fine print:

- Once parity is established, costs will follow
- Works for retrofit or new construction
- High PPFD is OK!
- W/sq ft is not relevant anymore
- Qualifying product specs are useful, but ever-evolving.

SEINERGY

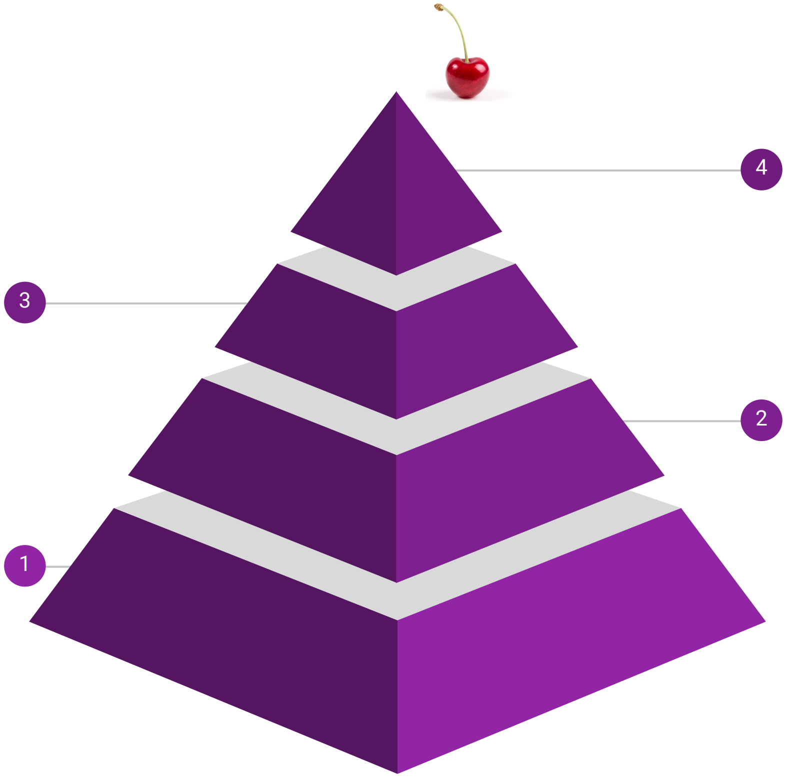
Savings Methodology 2 - EEM Loading Order

EEM 3 - HVAC Upgrade [DIRECT, HVAC]

How is proposed equipment cooling waste heat more efficiently? Include all systems (e.g.: pumps, water filtration). May use

EEM 1 - Lighting Upgrade [DIRECT, Lighting]

Energy and demand savings of LED over legacy/baseline/ISP. Proven; well understood.



EEM 4 - Reuse of Waste Heat [DIRECT HVAC]

Bonus points for doing something interesting with the waste heat?
Co-located distillery, anyone?

EEM 2 - Reduced Waste Heat [INDIRECT, HVAC]

Calculate/claim savings from reduced waste heat in the room. (Hint: it's all waste heat). May use baseline

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Tips for Utility Incentive Programs

1. **Start today**; emerging tech requires custom analysis; customers can't wait
2. **Standards are useful, but not perfect** (e.g.: DLC, UL, ETL)
3. **Beg, Borrow, Steal**. Cheat sheets. Don't recreate the wheel
4. **Collaborate** with manufacturers. Learn from the innovators.
5. **Engage**; talk to growers, show up; bring an open mind; say "cannabis" on your website

SEINERGY

Tips for Implementers, Manufacturers, Stakeholders

1. **Policy Matters** - get involved. Promote data based decisions and market transformation precedent. Poor regulation stifles innovation.

2. **Listen to growers**. They know best.

3. **Advocate for innovation -** we don’t know what we don’t know yet. This is emerging technology. Don’t paint it into a corner.

4. Efficiency means many things to many people.

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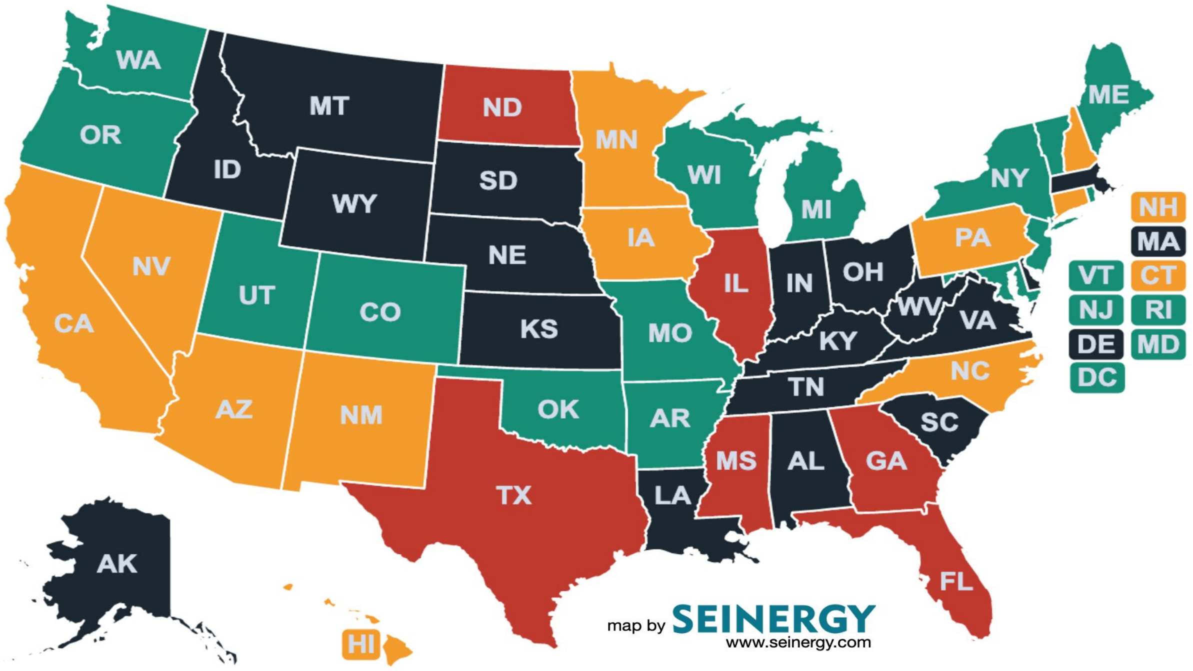

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Innovating Energy Efficiency

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CEM®
Certified Energy Manager
aee®
The Association of Energy Engineers

Q&A

Conclusion

We just gave you a lot of information!

- The technology
- The market landscape
- Getting to yes

How do we advance the conversation?

- Join the RII Utility Working Group
- Who you gonna call?

THANK YOU TO OUR GUEST SPEAKERS & ALL OF THE PARTICIPANTS

After the Workshop

RII Follow-up

- Look for an email with:
    - Recording of today's workshop
    - Slide deck
    - Links to RII resources
    - Information about our panelists and partner organizations

Breakout Sessions

Gretchen will assign you to breakout rooms:

- ***Data:*** Developing a collaborative open source data access plan to enable consistent and defensible custom incentive calculations
- ***Landscape:*** Identifying complementary policy and customer engagement approaches
- ***Technology:*** Deeper understanding of technology

Message Gretchen if you would like to move breakout rooms