Indoor Agriculture Energy Savings Deep Dive #1: RETROFITS

November 5, 2020

Presented by:

RESOURCE INNOVATION INSTITUTE

In cooperation with:

UMass Amherst

Organized by:

Massachusetts Energy Efficiency Partnership

MAEEP

A USDOE Energy Efficiency Partnership

nationalgrid EVERSOURCE

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Agenda

Welcome, introductions & purpose	1:00 pm
Cannabis production facility background	1:10 pm
Energy sources for cannabis cultivation operations	1:15 pm
Fuel mixes, typical energy use, electric demand, and energy costs	1:20 pm
Designing and optimizing for energy efficiency in retrofits	1:30 pm
Q&A	1:50 pm

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

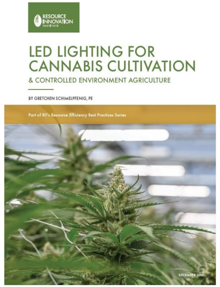
1. Provides guidance on development of standards
2. Shapes tools and resources to support best practices
3. Informs advocacy on policies, incentives and regulations

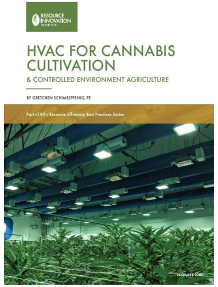


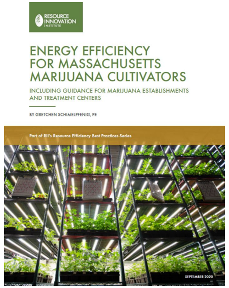
Technical Advisory Council Working Groups

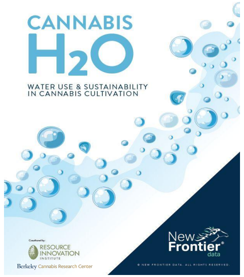
2019	Q1 2020	Q2 - Q4 2020	2021
Lighting	Utility	Water	*Design & Construction*
	HVAC	Massachusetts	*Carbon Emissions*
		Policy	
		Data	
		Controls	

IAES'20
Indoor Agriculture Energy Solutions









Best Practices Guides

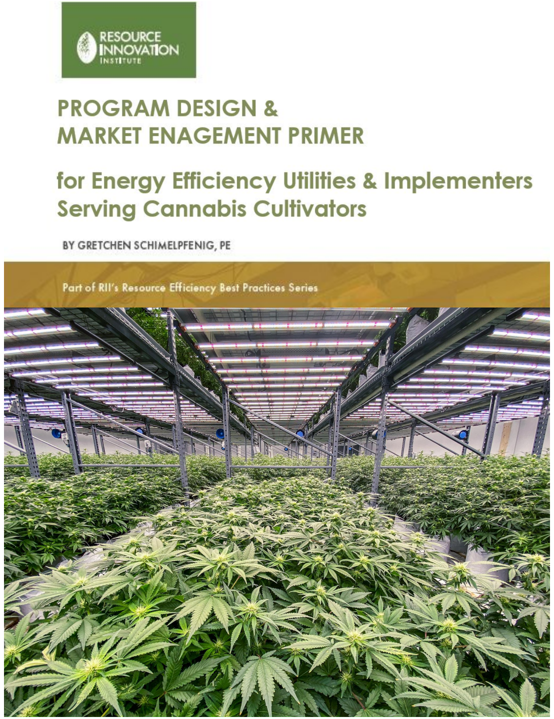
- **60+ contributors & peer reviewers**, including cultivators, architects, engineers, manufacturers
- Defines key terms
- Recommends KPIs
- Meets all growers where they are
- State-specific guidance for Massachusetts

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.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PROGRAM DESIGN &
MARKET ENAGEMENT PRIMER

for Energy Efficiency Utilities & Implementers
Serving Cannabis Cultivators

BY GRETCHEN SCHIMELPFENIG, PE

Part of RII's Resource Efficiency Best Practices Series

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

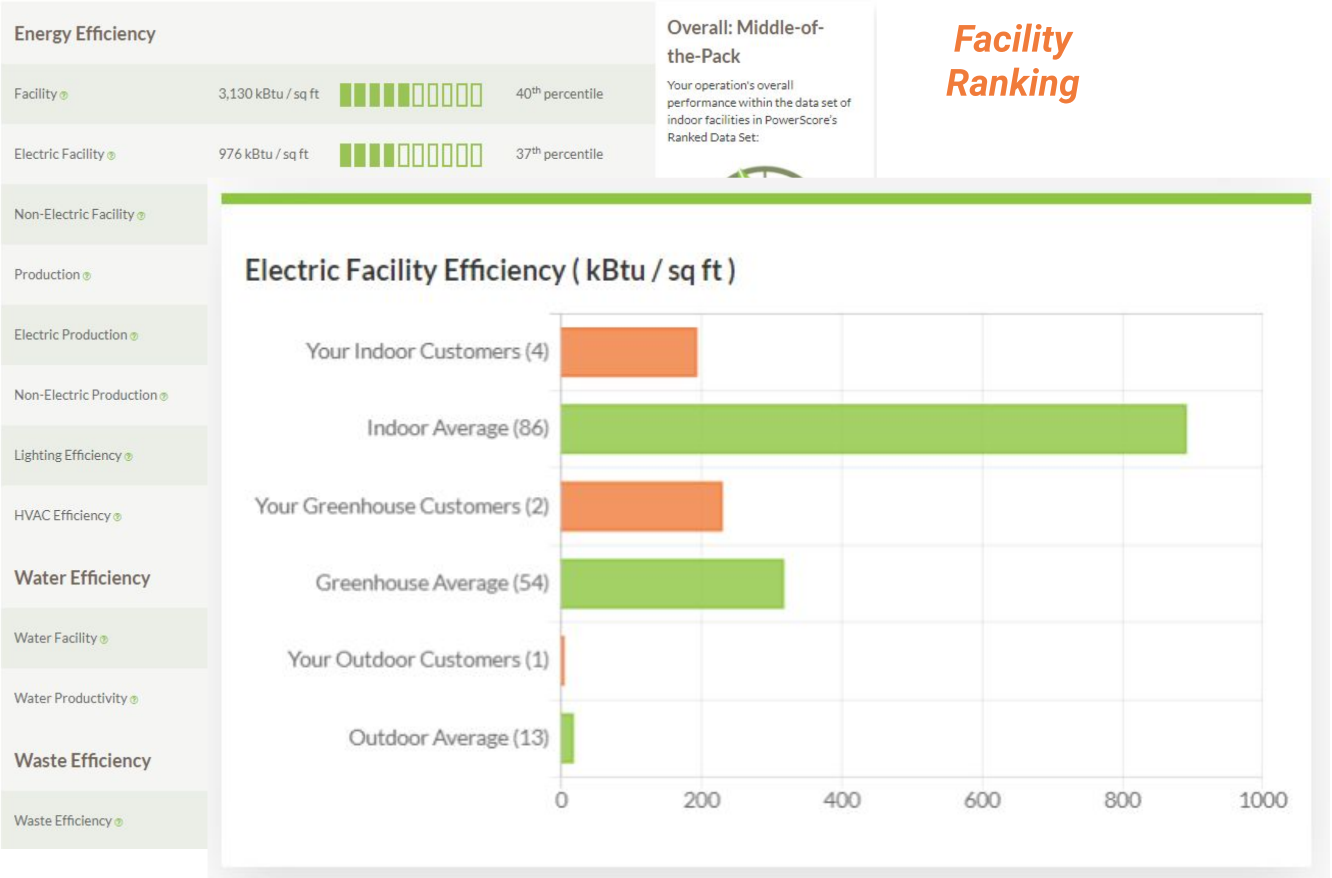
Confidential

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

RESOURCE INNOVATION INSTITUTE

PowerScore Performance Benchmarks

KPIs



Facility Ranking

Learning Objectives

You will leave today understanding:

- **Typical HVAC and lighting loads for cultivation facilities**
- **Energy use and demand of cannabis operations**
- **Challenges cultivators face with retrofitting existing buildings**
- **Designing and optimizing cannabis cultivation processes for efficient operations**
- **Cost-effective opportunities for retrofitting to high-performance building systems and equipment**
- **Options for savings methodologies for lighting, HVAC, and dehumidification retrofit projects**

Program Information

If you are a supply chain professional working with cultivators...

Partner with Mass Save program administrators for cannabis client projects

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Our Speakers

[Dario Boyce]

Project Manager
Anderson Porter Design

ANDERSON PORTER DESIGN

[Doug Oppedal]

Program Manager &
Senior Lighting Specialist
Evergreen Consulting Group

Evergreen Consulting Group

What are the typical processes occurring in indoor cannabis production facilities?

Why Cultivate Indoors if Energy Costs are Higher?

- Some commercial grows began as scaled up black market operations
  - Old school “indoor is safer” mentality
- Legalization **regulations** in some areas require indoor cultivation
  - Obscure plants from view
  - Control and manage odors
- Offer increased quality for craft cannabis
  - Avoid crop damage from weather and pests
- Can effectively control their environments
  - Tailor light spectrum and light intensity for cultivars
  - Optimize temperature and humidity to minimize mold and disease
  - Lengthen growing season and increase harvest cycles

Activities and Products in Cannabis Cultivation Facilities

- Cultivation
  - Propagation / Nursery
    - Cloning
    - Mothering
  - Vegetation
  - Flowering

Cutting: 14 days → **Stage 1 Veg**: 10-14 days → **Stage 2 Veg**: 7-14 days → **Flower:** 63 days → **Dry:** 14 days → **Cure, Store and Sale**

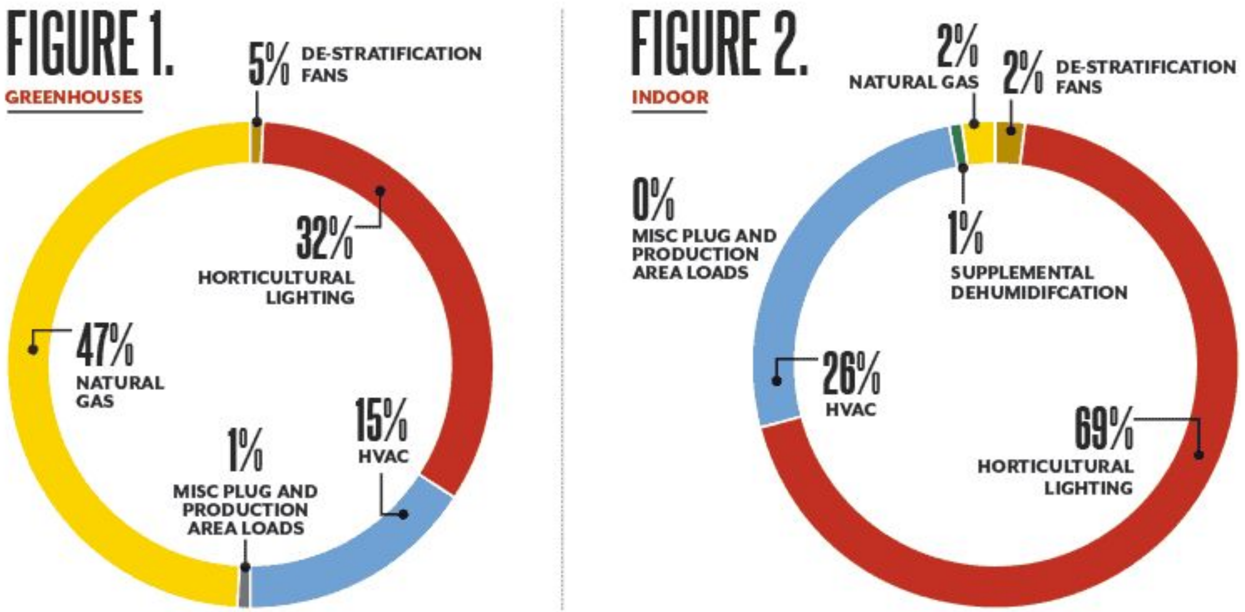
Activities and Products in Cannabis Cultivation Facilities

- Cultivation
  - Propagation / Nursery
    - Cloning
    - Mothering
  - Vegetation
  - Flowering

- Drying/Curing ---> **Smokeable product**
- Processing ---> **Oils / extracts**
- Manufacturing of products ---> **Pills, topicals, tinctures, etc.**

What are the energy sources and fuel mixes of cannabis operations?

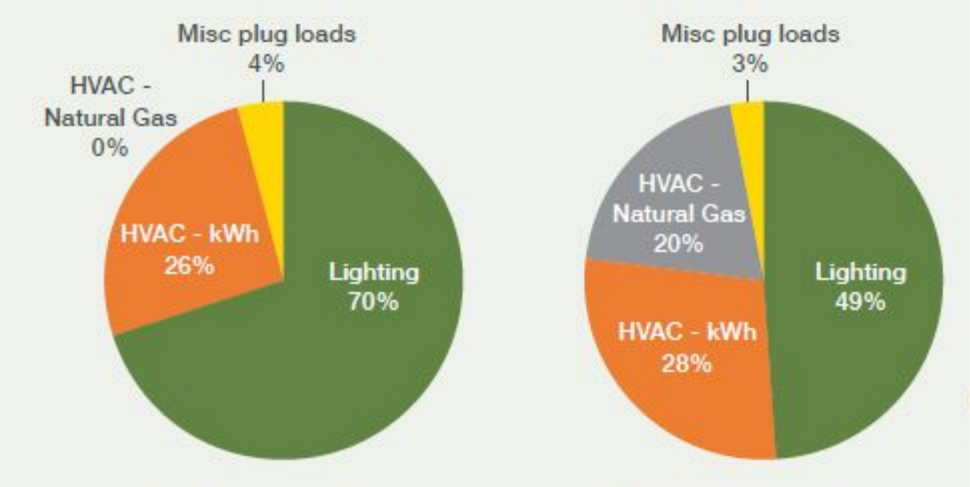
Primary Energy Sources in Grow Environments



Source: ERS & RII, The Carbon Emission Impacts of Greenhouse Cultivation, Cannabis Business Times
Source for data: Boulder County, Colorado Cannabis Cultivator Energy Efficiency Assessments performed by ERS

Primary Energy Sources in Indoor Facilities in Massachusetts

All electric indoor | Natural gas indoor



Source: RII, Massachusetts Best Practices Guide

What do cannabis production operations look like and what are their HVAC & lighting loads?

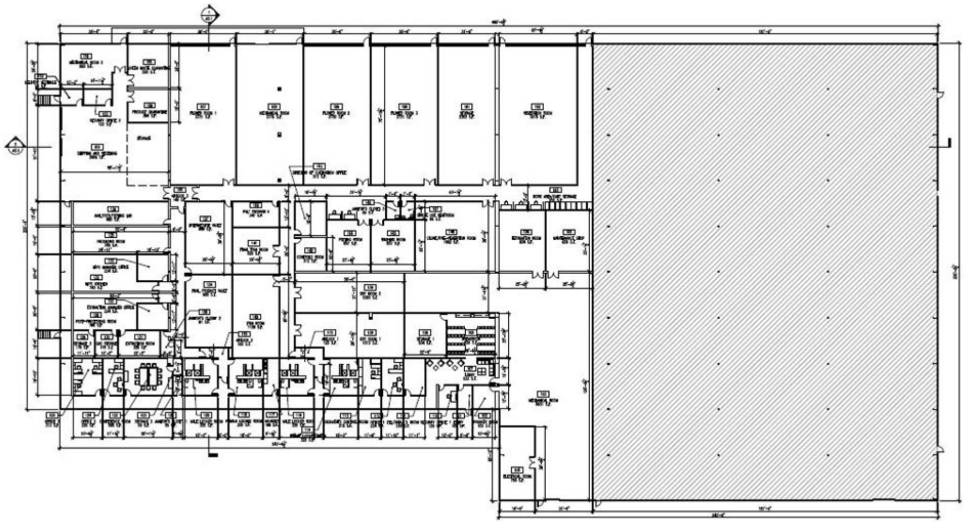
Michigan Example

Cultivation and Manufacturing Facility in MI

61,000 GSF/ 16,400 CSF in Flower (2-tier)
(950)x 645W LED lights
37.36 W/CSF (aka HLPD)

Dry Bulb & RH
Day: 75 F +/- 3 F @ 50%RH +/-5%
Night: 70 F +/- 3 F @ 40%RH +/- 5%
Chilled Water / 4-pipe to Modular AHUs
Ventilation: **+500CFM**, MERV 11, HEPA

Cooling Load: **340 Tons**
Electrical Load: **2,700 Amps 480V 3-phase**



Calculating Amperage for LED Lighting Systems

MA Tier 3 Facility Example

	Canopy Square Footage	Number of Fixtures	Wattage per Fixture	Hours per Day ON
Flower	10800	616	630	12
Veg	1485	100	275	18
Clone	400	50	112	24
Mom	180	12	200	18
Totals	12865	sq. ft.	**424**	kW, Peak
			5,330	kWh, per day

Amperage Required from Utility for Lighting		
Power Factor	0.95	unitless
Peak Power Demand	424	kW
Power Type	480	V, 3 phase, line to line
Peak Amperage Demand	536	A

This is for hort lighting only!!

How much energy does an indoor cannabis cultivation operation consume?

Electricity Consumption of Indoor Cannabis Operations

Cultivation facilities range widely in their energy consumption depending on their size:

- Some **small operations** with flowering canopy areas smaller than 5,000 square feet **may use as little as 60,000 kWh, but can also consume over 2,000,000 kWh a year**.

Electricity Consumption of Indoor Cannabis Operations

- Some **medium-sized facilities** with flowering canopy areas from 5,000 - 10,000 square feet **can use between 2 million and 3 million kWh a year**.
- **Larger facilities** with flowering canopy areas larger than 10,000 square feet **can use between 2 million and 6 million kWh a year**.

Whole-Building Performance of Indoor Cannabis Operations

- Average Facility Efficiency is 2,390 kBtu/sq ft when both electricity and natural gas are included. Massachusetts indoor facilities in **Cannabis PowerScore** have an average flowering canopy area of 6,150 square feet and produce an average of 355,500 grams of dry cannabis flower per year.
- Average energy usage of the Massachusetts operations is 2,700,000 kWh of electricity per year and 21,300 therms of natural gas per year.
- Utility costs for electricity and gas can exceed $100,000/month for a large facility with >10,000 sq ft of flowering canopy
- Average Horticultural LPD as measured by the CCC ($HLPD_{MA}$) of these indoor Massachusetts operations is 43.5 W/sq ft; Average Lighting Efficiency is 5,530 kWh/day.
- Average water usage is 483,000 gallons per year.

Electric Demand of Indoor Cannabis Cultivation Operations

- **Craft operations** with flowering canopy areas smaller than 2,000 square feet may have monthly peak demands ranging from 10 - 120 kW
- **Small - medium-sized facilities** with flowering canopy areas from 4,000 - 10,000 square feet may have monthly peak demands ranging from 165 - 500 kW
- **Larger facilities** with flowering canopy areas larger than 10,000 square feet may have monthly peak demands ranging from 1,100 - 1,400 kW
- Peak demand charges can range from $2,000 - $10,000/month

What kind of retrofits happen in cannabis production facilities?

Retrofits: Two Definitions

- Retrofit: renovation and **refurbishment of existing buildings** to change building use type (and maybe upgrade energy performance)
- Retrofit: installation of new or modified equipment in an existing system or building to **upgrade to more efficient technology**
- Projects in cannabis production facilities may be one or the other, or both at the same time:
    - A cannabis business **retrofits** a warehouse building for cultivation and processing activities, and performs a technology **retrofit** to upgrade systems to meet new loads and reduce operating expenses

Non-Energy Benefits of Retrofits to Existing Equipment

- LED lighting can provide better quality of light and more choices of spectrum to influence plant expression and product differentiation
- Lighting controls offer ability to gradually increase light intensity as plants grow and implement sequences such as sunrise/sunset
- High performance HVACD systems can better meet and maintain target environmental conditions, enhancing plant productivity
- Saving energy with high performance equipment leaves power available to expand canopy and product without buying more real estate
- Lower maintenance costs and associated labor hours
- Can grow cradle to grave on one shelf which reduces labor costs

Greatest Opportunities for Energy Savings

- LED horticultural lighting with lighting controls
- Efficient cooling
- Efficient dehumidification
- Efficient central plant
- VFDs for pumps and fans
- Smart airflow control strategies
- Automated HVACD controls
- Integrated HVACD and lighting systems
- Efficient industrial processes

What scale of energy savings and incentives are possible in these facilities?

Mass Save Customer Example #1

mass save
Savings through energy efficiency

- **Massachusetts example**

~ 15,000 sq. ft. flowering canopy

- Energy efficiency measures:
  - Heat pipe
  - Efficient chiller
  - Condensing boilers
  - Airflow set backs

- Potential yearly fuel savings for efficient system
  - Electric – **845,000 kWh**
  - Gas – **94,800 therms**

Mass Save Customer Example #2

mass save
Savings through energy efficiency

ECM #	Description of Energy Conservation Measure (ECM)	Annual Utility Bill Savings			Max Peak Demand Reduction kW	Incremental Cost $	Payback Period Years
		Electric kWh	Gas therms	Cost Savings $			
1	*LED Grow Lights*	*382,642*	*7,358*	***$57,028***	*82.6*	*$206,375*	**3.6**
2	*Exhaust Fans with EC Motors*	*1,251*		***$163***	*0.5*	*$1,350*	**8.3**
3	*Gas-Driven Chiller with Heat Recovery*	*286,674*	*-18,199*	***$19,251***	*49.3*	*$97,240*	**5.1**
4	*Condensing Boilers*		*1,565*	***$1,549***		*$20,018*	**12.9**
5	*VFDs on HWS & CW Pumps*	*16,114*		***$2,095***	*2.7*	*$7,093*	**3.4**

686,681 kWh

135 kW

Michigan HVAC Examples

- **Michigan #1**
  - Energy efficiency measures:
    - (2) – 21,500 MBH 92% efficient condensing boilers
  - Potential yearly fuel savings for efficient system
    - Gas – **7,961 MCF**
  - Cost savings per year
    - $39,805
  - Project cost / incremental cost
    - $621,500 / $186,450
  - Simple payback of incremental cost
    - 3.7 years

Michigan HVAC Examples

- **Michigan #2**
  - Energy efficiency measures:
    - (2) – 310 ton water-cooled chillers
  - Potential yearly fuel savings for efficient system
    - Electric – **509,103 kWh**
  - Cost savings per year
    - $50,910
  - Project cost / incremental cost
    - $581,411 / $254,200
  - Simple payback of incremental cost
    - 4 years

Michigan Examples

- **Michigan #3**
  - Energy efficiency measures:
    - (6) 1 - 4 ton heat pumps, (4) 210 - 320 PPD dehumidifiers
  - Potential yearly fuel savings for efficient system
    - Electric – **36,190 kWh**
  - Cost savings per year
    - $3,619
  - Project cost / incremental cost
    - $37,520 / $18,235
  - Simple payback of incremental cost
    - 4 years

Washington Example

- **Washington #1**

~ 2,000 sq. ft. flowering canopy

- Energy efficiency measures:
  - Liquid-cooled LED lighting; efficient central plant

- Potential yearly fuel savings for efficient system
  - Electric – **328,300 kWh** (230,400 kWh from HVAC)
- Project cost
  - $255,350
- Utility incentive
  - $139,675 *$0.43/kWh*

Oregon Example #1

Deschutes Growery

- Full-spectrum LEDs in the flower stage
- Blue spectrum for vegetative and cloning stages
- Dimmers to ramp up light as plants grow

"Deschutes Growery was also among the first of our customers to use new LED technology."

Doug Oppedal, Evergreen Consulting

Oregon Example #1

Deschutes Growery

- LED lighting in flower, vegetative and clone rooms
- $928,330 project costs
- $386,040 in cash incentives from Energy Trust
- $192,000 in annual energy costs savings
- 2.5 million annual kWh savings
- 1,361 tons annual carbon dioxide savings

"Energy Trust is very forward thinking. Its cash incentives helped soften the huge infrastructure cost of installing LEDs."

Oregon Example #1

Deschutes Growery

- LED lighting in flower, vegetative and clone rooms
- $928,330 project costs
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- $192,000 in annual energy costs savings
- 2.5 million annual kWh savings
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This was a new project in 2017 using an HPS HID load the virtual baseline. At the time and still today this is one of the most advanced LED projects in Oregon.

Oregon Example #1

- 3,500 SF flower room has 218, 1000-watt HPS grow lights
- Annual hours of operation are 4,380 (12/7)
- Replace with 600 watt LED

Oregon Example #1

- LED lighting cost $ 218,000
- Local utility incentive $ 64,000 (15 cents/kWh)
- 429,000 estimated annual kWh savings $ 47,739 (10 cents/kWh)
- Annual cooling load savings (20% of ltg kWh savings) $ 9,548
- Simple payback 2.7 years
    - Baseline lighting maintenance cost savings (HID re-lamp) $13,800 x 2.5 yr. = $34,500

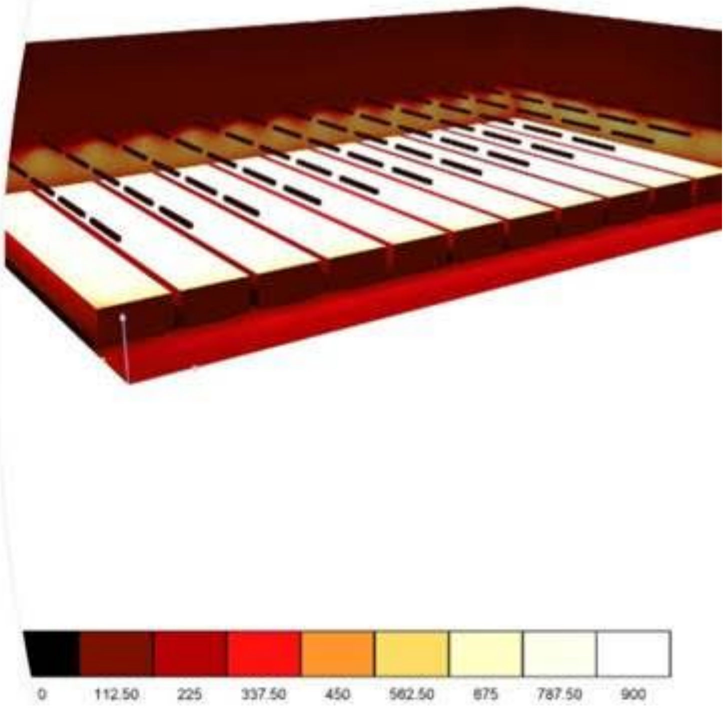
Oregon Example #1: Beating MA HLPD Requirements

- This example would just meet the 36 watts per SF requirement in MA
- Using a current advanced LED product that consumes 520 watts and provides the same or higher light levels, this example would re-calculate at **32 W/sq ft**
- Higher PPE grow lights with proper distribution will require less lights, lowering LPD
- Using higher PPE and more efficient LED light fixtures (450 W) this example would re-calculate at **28 W/sq ft**
- **Lighting controls** that automatically trim the light level at veg and slowly increase as plants grow will save additional kWh

Oregon Example #1: Beating MA HLPD Requirements

36/50 watts per sf requirements

- 1,500 sf flower room
- 1,056 sf canopy
- 60, 630-watt LED grow lights
- 900 PPFD
- 35 watts per canopy sf
- 25 watts per room sf

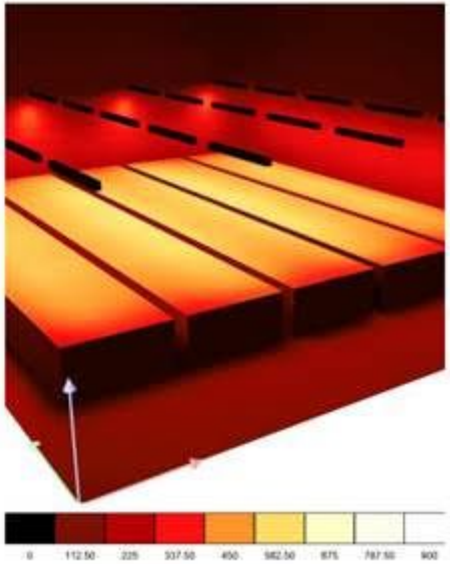


Fluence

Oregon Example #1: Beating MA HLPD Requirements

36/50 watts per sf requirements

- 750 sf veg room
- 480 sf canopy
- 20, 630-watt LED grow lights
- 675 PPFD
- 26 watts per canopy sf
- 17 watts per room

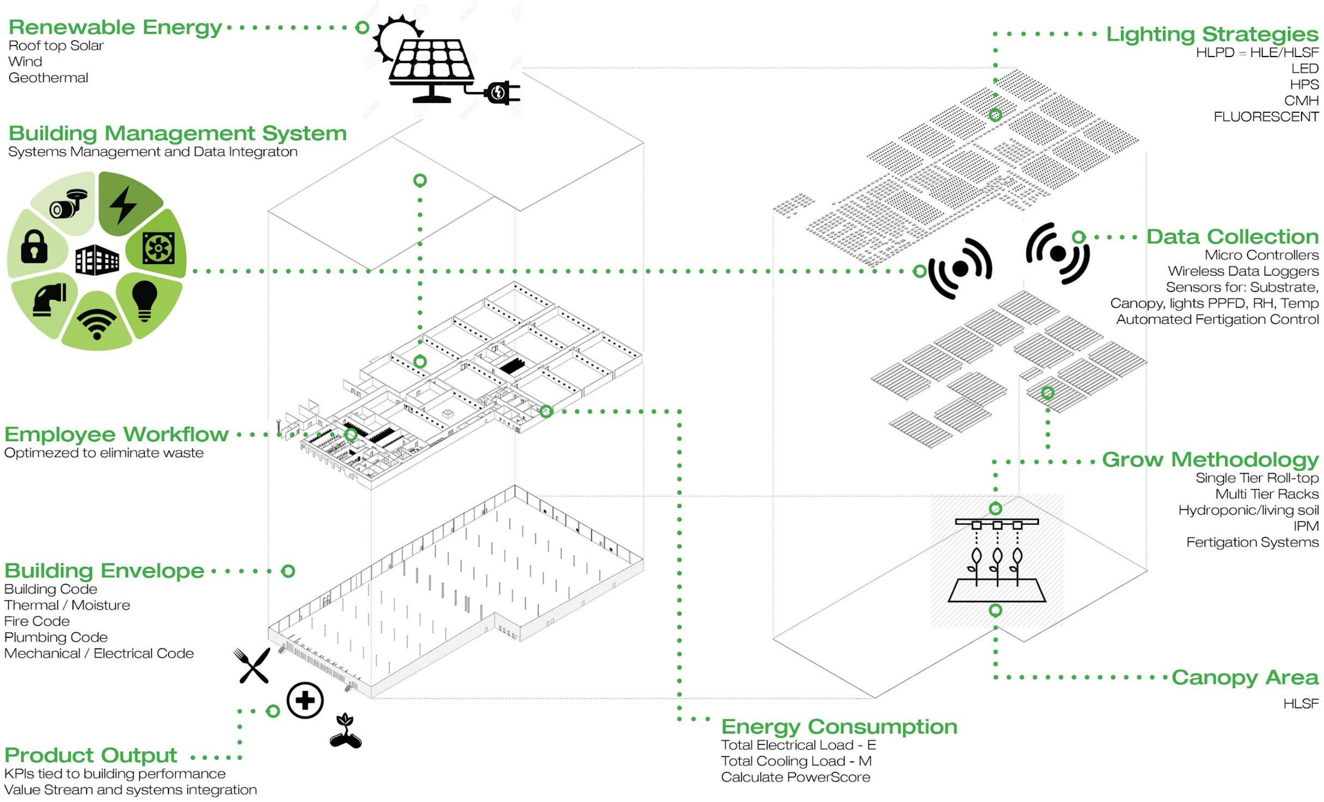


Fluence

How can project partners guide cannabis cultivators through infrastructure considerations?

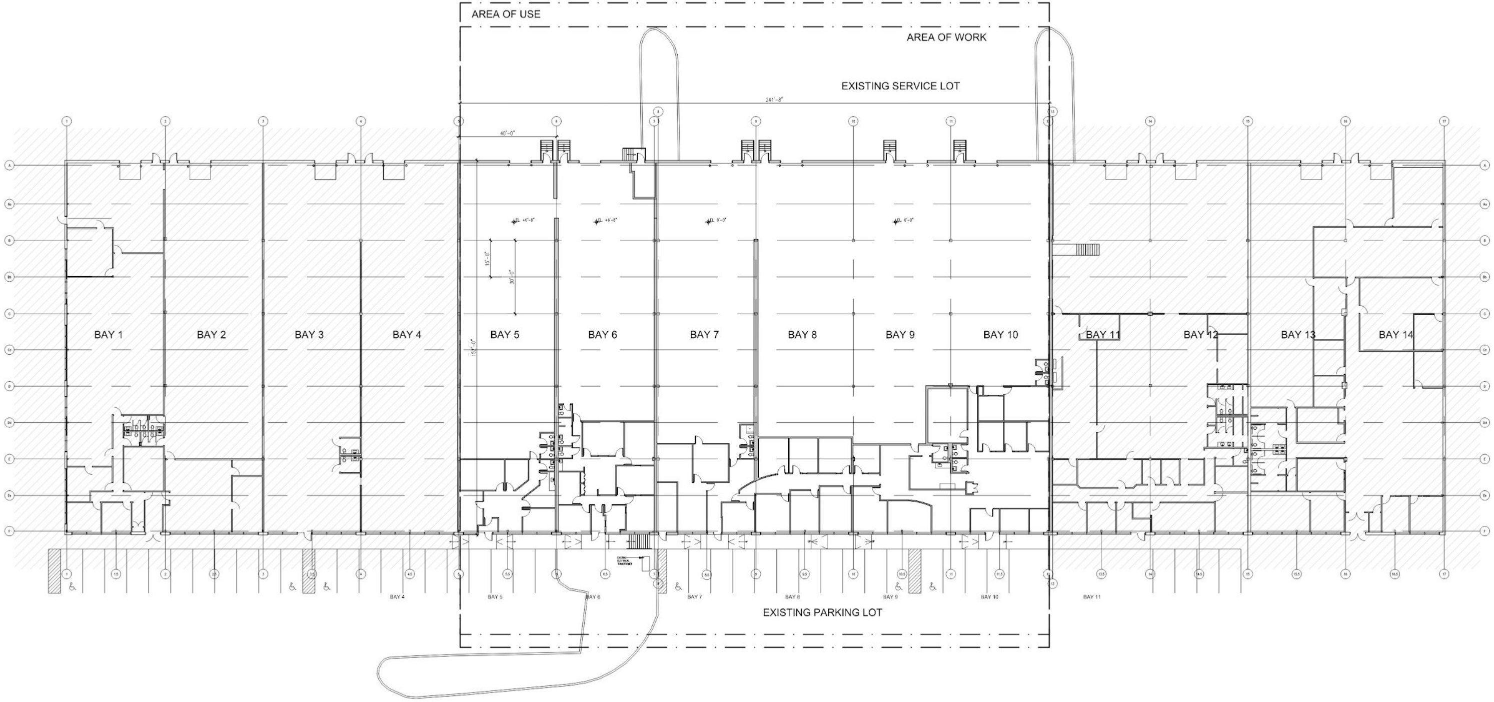

OWNER
ROOT & BLOOM
George Haseltine
Brad Kutcher
OWNER'S REPRESENTATIVE
2915 CONSULTING
Marc Cooperstein
ARCHITECT
ANDERSON PORTER DESIGN
Brian Anderson
Adam Sitterly
CIVIL ENGINEER
MILLENNIUM ENGINEERING
Chris York
GEOTECH
UTS of MA
Windward Shaw
FLOW TEST
PENNICHUCK WATER WORKS
ATTORNEY
MEAD, TALERMAN, & COSTA
Adam Costa
LANDSCAPE ARCHITECT
KDTURNER DESIGN
Kim Turner
HORTICULTURAL EXPERT
ZARTARIAN ENGINEERING
Mike Zartarian
EXTRACTION EXPERT
FAST FISH CONSULTING
Matthew Hoffman
M.E.P. / F.P. ENGINEERS
BLW ENGINEERS
Erik Gath
ACOUSTICS ENGINEER
ACENTECH
Andy Carballeira
STRUCTURAL ENGINEER
T.B.D.

Integrated Design Philosophy

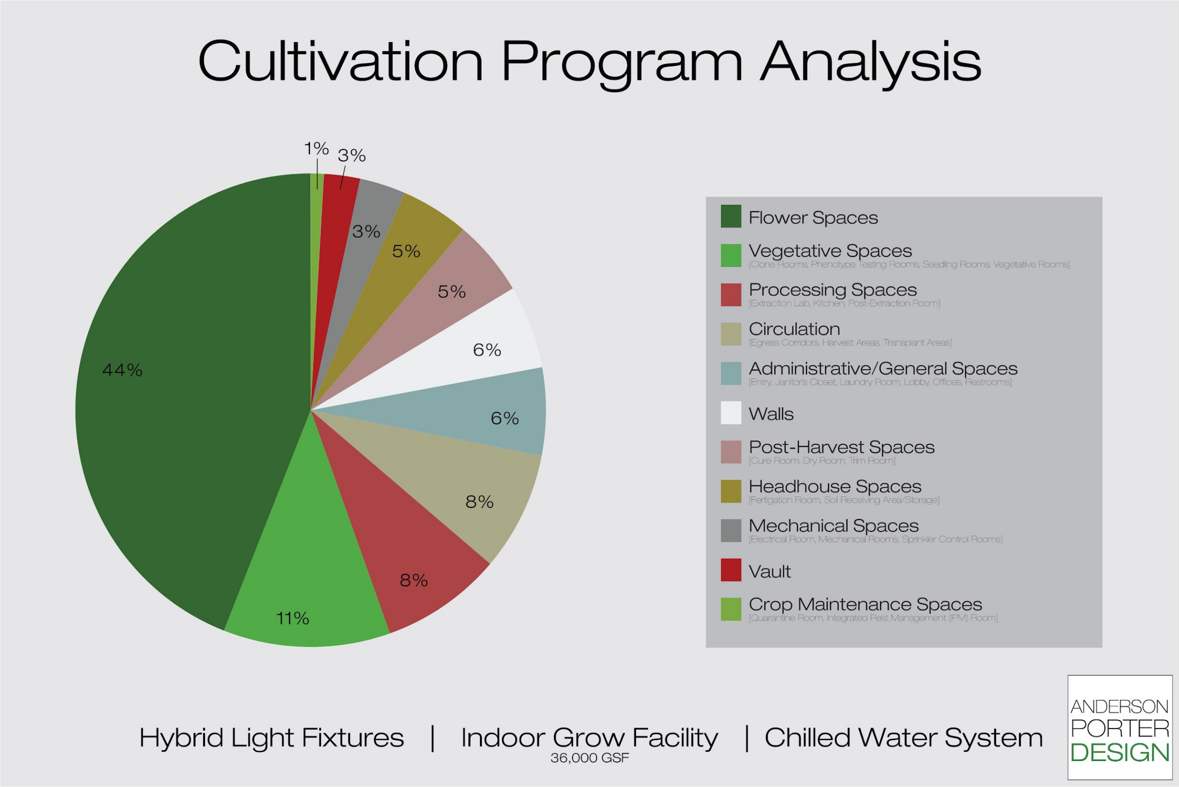


Massachusetts Design Example #1

Existing Building Electrical Load:
2000A; 408/277V; 3-phase



Massachusetts Design Example #1



Electrical Load: 4000A; 277/480; 3-phase (2000A needed for cultivation)

New 165kVA transformer needed

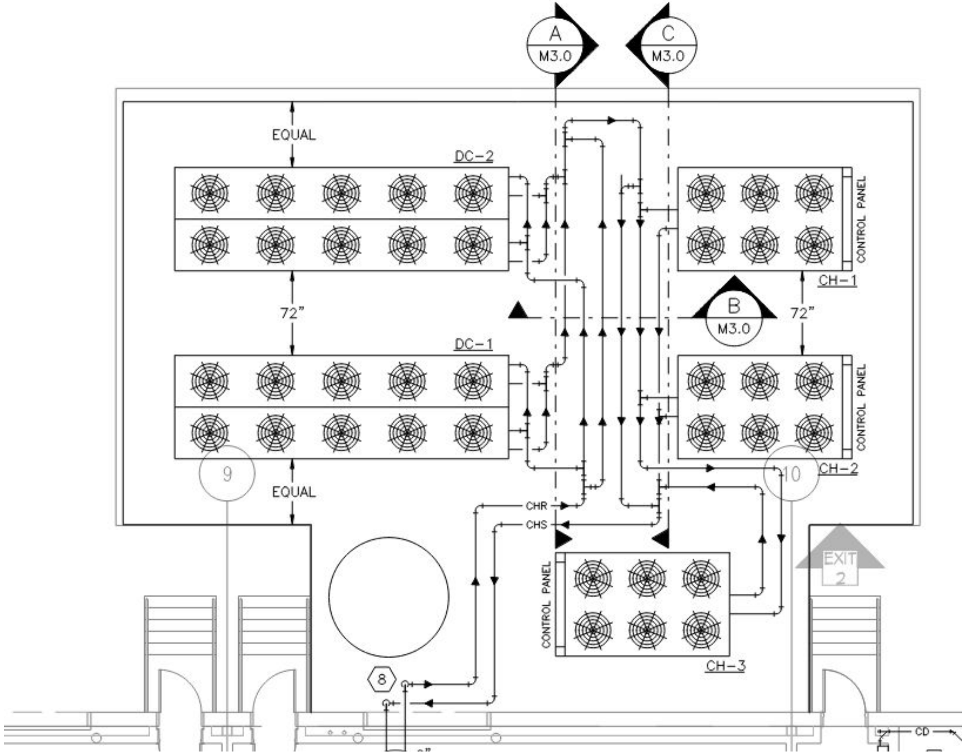
Canopy SF: 13,081 CSF

HPS Light Fixtures:
1000W (Flower): 590

CMH Light Fixtures:
450W (Veg): 100
350W (Mother & Veg): 48

LED Light Fixtures:
350W (Veg): 56
250W (Veg): 72

Massachusetts Design Example #1



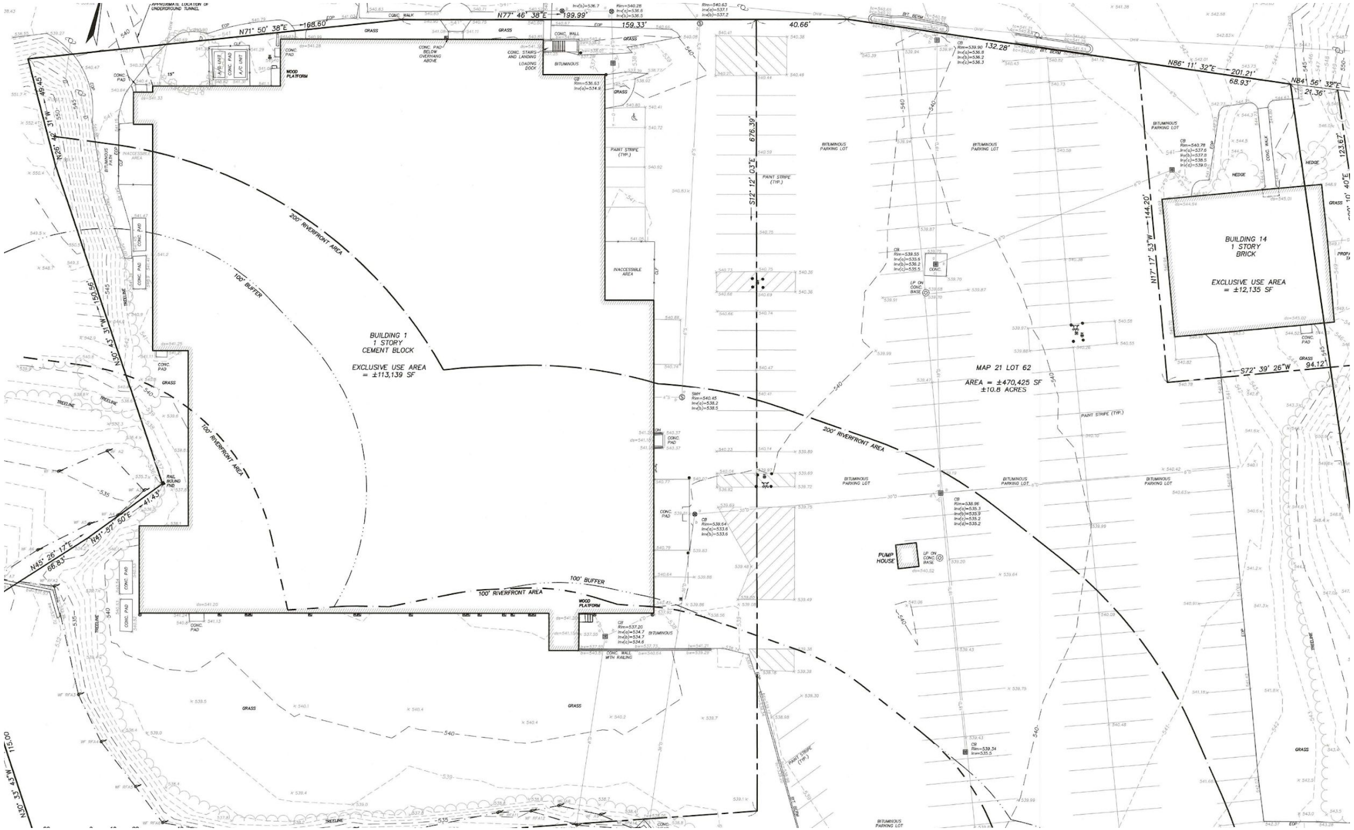
Chilled Water System:

3 air-cooled chillers
90 tons capacity each

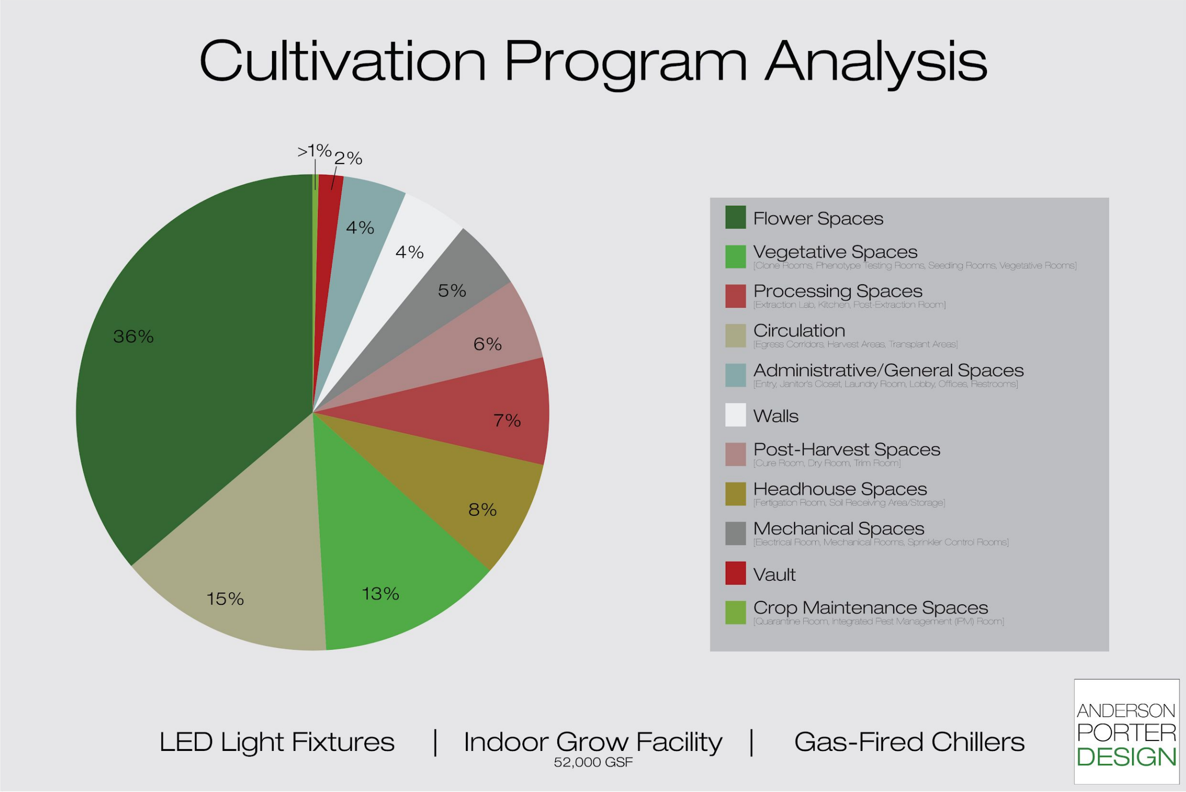
2 dry coolers

Massachusetts Design Example #2

Existing Building Electrical Load:
1000A; 408/277V; 3-phase



Massachusetts Design Example #2



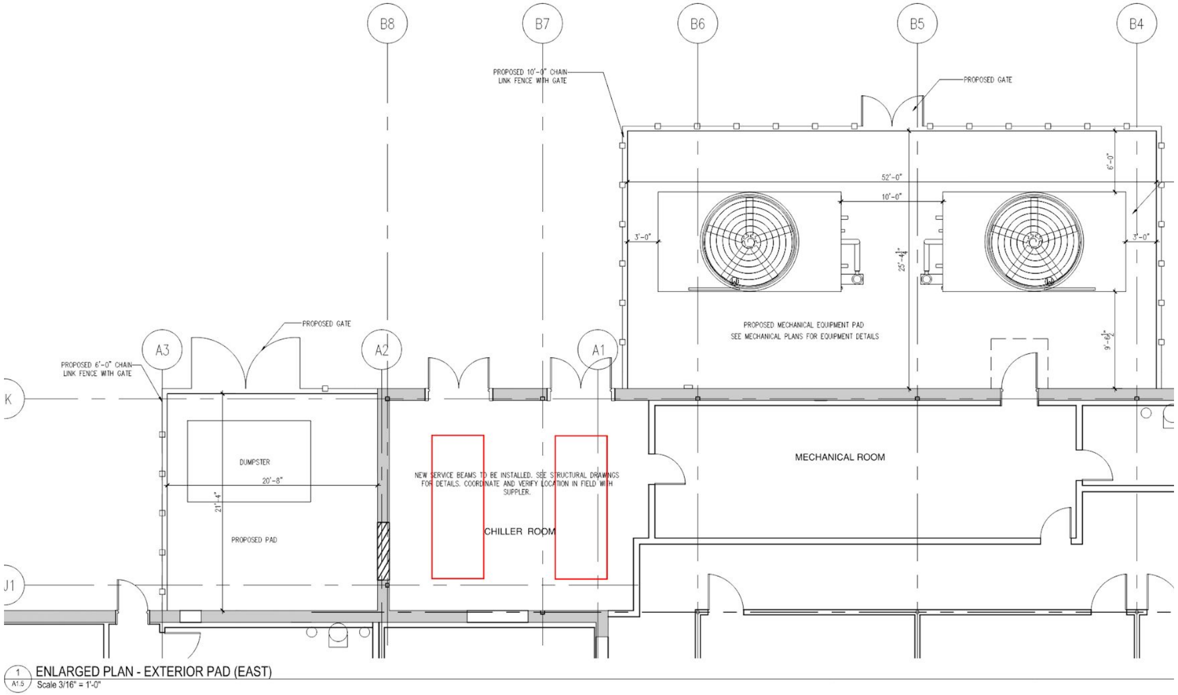
Electrical Load: 2500A; 277/480; 3-phase

New 450kVA transformer needed

Canopy SF: 16,514 CSF

LED Light Fixtures: 1,268

Massachusetts Design Example #2



Chilled Water System:

2 Tecogen chillers
200 tons capacity each

2 Evapco cooling towers

Next Steps

Your Assignment

- Provide feedback via SurveyMonkey
- Attend November 12 workshop on HVACD & Energy Recovery

RII Follow-up

Gretchen will:

- Send recording, slide deck and links to shared files from today's workshop
- Provide links to RII resources
- Share information about panelists and their organizations

THANK YOU

Massachusetts Energy Efficiency Partnership

MAEEP

A USDOE Energy Efficiency Partnership

nationalgrid EVERSOURCE

UMass Amherst

Presented by:

RESOURCE INNOVATION INSTITUTE

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Indoor Agriculture Energy Savings Deep Dive #2: ENERGY RECOVERY

Thursday, November 12

Presented by:

RESOURCE INNOVATION INSTITUTE

In cooperation with:

UMass Amherst

Organized by:

MAEEP

Massachusetts Energy Efficiency Partnership

nationalgrid EVERSOURCE

See you at next week's workshop!