



BOULDER COUNTY ENERGY IMPACT OFFSET FUND (BCEIOF) DEMAND SIDE MANAGEMENT STUDY

Phase 1

ABSTRACT

This study assesses the collective demand side management potential across the 12 cannabis facilities currently regulated by Boulder County. Policy actions are recommended to facilitate market forces to aid energy productivity improvements and distributed generation for the reduction of emissions in the cannabis industry.

Brad Queen

Cube Resources

brad@cuberresources.com

Office: 303-247-1187

<http://www.cuberresources.com/>



Table of Contents

Acknowledgements.....	2
Executive Summary.....	2
Background	4
Absolute comparisons.....	4
Portfolio grouping by type and location	4
Grouping of electricity consumption / emissions by location and type	6
Portfolio comparisons of intensity per sqft	9
Portfolio aggregation for coincident peak load, total energy, seasonality, etc.....	11
Disaggregation of lighting, HVAC, etc. by circuit (when available) and via season when operations are regular	18
Xcel rate structure applied to eGauge data.....	21
Trending of load profile stats to look for changes in operating strategies.....	23
Estimation of other costs (labor, rent, build-out).....	24
Market failures.....	25
Lack of trust: market share, productivity over efficiency, and secrecy	25
Conflicting policy goals	28
Policy has distorted the real estate market.....	29
Split incentives	29
Loss of price signals.....	30
Imperfect cost information and tools.....	31
Payback periods vs. market uncertainty, Risk, Financing, and Cash Flow	34
Refusal of banks to loan to the cannabis industry and related contracts	35
Poor adoption rates for utility company incentives	35
Lack of support from national labs and standards organizations.....	38
Lack of skilled, reliable contractors.....	38
Market potential for cost and emission reductions within program	39
End Notes.....	41

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These contributors have improved this report, but they are not responsible for its findings or any errors that may remain.

Executive Summary

This report represents a Phase 1 study of demand side management (DSM) potential within and outside of the Boulder County Energy Impact Offset Fund portfolio of County-regulated cannabis production facilities. The report is intended to inform County policy makers and DSM program designers for the application of offset funds. It is also intended for the use of similar research efforts by other government entities and cannabis industry professionals interested in energy and emissions reductions.

The portfolio of cannabis facilities in the BCEIOF currently stands as follows:

- 12 facilities: 2 mixed-use, 2 greenhouses, 2 indoor electric heat, and 6 indoor natural gas heat.
- These had a collective annual peak load over 2.2 Megawatts in 2017.
- They collectively consumed over 10,443 MWh in 2017 at a cost of approximately \$930,471.
- After baseline consumption allowances, \$189,329 in BCEIOF fees were levied in 2017.
- Both the collective peak and total consumption will probably increase in 2018.

The companies that run these facilities are subject to many challenges that less stigmatized industries don't face. They have been competing for market share as product demand has increased and facility space has been limited. They are ignored by capital markets, barred from some energy contracts, and are poorly served by utility DSM programs. They have high cash flow but high expenses, high regulatory burden, and legal uncertainty. On top of all of that, they suffer from the same market failures that can stymie energy efficiency in other commercial markets.

36% of the price signal in that \$930,471 in electricity cost (\$336,514) is lost due to the distortion of per square foot billing for 41.5% of portfolio energy use. A failure to fix this market failure greatly reduces the effectiveness of any demand-side reduction tactics. A mandate for sub-metered billing and even full pass-through of demand rates could fix this, so could a voluntary collaboration among renters facilitated by the existing BCEIOF metering. The full price signal of BCEIOF fees reaches all facilities due to the program's sub-metering design.

Of that 10,443 MWh in 2017 annual consumption, approximate end uses, and demand-side management considerations are as follows:

4,428 MWh	42%	Lighting: indicating that productivity of advanced lighting has economy of scale
1,249 MWh	12%	HVAC: tactics use in other sectors will be more effective due to 4-season usage
1,566 MWh	15%	Electric Heat: minority of load but conversion has quick payback
3,200 MWh	31%	Unknown: greenhouses which are probably mainly lighting, but need more info

Proving advanced lighting technologies and helping growers retrofit with them shows the most potential if lighting power densities can be reduced without sacrificing yield. There is no federal or non-profit laboratory that sorts through vendor claims and there is little to no commonly accepted empirical science of photon efficiency vs. plant productivity.

Ultimately, energy productivity (not efficiency) and overall emissions reductions are at issue. To evaluate productivity, METRC production data would be required in future analyses. To properly address emissions, natural gas consumption data would be required to evaluate how heating greenhouses burdens their lower electrical intensities. Similarly, the different heating technologies for indoor grows warrant evaluation.

At this time and with currently available data, we recommend the following priorities:

1. Engagement with the BCEIOF steering committee and growers with the findings of this report and support for next steps.
2. Organization of 5 growers behind shared utility company meter for the restoration of proper demand and energy price signals to fix major market failure. However, considerable care should be taken in resolving current cross-subsidies due to variation in intensities. Barring cooperation, a mandate for sub-metering with full rate structure pass-through should be considered.
3. Provision of energy dashboards and more training for all growers so they can better understand their energy use trends and relative productivity within this portfolio.
4. Initiate of discussions for land use and ownership models for distributed generation strategies that are not supported by current Xcel programs.
5. Reconcile the conflict between the findings for annualized energy consumption by system in this study with the findings in other studies. In particular, the 2012 Evan Mills study that estimates substantially higher HVAC and dehumidification energy use¹.
6. Initiate energy productivity study for advanced lighting in both indoor and greenhouse environments.
7. Provide payback analysis for conversion away from resistive electric heat.
8. Collection of natural gas and production data for complete "energy productivity" and "emissions productivity" analysis and comparisons across this portfolio.
9. Share data and partner with organizations working toward common goals, such as the Colorado Energy Office, the City of Denver Cannabis Sustainability Work Group, and the Resource Innovation Institute².
10. Begin Phase 2 study to refine both efficiency and distributed energy strategies, tactics, and draft program designs.

A more detailed breakdown of DSM technology focus areas is presented in the last section of this report (Market failures). Detailed evaluation of these technologies and tactics for facilitating their adoption are scoped for Phase 2 of this study along with the relative cost effectiveness of emissions reductions from distributed generation tactics.

Background

The Boulder County Energy Impact Offset Fund (BCEIOF) was established in 2014 with the intent of reducing the emissions of the local cannabis industry. To date, some of the offset fees collected have been used to establish the technical infrastructure of the program, which is comprised of eGauge electricity monitors and the software code to aggregate and analyze the data they produce. The eGauges were installed for the first program participants in early 2015. Participants have entered the program over time, so some data sets go back further than others. These eGauge installations persist so long as these participating growers still opt to have their electrical use aggregated automatically. The growers have direct access to the data and data visualization web interface that these devices provide. That feedback was part of the program intention, with the hope it could foster gradual self-directed efficiency improvements.

Boulder County is now shifting to apply most offset fees to reduce emissions through a combination of tactics that may include, but are not limited to:

- Analysis of energy intensity and energy productivity to discern best practices in this industry
- Technology evaluation
- Anonymized information sharing with other governments and researchers
- Addressing market failures, such as split incentives and missing price signals
- Addressing banking and contract law prohibitions that block conventional energy projects
- Resolving regulatory conflicts that force growers into higher intensity practices
- Creative market models for distributed generation
- Emissions reductions in other sectors when cost effective tactics are no longer cost effective within this sector

Absolute comparisons

Across the sites 10,443 MWh were consumed in aggregate over 2017. Over the same period of time, the entire Saint Vrain Valley School District (SVVSD) consumed 27,466 MWh. In 2016 the entire City of Boulder consumed 1,332,801 MWh³ The BCEIOF portfolio is therefore equivalent to 38% of SVVSD and 0.78 % of the entire City of Boulder

Portfolio grouping by type and location

This analysis will focus on the calendar year of 2017. Of the sites:

- 2 Mixed use
These include substantial office space, extraction operations, and other processing that decreases their intensity and makes them a poor comparison.
- 2 Greenhouse Grow
These are counter-cyclical to indoor grows, using more electricity in the winter, presumably for air handling for heat and supplemental lighting that is not needed in the summer.
- 2 Indoor, Electric Heat
These have been grouped due to their exceptional electrical intensity. One of them exhibits counter-cyclical behavior due to that heat.
- 6 Indoor Grow
These use natural gas heat and they are the most common facility type in the County and Cities. This includes the most recent addition to the portfolio, which will be excluded from stats and comparisons for most of this report.

It should be noted that:

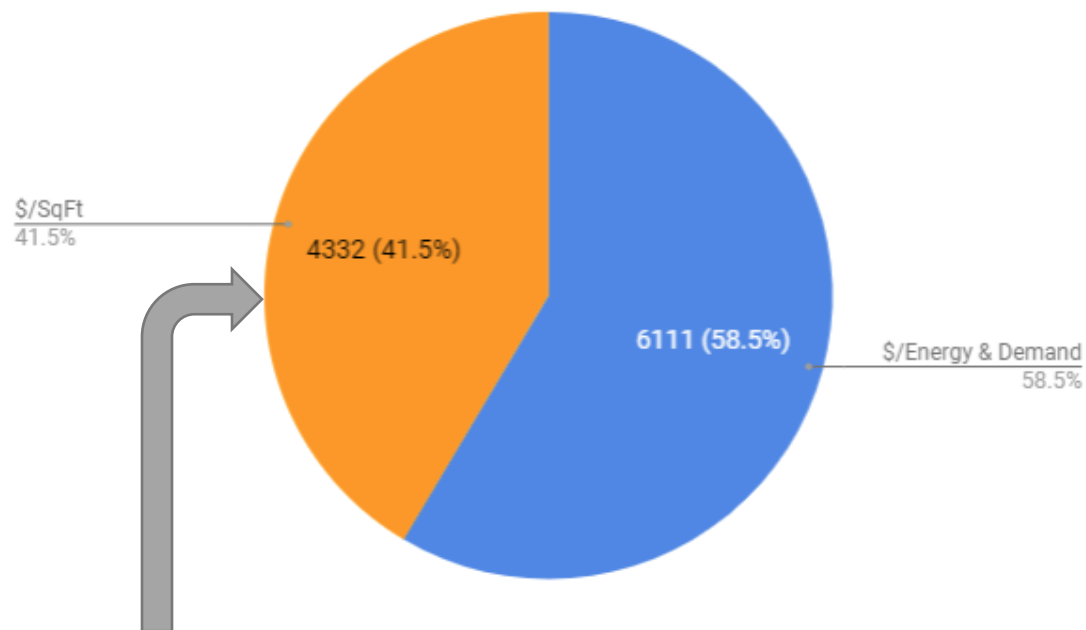
- *Operational patterns and scale of production can be considered sensitive business information. We have made efforts to maintain anonymity regarding which companies provided which data sets in this report.*
- Throughout this report, distinctions are made between utility company meters (which determine utility billing) and eGauges, which are also referred to as sub-meters. Some landlords also sub-meter with their own devices.
- We have no production data for any of these facilities.
- We do not have full annual records on natural gas consumption.
- Cube Resources has not visited 5 of these facilities, including both greenhouses. Their operational practices are therefore not reflected in this report.
- 7 facilities left the portfolio prior to 2017
 - 6 were annexed into the City of Boulder. Of these only 1 has an eGauge that is still online.
To our knowledge, these are all still in operation and were included in current public trend statistics on the BCEIOF web page.
 - 1 went inactive but the eGauge is still online.

Grouping of electricity consumption / emissions by location and type

Across the sites 10,443 MWh were consumed in aggregate over 2017. 41.5% of that electrical consumption was behind the shared utility company meter on the Foothills campus. Within that campus, the largest consumer represents 35.8% of that 41.5% of total portfolio consumption (14.9% of 10,443 = 1,550 MWh).

Those growers are all renters and their utility billing is apportioned on a per square-foot basis. They therefore lose most of the utility price signals for either energy or demand charges. We will return to that issue in the “Market failures” section of this report.

MWh by location and price signal



MWh within \$/SqFt of common meter

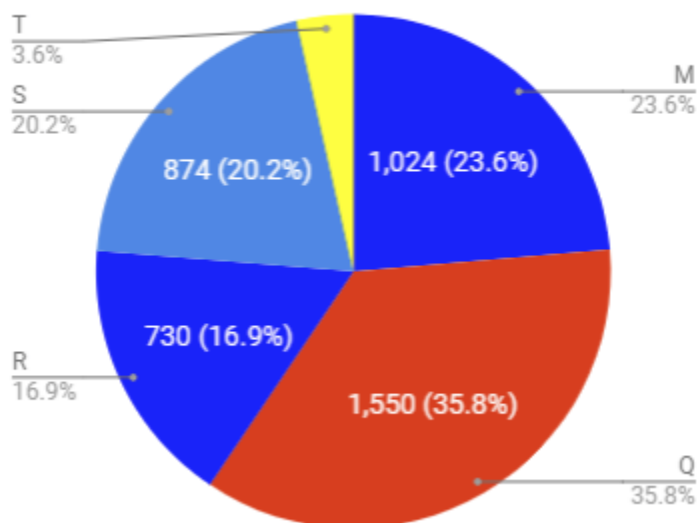


Figure 1 MWh by Location and Price Signal

The two greenhouse grows are the only grower-owned locations in 2017 data. Those represent 30.6% of consumption. They have lower intensities than the indoor grows, but comprise 43.3% of reported area, so they have substantial total consumption. While there are only two indoor grows with electric heat and those occupy less than a third of the greenhouse floor area, their energy intensity drives them to consume almost as much electricity as the greenhouses.

MWh by Own vs. Rent

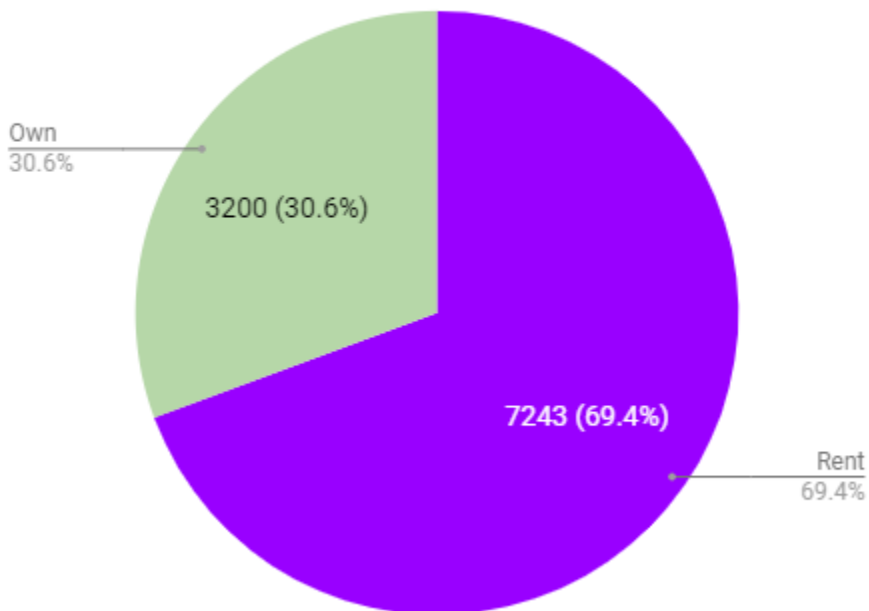


Figure 2 Total energy by ownership

MWh/Year

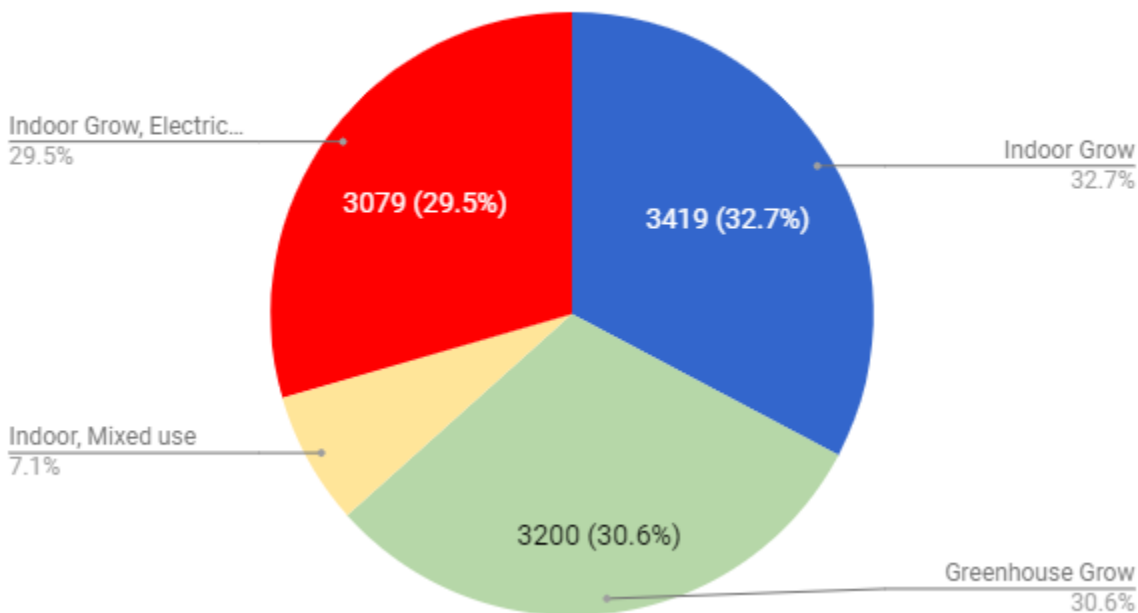


Figure 3 Total energy by facility type

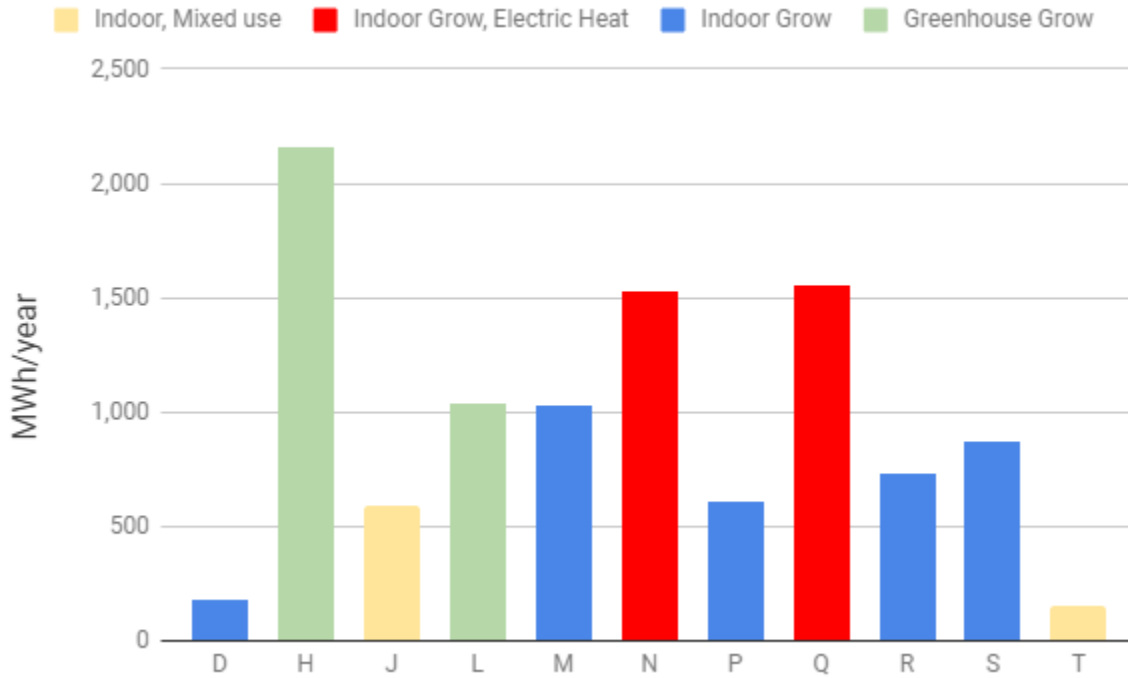


Figure 4 Total energy per year across portfolio

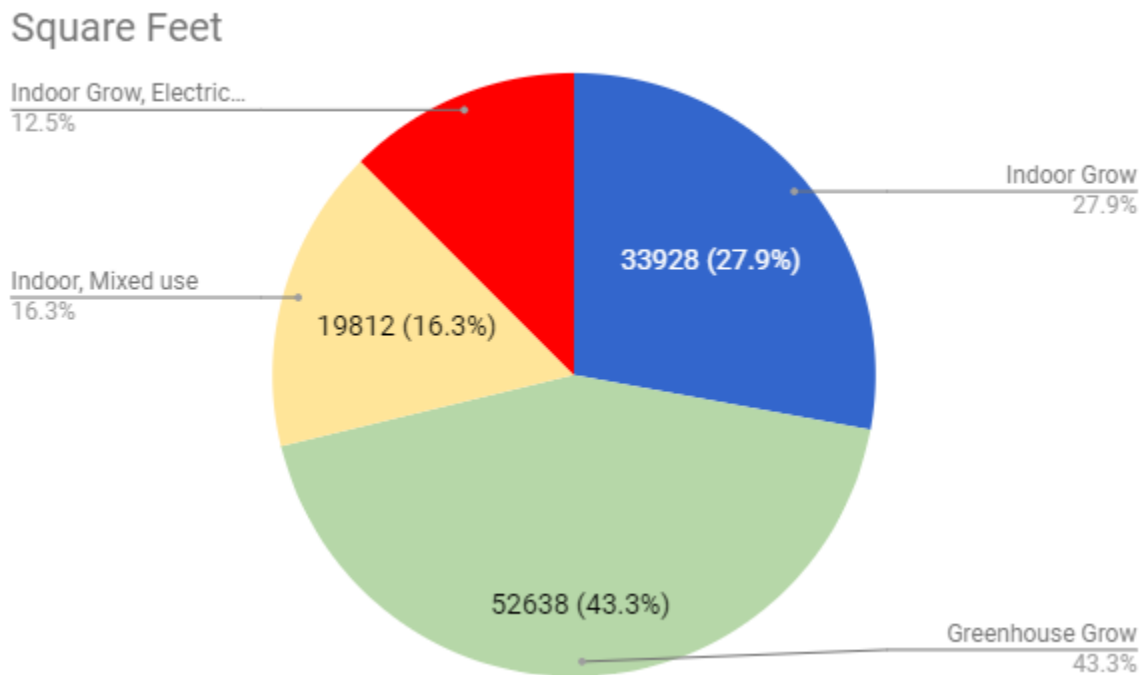


Figure 5 Square footage across portfolio

Portfolio comparisons of intensity per sqft

Dividing annual consumption by square footage yields the following intensities

- 2 Mixed use
These have the lowest intensity, but they are not even comparable to each other in their use of space.
- 2 Greenhouse Grow
These average 62 kWh/sqft/year and appear to produce year-round. It is therefore highly likely that they consume substantially more natural gas than indoor grows over 3 seasons to maintain temperature.
- 2 Indoor, Electric Heat
These have been grouped due to their exceptional electrical intensity. The facility consuming 243 kWh/sqft/year is using chillers and listed “lights” as it’s winter heat source, so it may also be using chillers for waste heat recovery. The facility consuming 174 kWh/sqft/year has no gas line to the building and uses electrical resistance heat with no waste heat recovery.
- 6 Indoor Grow
These use natural gas for heat and average 103 kWh/sqft/year. The most intensive of these, with an intensity of 136 kWh/sqft/year, reports that 60% of their floor area is devoted to vegetative growth and they have atypical daily and annual load profile patterns. However, facility N reports and exceedingly high proportion of their floor area being devoted to bloom, which is usually the most energy intensive process within grows (Figure 7).
- National Average commercial space energy intensity can be compared via the Commercial Buildings Energy Consumption Survey (CBECS)⁴. The Baseline Consumption Value allowance that is deducted from measured electricity prior to assessing BCEIOF fees has been set to 13.8 kWh/sqft/year since the beginning of the program based on the regional average of the 2003 CBECS data set and this is depicted on the right side of Figure 6. The 2012 data released in May of 2016 indicates that Boulder’s census region declined from 13.8 to 13.5 kWh/sqft.

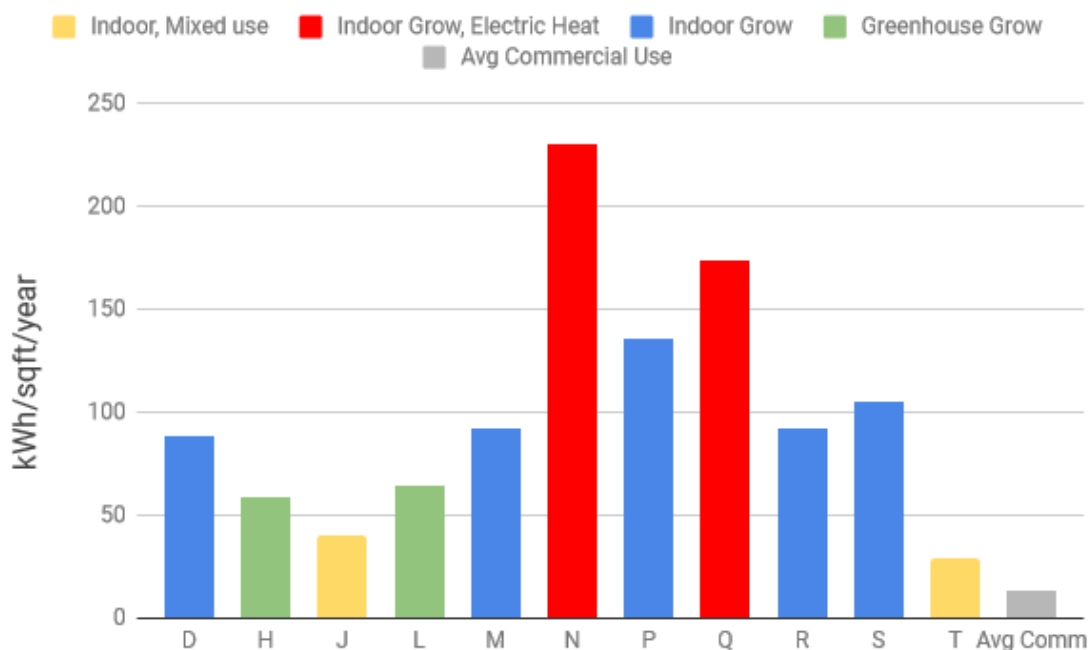
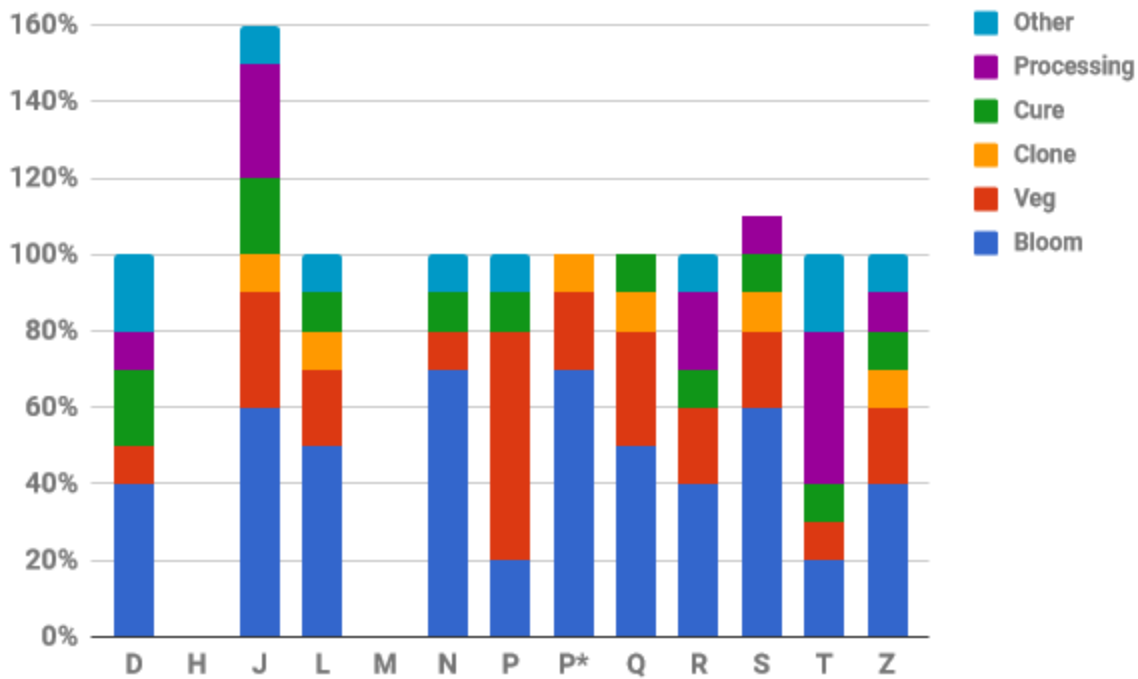


Figure 6 Intensity of facilities by type for 2017 (kWh/sqft/year)



5

Figure 7 Proportional use of floor area reported across all 12 facilities currently in the program.

The proportions in Figure 7 are self-reported. Their accuracy is probably drawn from mental estimates from survey respondents. The fact that two respondents reported allocations in excess of 100% shows that this is a very fallible way to collect this data. There is also one facility that had two different survey respondents (P and P*). The answers differed substantially and both responses are inconsistent with expectations. Two facilities did not respond to this part of the survey. That said, there is clearly a variation between the floor space utilization between facilities. This certainly effects their annualized energy intensities.

Note that bloom lighting schedules are almost always 12 hours on and 12 hours off to simulate the fall equinox and shift plant energy into flower growth. However, we do not yet have data on lighting power densities yet. We have one grower reporting 24/7 bloom lighting but that would violate almost universal practices and has not been confirmed.

As for vegetative lighting schedules, there is reported variation among facilities from 18 hours a day, all the way up to 24/7 lighting. We also don't yet have data on these lighting power densities.

As a point of comparison, in the fall of 2017 the City of Boulder supplied data for 24 of the approximately 80 facilities they regulate⁶. The majority of these cluster between 90 and 150 kWh/sqft/year. The more intensive outliers may have electric resistive heat. The low intensity outliers may be mixed-use facilities. Due to privacy concerns, we know nothing about the sites behind this energy and square footage data. The energy data was collected via Portfolio Manager, so there is no interval data to look at the load profiles of these sites.

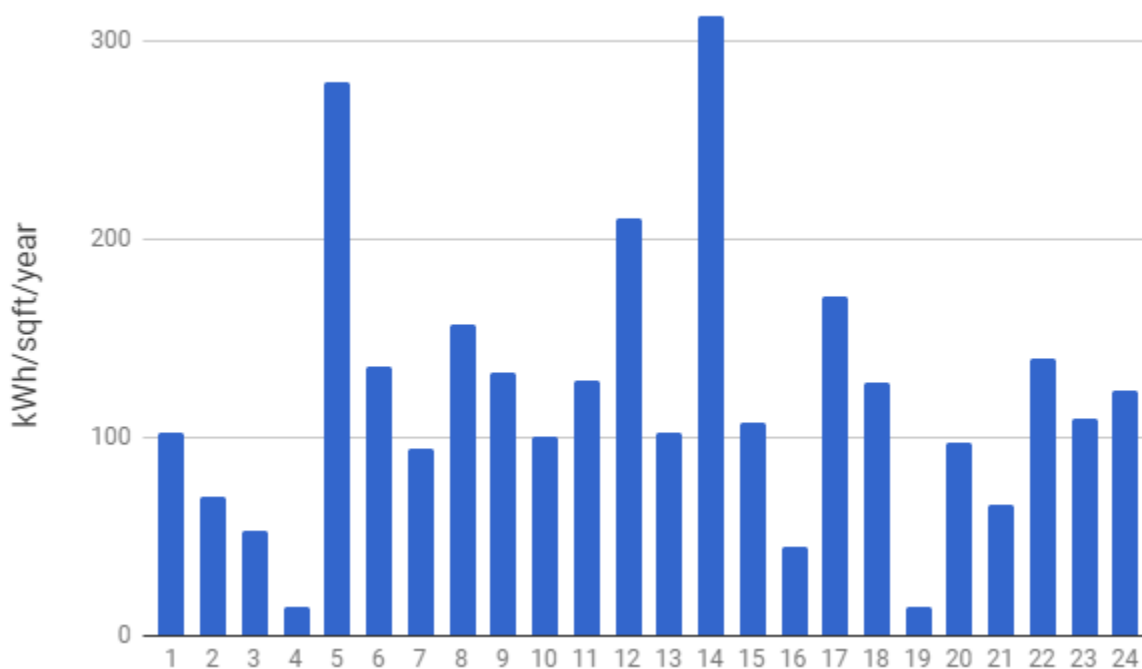


Figure 8 City of Boulder sites kWh/sqft/year

Portfolio aggregation for coincident peak load, total energy, seasonality, etc.

The annual aggregate peak demand of in 2017 was 2.2 Megawatts (Figure 9). Note that this was calculated as a stack of the largest 15-min average power interval across sites. To discern the true “coincident peak” on the grid will require a joining of data tables by time stamp, which is not complete at this time.

This interval data is publicly available via the BCEIOF web page:

<https://www.bouldercounty.org/environment/sustainability/marijuana-offset-fund/>

The largest greenhouse (tallest curve in Figure 10) is counter-cyclical, with its lowest electrical consumption in the summer. Electrical consumption at that site increases in the winter presumably due to supplemental lighting to maintain 12-hour bloom cycles and air handling for heating. The smaller greenhouse does not exhibit an annual cycle.

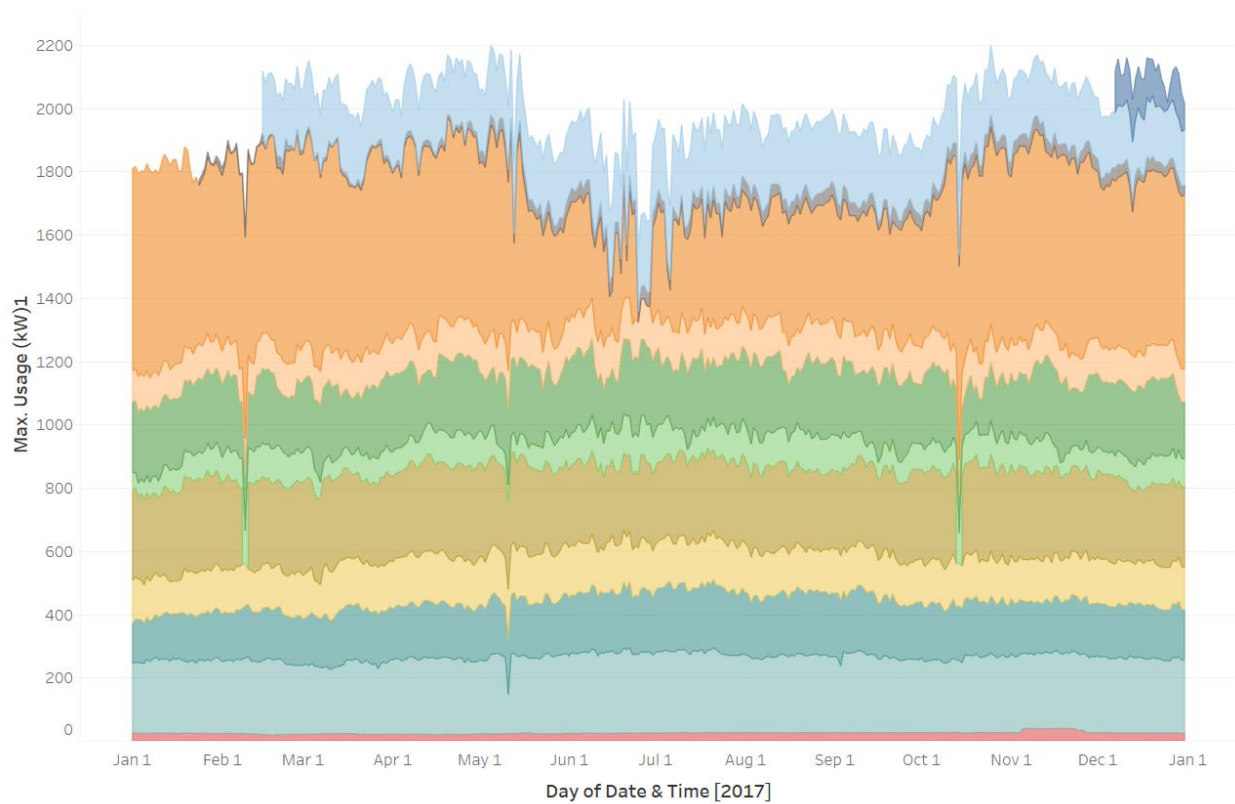


Figure 9 Aggregate Peak kW for all 12 facilities (highest 15-min interval on each day)

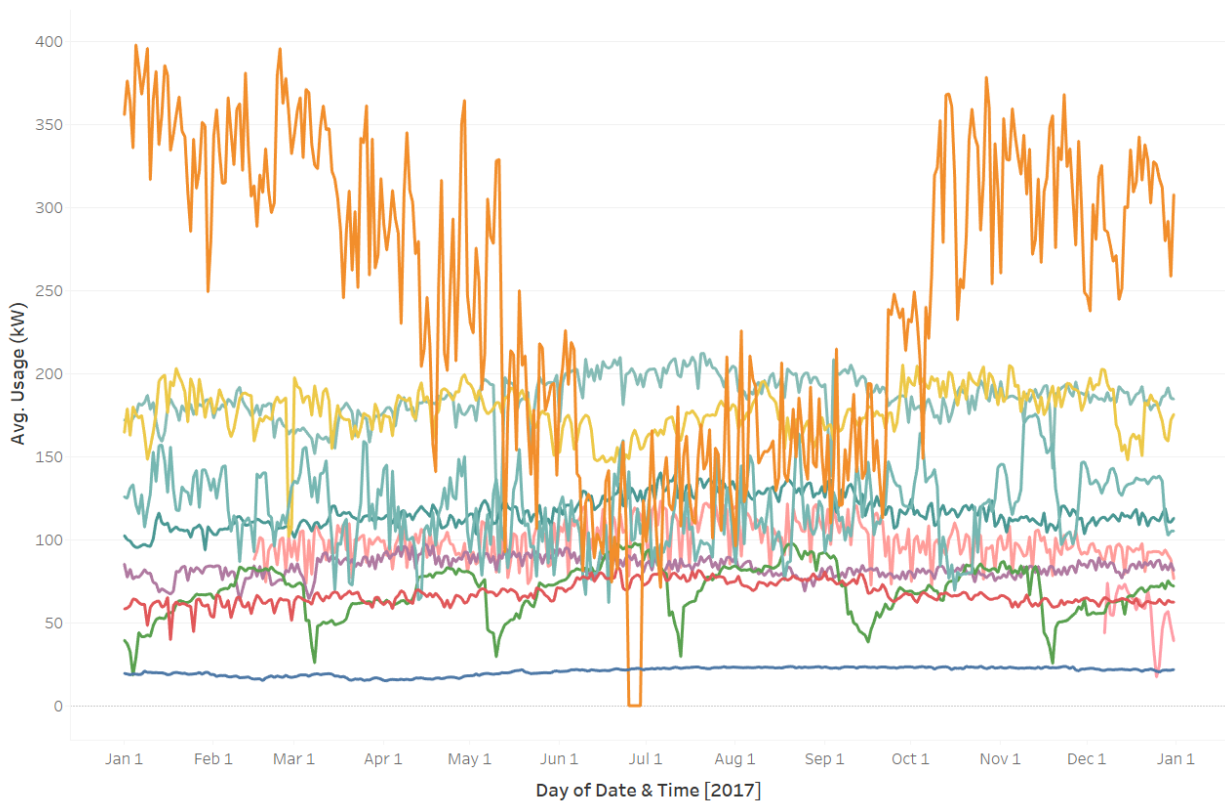


Figure 10 Average kW over daily intervals for all 10 sites

Removing the greenhouses to create Figure 11, the majority of sites exhibit their highest consumption in late summer AC season (normal seasonal cycle). Figure 12 shows the correlation of daily energy use to outdoor air temperature (normal seasonal cycle).

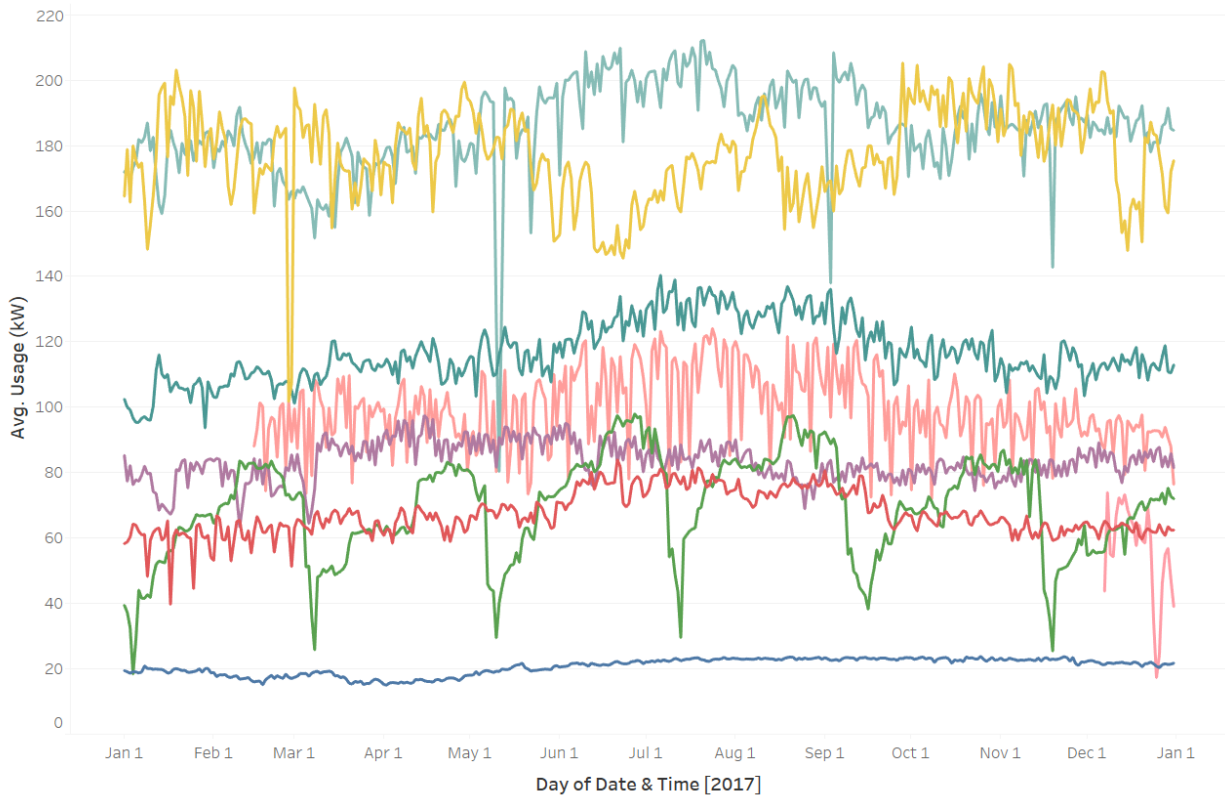


Figure 11 Average kW over daily intervals for 8 sites (excluding greenhouses)

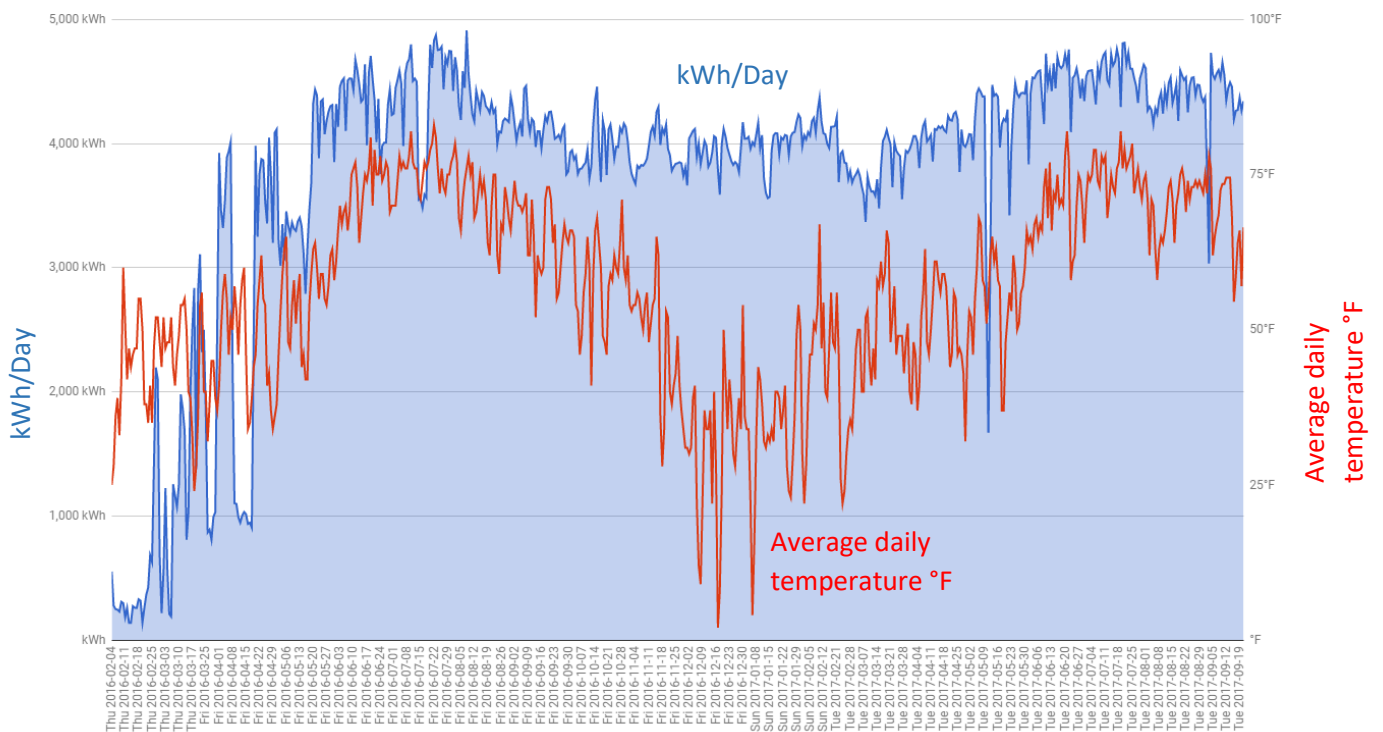


Figure 12 Correlation of annual energy use to outdoor air temperature (kWh/day in blue, average daily temperature °F in red)

Their peak loads are even more prominent in Figure 13, but this data also shows variations in facility utilization, schedule changes, and anomalous events. The tallest curve in this grouping relies on electric heat. Their consumption is therefore slightly counter-cyclical.

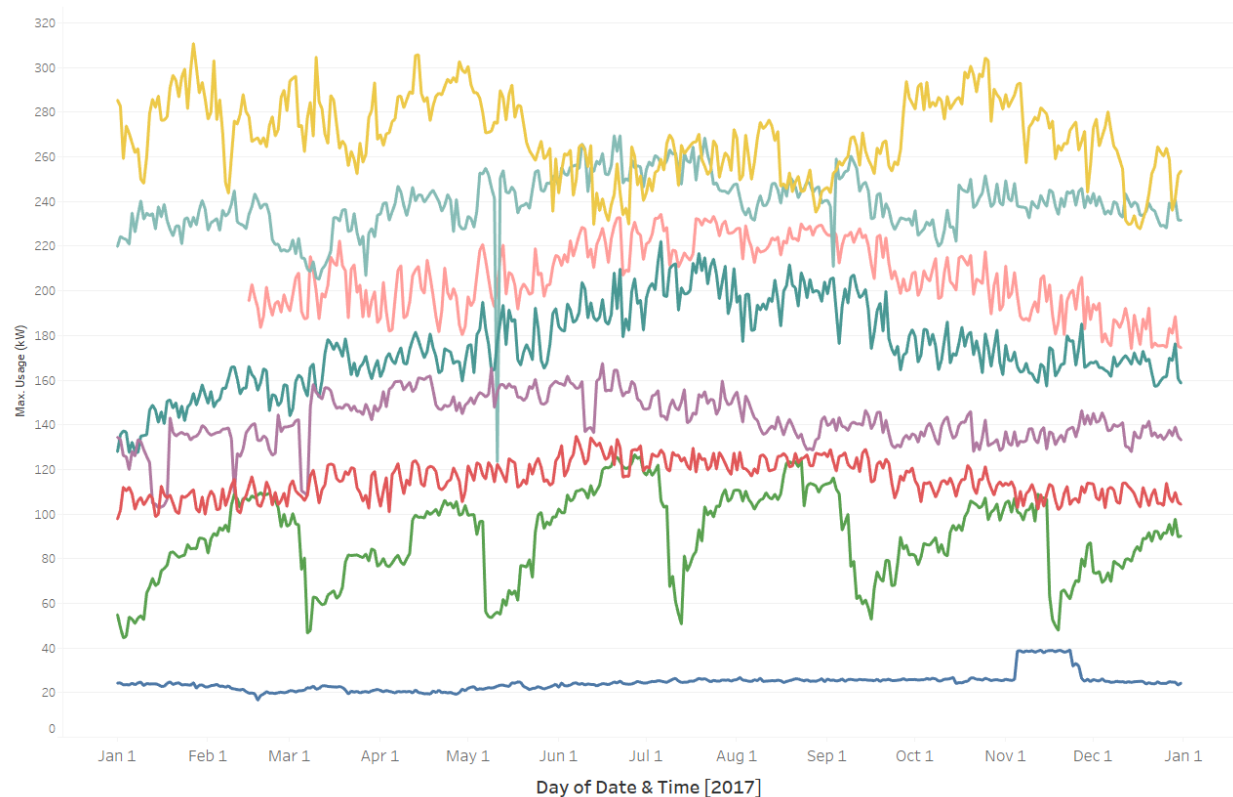


Figure 13 Peak kW each day over 15-minute intervals for 8 sites (excluding greenhouses)

Grouping the indoor grows that share a utility company meter and have their costs allocated by square footage (Figure 14), three of them show regular annual cycles and one is counter cyclical due to electric heat.

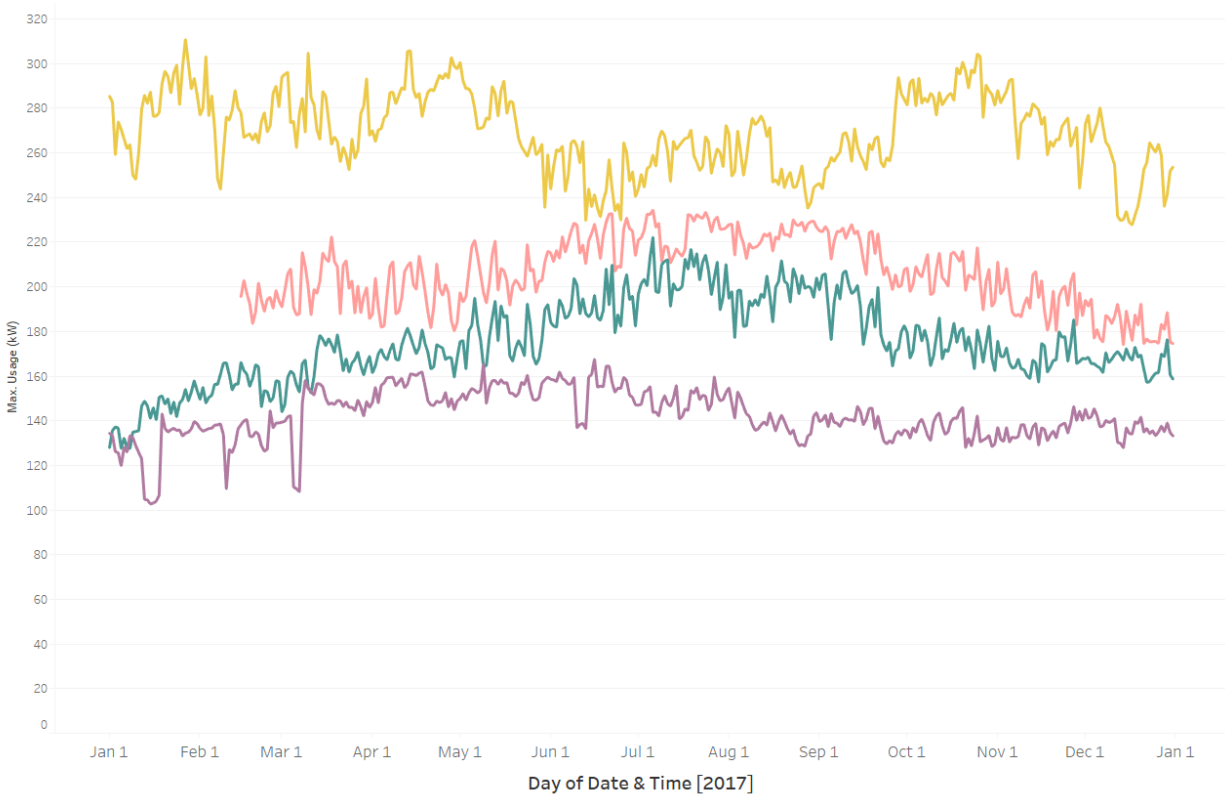


Figure 14 Peak kW on a daily basis behind shared utility company meter

Aggregating those peaks shows an annual peak of 895.1 kW on June 9th, 2017 (Figure 15). This is consistent with some sample Xcel bills from that shared utility company meter from that summer that show overall site peak load in excess of a megawatt, but include non-cannabis facilities that share the same utility company meter.

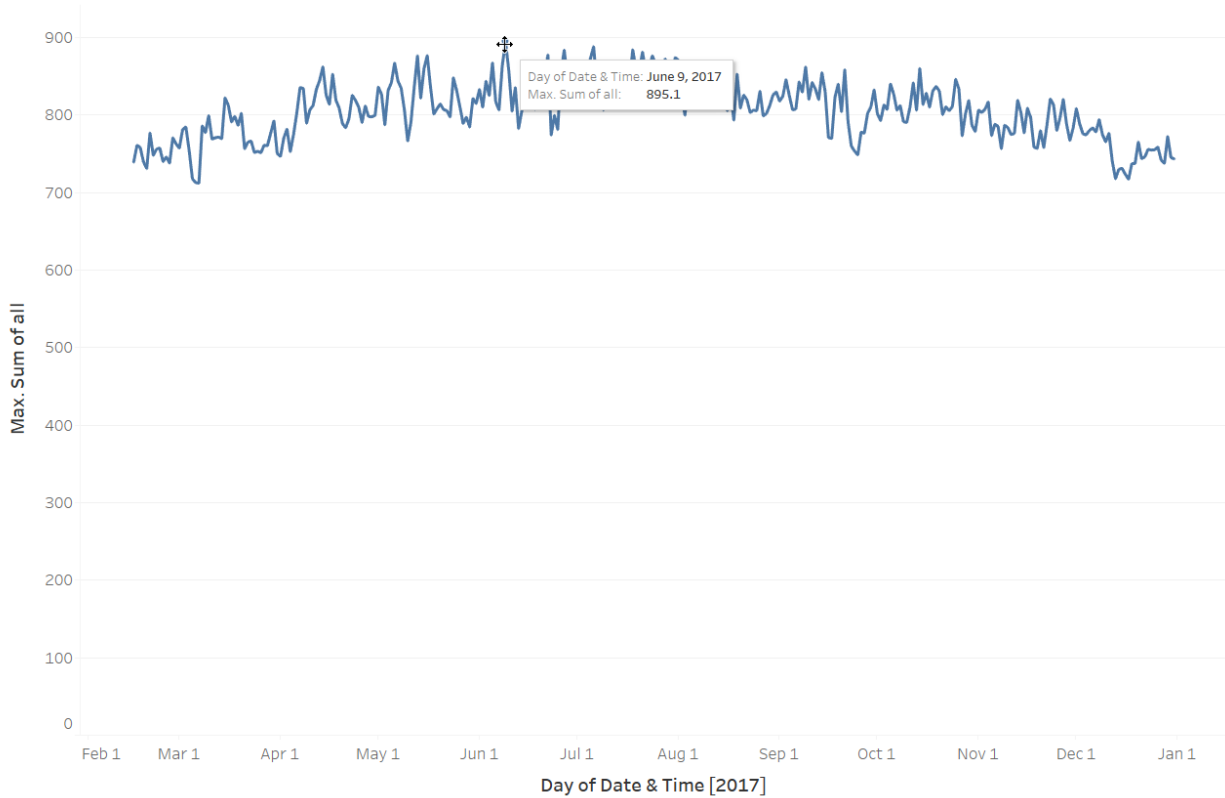


Figure 15 Aggregate Coincident Peak kW on a daily basis behind shared utility company meter

There is little to no bloom light schedule stagger within or even between these five facilities behind a shared utility company meter (Figure 16). This leads to the highest feasible daily and annual peak (Figure 17). The demand charge reduction potential across these facilities exceeds anything they could achieve individually, but the loss of a direct demand charge price signal to any one, disincentivizes any facility to act alone.

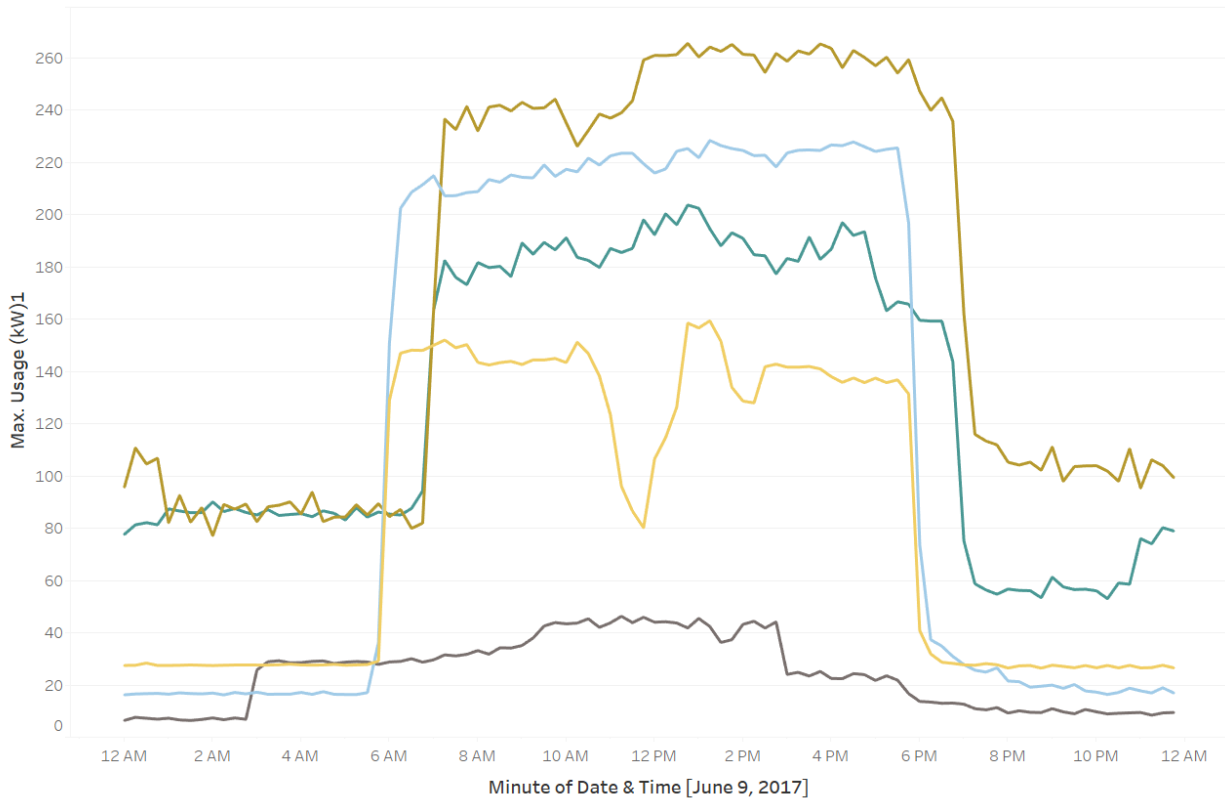


Figure 16 15-Minute load profiles for sites with shared utility company meter on peak day for 2017

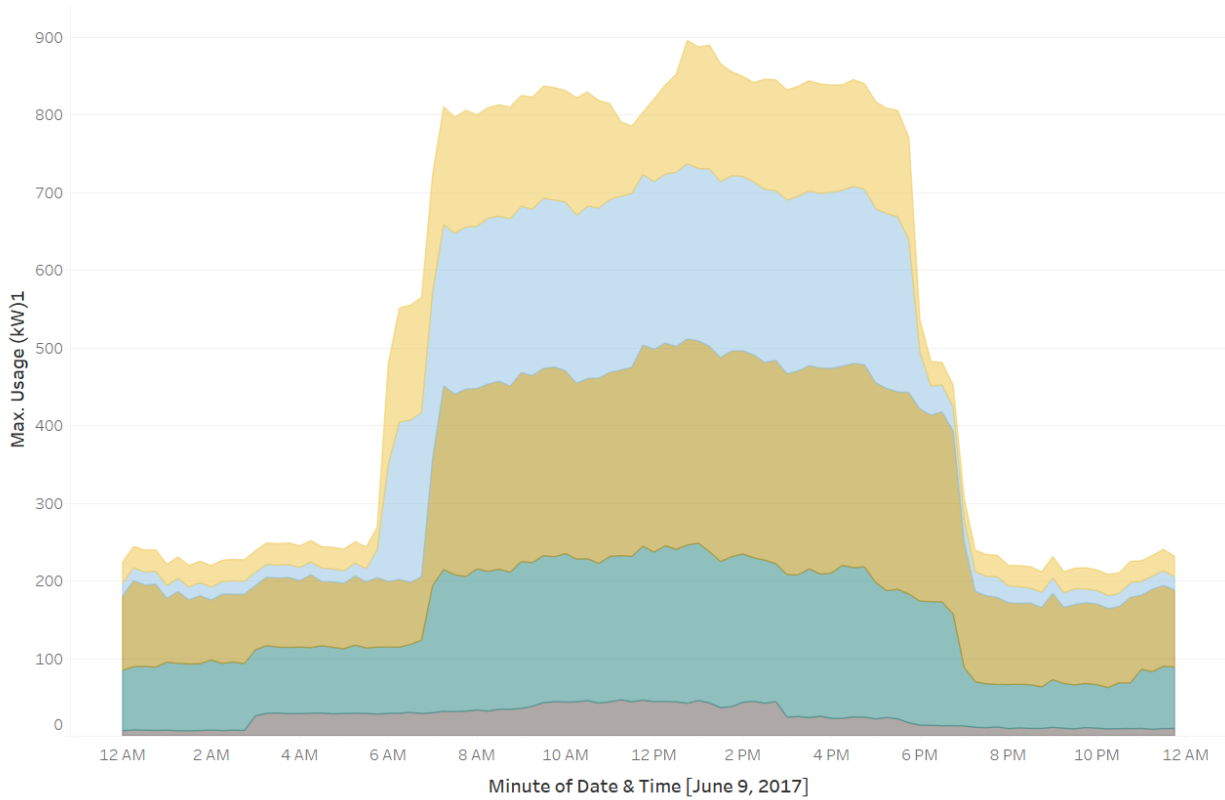


Figure 17 Aggregate 15-Minute load profile for sites behind shared utility company meter on peak day for 2017

Disaggregation of lighting, HVAC, etc. by circuit (when available) and via season when operations are regular

A number of facilities do not have central feeders and the power comes in via multiple external transformers. The layout of these facilities dictated that individual circuits be monitored and aggregated for capture of total facility consumption. In one instance, those circuits were segregated in a way that allows for isolation of HVAC and Lighting loads (Figure 18). This shows that on an annual basis, lighting comprised at most 78% of consumption and HVAC (including dehumidification) comprised at least 22%. This is consistent with a circuit-level analysis of a bloom room that we performed for a private client in 2015 (facility in the City of Boulder that is not part of BCEIOF). It is also consistent with a facility-level model for an August 2014 day that was also verified with facility-level eGauge data.

For sake of focus in our next phase of study, we contend that this estimate for the percentage of total facility electrical energy consumed in lighting energy is sufficiently representative of conventional indoor facilities in this region with natural gas heat. However, one reviewer of this study and other energy experts interpret an earlier 2012 study by Evan Mills¹ as an indication of much higher proportions of electrical energy being consumed in HVAC and dehumidification. We contacted Mills regarding these differences. His study was not based on this climate region. It was also based on modeling of “*smaller-scale residential-type grow operations for ‘average’ climates*”, but “*validated with measured data*”⁷. The proportions of end use in Mills’ paper is also expressed in terms of unit weight of emissions per unit weight of produced cannabis, includes natural gas, makes conversions of source to site energy, and included transportation fuels. Our current study is wholly on a basis of electricity consumed on site, as measured coming from utility meters (site energy for only electricity and without regard to production data).

Applying this ratio to all indoor grows and mixed-use facilities and leaving greenhouse end use consumption with an unknown disaggregation, this leads to the end use consumption estimate in Figure 21. Electric heat has been disaggregated by applying the average intensity of indoor facilities with natural gas heat to those with electric heat by floor area, with the difference in usage assumed to be electric heat.

We don’t have a sufficient basis for disaggregating of electrical energy in the two greenhouses at this time. We have not visited these sites or had any substantive communication with those operators. They are both counter-cyclical to the indoor grows, consuming considerably more electricity in the winter than during summer AC season for the indoor grows. During the winter, the greenhouse daily load curves appear to be dominated by the durations and rectangular load curves that are characteristic of lighting cycles. This would make sense to maintain 12-hour boom cycles and 18-hour vegetative cycles during times of year where daylight is limited. The greenhouses do not exhibit high overnight loads in the winter when air handling from natural gas or propane heating may be considerable. Summer load profile are less regular and we don’t know whether evaporative or mechanical cooling is employed, or what thermal limits are maintained. For these reasons we have listed all greenhouse electricity with an “unknown” end use in Figure 21.

Our recommendation is that more circuit-level monitoring be performed and combined with facility schedules to better understand end uses if the County wants more precise information for policy making.

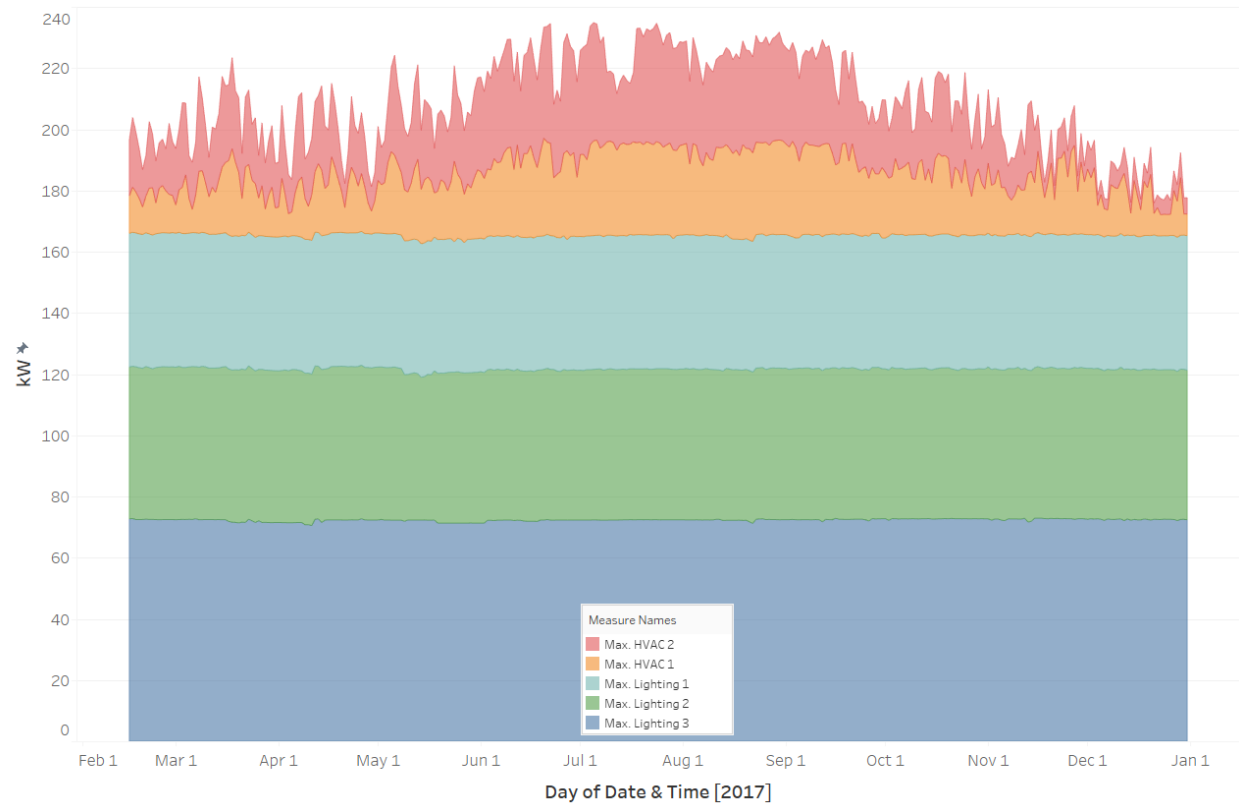


Figure 18 Circuit-level monitoring for one facility on Lighting and HVAC (red and orange) loads (all graphs forced to same power scale)

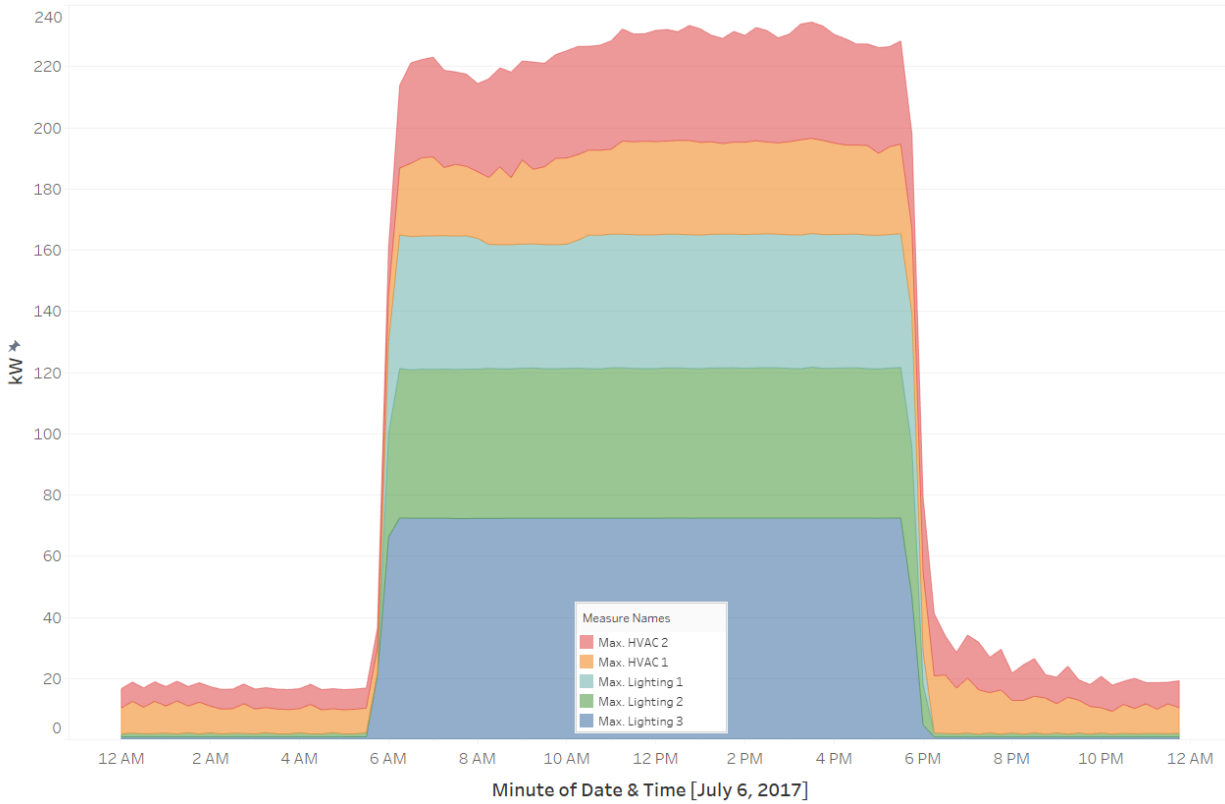


Figure 19 Annual peak day for one facility, Lighting and HVAC (red and orange) loads (all graphs forced to same power scale)

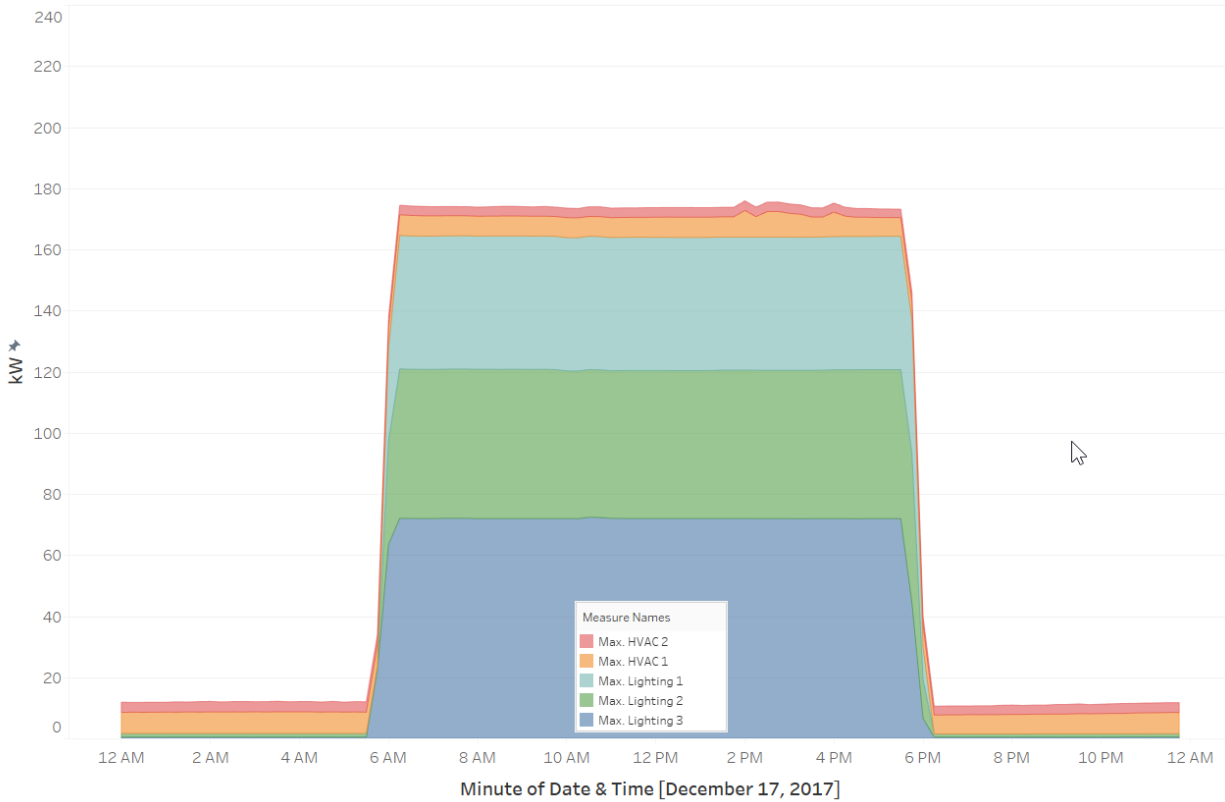


Figure 20 Winter minimum day for one facility, Lighting and HVAC (red and orange) loads (all graphs forced to same power scale)

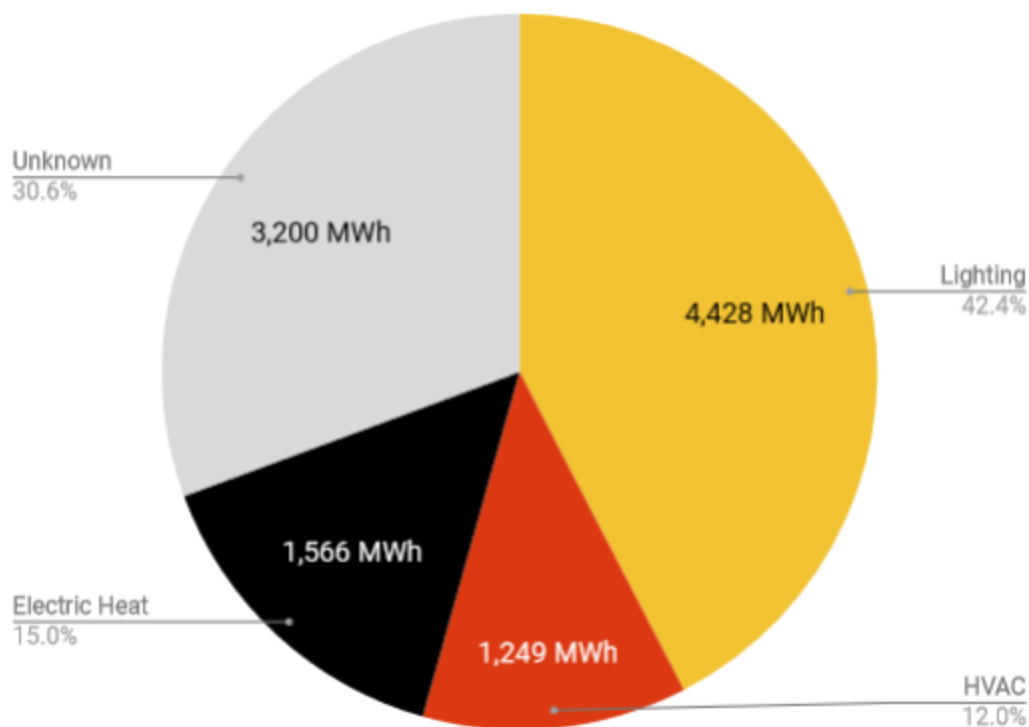


Figure 21 Collective end use of energy consumption by application for facilities (MWh/year)

Xcel rate structure applied to eGauge data

Looking at the fragmentary collection of bills we have across sites, we see blended rates (total billing/kWh, demand charge spread across kWh) between \$0.080 and \$0.097/kWh for load factors ranging between 50% and 61%. For the rest of this analysis, an average blended rate of \$0.090/kWh will be assumed.

These bills are under Primary General (PG) rates for the foothills sites and Secondary General (SG) rates for all other sites. PG rates are slightly lower. In Figure 22, actual blended rates from 2015 and 2017 are scatter plotted in blue dots and a simplified PG rate model is plotted as a orange dotted line. Cube Resources has worked with some local growers to schedule for lower peak loads and load factors in the 90%+ range. Under PG rates, such a load factor would drop blended costs to \$0.067/kWh

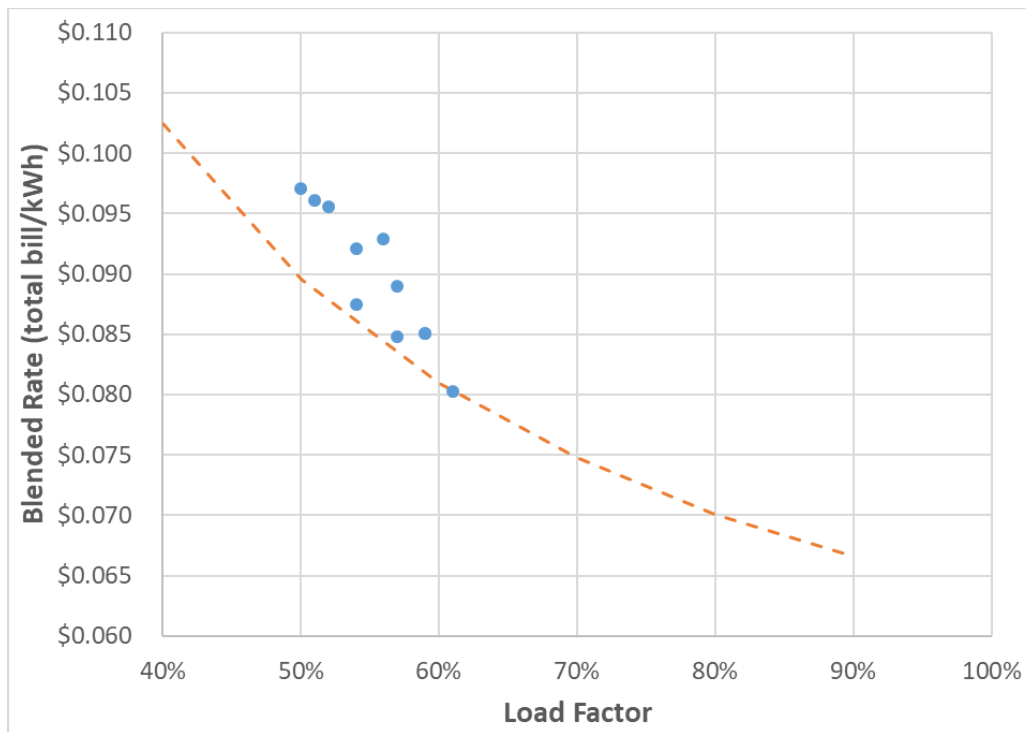


Figure 22 Relationship between blended rates and load factors

One of the smaller facilities in this portfolio staggered their scheduling based on eGauge data and advising. Over 2017 they have averaged an 85% load factor, with their best load factor at 93%. Figure 23 shows the variation of average daily load factor by site in 2017. It should be noted that a high load factor due to optimal scheduling provides a cost savings, while a high load factor due to excessively high baseload reduces blended rates for high consumption. The latter is not necessarily a good thing and can occur due to electric heat at night, 24-7 vegetative lighting cycles, and other high consumption practices.

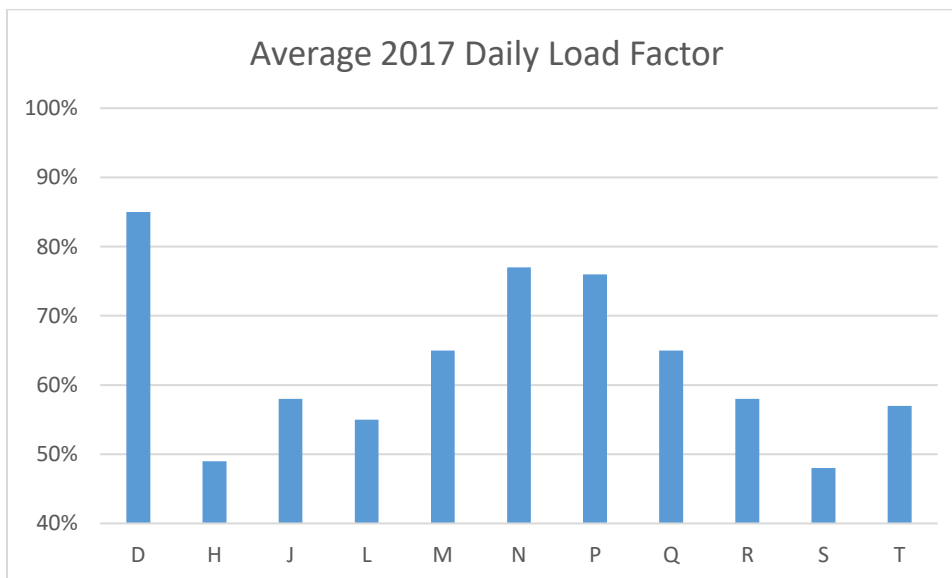


Figure 23 Average 2017 Daily Load Factor by site

Trending of load profile stats to look for changes in operating strategies

Long term trends show increasing kWh/day intensities across almost all sites (Figure 24). This is due to increased utilization and more consistent operation. There is only one site with enough historical data (over 3 years) to show stabilized operations across annual outdoor temperature cycles (Figure 25).

Load factors have improved dramatically in the one small site referenced in the section on rates structures, but trend data prior to that change was lost when their electrical contractor mistakenly tore out the original eGauge during facility expansion. The replacement eGauge then suffered a hardware failure, so the current device only has a record of current schedules in a newly expanded facility.

Other growers have been somewhat disinterested in rate optimization via scheduling. In one case this was due to discussions with the facility manager, as opposed to the owner. The former having to implement a more complex staffing schedule while the latter would reap the savings (a type of split incentive problem). Others have cited increased labor costs from schedule changes for their disinterest. Other growers are focused on competing priorities for their attention, such as labor costs, compliance issues, labor shortages, etc.

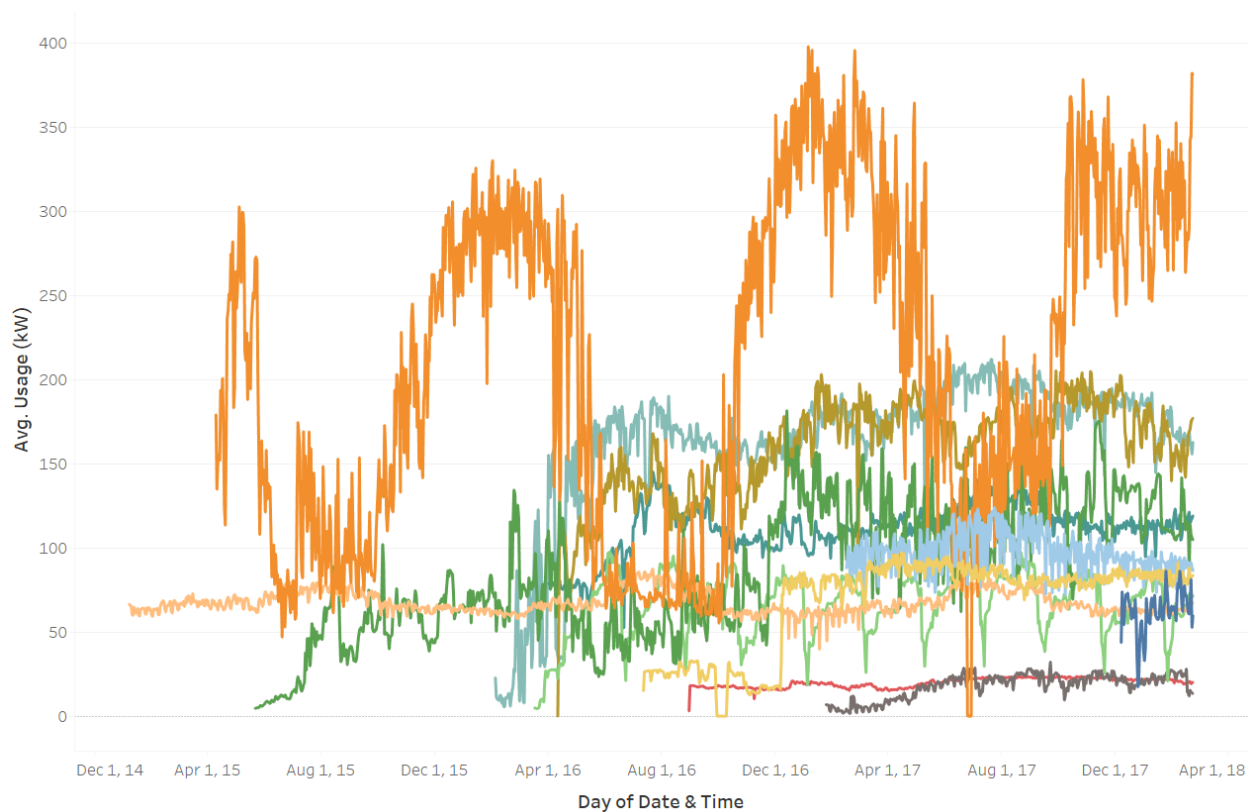


Figure 24 Long term upward trends in kWh/day

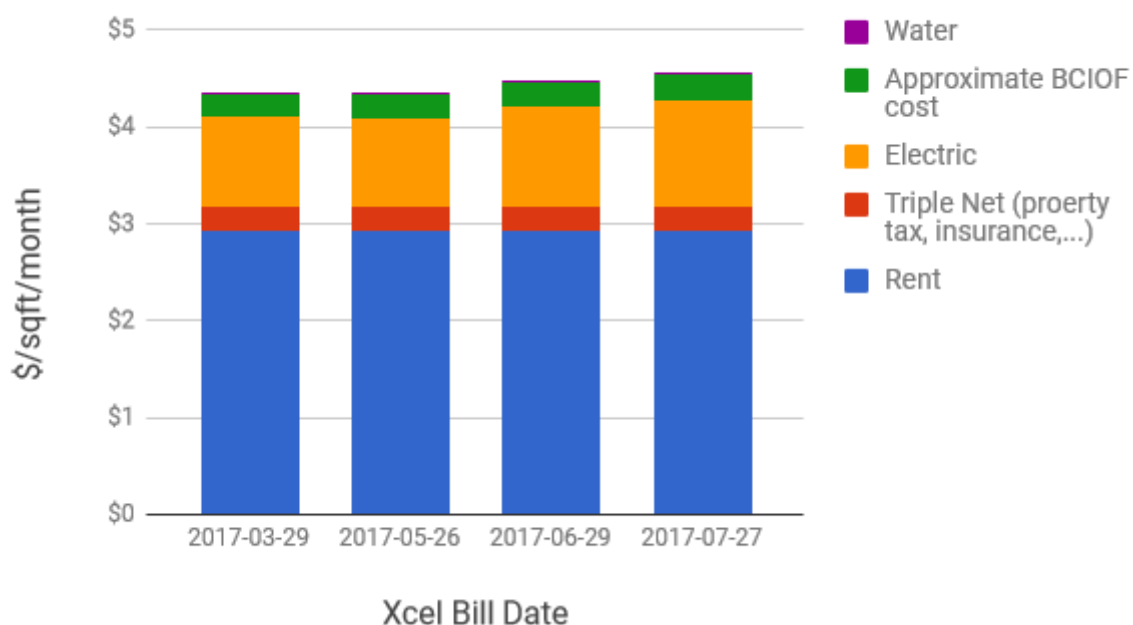


Figure 25 Long term stability in kWh/day

Estimation of other costs (labor, rent, build-out)

One grower provided full pass-through billing for four months in 2017. These are scaled with BCEIOF added in Figure 26. In this case rent clearly dominated facility costs and this was one of the most energy intensive growers. We do not have data on labor costs which are likely to also be substantial. This limited data implies that while energy costs may be high, other costs can overwhelm those in net cost of delivered product, thus disincentivizing energy efficiency improvements.

Recurring Facility Costs



Market failures

There are a number of market failures that hinder peak load and total energy reductions in these facilities.

- Lack of trust: market share, productivity over efficiency, and secrecy
- Conflicting policy goals
- Dominance of other costs
- The classical split incentive problem of capital investment in rented facilities and internal split incentives between staff and owners
- Imperfect cost information and tools for energy and cost tracking
- Payback periods vs. market uncertainty, Risk, Financing, and Cash Flow
- Refusal of banks to loan to the cannabis industry and related contracts
- Poor adoption rates for utility company incentives
- Lack of support from national labs and standards organizations.
- Lack of skilled, reliable contractors
- Loss of price signals from demand and energy charges

Lack of trust: market share, productivity over efficiency, and secrecy

The race to dominate market share has a number of negative consequences to efficiency. Growers have clearly valued overall productivity over efficiency (Figure 27), or energy productivity. They have also raced to bring production online and optimal design usually suffers with such haste. With the growers seeing each other as competitors, secrecy has trumped information sharing. These same effects were endemic in the early days of the craft brewing industry until those brewers realized they were taking market share away from mass market brewers more than competing among each other. Craft brewers have grown to share information amongst each other and see such cooperation as mutually beneficial.

The growers also have lingering privacy concerns due to the historical stigmatization of their industry and their need for security as mainly cash-only businesses with high-value finished product. Both cash and cured flower are often stored in safes on site. Many growers have stated that they are second-class corporate citizens, valued for their tax and fee contributions, but not deserving of the support that non-stigmatized industries get from government services. Some of that is more perception than fact, but the imposition of offset fees in and of itself differentiates these growers from other high energy intensity industries in the area. Using BCEIOF fees to benefit the industry that pays them may improve this perspective, but trust takes time to cultivate.

Rank your most important consideration for equipment investment decisions?

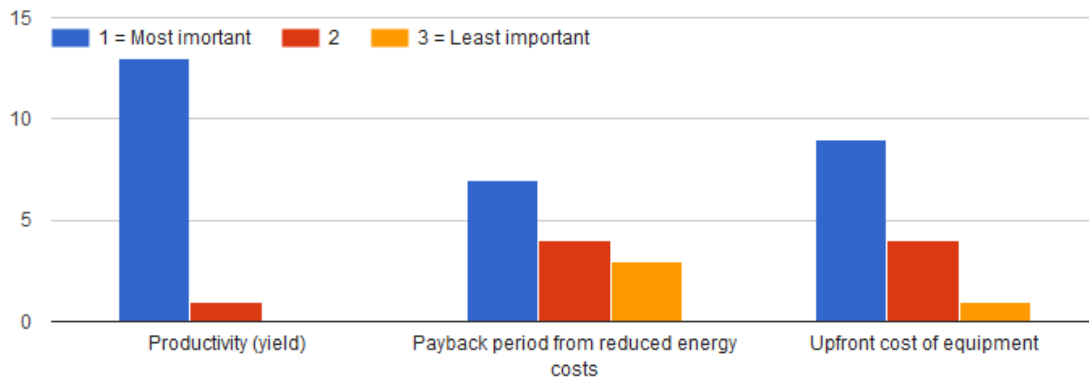


Figure 27 Productivity and upfront costs dominate equipment choices

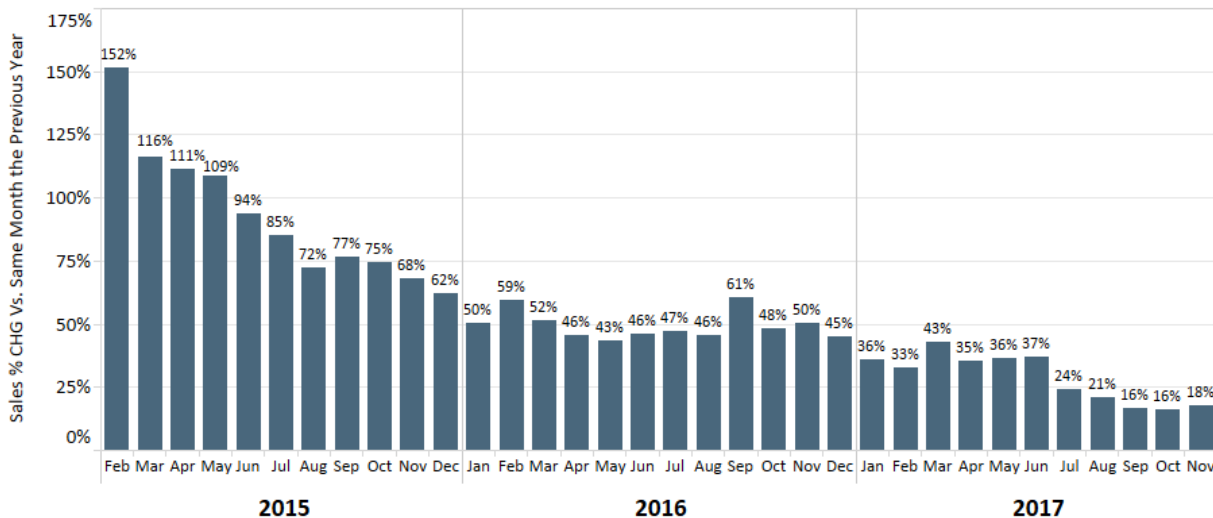
As for market expansion, that has been slowing down but is still in double digits (Figure 28). Product retail prices are declining (Figure 29). There is growing shift into extract-based products (which are less dependent on high quality flower) and some market analysts are predicting more market consolidation.

As further declines in average retail price struggle to generate sufficient increased demand, we should see prices even out. Should prices fall much further, we are likely to see reduction in the flower category, which would lead to attrition and consolidation among cultivators and perhaps even dispensaries.⁸

Department of Revenue statistics show what may be a market top at the end of 2017.⁹

These market pressures will squeeze margins and may make energy efficiency more attractive. They can also lead to caution regarding capital investment.

**Colorado Recreational Marijuana Market:
Retail Sales Percent Change Vs. Same Month the Previous Year**



Source: Colorado Department of Revenue
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Figure 28 Year on year change in recreational sales, Marijuana Business Daily¹⁰

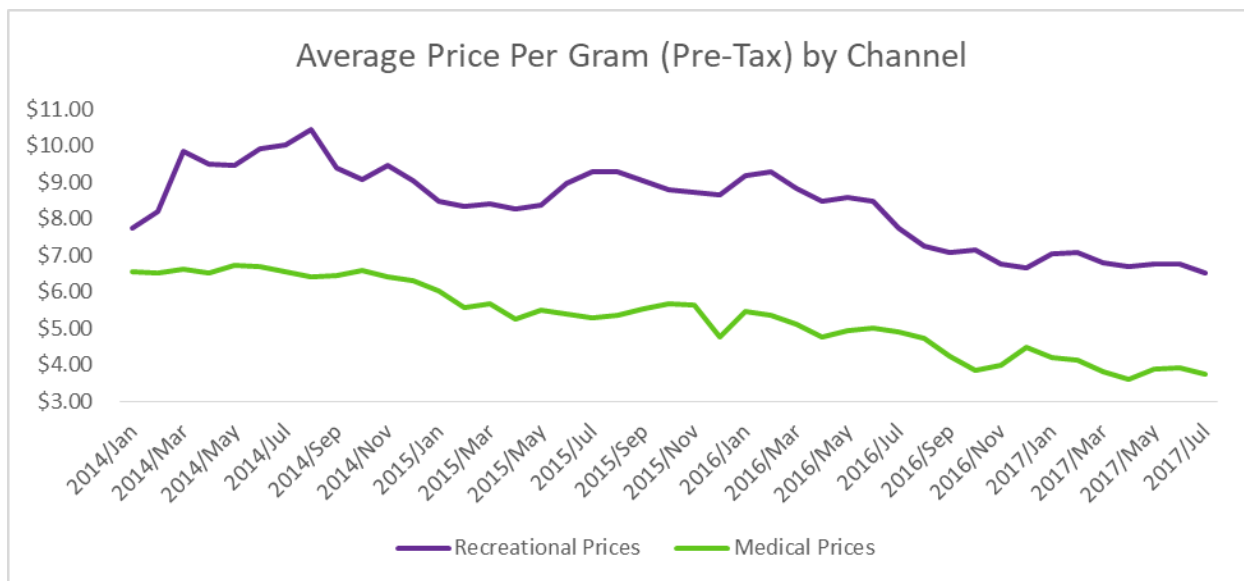


Figure 29 Average price per gram, BDS Analytics¹¹

Marijuana Sales

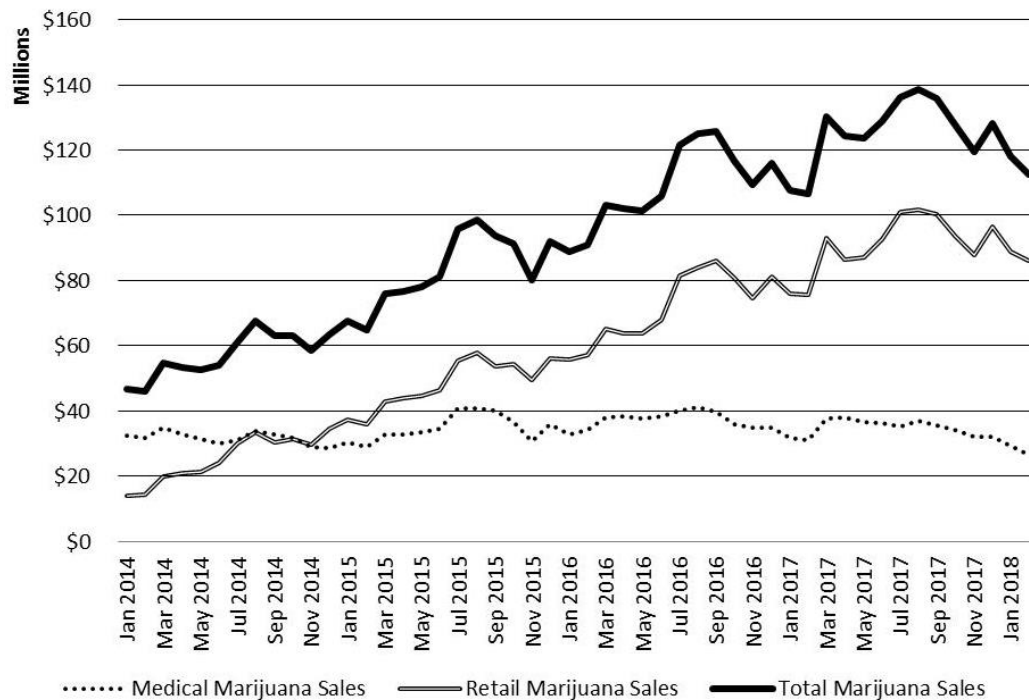


Figure 30 Marijuana Sales Reports | Department of Revenue

We must also note that there are indications that more cultivation product has been moving into extraction for Marijuana Infused Products (MIPs)¹². Some of this activity is occurring within Boulder County, but substantially more is occurring with outdoor cultivation, particularly in large operations in the Pueblo area. With research advances in specific cannabinoid efficacy and extraction/recombination technologies, this trend may persist and the more energy-intensive strain purity that indoor cultivators charge a premium for *may* lose value in the market.

Conflicting policy goals

Upon legalization, seed to sale tracking and security concerns kept this industry indoors. Sensibly, an agricultural product would have moved into greenhouses and even outdoors at that time, but these more liberal interpretations of security considerations took some time. Boulder County has also limited cannabis production to commercial / industrial zoning and discouraged the construction of greenhouses on land zoned agricultural.

Odor control requirements pose risk to both indoor facilities and greenhouses, not to mention outdoor grows. The proximity of neighbors and the subjectivity of these rules place odor above energy concerns in regulatory compliance. Evaporative cooling in greenhouses and extensive use of purge ventilation in indoor grows are efficiency tactics that make sense for reducing electricity consumption, but growers will not take full advantage of them if odor complaints force them to stop operating. This has been a concern locally and in other areas of the state¹³, leading to fines and political opposition.

Boulder County regulation states:

Article 8.5 b)¹⁴

Odor Control. Odors should not escape the property line. If any complaints are received, licensees will work with Public Health to rectify air quality concerns. Unresolved air quality complaints may be basis for action on the license pursuant to Article 13 of these Regulations.

City of Boulder regulation states:

6-16-8(h)¹⁵

Ventilation Required. A recreational marijuana business shall be ventilated so that the odor of marijuana cannot be detected by a person with a normal sense of smell at the exterior of the recreational marijuana business or at any adjoining use or property.

Policy has distorted the real estate market

Due to the rapid growth of this industry, initial intents to keep cultivation indoors, limited warehouse space, land use restrictions, and banking restrictions, new floor area is limited and rents are very high for indoor facilities. Figure 26 illustrates this for one renter. A constrained building market pushes up building ownership or rental costs to the point that renters are much less sensitive to energy waste as a bottom-line driver for business decisions.

The Denver Post noted this in a 2017 article entitled “*Marijuana real estate: Cannabis cultivation grows to 4.2 million square feet in Denver area, but Denver’s cap on grow, retail locations has put the brakes on expansion*”¹⁶

... “Overall, more than 96 percent of the industry’s footprint is clustered within just four submarkets — Airport, Boulder and two central Denver districts that span I-25 between Interstate 76 to the north and U.S. 285 to the south, according to CBRE.

All grows are located in aging Class B and C warehouses, but tenants still pay a premium over nonmarijuana tenants. According to CBRE’s review of 25 leases signed between 2014 and 2016, the average lease rate for marijuana grows was \$14.19 per square foot — two to three times higher than the overall average rate in the top four cultivation submarkets.”...

In 2015, the Marijuana Business Daily was citing even higher rental rates¹⁷, but this was a quotation from a broker who was marketing new greenhouse space being built in Walsenburg Colorado¹⁸.

...“rates for premium warehouse space in the Denver metro area, which is typically about \$15-\$25 per square foot.”

In 2016 Inc. Magazine has provocatively speculated that in Colorado “*The Marijuana Business Is Really the Real Estate Business*”¹⁹.

“It’s the green boom here in Colorado and real estate is at a premium,”

“If you own a building that is zoned properly, not including any improvements, it’s worth millions.”

Sally Vander Veer, co-founder and CFO of Medicine Man

Split incentives

The seller’s market for suitable cultivation space exacerbates the split incentives between landlords and tenants. These are classically defined as capital costs being born by landlords while efficiency benefits go to utility account holders, but they can occur when the person that needs to take action is not the beneficiary of that action. 9 of the facilities were rented in 2017. The 5 behind a shared utility company meter have a difficult relationship with their landlord and have trouble coordinating their actions for collective benefit. We do not know the lease terms in any of these sites, but improvements are often

done at tenant expense. That said, some of the sites behind the shared utility company meter were owner-occupied grow facilities before they became rentals. Mechanical improvements at these facilities may therefore be incorporated in higher rental costs.

In other instances, landlords have not afforded growers the professional courtesy they should deserve as leaseholders. One anecdotal example is a landlord within the City of Boulder that refused to submit a sales tax exemption request for purchased electricity and natural gas. In 2016, Cube represented one of their tenants, who is one of five growers behind a shared meter. The Colorado Department of Revenue allows growers to claim a sales tax exemption on these utilities, just as it does for manufactures and agricultural operations. Xcel Energy will honor these exemptions and stop collecting the tax, but the exemption must be signed by the account holder. In this case that account holder was the landlord, and that landlord refused to sign pre-prepared paperwork for this purpose. This denied their tenants as much as a 5% savings on their electricity and natural gas costs (thousands of dollars a year). Such refusals stem from the stigmatization of association with this industry, the lack of financial impact on the landlord, and the seller's market for rental warehouse space described in another section of this report. Note that only two of these five growers were responsive regarding cooperation for the reduction of demand charges, which is an example of lack of trust between competitors ("tragedy of the commons" noted earlier). It should also be noted that few Xcel representatives are aware of this tax exemption, while they are broadly aware of the same exemption for other industries.

Loss of price signals

In the case of the five facilities that share a common utility company meter and have their electricity costs passed through on a per square foot basis, cost savings from reductions in peak load or total energy use are spread across all tenants. For example, if facility Q occupies 21% of the floor area of the combined rented space for facilities (Q, M, S, R, and T), only 21% of any dollar they saved would be returned in their pass-through billing. 79% of the savings would be returned to the other four tenants. This effect is more pronounced for the tenants with lower ratios of the total floor area and illustrated in Figure 31. There is also some indeterminant loss of price signal depicted from landlord-tenant split incentives.

Meanwhile, due to the sub-metered structure of interval data collection for BCEIOF fee collection, the entire price signal of that fee reaches each grower proportional to their total energy consumption and therefore becomes as strong or even a stronger price signal than their utility rates.

Note that in instances where landlords do submeter, some pass-through a blended rate (total bill / kWh for all tenants * sub-metered kWh for tenant). This does not exist for facilities currently within BCEIOF, but it did occur among the facilities that were annexed into the City of Boulder in the fall of 2016.

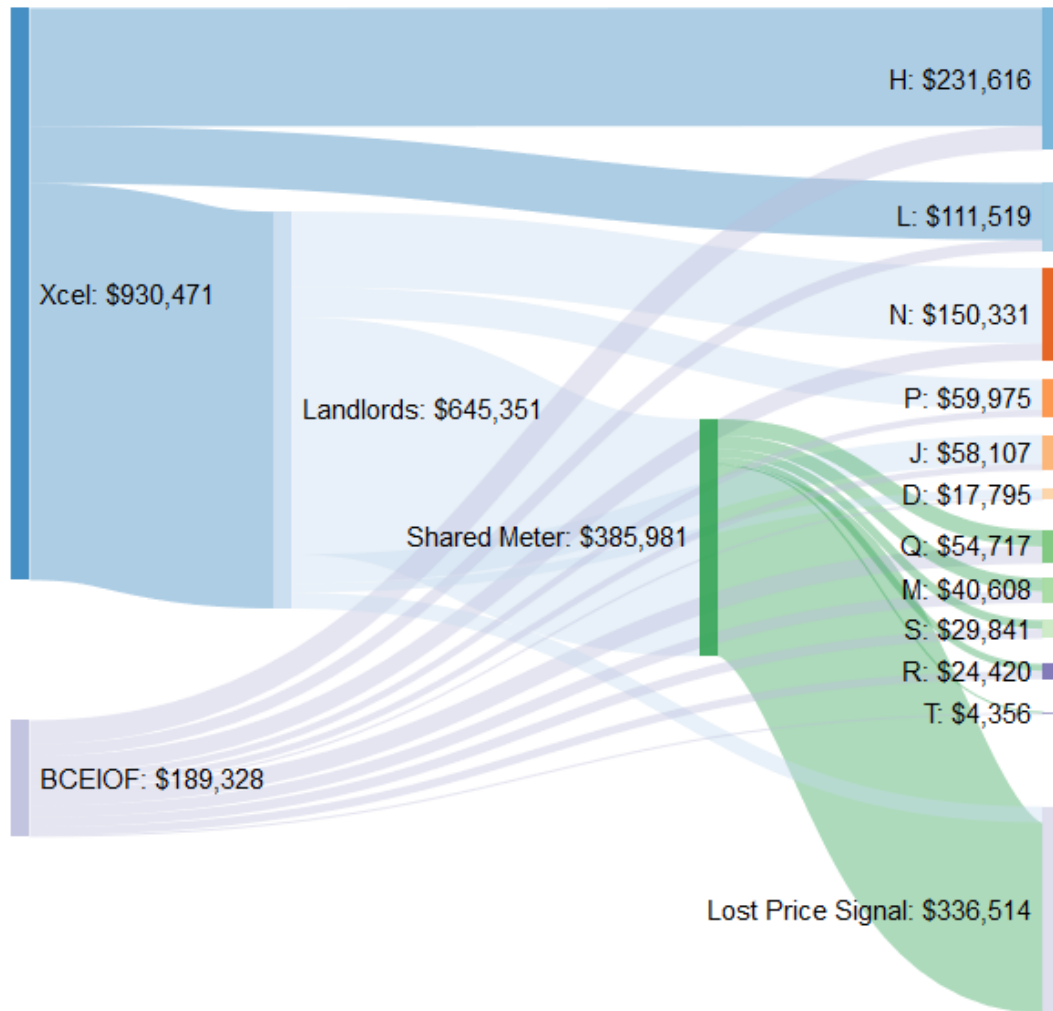


Figure 31 Source and loss of price signals

Imperfect cost information and tools

We have given two briefings to growers in this program. There has generally been a poor understanding of Xcel's demand rate structures by growers during these presentations and energy information data management tactics seem to vary substantially.

There have been a couple occasions where growers have questioned BCEIOF when their fee assessments rose from one quarter to another. In both instances these increases were driven by the seasonal variation of their AC or electric heat. These growers were apparently neither tracking their energy use independent of the program, nor were they cognizant of the behavior of their mechanical systems.

7 survey respondents reported that they tracked energy costs vs. yields, while 5 don't currently trend energy data but would like to. This question deserves greater scrutiny in future work, because these metrics are foundational for energy productivity improvements. We do not see substantial reductions in energy intensities via collected interval data, but perhaps yields are rising. There can also be social norming effects in these survey questions and only direct examination of practices can verify this reporting.

Energy awareness can be bolstered among BCEIOF participants by taking greater advantage of the data processing infrastructure we have already created for fee invoicing. The data tables that are used for invoicing and for some of the analysis in this report have a structure compatible with weather normalization and existing HTML templates for Cube energy dashboards (Figure 32). These dashboards also automate load profile overlays so that growers can see how energy consumption patterns vary from day to day (Figure 33). Fully deploying these dashboards and providing training for their use would provide growers with tools for process improvement and measurement & verification of energy retrofits. Cube Resources has extensive experience with energy savings from such dashboards in school districts across Colorado via the ReNew Our Schools program, which was an inspiration for the BCEIOF program design. Xcel offers energy dashboards with similar features via InfoWise (by Power TakeOff).

Adding comparisons across similar facilities within the portfolio (Figure 34) would also foster competition for best in class energy performance. This is the tactic that Opower has made exceptionally popular with utilities across the country, including Xcel.

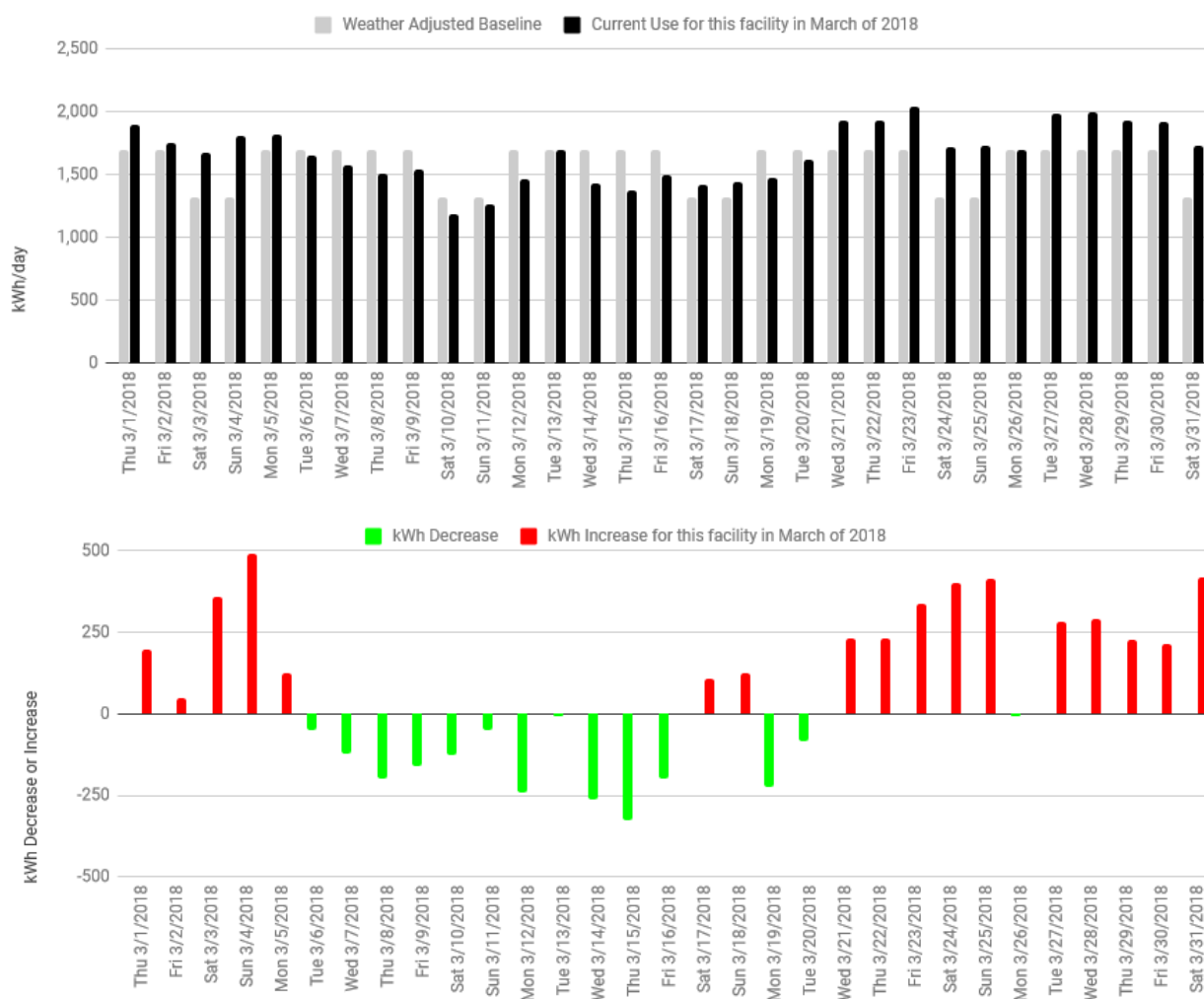


Figure 32 Daily performance vs. weather normalized baseline.

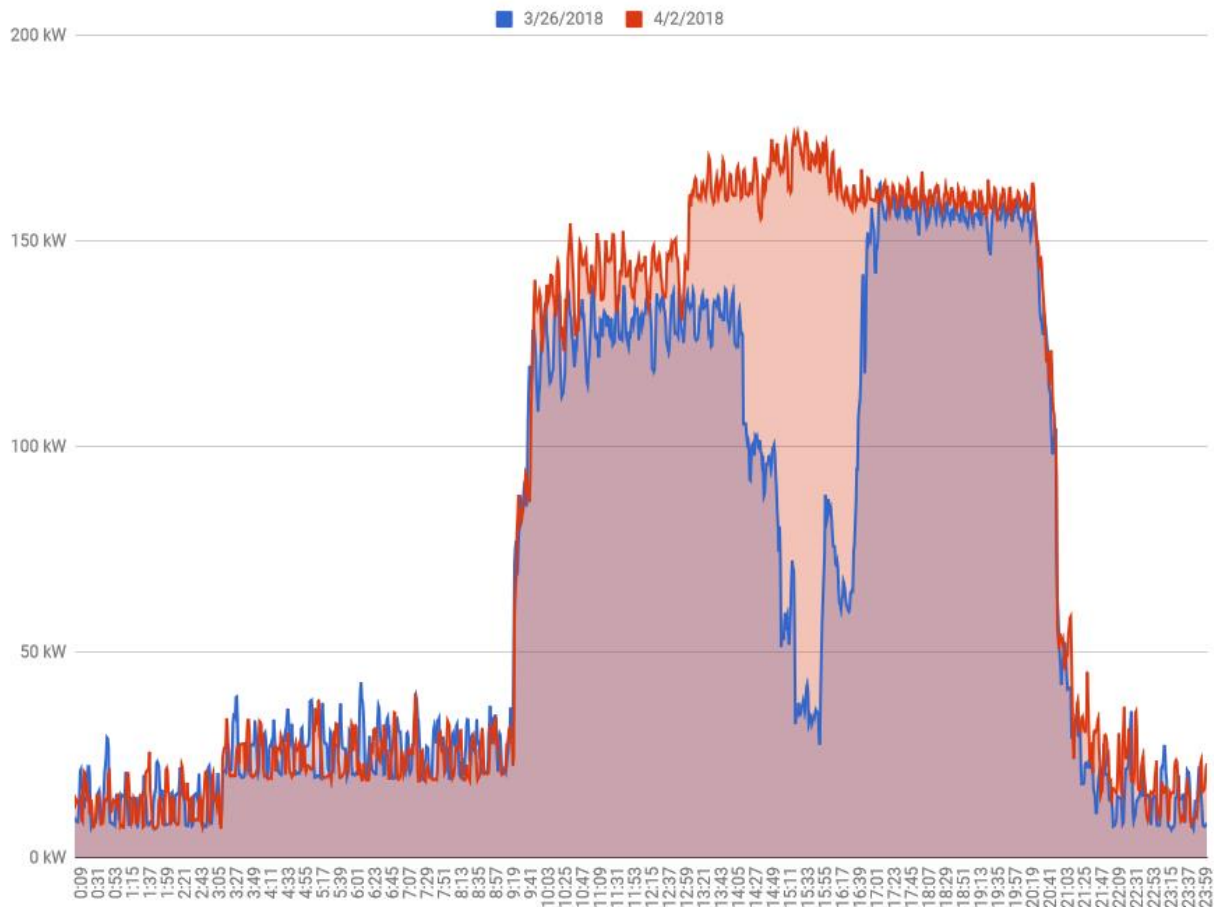


Figure 33 Dashboard-automated load profile overlays

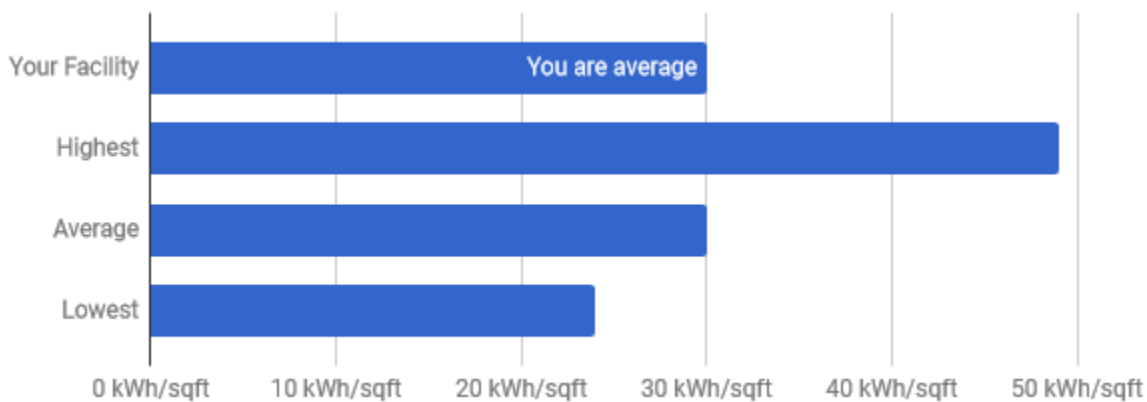


Figure 34 Example of potential intensity or energy portfolio comparison.

To these same ends, the Resource Innovation Institute has been promoting their Cannabis Power Score^{20, 21, 22}

"We've been encouraging utilities to fund a national baseline study with regional variations for two-plus years, but it is not being done," Smith told Utility Dive. "We hope they will, but in the meantime, we created this cannabis power score tool to at least begin the process of collecting much better data across states, climate and growing zones."

The tool asks growers for a wide range of information, including inputs from their utility bill, production cycles, lighting and HVAC equipment, and sales. In return, growers get a score that rates their energy use relative to similar growers, and an estimate of kWh used to produce a gram or pound of marijuana.

All of this information is necessary, Smith said, "so we can at least begin to make projections and estimates of what is the real energy impact of the energy industry, particularly as it's evolving and policies and regulations are coming into place."²³

Cube Resources has had some interactions with multiple consulting firms and an energy law firm regarding attempts to find funding for broader study and with potential intervention in the Colorado PUC docket for Demand Side Management. There is little to no industry organization to support such work collectively. Major utilities show interest in such studies but have offered little to no financial support, citing legal risk. This industry also represents substantial growth in electrical consumption while many utility business models are struggling with declining consumption.

Encouraging growers to apply for the Colorado Industrial Energy Efficiency Awards is another way we can foster information sharing and best practices in this industry. This program by the Southwest Energy Efficiency Project (SWEET) and the Colorado Energy Office (CEO)²⁴.

Payback periods vs. market uncertainty, Risk, Financing, and Cash Flow

The majority of survey respondents to our survey showed a tolerance for simple payback in the 3-5 year range (Figure 35). Tolerance for these payback periods can only be verified by tangible case studies. What is expressed as a interested in a survey doesn't always hold up when projects are proposed. It is not uncommon to wait for months on starting a project while a business owner deals with immediate emergencies.

Defining simple payback as "installed cost"/savings per year, what is the MAXIMUM payback period in years that you would accept?

14 responses

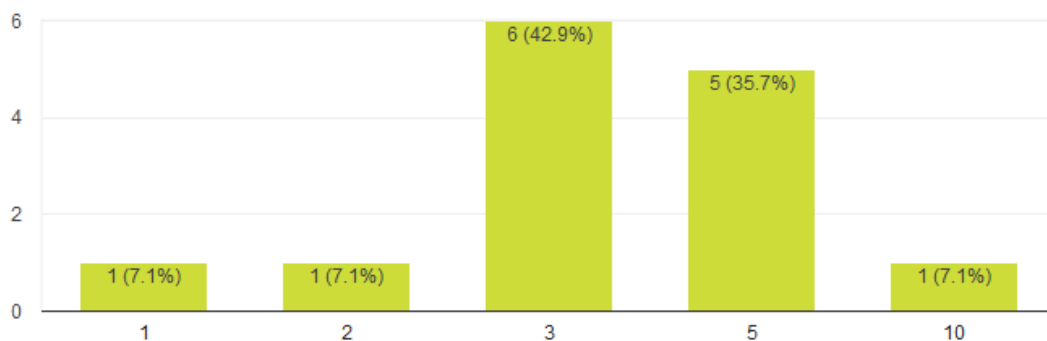


Figure 35 Acceptable payback periods

Refusal of banks to loan to the cannabis industry and related contracts

While some growers are starting to receive banking services for basic operations, they are still unbanked and rely on private investors for capital investments. Given recent uncertainty regarding federal policy toward this industry, risk tolerance has decreased. These politics are getting considerable attention in national media and that is affecting local investors²⁵. Meanwhile, legal liberalization has been proceeding at the state-level and there is little certainty as to what market consolidations will take place as larger corporate entities watch this industry.

Banking prohibitions affect commercial energy contracts. Third party solar ownership relies on capital under-writing and longer contract terms than most growers can support. These contracts are therefore not viable. Solar gardens have the similar capital behind them and will not execute contracts with growers. Even if they did, solar garden contracts have long terms, no exit clauses, and are therefore better suited to institutional clients. Commercial Property Assessed Clean Energy loans (Colorado C-PACE) also have conventional capital behind them and are also not viable for this industry.

Poor adoption rates for utility company incentives

Utilization of utility company demand side management incentives appears to be low (Figure 36) and some of those attempts have been short of expectations (Figure 37). This is not at all surprising and the industry response to our survey is probably not that different than the general finding of Partners for a Clean Environment (PACE) with the larger commercial market. Note that while multiple utility companies serve the Boulder County area, all current BCEIOF participants are in Xcel Energy electric service territory.

Xcel has made attempts to tailor DSM programs for the cannabis industry, but they have had very mixed results. Their first custom lighting rebate program was based on an energy productivity metric, but Xcel could not make sense of METRC data relative energy consumption data. Xcel then switched to a “photon efficiency” metric for lighting, but that is still a disputed comparison method. The change also forced existing rebate applicants to restart their application process. In many cases growers did not know what Xcel incentives were available and in some cases they were misinformed regarding eligibility/availability (Figure 38 and Figure 39). The problems of shared utility company meters and landlords being Xcel account holders are also substantial impediments to application for incentives.

In more mature industries, trade associations stabilize to focus on cost reductions and they find their niche within the PUC process and with consumer advocacy organizations. This has yet to occur for the Colorado cannabis industry and they have yet to receive sufficient attention in DSM strategy planning, as illustrated by this recent Xcel analysis finding.

*"This study includes the energy consumption from the marijuana industry as part of the Agriculture segment and does not consider it as a specific segment. While data provided by Xcel Energy suggests that energy consumption from the marijuana industry is growing rapidly, with as much as a 345% increase in sales since January 2011, there is still insufficient data available to segment the industry separately within the analysis and adequately characterize energy efficiency opportunities. This is recommended as an area for future study."*²⁶

In the context of BCEIOF, the question is whether that can be accelerated and whether program funds should be applied for that purpose. PACE can certainly act as an incentives assistance provider once the most cost-effective incentives are determined.

Even with the availability of attractive incentives, there are strong concerns regarding financing, qualified contractors, verifiable results, risks to current production (Figure 40).

Interest in solar gardens is predominantly tentative (Figure 41). This is probably due to little knowledge regarding how the program works. Any grower who had contacted a solar gardens provider would have answered “no” to this question, because those providers will not sign contracts with growers (due to their capital providers prohibiting it). Providing an alternative model for off-site solar is listed as a priority consideration in the summary of this study.

Have you ever applied for Xcel energy rebates/incentives

12 responses

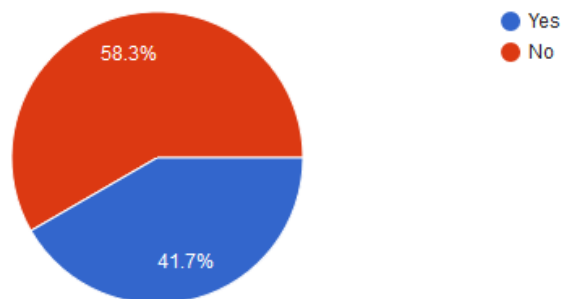


Figure 36 Applications for Xcel incentives

If you have applied for rebates/incentives, did you receive the full amount you applied for?

8 responses

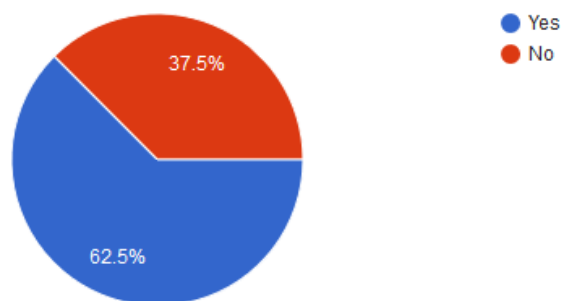


Figure 37 Success with Xcel incentives

If you have NOT applied for rebates/incentives, why?

7 responses

Do not know of any applicable programs
Don't know what's available
Not to my knowledge - We applied for exemptions, but not rebates/incentives through Xcel. Lack of communication and knowledge of what is available.
Not directly billed by XCEL
We lease a building with a shared meter. I also was informed that they do not give rebates for lights in Colorado.
already had upgrades before program
Unaware

Figure 38 Reasons for not applying for incentives

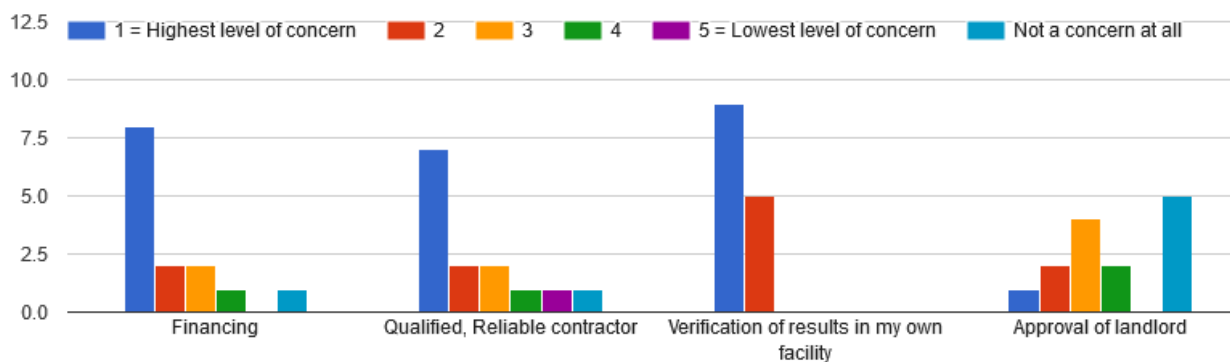
If you did not receive the full amount rebate/incentive amount you applied for, why?

4 responses

Unknown - N/A
I was told by Xcel that rebates are not available for Marijuana grow operations
It was a huge hassle though
-

Figure 39 Reasons full incentives were not received.

If cost savings is demonstrated and yield/quality are not affected, what would you need to accept a lighting, HVAC, or other energy retrofit? (rate each)



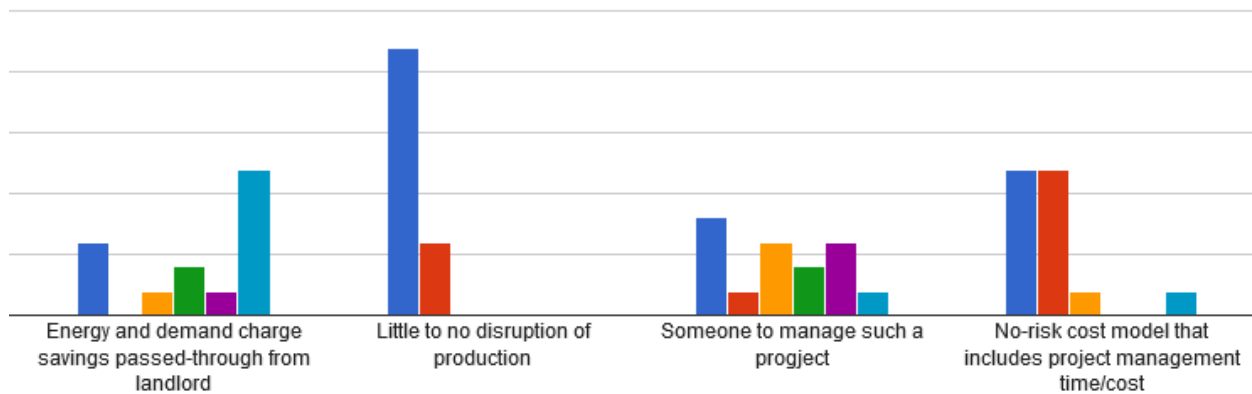


Figure 40 Energy retrofit concerns

If a solar garden provider could provide acceptable contract terms and the cost were proven as good or better than BCEIOF offsets, would you contract for community solar?

14 responses

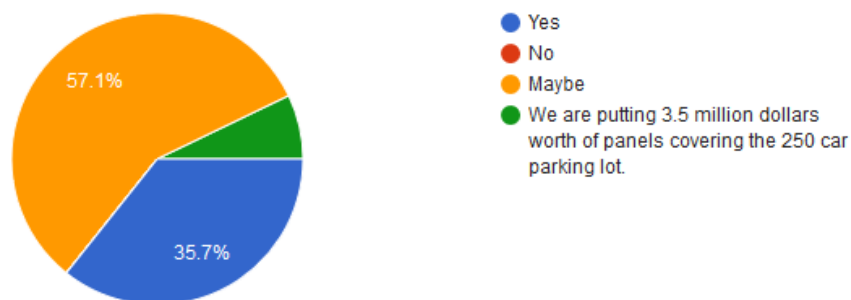


Figure 41 Interest in solar gardens

Lack of support from national labs and standards organizations.

Even with better adoption of utility company incentives, results will suffer from a lack of the support other industries receive from public sector institutions. National labs are prohibited from working directly on cannabis efficiency due to federal prohibition. These organizations sort through vendor claims and act as impartial evaluators. Without such support, growers are subject to potentially self-serving vendor and sales representative claims regarding the productivity of advanced lighting and other technologies. At one point in 2016 one local grower was approached with a technology that promised a kind of perpetual motion scheme. Luckily, the BCEIOF program determined this scheme was fraudulent and would not qualify as an energy offset, so the grower was not defrauded. As Evan Mills states: “For marijuana, there is no appropriate LEED rating, no ENERGY STAR label, no energy use transparency.”²⁷

Lack of skilled, reliable contractors

Indoor grow facilities can be classified into three evolutionary types

- First Generation: Initial market entry, driven by the need to get production online quickly. Energy efficiency was not much of a consideration for these.

- Second Generation: Scaled-up operation with the incorporation of lessons learned in facility design. The hope with these was to make them more efficient, but they were usually scaled-up by contractors and not subjected to integrated design and optimization by design professionals who understand indoor agriculture. Most don't have coordinated controls across HVAC units that may conflict with each other. Overall cooling capacity is oversized to the point of short cycling and has poorly coordinated ventilation and humidity control systems. The portfolio is dominated by this stage of evolution.
- Third Generation: These would be fully optimized designs based on sound system models. We have not seen evidence of this result within the portfolio yet, but some facilities may be within reach of this ideal with more work. There are several projects being proposed that are moving in this direction.

Contractors have helped many growers move from first to second generation facilities at considerable expense. Those same contractors may also hinder the evolution to third generation facilities if those goals exceed their technical ability or the client's willingness to make the investment in research and development to get there.

Anecdotally, many growers complain about the quality/competence of HVAC work done. Growers also show an interest in finding good electricians, which are particularly helpful in electrical rooms and panels that have been altered over the years and become poorly documented and labeled. Fostering the development of a vetted pool of contractors, such as was done for the Boulder County EnergySmart program and PACE, would be of benefit. Creating a recommendation system among these growers would probably be a cost-effective start. What they may think they would lose with competitive advantage, they would gain from fostering greater competence, experience, and financial stability with the contractors they do like and trust.

Lighting contractors are frequently criticized for making unsubstantiated claims about plant growth productivity increases from lighting retrofits that are not backed with testing from independent laboratories. Some lighting vendors have also struggled to obtain custom lighting rebates from Xcel and that has led to failed project ROI. The best vendors may allow growers to try a new product for a full bloom cycle before they buy it, but even such a generous policy represents a labor expense and risk. It appears that removing the risk and cash flow concerns of lighting upgrades is the highest potential end use technology efficiency improvement BCEIOF can consider. Lighting is the highest portion of consumption/emissions and reduced lighting power densities reduce cooling loads too.

Market potential for cost and emission reductions within program

Lighting is the largest end use of electricity, but energy productivity from lighting is a highly disputed subject. There has been a move to mandate lighting power densities in Massachusetts. We should study, but not necessarily mimic such efforts:

According to The Boston Globe, the Cannabis Control Commission's final rules for the recreational marijuana industry cap electricity use at 36 watts per square foot of cultivation space.^{28, 29}

*But a new regulation set by the Cannabis Control Commission to do just that — by limiting the amount of electricity that can be used **for lighting to an average of 36 watts per square foot of cultivation space** — has the industry howling in protest as it prepares for the debut of recreational sales this summer.³⁰*

*"If the commission's trying to ensure that Massachusetts is known as a state with poor-quality product and high prices, this is a great way to do it," said Kris Krane, president of 4Front Ventures, a cannabis consulting and investment firm that also plans to open its own dispensary in Worcester this year. "I'd love it if we could get to a place where it's feasible to grow high-quality product and keep prices down at 36 watts, but I've talked to experts around the country and the LED technology is just not there."*³¹

The following tactics should be considered in Phase 2 of this study. This Phase 1 report provides sufficient data to scope approximate market potential for each within this portfolio, but more work will need to be done to estimate the cost for pursuing them individually. We have placed speculative priorities in the executive summary.

- Increase energy intensity and energy productivity awareness through broad adoption of energy dashboard and comparisons between grows within types.
- Create a trusted source for technology evaluation in lieu of national labs
- Look for regulatory opportunities between reduced emissions vs. restricted land use.
- Determine the viability and cost of new distributed generation business models and compare those to behind the utility company meter efficiency work.
- Resolve the market failure of lost price signals
- Scheduling for the reduction of demand charges and cooling optimization
 - Staggering lighting schedules for peak load reduction
 - Biasing lighting loads toward cooler outdoor temperatures for off-peak rates and higher-efficiency cooling.
- Addition of circuit-level monitoring to segregate HVAC loads for optimization, M&V, and continuous commissioning and encourage growers to adopt this strategy.
- End use efficiency retrofits
 - Lighting:
 - Bloom
 - Vegetative
 - Controls
 - Coordinated controls across RTU (poor person's BAS)
 - Wi-Fi thermostats already present in some grows, but not coordinated
 - Temperature and humidity data joined to circuit-level consumption
 - Heating
 - Electric to natural gas
 - Electric or natural gas to heat pumps
 - Waste heat recovery
 - Cooling
 - Tune-ups
 - Optimization of outdoor air use via economizers
 - Variable frequency drive controllers (VFD) and high efficiency motors
 - Evaporative pre-cooling
 - Envelope improvements to reduce condensation and mold.

End Notes

- ¹ The carbon footprint of indoor Cannabis production, Evan Mills, 2012 Elsevier
<https://drive.google.com/file/d/0B1s8219SGDIjLUVFQXIBWVJIWEE/view>
- ² Budding marijuana sector brings big load growth, efficiency challenges for utilities | Utility Dive
<https://www.utilitydive.com/news/budding-marijuana-sector-brings-big-load-growth-efficiency-challenges-for/508267/>
- ³ 2016 Xcel Energy Annual Community Energy Report for the City of Boulder
- ⁴ CBECS 2012: Energy Usage Summary
<https://www.eia.gov/consumption/commercial/reports/2012/energyusage/index.php>
Energy Information Administration (EIA)- Commercial Buildings Energy Consumption Survey (CBECS) Data
<https://www.eia.gov/consumption/commercial/data/2012/>
- ⁵ Email survey conducted 2017-08-19 to 2017-12-18
- ⁶ City of Boulder cannabis grow data 2017-09-19
- ⁷ Email communication with Evan Mills on 2018-04-13
- ⁸ Marijuana Prices in Denver and Colorado: Fall 2017 Update | Colorado Pot Guide
<https://www.coloradopotguide.com/colorado-marijuana-blog/article/marijuana-prices-in-denver-and-colorado-fall-2017-update/>
- ⁹ Marijuana Sales Reports | Department of Revenue
<https://www.colorado.gov/pacific/revenue/colorado-marijuana-sales-reports>
- ¹⁰ Chart: Sales growth slowing in Colorado's recreational marijuana market - Marijuana Business Daily
<https://mjbizdaily.com/chart-sales-growth-slowing-colorados-recreational-marijuana-market/>
- ¹¹ Marijuana Prices in Denver and Colorado: Summer 2017 Update | Colorado Pot Guide
<https://www.coloradopotguide.com/colorado-marijuana-blog/article/marijuana-prices-in-denver-and-colorado-summer-2017-update/>
- ¹² Colorado infused products licenses skyrocket as MJ companies diversify - Marijuana Business Daily
<https://mjbizdaily.com/colorado-infused-products-licenses-skyrocket-companies-diversify/>
- ¹³ Marijuana odor from north Boulder grow irks neighbors, draws \$14,000 in fines - Boulder Daily Camera
Posted: 11/05/2016
http://www.dailycamera.com/news/boulder/ci_30542927/marijuana-odor-from-north-boulder-grow-irks-neighbors?source=rss
Marijuana odor from cultivation center continues to seep into north Boulder - Boulder Daily Camera
Posted: 11/26/2017
http://www.dailycamera.com/news/boulder/ci_31479226/marijuana-odor-from-greenhouse-grow-centers-continues-seep
Bid to double size of Lafayette's marijuana grow houses met with questions about odor, energy - Boulder Daily Camera
http://www.dailycamera.com/lafayette-news/ci_31599737/bid-double-size-lafayettes-marijuana-grow-houses-met
Odor monitoring ends at High Valley Farms marijuana grow near Basalt | AspenTimes.com
<https://www.aspentimes.com/news/marijuana/no-more-odor-monitoring-at-high-valley-farms/>
- ¹⁴ BOULDER COUNTY MARIJUANA LICENSING REGULATIONS
<https://assets.bouldercounty.org/wp-content/uploads/2018/03/marijuana-regulations-2018.pdf>
- ¹⁵ Chapter 16 - Recreational Marijuana | Municipal Code | Boulder, CO | Municode Library
https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT6HESASA_CH16REMA
- ¹⁶ Marijuana real estate: Cannabis cultivation grows to 4.2 million square feet in Denver area
But Denver's cap on grow, retail locations has put the brakes on expansion
<http://www.denverpost.com/2017/06/02/marijuana-commercial-real-estate/>
- ¹⁷ Firm Closes \$1.3M Deal on 332-Acre Site in Colorado for Enormous Cannabis Cultivation Operation - Marijuana Business Daily
<https://mjbizdaily.com/colorado-firm-hoping-develop-massive-cultivation-site-closes-1-3m-deal-land/>
- ¹⁸ Martra Campus at Walsenburg - YouTube
<https://www.youtube.com/watch?v=vbXe9PkL2bc>
<https://goo.gl/maps/yVjqjXiPsy>
- ¹⁹ The Marijuana Business Is Really the Real Estate Business | Inc.com

<https://www.inc.com/will-yakowicz/the-big-opportunity-in-marijuana-is-real-estate.html>

²⁰ See How You Stack Up - Cannabis PowerScore, by Resource Innovation Institute

<https://cannabispowerscore.org/>

²¹ Massachusetts agency wants efficiency standards for nascent pot industry | Utility Dive

<https://www.utilitydive.com/news/massachusetts-agency-wants-efficiency-standards-for-nascent-pot-industry/516879/>

²² Budding marijuana sector brings big load growth, efficiency challenges for utilities | Utility Dive

<https://www.utilitydive.com/news/budding-marijuana-sector-brings-big-load-growth-efficiency-challenges-for/508267/>

²³ Budding marijuana sector brings big load growth, efficiency challenges for utilities | Utility Dive

<https://www.utilitydive.com/news/budding-marijuana-sector-brings-big-load-growth-efficiency-challenges-for/508267/>

²⁴ Colorado Industrial Energy Efficiency Awards | | SWEEP

<http://www.swenergy.org/industrial/ciec/ciee-awards>

²⁵ Federal Crackdown On States' Legal Marijuana Drives Private Investors Away : NPR

<https://www.npr.org/2018/01/29/581503200/federal-crackdown-on-states-legal-marijuana-drives-private-investors-away>

²⁶ Xcel 2016 Demand-Side Management Potential Study

Attachment SMW-2

Proceeding No. 17A-XXXXEG

Hearing Exhibit 102

Navigant Consulting

²⁷ Indoor Pot: Climate in the Balance on November's Ballot - Energy Associates

<https://sites.google.com/site/millsenergyassociates/topics/energy-efficiency/energy-up-in-smoke/legalization-editorial>

²⁸ Massachusetts sets new rules that limit energy use by marijuana growers - Marijuana Business Daily

<https://mjbizdaily.com/massachusetts-sets-new-rules-limit-energy-use-marijuana-growers/>

²⁹ Massachusetts finalizes recreational cannabis regulations - Marijuana Business Daily

<https://mjbizdaily.com/massachusetts-finalizes-recreational-marijuana-regulations/>

³⁰ Skeptical of LED lights, marijuana growers decry lighting efficiency rule - The Boston Globe

<https://www.bostonglobe.com/metro/2018/03/08/skeptical-led-lights-marijuana-growers-decry-lighting-efficiency-rule/AC9qm18nmfM9rgaUrl26QK/story.html>

³¹ Ibid