Auraria
Sustainable
Campus
Program

Auraria Campus 2018–2028 PV Development Roadmap

2022 Revision

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Overview

This document aims to provide a roadmap for increasing solar generation on the Auraria campus as a primary strategy for attaining the commitment made, by all three institutions, to the American Colleges and University Presidents' Climate Commitment. This commitment calls for a 20% reduction in greenhouse gas emissions from a 2007/2008 baseline by 2020, 50% by 2030, and 80% by 2050. As such, this plan prioritizes short, middle, and long-term strategies among the physical spaces on campus; breaks down financial considerations and key stakeholders; and recommends policy implementation and techno-economic modeling resources to achieve proposed strategies.

We have already passed 2020 and the campus fell short of its 20% GHG reduction goal by 2.5%. We need to accelerate our efforts to hit the 50% by 2030 goal which has now also been adopted by the State of Colorado.

This document is intended to offer objective guidance to Auraria's administration and key stakeholders when weighing solar investment opportunities. This guidance is based on extensive research by the Auraria Sustainable Campus Program's staff and the calculation of Auraria's solar potential using a variety of open-source tools and software in addition to consulting with local experts and other stakeholders. Updates have been made to this document as of April 2022 and many relevant additions are in **green text** throughout.

Why now?

We are currently falling short of compliance with a climate commitment that all three institutions on this campus signed in 2007. It is a primary responsibility of the ASCP to keep moving toward these goals in an efficient manner. We installed the Library Solar Array in November of 2019, but we now need to continue our progress. Through our programming over the past 10 years, we have measurably reduced our campus emissions by 3.26% through our solar installations (2%), and energy efficiency programs (1.26%).

In addition to the climate commitment, our program is also beholden to the student referendum where the students voted, repeatedly, to have their fees spent on 'reducing our campus' reliance on fossil fuels'.

Auraria's roofs are only going to get older. As they age, this lowers the lifespan of solar and decreases financial favorability of the investment (the cost to take solar panels down and reinstall them is nearly 25% of the cost to purchase them). We should capitalize on our new or soon-to-be-replaced roofs to maximize profit margin.

Solar is popular among our constituents, high-impact, and a visible achievement that would increase our credibility with students and contribute to our identity as a sustainable college campus (which will become increasingly marketable to prospective students' decisions to attend school on this campus in the coming years). In fact, our recent survey (Fall,2020) of over 800 Auraria students found that 2/3rds of those surveyed Agreed or Strongly Agreed with the statement

“Environmental sustainability had an impact (or would have had an impact) on my choice of college or university”. This was a
This project will pay for itself, its maintenance, and provide a roughly 33% surplus that will be used to purchase more renewable projects in the future.

Executive Summary

E.1 Key Recommendation #1: Rooftop Installation and Phasing

After evaluating the solar potential of 25 roofs and parking lots on campus (out of forty buildings total), preliminary estimations suggest that Auraria's solar potential for these spaces is around 8.5 Megawatts*. By combining individual rooftop potential in conjunction with other factors that impact the economic feasibility of solar (roof age, utility rates and tariffs), the ASCP suggests the following general implementation priorities and timeline for the Auraria campus:

- *Phase 1: Short Term/Immediate (**Completed**)*
  - Library rooftop: 779 kW (DC), potentially producing 1,050,000 kWh annually and offsetting 70% of the library's annual energy consumption. This array would save us roughly $49,000 per year (average savings over 30 years) on electricity bills and prevent 15,000 metric tons of carbon dioxide (MTCO2e) from entering the atmosphere over a 25 year life. The ASCP recommends purchasing this system with our current cash surplus in order to start generating project revenue immediately and to maintain Renewable Energy Credits which will allow this investment to count toward the ACUPCC reduction goals. More details are provided in Section 2.3 Priority PV Locations.
    - Power Purchase Agreements (PPAs) are not being considered at this time due to the preferences of leadership. This does not affect the viability of solar as an option for our program.
  - Consider solar for newly constructed institutionally-owned buildings to maximize efficient placement of arrays.
- Phase 2: "Next Up"/Mid Term (1-3 years)
  - As roofs age toward replacement, consider next:
    - West Classroom and North Classroom (roof replacement needed in next few years)
    - Central Classroom
    - CU Wellness and CU Student Commons (if feasible to pursue)
    - Confluence and Cherry Creek (if feasible to pursue)
  - Implement Roof Replacement Policy: As roofs are up for replacement, consider solar installation. Refer to prioritization table for potential kW production and feasibility/fit.
- Phase 3: (5-8 years)
  - Continue to consider solar as roofs are replaced. Good candidates at this point may include:
    - PE Center
    - Plaza Building
    - King Center
  - Consider PPAs if we are struggling with financing up-front costs on future projects and don't need Renewable Energy Credits immediately (can recapture RECs if purchase system outright after a depreciation period)

    - If cost of stand-alone solar canopies (over parking garages) decrease, consider installing on expansive parking lot spaces

**Note: aside from Library, Science, Plaza, West, Arts, and parking garages (which came from the 2016 Ameresco report) this is truly a "ballpark" figure, calculated using available tools to give a general idea of solar capacity. For a more accurate figure, AHEC would need to engage a professional contractor or NREL's Solar Technical Assistance Team. For more detailed information on the tools and assumptions utilized to arrive at these figure, please see Appendix A for Methodology.*

E.2 Key Recommendation #2: Green Revolving Fund

In order to generate funding for future projects that will reduce Auraria's reliance on fossil fuels, the ASCP proposes a Green Revolving Fund. Under this model, savings generated from solar projects would be captured and reinvested into energy efficiency projects that would further reduce campus energy use and utility costs or go toward investing in the operation, maintenance and future solar installations. Please see section 5.5 for more information.

E.3 Other Key Findings: Improvements in Solar Tech/Cost, Resources

- Both the technology and cost of solar have improved tremendously in the past few years, particularly among multi-crystalline modules.
    - Cost: The installed cost per watt for commercial scale solar is now around $1.50 (Fu et. al 2017), compared with the $2.29/watt that Auraria was quoted by Ameresco in 2016 (Ameresco, 2016) and the $4.85/watt cost on the Arts solar array in 2011 and 2013.
    - Technology: A July 2018 proposal from Namaste Solar (Namaste 2018) included a per-module wattage of 350 watts, compared to Ameresco's 2016 proposal which included 315 watt modules (Ameresco 2016), meaning the array itself will be more efficient with the space. The panels on our arts building installed five years ago produce around 200 watts/module.
- There are numerous no and low cost resources in Auraria's own backyard available to provide technical assistance, techno-economic analysis and financial incentives. We highly recommend further investigation and pursuit of the resources outlined in the "Resources and Appendices" section of this report for future solar feasibility studies.

Section 1: Background

1.1 Auraria's Current Energy Consumption and Rate Structure

In the 2017-2018 fiscal year, the Auraria campus consumed 48,560,443 kWh of electricity, costing the campus nearly $4.1 million.[1] This comprises 69% of Auraria's utility budget and nearly 27% of our facilities budget. To put this in perspective, this is roughly equivalent to the annual electrical consumption of 5,417 American homes.[2]

The majority of the Auraria campus, roughly 75% of AHEC's buildings, is billed on the Primary General Rate class, at between $0.038/kWh and $0.04/kWh (current utility rates can be accessed at openei.org[3] or via Xcel Energy[4]).[5] We are afforded this low rate because we receive energy at high voltages from a nearby transformer and have our own "distribution unit" on the first floor of the Arts Building where we step down high voltage and distribute power to the rest of campus. There are five buildings on campus that are still billed on the secondary general rate, and those are the Admin Building, the 5th Street Hub, the Modular Classrooms, the Tivoli, and the King Center. These buildings are billed at roughly $0.0473/kWh and will be moved to the Primary General meter in the next couple years.[6]

Most commercial customers in Colorado who *don't* distribute their own energy pay around $0.092/kWh for electricity.[7] In fact, electricity in Colorado is relatively cheap when compared with the rest of the county, with commercial rates 6.94% cheaper than the national average. A below market rate for electricity makes it difficult for solar to a) offer a rapid payback (when purchasing a system) or b) look financially appealing (when buying energy back from a solar developer through a PPA). However, it is important to remember that part of the reason our electricity is so cheap is because 44% of Xcel's generation mix is comprised of coal[8], a fossil fuel source that is "cheap" because it is heavily subsidized by our public policy and fails to internalize the health and environmental ramifications of its extraction and combustion.[9] In this sense, the argument that "solar will never be cheaper than coal"

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1 Ross, Ken. Auraria Higher Education Center Facilities Management. E-mail messages received summer 2018.

2 "Greenhouse Gas Equivalencies Calculator." EPA Greenhouse Gas Equivalencies Calculator, U.S. Environmental Protection Agency (EPA), accessed July 2018 https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

3 Utility Rate Database. Openei, National Renewable Energy Laboratory, Accessed July 2018. https://openei.org/wiki/Utility_Rate_Database

4 Xcel Energy. "Colorado Commercial and Industrial Gas and electric rate schedule summaries." January 1, 2017. https://www.xcelenergy.com/staticfiles/xe/Regulatory/COBusRates.pdf

5 Ross, Ken.

6 Ibid.

7 Utility Rate Database. Openei, National Renewable Energy Laboratory.

8 "Power Generation." Energy Portfolio: Electricity, Xcel Energy, accessed July 2018 https://www.xcelenergy.com/energy_portfolio/electricity/power_generation

9 Redman, Janet. "Dirty Energy Dominance: Dependent on Denial – How the U.S. Fossil Fuel Industry Depends on Subsidies and Climate Denial." *Oil Change International*, October 3, 2017. http://priceofoil.org/2017/10/03/dirty-energy-dominance-us-subsidies

is not universally true.

It is worth noting that 54% (or roughly $2.2 million) of Auraria's electricity costs do not even come from electrical consumption, but rather from demand charges.[10] This presents an opportunity to reduce costs further by participating in a demand management or demand response program. Hiring an Energy Manager would help Auraria identify demand management strategies and "free money" that we are currently leaving on the table. In conjunction with solar, demand management has the potential to provide considerable cost savings for the Auraria campus.

[10] Ross, Ken.

Section 2: Campus PV Development Team

2.1 Key Points of Contact

The key points of contact during the compilation of this report include the following:

- ASCP Staff
  - Chris Herr – Director of Sustainability – Chris.Herr@ahec.edu
  - Jackie Slocombe – ASCP Graduate Assistant – Jackie.Slocombe@ahec.edu
  - Karmen Burchett – ASCP Ambassador – Karmen.Burchett@ahec.edu
- AHEC Facilities Staff
  - Provided information on Auraria's buildings, energy and electricity consumption, roof ages and types, billing rates and structures, AHEC facilities project timelines.
  - Ken Ross, Facilities Management Director
  - Pete Candelaria, Electrical Manager
- Xcel Energy
  - Provided insight on billing and Xcel's Solar Rewards Incentive
  - Melanie Gavin, AHEC's Account Manager at Xcel Energy
- Green Schools Listserv
  - Crowdsourcing platform for sustainability in higher education
- Heath Mackey from Namaste Solar
  - Compiled preliminary PV potential and cost analysis for Library and Science Buildings
- Renato Nitura from Kinect Energy
  - Compiled preliminary PV potential and cost analysis for Library

2.2 Student Engagement, Retention, and Incentives

This plan would not be possible without the significant contributions from the student interns and student staff of the ASCP. One student participated for course credit through an internship program and others gained applicable work experience related to their course work via a work-study position. Students also had the opportunity to receive important training through the Midwest Renewable Energy Association's PV 101 course.

2.3 Stakeholder Incentives

One of the Auraria Sustainable Campus Programs' major goals, set officially through the three schools' agreement to the American College & University Presidents' Climate Commitment, is to reduce our campus emissions 20% by 2020, 50% by 2030, and 80% by 2050. Renewables will play a large part in maintaining a pace necessary to hit those goals.

Section 3: PV Development Sites

3.1 Potential PV Locations

A prioritization ranking was assigned to each building based on the following criteria:

1) Potential Array Size and Production (kW and kWh, respectively)
    a. Availability of "Usable" space (lack of obstacles, HVAC equipment, etc.)
2) Roof Age
3) Utility rate structure (Primary General or Secondary General)

Roofs with greater potential capacity that are either new or nearing replacement were prioritized over others, as these roofs would be likely to produce more savings over a greater time period.

A series of steps were utilized to estimate module size and potential production. As noted earlier, these were estimations made using a combination of best available technology and open source software, including NREL's PVWatts tool, Google Earth/Google Maps, Unirac's U-Builder Design tool, and direct communication with a handful of solar companies. The final figures in this report are considered best estimates and are intended to provide a general idea of solar capacity. The detailed methodology used to arrive at these figures, as well as the full table of PV locations and potential solar production and financial savings, can be found in Appendix A. A sample is provided here below:

Building	Priority	Roof Age	Roof Size	Potential Array Size (kw-DC)	Potential Array Size (kw-AC)	Average Annual Production (kWh)	Average Annual Savings ($)
Arts	0	1999 or 2003	149,889	75	63	115,350	5,454
Library	1	2016	100,580	711	593	967,072	45,727.45
Science	2	1994	35,000	258	215	346,713	16,394.11
West	3	1998	40,350	450	375	587,999	27,803.21
Central (+ ped bridge)	4	1999	30,000	300	250	391,999	18,535.47
CU Wellness Center	5	2018	28,000	260	217	339,733	32,973.61
CU Student Commons	5	2015	150,000	150	125	196,000	19,023.28

Table 1: Sample of PV Development Site Potential Table (full version in Appendix A)

3.2 Implementation Timeline

- Phase 1: Short Term/Immediate (**Completed**)
    - Library rooftop: 779 kW (DC), potentially producing 1,050,000 kWh11 annually and offsetting 70% of the library's annual energy consumption. This array would save us roughly $49,000 per year (average savings over 30 years) on electricity bills and prevent over 15,000 metric tons of

[11] Updated May, 2019 after receiving a more accurate projects from Namaste Solar

carbon dioxide ($MTCO_2e$) from entering the atmosphere over a 25 year life. The ASCP recommends purchasing this system with our current cash surplus in order to start generating project revenue immediately and to maintain Renewable Energy Credits which will allow this investment to count toward the ACUPCC reduction goals. More details are provided in Section 2.3 Priority PV Locations.
    - Consider solar for newly constructed institutionally-owned buildings to maximize efficient placement of arrays.
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    - If cost of stand-alone solar canopies (over parking garages) decrease, consider installing on expansive parking lot spaces

3.3 Priority PV Locations

This section features the "top 5" buildings on campus in terms of solar feasibility (kW potential combined with roof age, etc.) The tools mentioned in Section 2.2 and in Appendix A were used to visually spec out an array and capacity for these priority buildings.

Library[12]:

The library is the most ideal candidate for solar because the roof is only two years old (2016); there is a sizable amount of flat, unobstructed space to mount contiguous panels; and the building is a shared AHEC-owned building. (**This project was completed in 2019**)

Roof Area (ft²)	Size (kW DC)	Size (kW AC)	# of modules	Potential Annual Production (kWh)	Potential Annual Value ($)
100,580	712	600	2,034	967,072	$45,727

Table 2: Estimated Library PV Energy Generation and Savings

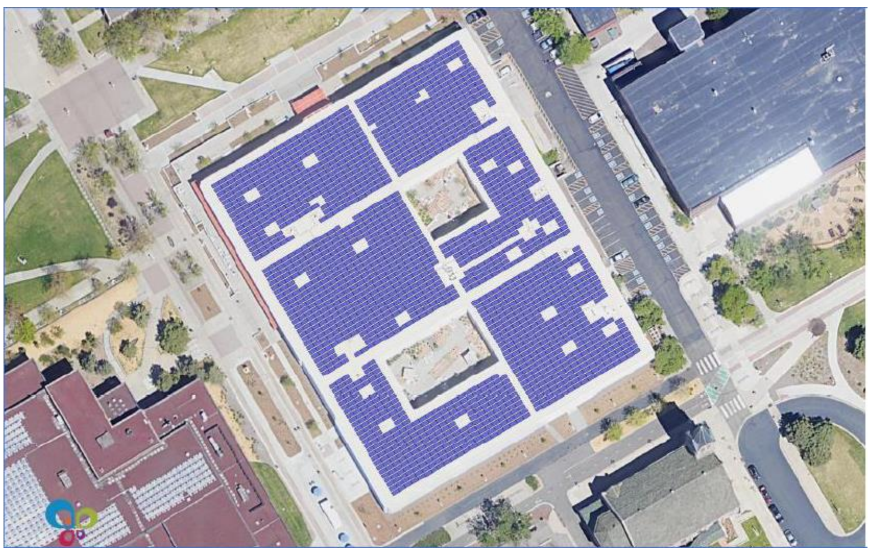

Figure 1: Library Roof PV Mockup using Unirac U-Builder

Science:

The science building is another ideal candidate, again because the roof is flat and largely unobstructed. The science building is our most energy intensive buildings, so solar is an important step toward net zero electricity. If the roof is updated, this would be a strong choice.

Roof Area (ft²)	Size (kW DC)	Size (kW AC)	# of modules	Potential Annual Production (kWh)	Potential Annual Value ($)
35,000	258.3	200	738	346,713	$16,394

Table 3: Estimated Science PV Energy Generation and Savings

12 After publication of this PV Roadmap, the Library Solar Array has been approved and will be completed before November, 2019.

Figure 2: Science Roof PV Mockup using Unirac U-Builder

<u>West Classrooms:</u>
As a flat, AHEC-owned building that is free from major obstruction and will be up for roof replacement in the near future, West classroom provides an ideal mid-term location for a 450 kW array.

Roof Area (ft^2)	Size (kW DC)	Size (kW AC)	# of modules	Potential Annual Production (kWh)	Potential Annual Value ($)
40,350	450	375	1,084	587,999	$27,803

Table 4: Estimated West PV Energy Generation and Savings

Figure 3: West Roof PV Mockup using Unirac U-Builder

RESULTS

Print Results

631,733 kWh/Year*

System output may range from 586,817 to 650,369 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.42	37,367	1,308
February	4.31	43,162	1,511
March	4.86	53,443	1,871
April	4.93	52,635	1,842
May	5.97	64,432	2,255
June	7.28	72,836	2,549
July	6.43	66,931	2,343
August	6.59	67,866	2,375
September	5.51	55,975	1,959
October	4.28	46,109	1,614
November	3.60	37,919	1,327
December	2.97	33,057	1,157
Annual	5.01	631,732	$ 22,111

Table 5: Estimated Monthly Generation, West

<u>Central:</u>
As a flat, AHEC-owned building that is free from major obstruction and will be up for roof replacement in the near future, West classroom provides an ideal mid-term location for a 450 kW array. This would complete the arts-west-central triumvirate.

Roof Area (ft²)	Size (kW DC)	Size (kW AC)	# of modules	Potential Annual Production (kWh)	Potential Annual Value ($)
30,000	300	250	720	392,000	$18,535

Table 6: Estimated Central PV Energy Generation and Savings

Figure 4: Central Roof PV Mockup using Unirac U-Builder

RESULTS

Print Results

421,155 kWh/Year*

System output may range from 391,211 to 433,579 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.42	24,911	872
February	4.31	28,774	1,007
March	4.86	35,629	1,247
April	4.93	35,090	1,228
May	5.97	42,955	1,503
June	7.28	48,557	1,700
July	6.43	44,620	1,562
August	6.59	45,244	1,584
September	5.51	37,317	1,306
October	4.28	30,739	1,076
November	3.60	25,279	885
December	2.97	22,038	771
Annual	5.01	421,153	$ 14,741

Table 7: Estimated Monthly Generation, Central

CU Wellness and Commons Buildings:
CU Wellness and Commons buildings are particularly suitable for solar because they are both flat and young. Furthermore, they are billed much higher than the primary general rate, at a blended rate of $0.078. Therefore, the cost savings are bolstered. While this is an institutionally-owned building, AHEC should work with CU Denver to consider this potential.

Roof Area (ft^2)	Size (kW DC)	Size (kW AC)	# of modules	Potential Annual Production (kWh)	Potential Annual Value ($)
43,000	410 (260 and 150)	342	920	535,733	$51,997

Table 7: Estimated CU Wellness and CU Commons PV Energy Generation and Savings

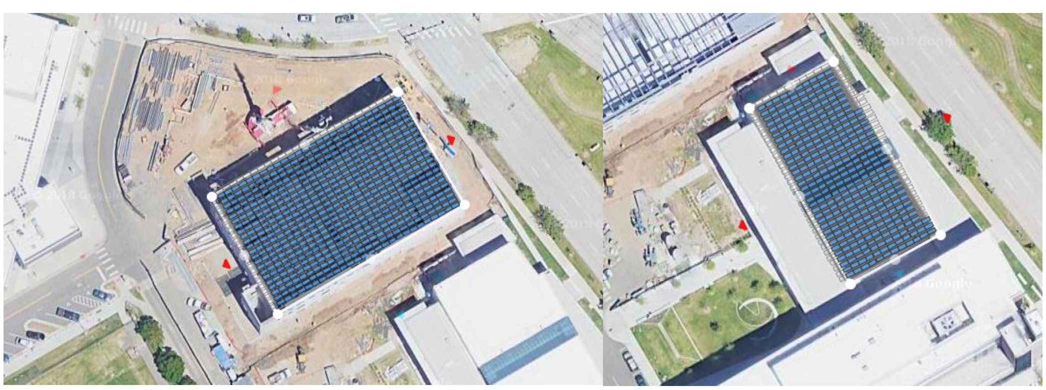

Figure 4: CU Wellness and Commons Roof PV Mockup using Unirac U-Builder

RESULTS

Print Results

575,579 kWh/Year*

System output may range from 534,655 to 592,559 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.42	34,045	1,192
February	4.31	39,325	1,376
March	4.86	48,693	1,704
April	4.93	47,957	1,678
May	5.97	58,705	2,055
June	7.28	66,362	2,323
July	6.43	60,981	2,134
August	6.59	61,834	2,164
September	5.51	51,000	1,785
October	4.28	42,011	1,470
November	3.60	34,548	1,209
December	2.97	30,119	1,054
Annual	5.01	575,580	$ 20,144

Table 8: Estimated Monthly Generation, CU Wellness and Commons

3.4 Institutionally Owned Buildings

As is visible in the latest AHEC Master Plan, many of the new buildings being constructed on campus are being built individually by one of the three institutions. Such is the case with CU Denver's Wellness Center and Student Commons, CCD's Confluence Building, and MSU's Aerospace Science Building, Student Success Building and Marriott Suites.

Because AHEC must represent all three of the institution's interests equally, and not individually, it was deemed to be too complicated to pursue solar on these roofs, regardless of how well-positioned they might be for solar given the youth of their roofs and the potential to increase their US Green Business Council LEED rating from Gold to Platinum. As such, they were not seriously considered in this master plan. However, as new buildings offer the most optimal platforms for solar production, we highly recommend that Auraria consider a path to pursue these spaces or to encourage each individual institution to pursue these rooftops. While each institution has its prerogatives, we share one atmosphere and one common mission of reducing *Auraria's* campus dependence on fossil fuels. As each school pursues expansion of its institutional "neighborhood," it is imperative that we remember these climate goals and priorities shared by the students from all three institutions.

Figure 5: Auraria Campus Neighborhoods and Expansion Plans

Section 4: Costs and Risk: Approvals and Legal/Regulatory Considerations

4.1 Utility Interconnection Requirements and Fees
After speaking with our designated Xcel representative, it was determined that the rough estimate for interconnection fees would not exceed $2,000 for each site or $4,000 total for Phase I.

4.2 Permitting and Inspection Requirement and Fees
We will set aside $2,500 for each site for State inspection and permitting costs, $5,000 total for Phase I.

4.3 Characteristics Influencing Cost or Risk
Most risks were evaluated and overcome when the original array went up on the Arts building. The on-going costs and risks associated with this project include:

- Operations &Maintenance
- 0.5% Degradation annually in the panels
- Inverter Replacements
- Other costs associated with roof replacement

4.4 Xcel's On-Site Generation Limit
Due to several factors that are not easily summarized here, Xcel currently has a limit of on-site energy generation based on a percentage of our lowest daily peak usage. As of this updated in April of 2022, we are cleared to install between 750kW – 1 MW of additional solar capacity before running up against these limits.

Section 5: Project Financial Goals and University Investment Opportunities

5.1 Why Now? Cost and Technology Increases:

The costs for solar have continued to plummet each year, finally reaching a level where it can compete with conventional energy sources on a per watt basis. When we last installed solar on this campus (2011 and subsequently 2014) we paid $4.85 per watt. As of Quarter 1, 2017 NREL (National Renewable Energy Lab) reports indicated that the national average had dropped all the way to $1.85 per watt. After our preliminary conversations with local solar providers, we

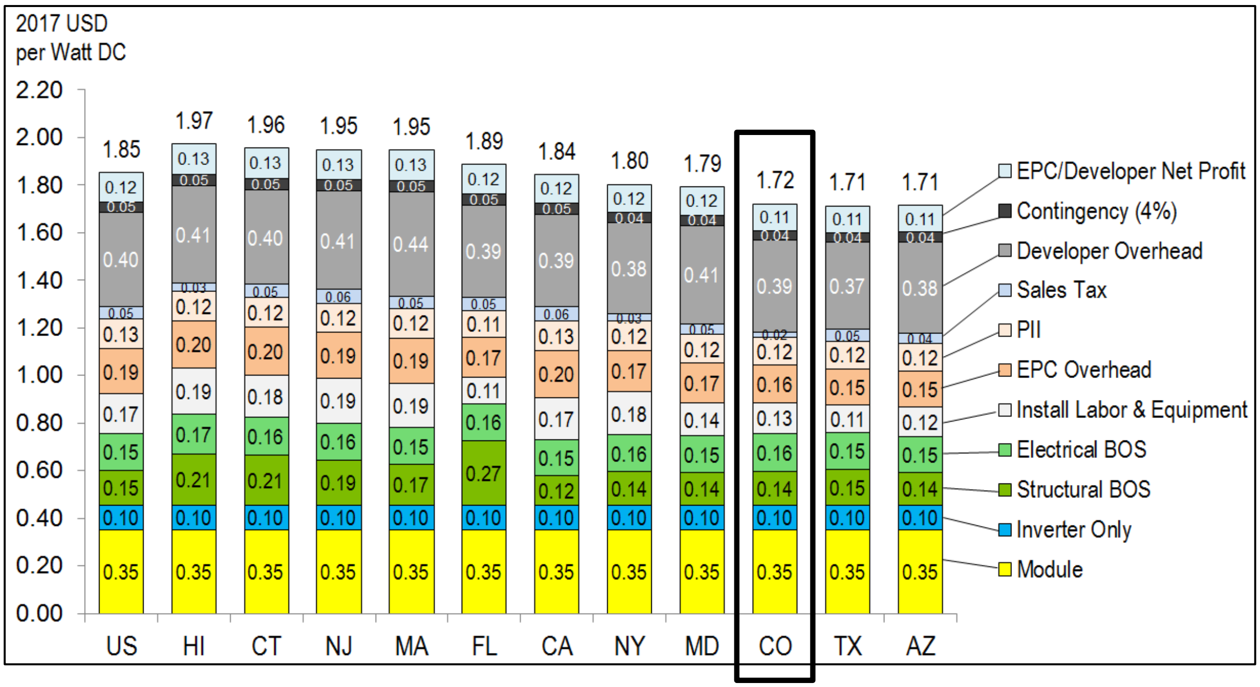

Figure 6: 2017 Solar Cost per Watt (NREL)[13]

found that the actual all-in cost of solar here in Colorado is under $1.50 per watt. That's a 69% reduction in cost from our first solar installations to our proposed system! The previous quote from the Ameresco design would have cost $2.29 per watt just two years ago, so this new proposal will save 34% from that quote if initiated before 2019.

Update: our final installed cost of the Library Solar Array in 2019 came out to just under $1.30 per watt which was even better than projected. We expect any future installations (assuming supply chain issues are not persistent) will be roughly the same.

[13] Fu et. al. "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017." *National Renewable Energy Laboratory*. August, 2017. https://www.nrel.gov/docs/fy17osti/68925.pdf.

5.2 Description of Financial Models and Incentives

There are a myriad of options for purchasing and financing solar, particularly at the commercial scale and on a college campus. For the purposes of this report, we will focus on the two options deemed most relevant at Auraria: purchasing outright with cash or utilizing a Power Purchase Agreement (PPA). Within these two key scenarios, several other financing mechanisms come into play, such as utility incentives, rebates, tax credits, Renewable Energy Credits (RECs), etc. The following section intends to lay out the options and points of consideration that contribute to ROI, payback period, etc.

Federal Income Tax Credits:

In addition to the massive cost reductions, the Federal Tax Incentive for solar installations will still be fully active through fiscal year 2019. These incentives are evaluated for for-profit entities that choose to build solar, and Power Purchase Agreement would allow AHEC to benefit from these financial incentives via a 3rd party:

	2016	2017	2018	2019	2020	2021	2022
Tax Credit	30%	30%	30%	30%	26%	22%	10%

Figure 7: 2017 Solar Cost per Watt (NREL)[14] ****Note: The Biden Administration has held the 26% incentive through at least 2022****

However, due to the lower-than-average cost of energy on our campus, it seems the cash option provides the most benefit to our program at this time.

Xcel Solar Rewards: In order to make the PPA rate competitive with Auraria's below-market Primary General electricity rates ($0.038/kWh), we would need to utilize Xcel's Solar Rewards incentives. These offer a customer a subsidy of $0.0425/kWh. In exchange for offering this financial incentive, however, Xcel gets to keep the RECs (not Auraria) and the additional cost would be paid for by the ASCP. Please see below for further information regarding PPA options.

Update: This option was fully capitalized upon for 500 kW of the Library Solar Array in 2019. This results in around $27,000 annually back to the ASCP for a 20-year period which will be reinvested in renewable energy opportunities on campus.

[14] Fue et. al.

PPA (Power Purchase Agreement): While the ASCP is not recommending a PPA agreement for the Phase 1 project, it is important to have a general understanding of the process as it will likely be a viable option for Phase 2 and Phase 3. Here is a brief explanation:

A Power Purchase Agreement is a popular financing option for nonprofit or government institutions in our state of Colorado because of 3 main reasons:

- Little to no up-front build costs
- No maintenance
- Allows the savings from the Federal Tax Credit opportunities
  - This is possible because the 3rd party who is executing the PPA agreement between the client and the utility company will realize these savings as a for-profit entity. As a tax-exempt entity, the Auraria Higher Education Center is not eligible to claim these credits on our own.

Purchase	PPA
Own RECs, can claim carbon offsets on climate commitments (+)	Often, but not always, sacrifice RECs and can't claim green power sourcing (-)
Doesn't utilize federal tax credits to subsidize a deal because tax exempt entity (-)	Take advantage of federal tax credits that AHEC isn't eligible for, lowering system costs (+)
AHEC responsible for repairing damage due to hail, lightning, etc (-)	Maintenance and repairs covered by solar developer. No liability for AHEC (+)
Begin earning back revenue/savings immediately (+)	Do not earn revenue back until purchase system outright (-)

Table 9: Comparison of Cash Purchase and Power Purchase Agreement (PPA)

Here's how it generally works: The 'Consumer' (AHEC), would contract with a 'System Owner' (Third party builder) to build a solar system on our campus. This 'System Owner' would pay for installation and maintenance, incentivized by the depreciation and rebate benefits available to for-profit entities who build solar systems at a commercial level. The 'Consumer' would then purchase power from the 'System Owner' and the 'Utility' (Xcel) while the 'System Owner' would make a profit through the contracted PPA rate the 'Consumer' pays as well as through selling the Renewable Energy Credits to the 'Utility'. Please refer to Figure 8 for a visual representation of what an agreement looks like.

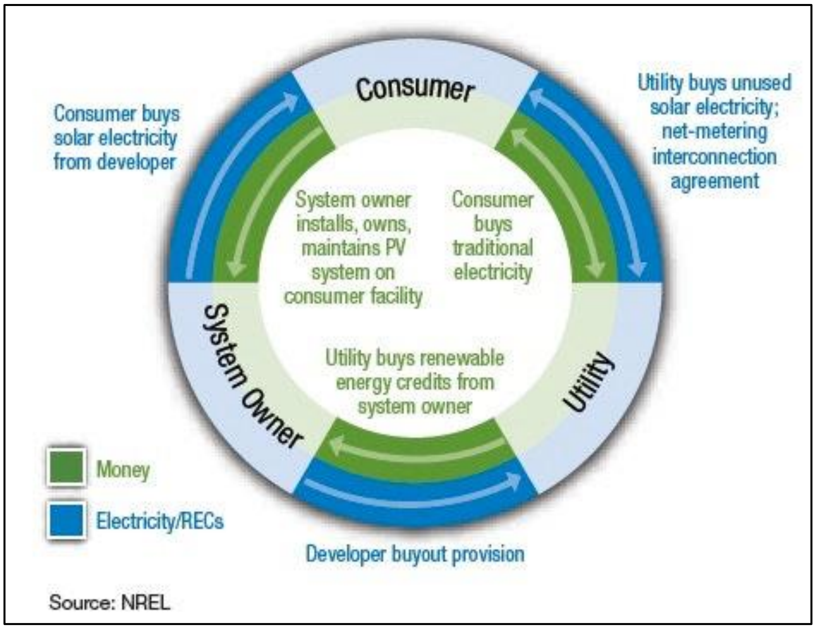

Figure 8: 2017 PPA Agreement Diagram (NREL)

While these benefits may sound appealing, we have determined that a PPA is not an attractive option for our current Phase 1 project for numerous reasons. Primarily, we must retain the Renewable Energy Credits for our project so we can apply our progress to the ACUPCC goals. Secondarily, after consulting with numerous local solar providers, we found that there is no attractive way to make a PPA financially beneficial or neutral given our current energy rates.

Please see the PPA Proforma in the Appendix C for more details.

Perhaps the largest consideration when deciding between owning a system and utilizing a PPA are the Renewable Energy Credits. When acquiring a solar system through a PPA, the solar develop maintains the RECs, not Auraria. Essentially, Auraria could not claim credit for the green energy our roofs are producing because we do not own the system and we are simply buying power back from Xcel's blended generation mix (which includes renewable and non-renewable sources) at a discounted rate. Because Auraria has a vested interest in lowering our fossil fuel reliance (see ASCP Mission Statement) and meeting a carbon reduction agreement (Second Nature/ACUPCC), it is of interest to us that we maintain credit for producing solar energy on our rooftops. In this way, we can claim carbon offsets to meet the carbon reduction goals the campus signed onto through the President's Climate Commitment in 2007. While paying for the system outright allows Auraria to claim these RECs immediately, we also have the opportunity to earn them upon purchasing a system from a PPA agreement after the panels price tag has depreciated if we choose that route.

5.3 Financial Analysis of Project Benefits

There are numerous benefits to installing a solar system on the Auraria Campus including: Energy savings, MTCO2e reductions, progress toward our ACUPCC goals, financial savings, and education opportunities. We'll evaluate the two more important, and easily quantifiable, benefits in this section: Financial/Energy Savings and Environmental Impact. Please note that 'Other Costs over Life' include Operations and Maintenance, Permitting, Interconnection Agreements, Cell Degradation, and Inverter Replacements. Option #1 has the largest economy of scale and provides the best overall discount. #2 and #3 are in the case of accomplishing each separately. Here is the financial breakdown for our proposed Phase 1 project broken into various scenarios.

Phase 1: Library

Library	
Upfront Cost	$1,034,409
Total Energy Savings (Over 30 years)	$1,371,823.52
Net for ASCP	$337,414.52

Table 10: Financial/Energy Savings for Library Installation

Environmental Impact	
Energy Savings (kWh/Year)	1,050,000 kWh
Emissions Saved/Avoided (MTCO2e)	574 MTCO2e
Total MTCO2e saved over 25-year life	14,350 MTCO2e

Table 11: Environmental Impact for Library Installation

The impact of this project both financially and environmentally cannot be overstated. The emissions reductions will help the ASCP get the Auraria Campus back on track for our 50% by 2030 goal set by each of the schools' leadership. Please refer to the Pro Forma in Appendix C for more detailed information.

5.4 Current Portfolio

The current surplus for the ASCP is not typical, and this opportunity is rare. It has always been a priority of students and this program to pursue solar above and beyond our current 75 KW system. This investment would pay for itself, its maintenance, and more over the average life of a solar array.

5.5 Potential PV Project Investment Fund/Green Revolving Fund

In order to generate funding for future projects that will reduce Auraria's reliance on fossil fuels, the ASCP proposes a Green Revolving Fund (GRF). When the ASCP initiates and funds a solar installation, the revenue and financial savings realized as a result of solar generation and avoided energy costs should be reinvested in future campus sustainability efforts. While there are several GRF models to consider should this concept be formalized, the ASCP initially supports a GRF model where the project revenue/savings are specifically earmarked for energy efficiency projects such as lighting and HVAC upgrades. Under this model, both the ASCP and the project partner (in most cases facilities) benefit financially from the reinvestment of green funds.

There are over 80 GRFs in operation in North America comprising over $111 million of investment.[15] Since its inception in the early 2000s, Harvard University's Green Revolving Fund has "achieved average annual returns of 30 percent and saved the university $4.8 million dollars annually".[16] Harvard is an active member of the Billion Dollar Green Challenge, an initiative of the Sustainable Endowments Institute that offers resources and tools for schools looking to initiative Green Revolving Funds.

Should the Auraria campus and the ASCP decide to formalize a Green Revolving Fund, the Billion Dollar Green Challenge offers a thorough implementation guide and case studies of other universities and Harvard University offers a prime case study. Those can be found at the following websites:

- http://greenbillion.org/wp-content/uploads/2015/07/GRF_Full_Implementation_Guide.pdf
- https://green.harvard.edu/programs/green-revolving-fund

[15] Indvick, Joe; Foley, Robert; Orlowski, Mark. "Green Revolving Funds: A Guide to Implementation & Management." *Sustainable Endowment Institute and ICF International.* July 2015. http://greenbillion.org/wp-content/uploads/2015/07/GRF_Full_Implementation_Guide.pdf.

Section 6: Recommendation and Conclusion

6.1 Environmental Goals and Stakeholder Support

Our program is student fee funded, and so requires an enhanced level of support for each project. To ensure that this is something student would like their fees spent on, we took a close look at the 2 most recent voting opportunities for the student body on this issue, the 178 student survey responses our office collected, and the ACUPCC to which all three schools have committed.

Student Fee Referendums

- The ASCP student fee was brought to a vote in 2011, receiving 95% votes in favor of the fee across all three institutions.
- The ASCP student fee was brought to a vote again in 2016, this time to make the fee permanent. This passed with 82% in favor.
- The language contained in these referendums both specifically list renewable energy as a priority.

Student Survey Responses

Our office has collected student surveys in 2017, 2018, 2020 and 2021 which has resulted in over 2,000 responses to ensure that there was a still support for sustainability and renewable energy on this campus. Here were their responses when asked "how Important is it that the Auraria Campus become more sustainable?"

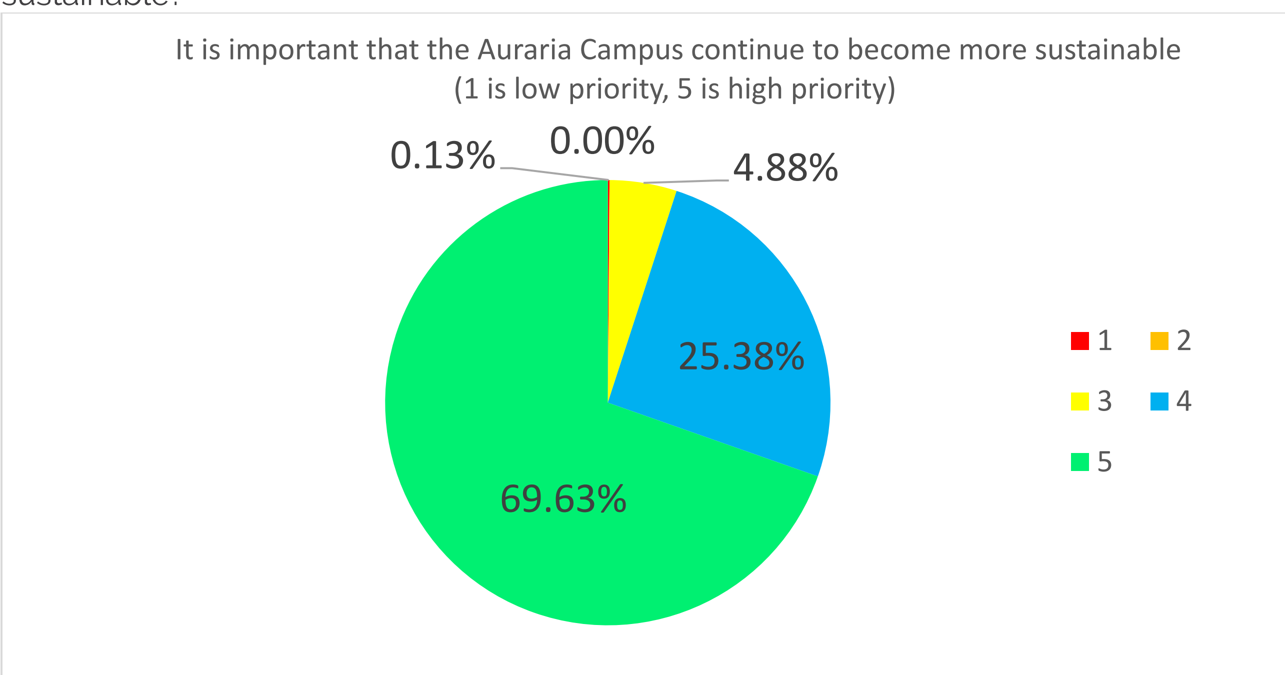

Figure 9: Student Survey Responses Fall 2021 – 802 responses (ASCP, 2021)

To gain a better understanding of what students valued most out of potential projects, we also asked 802 students "On a scale of 1-5 (where 1 is least important and 5 is most important), how would you rate the following sustainability focus areas?" Out of 11 total options, here are the results of the top results with the most 4's and 5's. Eliminate or reduce plastics on campus was number 1 in priority, followed by increasing alternative transportation access, increasing hard to recycle programs, and then adding more solar on campus.

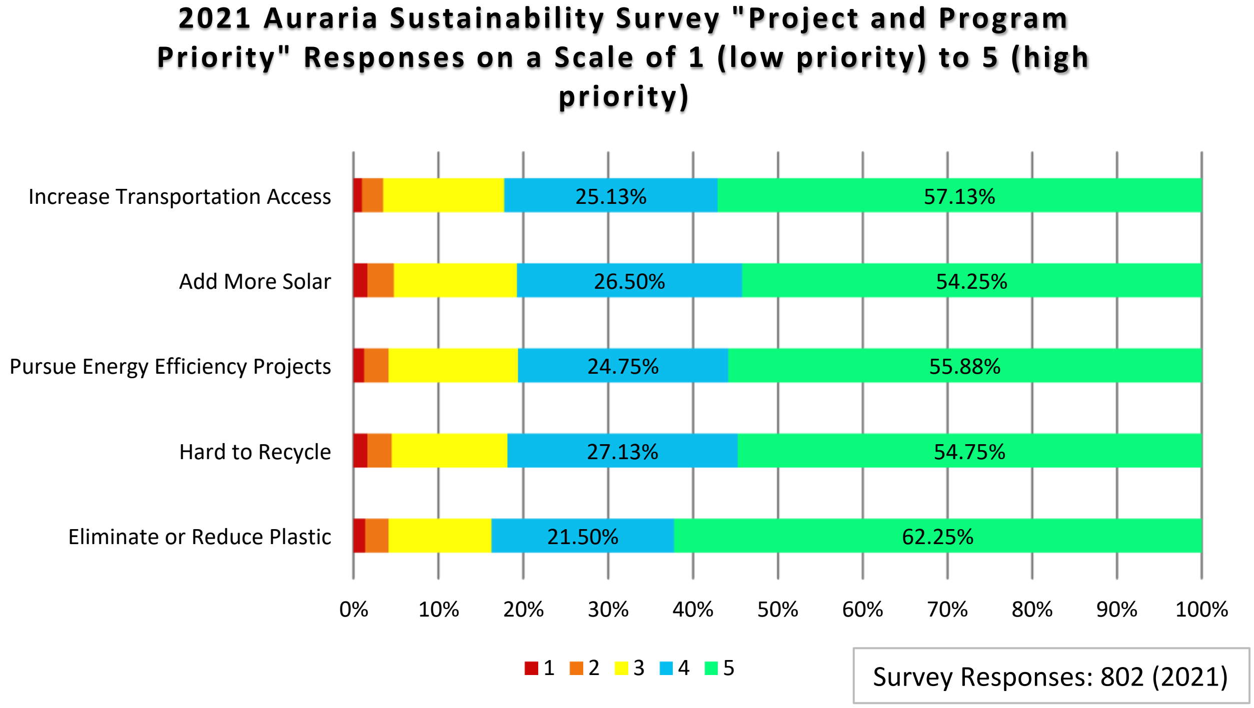

Figure 11: Student Survey Responses Fall 2021 (ASCP, 2021)

When we asked the same question and gave students our 7 pillars as the options, the results were slightly different but still highlight the importance of energy efficiency and renewable energy. Water conservation has the most responses ranking it as a 4 or 5, followed closely by Energy Efficiency and Renewable Energy.

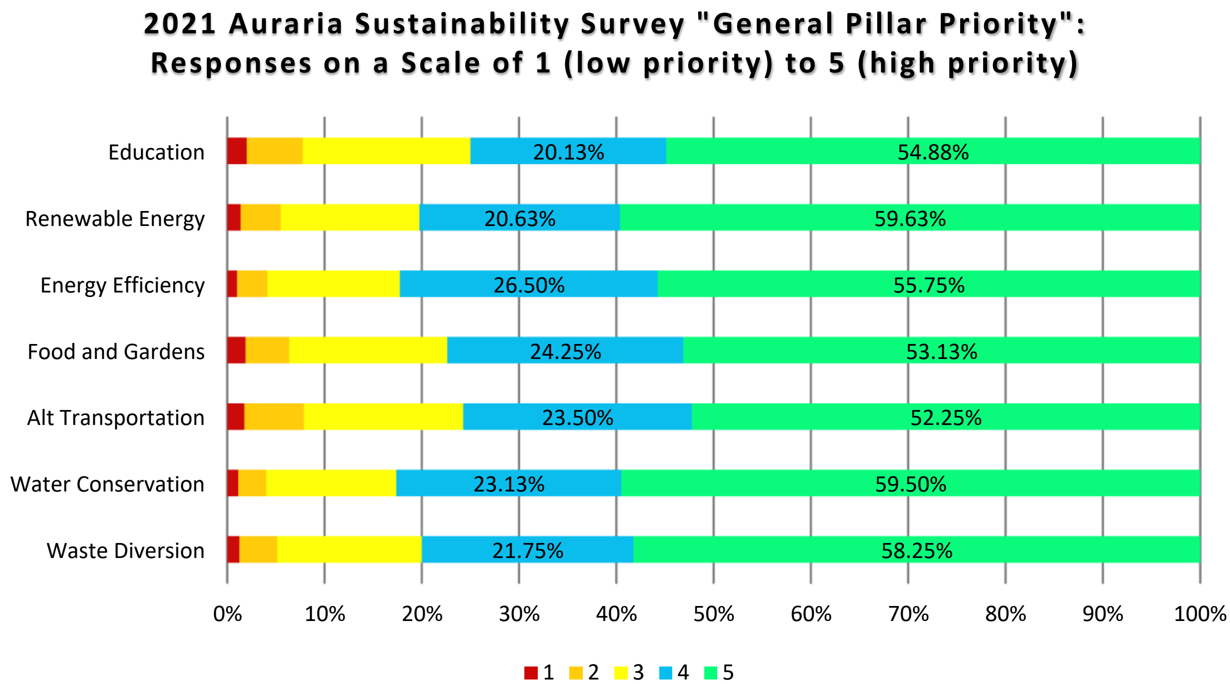

Figure 12: Student Survey Responses Fall 2018 (ASCP, 2018)

Climate Commitment

In 2011, all three institutions on the Auraria campus signed American College and University Presidents Climate Commitment (ACUPCC), committing them to reduce their carbon emissions as follows:

- 20% below 2008 (baseline) levels by 2020
- 50% below baseline by 2030
- 80% below baseline by 2050
- 100% below baseline by 2099
- **CU Denver used 2007 as a baseline year and did not commit to the final 100% reduction*

Update: The ASCP, in 2020-21, has developed a comprehensive Climate Action Plan that aligns with the city, state, and institutional goals while updating the urgency of our evolving situation. Climate change is a critical issue for students and our institutions, it's time to re-commit to an updated vision of becoming a leader in sustainability and greenhouse gas reductions. Our Climate Action Plan outlines exactly how we can do it and which goals are achievable.

Our students have even indicated that environmental sustainability is so important to them, that **over 2/3rds of respondents to our 2021 survey stated that sustainability had or would have had an impact on their choice of college or university (ASCP, 2021).** Our office can support the overall mission of the institutions on the Auraria Campus by helping recruit and retain students who may have otherwise chosen a different school.

6.2 Conclusion

The price of solar has plummeted, the urgency for reducing our reliance on fossil fuels has intensified, and the student body and leadership have all formally endorsed our progress as a program. Now is the time for an investment in solar and we believe purchasing the largest array we can with our cash on hand would be the more efficient use of funds.

Section 7: Resources

As mentioned in the executive summary, during this project we came across several in the process of compiling this report that would serve Auraria facilities, administration and future SCP team members in assessing solar potential in the future. We highly recommend that any internal AHEC staff consult these tools the next time we are in the preliminary phases of assessing potential solar production and cost.

Technical Assistance

- NREL's ReOpt Techno-Economic Analysis model and services/technical assistance partnership opportunities: https://reopt.nrel.gov/about/services.html. See campus planning here: https://reopt.nrel.gov/projects/index.html
- Unirac U-Builder Array Design/Modeling Tool: Design commercial scale (or other) arrays based on particular panels (we used REC's TwinPeak 25 72 Series) by drawing a polygon on a roof. Customize parts (inverter, ballasting, etc.) to make more precise. See Appendix E for an output example. http://design.unirac.com/tool/project_info/rm/
- PV Watts: https://pvwatts.nrel.gov/

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Appendix A: Array Size and kWh Output Calculation Methodology

To populate the figures in the building prioritization table, we deployed a number of techniques, software systems and resources in conjunction with one another. In the end, the most streamlined and common method (aside from receiving quotes directly from a solar company), ended up being the following:

1) Measure the available roof square footage using the ruler/measurement tool in Google Maps aerial view (measuring around obstructions)
2) Convert square footage to array size (kW DC) by assuming a *conservative* commercial production factor of 12 watts/ft² (ft² x 12 watts/ft² ÷1000 watts/kW)
3) Divide array size (kW DC) by a 1.2 load ratio (to account for system losses during inversion) to estimate kW AC
4) Multiply by 1730 (NREL's PVWatts estimation of available annual sunlight hours based on Aurora weather station) to estimate annual production (kWh)
5) Multiply potential annual production by $0.035/kWh (what AHEC pays for Primary General rate buildings) to calculate potential cost savings/revenue

In reality, however, there were several instances where we reconciled the results of multiple different strategies and imposed our reasoning and judgement to arrive at a figure that seemed most representative. A fully detailed list of strategies for populating the table (and beyond that, for producing the array mockups and annual production tables found above), are listed here:

- Roof square footage for most of Auraria's buildings was provided by Ken Ross. However, due to inconsistencies and uncertainty in the worksheet provided, roof square footage was almost always recalculated using the Google Maps measurement tool in aerial view. This manual method allowed us to capture *usable* rectangular areas (devoid of obstructions and shading from infrastructure) that would accommodate an array, not simply raw square footage. In some instances, square footage was taken from Unirac's automatic calculation after drawing a polygon on the roof of the building. However, it seems this method potentially overestimates roof square footage. Moving forward, measuring with Google Maps tool seems to provide the most accurate measurement of usable space.
- Array size (kW DC) was estimated by reconciling several different techniques, often simultaneously, to arrive at a figure:
  1) Using Unirac's U-Builder Design tool. This method involved drawing a polygon atop an aerial building image and selecting the specific panel type quoted to us by Namaste (REC's Twin Peak 25 72 Series 350 Watt), as well as a handful of other weather and building related specs. This method seemed to either overestimate production or occasionally be spot on.
  2) Based off of the nameplate rating, dimensions and specs for the solar panels and modules quoted in AHEC's most recent solar proposal from Namaste (Appendix D). Specifically, with 6.7 ft. x 3.3 ft. dimensions (about

21.603 square feet) and a 350 wattage output rating on REC's Twin Peak 25 72 Series panels, we used the following calculation to get from square footage to array size:

    a. Roof square footage/2.603 square feet per module x 350 watts per module /1000 watts per kW = kw DC output

3) Calculated based on square footage "Industry standard" outputs provided by solar installers in the Midwest (one claimed 12 watts/ft^2, one said 13 watts/ft^2, one said 16 watts/ft^2). We took the conservative tact and used 12 watts/ft^2 as our primary factor.

- Annual Production, when not directly calculated by assuming the 1730 sunlight hours mentioned above, was taken from NREL's PVWatts® tool or Urirac's U-Builder Design Tool. The vast majority of the time, we input our estimated array size (kW DC) into National Renewable Energy Lab's (NREL) PVWatts® software tool to calculate monthly and annual production.
- Roof Age was acquired from Ken Ross (in the instance of AHEC buildings) and from project managers (in the case of institutionally-owned buildings).

Appendix B: PV Priority List by Building/Lot

Note: The following figures were used for primary general, secondary general and blended rates, based on AHEC's Xcel bills and utility bill tracking in EnergyCap database: $0.038, $0.046, $0.078. These are subject to change over time depending on tariffs and fees and, generally speaking, $/kWh prices are estimated to appreciate annually by 1.5% (both our facilities team and solar consultant corroborated this assumption).

Average annual production (kWh) and average annual savings ($) were calculated as an average over an assumed thirty-year life span, accounting for a 1.5% annual increase in electricity rates and a 0.5% annual decrease in module performance.

Building	Priority	Roof Age	Roof Size	Potential Array Size (kw-DC)	Potential Array Size (kw-AC)	Average Annual Production (kWh)	Average Annual Savings ($)	Primary or Secondary (rates?)
Arts	0	1999 or 2003	149,889	75	63	115,350	5,454	Primary
Library	1	2016	100,580	711	593	967,072	45,727.45	Primary
Science	2	1994	35,000	258	215	346,713	16,394.11	Primary
West	3	1998	40,350	450	375	587,999	27,803.21	Primary
Central (+ ped bridge)	4	1999	30,000	300	250	391,999	18,535.47	Primary
CU Wellness Center	5	2018	28,000	260	217	339,733	32,973.61	Blended
CU Student Commons	5	2015	150,000	150	125	196,000	19,023.28	Blended
Cherry Creek	?	2002	72,750	700	583	939,304	91,166.54	Blended
Holly Parking Lot	P	?	12,300	1,107	923	1,485,442	70,238.28	Primary
Seventh St Garage	P	1996	150,000	826	688	1,108,245	52,402.75	Primary
Boulder Creek	?	1998	51,000	600	500	805,118	78,142.73	Blended
5th Street Garage	P	?	69,000	479	399	642,484	30,379.48	Primary
Confluence Building	?	?	37,975	456	380	611,487	59,349.43	Blended
North Classroom	?	?	32,400	389	324	521,716	24,669.07	Primary
PE Center	?	?	67,200	380	317	509,908	24,110.70	Primary
7th Street Classroom	?	?	20,800	250	208	334,929	15,836.93	Primary
Admin	?	2000	19,435	220	183	295,210	16,897.56	Secondary
Tivoli Parking Garage	P	?	51,800	200	167	268,372	12,689.84	Primary
King Center	?	2000	45,919	150	125	201,279	11,521.06	Secondary
Plaza	?	1999	26,705	150	125	201,279	9,517.40	Primary
Early Learning Center	?	?	10,800	130	108	173,905	8,223.02	Primary
Facilities Services	?	2017	8,835	120	100	161,024	7,613.91	Primary
Facilities Annex	?	2006	7,300	100	83	134,187	6,344.93	Primary
MSU Aerospace	N/A?	?	-	-	-			Blended
MSU Student Success	N/A?	?	-	-	-			Blended
Total			1,218,038	8,460	7,050	11,223,408	679,560.74	

Appendix C: Pro Forma Projections

Keep in mind that annual operating costs and maintenance are not the responsibility of the ASCP and are therefore not represented here.

Financial Summary: Library											
	Total	**$ 1,034,409.00**									
Year		1	2	3	4	5	6	7	8	9	10
System Output		1,039,000.00	1,033,805.00	1,028,635.98	1,023,492.80	1,018,375.33	1,013,283.45	1,008,217.04	1,003,175.95	998,160.07	993,169.27
Installation Cost											
ASCP	$ 1,034,409.00										
Revenue											
Electricity Savings		$ 39,482.00	$ 39,873.86	$ 40,269.61	$ 40,669.28	$ 41,072.93	$ 41,480.57	$ 41,892.27	$ 42,308.05	$ 42,727.96	$ 43,152.03
Total Savings over Term											
Projected Electricity Rate Increases (%)		1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Total Rate per kWh		0.038	0.03857	0.03914855	0.039735778	0.040331815	0.040936792	0.041550844	0.042174107	0.042806718	0.043448819

Summary

Total Project Cost	$ (1,034,409.00)
Total Energy Costs Avoided over 30 years	$ 1,371,823.52
Net for ASCP	**$ 337,414.52**
Total amount to be used on Energy Efficiency Upgrades	**$ 1,371,823.52**

11	12	13	14	15	16	17	18	19	20	21
988,203.43	983,262.41	978,346.10	973,454.37	968,587.09	963,744.16	958,925.44	954,130.81	949,360.16	944,613.36	939,890.29
$ 43,580.32	$ 44,012.85	$ 44,449.68	$ 44,890.84	$ 45,336.38	$ 45,786.35	$ 46,240.78	$ 46,699.72	$ 47,163.21	$ 47,631.31	$ 48,104.05
1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
0.044100551	0.04476206	0.045433491	0.046114993	0.046806718	0.047508819	0.048221451	0.048944773	0.049678944	0.050424128	0.05118049

22	23	24	25	26	27	28	29	30	Total
935,190.84	930,514.88	925,862.31	921,233.00	916,626.83	912,043.70	907,483.48	902,946.06	898,431.33	
									$ 1,034,409.00
$ 48,581.48	$ 49,063.65	$ 49,550.61	$ 50,042.40	$ 50,539.07	$ 51,040.67	$ 51,547.25	$ 52,058.85	$ 52,575.54	$ 1,371,823.52
									$ 337,414.52
1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	
0.051948198	0.052727421	0.053518332	0.054321107	0.055135923	0.055962962	0.056802407	0.057654443	0.058519259	

Appendix D: Additional Resources List

Cost Modeling Tools:

- https://www.cleanpower.com/products/wattplan/
- https://www.energyperiscope.com/
- https://pvwatts.nrel.gov/
- https://nccleantech.ncsu.edu/
- http://www.ongrid.net/index?page=tool_about

Financing Programs:

- https://www1.eere.energy.gov/wip/pdfs/commercial_pace_primer_revised.pdf
- https://www.energy.gov/eere/slsc/state-and-local-solution-center
- https://www.energy.gov/eere/slsc/develop-energy-plan
- https://www.energy.gov/eere/slsc/revolving-loan-funds

Third Party Loans energy.gov

- https://www.energy.gov/eere/solar/solar-energy-technologies-office
- https://www.energy.gov/eere/slsc/energy-savings-performance-contracting
- https://www.energy.gov/eere/slsc/bill-financing-and-repayment-programs
- https://www.energy.gov/eere/wipo/state-energy-program
- http://www.smartcommunities.ncat.org/municipal/financing.shtml

More resources from MREA

- http://www.solarendowment.org
- http://www.solarendowment.org/resources