Neighborhood-scale Energy System Transition Strategy Development
The Colorado Chautauqua Pilot Project

EXECUTIVE SUMMARY

The Boulder Chautauqua Energy System Transition pilot project is part of the Carbon Neutral Cities Alliance (CNCA) funded "Whole Energy System Transition Strategy Development" collaboration between three cities—Boulder, CO; Seattle, WA; and Minneapolis, MN. This group of cities, working with The Integral Group, has developed an energy system analysis and transition planning framework—the "Playbook" to help guide themselves and other cities towards the rapid de-carbonization of their energy systems.

The Boulder Chautauqua pilot project is the first attempt to apply the Playbook developed in this collaboration. The purpose of this pilot project was to apply the playbook in a real world setting with the intended outcome of an implementable plan that will result in a rapid transition off fossil fuels in all major energy use sectors of this "neighborhood" of the larger Boulder Community. The report that follows uses the basic framework of the CNCA Energy Transition Playbook. Several modifications to the playbook approach were developed to adapt the general guide to the specific circumstances encountered in this pilot project.

The successful transition of Chautauqua and other urban and sub-urban locations to a low emission, renewable energy-based system will require actions in three major areas: energy supply systems, building systems, and transportation systems.[1] This analysis focuses primarily on the energy source and building aspects of this transition. As noted in the report, the transportation aspects are currently the focus of an extensive Chautatuqua area transportation planning process being conducted by the City of Boulder Transportation Department. The results of that analysis and its recommendations will be integrated into this plan when completed.

The major finding of this project is the high potential to achieve deep emissions reduction through the implementation of locally generated solar energy integrated into the Chautauqua building network. A range of options exist to apply this approach. However, these options will be significantly impacted by the outcome of the city's current efforts to municipalize the electric infrastructure system within the city boundaries. Despite these factors, it appears a pathway is available for the Chautauqua neighborhood to implement energy supply and management systems that would significantly reduce its emissions impacts and potentially substantially improve its resilience to disruptions in the surround electric grid.

[1] Adapted from CNCA's Framework for Long-Term Deep Carbon Reduction Planning, 2015.

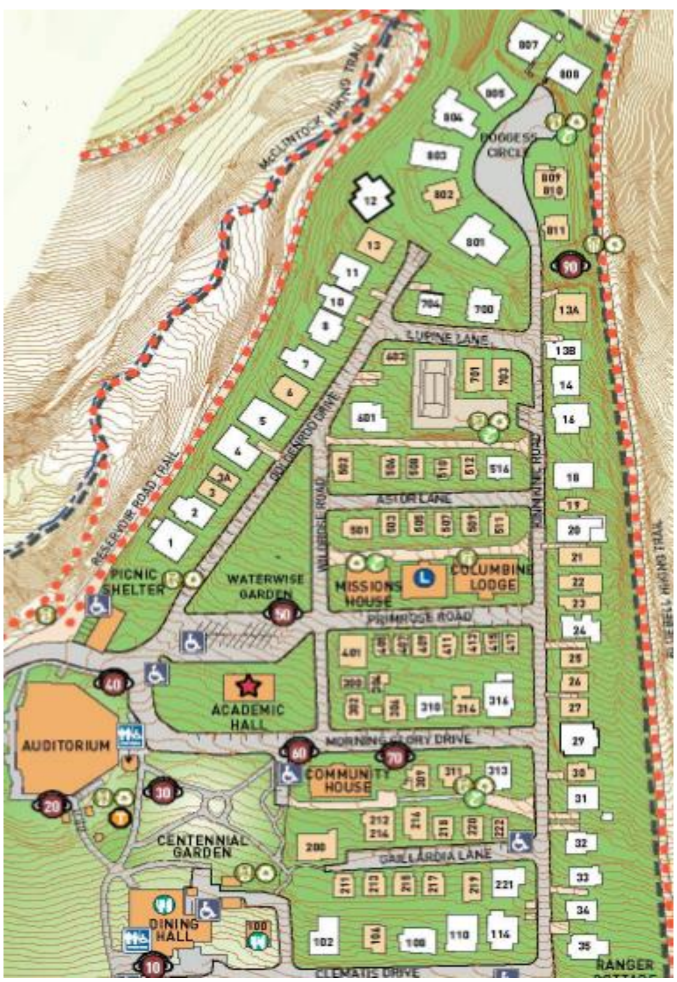
TABLE OF CONTENTS

I. **INTRODUCTION TO CHAUTUAQUA PROJECT**

a. **Background on Chautauqua**

Boulder has a long history and tradition of community driven initiatives to improve the social and environmental well-being of its community and the larger society. The iconic Boulder Chautauqua, perched on a hill overlooking the Boulder valley, is a symbol of this tradition. Founded in the 1890s as a summer teaching center and home to the growing movement of summer Chautauquas, these gathering spots were designed to bring arts, education and world awareness to rural and remote locations. The Boulder-based Colorado Chautauqua is now a national landmark and the only functioning Chautauqua remaining west of the Mississippi. The Colorado Chautauqua has also been a leader in exploring the implications of environmental awareness and stewardship. As part of its operations, Chautauqua has attempted to integrate best practices in energy efficiency, waste reduction and natural landscaping.

A unique feature of the Chautauqua site is its development characteristics. Originally developed as small summer cottages surrounding the main performance hall and a series of shared service community buildings, Chautauqua is in many ways a small community in itself, with a main dining hall, community building, administrative center and other both private and common facilities.



In the late 1890s, the Texas Board of Regents decided to establish a summer school for teachers in a cool climate. Located at the base of Boulder's Flatirons and one of only 25 National Historic Landmarks in the state of Colorado, the Colorado Chautauqua is one of only a few remaining chautauquas in the U.S. The Colorado Chautauqua is currently co-stewarded by the City of Boulder and the Colorado Chautauqua Association(CCA). The City leases 26 acres and the commercial buildings to the Colorado Chautauqua Assoc. which owns the Community House, the Missions House Lodge and the Columbine Lodge as well as 60 of the 99 cottages on the premises. The other 39 cottages are privately owned. All buildings are subject to Landmark Design Guidelines administered by the City of Boulder.

(www.chautauqua.com)

Map oriented with north facing down.

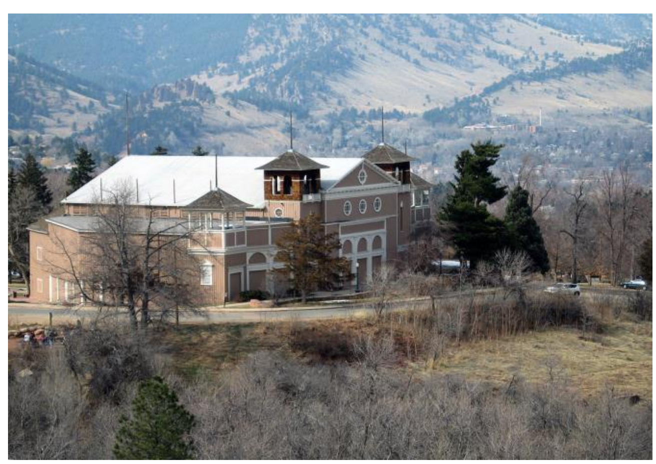
a. **Current Energy service and distribution –** The Chautauqua area is currently serviced by XCEL energy for both electricity and natural gas service and the City of Boulder for municipal water service. Each building has its own electric meter, gas meter and water meter, with a few exceptions. Most notably, there are several rental residential units with shared water meters. The multi-unit rental buildings have multiple meters to individual units, and the Auditorium is an un-conditioned space, used seasonally and has only electrical power. Privately owned cottages each pay their own bills, the Dining Hall bills are paid by the current leasing restaurateur, and the rest of the building's bills are paid directly by the Chautauqua Association.

b. **Buildings**

   i. **Building Typology -** The Chautauqua can be divided into three main categories of buildings with several subcategories:

1. Cottages	a. Private Owned Residences b. Chautauqua Owned Rentals
2. Community Buildings	a. Administrative Offices b. Mixed-Use Rental/Meeting Space
3. Commercial Facilities	a. Dining Hall Restaurant b. Auditorium Performance Hall

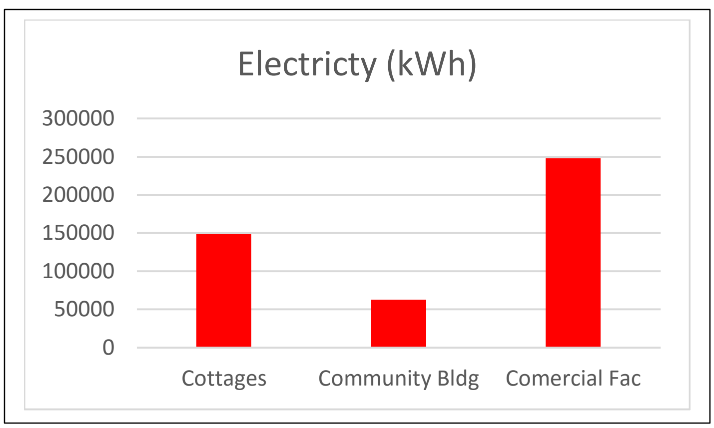


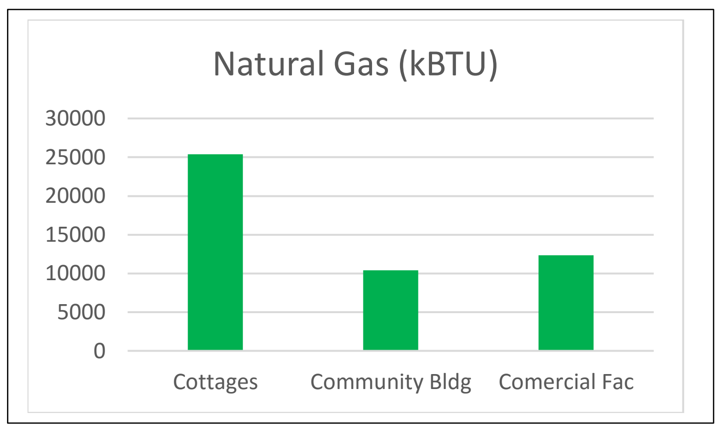



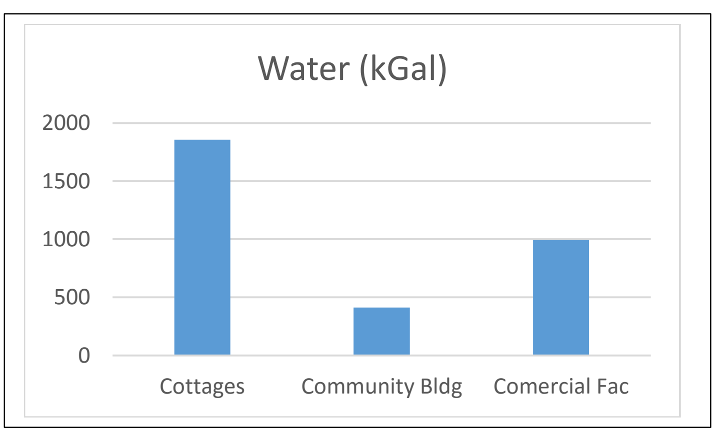
ii. **Energy Use by Type**

Below is a summary of the average energy use per month by building typology and energy source. Note that the Chautauqua actual usage is seasonal and will show great variation during different times of the year.

Building Type	Total Electricity Use per year(kWh)	Total Natural Gas Use per year (kBTU)	Total Water Use per year (kGal)
Cottages	**148,443**	**25,385**	**1,857**
Less than 500 SQFT	39,934	9,399	444
Btw 501 and 750 SQFT	55,876	6,028	623
Great than 751 SQFT	18,830	4,360	381
Private Residences various	33,803	5,598	409
Community Buildings	**62,691**	**10,401**	**411**
Columbine	5,191	3,474	139
Missions House	7,060	1,597	91
Community House	13,259	4,021	139
Office Building	37,181	1,309	42
Commercial Facilities	**247,858**	**12,348**	**992**
Auditorium	4,978	n/a	n/a
Dining Hall	242,880	12,348	992
GRAND TOTAL	**458992**	**48134**	**3260**







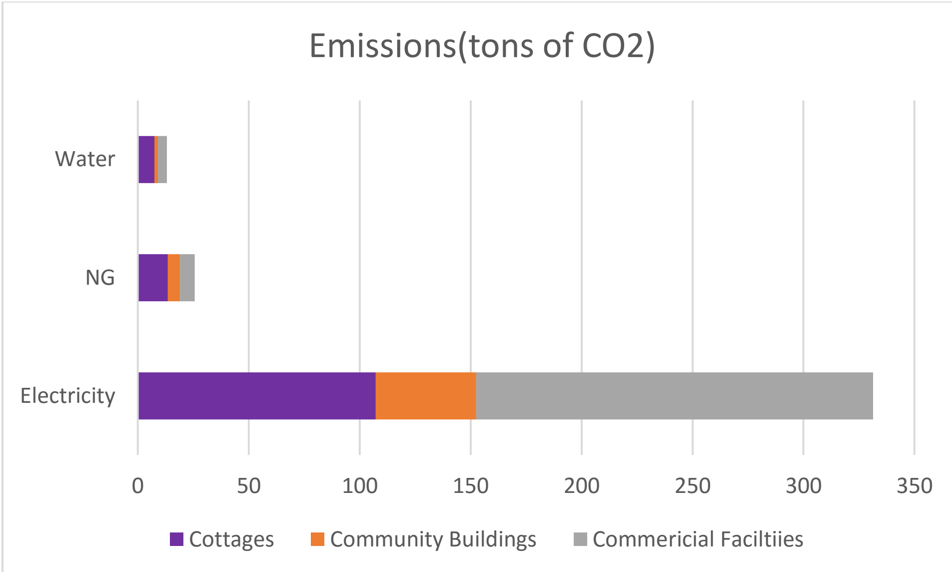
iii. **Improvements implemented to-date –** The Colorado Chautauqua was designated as a national historic landmark in 2006 and is therefore subject to the specific restrictions which accompany this designation. With that in mind, several **energy efficiency and comfort upgrades** that have been implemented over the past few years. These include: converting crawl spaces and attics to conditioned spaces by installing air sealing; adding continuous vapor barriers; installing insulation; and adding venting. In addition, staff have replaced almost all lighting fixtures with LED lights, including recent theater quality Auditorium lighting upgrades. **Water conservation measures** have included: water sensing plumbing fixtures; smart irrigation controllers; and aerator installations. **Other measures include**: installation of high efficiency whole house fans with night cooling strategy; installation of high efficiency tank-less water heaters; and installation of high efficiency sealed combustion heating equipment. Staff has verified the effectiveness of these upgrades through third party testing for efficiency using of a blower door and IR technology. A number of useful lessons learned around efficiency upgrades in this historic development setting are outlined in APPENDIX A.

c. **Transportation –** The CNCA playbook is intended to examine and formulate strategies around all aspects of a locations energy system—energy supply systems, building systems and transportation systems. This pilot was originally intended to cover all three of these areas. However, the transportation section of this study has been postponed to incorporate a major transportation analysis being conducted by the City of Boulder's Transportation Department as part of the Chautauqua Neighborhood Access Management Study. Because of the extensive community engagement taking place in the larger neighborhood area, the transportation analysis for the Chautauqua area will be incorporated in this more comprehensive process. The final results of this transportation area planning initiative will be integrated into this analysis when available in late 2016 or early 2017.

The end objective for this pilot project is the development of an assessment sufficient to inform the development of an RFP for specific elements of the implementation strategy that begin to implement this energy transition strategy. The remaining sections of this report outline the results of the analysis that will be incorporated into the documentation that will support that RFP.

III. BASELINE EMISSIONS

Building Type	Tons of CO2 from Electricity	Tons of CO2 from NG	Tons of CO2 from Water	Total all Sources
Cottages	107	14	7	128
Community Buildings	45	6	2	52
Commercial Facilities	179	7	4	189



IV. SPHERE OF INFLUENCE ANALYSIS

The role of the Sphere of Influence Analysis, as outlined by the "Playbook" guide for energy transition planning, is to determine the levels of influence or control that a municipal government has over key aspects of an energy transition strategy element e.g. building codes, energy supply, transit system etc. However, as noted in the Playbook, the full implementation of an energy transition will require the active involvement of a wide variety of entities, interests and actors. Each has different levels of control around each of the many factors that are in motion in an energy transition process.

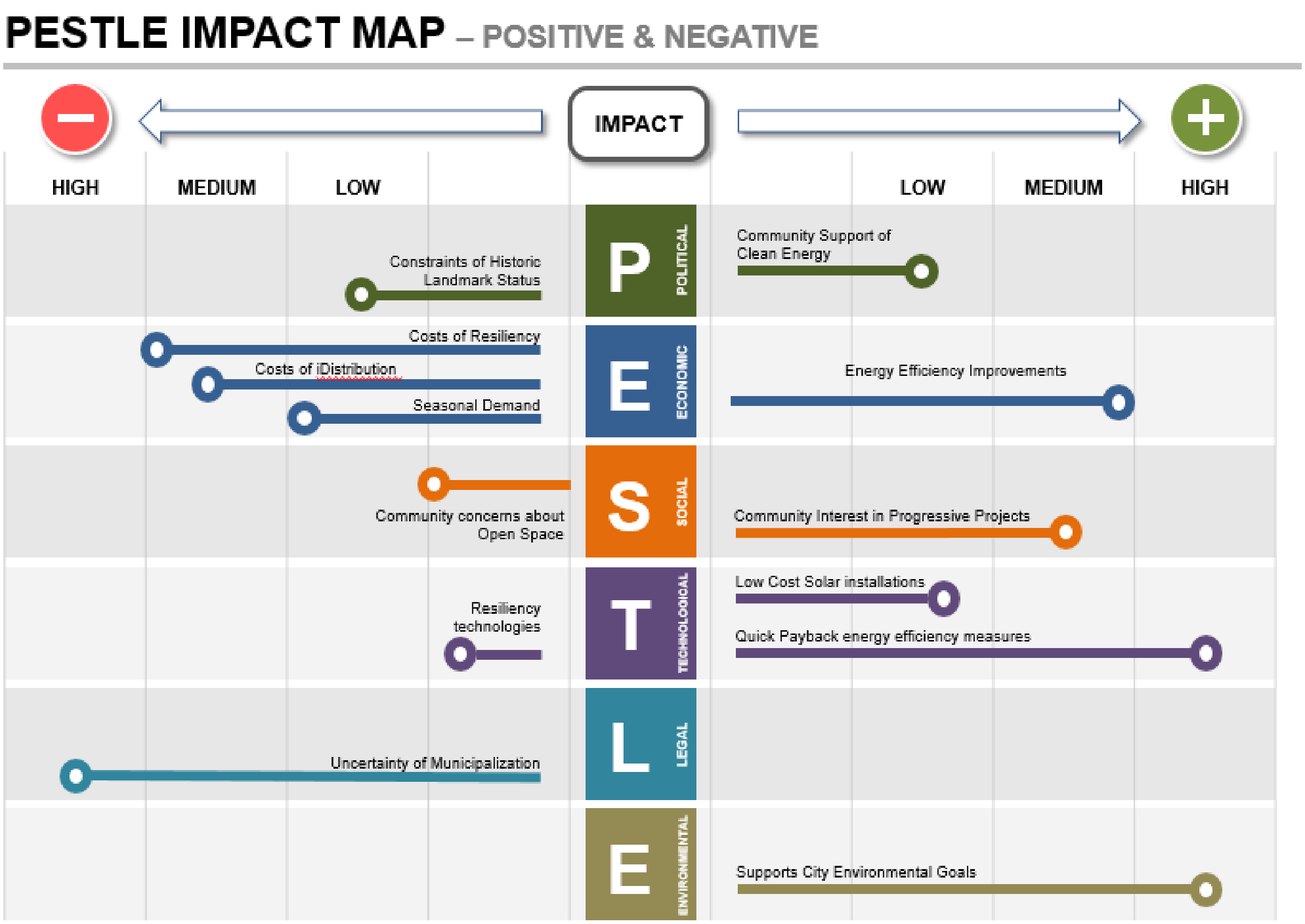
This multidimensional impact of multiple actors within a process made the application of the Sphere of Influence Analysis a less useful element of the Playbook in the Chautauqua pilot. For example, while the City of Boulder owns the underlying property upon which the Chautauqua sits, the Chautauqua Association controls major elements of the built environment. At the same time, Chautauqua's historic status introduces a whole series of additional actors that each change the balance of control over building uses that limit both the city and the Association.

Finally, a major factor affecting the choices available to both the city and the Association depend on the outcomes of efforts currently underway to municipalize the electrical services within the city boundaries. The very different options available under each of these scenarios are outlined in the PESTLE analysis outlined below.

Based on these factors, the project team focused more on the stakeholder and PESTLE analysis tools to determine key barriers and opportunities than on the Sphere of Influence mapping process.

V. BARRIERS AND OPPORTUNITIES IDENTIFICATION—The PESTLE Analysis

As part of developing a systematic approach to identifying the barriers and opportunities that could affect the viability of implementing an energy transition strategy at Chautauqua, the project team utilized the PESTLE tool outlined in the CNCA Playbook. The PESTLE tool offers a useful framework for identifying the different kinds of factors that should be considered when evaluating strategies and their feasibility in a broad range of environments or spheres. Answering key questions about the Political, Economic, Socio-Cultural, Technological, Legal and Environmental nature of a neighborhood will allow municipal governments to tease out the different factors and forces that can affect the outcome of various carbon reduction strategies. The key factors considered and their relative impacts on the project are depicted in the graphic below.



a. Key Issues Impacting Project Implementation – Electric Utility Management

Of all of the barrier and opportunity factors considered in this analysis, the single most influential consideration is the outcome of the current city effort to form a municipal utility. Because of the existing utility policies of both the State of Colorado and the current incumbent electric utility, Xcel, many of the key actions that are necessary to implement the energy transition strategy identified in this project will be determined by which of these two utility scenarios takes place. The major characteristics of these two scenarios are described below.

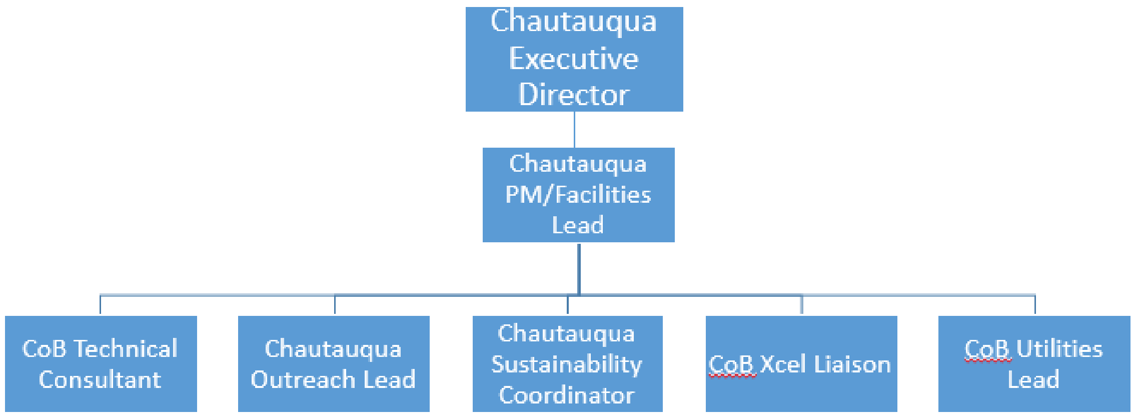
i. **Current utility scenario** - As of the summer of 2016, the City of Boulder is supplied electrical energy by Xcel Energy. Since Colorado does not allow more than one utility to provide retail service to a specific area, customers within Boulder city limits have no choice in who provides them with power. This Buyer-Seller arrangement with Xcel is governed by very strict rules and regulations that dictate the allowed installation and connection of non-Xcel owned generation. This means that even if a solar project is theoretically, technically and economically feasible, it may not be possible to execute based on the legal restrictions of the current system. Examples of these restrictions include such limitations as:
   - To qualify for net energy metering (an accounting mechanism that significantly improves the economics of many photovoltaic (PV) projects), the annual power output (kWh) of an on-site PV system can be no greater than 120% of the total customer usage from the previous 12 months.
   - An individual customer (such as the City of Boulder) cannot install a net metered solar system at one location (such as on top of downtown parking garages) and use the output to offset consumption at other locations.
   - Customers cannot sell their excess solar generation to neighbors (e.g. Neighbor A has a large unshaded roof ideal for rooftop PV while neighbor B has a small, shaded roof not suitable for PV).
   - A single customer can subscribe to no more than 60% of the output of an individual community (off-site) solar project.
   - Customers can only purchase the output of a community solar project built within the county or a neighboring county of their home or business.
   - Customers with on-site PV that take advantage of ratepayer-funded solar incentives cannot keep the Renewable Energy Credits (REC)

ii. **Municipal utility scenario -** The city has remained open to partnership with Xcel, and has continued to offer suggestions on how both organizations could partner to form the electric utility of the future, but it has also considered separately creating its own municipalized utility. This removes most of the legal restrictions as listed above, one exception being prior community solar lease agreements which are 20 year contracts. It would also allow the city to take advantage of some ancillary services.

VI. ENGAGEMENT PROCESS OVERVIEW

In order to complete a feasibility study, it is crucial to understand resource needs and outreach requirements. A project team was assembled to assess these areas.

a. Project Management Team – The project management team was composed of experts in each functional area of the project scope.



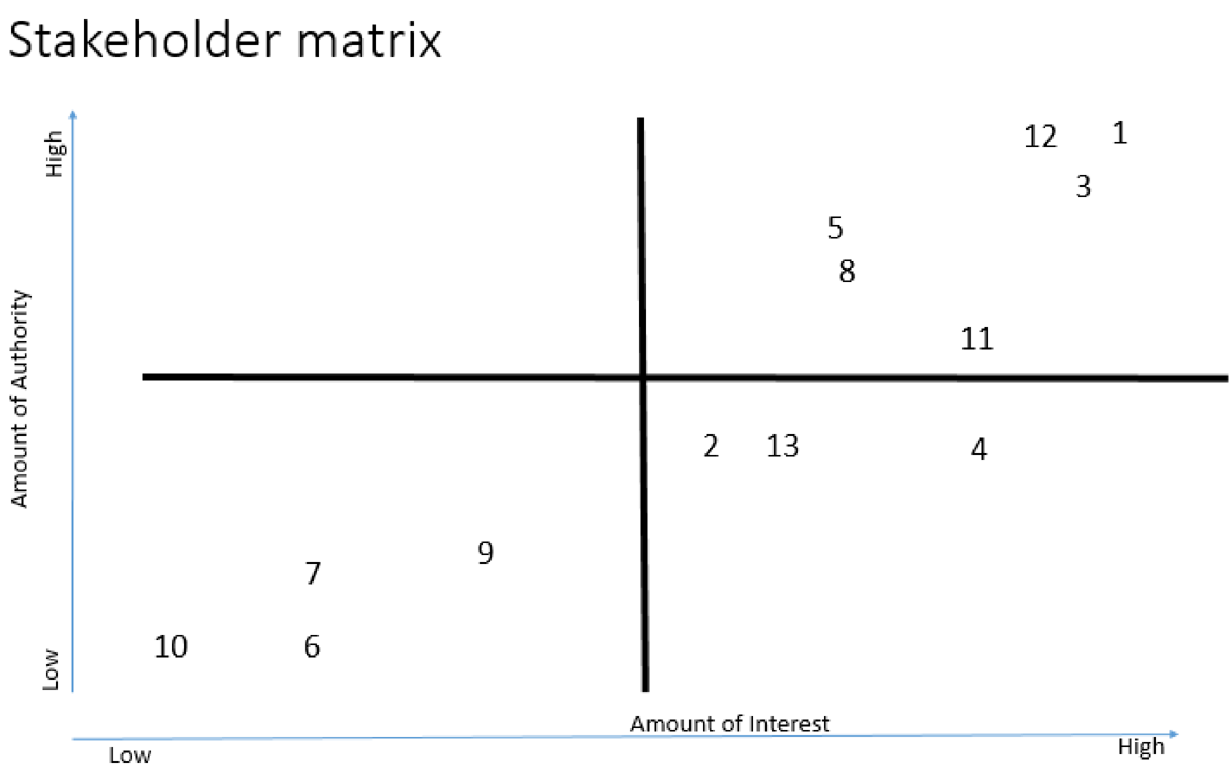
Role	Responsibilities
CoB Technical Consultant	Available to PM for consulting on PMP and coordination with CoB and overall CNCA process including development of communication materials.
Chautauqua PM/Facilities Lead	Owns overall project management plan, budget and schedule. Owns coordination of pre-planning facilities information and oversight of construction activity planning
Chautauqua Outreach Lead	Lead outreach and communication to stakeholder group.
Chautauqua Sustainability Coordinator	Assist with coordination of information and project implementation
Chautauqua Executive Director	Support CNCA project including liaison with board. Identify any high level risks to project completion.
CoB XCEL Liason	Support understanding contract with XCEL, identifying any conflicts with project planning and XCEL contract.
CoB Utilities Lead	Support construction activities as they relate to CoB Utility Infrastructure.

b. Outreach Strategy - One of the first activities completed was a stakeholder analysis. The Chautauqua site is particularly complicated due to the variety of building owners, types of buildings, historic landmark status, adjoining park, and its age. Below is the table and chart resulting from that stakeholder analysis. The middle two columns are hidden to protect sensitive information provided by stakeholders during the engagement process.

Stakeholder Identification Template

	Organization/ Rep Name	Authority over Project	Interest in Project	Engagement Required by Phase
1	Coloardo Chautauqua Association	Primary decision making	Accountable for stewarding Chautauqua	Phase 1-Brief email describing project and future opportunities to learn more
2	Friends of Chautauqua/Historic Boulder	No authority, could raise public concern	Concerned about over development of Chautauqua	Phase 1-Brief email describing project and future opportunities to learn more.
3	Residents	Individual authority over their own cottage, also could band together	High interested changes in operation/billing/ viisual impacts	Phase 1-Live meeting describing project and future opportunities to learn more
4	Friends of a sustainable	No authority, could raise public concern with legal action		Phase 1 – Brief email describing project and future opportunities to learn more.
5	Landmarks Board	Authority to approve changes to external aspects of facilities		Phase 1 – already aware nothing further until Phase 2
6	National trust green lab	No authority	May have synergies with funding for project	Phase 1 - None until Phase 2
7	City Utility Group	No direct authority	Will likely need to assist in the execution of the project	Phase 1 – already aware nothing further until Phase 2
8	History Colorado	Limited authority over historic preservation of facilities	Likely only interested in minimizing visual changes	Phase 1 – Brief email describing project and future opportunities to learn more.
9	Dining Hall Operator	None	Effect of energy efficiency on operations in dining hall	Phase 1- None until Phase 2 or 3
10	Music Promoter	None	Possibly none – maybe incentivize EE practices	Phase 1- None until Phase 2 or 3
11	Chautauqua coordinating team	No direct authority	Interest in how their support will be required for implementation	Phase 1 – Brief verbal update , describing project and timeline for future updates
12	Boulder City Council	Primary authority for City staff	Interested as the project supports City Planning goals	Phase 1 – already aware,
13	Open Space and Park Departments	Primary Authority for surrounding land	Land use	Phase 1 – Live meeting to understand constraints

c. **Results of Outreach –** Initially the project team placed each stakeholder on a 2 x 2 matrix which indicated interest and authority over the project. The team began outreach based on the prioritization of this matrix. Initial results indicated, in certain cases, the team incorrectly assessed the placement of the stakeholder in the matrix. As such, while the team assumed some stakeholders were expected to have a high interest throughout the process, some were found to be appreciative of early engagement. As a consequence they were not interested in the more detailed discussions of early stage project anlaysis. Conversely, there was a greater level of concern than expected from departments within the city who have jurisdiction over the utility infrastructure or the use of adjacent land. These concerns arose in understanding the implementation of future plans. Because some of those details will not be determined until a full Request for Proposal (RFP) process has been completed, it left a level of uncertainty about the level of support from these work groups within the city. Again, definitive dates and points of re-engagement helped to alleviate immediate concerns



Note: Number correspond to the stakeholder table on the previous page.

VII. ACTION PLAN

There are three primary areas for action in the development and implementation of an energy transition plan: substitutions of renewable energy sources for fossil fuel sources; improvements to buildings and associated energy uses; and changes in transportation systems the alleviate the need for fossil fuels. As noted above, the transportation elements will be addressed as part of the larger area transportation plan currently being developed by the city's Transportation Department. Building improvements will continue to take place at Chautauqua, but many of the most productive actions have already been taken in this area. Of the three focus areas, this action plan focuses primarily on the development of new low carbon energy supply, distribution and management options that can rapidly reduce the carbon intensity of the energy used in the Chautauqua community.

a. **Energy supply -** There are several types of renewable supplies available. One solution outlined below is to maintain the existing utility provider, in this case with many renewable supply solutions available, but those decisions would be made by the utility. The scale of this project limits the local potential solutions to solar. Wind at this scale is not found to be economically viable, space restrictions prevent even a viability study for geothermal or biomass and solar thermal is also currently not cost-competitive with solar panels. With the assumption of solar panels being the only viable solution for this project, location and configuration of the panel array become the most important considerations.

    i. **Generation and Delivery options**

        1. **Existing Utility –** It would be completely viable to maintain the existing electricity provider, if the provider intended on moving towards 100% renewable energy. To date, XCEL is currently at 25% renewable energy supply and plans to move to 40%. There are no published plans past that level, so it is not possible to achieve our goals with this scenario.
        2. **Community Solar –** Several local companies are developing community solar gardens. These sites typically generate around 2 MW of solar power to which any customer may subscribe. Community solar still uses the existing infrastructure of poles and wires to transmit electricity and so, while it is renewable, it is no more reliable than the existing grid.
            a. **On-site –** Developing a new community solar project at the Chautauqua facility was considered, which would leave flexibility for future micro-grid by which Chautauqua could supply all of its energy on-site, however, four to six acres of land are required to develop a community solar project and this would violate current open space regulations in the City of Boulder.
            b. **Off-site –** Currently, Colorado regulation allows customers to subscribe to community solar developments which are physically in

the same county or an adjacent county to the physical location of the customer.

In this solution, the community solar develop finances the project, but the contracts with the customer are typically 20 years.

3. **Local Solar –** Chautauqua has several options to develop solar energy supply on-site. Several buildings have rooftops that are structurally stable and have sufficient solar exposure.
    a. The water pit storage area offers two acres of flat roof area just a few feet above ground, which provides an ideal site for a solar panel array. This provides the most synergies in construction and installation, however, because of current Public Utilities Commission (PUC) rules, we cannot simply run a single wire down into the park and then interconnect each building and transmit power where needed. We must run the supply to the individual meters. The water storage roof is capable of housing a 500kW system which consists of 1495 individual Sun Power SPR-P17-34-COM 340-Watt modules which would provide just over 700,000 kWh/yr. However, we will actually be limited to 120% of the typical use of any meter connected to the supply, the maximum amount we could actually install would be 528,000 kWh which would be a 350 kW system.
    b. A majority of the individual buildings are suitable for solar panel installations. The two major exceptions being the Auditorium (previous structural analysis show insufficient load capacity) and the Community House (roof design includes dormers making panel installation difficult). In most cases, roof space is sufficient to power 100% of that building's demand. The biggest exception to this is the Dining Hall facility, which is a year-round, fully functional restaurant and draws over 50% of the entire load.
    c. Based on the inability to supply the Dining Hall with sufficient solar from its roof, the solution of multiple locations was reviewed. This solution has the least amount of synergy in construction but will allow for 100% of energy to be generated on-site. From a preliminary assessment, it appears as if the energy supply could be matched as follows:

Academic hall – 50% from rooftop, 50% from adjacent Picnic Structure
Auditorium – 100% of energy supplied from adjacent Picnic Structure
Columbine House – 100% from rooftop
Community House – 100% from water storage area, or new covered parking
Dining Hall –100% from water storage area mounted solar
Missions House – 100% from rooftop

d. **Solar installation details –** There are several methods by which solar panels can be installed and connected to a distribution and/or storage network(s). Each of these methods has technical and economic advantages and disadvantages. These configurations are highlighted in Appendix A. These details are critical for the detailed design and budgeting aspect of the project.

ii. Resilience options – In addition to achieving carbon neutrality, this project strove to provide the highest level of resilience possible. Resilience in this case means that the supply and distribution reliability are NOT correlated to the grid reliability.

1. **Battery storage** - Battery storage for each individual building was reviewed. Based on the configuration of the solar installation, the amount of supply from the batteries will vary. In most cases it is possible to provide full resiliency, i.e. all critical loads could be continuously supplied (assuming no more than one full day of no solar radiation). However, battery storage quickly becomes uneconomical based on its amount of use. Batteries have the disadvantage of needing to be charged before they can supply power and so, without grid power, they are at the limitation of the attached solar supply, as such they cannot scale their production.
2. **Hydrogen Fuel Cell** - Hydrogen fuel cell can be installed and used for back-up energy supply in place of batteries. These installations are currently ~15% more expensive in initial install, but because they run on natural gas supply they are inexpensive to operate and can scale instantaneously. While a hydrogen fuel cell will have zero emissions, its natural gas fuel source is not considered renewable.
3. **Other renewable fuel based generator** - While there are other renewable fuel based generators for peak back-up load, these require the delivery of the alternative fuel and move the project further away from local resiliency and thus have not been considered.

iii. **Regulatory context**

1. **Potential Configurations- Removing the Current Regulatory System** -The current regulatory structure limits the potential solutions in two major ways. First, if the legal limitations were removed on matching supply and demand by each individual meter, the most optimal system could be designed by matching supply and demand at the aggregate level and allowing for a fully functioning micro-grid. For example, if the roof of the Columbine House could support twice the amount of solar that it consumed, then the extra supply could be fed to an adjacent building. Or, all of the energy supply could be mounted at the water storage area and connected via a single powerline to the Chautauqua grid and provide power to each individual meter as needed. This in turn would have the least effect on structures with the Landmark designation. Secondly, if the City of Boulder were to municipalize and control its own electricity system, installations such as this project could additionally supply ancillary services.
2. **Uncertainty of Regulatory System -** In order to mitigate the impact of the uncertainty of the regulatory system, it is possible to execute this project in phases. For example, it would be possible to address the larger commercial loads as a single initial project, and delay the residential loads until there is a better understanding of potential adjustments to the regulatory system which would reduce the cost of bringing residential loads to a carbon neutral status

b. Buildings – Buildings are what generally drive our energy consumption. As previously described, it is critical to perform an accurate and comprehensive energy efficiency assessment and address as many energy saving improvements as possible. Another critical aspect to becoming completely carbon neutral is to remove natural gas loads. This can be very difficult and may not be immediately cost effective depending on the current price of natural gas. In this preliminary feasibility assessment, considerations were made to understand the potential of increasing on-site solar supply and transitioning natural gas loads to electric loads once electricity was supplied from carbon neutral sources.

c. Transportation – Similar to buildings, the other cause of carbon emissions is transportation. Personal combustion engine vehicles create one of the largest sources. As previously noted, Chautauqua is unique in that almost all of its transportation is tourist based and thus does not follow typical use patterns. Thus, typical solutions such as mode shifting, electric car adoption, and reducing the number of miles traveled cannot be implemented in the usual manner. The greater area transportation study, which is being run by the City of Boulder in parallel to this work, will incorporate solutions for Chautauqua.

d. Preliminary feasibility assessment

i. Criteria - The following criteria was used to assess each of the technically potential solutions.

Cost The total cost of the system including upfront capital cost as well as operating costs
Reduction of Emissions The ability of the system to reduce Chautauqua's carbon emissions to zero
Complexity of Procurement Process The number of different parties and or contracts that need to be engaged in order to implement solution
Amount of Resiliency The number of critical loads which can be supplied solely by the proposed solution
Complexity of Construction Required The number of different locations/facilities/buildings which will be effected by the proposed solution and the difficulty of the installations.
Lack of Impact on Landmark buildings The impact the proposed solution has on any entity with Landmark status. (To keep the scoring consistent this is listed as a "lack of impact" where by a darkened circle indicates the best or no impact and an open circle indicates the worst or a lot of impact.)

ii. Ranking of Criteria - The chart below represents a relative comparison of each of the vetted solutions. The criteria were rated from 0 (least) to 4 (most) advantageous. This initial ranking only rates the criteria relatively based on each solution. The next phase of the project will include weighting these criteria based on the overall project goals.

POTENTIAL SOLUTIONS	Cost	Emissions	Procurement	Resiliency	Construction	Landmark	Total
Water Tank	2	2	3	2	3	4	16
Water Tank w/battery	1	3	2	3	2	3	14
Rooftop	3	2	2	1	2	1	11
Rooftop w/battery	2	3	2	2	1	0	10
Mixed	2	3	2	3	2	3	15
Mixed w/battery	1	4	2	4	1	2	14
Community Solar offsite	4	3	4	0	4	4	19
Community Solar off w/battery	3	3	2	2	3	3	16
Community Solar on-site	3	3	2	0	1	1	10
Community Solar on w/battery	2	3	2	2	0	0	9

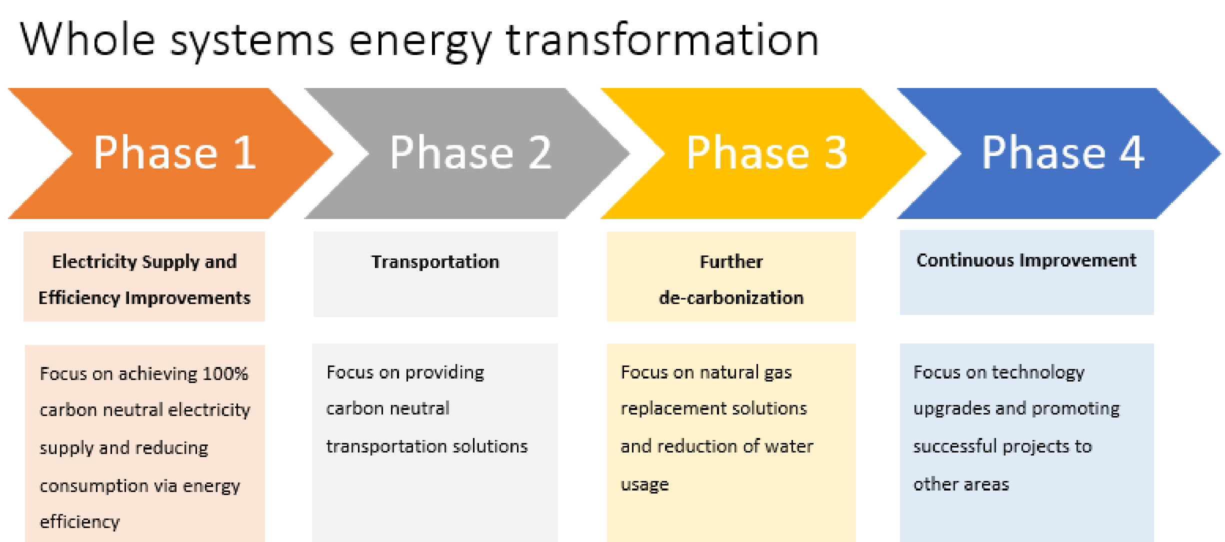
VIII. ACTIONS FOR FURTHER ANALYSIS

In order to beginning to prepare an RFP, a more detailed design and cost analysis will need to occur on the top two design options. This would include:

- Further stakeholder analysis
- Solution selection from among all possible technical solutions
- Solution approval
- RFP preparation, including the determination of specific timing and schedules. This would also include a more refined budget value and financing options
- Implementation
- Project close-out

IX. OVERVIEW OF NEXT STEPS

The overall focus of actions described in this report can be described as Phase 1 of a four stage process. This larger timeframe is shown in the graphics below. A detailed description of the remaining tasks anticipated to complete Phase 1 are outlined in the table below.



Remaining Phase I Task Plan

TASK	TARGET DATE
STAKEHOLDER ENGAGEMENT	
Vet proposed solutions with required stakeholders	OCT '16
SOLUTION SELECTION	
Confirm Top 2 solutions	NOV '16
Identify barriers (policy, cost, operational) to potential solutions	DEC '17
Complete detailed design on Top 2 solutions	JAN '17
Review Top 2 solution plans	FEB '17
Select solution including financing plan	MAR '17
SOLUTION APPROVAL	
Solution report	APR '17
Approval process	MAY '17
RFP PREPERATION	
Prepare detailed RFP for selection solution	JUN '17
Selection contractor(s)	JUL '17
IMPLEMENTATION	
Develop Project Managment Plan	JUL '17
Order long lead time items	AUG '17
Develop key performance indicators	SEPT '17
Begin construction (*critical to wait for off-season)	SEPT '17
End construction	NOV '17
PROJECT CLOSE-OUT	
Finalize project/lessons learned	DEC '17

APPENDIX A – Energy Efficiency Improvement Guidelines

1. Lighting –

   It is typically worth it to replace incandescent lights immediately with LED lights, rather than waiting for the old bulbs to burn out. Your utility provider may provide free assessments which give your exact payback times and rebates for the purchase of higher efficiency lighting and fixtures.

2. Occupancy Sensors –

   Occupancy sensors are typically easy to install and provide a method to increase savings which removes the human behavior component.

3. Thermostats
   a. Smart thermostats are typically an easy installation and provide a similar benefit to occupancy sensors. However, in older buildings it is likely that constant power wire was not run and it is possible the thermostats have mercury in them. In this case, it may not be advantageous to replace them.

4. Pipe Insulation

   This is an extremely easy and inexpensive way to cut down on wasted heat.

5. Window Film

   Adding window film reduces heat from natural lighting while still allowing illumination. Rebates are often available via your utility provider. Many products are now not visible to the naked eye.

6. Air Sealing

   Maintaining a tight building envelop seal is one of the most critical activities to reducing energy use. However, this gets increasingly difficult with the age of the building.

7. Service Equipment

   Rebates are typically available for EnergyStar® products. All appliances and service equipment should be EnergyStar® rated

8. HVAC Equipment

   Your utility provider will typically offer assessments of HVAC equipment and can help with replacements or operation optimization.

9. Aerators

   Adding aerators to water faucets is an easy way to reduce water use.

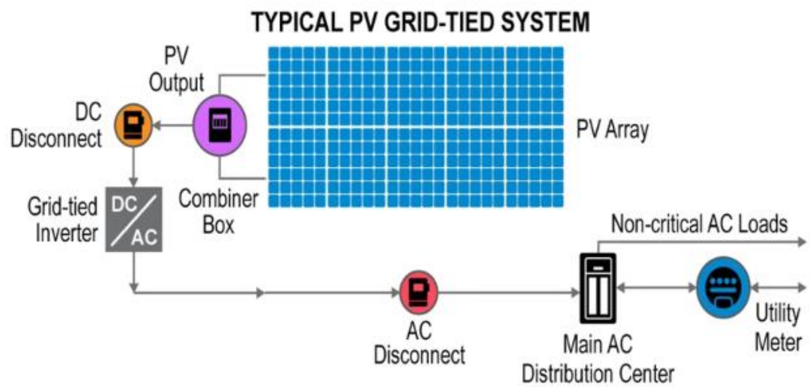
10. City Program

Your city may also offer: rebate programs, free energy assessments, incentive for efficiency improvements, and/or resources to implement improvements.

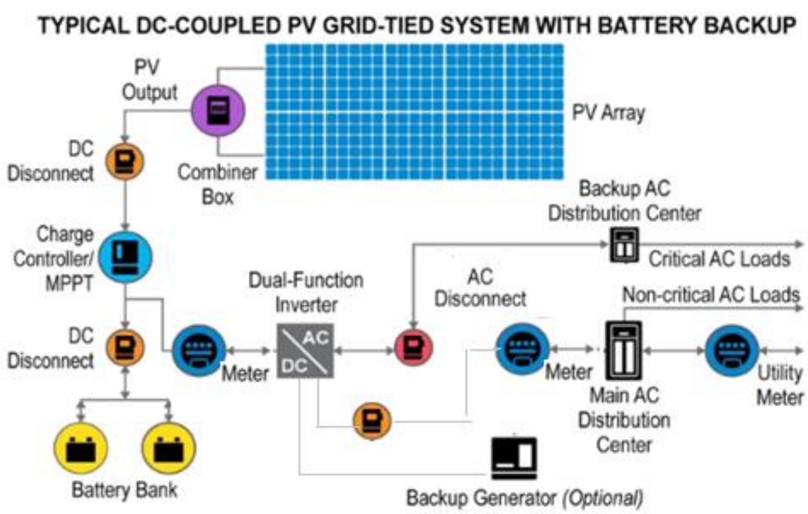
APPENDIX B – Solar Installation Details

In order to determine the technically feasible solutions, it was necessary to go through a preliminary design. Working with a variety of developers and installers, the following information was collected while determining the potential solar supply, the estimated demand and the optimal way in which to configure a supply and distribution system. With the assumption of solar panels being the only viable solution for this project, what becomes important is the location and configuration of the panel array. Below are diagrams of the three most common ways to install solar panels.

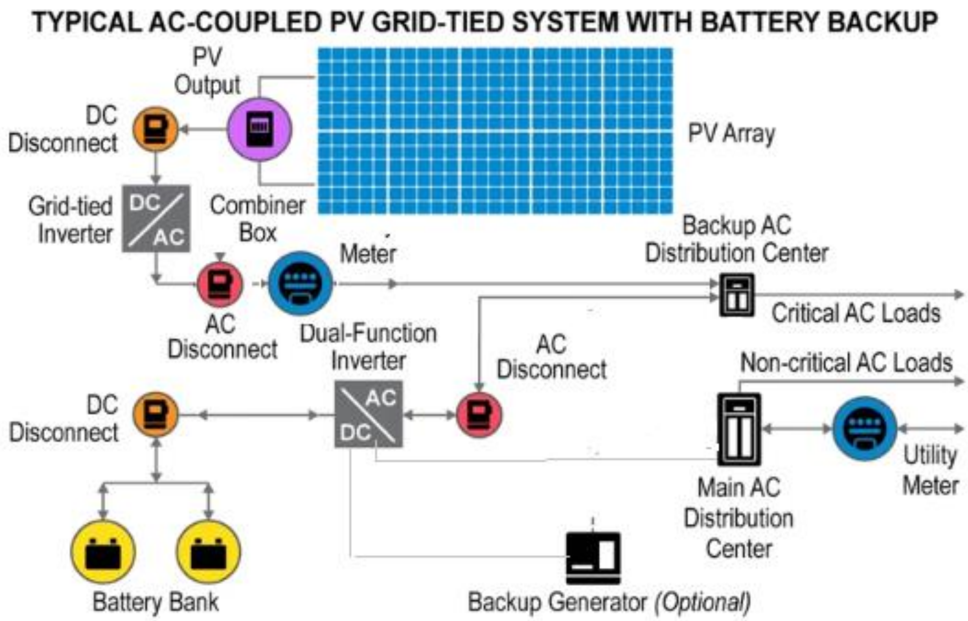
The first titled "Typical PV Grid-Tied System" is the simplest and cheapest method but has the distinct disadvantage of using a "micro-inverter" which needs grid power to function. Thus if the grid is down the solar panels can NOT supply energy to the system, even if they are generating energy. This system also does not use a battery back-up and is very limited in its functionality.



The second configuration is a DC-Coupled Grid-Tied system with a battery back-up. As illustrated, this system uses a dual-function inverter which can function without grid power.



The third configuration is the AC-Coupled system. In addition to what the DC-Coupled system can do, the AC system can also charge its batteries from grid power, in the event the solar panels are not charging the batteries. This system has the most hardware and highest capital cost, but provides the most flexibility and the potential for the lowest operating cost if properly optimized.



PRELIMINARY CONCLUSION

After a comprehensive technical review, the third option "AC-Coupled Grid Tie" option is recommended as the lowest overall cost and highest flexibility system. For cost estimating purposes, this design was considered in all cases.

Additionally, there are a multitude of suppliers for this type of hardware, most notable are the differences in solar panel and battery manufacturers. For estimating purposes SunPower 340 or 345 W panels were used and Sun Xtender brand batteries.