Solar Strategy Appendix
Evaluation Criteria, Project Background, Research Methods, City Facilities Documents, and Supporting Analysis

City of Boulder

Prepared By:

Colorado Energy Group Inc. & Optony Inc.
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Section 1. Evaluation Criteria Descriptions

The development of the Boulder Solar Action Strategies plan included the presentation of dozens of potential strategy options. Before any evaluation of these options could take place, a set of criteria was first created to capture those values considered by the community of Boulder, and the energy planning experts within City of Boulder staff, to be of utmost importance. Each strategy was then evaluated by the Authors of this plan across all the determined criteria. This information is presented in an abbreviated table in each strategy in the Solar Action Strategies plan for the reader to briefly note the rank and evaluation of key activities and considerations for program implementation. A reference guide to the full breakdown of the evaluation criteria for each of the final ten selected strategies is presented in Section 12 of this Appendix (page 45). The final evaluation framework takes into consideration the following categories which identify the strengths, opportunities, and challenges for the various program options considered:

1. Target Impact on Potential Megawatts (MW) of New Solar Capacity

   The amount of potential new solar capacity added through each strategy is one of the most important criteria. This is a straightforward assessment and estimated calculation of the potential megawatts (MWs) of solar capacity that can be expected from implementing the strategy over a set period (for example, from 2018 to 2020).

2. Is Local Generation Possible?

   Boulder desires more installed capacity of local renewable energy generation. Strategies should increase local generation, and provide benefits towards emissions reductions. The score (Yes/No) describes if the strategy will most likely result in increased local generation, where “local” infers a preference for generation within city limits but also includes Boulder County.

3. Increases Community and/or Grid Resiliency

   Community-wide resiliency is a Boulder goal that crosses most areas of sustainability and energy planning. Each strategy should be evaluated as it relates to energy assurance and the ability to provide power during a natural disaster or emergency. Successful strategies may also serve to restore power quickly during these types of events. Scoring includes “Low”, “Moderate” or “High” impact assessment.

4. Innovative Use of Solar Technology

   Boulder places significant importance on technical innovation and the ability to exercise greater control over local energy destiny. When practical strategies should incorporate innovative technologies, which can allow the City to become a test bed for energy innovation and a leader in the future of clean energy communities. However, strategies must also be reliable, and innovative application of proven technologies are also considered. Scoring (Yes/No) describes, in the general judgment of the Authors, whether technologies or applications are an innovative part of the strategy.

5. Accessibility to Residents with Low and Middle Income (LMI)

   The City of Boulder has a strong record of involving residents with low income in solar programs. This criterion evaluates how the strategy positively or negatively impacts low-income residents. The Authors look at the extent to which the strategy results in increased solar PV installations on
low-income properties, and whether it creates or hinders more opportunities for the installation of solar PV on low income residences. Scoring (Yes/No) reflects whether the strategy allows or increases access for low-income customers.

6. Potential Funding Sources

This criterion examines whether practical potential funding sources exist. Scoring (Yes/No) reflects whether the strategy is likely to find suitable funding by the time it is intended for launch. A sample list of potential future funding sources for the strategy is provided. The Solar Action Strategies plan focuses only on strategies with high potential viability. Of course, identification of the final funding source (or sources) will almost certainly change over time, and the ultimate choice of funding for each strategy remains a later responsibility for the City.

7. Key Partners

This criterion lists any key or crucial partners necessary for success with the strategy in question, depending on which sector the strategy addresses. Options include residential (also identify if single family, multifamily, or low-income), commercial, industrial, non-profit, institutional (school districts, special districts, CU), and government (City, County, state, or federal).

8. Technical Feasibility

Strategies should be technically feasible at the time they are intended for launch. More technically feasible strategies should be deployed in the earlier phases, and strategies which have limited current technical feasibility should be delayed until later phases. Completely unfeasible strategies should not be considered. This criterion uses a qualitative assessment of the technical capabilities and years in service of the technology inherent in each strategy. Scoring reflects if the strategy relies on new, unproven technology or methodology. The strategy will be scored “Easier” if involving a proven technology, “Moderate” if there is some experience with the technologies in question (even if newer), and “Difficult” if the technology is emerging generally with little documented deployment experience.

9. Technical Challenges (Implementation Degree of Difficulty)

Successful strategies should be applicable in the specific circumstances of the City of Boulder; the previous success of a strategy elsewhere does not guarantee that is can be easily replicated in the City of Boulder. To the extent possible, unique circumstances and any barriers discovered by other communities implementing the same or similar strategy will be considered here. Implementation differences for the City of Boulder as either a new municipal electric utility or continuing as a customer of Xcel will be evaluated here. Based on the degree of difficulty expected with implementation, the strategy will be given a ranking (Low, Moderate, High) and a score on a scale of one to ten.

10. Administrative Burden to City

This criterion is an objective assessment of the overall lift that would be required by the City of Boulder in terms of staffing (full time equivalents, FTEs), and implicit FTE-related funding requirements of the strategy in question. This useful qualitative criterion differs from the “Technical Challenges” by focusing specifically on the administrative (personnel) impact(s) of the given strategy versus the overall difficulty inherent in implementing a particular strategy.
Estimates include budget for outsourcing when it is likely to be of use. Scoring includes an assessment (Low, Moderate, High); a specific FTE or cost is estimated by year when possible.

11. **Transferring to a New Municipal Electric Utility (Degree of Difficulty)**

All strategies should be successful under both a municipalization scenario, and the continuing Xcel service scenario. Any strategy started in 2018 or later (with the City of Boulder as an Xcel customer) will likely need to be transferred or changed (slightly or severely) as the City becomes a municipal utility a few years later. Some strategies are expected to be easy to transfer while others are more difficult. Based on past experience, the Authors provide a rank (Easier, Moderate, Difficult) for transfer to a Boulder municipal electric utility, and a score on a scale from one to ten. Known major barriers to accompany each strategy are listed. Where important, these major barriers are discussed in more general information presented in the text box at the end of each strategy in the Boulder Solar Action Strategies plan.

**Additional Goals and Metrics for Success Beyond Evaluation Criteria**

Relevant metrics will differ between strategies; however, potential metrics include:

1. Annual number of new installations by sector (tracked in building permit data)
2. Annual new installed solar capacity (measured in megawatts, this can also be tracked in building permit data)
3. Annual climate impact (based on information gathered above and carbon intensity of electricity mix)
4. Economic impact to low and moderate-income residents of Boulder (number of low-income housing units benefitting from solar PV, whether by rooftop PV installations or Community Solar Garden subscriptions; measured by building permit data and Community Solar subscriptions)
5. Other suitable metrics identified by the Authors and COB staff: For example, the CSG strategy would also include number of subscribers, property type, subscription level, and level of turnover. A strategy to increase incentives and rebates would include number of recipients by sector, amount of incentive, projected/actual savings, etc.
Section 2. Strategies Not Considered

At the July 17–18, 2017, project Kick-off meeting a list of program strategies was shared with City of Boulder staff and members of the Solar Working Group. These initial suggestions were used to facilitate a discussion and learn more about what the City and community have been doing (or planning) to accelerate PV deployment. The initial 52 regulatory, policy, and financing concepts presented at the Kick-off meeting are listed below:

1. Behavior-based approaches/recognition & competitions
2. Develop new solar at City wastewater treatment facilities
3. Develop solar at Boulder Municipal Airport
4. Collaborative solar PV procurement
5. Community solar / solar gardens
6. Develop Competitive Renewable Energy Zones (CREZs)
7. Direct purchase options
8. Monitor emerging technology opportunities (for example, grid-interactive water heaters)
9. Promote solar leases
10. Municipal solar Power Purchase Agreements (PPAs)
11. Online purchasing platform for end-use sectors
12. Promote C-PACE
13. Design rate structures that reward solar and storage
14. Pursue opportunities with federal facilities
15. Shared Savings Agreement (SSA) options
16. Streamline solar PV and storage permitting and inspections
17. Increased University of Colorado collaboration
18. Increased Boulder Valley School District (BVSD) collaboration
19. Consider use of Climate Action Plan Tax for solar
20. Community service volunteerism with GRIDAlternatives or similar organization
21. Develop new solar legislative and regulatory strategies (CCE/CCA)
22. Update EnergySmart rebates and incentives
23. Increase electrification/transportation initiatives
24. Adjust permitting fees for City-licensed contractors
25. Encourage financing options from local banks
26. Foster micro-lending platforms
27. Develop solar and storage microgrids
28. Incorporate solar into Housing Boulder strategic plan
29. Require solar in 2019 COBECC for retrofits
30. Revolving loan fund
31. Add solar PV to SmartRegs
32. Encourage solar and storage in large re/developments
33. Solar installation tied to square footage electricity use (Building Performance Ordinance)
34. Tax credits to property owners for installing City-owned panels (LADWP program)
35. Increase solar funding to Boulder Energy Challenge
36. New local solar workforce development program
37. Increase solar public education and outreach efforts
38. Consider a new solar utility allowance for low-income properties (Tulare County, CA)
39. Make changes to City of Boulder tax structure (sales tax, property tax, business property)
40. Develop new guidelines for solar installations (ground-mounted, glare, aesthetics, etc.)
41. Encourage solar PV on parking lot structures and EV charging stations
42. Encourage solar shingles as alternatives to rooftop solar PV
43. Provide incentives to attract solar industry
44. Pursue U.S. DOE and other federal funding opportunities
45. Address solar and storage on historic properties
46. Allow third-party ownership of City solar projects
47. Increase collaboration with Boulder County
48. Establish formal energy storage targets
49. Consider opportunities for solar installations on City-owned land
50. Pursue solar development on private agricultural land
51. Build small demonstration projects and exhibits to help educate the public
52. Increase public/private solar partnerships

Four months later a Draft Solar Action Strategies document was presented to City staff at an all-day meeting on November 29, 2017. Over that time the Draft Solar Action Strategies plan had been narrowed and refined to include a list of the following 20 strategies, based on feedback from the Kick-off meeting and ongoing conversations with City staff:

1. Stronger State-level legislative and regulatory advocacy
2. Community Solar Gardens
3. Solar PV rebates and incentives
4. Increased collaboration with other public-sector partners
5. New solar agreements and partnerships with Xcel Energy
6. Parallel Performance-based Incentive (PBI)
7. Promote a new Renewable Facility (RF) tariff at the public utilities board
8. Commercial and industrial public recognition program
9. Comprehensive education, outreach and solar recognition initiative
10. Promote green leases
11. One-stop solar resource center
12. Promote C-PACE
13. Support solarize Boulder initiatives
14. City of Boulder Energy Conservation Code (COBECC) amendments
15. Planning and other building code amendments
16. Community solar at City facilities
17. Power Purchase Agreements (PPA)
18. Collaborative solar procurement
19. Pay-for-performance contracting
20. Energy storage deployment strategies for City facilities
After receiving constructive feedback from City staff of the draft document the strategies were narrowed to the ten select programmatic actions as presented in the December 30th, 2017, Final Solar Action Strategies document. Several strategies were removed from the final document which would be duplicative. As a result of the repeated refining process many strategies were not included the final report despite their merits, including:

1. **Amendments to the Boulder Energy Conservation Code (COBECC).** This strategy would have broadened number of renovations that would be required to be “Solar Ready”, but would likely not result in a significant number of new installations.

2. **Amendments to other building codes.** If implemented this strategy would have resulted in a small number of existing homes to be made “Solar-Ready” using planning/zoning requirements. The strategy recommended actions such as energy “reach codes” for large developments such as CU-Boulder South and mixed-use properties that would require solar and storage. Ultimately other actions were considered a more effective use of staff resources.

3. **Increased Collaboration with other Public-Sector Partners.** The strategy would have the City taking a more proactive role with the various public-sector property owners within the City to install solar PV systems but has been incorporated into the Collaborative Solar Procurement strategy and On-site Energy Storage strategy.

4. **Solarize Boulder initiatives.** The strategy would have encouraged the City to be a more active stakeholder in support of grassroots initiatives. Given that these initiatives have been applied previously and are already partly addressed in the collaborative procurement this strategy was not considered independently as an innovative and significant new driver of local solar deployment.

5. **New Solar Agreements and Partnerships with Xcel Energy.** This strategy called for increased engagement with Xcel Energy, however, Energy Future and Boulder utilities staff are already working at capacity in this topic area, and new interventions would potentially have disrupted current progress.

6. **Solar PV Rebates and Incentives.** The City has currently operational solar grant funding available and additional incentives would overlap with PBI strategy. Based on City feedback (and supported by the Authors’ research) rebates and incentives strategies are important, particularly as the federal tax credit is reduced. This strategy may be revisited as a future improvement to the PBI to enhance the recovery and management of local RECs under the municipalization scenario which would require REC retirement for compliance with the State’s RES.

7. **Pay-for-performance Contracting.** This strategy is largely underway already through energy savings performance contracts, and energy efficiency retrofit programs. However, the future innovative applications of pay-for-performance for on-site energy storage deployment are included in the final strategies.

8. **Power Purchase Agreements (PPAs).** Rooftop PV PPAs are an established business-as-usual practice and not sufficiently innovative to be considered as an as independent strategy. The availability of PPAs as a financing option (an alternative to direct purchase or lease) for small projects is implied in other applicable strategies, and wholesale PPAs is presented as an important component for the new tariffs strategy (feed-in tariff, renewable facility tariff, etc.) in Phase 3 of the final plan.
Section 3. Strategy Megawatt Contributions

Producing clean electricity is a high priority for the City of Boulder and the goals of the City’s recent Energy Vision are clear: chart a path to 100% clean electricity by 2030, increase local authority over energy infrastructure investment decisions, and make infrastructure investments to support innovation and sustain the local economy. The City agreed to pursue aggressive Climate Commitment targets of 80% reductions in both City emissions (by 2030), and in community emissions (by 2050). Included across these goals is the commitment to generate 50 megawatts (MW) of local renewable energy generation by 2020, 100 MW by 2030, and 175 MW by 2050.

It is understood that much of this generation will come from solar photovoltaics (PV) due to falling costs, the technology’s market maturity, and Boulder’s solar resource which provides more than 300 days of sunshine each year. A total of ~500MW of potential rooftop space for new solar was identified and is presented in the maps contained in this report and the “Confirming Solar Resource Feasibility” segment of the Final Solar Action Strategies plan. Given that there is roughly 21 MW of local PV generation installed at the time of writing, the first goal of 50 MW by 2020 requires that the City increase the amount of installed PV by 50% in three years. Despite 6 MW of PV that IBM plans to add in 2018, meeting the City’s solar targets is a significant challenge.

Forecast analysis can use a current estimated capacity of 37MW (18MW of PV within City limits from permit data and Xcel community energy report, 2MW on University of Colorado campus, 1MW at City facilities in Boulder County, plus the City of Boulder hydroelectric capacity of 16MW). Since, it is generally assumed that future PV growth will accelerate as PV module prices continue to decline in coming years, and using City staff estimates of recent average PV growth rate of 3 MW annually, analysis would project that over the following 33 years (from the beginning of 2018 to the end of 2050) that the City would have total new capacity of 99MW of local solar. Thus, total capacity in 2050 would be 136MW (a 39MW shortfall from the 175MW target).

However, this projection mistakenly ignores the typical system lifetime for PV of 25 years. If it can be assumed that a majority of systems were installed beginning in 2005, then by 2030 the number of PV systems that are reaching the end of their useful lifetime will be roughly equal to the number of new systems. This growth must be further tempered against other events which are projected to hinder the continuation of Boulder’s past growth rate. These events include: a recent International Trade Commission case restricting import of cheap solar modules from abroad; the decreasing value of the investment tax credit for solar; negative grid impacts of daytime over-production; and a general trend of utilities shifting toward evening-weighted time-of-use rates.

Therefore, even with current aggressive policies and general community support, business-as-usual (BAU) growth under existing policies and programs will fall far short of obtaining the city’s long-term solar capacity goals.

The gaps between BAU growth and target local generation are estimated at 6MW by 2020, 26MW by 2030, and 74MW by 2050. The Solar Action Strategies plan therefore focuses on filling these PV growth gaps based on an analysis of real potential local capacity, and recommendations which prioritize program deployment and implementation in three phases as shown in the tables on the following pages.

<table>
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<tr>
<th>New Strategies</th>
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<th>2019</th>
<th>2020</th>
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<td>0.2</td>
<td>0.2</td>
<td>0.5</td>
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<td>3.2</td>
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**Completed Strategies**

**Total Strategies Impact by 2020** 6.0MW

## Phase 2 (2021-2030): Filling Projected 26MW Gap by Close of 2030

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<th>2025-26</th>
<th>2027-28</th>
<th>2029-30</th>
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<td>-</td>
<td>1.5</td>
<td>-</td>
<td>3.5</td>
</tr>
<tr>
<td>Expand Property Assessed Clean Energy (PACE)</td>
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<td>-</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
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<tr>
<td>Community Solar on City Property</td>
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<td>-</td>
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<td><strong>Phase 1 Ongoing Strategies</strong></td>
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**Completed Strategies**

**Total Strategies Impact by 2030** 26.0MW
### Phase 3 (2031-2050): Filling Projected 74MW Gap by Close of 2050

<table>
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<tr>
<th>2031-34</th>
<th>2035-38</th>
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<tr>
<td>PV + Bulk Energy Storage</td>
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<td>PV+ On-site Energy Storage</td>
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<tr>
<td>Phase 1 Ongoing Strategies</td>
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<tr>
<td>Parallel Performance Based Incentives (PBI)</td>
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<td>One-Stop Solar Resource: Education, Outreach, and Recognition</td>
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<td>Advocacy: Community Solar Gardens</td>
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<td>Total Strategies Impact by 2050</td>
<td>26.0</td>
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**Total Strategies Impact by 2050** 74.0MW
Section 4. City-wide Solar Potential Mapping and Measurement

Our team completed a city-wide survey of rooftop solar potential. This survey was completed using a ground-up approach, with 640 representative buildings being measured and the resulting solar potential being scaled to the full City.

To conduct this survey, the City was divided into six (6) geographic regions representing similar zoning types and building stock. These zones were defined using the City zoning maps as a starting point, and refining the boundaries using aerial images to visibly confirm continuity of building size and density within each zone. The survey features two (2) residential zones, two (2) industrial zones, one (1) downtown zone, and one (1) university zone:

![Six Zones in City-wide Rooftop Potential Survey](image)

The reader will notice that the boundaries of the sample zones do not exactly follow the City limits. There are a few reasons for this, though it is typically driven by a lack of usable rooftop space in excluded areas. Because our methodology scales rooftop potential up based on the physical size of our zones, the zones should not include extensive areas of land without usable structures, or the solar potential would be overestimated. You can see examples of this in the image below for Zone 5. There is a large section of housing just below Hayden Lake (top center in the image) that is excluded because it is mobile housing. Note: there is some permanent housing in this area which
has been included in Zone 2. This logic also applies to the municipal airport (top center) and the Valmont Bike Park (middle center).

Within each zone, a representative sample of ten (10) blocks was selected. The blocks were selected to best reflect both the density of the built environment and the solar access within the entire zone:

![Map of Zone 5: Industrial East (blue border) with the ten blocks (white borders) within](image)

The blocks varied both in area and in number of buildings, as a reflection of the zone they were in. The most densely populated block contained 43 structures; the average block contained 11 structures.
Within each block, the physical rooftop space of each structure was measured:

Two blocks (white borders) along with the structures (black edges) within

The table below provides a summary of the area of each zone and the number of structures:

<table>
<thead>
<tr>
<th>Zone Description</th>
<th>Area (sq. miles)</th>
<th>Number of Measured Structures</th>
<th>Estimated Number of Total Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1: Residential South</td>
<td>6.5</td>
<td>90</td>
<td>12,244</td>
</tr>
<tr>
<td>Zone 2: Residential North</td>
<td>5.3</td>
<td>96</td>
<td>11,240</td>
</tr>
<tr>
<td>Zone 3: Business Core</td>
<td>1.3</td>
<td>97</td>
<td>716</td>
</tr>
<tr>
<td>Zone 4: University</td>
<td>1.1</td>
<td>167</td>
<td>552</td>
</tr>
<tr>
<td>Zone 5: Industrial East</td>
<td>1.6</td>
<td>89</td>
<td>355</td>
</tr>
<tr>
<td>Zone 6: Industrial Satellite</td>
<td>1.5</td>
<td>101</td>
<td>212</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>17.3</strong></td>
<td><strong>640</strong></td>
<td><strong>25,319</strong></td>
</tr>
</tbody>
</table>

Total City-wide rooftop solar potential is calculated to be around 500MW. The roof area of each structure is cataloged in a spreadsheet. The number of roofs ill-suited for solar PV systems due to tree shading on each block is also tracked. After discounting for shading losses, the total usable rooftop area of each block is calculated. This quantity, in combination with the usable areas of the other 9 blocks, is scaled up to define the total usable area of the whole zone.

Once the total area is known, the solar potential can be calculated. Fill factors are applied to the roof area to account for the fact that solar cannot cover the entire roof. The fill factors used are 30% for residential (where roofs are typically pitched and only one face is available), 60% for medium commercial/industrial, and 68% for large commercial/industrial. These fill factors yield a total solar coverage area, and from there standard efficiency solar modules are assumed in calculating the total solar potential in kW.
Within the spreadsheet, the results are categorized by building area, providing a picture of the system size distribution throughout the City:

![System size distribution throughout the city](image)

The total City-wide rooftop solar potential is calculated to be around 500MW.

Some notes and assumptions associated with these numbers:

- Includes only shade-free rooftops (shaded rooftops are ignored in these results)
- Does not account for systems that may need to be downsized based on limited electricity consumption of the host facility or downsized for budgetary reasons, but rather assumes that each roof would be “maxed-out”
- The solar fill factor on each roof accounts for good design principles. Only south facing residential roofs are considered, and for larger flat roofs space is left open for existing equipment and obstructions. A setback from the roof edge is maintained on all structures
- Does not discount totals for existing solar installation, so that this number represents the theoretical maximum deployable rooftop capacity (not incremental additional capacity) including the assumed 18MW of rooftop solar within City limits.
Section 5. Solar Potential at Municipal Facilities

Solar potential at municipal facilities was assessed using satellite imagery and street level views. Starting from a list of 143 municipal facilities, after eliminating those with no solar potential (and considering some facilities were on the same or adjoining parcels), solar potential was ultimately measured at 83 properties.

All solar layouts were completed using Helioscope solar design software. Rooftops, open land, and parking lots were all considered viable areas. Below is a sample layout for the Public Safety Building, which hosts a 380kW PV system spread across 2 buildings (150kW) and 3 solar carports (220kW):

The layout takes into consideration existing rooftop obstacles (orange shaded areas), setbacks from the roof edge (light orange perimeter) and shading from rooftop AC units (shaded projections on north side of equipment):
At each site, the potential solar capacity was measured, and detailed solar production data was modeled using typical meteorological data and site-specific conditions as shown below:

### Annual Production

<table>
<thead>
<tr>
<th>Description</th>
<th>Output</th>
<th>% Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Global Horizontal Irradiance</td>
<td>1,688.7</td>
<td>0.0%</td>
</tr>
<tr>
<td>PDA Irradiance</td>
<td>1,735.6</td>
<td>3.0%</td>
</tr>
<tr>
<td>Shaded Irradiance</td>
<td>1,727.0</td>
<td>-0.7%</td>
</tr>
<tr>
<td>Irradiance after Reflection</td>
<td>1,656.9</td>
<td>-2.0%</td>
</tr>
<tr>
<td>Irradiance after Sooting</td>
<td>1,597.3</td>
<td>-3.8%</td>
</tr>
<tr>
<td><strong>Total Collector Irradiance</strong></td>
<td><strong>1,597.3</strong></td>
<td><strong>0.0%</strong></td>
</tr>
</tbody>
</table>

### Energy (kWh)

<table>
<thead>
<tr>
<th>Description</th>
<th>Output</th>
<th>% Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nameplate</td>
<td>609,192.4</td>
<td></td>
</tr>
<tr>
<td>Output at Irradiance Levels</td>
<td>588,002.5</td>
<td>-3.5%</td>
</tr>
<tr>
<td>Output at Cell Temperature Derate</td>
<td>570,004.1</td>
<td>-2.0%</td>
</tr>
<tr>
<td>Output After Mismatch</td>
<td>570,665.9</td>
<td>-0.1%</td>
</tr>
<tr>
<td>Optimal DC Output</td>
<td>570,669.0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Constrained DC Output</td>
<td>571,140.9</td>
<td>0.1%</td>
</tr>
<tr>
<td>Inverter Output</td>
<td>549,458.0</td>
<td>-3.7%</td>
</tr>
<tr>
<td><strong>Energy to Grid</strong></td>
<td><strong>540,794.0</strong></td>
<td><strong>-1.6%</strong></td>
</tr>
</tbody>
</table>

Hourly solar output is modeled throughout the year:

![Annual Production Table](image)

Sources of system losses are also tabulated to help optimize system design:

![Sources of System Loss](image)
Each facility was given a feasibility ranking of “A”, “B”, or “C”. The ranking system guidance is as follows:

- **“A”** sites have excellent solar potential and current conditions support immediate deployment. Generally, these projects have potential for a larger system with minimal shading and no major technical hurdles.

- **“B”** sites also have solar potential and could be developed immediately, but have site-specific challenges. This could mean older roof surfaces that may need to be replaced, some shading concerns, potential need for electrical equipment upgrades, or a site with a more difficult installation type (such as a carport built on the top level of a parking garage). Sites that are clean but only allow for a small system size are also placed in this category.

- **“C”** sites have high-risk technical issues or are otherwise troublesome sites. While a PV system may still be feasible, it is unlikely that these systems will be able to provide economic savings to justify the cost of the systems at this time.

To provide a comprehensive overview of solar potential across the City’s full portfolio of properties, all sites were mapped in Google Earth. Below is a screenshot of the “A” ranked properties near the City core:

![A ranked properties near the City center](image)
The mapping file allows the user to filter by site rank (“A” “B” or “C”) or by Department (Parks, Libraries, etc.) by toggling the visibility on/off:

- [ ] Boulder Municipal Properties
- [ ] By Rank
  - [ ] “A” Sites
  - [ ] “B” Sites
  - [ ] “C” Sites
- [ ] By Department
  - [ ] Parks
  - [ ] Library
  - [ ] General/Other
  - [ ] Police/Fire/Justice
  - [ ] Housing
  - [ ] Utilities
  - [ ] Parking
  - [ ] Public Works

Below is a sample filtered view of all Parks Department properties with an “A” feasibility ranking. Bus icons indicate the installation is a solar carport, while house icons indicated a roof mounted system:
While the map is a simple visual tool to see the locations, sizes, and types of PV installations possible throughout the City, the core data for each facility is catalogued in a spreadsheet database. The database includes solar data for each site including feasibility rank, system size, and annual output (kWh/yr.) along with notes on each host facility including age, ownership, and occupancy.

Key summary statistics by site feasibility ranking for all surveyed City facilities:

<table>
<thead>
<tr>
<th>Site Feasibility</th>
<th>Number of Sites (Qty)</th>
<th>Average System Size (kW)</th>
<th>Total Solar Potential (kW)</th>
<th>Annual Production (MWh/yr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“A” Sites</td>
<td>37</td>
<td>508</td>
<td>18,798</td>
<td>27,237</td>
</tr>
<tr>
<td>“B” Sites</td>
<td>30</td>
<td>76</td>
<td>2,285</td>
<td>3,196</td>
</tr>
<tr>
<td>“C” Sites</td>
<td>16</td>
<td>5</td>
<td>94</td>
<td>132</td>
</tr>
</tbody>
</table>

Key summary statistics for all surveyed City facilities by Department:

<table>
<thead>
<tr>
<th>Department</th>
<th>“A” Sites</th>
<th>“B” Sites</th>
<th>Total “A+B” Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of Sites</td>
<td>Solar Potential (kW)</td>
<td>Annual Production (MWh/yr.)</td>
</tr>
<tr>
<td>Utilities</td>
<td>7</td>
<td>8,010</td>
<td>11,987</td>
</tr>
<tr>
<td>Parks</td>
<td>13</td>
<td>3,019</td>
<td>4,217</td>
</tr>
<tr>
<td>General</td>
<td>2</td>
<td>2,194</td>
<td>3,362</td>
</tr>
<tr>
<td>Public Works</td>
<td>3</td>
<td>1,394</td>
<td>1,779</td>
</tr>
<tr>
<td>Library</td>
<td>4</td>
<td>1,212</td>
<td>1,727</td>
</tr>
<tr>
<td>Housing</td>
<td>3</td>
<td>940</td>
<td>1,312</td>
</tr>
<tr>
<td>Police</td>
<td>2</td>
<td>729</td>
<td>1,024</td>
</tr>
<tr>
<td>Parking</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Fleet</td>
<td>1</td>
<td>446</td>
<td>630</td>
</tr>
<tr>
<td>Courts</td>
<td>1</td>
<td>443</td>
<td>633</td>
</tr>
<tr>
<td>LEAD</td>
<td>1</td>
<td>410</td>
<td>566</td>
</tr>
<tr>
<td>Fire</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Note 1: Includes the Municipal Building, Atrium, 95th Street parcel, Center Green Lease, Park Central Office Building, Brenton Building, 1720 Building, and New Britain.

Large systems would be installed only under a municipalization scenario because under Xcel programmatic restrictions on system size or hosting capacity of the utility feeder supplying these areas would limit size. For tabulation purposes in the totals shown above, 2MW is considered to be the maximum size at any given site. Electricity consumption data was not reviewed, so these sizes do not give consideration for electrical...
demand on site. Approximate maximum system sizes are based on available area; ultimate size may be lower due to limited electricity demand or grid hosting capacity.

Several properties have acres of open land that could support large systems:

- Vacant parcel near 95th St and Lookout Rd: 60MW
- Open land at 6800 Arapahoe Rd: 7MW
- 75th St Water Treatment Plant: 5MW

Full summary of identified kW capacity at City Facilities

<table>
<thead>
<tr>
<th>Department</th>
<th>Site</th>
<th>Size (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilities</td>
<td>Open land on Arapahoe</td>
<td>2,000</td>
</tr>
<tr>
<td>Utilities</td>
<td>75th St WTP</td>
<td>2,000</td>
</tr>
<tr>
<td>Utilities</td>
<td>63rd St WTP</td>
<td>2,000</td>
</tr>
<tr>
<td>Utilities</td>
<td>Kohler Tank</td>
<td>846</td>
</tr>
<tr>
<td>Utilities</td>
<td>Maxwell Reservoir</td>
<td>582</td>
</tr>
<tr>
<td>Utilities</td>
<td>Chautauqua Reservoir</td>
<td>490</td>
</tr>
<tr>
<td>Utilities</td>
<td>Gunbarrel Tank</td>
<td>92</td>
</tr>
<tr>
<td>Parks</td>
<td>Flatiroms Event Center</td>
<td>559</td>
</tr>
<tr>
<td>Parks</td>
<td>East Boulder Play Pavilion</td>
<td>450</td>
</tr>
<tr>
<td>Parks</td>
<td>Scott Carpenter Park</td>
<td>342</td>
</tr>
<tr>
<td>Parks</td>
<td>Valmont Storage</td>
<td>284</td>
</tr>
<tr>
<td>Parks</td>
<td>Foothills Maintenance Facility</td>
<td>222</td>
</tr>
<tr>
<td>Parks</td>
<td>So. Mesa</td>
<td>221</td>
</tr>
<tr>
<td>Parks</td>
<td>East Boulder Recreation Center</td>
<td>183</td>
</tr>
<tr>
<td>Parks</td>
<td>Spruce Pool Bath House/Filter</td>
<td>173</td>
</tr>
<tr>
<td>Parks</td>
<td>Iris Center</td>
<td>169</td>
</tr>
<tr>
<td>Parks</td>
<td>North Boulder Recreation Center</td>
<td>145</td>
</tr>
<tr>
<td>Parks</td>
<td>Park Operations</td>
<td>137</td>
</tr>
<tr>
<td>Parks</td>
<td>Dunn</td>
<td>92</td>
</tr>
<tr>
<td>Parks</td>
<td>Chautauqua Auditorium</td>
<td>44</td>
</tr>
<tr>
<td>General</td>
<td>95th St Parcel</td>
<td>2,000</td>
</tr>
<tr>
<td>General</td>
<td>Atrium</td>
<td>194</td>
</tr>
<tr>
<td>Public Works</td>
<td>Airport Hangars</td>
<td>799</td>
</tr>
<tr>
<td>Public Works</td>
<td>Airport Roof/Carport</td>
<td>548</td>
</tr>
<tr>
<td>Public Works</td>
<td>Roadway Building</td>
<td>47</td>
</tr>
<tr>
<td>Library</td>
<td>Main Library</td>
<td>399</td>
</tr>
<tr>
<td>Library</td>
<td>Meadows Library</td>
<td>362</td>
</tr>
<tr>
<td>Library</td>
<td>Dairy Center for the Arts</td>
<td>315</td>
</tr>
<tr>
<td>Library</td>
<td>MOCA</td>
<td>136</td>
</tr>
<tr>
<td>Housing</td>
<td>Transit Village</td>
<td>724</td>
</tr>
<tr>
<td>Housing</td>
<td>West Senior Center</td>
<td>153</td>
</tr>
<tr>
<td>Housing</td>
<td>Echo House</td>
<td>63</td>
</tr>
<tr>
<td>Police/Fire</td>
<td>Public Safety Building</td>
<td>380</td>
</tr>
<tr>
<td>Police/Fire</td>
<td>Fire Training Center</td>
<td>349</td>
</tr>
<tr>
<td>Fleet</td>
<td>Fleet Services</td>
<td>446</td>
</tr>
<tr>
<td>Courts</td>
<td>Justice Center</td>
<td>443</td>
</tr>
<tr>
<td>LEAD</td>
<td>Recycling Center</td>
<td>410</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>18,799 kW</strong></td>
</tr>
</tbody>
</table>
Section 6. Distribution System Impacts Feeder Analysis

Further research is needed of the line segment hosting capacity and voltage limits of transformers to make any meaningful determination of the impacts of the target levels of PV on the feeder system under its current conditions. Xcel Energy has an online map of hosting capacity for new PV which appears not to be fully activated for Colorado at the time of writing\(^1\). It is understood that PV penetration at the levels intended by the Solar Action Strategies have the potential to cause significant stress to the current distribution system. In the experience of the Authors any single large industrial PV installation that is intended to offset a majority of on-site load will trigger grid system upgrade costs. However, the determination of impact for multiple smaller systems and the adequacy of the “120% Rule” to prevent overbuilding of residential feeder segments was considered using general approximations.

The State of Colorado has established reliability limits under a “120% Rule” which states, “Retail renewable distributed generation shall be sized to supply no more than 120 percent of the customer’s average annual electricity consumption\(^2\)”. As mentioned above, past project experience has shown that for medium and large projects (over 11kW) each site should expect some level of grid impact and the interconnection study process should be used to determine that impact on a case-by-case basis. For residential systems a generalized analysis of the grid impacts resulting from the 120% requirement follows for distributed rooftop solar:

Feeder analysis starts with the 120% rule, as based on total annual use, \(\text{Tot}_{\text{Annual}}\)

Then define an average hourly use, \(\text{Hour}_{\text{Avg}} = \text{Tot}_{\text{Annual}} / 8760\) hours per year

• Thus, \(\text{Tot}_{\text{Annual}} = \text{Hour}_{\text{Avg}} \times 8760\) hours per year [and using naming convention, Eqn 1]

Again, define residential system size in kW, \(\text{Roof}_{\text{kW}}\)

• Thus, annual production, \(\text{Prod}_{\text{Annual}} = \text{Roof}_{\text{kW}} \times 1500\) kWh/kW (typical yield) [and using naming convention, Eqn 2]

From the original definitions:

\[
120\% \, \text{PV system size: } \text{Prod}_{\text{Annual}} \, \{\text{Eqn 2}\} = 120\% \times \text{Tot}_{\text{Annual}} \, \{\text{Eqn 1}\}
\]

Thus, substituting for \(\text{Prod}_{\text{Annual}}\) with Eqn 2 and \(\text{Tot}_{\text{Annual}}\) with Eqn 1:

• \(\text{Roof}_{\text{kW}} \times 1500\) kWh/kW = 1.2 \times \text{Hour}_{\text{Avg}} \times 8760\) hours per year
• Or, \(\text{Roof}_{\text{kW}} = (1.2 \times \text{Hour}_{\text{Avg}} \times 8760\) hrs) / 1500 hrs
• Finally, \(\text{Roof}_{\text{kW}} = 7 \times \text{Hour}_{\text{Avg}}\)

---

\(^1\) http://192.234.137.143/working_with_us/how_to_interconnect/hosting_capacity_map

\(^2\) https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=5595

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Now assume feeder reliability based on limit to peak load, $F_{\text{Lim}}$, and define average feeder load, $F_{\text{Avg}}$, and define feeder peak solar output $F_{\text{Sol}}$ as:

- $F_{\text{Avg}} = \text{Total number of buildings on feeder} \times H_{\text{Avg}} = N_{\text{B}} \times \text{Hour}_{\text{Avg}}$; and define feeder peak solar output $F_{\text{Sol}} = \text{Number of buildings with solar} \times \text{Roof}_{\text{kW}} = N_{\text{Sol}} \times \text{Roof}_{\text{kW}}$

Assume worst-case scenario: solar output at peak production with no directly-offset load, and furthermore assume:

- $F_{\text{Lim}} = 5 \times F_{\text{Avg}}$

Then the maximum total carrying capacity of residential solar can be modeled at the total limit of the feeder, $F_{\text{Lim}} = F_{\text{Sol}}$:

- Thus, $5 \times N_{\text{B}} \times \text{Hour}_{\text{Avg}} = N_{\text{Sol}} \times 7 \times \text{Hour}_{\text{Avg}}$
- Or, $\frac{N_{\text{Sol}}}{N_{\text{B}}} = \frac{5}{7} = 71\%$

Citywide mapping results show that in residential zones (Zone 1 and Zone 2) approximately 67% of buildings have viable solar resource without shading issues, therefore total buildout of all viable residential solar under the maximum buildout scenario is feasible only under an ideally-distributed even feeder impact across all line segments. However, a more reasonable buildout plan calls for solar on 39% of large structures, 33% of total medium structures, and a buildout of 23% of total available residential structures (less than double the current residential capacity). This more reasonable scenario provides an estimated worst-case feeder safety factor of approximately 3.1, for the ratio $F_{\text{Lim}}:F_{\text{Sol}}$.

As a final note, by no means is this analysis sufficient without further research of the plans for replacement of conductors and transformers under the Xcel separation plan. In fact, the grid integration after Xcel separation will be a critical component to the ultimate success of the final solar strategy. A fully integrated solar strategy with a penetration of 175MW would be best served by a municipalization plan that provides eventual distribution upgrades and substation reconfiguring which take into account a future deployment of local generation serving up to 90% of hourly coincident load at peak summer production. Certainly the potential exists, such that with increased local solar capacity, building efficiency, and a properly designed distribution grid Boulder Could support a unequivocally locally powered community during some midday hours of the summer months.
Section 7. Energy Storage Siting Strategy

A strategy for the prioritization and ranking of potential sites for standalone or integrated solar and storage is one of the first requirements in a planning process designed to maximize the benefits of local energy systems. Finding the sites that provide the best mix of financial savings and non-energy benefits can be completed by either internal municipal staff, external consultants, or prospective developers. However, ranking and selecting sites for implementation is dependent upon existing public process as projects will encounter specific and nuanced needs given ownership, financing, permitting, or design variables.

The sections below outline recommended strategies for identifying sites for solar or storage either as standalone or integrated projects.

Expected Outcomes

Developing solar plus storage or standalone energy storage systems can result in the following outcomes for the City of Boulder:

1. Energy savings
2. Created energy cost savings
3. Reduced greenhouse gas emissions
4. Local employment
5. Increased resilience capacity
6. Increased local energy flexibility
7. Reduced Transmission and Distribution Charges (if integrated with storage under a municipalization scenario)

These outcomes align with existing planning goals as defined by the Climate Action Plan and if translated into quantified Key Performance Metrics (KPMs) can be used to both evaluate the performance of existing projects as well predict the outcomes created by new proposed projects. Our recommendations for a program evaluation methodology is further defined in the Program Evaluation and Procurement Guidance Appendix Item.

Storage Evaluation Road Map

- Stage 1: Set Storage Goals
- Stage 2: ID Locational Attributes
- Stage 3: ID Temporal Attributes
- Stage 4: Consider business Model and Risk

Stage 1: Set Storage Goals

To begin the storage planning process the City of Boulder should first work to clearly define the intended outcomes they wish to create by developing energy storage capacity. Given the several use cases for energy storage defining which ones are most desirable will allow the City to target product features and filter the range of available options to fit those needs.
Perhaps the most valuable service provided by energy storage is backup power. The ability to keep the lights on in the event of unforeseen events such as storm, blackout, or urban unrest can in some cases save lives by allowing for emergency response. Essential service centers such as hospitals, public meeting places, or police and fire buildings often require diesel backup; a role that can be filled by batteries plus storage. As a result, energy storage planning overlaps closely with local resilience and emergency planning and energy storage development should include contingent risk planning for emergency use.

Outside of providing emergency backup power energy storage offers a range of benefits and the City should work to narrow its storage goals by visiting the following questions:

- Who benefits and in what way from new storage projects?
- Are goals and outcomes defined by pursuit of social, economic, or environmental returns? Which is most material to our planning process? How will returns be measured and reported to show project progress and performance?
- How will the jurisdiction pay for the technology? Who holds ownership of the equipment? What are the risks rewards of different ownership models?
- Has the jurisdiction considered regional incentives in our project development project? Is the jurisdiction fully maximizing returns from load shaping and TOU tariff structures or other state or utility incentives?
- Will the project reduce or increase the need for new transmission infrastructure?

Stage 2: Identify Locational Attributes:

Next the City should work to identify the locational attributes of a project site that impact the technology selection process as the value of energy storage will change based on the characteristics of the site on which storage is deployed.

Access to existing grid infrastructure, renewables, or the presence of pre-existing backup systems all play a role in configuration and use cases of the storage technology. As a result, before selecting storage technology mapping or site surveys should be conducted to identify locations able to provide the widest range of use cases. As a general guide this report recommends asking the following questions to identify locational attributes that will define storage technology fit:

- Is the energy source on site renewable or provided by the grid?
- Does the site have other backup power such as a diesel generator? Can storage cover that requirement?
- What infrastructure currently connects to the site? Who owns those assets? Is new T&D infrastructure needed to support new storage technology or is the need for T&D reduced?
- What energy capacity is needed on site to create intended outcomes?
- Does site selection provide any co-benefits (environmental, social or economic) from storage energy to local tenants, asset owners, or other stakeholder groups?
- Does storage location, capacity, or features provide benefits or costs to any neighboring energy projects, buildings, or assets?
- If linked with solar how will weather, shade or other macro environmental factors change the projects ability to generate and store electricity?
Navigating these questions will allow the City to narrow the focus of storage projects and define clearly define product and service needs. As Boulder is working to achieve many long-term planning goals, siting analysis should focus on the ability for an implemented project to advance broader planning outcomes. These may include: financial savings, or returns, improved resilience capacity, and creating community benefit. The tables below show the site traits that are best suited to creating these outcomes for the City of Boulder.

Sites equipped for generating financial returns:

A site that is a good fit for an energy storage system able to provide the most financial returns will have the following traits:

<table>
<thead>
<tr>
<th>Site Traits Advantageous to Financial Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
</tr>
<tr>
<td>• Adequate light exposure</td>
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<tr>
<td>• Rooftop or open space fit to support PV</td>
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<tr>
<td>installation</td>
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<tr>
<td>• Ability to interconnect to grid</td>
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<tr>
<td>• Ability to utilize TOU rates or advance</td>
</tr>
<tr>
<td>metering tariffs</td>
</tr>
<tr>
<td>Storage</td>
</tr>
<tr>
<td>i. Available 15 Min interval data or</td>
</tr>
<tr>
<td>Trailing Twelve Month Electricity Usage</td>
</tr>
<tr>
<td>(TTM).</td>
</tr>
<tr>
<td>ii. High demand charges and/or TOU Tariff or</td>
</tr>
<tr>
<td>ability to switch to a TOU Tariff.</td>
</tr>
<tr>
<td>iii. High or variable peaks in energy use</td>
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<tr>
<td>during on peak or partial peak billing</td>
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<tr>
<td>hours.</td>
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<tr>
<td>iv. Adequate space for storage and ability</td>
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<tr>
<td>for storage configuration to link with</td>
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<tr>
<td>existing electrical system.</td>
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<tr>
<td>v. Areas where PV production could exceed</td>
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<tr>
<td>allowable output or amperage as defined</td>
</tr>
<tr>
<td>by national electric code or local utility</td>
</tr>
<tr>
<td>ordinance. As a battery system would act</td>
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<tr>
<td>as a buffer to excess generation and</td>
</tr>
<tr>
<td>resulting frequency spikes.</td>
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</table>
Sites Equipped for Improving Resilience

A site that is best fit to improve resilience capacity through addition of energy storage will have the following traits:

<table>
<thead>
<tr>
<th>Site Traits Advantageous to Improved Resilience</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>Storage</td>
</tr>
<tr>
<td>• Remote location or difficulty accessing transmission infrastructure</td>
<td>• Have critical need for power backup capacity (or existing backup) such as a hospital, public safety building, fire, police etc.</td>
</tr>
<tr>
<td>• Site exposure to regular events that cause power outages such as snow or storm</td>
<td>• Be an emergency response center or public meeting place (cooling center, community center).</td>
</tr>
<tr>
<td>• Community centers or public meeting places</td>
<td>• Property owners willing to offer right of way to public use in event of emergency or outage.</td>
</tr>
<tr>
<td>• Critical public safety infrastructure (hospitals, police, fire etc.)</td>
<td>• Existing or possible solar integration to create net zero and self-reliant energy supply and usage</td>
</tr>
<tr>
<td>• Property owners willing to offer right of way to public use in event of emergency or outage.</td>
<td></td>
</tr>
</tbody>
</table>

Sites Equipped to Create Community Benefit

A site that is best fit to provide community co-benefits will have the following traits:

<table>
<thead>
<tr>
<th>Site Traits Advantageous to Creating Community Benefit</th>
<th>Storage</th>
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</thead>
<tbody>
<tr>
<td>Solar</td>
<td>Storage</td>
</tr>
<tr>
<td>• Sited in a low-income community</td>
<td>• Existing backup system running on fossil fuels such as diesel or natural gas.</td>
</tr>
<tr>
<td>• Tied to LMI programs such as Performance Based Incentives, TOU rate structure under municipalization scenario</td>
<td>• Be within a defined disadvantaged or low-income community.</td>
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<tr>
<td></td>
<td>• Be owned or operated by a local property manager.</td>
</tr>
</tbody>
</table>
Stage 3: Identify Temporal Attributes:

Once a site has been identified and key attributes of the site have been identified the City should work to identify the temporal attributes of energy generation, charging, discharge, and battery life that pertain to the project. For example, several of the use cases for energy storage depend on energy arbitrage to generate revenue, through the process of buying energy at low market prices and using it as demand response when prices are high.

Planners must consider how much energy storage capacity must be retained to provide building life support services versus how much can be used to trade in the energy market or provide other energy use cases. Keeping safe reserves and defining when and how those reserves get used will be essential to share with all stakeholders involved in a project to establish clear terms of use for the storage asset.

Stage 4: Consider Risks:

Fourth, it is recommended to revisit stages 1-3 and consider how a proposed project will impact the original risk assumptions. The City should consider mitigative capacity of the system being installed and ask and analysis if the design, configuration, or attributes of this project reduce the probability of adverse event or increase it? For example, storage systems can provide grid services such as acting as a buffer during periods of excess load generation as well as providing back up power in the event of loss of load. However, storage systems can also make changes to existing infrastructure, and impact existing operational planning of the grid.

Risk factors and mitigation can also apply to public and social outcomes. Having back-up systems ultimately add resilience to a system due to its distributed and local nature. Being able to provide emergency power can have large social and environmental benefits. Siting storage assets in at risk communities, at cooling centers, or within essential service buildings such as hospitals or public safety buildings can improve a city’s ability insulate itself from systems shock and respond effectively to adverse events.

Stage 5: Select Technology

Finally, once goals have been defined, location, temporal, and risk attributes have all been evaluated the City can begin the technology selection process. To assist this stage this report has developed a high-level matrix designed to capture the key features of off-the-shelf technology currently available as well as aggregate technology still in development that may become commercially viable soon. It is important to note that the technology and business models around energy storage are evolving rapidly. As a result, this report recommends a formal RFP process be facilitated that highlights the cities storage goals, specific site criteria, and temporal needs to solicit technology from the market and find the most cost effective, and best fit technology to meet a specific project’s needs.

Conclusions:

Ultimately, costs are only one driving consideration of storage and solar placement, several other characteristics including, power rating, cycle capacity, storage capacity, and size of supporting infrastructure are material to the selection of an ESS system best fit local needs. Municipalities must ask during planning what their goals are when procuring ESS systems and match their priorities to technological capabilities, locational, and temporal attributes. Analysis of business
models, economics and risk mitigation should all be part of the selection framework for energy storage technology.

While a lengthy process, successfully implementing a storage procurement strategy that incorporates this planning will accelerate the city’s ability to meet their local renewable energy goals. Energy storage systems present economic opportunities such as new revenue streams and cost savings, provide environmental benefits such as reduced emissions, and provide invaluable social benefits such as improved resilience capacity. Despite the many upsides and use cases for energy storage market is saturated with technological options and decision points about cost, application, ownership, and revenue models.

As a result, best practices for storage development will be iterative in nature and be designed to frequently survey and gather input from the private sector and energy service providers. This report recommends that at the end of the attribute discovery process the City work to establish multi-stakeholder partnerships through a formal RFP process to successful identify the technology fit, products and business models that meet their pre-defined goals.
### Section 8. Template Solar and Storage Evaluation Form

**Overview:**

This scorecard template is designed as a standardized approach across all City of Boulder departments to evaluate solicited and unsolicited solar and energy storage project proposals. Points levels are left blank and intended for determination internally by the City. This approach allows reviewers to quickly identify quality proposals and to simplify purchasing and avoid later delays in project implementation. It builds on the citywide solar planning maps for City facilities created by Optony.

<table>
<thead>
<tr>
<th>Requirements or Points</th>
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#### 1. Bidder Experience & Qualifications

| A) Supplied proof of required insurance, licenses, and certification |
| B) Qualifications and strengths are apparent |
| C) Shows comparable experience with previous work |
| D) Demonstrates ability to deliver a completed project |

| Go | No-Go |
| Go | No-Go |
| Go | No-Go |

**Additional Points**

| E) Utilizes local suppliers, staff, and/or firms |
| F) Has a history of successful project implementation for the City of Boulder |

| [ ] pts |

#### 2. Project Design, Technology, Contract, & Performance Warranties

| A) Is sized within the site energy plan range as shown on City facilities solar planning maps; or provides specific explanation for alternative proposed sizing |
| B) The system design, layouts, technical documentation, and components are provided and consistent with City standards presented on the solar planning maps |
| C) If applicable from planning maps energy storage is considered in the proposal |
| D) Plans demonstrate facility existing electrical system capacity and design feasibility |
| E) Production estimates and energy yield (kWh/kW) correspond to site plan; or provide specific explanation for nonconformance |

| Go | No-Go |
| Go | No-Go |
| Go | No-Go |
| Go | No-Go |

**Additional Points**

| F) Bill savings (20-25yr) provided using planned tariffs, and off-taker scenario |
| G) Considers interconnection impact costs and interconnection is realistically priced |
| H) Plan considers site constraints and the best overall use of space |
| I) Adds quality infrastructure (foundations, racking, canopy, etc.) which are lasting and useful beyond the remaining limited-lifetime components (PV / battery cells etc.) |
| J) System architectural elements are submitted demonstrating outstanding design principles and compliance with code requirements |

| [ ] pts |
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| [ ] pts |
### 3. Implementation Plan

1. Existing zoning requirements and any permitting hurdles (e.g. environmental impact assessments for ground mounts or structural suitability for roof mounts) are identified  
2. Cost of retrofit has been identified and is reasonable

#### Additional Points

3. The contained implementation plan is detailed, specific, measurable, actionable, realistic, and timely. It adequately highlights key phases, steps, and responsible parties from planning to implementation and ongoing operations
4. Time requirements of City staff is quantified for each phase of the project from planning to implementation and ongoing operations

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<td>4</td>
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### 4. Financials

A. Standard metrics on the project are contained in the evaluation including profit and loss, definition of useful life of the project, cost of capital, internal rate of return, revenues, and expenses  
B. The proposal clearly outlines upfront and ongoing costs and expenses to the City and describes in detail where those costs are allocated (i.e. for what key activities, work, or capital requirements)

#### Additional Points

C. Local, State, and federal rebates and incentives have been considered and incorporated into analysis  
D. If the project includes recurring payments (power purchase agreement, pay-for-performance contract, or on-bill financing) the dates and amounts of payment clearly benefit the buyer and are disclosed in a financing plan  
E. Potential risks to project financial performance and ongoing operation have been extensively reviewed and quantified  
F. Risk has been addressed and recommendations for management are present, realistic and well thought out

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### 5. Environmental and Social Impacts

A. The bidder has identified and quantified non-financial impacts of the project including any anticipated negative or positive externalities including avoided energy use (kWh) and associated CO₂ emissions
B. Social justice or community outcomes or impacts, including impacts on human health, resilience, natural habitat and ecosystems are present and considered in the proposal  
C. The bidder has considered either innovative and/or proven ways of including disadvantaged community members or low, moderate-income populations in the project; if needed, mitigation of adverse environmental effect is included and is realistic

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Bidder Inputs

The following lists required inputs from a developer for them to be successfully judged based on the scoring guidance contained in this document:

1) **Bidder Experience and Qualifications:**
   - Team bios and CVs showing past work, education, and relevant knowledge, skills, or abilities
   - Reference letters (also statement of support for social impact projects)
   - List of partners, subcontractors, and suppliers necessary for project planning, implementation, financing, and operation
   - Contact info and organization websites
   - Letters of Intent (LOI) or Memorandum of Understanding (MOU) if a collaborative program

2) **Project Design, Technology & Contract & Performance Warranties**
   - System layouts showing location of modules, inverters, other major electrical equipment, and point of interconnection
   - Equipment spec sheets and sourcing list for modules, inverters, racking system, and monitoring equipment at a minimum
   - Production estimates by year including inputs/calculations used to derive
   - Performance guarantee levels and any associated conditions
   - Monitoring platform overview and length of hosting term included in cost
   - Warranty lengths for major components (modules, inverters, racking, and balance of system) and for installation labor and workmanship
   - For the contract, provide either a sample contract, a list of key contract terms and conditions, or a list of exceptions to a template contract provided by the City

3) **Implementation Plan**
   - Gantt chart or implementation timeline showing key phases of the project and key actions/activities of included staff from the City, bidder, or partnering agency

**Financials**

- Proforma cashflow showing revenue, expenses (capital costs, and ongoing operational costs), profit and loss, cost of capital, interest rates
- Calculated metrics including: net present value (NPV), IRR, simple payback years
- Scenario analysis showing potential financial performance ranges
- Description of financing plan including capital source
- Rebates and incentives used or claimed from both State or federal sources
- Disclosure of ongoing payment plan or reimbursement through on-bill financing, regular PPA agreements or other financing mechanism
- Analysis of risk and contingency or mitigation plans
- Direct purchase offer compared to PPA
- Disclosure of energy impacts including avoided or anticipated kWh savings or consumption on municipal energy bills, disclosure of impact to partner agency electric bills
- Quantification and/or monetization of positive or negative financial externalities of the project including indirect or induced economic activity
- Quantification of total avoided CO₂ Emissions over project life with supporting evidence for the reduction. Can also be displayed as a year over year metric in the proforma
- Disclosure of Social justice or community outcomes and impacts, including impacts on human health, resilience, natural habitat and ecosystems are present and considered in the proposal.
- Disclosure of mitigation methods for reducing adverse environmental effect resulting from the project
- Disclosure of positive impacts of the project that improve biodiversity or support ecosystem health
Section 9. Education and Outreach Opportunities

Following is a list of education, outreach, and publication opportunities identified through stakeholder engagement and discussions with staff. They are primary opportunities to employ in the local solar energy resource center, identified in the strategies as a one-stop hub for data and support needed by community members and other City departments.

Meetings and Special Events
- County Fairs
- Holiday events
- Piggybacking other City events
- Project “Birthday Parties” celebrating annual solar installation dates
- Annual State of the City solar celebration
- Solar company ribbon cuttings
- Energy-efficient and solar home tours
- Chamber of Commerce events

General Renewable Energy Campaigns and Outreach Products
- Posters, flyers, demonstration kits, interactive displays
- Web site presence and support
- Prizes, rewards and recognition within the City for solar-related leadership
- Stand-alone interactive solar kiosks and interactive displays
- Media outreach programs
- Electronic or traditional billboards
- Educational solar curricula and on-site kits for grades K-12
- Photovoltaics (PV) displays at visitor centers, lobbies, etc.
- Combined fliers with customer water bills
- Video production and distribution
- Educational surveys that inform the consumer or businesses, and also give valuable feedback to the City
- Water bill stuffers
- Direct mail campaigns to Boulder residents and businesses
- Newspaper articles and ads

Internet-based Solar Outreach
- Solar social media campaigns targeted at consumers and businesses
- YouTube and other short videos for the public, segregated by markets (i.e. homeowners, businesses, etc.)
• Interactive new Apps that communicate the City’s and public’s energy use back-and-forth
• Expanded use of Facebook and Twitter
• Digital email newsletters and blasts

Publications
• City of Boulder Solar Consumer’s Guide
• Feature stories for magazine articles
• Solar Best Practices Guides

Technology- and Issue-Specific Campaigns, Including Financing
• Solar and storage demonstration and education programs
• Outreach documents describing solar financing tools, or solar financing available, including available rebates and incentives
• Zero Net Energy (ZNE) residential and commercial background information for the public with a focus on solar role in ZNE
Section 10. Procurement Guidance and Program Evaluation Methods

As Boulder works to meet its ambitious Climate Commitment goals of reducing community emissions by 80% and providing 100% of electricity supply from renewable resources by 2050, they will consider several projects and business models proposed by either internal staff, or outside service providers. Proposed projects are expected to range in total energy savings, capital needs, or program support requirements. The ability to compare proposals should be accomplished by establishing common evaluation metrics that quantify and qualify the benefits of local clean energy, financial value, and avoided CO\textsubscript{2} emissions regardless of proposed project type. Linking key metrics or Key Performance Indicators (KPIs) to an integrating planning process that considers Boulder’s Climate Commitment will allow for internal staff and outside contractors to design and implement projects and programs within the Solar Action Strategy that contribute to long term planning goals in a quantifiable and measurable way.

In addition, any KPIs that are developed for evaluating proposed projects can also be applied to conduct historical program evaluation of the city’s existing portfolio of climate mitigation and energy programing. Doing so will identify opportunities for efficiency gains as well as program improvement and establish a project performance scorecard which can be applied to identify which projects and programs provide the best dollar-cost-averaged impact as they are deployed to advance the community towards achieving any of the predefined planning goals.

By establishing a standard framework of program comparison and evaluation highly ranked programs that return the most environmental, social, or economic benefits per invested resource and financial capital may merit additional funding or replication to new markets while simultaneously defining the performance metrics the City seeks to maximize as it directs the key activities and work of internal staff or external partners.

The methodology outlined in this document can be applied to any energy or climate program but when used to evaluate PV or storage programs the City will be able to compare projects on a level playing field regardless of project size, capital need, or involved partners.

Recommended Process:

1. Set up rolling procurement period for projects categorized by sector or asset class. Start with Municipally owned and operated assets.
2. Develop investment thresholds of financial, environmental, or social returns required for a proposed project to earn municipal support or investment.
3. Establish RFP requirements for bidders to report the inputs needed to determine if their proposed project qualifies and meets thresholds defined in step 2.
4. Incorporate true cost and benefit analysis into through application of the Social Cost of Carbon and local money multipliers to determine Sustainable Return on Investment (SROI) metrics to identify the environmental, social and economic returns of program implementation.
5. Perform final ranking and selection of proposed options and implement winners.
6. Measurement and Verification (M&V) requirement for 1, 2, 3 years after implementation.
Throughout this document the following terms are used to define specific ideas or calculations:

- **Inputs**: inputs are defined as any resource that is contributed to the program design or implementation. They include fixed and variable costs as well as information on resources used in the program's design or roll out.

- **Multipliers**: Multipliers are used by our model to convert inputs into meaningful metrics and performance indicators. Multipliers include the cost of energy, emission factors, and the social cost of carbon. More information on these multipliers are outlined later in this paper.

- **Outcomes**: Outcomes are the resulting values used to measure program performance. The recommended evaluation includes environmental factors like energy savings and the embedded GHG saving of avoided energy use. This evaluation also tracks economic outcomes, such as the value of energy savings and local money multipliers.

### Step 1 – Rolling Procurement Periods

Boulder can use procurement strategies to find and vet the programs that enable them to meet ambitious goals by establishing rolling procurement periods categorized by sector or asset class and designed to attract project ideas from outside consultants, energy service providers and property owners. While a rolling procurement periods can be designed to accommodate projects that work for privately owned buildings as well as residential buildings this report recommend beginning procurement for projects that service municipally owned and operated facilities or assets.

### Pay-for-performance and At-risk Contracting

This report puts emphasis on Pay-for-performance and at-risk contracting as it offers a means through which the City can source program and project ideas at little to no out of pocket costs. Under this model of procurement, the City will design a RFP that outlines specific organization and project outcomes that they are looking to create through partnership with energy service providers and outside contractors. Rather than offer a payment for a scope of work the City then ties payment to a percent of total new generation or energy savings revenue after project commissioning or through on-bill financing. This method is sometimes referred to at risk contracting as the outside service provider carries the risk of project design, finance and implementation and only receives payment for the upside returns they create for the City.

It is notable that early pay for performance contracting will work best for services offered to City owned and operated assets. The program can also scale to serve residential, industrial, and commercial customers should the City of Boulder choose to switch to a municipal energy structure. Alternatively, in later years the City can offer to facilitate procurement guidance and support on behalf of commercial or industrial property owners. Doing so will provide an incentive to private sector property owners or managers in the form of offered human capacity with the expertise and experience managing pay for performance and at risk contracting procurement processes.
It is recommended that pay-for-performance and at-risk contracts should always be accompanied by a post-project measurement and verification process designed to verify that energy savings, sales other revenues and project costs have been implemented and achieved prior to any payment being issued. Contracting terms around payment conditions should be clearly defined with the support of Boulders legal team prior to any RFP issuance.

To work efficiently Boulder may need to make energy use records for assets targeted during a rolling procurement term available through a web-platform to generate high quality bids based on real data and savings or revenue generation.

Essential elements of pay-for-performance RFP should include:

1. Clear quantifiable definition of desired outcomes including energy savings or new generation capacity/volume
2. Development of an outreach list to circulate and share a RFP and location for public online release
3. Development of payment terms and conditions with the support of internal legal team; choice of lump sum payment after M&V true-up or as an on-bill payment
4. Clear definition of which properties are open for project proposal
5. Accessible public release of municipal energy data and usage history including Trailing Twelve Month and 15-minute interval data for target facilities or assets
6. Public release of existing planning or projects ongoing at target facilities or assets
7. Definition of response deadlines and content requirements
8. Creation of internal ranking protocol or return thresholds for determining winning bid
9. Assignment of internal staff or as needed consultant for review of RFP responses
10. Engagement with any stakeholders affected by procurement process or implemented process to inform them of a coming RFP accompanied with a feedback period for directly affected stakeholders who will experience financial, environmental or planning impacts from the projects implementation

**Step 2 – Define Project Return Thresholds**

Prior to listing a formal RFP, the City should work to develop thresholds of financial, environmental, or social returns required a proposed project must meet to earn muni support or investment. This report recommends the following return indices be used:

**Return on Investment (ROI):** Shows the expected payback period in years at which initial investment costs break even.

**Net Present Value:** Net Present Value shows the value of the project over its lifetime factoring in revenue and expenses.

**Internal Rate of Return:** Shows the rate of return that another project would have to beat in order to provide a better investment
Profitability Index: Profitability Index shows the expected profit for every dollar spent on the program.

Cost ($)/kWh: Shows the cost of energy associated with the project in terms of a dollar amount per kilowatt hour.

Total project lifetime kWh savings: Shows the total energy savings over the projects lifetime.

Cost ($) /ton CO$_2$-E avoided: Shows how much it costs through the project to generate one ton of CO$_2$-E savings.

Total project lifetime CO$_2$-E avoided: Shows the total amount of CO$_2$-E that is avoided over the projects life.

Once identified for a portfolio of proposed projects the City will be able to compare and contrast project level investments based on the metrics they which to maximize, as well as design a portfolio of program strategies designed to balance risk and return while protecting the financials and credit worthiness of the City. Quantifying the ratios or “threshold” at which these metrics are deemed appropriate for investment should be accomplished through internal engagement within the City across departments and based on feedback from key financial, accounting, and energy staff.

It is notable that return thresholds may change based on capital sources that require their own tolerable risk and return ratios or require consideration of administrative burden. As a result, this report recommends also considering which projects are best funded by which capital sources, such as rebates/incentives, build own operate models, revolving funds, grant funds or other capital sources.

**Step 3 – Establish RFP Requirements**

Once internal thresholds for investment have been defined the City should work to develop the specific details required to gather projects that have the potential to meet investment thresholds through a formal RFP process. While projects may vary in their approach to creating energy savings, technology, or generating new local renewable capacity the City can gather essential information that should be present across all proposals.

There may be scenarios where energy service providers will supply bids that require no out of pocket financing from the municipality. Under such cases projects should still be evaluated based on their performance metrics but staff will be required to also consider revenue splits and clearly understand contract terms and conditions to determine final impact on City balance sheets. RFP contract terms should clearly define Boulder’s willingness to collaborate on pay for performance, on bill financing, or lease to own contracting.

The list below outlines a bare minimum of required data and information needed for a proposal to be evaluated for its ability to meet defined investment thresholds and key performance metrics.

**Project Description:**

- Site address
- Energy capacity or project details:
- Engaged partners or team members:
- Trailing-twelve-month energy usage
- Existing and proposed new Rate Tariff and expected rate forecast over project lifetime
- 15 Min interval data if available

**Financial Inputs needed:**
- Inflation Rate (assumed)
- Project terms (years)
- Cost of Capital

**Revenue:**
- Avoided cost of energy
- Avoided T&D costs if applicable
- Revenue from energy sales
- Other revenue

**Expenses:**
- Siting surveys
- Environmental review costs
- Planning analysis costs
- Capital expenses
- Operation and maintenance
- Interconnection fees
- Assumed rate or tariff increase
- Other expenses

**Financial Metrics (Calculated)**
- Net Present Value
- Internal Rate of Return
- Simple Payback (ROI) (yrs.)
- Profitability Index

**Performance Metrics (Calculated)**
- Total energy savings or sales over project lifetime (kWh)
- $/kWh
- Total CO₂-E savings over project lifetime (tons)
- $/ton of CO₂-E saved over project useful lifetime

**Additional Data Needed for Solar or PV analysis:**
While the above list represents the data needs for any energy project specific project types such as PV and Storage projects may require additional information to be collected through the procurement process. The list below outlines the specific information likely to be needed for project evaluation. In some cases, outside energy service providers may request the data below.
from the City if they are looking to develop analysis and proposals for deployment on municipally owned or operated assets.

- 15 Min interval meter data if available.
- Any plans “as-built” of the building electrical system
- Trailing Twelve Month (TTM) dataset showing facility energy usage.

**Step 4 – Apply True Cost Analysis**

**Converting kWh to GHG:**

Once total energy savings were calculated, an emission coefficient is applied to convert kWh savings into a greenhouse gas savings. For guidance on what emission coefficient should be used to convert EUI into GHG intensity, this report recommends referring to the standards set by the GHG Protocol. GHG savings are normally represented by their Carbon Dioxide Equivalency (CO₂-E) value. Generally, emissions coefficients stay constant by fuel type, but local municipalities will have different energy generation mixes based on their local grids and sources of energy. As a result, calculating local CO₂-E emissions requires understanding local energy use and distribution. The recommended equation for calculating a total GHG footprint is:

\[
\text{Total GHG Footprint (tons CO}_2\text{-E)} = \text{kWh} \times \text{Emission Coefficient}
\]

This step can be easily completed by RFP respondents or by internal staff, but this report recommends that City staff understand the conversion to be able to communicate and support the program evaluation process as needed.

**Monetization and Money Multipliers**

Once total energy savings and/or total GHG savings are known, the savings can be monetized. Monetization allows for all financial, environmental as well as social impacts to be valued in terms of the US dollar. Having all the data translated into a financial metric, traditional financial modeling tools can be applied to understand impact using a common and pre-existing language. This also provides a common denominator to compare and contrast financial, social and environmental impacts, where previously this was not possible due to the strictly qualitative nature of social and environmental data.

As explored in the previous section, the environmental impact of energy savings can be directly correlated into GHG emissions. However, measuring the social implications of the reduced energy use and subsequent GHG emissions reductions requires further steps. One methodology posits that a jurisdiction cannot truly understand the full impact spectrum of clean energy projects if that jurisdiction cannot also calculate the social costs and benefits of program implementation. The following table highlights some of the outputs that are material to a complete a triple bottom line assessment of energy efficiency programs. Specifically, this report examines the impact that energy projects can have on local economic stimulation, as well as health and community wellbeing through a Social Cost of carbon and a Local Money Multiplier.
Applying the Social Cost of Carbon

The social cost of carbon to greenhouse gas savings is used to capture the economic value of abated externalities from pollution on human health, economic activity, and environmental degradation. “EPA and other federal agencies use the social cost of carbon (SC-CO$_2$) to estimate the climate benefits of rule makings. The SC-CO$_2$ is an estimate of the economic damages associated with a small increase in carbon dioxide (CO$_2$) emissions, conventionally one metric ton, in a given year. This dollar figure also represents the value of damages avoided for a small emission reduction (i.e., the benefit of one ton of CO$_2$ reduction).”

The table below outlines the monetized value of one ton of CO$_2$ in terms of its economic, social and environmental impact.

<table>
<thead>
<tr>
<th>Year</th>
<th>5% Average</th>
<th>3% Average</th>
<th>2.5% Average</th>
<th>3% 95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>$12</td>
<td>$40</td>
<td>$62</td>
<td>$120</td>
</tr>
<tr>
<td>2020</td>
<td>$13</td>
<td>$47</td>
<td>$69</td>
<td>$140</td>
</tr>
<tr>
<td>2025</td>
<td>$16</td>
<td>$51</td>
<td>$76</td>
<td>$150</td>
</tr>
<tr>
<td>2030</td>
<td>$18</td>
<td>$56</td>
<td>$81</td>
<td>$170</td>
</tr>
<tr>
<td>2035</td>
<td>$20</td>
<td>$61</td>
<td>$87</td>
<td>$190</td>
</tr>
<tr>
<td>2040</td>
<td>$23</td>
<td>$67</td>
<td>$93</td>
<td>$200</td>
</tr>
<tr>
<td>2045</td>
<td>$26</td>
<td>$71</td>
<td>$99</td>
<td>$220</td>
</tr>
<tr>
<td>2050</td>
<td>$29</td>
<td>$77</td>
<td>$110</td>
<td>$240</td>
</tr>
</tbody>
</table>

This report recommends using the 5% average value as a conservative estimate of the aggregate impacts of Carbon Dioxide pollution. The following equation can be used to calculate the social cost of carbon of emission reductions resulting from proposed or existing energy projects.

\[
\text{Social Cost of Carbon} = \text{Annual Greenhouse Gas Savings in CO}_2\text{-E} \times \text{Forecasted 5\% average discount rate Social Cost of Carbon}
\]

Applying Local Money Multipliers:

A robust triple bottom line analysis of potential project impact should include a monetization of a program’s impact on Boulder’s local economy. By applying what is a ‘Local Money Multiplier’ which can be sourced from regional IMPLAN models, or as secondary data inputs from other similar project types Boulder can begin to estimate the local economic impact resulting from energy project investment. This report recommends the following equation to evaluate economic forcing, regardless of where a Local Money Multiplier is sourced.

\[
\text{Value of Economic Forcing} = \text{Program Investment Costs} \times \text{Local Money Multiplier}
\]
Step 5 – Ranking and Selection

Outcomes and Results:

At this stage in the analysis the methodology has captured the inputs that are material to project evaluation, converted raw data into energy and greenhouse gas savings, and monetized the value of these savings. If analysis were to stop here it would demonstrate the energy and financial impacts of the project. However, questions would remain about how to interpret the overall health and performance of the program and compare it to other investment options.

To continue analysis, this report recommends deploying traditional financial analysis metrics including evaluation of the program or project’s net present value (NPV), Internal Rate of Return (IRR), and profitability index (PI) of all anticipated future energy savings or sales. In addition, this report recommends evaluating the Triple Bottom Line (TBL) NPV of the program; which rolls together financial, social, and environmental direct impacts, co-benefits and costs into a single metric.

The following equations represent the final programs Return Indices needed to weigh proposals based on their full impact to Boulder’s environmental, social, and economic outcomes.

Return Indices:

**Net Present Value of Energy Savings**

\[ NPV \times \left( \text{program costs} - \text{(Value of energy savings)} \right) \]

*Net Present Value shows the present value of all future cashflows resulting from program costs, as well as the value of saved energy.*

**Profitability Index**

\[ \frac{\text{NPV of Energy Savings}}{\text{Program Costs}} \]

*Profitability Index shows the expected value of energy savings returned for every dollar spent on the program.*

**Sustainable Return Indices**

**Triple Bottom Line (TBL) NPV**

\[ NPV \times \left( \text{Program Costs} - \text{(Value of energy savings, Social Cost of Carbon, value of generated economic activity)} \right) \]

*Net Total Benefit shows the present values of all environmental, economic and social cash flows resulting from the program.*

Next, the Net Total Benefit of the program is divided by the cost of investment required to run the program and a profitability index is created. It effectively shows the triple bottom line resource productivity of the program. This report uses the triple bottom line profitability index to represent the Sustainable Return On Investment (SROI) of the program.

**Profitability Index of Net Total Benefit**

or **Sustainable Return on Investment (SROI)**

\[ \frac{\text{TBL NPV}}{\text{Program Expenses}} \]

*SROI shows the total environmental, economic and social return of the program per dollar invested*
Interpreting the Results

NPV was defined as the present value of all future cash flows resulting from program costs, including the value of energy savings, and the Profitability index as the expected value of energy savings returned for every dollar spent on the program. But how does the jurisdiction determine if the values yielded in the program evaluation are “good” or “bad”?

These metrics are often used in traditional financial analysis to determine whether a program is deemed worthy of investment or not. While no single index should be used as a steadfast indicator of returns, each metric can paint a picture of what future cash flows as well as social and environmental return might look like. A traditional financial analysis would usually choose to invest in a project so long as it had a positive NPV, and the higher the NPV, the higher the investment quality.

Traditional financial analysis would most often choose to invest in a project so long as the profitability index is also greater than one. If the profitability index were negative, it would suggest that the project’s return would be less than the initial investment put into the project. Clearly, this outcome would be unfavorable.

Not all social and environmental outcomes are captured in this methodology. For example, the impacts on social equity, or non GHG related environmental contamination are not considered. For this reason, Boulder should not rely strictly on the TBL NPV or the profitability index to indicate whether a project should be considered. The organization must consider a myriad of factors when determining where to invest their time and resources. However, the results of these calculations can add a depth of analysis not previously attainable; the results of the program evaluation can be used as an additional tool to communicate potential and realized value to program managers and the public alike.

Step 6 – Measurement and Verification

The final step of the procurement and program evaluation process is to conduct summative program evaluation of the cities implemented projects and programs on a rolling basis. Doing so will enable the City to true up for pay-for-performance contracts, confirm project revenue and expenses, and identify differences in predicted versus real savings or generation capacity. Doing so will identify opportunities for operational and efficiency improvements as the City continues the process of rolling procurement as well as allow for the City to track its progress towards integrated planning goals such as MW of new generation created, or tons of CO$_2$-E reduced.

During the M&V process project level impacts can be compared to identify which projects have provided the largest progress towards the cities goals based on our recommended KPIs. Once known these metrics can be bundled across project type to paint picture at a program level. For example, if the return metrics of all energy storage programs are able to be calculated they can be aggregated to show the total impact of the cities programmatic energy storage activity. Doing so will allow for a higher-level overview across program types to be captured and for City staff to identify which programs are in need of additional resources to provide returns, or alternatively to inform reinvestment decisions to guide the deployment of human or financial capital in order to scale programs that are high performers.
Section 11. Collaborative Procurement and SEED Fund Impacts

The Sustainable Energy & Economic Development Fund (SEED Fund) methodology is one of several collaborative procurement processes, as shown in the figure below. Collaborative procurements methods (such as the SEED Fund) have shown reduced administrative and legal costs for partner public agencies by 50-75%. Bundling multiple projects into a single portfolio has also lowered procurement cost by 12-14% when compared to similar site-by-site individual project procurements.

The SEED Fund program is set apart from other bundled procurement methods through the use of a public-private revolving fund. At the beginning of each round of procurement no-cost services are provided to potential participants which lays the groundwork for identifying and evaluating the individual projects for the portfolio procurement; during this period the Fund is depleted as these no-cost services are provided by a program development team. At the end of each round of project construction reimbursements are recovered only from developers of successful projects. These reimbursements then replenish the Fund which is redeployed to lay a groundwork of no-cost services (participant support, site identification and evaluation, etc.) for the subsequent round.

Thus far all SEED Fund rounds have taken place in California. Round One of the SEED Fund brought together thirteen public agencies in Napa, Marin, and Sonoma Counties. This led to reduced project risk and project cost, as judged by the participants. SEED Fund Round Two is led by County of Santa Cruz, and is in the contracting stages with renewable energy systems providers. The launch of Round Three is expected in the Sierra mountains region this year. All projects have leveraged the same initial revolving fund to defer upfront costs of renewable energy project planning, project management, site assessments, and procurement activities.
Implementation of the SEED Fund is based on a 11-step process designed to move quickly from recruitment through commission and operation of solar assets. The Fund is an example of at-risk program implementation since initial steps are paid for by the fund and provided to participants with no upfront costs as follows:

1. Regional recruitment of participants and lead agency
2. Gather necessary data from intended participants
3. Kick-off workshop with stakeholders and intended participants
4. Consolidate and disseminate site analysis reports to intended participants
5. Decision to participate and authorization of memorandum of understanding (MOU)
6. Establish procurement process schedule and design procurement documents
7. Issue bundled portfolio RFP on behalf of participants
8. Proposal evaluation, selection, negotiation, and contract awards
9. Construction quality and project management of the installation
10. Commissioning and operation
11. Reimbursements issued to replenish revolving fund

The table below summarized the total impact and pooled assets mobilized through the program.

<table>
<thead>
<tr>
<th>SEED FUND LOCATION:</th>
<th>NORTH SF BAY</th>
<th>MONTEREY BAY</th>
<th>SIERRA MOUNTAINS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAD AGENCY</td>
<td>City of San Rafael</td>
<td>County of Santa Cruz</td>
<td>County of Amador (proposed)</td>
</tr>
<tr>
<td>CONVENER</td>
<td>Marin Clean Energy Practitioners</td>
<td>Association of Monterey Bay Area Governments</td>
<td>Sierra Business Council</td>
</tr>
<tr>
<td>FUNDING BY</td>
<td>California Solar Initiative</td>
<td>SEED Fund North Bay</td>
<td>SEED Fund Monterey Bay, US Department of Energy</td>
</tr>
<tr>
<td># OF RFP PARTICIPANTS</td>
<td>13</td>
<td>8</td>
<td>6-10 (target)</td>
</tr>
<tr>
<td># OF SITES (BUNDLED)</td>
<td>29</td>
<td>28</td>
<td>20-25 (target)</td>
</tr>
<tr>
<td># OF MW IN RFP</td>
<td>~ 4.3 MW</td>
<td>~ 7.0 MW</td>
<td>3-5 (target)</td>
</tr>
<tr>
<td># OF MW CONTRACTED</td>
<td>~ 3.1 MW</td>
<td>~ 2.3 MW +</td>
<td>TBD</td>
</tr>
<tr>
<td># OF MW BUILT</td>
<td>~ 1.3 MW +</td>
<td>TBD</td>
<td>TBD</td>
</tr>
</tbody>
</table>

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### Phase 1 - Strategy 1
#### Parallel Performance Based Incentives (PBI)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Impact on New Generation</strong></td>
<td>High (2.5 by 2020; 5.5MW total by 2030; no additional after 2030)</td>
</tr>
<tr>
<td><strong>Local Generation</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
<td>Yes, dependent on technology application and possible relation of new C &amp; I solar projects to City energy emergency plans</td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
<td>No</td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
<td>No</td>
</tr>
</tbody>
</table>

#### Implementations Details

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potential Funding Sources</strong></td>
<td>Yes. City of Boulder General Fund, EIOF</td>
</tr>
<tr>
<td><strong>Key Partner(s)</strong></td>
<td>Top C&amp;I customers, a few leaders and early adopters</td>
</tr>
<tr>
<td><strong>Technical Feasibility</strong></td>
<td>Easier. PV projects have respond well to past direct subsidies</td>
</tr>
<tr>
<td><strong>Technical Challenges</strong></td>
<td>Moderate (3.5/10), due to acquiring Xcel customer production data</td>
</tr>
<tr>
<td><strong>Administrative Burden to City</strong></td>
<td>Easier, new systems are relatively easy to put in place</td>
</tr>
<tr>
<td><strong>Difficulty to Transfer to Muni Utility</strong></td>
<td>Easier (1/10), this incentive is one typically managed by a public or private electric</td>
</tr>
</tbody>
</table>
## Phase 1 - Strategy 2
### One-stop Solar Resource Center: Education, Outreach, and Recognition

<table>
<thead>
<tr>
<th>Target Impact on New Generation</th>
<th>Moderate (0.5MW by 2020; 2.5 total MW by 2030; 4.5 total MW by 2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Generation</td>
<td>NA</td>
</tr>
<tr>
<td>Community and/or Grid Resiliency</td>
<td>Yes, community resiliency can be increased through public education efforts</td>
</tr>
<tr>
<td>Innovative Use of Solar Technology</td>
<td>Not applicable, aside from a solar-powered kiosk at the Boulder Creek Festival</td>
</tr>
<tr>
<td>Access Provided to LMI Residents</td>
<td>Yes, programs can be targeted to all customer classes</td>
</tr>
</tbody>
</table>

### Implementations Details

<table>
<thead>
<tr>
<th>Potential Funding Sources</th>
<th>Yes. City general fund, Federal (U.S. DOE), State (CEO) entities, and private foundation grants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Partner(s)</td>
<td>U.S. DOE Office of Energy Efficiency and Renewable Energy (EERE), RMI, CEO, NGOs, University, and the BVSD</td>
</tr>
<tr>
<td>Technical Feasibility</td>
<td>Low</td>
</tr>
<tr>
<td>Technical Challenges</td>
<td>Low (2/10) Focus is on website communications and public outreach via local cable and print media</td>
</tr>
<tr>
<td>Administrative Burden to City</td>
<td>Low, not expected to be particularly burdensome</td>
</tr>
<tr>
<td>Difficulty to Transfer to Muni Utility</td>
<td>Easy (1/10) Same City staff would continue to manage</td>
</tr>
</tbody>
</table>
### Phase 1 - Strategy 3
Collaborative Procurement

<table>
<thead>
<tr>
<th><strong>Target Impact on New Generation</strong></th>
<th>High (3MW by 2020; 5 total MW by 2030; 7 total MW by 2050), based on the substantial number of rooftops and available land owned by public entities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local Generation</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
<td>Dependent upon technology and partnership</td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
<td>Not applicable</td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
<td>Not specifically targeted, however, LMI housing agency participation should be encouraged</td>
</tr>
</tbody>
</table>

### Implementations Details

<table>
<thead>
<tr>
<th><strong>Potential Funding Sources</strong></th>
<th>Yes. All key partners listed below have resources to leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Partner(s)</strong></td>
<td>BVSD, the University, the state and federal governments, local national laboratories, Boulder County</td>
</tr>
<tr>
<td><strong>Technical Feasibility</strong></td>
<td>Easier, joint agreements are commonplace</td>
</tr>
<tr>
<td><strong>Technical Challenges</strong></td>
<td>Moderate (5/10)</td>
</tr>
<tr>
<td>(Implementation Degree of Difficulty)</td>
<td></td>
</tr>
<tr>
<td><strong>Administrative Burden to City</strong></td>
<td>Low, legal review can be time consuming but covered by existing budgets</td>
</tr>
<tr>
<td><strong>Difficulty to Transfer to Muni Utility</strong></td>
<td>Easier (2/10). This strategy is on-going under both scenarios.</td>
</tr>
</tbody>
</table>
| **Phase 2 - Strategy 1**  
**Green Leases and Solar Rooftop Leases** |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Impact on New Generation</strong></td>
</tr>
<tr>
<td><strong>Local Generation</strong></td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
</tr>
</tbody>
</table>

**Implementations Details**

<table>
<thead>
<tr>
<th><strong>Potential Funding Sources</strong></th>
<th>Yes. General fund, other sustainability funding grants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Partner(s)</strong></td>
<td>Boulder Rental Housing Association, (name of commercial rental property trade assoc.), Boulder Area Realtor Association, local Building Owners and Managers Association (BOMA) members, Rocky Mountain Institute (RMI), and Office of Economic Vitality</td>
</tr>
<tr>
<td><strong>Technical Feasibility</strong></td>
<td>Easier</td>
</tr>
</tbody>
</table>
| **Technical Challenges**  
(Implementation Degree of Difficulty) | Moderate (4/10) |
| **Administrative Burden to City** | Easier |
| **Difficulty to Transfer to Muni Utility** | Easier (1/10)  
Stays inside sustainability, building, planning departments |
### Phase 2 - Strategy 2
**Advocacy for Community Solar Gardens**

<table>
<thead>
<tr>
<th><strong>Target Impact on New Generation</strong></th>
<th>High (3.5 by 2030; 5.5 total MW by 2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local Generation</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
<td>Yes. Involvement at the state level tends to benefit all Boulder residents regardless of income.</td>
</tr>
</tbody>
</table>

#### Implementations Details

<table>
<thead>
<tr>
<th><strong>Potential Funding Sources</strong></th>
<th>Yes. General fund, Energy Foundation[^1^], other advocacy organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Partner(s)</strong></td>
<td>Other municipal governments, Boulder County, NGOs, and trade associations</td>
</tr>
<tr>
<td><strong>Technical Feasibility</strong></td>
<td>High</td>
</tr>
<tr>
<td><strong>Technical Challenges</strong></td>
<td>Moderate (5/10)</td>
</tr>
<tr>
<td>(Implementation Degree of Difficulty)</td>
<td>Requires complex negotiations and orchestration of lobbyists and legal advisors</td>
</tr>
<tr>
<td><strong>Administrative Burden to City</strong></td>
<td>Moderate. Responsibility falls on a select few senior managers and outsourcing</td>
</tr>
<tr>
<td><strong>Difficulty to Transfer to Muni Utility</strong></td>
<td>Difficult (8/10)</td>
</tr>
</tbody>
</table>

[^1^]: [http://www.ef.org/about-us/](http://www.ef.org/about-us/)

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[^1^]: [http://www.ef.org/about-us/]
# Phase 2 - Strategy 3

Promote Property Assessed Clean Energy (PACE)

<table>
<thead>
<tr>
<th><strong>Target Impact on New Generation</strong></th>
<th>Moderate (3MW by 2030; 4 total MW by 2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local Generation</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
<td>No</td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
<td>No</td>
</tr>
</tbody>
</table>

## Implementations Details

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Partner(s)</strong></td>
<td>Boulder County, Boulder Chamber of Commerce, Boulder C-PACE participants</td>
</tr>
<tr>
<td><strong>Technical Feasibility</strong></td>
<td>Easier</td>
</tr>
<tr>
<td><strong>Technical Challenges</strong> (Implementation Degree of Difficulty)</td>
<td>Moderate (4/10)</td>
</tr>
<tr>
<td><strong>Administrative Burden to City</strong></td>
<td>Easier</td>
</tr>
<tr>
<td><strong>Difficulty to Transfer to Muni Utility</strong></td>
<td>Moderate (6/10)</td>
</tr>
</tbody>
</table>

[^1]: [http://www.energyoutreach.org/grants](http://www.energyoutreach.org/grants)
### Phase 2 - Strategy 4

**Community Solar Gardens at City Facilities**

<table>
<thead>
<tr>
<th><strong>Final Potential MWs</strong></th>
<th>Moderate (2MW by 2030; 4 total MW by 2050) as an Xcel customer. Possibly higher under municipalization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local Generation</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
<td>Yes, community resiliency via distributed, decentralized energy projects</td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
<td>No, however, accounting and software that tracks RECs and energy consumption adds potential innovation in data handling and tracking</td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Implementations Details

<table>
<thead>
<tr>
<th><strong>Potential Funding Sources</strong></th>
<th>Yes. CSG developers (Clean Energy Collective etc.) Xcel, federal and state government, Energy Impact Offset Fund (EIOF),</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Partner(s)</strong></td>
<td>Xcel, Boulder County, commercial and industrial businesses with load, the Coalition for Community Solar Access, NREL, GRID Alternatives</td>
</tr>
<tr>
<td><strong>Technical Feasibility</strong></td>
<td>Moderate. Projects generally rely on traditional, proven ground mount systems</td>
</tr>
<tr>
<td><strong>Technical Challenges</strong></td>
<td>Moderate (6/10)</td>
</tr>
<tr>
<td><strong>Administrative Burden to City</strong></td>
<td>Moderate, tied to start-up costs and administration, and tracking energy use after obtaining the energy production data from Xcel</td>
</tr>
<tr>
<td><strong>Difficulty to Transfer to Muni Utility</strong></td>
<td>Moderate 6/10 Planning for transfer to municipal utility by including specific transfer clause in CSG contracting adds to setup cost and complexity but can reduce difficulty at transfer point</td>
</tr>
<tr>
<td>Phase 3 - Strategy 1: Promote New Tariffs at Muni or State Level</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Target Impact on New Generation</strong></td>
<td>High (20 MW by 2050)</td>
</tr>
<tr>
<td><strong>Local Generation</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
<td>Yes, depending on placement of new projects</td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
<td>Innovative mechanism to leverage low-cost wholesale Power Purchase Agreements (PPAs)</td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
<td>Low under Xcel, Moderate-high under Municipalization</td>
</tr>
</tbody>
</table>

**Implementations Details**

<p>| <strong>Potential Funding Sources</strong>                                 | Yes. Funded through normal energy service rates            |
| <strong>Key Partner(s)</strong>                                           | City legal team, consultants able to provide contract term support, third party developer, land owners, building managers |
| <strong>Technical Feasibility</strong>                                    | Easier                                                    |
| <strong>Technical Challenges (Implementation Degree of Difficulty)</strong>| Muni scenario: Easier (3/10) Non-muni scenario: Difficult (9/10) |
| <strong>Administrative Burden to City</strong>                            | Scales with volume of procurement, begin with one part-time and consultant |
| <strong>Difficulty to Transfer to Muni Utility</strong>                   | Difficult (7/10) The municipal utility may be conflicted between desires to lower rates, or recover additional revenues; it may also be conflicted between existing local generation tariffs that it has previously created and new tariffs |</p>
<table>
<thead>
<tr>
<th>Phase 3 - Strategy 2: PV + Bulk Energy Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Impact on New Generation</strong></td>
</tr>
<tr>
<td><strong>Local Generation</strong></td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
</tr>
</tbody>
</table>

**Implementation Details**

| **Potential Funding Sources** | Yes. Muni bonds, municipal debt service funding, City of Boulder carbon tax, muni special funds, energy sales revenue |
| **Key Partner(s)** | Xcel energy, City utilities, outside consultants, City legal team, third party developer, land owners |
| **Technical Feasibility** | Moderate as an Xcel customer, High under municipalization scenario |
| **Technical Challenges (Implementation Degree of Difficulty)** | Moderate (9/10), requires a long design and construction process and external experts |
| **Administrative Burden to City** | Moderate to High, greater under Municipalization |
| **Difficulty to Transfer to Muni Utility** | 6/10 |

However, provides essential resource to muni utility, and may be viable using existing water plants for pumped-hydroelectric storage
| **Phase 3 - Strategy 3:**  
On-Site PV + Energy Storage (Pilot at City Facilities) |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Impact on New Generation</strong></td>
</tr>
<tr>
<td><strong>Local Generation</strong></td>
</tr>
<tr>
<td><strong>Community and/or Grid Resiliency</strong></td>
</tr>
<tr>
<td><strong>Innovative Use of Solar Technology</strong></td>
</tr>
<tr>
<td><strong>Access Provided to LMI Residents</strong></td>
</tr>
</tbody>
</table>

**Implementations Details**

| **Potential Funding Sources** | Yes. Pay-for-performance contracting, State of Colorado, federal grants, Boulder County |
| **Key Partner(s)** | Boulder Housing Partners, BVSD, University of Colorado, State of Colorado, facilities team, police and fire departments |
| **Technical Feasibility** | Easy, joint agreements are commonplace |
| **Technical Challenges**  
(Implementation Degree of Difficulty) | High (8/10)  
May include regulatory advocacy |
| **Administrative Burden to City** | Low |
| **Difficulty to Transfer to Muni Utility** | Moderate (5/10)  
Will likely require ancillary services tariff planning, and dispatchability oversight |
Section 13. Additional References

1. Denver Post, June 2017, Xcel Energy gets go-ahead to modernize power grid and recoup costs
2. https://www.dora.state.co.us/pls/efi/EFI_Show_Filing?p_session_id=&p_fil=G_678020
3. State Policies to Fully Charge Advanced Energy Storage
4. MARKET AND POLICY BARRIERS TO ENERGY STORAGE DEPLOYMENT
5. SB17-089
6. RMI, 2015: The Economics of Battery Energy Storage How Muti-use, Customer-Sited Batteries Deliver the Most services and Value to Customers and the Grid
9. MARKET AND POLICY BARRIERS TO ENERGY STORAGE DEPLOYMENT
10. SB17-089
11. RMI, 2015: The Economics of Battery Energy Storage How Muti-use, Customer-Sited Batteries Deliver the Most services and Value to Customers and the Grid
14. Adapted Annual Community Energy Report by Xcel Energy

<table>
<thead>
<tr>
<th>Community:</th>
<th>City of Boulder, Colorado</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Data:</td>
<td>2016</td>
</tr>
<tr>
<td>Utility System Characteristics [1]</td>
<td></td>
</tr>
<tr>
<td>Electric</td>
<td>0.5990 metric tons CO2/ MWh [2]</td>
</tr>
<tr>
<td>Gas</td>
<td>0.0053 metric tons CO2/ Th [3]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>46.00%</td>
<td>Solar</td>
<td>2.00%</td>
</tr>
<tr>
<td>Gas</td>
<td>25.00%</td>
<td>Nuclear</td>
<td>0.00%</td>
</tr>
<tr>
<td>Wind</td>
<td>23.00%</td>
<td>Bio Mass</td>
<td>0.00%</td>
</tr>
<tr>
<td>Hydro</td>
<td>4.00%</td>
<td>Other</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
### Electricity

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
<td>7,318</td>
<td>1,084,109,786</td>
<td>649,382</td>
<td>$86,204,363</td>
<td>0</td>
</tr>
<tr>
<td>Residential</td>
<td>41,878</td>
<td>241,461,620</td>
<td>144,636</td>
<td>$28,053,532</td>
<td>0</td>
</tr>
<tr>
<td>Street Lighting - Metered</td>
<td>n/a</td>
<td>236,598</td>
<td>142</td>
<td>$25,624</td>
<td>-</td>
</tr>
<tr>
<td>Street Lighting - Non-Metered/Xcel-Owned</td>
<td>n/a</td>
<td>3,862,011</td>
<td>2,313</td>
<td>$1,080,435</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>49,196</td>
<td>1,329,670,015</td>
<td>796,472</td>
<td>$115,363,954</td>
<td></td>
</tr>
</tbody>
</table>

### Natural Gas

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
<td>5,140</td>
<td>37,835,883</td>
<td>200,530</td>
<td>$12,464,927</td>
<td>0</td>
</tr>
<tr>
<td>Residential</td>
<td>30,561</td>
<td>19,870,182</td>
<td>105,312</td>
<td>$13,791,629</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>35,701</td>
<td>57,706,065</td>
<td>305,842</td>
<td>$26,256,556</td>
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</tr>
</tbody>
</table>

### Programmatic Data [10]

<table>
<thead>
<tr>
<th>Windsource</th>
<th>Number of Customers</th>
<th>Subscribed Energy (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community - Business Total</td>
<td>254</td>
<td>19,201,193</td>
</tr>
<tr>
<td>Community - Residential Total</td>
<td>3,998</td>
<td>12,795,532</td>
</tr>
<tr>
<td>Colorado - Business Total</td>
<td>761</td>
<td>64,198,766</td>
</tr>
<tr>
<td>Colorado - Residential Total</td>
<td>44,549</td>
<td>120,286,300</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community - Business Total</td>
<td>$1,102,456</td>
<td>12,127,195</td>
</tr>
<tr>
<td>Community - Residential Total</td>
<td>$31,924</td>
<td>1,489,219</td>
</tr>
<tr>
<td>Colorado - Business Total</td>
<td>$24,657,255</td>
<td>253,804,402</td>
</tr>
<tr>
<td>Colorado - Residential Total</td>
<td>$1,160,212</td>
<td>71,612,750</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>On-site Solar (non-Solar*Rewards)</th>
<th>Total Installations</th>
<th>Installations During Reporting Year</th>
<th>Total Capacity (kW)</th>
<th>Capacity Installed During Reporting Year (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community - Business Total</td>
<td>n/a</td>
<td>0</td>
<td>n/a</td>
<td>0</td>
</tr>
<tr>
<td>Community - Residential Total</td>
<td>n/a</td>
<td>99</td>
<td>n/a</td>
<td>492</td>
</tr>
<tr>
<td>Colorado - Business Total</td>
<td>n/a</td>
<td>12</td>
<td>n/a</td>
<td>208</td>
</tr>
<tr>
<td>Colorado - Residential Total</td>
<td>n/a</td>
<td>2,238</td>
<td>n/a</td>
<td>12,869</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solar Gardens (PV)</th>
<th>Number of Customers</th>
<th>Subscribed Capacity (kW)</th>
<th>Subscribed Energy (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community - Business Total</td>
<td>15</td>
<td>320</td>
<td>571,680</td>
</tr>
<tr>
<td>Community - Residential Total</td>
<td>66</td>
<td>207</td>
<td>311,705</td>
</tr>
<tr>
<td>Colorado - Business Total</td>
<td>402</td>
<td>15,262</td>
<td>25,510,659</td>
</tr>
<tr>
<td>Colorado - Residential Total</td>
<td>675</td>
<td>2,527</td>
<td>3,861,232</td>
</tr>
</tbody>
</table>
### Energy Conservation

<table>
<thead>
<tr>
<th></th>
<th>Electric Demand Savings (kW)</th>
<th>Natural Gas Energy Savings (Th)</th>
<th>Rebates or Incentives Paid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community - Business Total</td>
<td>4,118</td>
<td>58,751</td>
<td>$1,813,700</td>
</tr>
<tr>
<td>Community - Residential Total</td>
<td>301</td>
<td>93,767</td>
<td>$315,301</td>
</tr>
<tr>
<td>Colorado - Business Total</td>
<td>38,388</td>
<td>1,141,117</td>
<td>$27,473,535</td>
</tr>
<tr>
<td>Colorado - Residential Total</td>
<td>42,184</td>
<td>6,279,259</td>
<td>$26,600,724</td>
</tr>
</tbody>
</table>

### Load Management (Demand Response)

<table>
<thead>
<tr>
<th></th>
<th>Number of Customers</th>
<th>Available Capacity (kW)</th>
<th>Rebates or Incentives Paid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community - Business Total</td>
<td>1</td>
<td>386</td>
<td>$0</td>
</tr>
<tr>
<td>Community - Residential Total</td>
<td>4,626</td>
<td>4,925</td>
<td>$185,123</td>
</tr>
<tr>
<td>Colorado - Business Total</td>
<td>89</td>
<td>237,942</td>
<td>$0</td>
</tr>
<tr>
<td>Colorado - Residential Total</td>
<td>188,454</td>
<td>197,610</td>
<td>$7,547,725</td>
</tr>
</tbody>
</table>
### Xcel Energy Report Footnotes

[1] Available in the latest Energy and Carbon at a Glance Sheet at: https://www.xcelenergy.com/Environment/Policy/Carbon_Policy. See the table on page 3, which shows our latest CO2 intensity by region in metric tons/MWh and lbs/MWh, as calculated using The Climate Registry’s electric power sector protocol. Note these are system-wide metrics and do not reflect differences between communities.

[2] Note that the CO2 emission factor for electricity is a preliminary estimate, as calculated using The Climate Registry protocols but not yet third-party verified. This reflects the most accurate and current emissions information available, but sometimes emissions data changes slightly as our power suppliers send us revised information, as our emissions go through third-party verification, or as reporting protocols improve. Note also that this emission factor does not include biogenic CO2 from biomass power generation, which is reported separately under The Climate Registry protocols.

[3] In the customer energy usage section, if minimum aggregation standards are not met, Xcel Energy will combine Commercial and Industrial classes into one "Business" line before not presenting data.

[4] In the customer energy usage section, if minimum aggregation standards are not met (see note 8 below), Xcel Energy will combine Commercial and Industrial classes into one "Business" line before not presenting data. Commercial Customers are classified by 2-digit NAICS sector falling between 1 and 49, while Industrial Customers are classified by 2-digit NAICS sector falling between 50 and 98. These classifications are collected by Xcel Energy through a voluntary third party customer survey. Due to the fact that not all customers respond to this survey, where no other information is available, Xcel Energy assigns those customers to the Commercial class.

[5] The number of customers represents the number of active service connections during the reporting year. The number of actual business or residences within the jurisdiction is smaller than that shown due to the fact that more than one service connection can be assigned to one customer at a given location.

[6] Estimated total carbon emissions from electricity for a customer class are equal to the total kWh consumed by the customer class, multiplied by the CO2 emission factor for the Xcel Energy system in the applicable region. This does not account for transmission and distribution system line losses or for the fact that some customers within a class may be participating in voluntary renewable energy programs.

[7] Revenues are the bill components associated only with metered energy and demand.

[8] To protect individual customer confidentiality, Xcel Energy applies the "15/15 rule" as an aggregation standard to the energy consumption section of this report. So long as a given aggregated value contains 15 or more customers and no single customer makes up 15 percent or more of the aggregated value, the value can be publicized in this report. If these conditions are not met, customers will be removed. The number of customers removed is presented for informational purposes. For more information about Xcel Energy's Privacy Policy, please visit https://www.xcelenergy.com/billing_and_payment/customer_data_&_privacy/privacy_policy_&_customer_data_access

[9] Estimated total carbon emissions from natural gas for a customer class are equal to the total therms consumed by the customer class, multiplied by the standard CO2 coefficient of 11.7 lbs/therm.
This section simply reports participation by customer class, within the geographic boundaries of the community or state being reported, in various voluntary wind and solar programs. No representations are made as to the ownership of the renewable or CO2-free attributes of the electricity being purchased by those customers. In the case of Windsource, Xcel Energy retires Renewable Energy Credits (RECs) on behalf of the participating customer; treatment of RECs varies among the solar programs. In general, ownership of environmental attributes is either with the customer or remains with Xcel Energy, unless specifically transferred to the community, so cannot be claimed by the community. In addition, our accounting methods do not allow us to adjust the system CO2 emission factors for individual jurisdictions to remove the effects of any CO2-free kWh transferred to customers under our voluntary programs.

For Solar*Rewards customers, the energy production value shown reflects that of customers who have a dedicated production meter for their photovoltaic system as well as an estimated value for those that do not. For those customers that do not have a production meter, the estimated production value is based off of the average generation per nominal capacity of production-metered systems multiplied by the known nominal capacity of the customer system. Number includes Made in Minnesota production.

Incentives Paid are those Solar Rewards incentives paid by Xcel Energy only. Does not include Made in Minnesota payments.

*As described in note 8 above, an asterisk represents a row of values for which one or more customers were removed due to implementation of Xcel Energy's Privacy Policy.

The information contained in this report relies on various assumptions, including some identified in footnotes, and is intended for general informational and instructional purposes only. The report is not to be relied upon for any other reason, including any litigated or other contested proceedings. Any customer data removed from the report is done so in compliance with Xcel Energy’s Privacy Policy and applicable state commission customer information and data privacy requirements.