Understanding this Document

This is the third of six SEP documents. The purpose of this document is to provide an overview of the renewable resource potential in the City of Santa Barbara, explore the state of the community-wide electric load and distribution grid and provide a comparison between the estimated generation potential within city limits and the amount of renewable generation needed to meet the City's renewable energy goals. The results discussed in this report were used to inform policy, program and project design, as well as strategy impact modeling, throughout the SEP process.

Introduction

This resource assessment, conducted as part of the SEP process, examined the potential of every resource considered renewable under the California Renewable Portfolio Standard (RPS) definition, including solar, wind, cogeneration (biogas), and small hydro. In order to reflect the City's prioritization of energy efficiency, as well as the importance of reliability and resiliency, the potential of non-generating resources such as energy efficiency and battery storage was also assessed.

All of the generation potential within the city limits, with the exception of select municipal facilities mentioned in "Municipal Pilot Projects", is solar potential. There was no identifiable hydroelectric or cogeneration potential within the community. Accordingly, this document focuses on the community-wide solar potential and the potential for energy efficiency and battery storage. Table 1 provides a summary of resource potential by type. For context, as of 2018 Santa Barbara had about 12 MW of residential and about 4 MW of non-residential solar installed. The solar resource assessment revealed significant additional potential.

Table 1: Summary of Total Resource Potential

Resource Type		Generation Capacity (MW)	Annual Generation (MWh)
Solar	Rooftops (non-historic)	137 – 173	184,802 – 251,010
	Historic Districts	13 – 18	17,078 – 26,028
	Total Solar	150 – 191	225,450 – 253,750
Energy Efficiency	Lighting	14 – 16	42,400 – 44,400
	Total Energy Efficiency	14 – 16	42,400 – 44,400
Grand Total		**141 - 207**	**267,850 – 297,750**

A Note on Wind

Wind potential is dependent on local wind patterns, which vary more than local solar patterns due to disruption caused by topographic features such as mountains and forests and urban features such as buildings. As a result, wind potential is often very low in heavily urban areas due to the large amount of structures on the ground. Therefore, on-shore wind potential was not considered in this study.

Any potential off-shore wind installation would likely be outside City limits, which only extend to 3 miles away from the shore. As such, off-shore wind potential was also not considered for this study.

Community-wide Electricity Load & Interconnection Capacity

The total electricity used by residents and businesses in Santa Barbara is important to determine for several reasons. First, it enables the City to determine the magnitude of the load that needs to be offset by energy efficiency and renewable generation to meet its 100% renewable electricity goal. Second, it places an upper bound on the total amount of distributed renewable generation that could be installed within city limits. Community-wide consumption was determined through a combination of Interconnection Capacity Analysis (ICA) maps and utility consumption information, both provided by SoCal Edison. They indicate a city-wide peak electricity demand of 59 – 72 MW and a total annual electricity usage of 350 – 425 GWh.

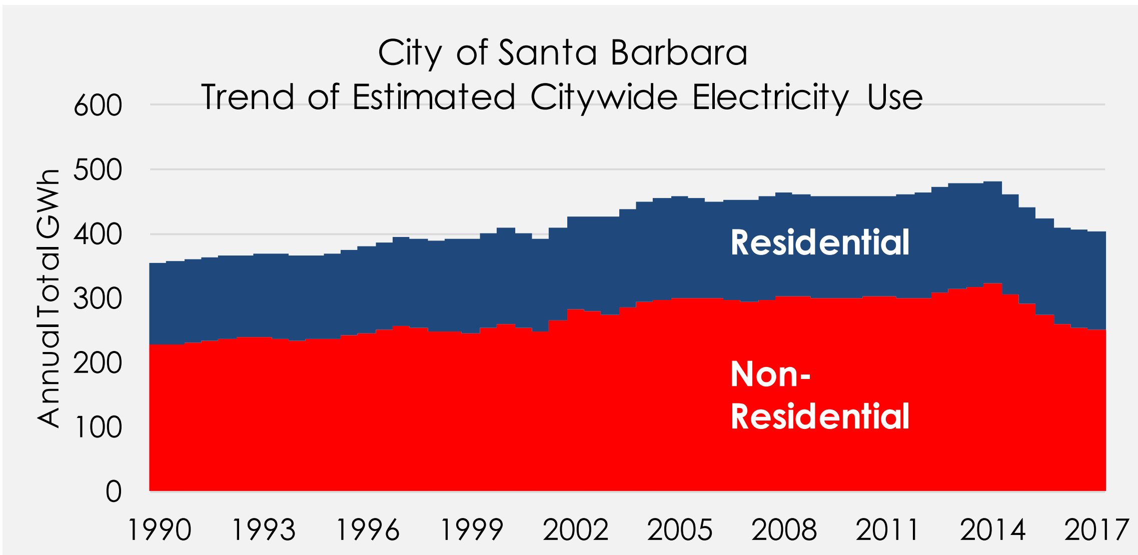

Figure 1: Estimated Historical Electricity Use

The ICA maps also indicate areas within Santa Barbara where SoCal Edison has determined that distributed energy development is more, or less, feasible from an interconnection perspective. An example of these maps is shown below.

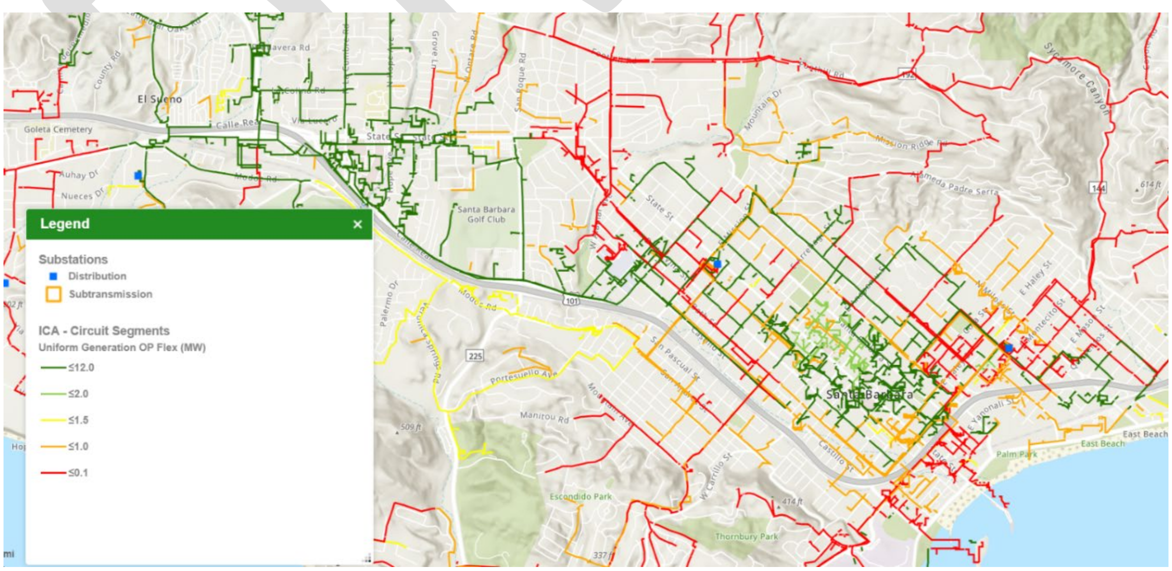

Figure 2: Examples of SoCal Edison ICA Map in the City of Santa Barbara

Projects being developed in the green areas of the grid can take advantage of an expedited interconnection process, as these sections of the distribution grid have already been determined to have sufficient capacity to support development. Projects being developed in the yellow, orange and red areas need greater study, and therefore present more hurdles for developers. The Statistical Survey Zones (see Figure 2) that have the greatest interconnection potential are the Historic Districts and Commercial West zones, whereas the Residential and Commercial Downtown Zones are more constrained. Overall, the total solar potential in Santa Barbara that is eligible for expedited interconnection without further study is approximately 47 MW, or approximately 20% of the generation needed to meet the City's goal.

Solar Statistical Survey

In order to estimate the solar resource potential within the City of Santa Barbara a ground-up statistical analysis of rooftop urban solar potential was conducted. To conduct this analysis, the city was divided into 5 regions based on geography, zoning types, and building stock. These zones were defined using the City zoning maps and aerial imaging to visibly confirm boundaries of building type and density. The five zones included one zone representing the various designated historic districts, two primarily commercial zones, and two primarily residential zones. The two commercial zones and the two residential zones differ from each other in their building density and roof structure, as well as how many of the buildings have Mission-styled red roofs.

A total of 544 representative rooftops were measured. The resulting solar potential scaled was scaled to the entire city, resulting in a solar resource potential estimate.

Solar Statistical Survey Zones

The five zones used in the analysis are depicted below.

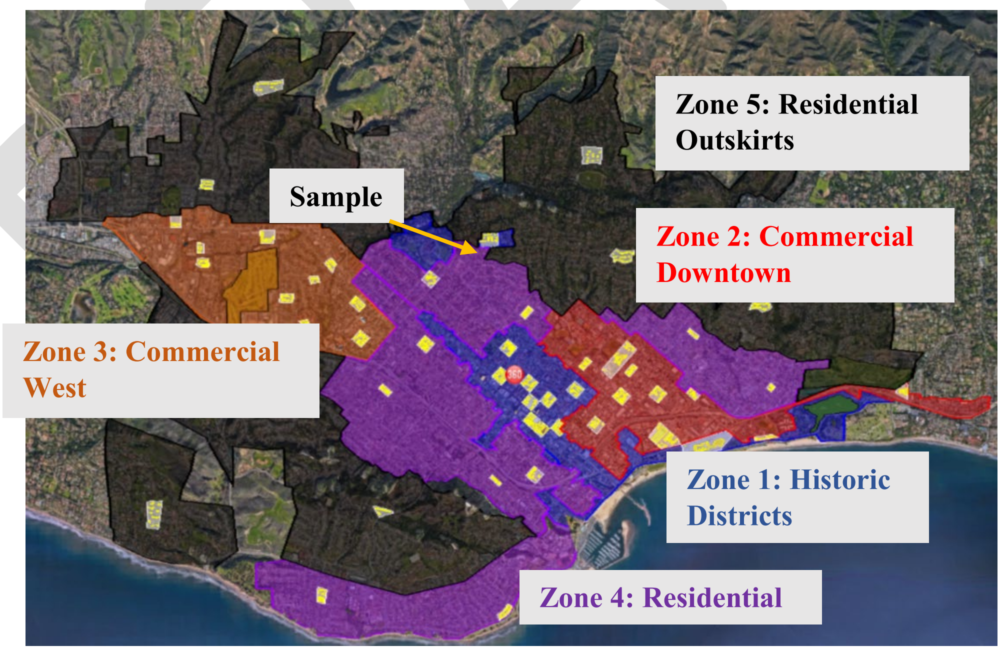

Figure 3: Solar Statistical Analysis Zones & Sample Areas

The boundaries of these statistical zones do not adhere exactly to the City limits in order to exclude areas containing large spaces unusable for building development, and therefore unsuitable for urban solar PV installations. Since the methodology used in this analysis scaled PV potential based on the physical size of the zones, including these areas would have overestimated solar potential in the city. There was a large section of area within the city limits to the northeast of Zone 5 that was excluded because it was unsuitable for development due to its topology (see Figure 3). For a similar reason, the areas of the Montecito Country Club, Cachuma Lake, and the Santa Barbara Golf Club were also excluded. However, some areas within the city boundaries that were currently undeveloped but looked suitable for future commercial or residential building development, were included. Thus, this analysis accounts for solar PV capacity existing on future building development within city limits that will likely include solar due to California state policies. This study does not account for increased solar PV potential that may result from an expansion of the City boundaries.

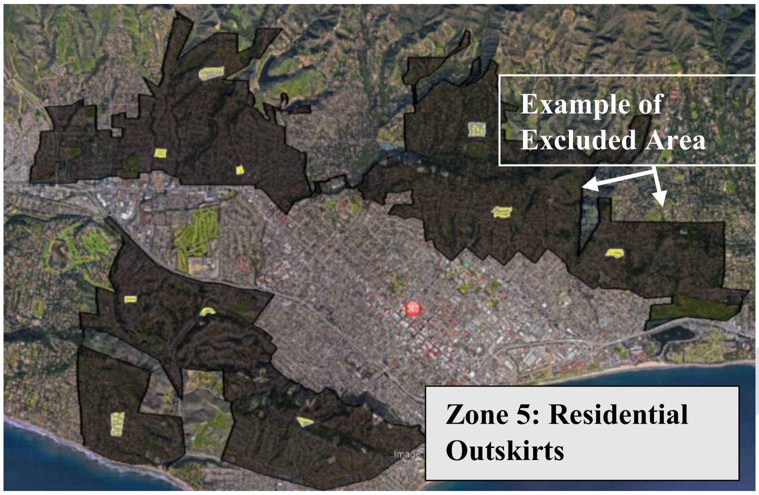

Figure 4: Example of Excluded Area

Statistical Sampling of Building Stock

Within each zone, a representative sample of 10 blocks was selected. These blocks were chosen to best reflect both building density and solar access within the entire zone.

The blocks varied in both area and the number of buildings. The Residential Outskirts zone was the largest in area, but had relatively low building density and high shading, whereas the Commercial Downtown zone was the opposite. The average block had roughly 17 structures, whereas the densest block had 56 structures. Within each block, the physical rooftop space was measured.

Figure 5: Example of Representative Block Sample

Table 2 provides a summary of the estimated area of each Zone and the number of structures within that Zone.

Table 2: Area, Measured Structures & Total Estimated Structures by Zone

	Area (sq. miles)	Number of Measured Structures	Estimated Number of Total Structures

Zone 1: Historic Districts	1.13	175	1460
Zone 2: Commercial Downtown	1.09	158	1562
Zone 3: Commercial West	1.29	113	2249
Zone 4: Residential	3.62	228	13617
Zone 5: Residential Outskirts	8.76	151	12981
TOTAL	15.90	825	31870

The rooftop area of each structure, the number of roofs ill-suited for solar PV systems due to shading or poor roof orientation, as well as the number of Mission-style roofs were catalogued and categorized. After discounting for these losses, the total usable rooftop area of each block was calculated. The usable area from each block was summed, and then scaled up to define the total usable area of the whole zone, as well as the number of Mission-style roofs.

Once the total area was estimated, the solar potential could be more accurately estimated. Fill factors were applied to the roof area to account for the fact that solar cannot cover the entire roof. The fill factors used were based on rooftop size: 10-30% for small roofs (defined as roofs <2500 ft^2), since residential roofs are typically pitched and have only one face available, 40-70% for medium roofs (<11000 ft^2), and 67-73% for large roofs (>11000 ft^2). These fill factors yield a total solar coverage area, and from there, standard efficiency solar modules were assumed in calculating the total solar potential. Within the statistical model, the results were categorized by building area, providing a picture of system size distribution throughout the city.

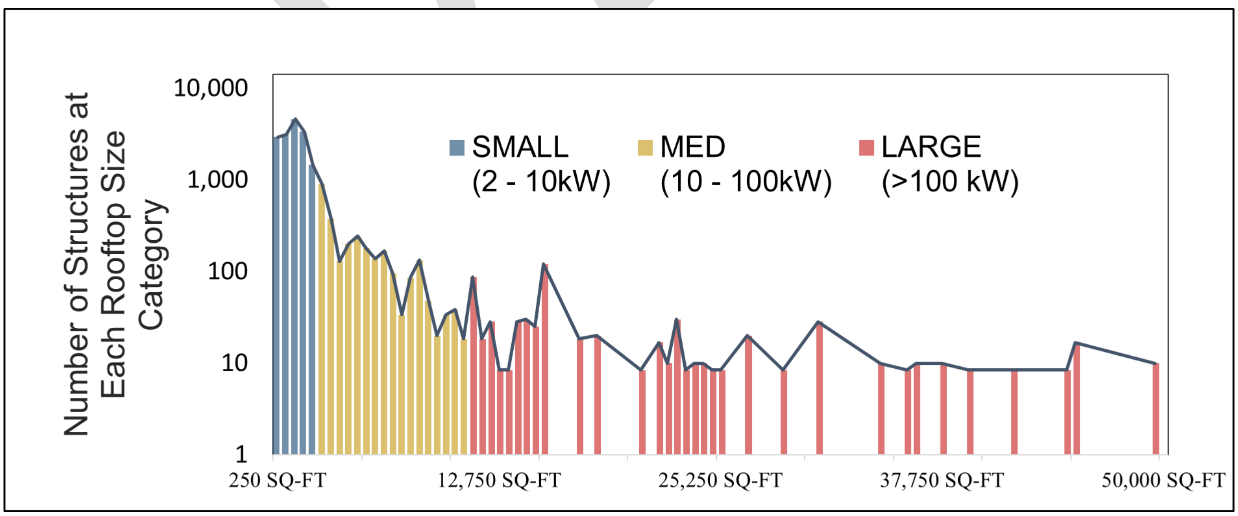

Figure 6: Estimated PV System Size Distribution

Total Solar Resource Potential

Total citywide rooftop solar potential, assuming every single viable rooftop realized its solar PV potential, is roughly 340 – 353 MW, equating to generation potential of 459,000 – 511,850 MWh. It is important to note, however, that achieving 100% participation is highly unlikely. Accordingly, various participation factors, based on building size and neighborhood type, were applied. The resulting total viable solar potential, after applying participation factors, is 150 – 191MW. These results are summarized below in Table 3.

Table 3: Solar Resource Potential

	Maximum Potential (MW)	Participation Factor (blended average)[1]	Viable Potential (MW)
Residential	75 – 77	24-34%	18 – 26
Small Commercial	166 – 176	53-63%	88 – 111
Large Commercial/ Industrial	99 – 100	44-54%	44 – 54
TOTAL	340 – 353	-	150 – 191

It is important to compare the total viable solar potential of 150 – 191 MW to the distribution system capacity that was assessed through the ICA maps. While the buildings throughout the city can support 150 – 191 MW of solar capacity from a spatial point of view, the City's distribution grid only has space for 47 MW of easily developed capacity. Generally, any solar capacity in excess of the initial 47 MW is subject to additional review by the utility and is thus less likely to be developed. Accordingly, the 150 – 191 MW of viable solar potential is used as an upper bound of possible develop to inform SEP modeling, not as an expected amount of local solar development. In the scenarios of 100% renewable energy modeled during the SEP process, about 110 MW of local solar development through 2030 was used.

There are several additional assumptions that are important to note as a part of this analysis.

- Estimates include only shade-free and correctly-oriented roofs (shaded and north-oriented roofs are counted as unviable in these results).
- The solar fill factor on each roof accounts for good design principles, such as residential buildings only installing panels on one face, 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.
- This analysis does not account for systems that may need to be downsized based on limited electricity consumption of the host facility or for budgetary reasons.
- This analysis does not discount totals for existing solar installations, so this number represents the total realistic rooftop capacity (not incremental additional capacity), including the already existing solar capacity within the city limits.

Accounting for Costs

[1] The participation factors listed here are blended averages of all participation factors used for a given building category throughout the city. The exact factors used varied depending on statistical sampling zone and whether the building was located in a historical district. A discussion of participation factors can be found in the SEP Appendix.

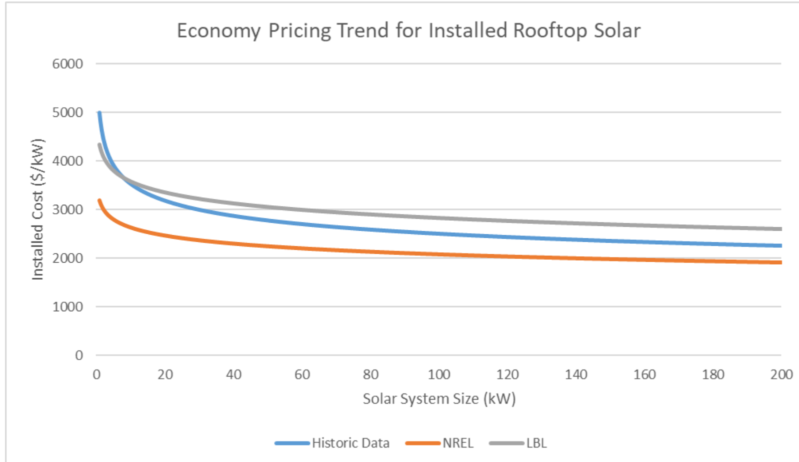

Figure 7: Rooftop Solar PV Pricing Trends

System cost and financial feasibility are also important constraints to consider when assessing solar potential. A general levelized cost of energy can be estimated for installed systems in Santa Barbara but the results depend heavily on capital cost assumptions. Different sources report different capital costs for installation. Based on data from the National Renewable Energy Lab (NREL), utility energy costs exceed levelized solar costs at every size, whereas based on data from Lawrence Berkeley National Lab (LBNL), utility energy costs are lower than levelized solar costs at every size. Optony historic data[2] indicates higher levelized electricity costs from solar for residential systems, but lower levelized electricity costs from solar for commercial and industrial systems. Generally, this means that, on a per kWh generated basis, residential solar PV is more expensive than commercial and industrial systems. This is because installing larger system sizes allows for economies of scale that reduce the unit cost of the system (even if the total cost is larger).

On a project by project basis, the levelized cost of electricity often determines whether a project is developed. Based on the variable costs shown in Figure 6, the levelized cost of electricity from solar projects in Santa Barbara is likely between .08 $/kWh and .11 $/kWh. When compared to SoCal Edison's new rates, which range from an average of .09 $/kWh to .25 $/kWh for commercial rates and between .12 $/kWh and .40 $/kWh for residential rates[3], solar looks to be a viable proposition in Santa Barbara. The shifting time-of-use (TOU) periods introduced by SoCal Edison in March 2019, however, complicate this picture as they make the most expensive electricity prices during the evening when solar has limited ability to offset that cost. The addition of a battery storage system can offset the effects of this TOU shift, but also increases system cost. Thus, the financial viability of a specific project will be dependent on the specific project characteristics.

Energy Efficiency Potential

Energy efficiency is a valuable non-generating resource that will play an important role in helping the City achieve its renewable energy goals. For this analysis, the only energy measure examined was lighting upgrades, as other electrical energy efficiency upgrades are too site dependent too accurately model.

The statistical sampling method for categorizing building type used to estimate the solar resource potential can also be used to estimate the potential for energy efficiency throughout Santa Barbara. Using this same method and applying assumptions for energy use reductions from LED retrofits, it is estimated that there is the potential for reducing between 42,400 – 43,400 MWh of electricity use in Santa Barbara. This represents about 10% of the projected annual electricity use in Santa Barbara in 2019.

[2] Proprietary data from past experiences and projects executed by Optony.
[3] Data from new SolCal Edison rate structures introduced on March 1st, 2019.

Energy Efficiency Assumptions

The energy efficiency potential estimate includes several important assumptions. First, the participation factors used for this analysis were 45% for small buildings, 75% for medium buildings and 90% for large buildings. Higher participation factors are used compared to solar development because investments in improved lighting have far fewer hurdles than investments in solar panels. There are no regulatory or technical feasibility hurdles to upgrading lighting, and utilities have more programs, such as on-bill financing, for energy efficiency investments than they do for solar investments.

This estimated potential is an overall number and does not account for business-as-usual activity. Thus, while some of this potential may be realized through specific SEP strategies, a portion of it will also be realized naturally as a result of California State Building Codes and other energy efficiency policies.

Battery Storage Potential

Battery storage is another non-generating resource that will play an important role in the City of Santa Barbara achieving its renewable energy goal. Within the context of the City's goals, the value of battery storage lies in both its ability to capture excess solar generation and use it when solar systems are not generating electricity and provide services that improve grid resilience and reliability.

Unlike solar potential, which is constrained by available space and other site characteristics like shading, and energy efficiency potential which is constrained by building type and size, battery storage is generally small and easy to site physically. Thus, assessing storage potential on a spatial basis is not a useful exercise.

Instead, battery storage potential is better assessed within the context of several other constraints. Table 4 presents these constraints and the battery storage system type to which they apply.

Table 4: Battery Storage Development Constraints

	Constraints			
System Type	System Cost	Financial Feasibility	Electrical Service Size	Distribution System Feeder Size
Behind-the-meter	X	X	X	
Front-of-Meter	X	X		X

Primary among these is the financial feasibility constraint. Financial feasibility of a battery storage projects is variable and depends on the service, or services, being performed by the battery in a specific project. Given the variety of services that can be performed by a battery system, the financial feasibility of a battery system can only be reliably assessed on a project by project basis. For a behind-the-meter system, depending on the desired service (e.g. peak demand shaving or back-up power), the electrical load characteristics and utility rate characteristics, a battery system can be sized to optimize the financial feasibility.

For front-of-meter battery systems, the services being provided are usually grid services that support the operations of the California Independent System Operator (CAISO). From a technology perspective, front-of-meter battery projects can also support the development of distributed generation such as solar, but under interconnection rules energy storage is counted as generation. This creates a misalignment between the technology's capabilities and the utility's rules. Thus, for battery storage systems, under current interconnection rules, the size of the feeders in the electrical distribution system will constrain the number and size of battery projects that can be interconnected on to the grid. This constraint is likely to increase in importance as the projects resulting from SoCal Edison's new capacity RFP for the Moorpark – Goleta electric service area are developed, as the only projects to proceed from that RFP were stand-alone, front-of-meter battery storage projects[4]. To the extent that these projects satisfy the need for new capacity in the Santa Barbara region, they may also further constrain the distribution system and competes with solar for space on the distribution grid. Unless the rules governing interconnection for front-of-meter battery storage are changed, battery storage development will be constrained by other distributed generation resources interconnected to the distribution grid.

Due to the project-specific variability of battery storage, no estimate was made for overall potential within Santa Barbara. As Santa Barbara moves towards its renewable energy goals battery storage will play important roles through its ability to capture excess solar generation and provide services that improve grid resilience and reliability. The constraints discussed here will be important for the City to consider as more battery storage projects are developed and as the City seeks to develop projects at municipal facilities.

Community-wide Resource Potential vs Community-wide Goal

About 235-240 MW of local solar would be needed to meet the City's projected electrical usage in 2030, thereby achieving its renewable energy goals. The results of this analysis indicate that , even in a scenario where the maximum viable potential of 151-190 MW of solar is developed, renewable generation outside of city limits will be needed to meet the City's goal. Despite this need, the SEP strategies were designed to maximize local generation before turning to generation from outside of the City. As discussed in the "Total Solar Resource Potential" section, the scenarios modeled during the SEP process estimate that about 110 MW of local solar will be developed in the City of Santa Barbra by 2030. This 110 MW is a result of continued development of renewable resources at the current rate in Santa Barbara and accelerated development caused by the strategies implemented by the City as recommended in the SEP. This modeling assumes a certain level of investment by the City and the impacts of the strategies could be expanded through increased investment, enabling the City to capture more of its local renewable potential.

[4] Community Stakeholder Presentation Summary of LCR RFP Offers Received, July 16, 2018