BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF PUBLIC SERVICE COMPANY OF NEW MEXICO'S APPLICATION FOR A CERTIFICATE OF PUBLIC CONVENIENCE AND NECCESITY TO PURCHASE, OWN, AND OPERATE TWELVE MEGAWATTS OF BATTERY STORAGE FACILITIES	)	**Case No. 23-00162- UT**
PUBLIC SERVICE COMPANY OF NEW MEXICO,	)	
Applicant	)	

DIRECT TESTIMONY

OF

LUCAS MCINTOSH

May 3, 2023

NMPRC CASE NO. 23-_______-UT
INDEX TO THE DIRECT TESTIMONY OF
LUCAS MCINTOSH

WITNESS FOR
PUBLIC SERVICE COMPANY OF NEW MEXICO

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Self-Verification

I. INTRODUCTION AND PURPOSE

Q. PLEASE STATE YOUR NAME, POSITION, AND BUSINESS ADDRESS.

A. My name is Lucas McIntosh. I am the Managing Director of the Power Grid Advisory team at 1898 & Co., a division of Burns & McDonnell Engineering Co. ("Burns & McDonnell"). My office address is 9400 Ward Parkway, Kansas City, MO 64114. A copy of my statement of qualifications is attached as PNM Exhibit LM-1. I am submitting this testimony on behalf of the Applicant, Public Service Company of New Mexico ("PNM").

Q. WHAT ROLE HAS BURNS & MCDONNELL PLAYED IN THE DEVELOPMENT OF THE PROPOSED 12 MW BATTERY ENERGY STORAGE SYSTEM?

A. Burns & McDonnell has provided engineering technical support and analysis to PNM in developing and preparing the request for a certificate of public convenience and necessity ("CCN") for PNM's proposed 12 MW battery energy storage system project ("BESS Project"). To that end, I recap a report prepared by Burns & McDonnell in 2021 that helped examine and quantify the potential benefits that distributed battery energy storage systems ("BESS") may offer to PNM interconnected at various locations and operating under various assumed conditions. A copy of the Burns & McDonnell 2021 BESS Report ("2021 Report") is attached as PNM Exhibit LM-2. I also provide a summary of another study conducted in 2022 by Burns & McDonnell that provided PNM with an estimate of the construction and installation costs of each BESS site not included in the BESS vendor equipment and services. A copy of the Burns & McDonnell 2022 cost estimate ("2022 Estimate") is attached as PNM Exhibit LM-3. I also provide a brief review of some comparable projects and applications of BESS across the electric utility industry.

Based on the assessments provided, I conclude that distributed BESS is a prudent and important utility strategy for managing safe and reliable operations of electric infrastructure that hosts high penetrations of distributed intermittent solar generation capacity. PNM's proposed BESS Project is a reasonable application of this strategy that provides quantified benefits to PNM's system and customers.

Q. WHAT QUALIFICATIONS DOES BURNS & MCDONNELL HAVE TO SUPPORT THE PROPOSED 12 MW BESS?

A. Burns & McDonnell has served the electric utility industry for over half a century. Services range from technical analysis and advisory to engineering and construction of infrastructure across the entire value chain (centralized generation, transmission lines, substations, distribution lines, and behind the meter resources). Most relevant to the proposed BESS Project are Burns & McDonnell's unique combination of experience in distribution planning and design and construction of battery energy storage facilities. A copy of a summary of Burns & McDonnell's BESS qualifications is attached as PNM Exhibit LM-4.

II. 2021 REPORT PREPARED BY BURNS & MCDONNELL

Q. WHAT WERE THE OBJECTIVES OF THE 2021 REPORT PREPARED BY BURNS & MCDONNELL?

A. PNM enlisted the support of Burns & McDonnell to conduct analysis and simulation to assess potential applications and estimate impacts of distributed BESS located and interconnected on PNM distribution feeders already hosting solar distributed generation ("DG") beyond the hosting capacity of the feeders. The work was primarily intended to evaluate potential benefits and inform the selection of sites, the megawatt capacity of BESS, and the duration of stored energy needed in the systems that could be deployed.

Q. WHAT WAS THE GENERAL APPROACH OF THE 2021 REPORT?

A. The 2021 Report involved three specific assessments:

1. "Site & Circuit Identification" – The 2021 Report helped PNM screen and evaluate potential battery co-location opportunities, including evaluation of existing solar DG sites identified by PNM as having distribution circuit (used interchangeably with the term feeder) and substation impacts. This

involved assessing power flows and general storage impacts across 10 sites and then comparing and ranking them based on various targeted factors.

2. "System Capacity Value Assessment" – The 2021 Report helped identify the minimum size BESS, assumed to be in the vicinity of each solar DG site, to reduce risk of thermal overload from reverse power flow. This involved an assessment of how various combinations of size and duration of co-located BESS can reduce or eliminate overcapacity occurrence on three sample sites.

3. "Energy Arbitrage Value Estimation" – The 2021 Report used historical nearby electricity market data to estimate the potential economic value of BESS operated to reduce the cost of supplying electricity to customers through arbitrage (charge the BESS when electricity is cheap and discharge to serve customer loads when electricity is expensive to buy or generate).

Q. WHICH SITES AND CIRCUITS WERE ASSESSED IN THE SITE & CIRCUIT IDENTIFICATION PORTION OF THE 2021 REPORT AND WHAT WERE THE RESULTS?

A. The 2021 Report analyzed the addition of BESS at select sites and circuits to assess ability to unlock additional hosting capacity for residential customers. Ten example sites were evaluated and screened in the report. Their names, substations, associated circuits, and size are listed in PNM Table LM-1 below.

PNM Table LM-1

PV Site	Substation	Feeder (Circuit)	Aggregate Feeder Solar DG Hosted
Facebook 3 Solar	Lost Horizon	LOHO-12	9.9 MW
Santolina Solar	Lost Horizon	LOHO-13	11.0 MW
Facebook 2 Solar	Lost Horizon	LOHO-14	11.0 MW
Rio Rancho Solar	Scenic	SCEN-12	9.1 MW
South Valley Solar	South Coors	SOCO-12	10.3 MW
Rio Del Oro Solar	Tome	TOME-12	9.9 MW
Manzano Solar	College	COLL-12	8.4 MW
Facebook 1 Solar	Los Morros	LSMO-12	10.0 MW
Sandoval Solar	Progress	PROG-13	6.4 MW
Santa Fe Solar	State Pen	STPE-12	9.5 MW

Each site was assessed on four factors for comparison and ranking:

1. Reverse Power Flow: This factor assesses how much reverse power flow is present during maximum solar generation. A high score was given to sites/circuits that experience higher magnitudes of reverse power flow and present higher risk of thermal overload.

2. Load Composition / Customer Class: this factor considers feeder length and types of customers served by the feeder. A high score was given to sites/circuits that serve residential customers and lower scores if serving primarily industrial and commercial customers. A priority was to add hosting capacity for residential customers.

3. BESS Integrated Hosting Capacity: this factor considers how much additional hosting capacity a BESS can provide for each feeder. A high score was given to sites/circuits that result in the highest amount of

additional hosting capacity enabled by the addition of a 5 MW BESS. It is important to note this factor and associated scores were focused on unlocking additional hosting capacity at the time of this study which is different from the current approach of prioritizing sites with greatest existing operational risk due to over-capacity condition.

4. Stiffness Ratio: this factor represents the feeder's stability and expected ability to accommodate complexity in power flows that could arise from the addition of a BESS. It is the ratio of distribution system fault current at interconnection location to the maximum rated output current of the BESS. A high score was given to sites/circuits with a higher stiffness ratio, indicating a more stable system able to safely accommodate the complexity in power flows without impacting service quality to customers.

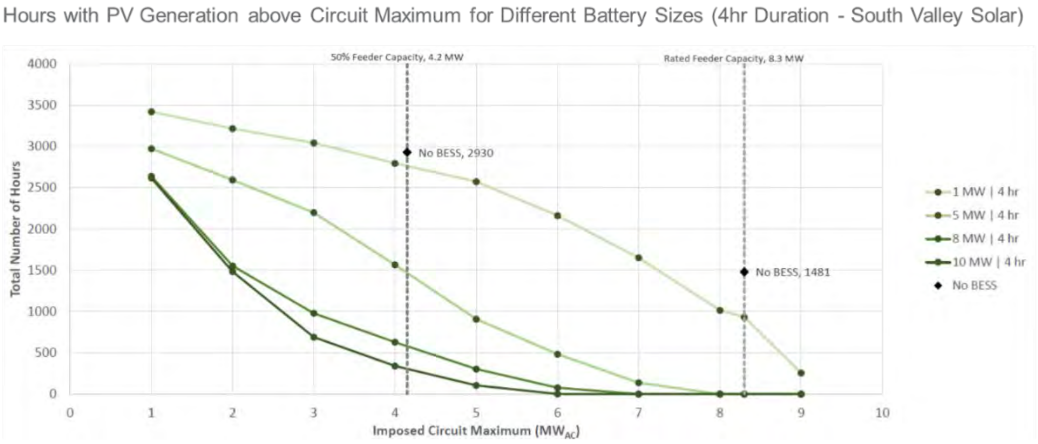
The sites and hosting circuits were then ranked based on a weighted score involving all four factors. PNM's prioritization of hosting capacity for residential customers is reflected in the scoring methodology for these factors and associated ranking formula. Scores and rankings resulted in negligible differentiation across the sites indicating similar value and benefits of BESS at each site.

Q. WHICH SITES AND CIRCUITS WERE ASSESSED FOR SYSTEM CAPACITY VALUES AND WHAT WERE THE RESULTS?

A. The three example sites selected for system capacity analysis were South Valley Solar, Rio Rancho Solar, and Facebook 2 Solar. These three sites were chosen for further analysis because they scored highest in the initial iteration of the screening process, however, the results should be representative for all sites meeting these similar criteria. The screening results shifted slightly after adding four new sites (see Section 2.3 of the 2021 Report).

Using an hourly storage simulation approach leveraging actual 2020 solar generation data provided by PNM, Burns & McDonnell plotted the decrease in number of hours of net solar generation would have exceeded the rated capacity of the feeder with different size and duration BESS configurations. An example result of this analysis is shown in PNM Figure LM-1 (from Appendix B of the 2021 Report) below for various BESS capacities with four-hour duration.

PNM Figure LM-1

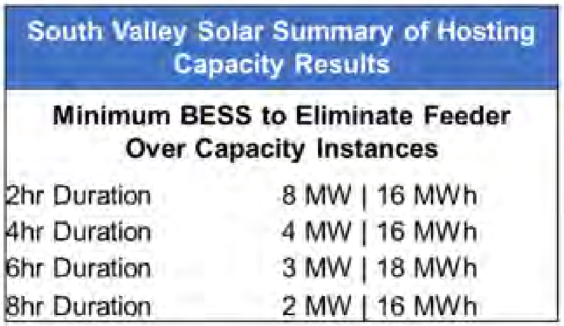


Without considering coincident load on the circuit, the chart above shows that without a BESS, the reverse power flow with interconnected solar DG on the feeder would have exceeded the rated feeder capacity of 8.3 MW for a total of 1,481 hours out of a possible 8,760 throughout the year. Except for the smallest BESS capacity considered (1 MW BESS scenario), all other BESS capacities simulated (5 MW, 8 MW, and 10 MW) reduced the quantity of hours when net reverse power flow would have exceeded rated feeder capacity to zero.

As a result of exploring various BESS capacities and durations, the minimum size and duration of BESS to eliminate overcapacity risk was calculated for each of the three selected sites. PNM Figure LM-2 (Table 4 from the 2021 Report) provides an example of those results for the South Valley Solar site on the South Coors 12 feeder. For example, this analysis calculated that a 4 MW | 16 MWh BESS at the

South Valley Solar site, without considering coincident load, would be able to eliminate feeder over capacity under similar solar generation conditions to 2020.

PNM Figure LM-2



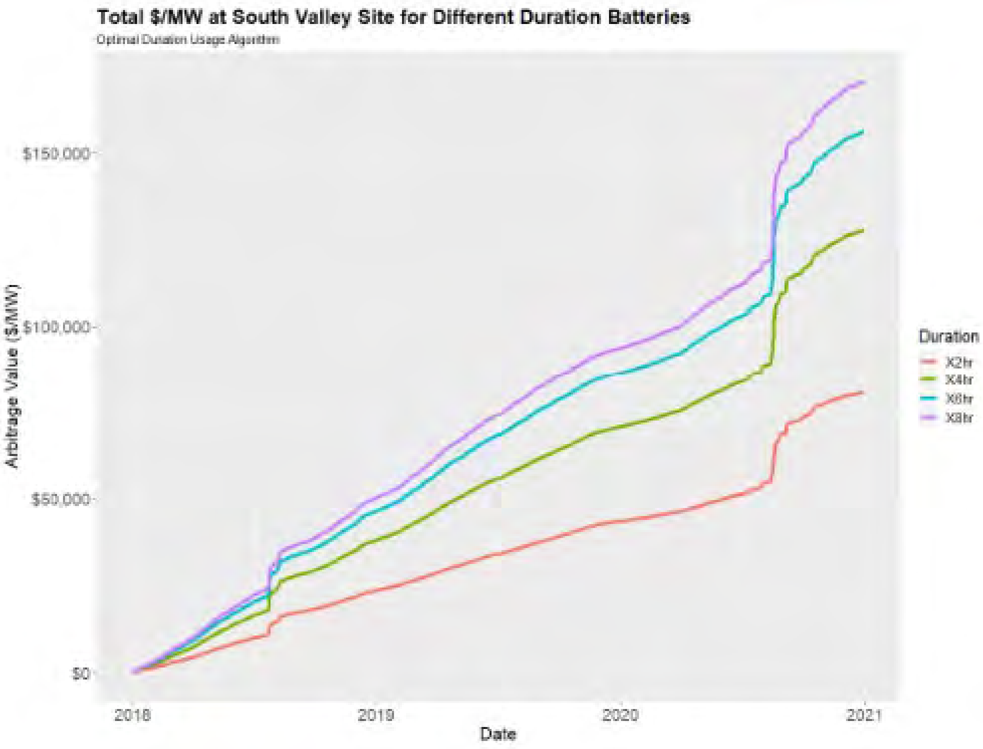
South Valley Solar Summary of Hosting Capacity Results	
Minimum BESS to Eliminate Feeder Over Capacity Instances	
2hr Duration	8 MW | 16 MWh
4hr Duration	4 MW | 16 MWh
6hr Duration	3 MW | 18 MWh
8hr Duration	2 MW | 16 MWh

Q. WHICH SITES AND CIRCUITS WERE ASSESSED FOR ENERGY ARBITRAGE VALUES AND WHAT WERE THE RESULTS?

A. The same three example sites (South Valley Solar, Rio Rancho Solar, and Facebook 2 Solar) were analyzed for energy arbitrage value that could be provided to customers overall from a financial perspective. Historical data from nearby locational marginal prices ("LMP") from California Independent System Operator ("CAISO") and Southwest Power Pool ("SPP") nodes were used to interpolate estimated hourly energy values for PNM from 2018-2020. Then operation of a BESS was simulated to operate optimally over that historical time period to estimate the net value potential of a BESS focused on charging when energy values are low ("buying energy") and then discharging that energy when energy values are high ("selling energy").

PNM Figure LM-3 (Figure 7 of the 2021 Report) below summarizes the results of this analysis for four different durations of BESS. The values are normalized on a $/MW of BESS capacity basis. This analysis estimates that a BESS with four-hour (green line) duration could have accumulated just over $125,000/MW over these three years of operation. For a relevant example, a 6 MW | 24 MWh (6 x 4=24) BESS could have accumulated over $750,000 ($125,000/MW x 6 MW = $750,000) in arbitrage value over these three years if buying and selling energy according to the interpolated LMPs derived for this study. If realized, this supplemental value would offset costs of deploying and maintaining the BESS systems to lessen the net costs of the system on behalf of customers.

PNM Figure LM-3



III. 2022 COST ESTIMATE PERFORMED BY BURNS & MCDONNELL

Q. WHAT WERE THE OBJECTIVES OF THE 2022 COST ESTIMATE PERFORMED BY BURNS & MCDONNELL?

A. PNM enlisted the support of Burns & McDonnell to estimate the construction and procurement costs of the balance of work and materials at each site that will not be performed by the BESS equipment vendor. This primarily includes civil work to grade and build foundations, receipt and installation of BESS equipment, installation of electrical cables between equipment, and associated construction management for each site.

Q. WHICH SITES AND CIRCUITS WERE ASSESSED IN THE 2022 ESTIMATE AND WHAT WERE THE RESULTS?

A. The 2022 Estimate considered seven potential sites identified by PNM and listed in PNM Table LM-2. A single generic cost estimate was developed as representative of all the sites utilizing assumptions that account for expected conditions for all seven sites since all sites are relatively similar in grade and other conditions listed in the assumptions table of the report.

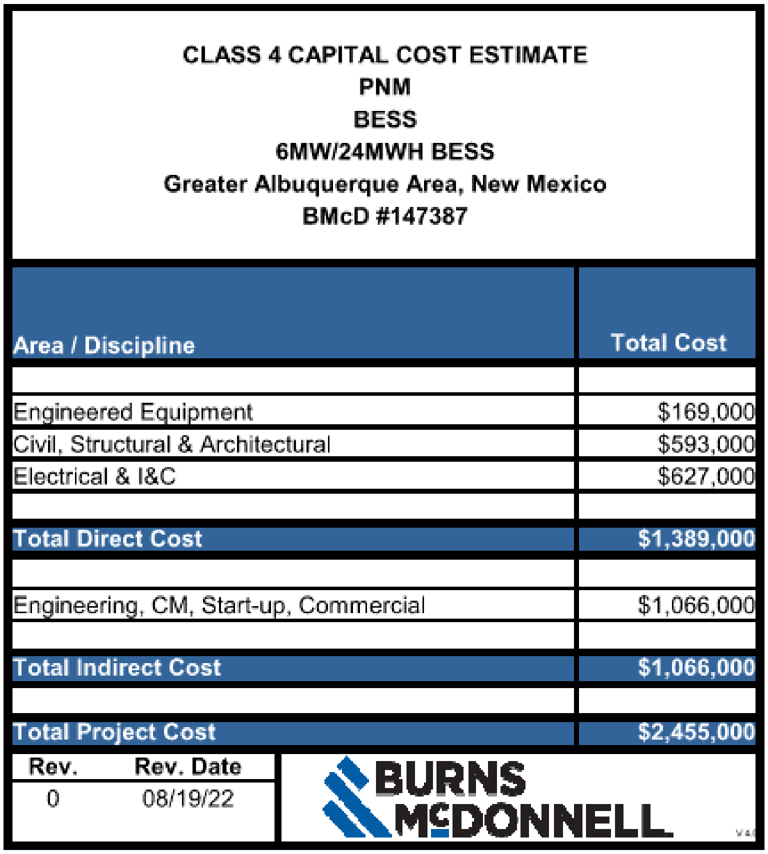
PNM Table LM-2

Site	County	Feeder (Circuit)
Rio Del Oro Solar	Valencia	TOME-12
South Valley Solar	Bernalillo	SOCO-12
Manzano Solar	Valencia	COLL-12
Rio Rancho Solar	Bernalillo	SCEN-12

Site	County	Feeder (Circuit)
Sandoval Solar	Sandoval	PROG-13
Santa Fe Solar	Santa Fe	STPE-12
Santolina Solar	Bernalillo	LOHO-13

The 2022 Estimate resulted in a Class 4 estimate of the cost of construction and installation work for each site, in addition to the equipment and services expected to be provided by the BESS vendor, to be $2,455,000 as calculated in August 2022 and detailed in PNM Figure LM-4 below.

PNM Figure LM-4



CLASS 4 CAPITAL COST ESTIMATE
PNM
BESS
6MW/24MWH BESS
Greater Albuquerque Area, New Mexico
BMcD #147387

Area / Discipline	Total Cost
Engineered Equipment	$169,000
Civil, Structural & Architectural	$593,000
Electrical & I&C	$627,000
Total Direct Cost	**$1,389,000**
Engineering, CM, Start-up, Commercial	$1,066,000
Total Indirect Cost	**$1,066,000**
Total Project Cost	**$2,455,000**

Rev.	Rev. Date
0	08/19/22

BURNS McDONNELL

Detailed assumptions associated with this estimate are described in the 2022 Estimate. The 2022 Estimate represents an opinion based on experience, reference projects, historical information, and judgement of Burns & McDonnell. It is important to note that current materials and equipment markets are changing quickly. Some of the material and labor estimates used in this study may already be out of date, especially for specialty equipment like electrical switchgear, transformers, etc.

IV. SIMILAR INDUSTRY APPLICATIONS OF BESS

Q. IS THERE GROWING USE OF BESS BY ELECTRIC UTILITIES?

A. Yes. The emerging landscape of stationary energy storage has been evolving quickly. Technological advancements are positioning distributed storage to support increased penetration of renewable electricity generation resources. The economics of storage has shifted to focus on where and how these technologies can most effectively and efficiently be deployed to help utilities achieve their goals.

The bulk of recent utility-scale battery storage deployment has occurred in areas of the country that have policies that mandate, or markets that incent BESS. Most deployments in 2021 occurred in California and Texas due to market design, economic conditions, and state policies that have supported increased energy storage deployment in these regions. These are also very large states and markets. However, distributed storage planning is now taking place across the country, as BESS is increasingly being applied as a versatile and cost-effective resource for all levels of the electricity ecosystem.

Q. DO YOU HAVE SOME EXAMPLES WHERE BESS HAS BEEN USED ON UTILITY DISTRIBUTION SYSTEMS TO AID IN THE ACCOMMODATION OF SOLAR DG RESOURCES?

A. Yes. The following are some specific examples:

Alliant Energy – Alliant Energy built a 2.5 MW/2.922 MWh Samsung lithium-ion battery system on a feeder in Decorah, Iowa.[1] This feeder is near hosting capacity as customers increasingly install private solar. This utility-owned system, that became operational in 2020, helps increase the reliability, resilience, and hosting capacity of the local energy grid by storing excess solar power generated during the day and releasing that energy during the evening peak demand period. The system also regulates voltage through its voltage variation function, and its oversized inverter provides increased variation capability.

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[1] https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Energy-Storage/Energy_Storage_Case_Studies-062021.pdf#page=12

Arizona Public Service ("APS") - APS owns and operates two 2 MW/2 MWh lithium-ion Fluence batteries for integrating solar energy resources in areas with high rooftop solar penetration, and grid services including voltage regulation and power quality.[2] One of the batteries is near the Festival Ranch development, and the other is near the McMicken substation. While the McMicken BESS experienced a significant failure event that resulted in an explosion, this early deployment of lithium-ion batteries in containers and configurations like these has taught all BESS vendors and the utility industry valuable lessons in leveraging this technology safely.

Southern California Edison ("SCE") - SCE owns and operates the 2.8 MW / 5.6 MWh Connolly battery energy storage system located the desert community of Lancaster, CA.[3] It is connected to a feeder that supports 15 small solar farms and rooftop solar installations. When customers are not using much electricity, excess power can overload the feeder. SCE uses the battery energy storage system to manage this reverse flow. The BESS also helps "further [SCE's] understanding of how to use relatively small energy storage systems to improve power quality and reliability for [SCE's] customers."[4]

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[2] https://www.aps.com/-/media/APS/APSCOM-PDFs/About/Our-Company/Newsroom/APS-batteries_fact-sheet.ashx?la=en&hash=5CAE58EA3EEB9331F2D9CE9BA0C9516D

[3] https://www.powermag.com/how-different-power-grid-operators-are-approaching-renewable-storage-hybrid-participation/

[4] https://energized.edison.com/stories/saving-solar-and-wind

Duke Energy ("Duke") - Duke is operating a 9 MW lithium-ion Samsung battery system next to a Duke Energy substation in the Shiloh community of Asheville, NC.[5] The battery energy storage system will help Duke operate the grid more efficiently and make it possible to add more renewable energy to the region. It is part of the Western Carolinas Modernization Project, a plan that includes strengthening the grid, retiring a 55-year-old coal plant, replacing it with a more efficient natural gas plant, and adding more renewable energy to the area. It will provide energy support to the electric system, including frequency regulation and other grid support services.

Pacific Gas & Electric ("PG&E") - PG&E, in partnership with the California Energy Commission and the Clean Coalition, added 548 kW and 1096 kWh of energy storage that is configured to absorb solar generation and shift it into the grid's critical peak load hours.[6] Sited at the Valencia Gardens Apartments ("VGA"), a 300,000-square-foot low-income and senior housing facility, there is 580 kW of total solar generation on the feeder with 516 kW front-of-meter ("FOM") solar generation sited atop the VGA and interconnected to a distribution

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[5] https://news.duke-energy.com/releases/north-carolinas-largest-battery-system-now-operating-at-duke-energy-substation

[6] https://www.vmwp.com/new-energy-storage-project-to-be-implemented-at-valencia-gardens-affordable-housing-site/

feeder that has exceeded its solar hosting capacity. The addition of FOM energy storage enhances the solar hosting capacity of the existing feeder by more than 25%. It also demonstrates how targeted deployment of energy storage can increase the grid's ability to handle greater amounts of local solar, yielding substantial grid and ratepayer benefits.

V. CONCLUSION AND RECOMMENDATIONS

Q. IN YOUR OPINION, DOES THE BESS PROJECT PRESENT A PREFERRED ALTERNATIVE TO THE NEEDS PNM FACES ON THESE FEEDERS THAN A MORE TRADITIONAL "WIRES" APPROACH?

A. Yes. Regarding service quality and feeder capacity needs, the BESS Project provides a versatile "non-wires" alternative to building new feeders in the area or upgrading existing feeders and substations, which can be lengthy and cumbersome projects that can disrupt operations and customers in the local area. The BESS Project also adds a versatile tool to PNM's infrastructure to help optimize operations and performance of the system while also accommodating growing numbers of distributed solar facilities safely and reliably.

Q. DO YOU HAVE ANY CONCLUDING REMARKS?

A. PNM currently has numerous distribution feeders that are hosting solar DG that exceeds their hosting capacity. This prohibits other customers located on those distribution feeders from installing and benefiting from rooftop solar. Energy storage provides a dispatchable and flexible resource that can help PNM safely and reliably continue to host high amounts of distributed solar generation and enable more customers to choose rooftop solar in moving forward toward the carbon-free future New Mexico envisions. The proposed BESS Project will reduce the operational risk of two of those most constrained feeders on PNM's system while avoiding cumbersome traditional and non-standard upgrade projects to the impacted feeders. They will also represent the first PNM-operated distributed BESS assets that will help inform and shape PNM's energy storage deployment, operations, and maintenance strategies moving forward.

The Burns & McDonnell 2021 Report helped inform PNM technical experts on the feasibility, expectations, and approximate sizing of potential projects and applications of BESS as a "non-wires" solution to better manage high penetrations of solar DG and defer distribution capacity upgrade investments. As PNM advanced the selection and procurement process for the BESS equipment, the Burns & McDonnell 2022 Estimate helped establish a more complete understanding of the full costs of deploying and integrating this equipment. This estimate takes into consideration recent industry conditions indicative of increasing cost trends.

Construction costs in today's markets are subject to fluctuation, and it would not be unreasonable for actual costs to vary depending on the timing of execution.

Depending on the outcomes of this initial project, PNM should evaluate expanding this rapid relief of distribution feeders at other constrained locations. Energy storage coupled at the distribution level holds the potential to increase the hosting capacity of the system and increase the utilization of existing infrastructure, deferring expensive and cumbersome upgrades until they can be implemented safely and conveniently. Distributed solar electricity generation is an important component of the carbon-free grid and energy storage will help facilitate safe and reliable support of it.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

GCG#530826

PNM Exhibit LM-1

Is contained in the following 1 page.

PNM Exhibit LM-1

LUCAS MCINTOSH
EDUCATION AND PROFESSIONAL SUMMARY

Name: Lucas McIntosh

Address: Burns & McDonnell
9400 Ward Pkwy
Kansas City, MO 64114

Position: Managing Director of Management Consulting Department and Lead of Power Grid Advisory Group

Education: Bachelor of Physics, Knox College, 2000
Bachelor of Mechanical Engineering, Washington University in St. Louis, 2000
Masters of Mechanical Eng., University of Illinois at Urbana-Champaign, 2008
Masters of Business Admin., University of Illinois at Urbana-Champaign, 2008

Professional Licenses: Professional Engineer, KS
LEED AP

Employment: Burns & McDonnell Engineering Company Inc.:
Managing Director, Power Grid Advisory (2020-Present)
Director, Grid Modernization & Distribution Planning (2016-2020)
Project Manager, Utility Consulting (2012-2016)
Sr. Consultant, Utility Consulting (2009-2012)

University of Illinois at Urbana-Champaign:
Graduate Research Assistant, Amy Wagoner-Johnson (2005-2009)

Lockheed Martin Space Systems Company:
Design Engineer, Atlas Launch Vehicles – Payload Int. (2002-2005)
Engineering Leadership Development Program (2000-2002)

PNM Exhibit LM-2

Is contained in the following 128 pages.

Distribution Level Storage Portfolio Analysis Report

Public Service Company of New Mexico

BESS Portfolio Analysis
Project No. 135561

Revision 0
November 2021

Distribution Level Storage Portfolio Analysis Report

prepared for

Public Service Company of New Mexico
BESS Portfolio Analysis
New Mexico

Project No. 135561

Revision 0
November 2021

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

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APPENDIX A - BESS DISTRITBUTION PORTFOLIO PRESENTATION
APPENDIX B – HOSTING CAPACITY PRESENTATION
APPENDIX C – ENERGY ARBITRAGE PRESENTATION

1.0 INTRODUCTION

Public Service of New Mexico (PNM or Owner) retained Burns & McDonnell Engineering Company (BMcD) to provide technical assistance to support PNM in screening and evaluating potential battery co-location opportunities within their service territory. This process included evaluation of existing PV sites identified by PNM as having distribution circuit and substations impacts (primarily concerning PV generation about rated equipment capacity), evaluation of potential use cases for the storage when dispatched across the breadth of the sites prioritized for storage development, preparation of BMcD's proprietary Grid Battery Energy and Solar Toolkit (GridBEAST) models, and preliminary economic analysis for sizing and making recommendations on the configuration of the storage system.

1.1 Project Understanding

BMcD understands that PNM is evaluating the preliminary technical and economic parameters for the development of storage projects in their service territory in New Mexico. Specifically, BMcD also understands that the information prepared as part of this assessment will aid PNM in developing strategic plans for securing generating and storage capacity in the near future. While this assessment is not intended to compare offers prepared by others for development of these or any other sites, it is expected to guide the process that PNM may use in the future to prioritize development of other portions of their service territory.

1.2 Project Purpose

The purpose of this BESS Portfolio Analysis Study (Study or Assessment) is to screen potential battery development opportunities within their service territory. It is the understanding of BMcD that this Study will support the Owner's preliminary evaluation of siting and project development to prioritize locations at which pilot or utility scale BESS projects may be installed to yield distribution system or generation portfolio benefits. This assessment is only intended to be preliminary in nature and is not a substitute for further detailed consideration and development of the technical details to interconnect at the distribution level, economic impact of changes to the energy supply mix, and further performance analysis of the assets near to the selected energy storage sites. Should any of the options evaluated in this assessment appear to provide significant enough benefits to PNM's near and long terms goals, subsequent study will be required to further define the scope requirements, further optimize the individual and combination of systems deployed, and refine project costs through the lifecycle of the asset.

1.3 Project Approach

The findings of this Study are the result of a gated approach to concentrate the development teams' efforts on the sites that demonstrate the greatest opportunity to have significant enough benefits for the PNM distribution and generation systems.

1.3.1 Site & Circuit Identification

Following the project kick-off call, BMcD reviewed the plan and objective for the storage development portfolio. The first phase of the study was focused on evaluating a subset of solar sites within PNM's service area on distribution circuits to identify potential constraints and benefits of the co-locating an energy storage system. The initial assessment included the six solar sites shown in Table 1. An additional four solar sites shown in Table 2 were added to the scope of the assessment following preliminary review by PNM's project team. The process through which these sites were prioritized, and the result of the prioritization is summarized in Section 2.0. The top three sites were advanced to the next step in the project approach, Storage Value and Use Case Study.

Table 1: Initial Six PV Sites for Prioritization Analysis

PV Site	Substation	Feeder	Generation
Facebook 3 Solar	Lost Horizon	LOHO-12	9.9 MW
Santolina Solar	Lost Horizon	LOHO-13	11.0 MW
Facebook 2 Solar	Lost Horizon	LOHO-14	11.0 MW
Rio Rancho Solar	Scenic	SCEN-12	9.1 MW
South Valley Solar	South Coors	SOCO-12	10.3 MW
Rio de Oro Solar	Tome	TOME-12	9.9 MW

1.3.2 Storage Value and Use Case Study

BMcD prepared a discussion with PNM to develop a screening level summary of technical and economic considerations to implement a BESS at each candidate site. As shown in Figure 1, avoided customer interruption costs, transmission deferral value, energy arbitrage value, and system capacity value were considered as potential benefits for which approximations in value were considered during the assessment. The primary measures of value investigated in this Study were the System Capacity Value (in regard to alleviating feeder over capacity instances), and the Energy Arbitrage Value.

Table 2: Following Four PV Sites for Prioritization Analysis

PV Site	Substation	Feeder	Generation
Manzano Solar	College	COLL-12	8.4 MW
Facebook 1 Solar	Los Morros	LSMO-12	10.0 MW
Sandoval Solar	Progress	PROG-13	6.4 MW
Santa Fe Solar	State Pen	STPE-12	9.5 MW

The System Capacity Value methodology to determine minimum BESS capacity and power configurations to eliminate instances of feeder overcapacity is described in Section 3.2.1. The Energy Arbitrage Value methodology to evaluate the economic potential with daily cycling as allowable to meet the elimination of the overcapacity instances in the available data is described Section 3.2.2. Avoided Customer Interruption Costs if the BESS system was installed was potentially calculable based on hourly circuit demand, current interruption data, and measurement of the potential improvements at the feeder / circuit level using calculators available from the Department of Energy (DOE) Interruption Cost Estimate (ICE) publicly available tools. This portion of the analysis should remain for consideration in further study once specific sites and interconnection locations to PNM's system are defined. The Transmission Deferral Value Analysis was considered, and conversations were initiated with PNM's transmission team. Based on the feedback provided by PNM, this value stream was not further evaluated, as the total installation capacities being considered for the sites advanced to the next level of study in the areas near Albuquerque were not expected to be significant to the transmission projects. If the total installed capacity were to be of 3-5x of the total present capacity, this conversation should be reconsidered to confirm the same outcome. Ancillary services were not included or considered as part of this assessment, since this value stream will largely depend on holistic assessment of PNM's resources and direct participation into CAISO's ancillary market. Given the focus on the distributed impacts of the portfolio, more pressing benefits to PNM from the other value streams, and BMcD's experience in evaluating ancillary service value for standalone storage assets in other markets, this value stream was not considered.

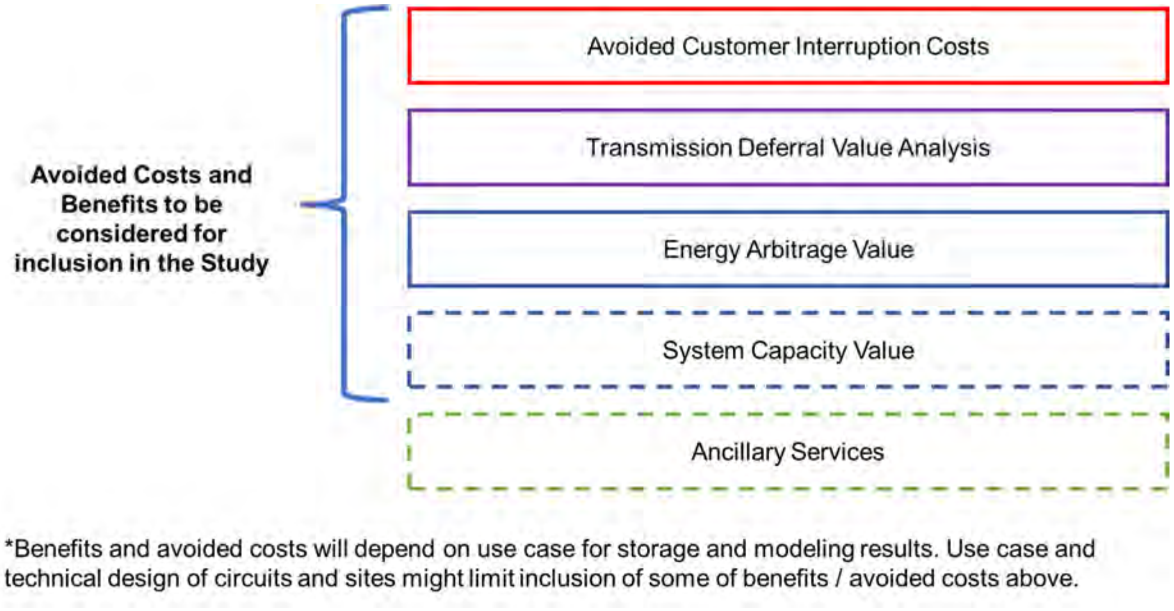


Figure 1: Storage System Value Streams or Consideration in Study

1.3.3 BESS Integration Model

BMcD used its proprietary GridBEAST modeling suite to estimate the performance of the storage technology with respect to the value streams identified in Section 1.3.2. GridBEAST modeling is based on an hourly annual profile that accounts for the solar generation profiles at the evaluated PV sites for 2020 as provided by PNM. The model considers this generation profile, battery energy storage system (BESS) state of charge, feeder capacity limits, HVAC/auxiliary loads, and system efficiency losses, as applicable at each site. As applicable for each, the BESS charges or discharges energy according to the energy value profile described in Section 3.2.2 the available energy from the renewable generation source, and the limits on the capacity of the feeder. The model assumes that the system is located in close physical proximity to the PV sites to most easily model the impact of the installation to the affected feeders.

A sample result from the time series is included in this section (Figure 2) to illustrate some of the sample hourly granularity components of the overall analysis produced by the model. The X-axis represents one day in 24 hourly increments and the primary Y-axis measures energy in kWh. The secondary Y-axis on the right side is the state of charge (SOC) of the battery as a percentage. In this generic scenario, the PV is causing overcapacity feeder issues at the South Valley Solar site and the battery is used to shift solar energy for nighttime consumption.

Further descriptions on the methodology and results for each part of the system value stack studied and referred to in this Project Approach is included in Section 3.0.

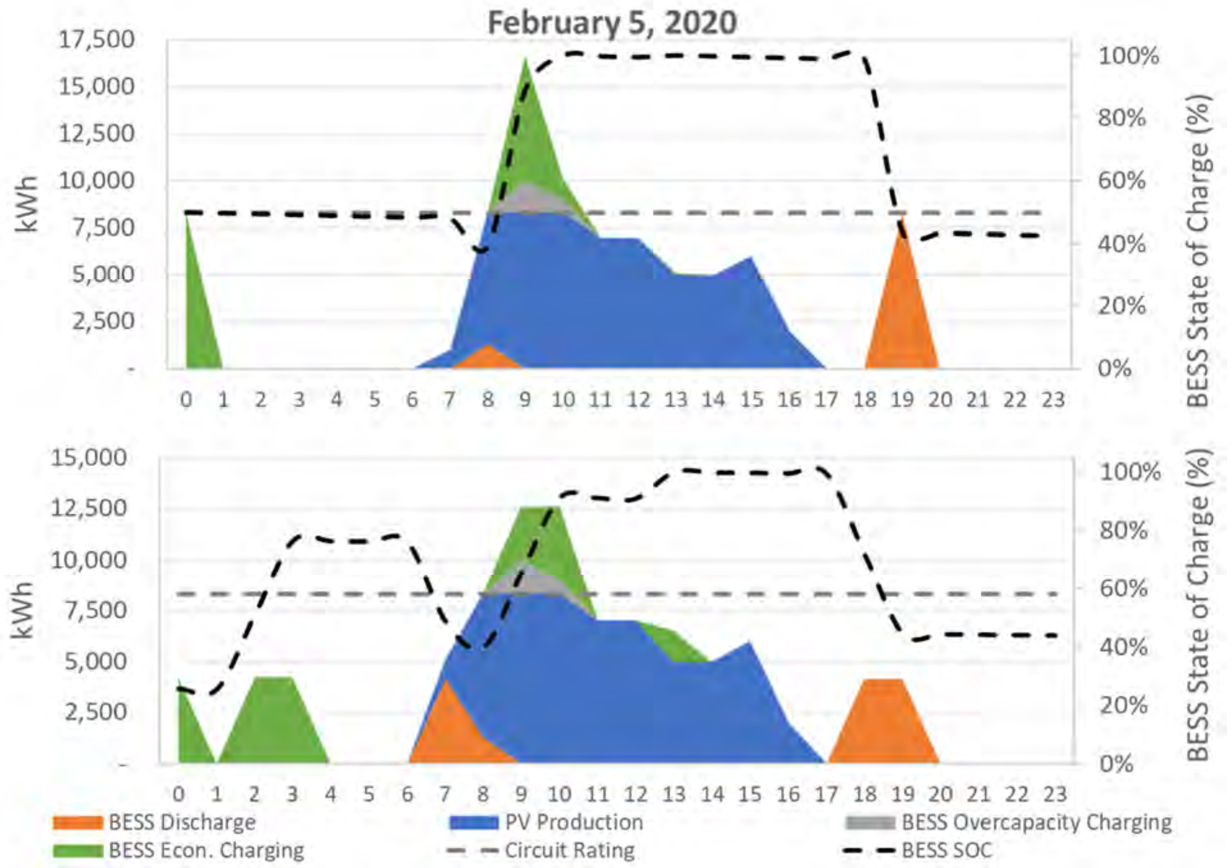


Figure 2: Sample BESS Dispatch Result from GridBEAST at South Valley Solar at 8 MW | 2hr (top) and 4 MW | 4 hr (bottom) configurations

1.4 Statement of Limitations

Estimates and projections prepared by BMcD relating to technical and economic performance, construction costs, and operating and maintenance costs are based on experience, qualifications, and judgment as a professional consultant. BMcD has no control over weather, cost and availability of labor, material and equipment, labor productivity, construction contractor's procedures and methods, unavoidable delays, construction contractor's method of determining prices, economic conditions, government regulations and laws (including interpretation thereof), competitive bidding and market conditions or other factors affecting such estimates or projections. Actual rates, costs, performance ratings, schedules, etc., may vary from the data provided.

2.0 SITE & CIRCUIT IDENTIFICATION

2.1 Introduction

This section of the report focuses on the methodology and results of the initial site & circuit identification process. Appendix A shows the distribution maps, relative locations of the PV sites to the affected substations and the feeders connecting each to the other as part of an overall summary of the results of the assessment. A map of PV site locations analyzed is also included in Figure 3 for reference purposes of the sites provided by PNM. Table 3 includes the results of the scoring matrix.

2.2 Methodology

Four main factors were taken into consideration to come up with the ranking for each substation feeders with PV sites under analysis, utilizing DNVGL’s Synergi Electric distribution planning software (Synergi). The factors are as follows:

1. Reverse power Flow: Reverse power flow during maximum PV generation was captured by running Load Flow Analysis for each feeder and were scored based on feeder that sees maximum reverse power flow.
2. Load composition / Customer Class: Each feeder was scored based on the circuit length along with customer class. A qualitative assessment was also involved in scoring circuits with potential for PV installations with the addition of BESS.
3. Available Hosting capacity: ICA analysis was performed by applying PNM’s criteria to calculate the hosting capacity on each feeder and scored them based on hosting capacity enablement with the addition of 5 MW BESS.
4. Stiffness ratio: Ratio of distribution system fault current at interconnection location to the maximum rated output current of the BESS was calculated to score feeders based on stiffness/Interconnection facility feasibility. Fault Analysis was performed on substations under analysis to calculate stiffness ratio.

These individual scores were utilized in the following equation to obtain the final score for each feeder under analysis:

10 % Reverse Power Flow + 30 % (Load composition + Hosting capacity + Stiffness Ratio) = Final Score

2.3 Results

The presentation included in Appendix A includes the main summary table presented in Table 3. When this portion of the assessment was first completed, the top three sites for analysis prioritization were

South Valley, Facebook 2, and Rio Rancho Solar sites. South Valley and Rio Rancho Solar both had clear overcapacity issues as evidenced by higher PV generation in relation to the feeder capacity. This factor was not apparent for Facebook 2, however, the other weighted assessment factors (stiffness ratio, reverse power flow, etc.) highlighted the problems at the site. Following the analysis of additional sites, Sandoval, Santa Fe and Facebook 1 Solar could be considered for the same following process of assessment in determining the appropriate size of the BESS to address some of the issues identified in this prioritization.

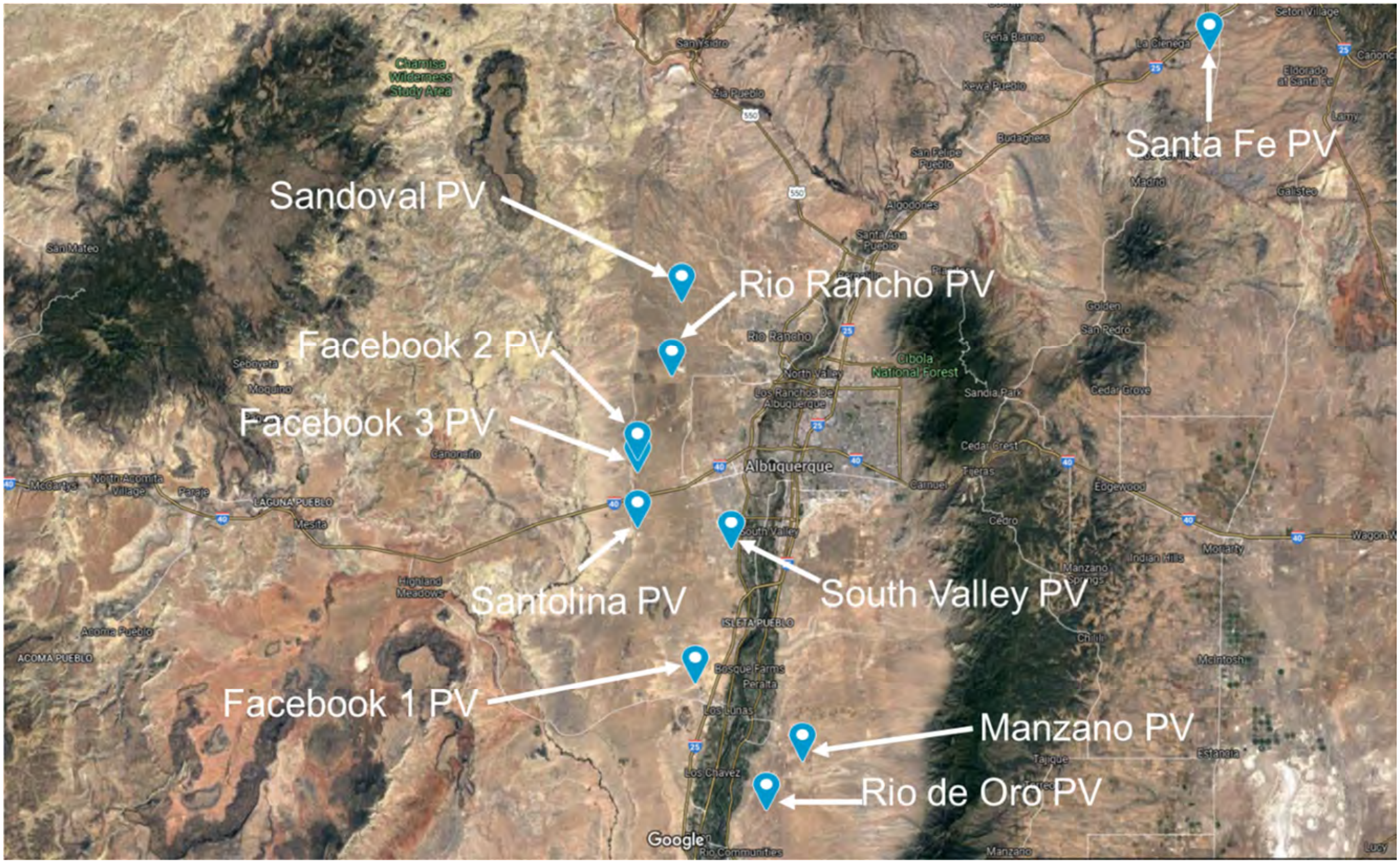
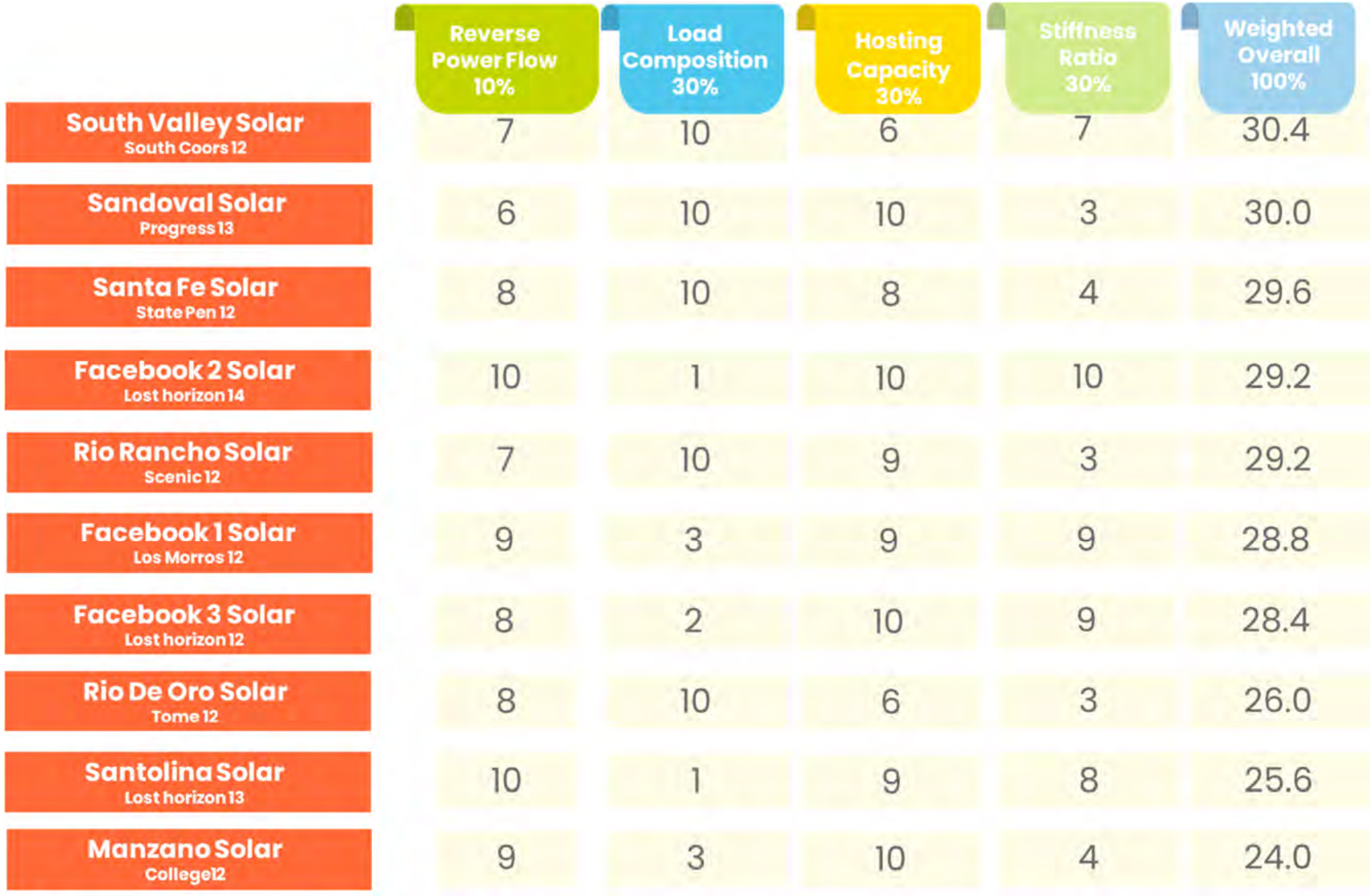


Figure 3: PV Site Locations in the Albuquerque Surrounding Area

Table 3: Scoring Matrix Results for the Evaluated Solar Sites



	Reverse Power Flow 10%	Load Composition 30%	Hosting Capacity 30%	Stiffness Ratio 30%	Weighted Overall 100%
South Valley Solar South Coors 12	7	10	6	7	30.4
Sandoval Solar Progress 13	6	10	10	3	30.0
Santa Fe Solar State Pen 12	8	10	8	4	29.6
Facebook 2 Solar Lost horizon 14	10	1	10	10	29.2
Rio Rancho Solar Scenic 12	7	10	9	3	29.2
Facebook 1 Solar Los Morros 12	9	3	9	9	28.8
Facebook 3 Solar Lost horizon 12	8	2	10	9	28.4
Rio De Oro Solar Tome 12	8	10	6	3	26.0
Santolina Solar Lost horizon 13	10	1	9	8	25.6
Manzano Solar College12	9	3	10	4	24.0

3.0 BESS INTEGRATION MODEL

3.1 Introduction

The section of the report focuses on the methodology and results of the BESS models developed with the GridBEAST modeling suite. Appendix B shows the system sizing results and hosting capacity implications in presentation format as was delivered to PNM. Appendix C provides a graphical representation of the process to determine the Energy Arbitrage Value of the BESS systems at each site. Both presentations' content is summarized in this section.

3.2 Methodology

This section of the report focuses on the methodology for arriving at the battery energy system sizing configuration based on the solar generation data supplied by PNM, BMcD internal system configuration one-lines for estimating losses and experience in system design.

3.2.1 System Capacity Value Methodology

The objective of the system capacity value assessment was to identify the minimum size BESS to the located in the vicinity of the solar plants & feeders prioritized in the previous portion of the assessment to yield potential improvements to generation and distribution capabilities using BMcD's GridBEAST to model the hourly performance of the BESS system. This model was used the quantify the incidence of events in which the solar site output exceeded the feeder rated capacity, the reduction of these instances through the installation of storage, and the total battery energy throughput to ensure that expected limitations on operation (total number of cycles per day, for example) would not be exceeded. This information was then used to recommend a series of storage configurations conservatively sized to allow for the feeder's overall hosting capacity for additional generation could be improved. The feeder hosting capacity estimates provided in this section are expected to be conservative due to the expected degradation of the solar sites and the exclusion of the energy consumers on the feeders. In other words, only the solar generation data and the feeder capacity were compared in BMcD's analysis in order to ensure that the battery would have sufficient capacity to achieve the feeder overcapacity events as stipulated.

The solar data used in this analysis was provided by PNM in Excel format which was summarized and organized in a usable 8760 format (8760 being the number of hours in a year) using Power BI. An illustration of the monthly tables supplied by PNM to single column transformation is shown in Figure 4. BMcD understands that the data provided by PNM is of the solar performance specifically for 2020 and is provided in units of MW for each hour – making it equivalent to the MWh of generation for that length of time. Since this is an average value, it is possible for excursions that are above this overall capacity to occur on a sub-hourly granularity. Due to the limitations from this data, this is a potential risk factor in the quantity of potential additional hosting capacity available when adding storage.

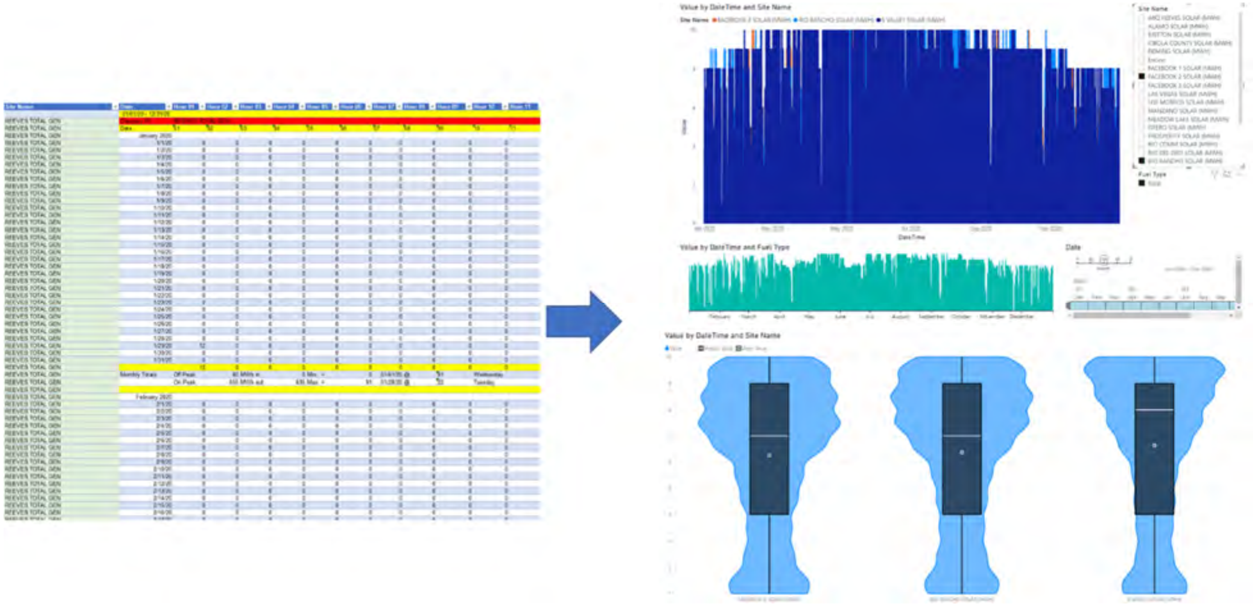


Figure 4: Illustration of PNM Provided Data to Power BI Transformation

The solar performance was input into the GridBEAST model assuming that the BESS would be a separate system from the solar site, located on the same feeder (and thereby connected to the grid). BESS configurations from 1 to 10 MWAC were considered for one year of performance. No degradation of the system was considered. If the BESS system were to be installed, it would be assumed that the performance (capacity of the battery and availability of the inverters) would be maintained through operating and maintenance costs allowances that would include system augmentation over time. Additionally, it would be assumed that industry standard overbuild of total capacity to nominal usable capacity would be installed. System losses for the BESS for charging and discharging totaled approximately 87% round-trip efficiency for the period considered. The battery was assumed to discharge after no additional solar generation was expected every night in order to allow maximum potential availability of the battery capacity for the purposes of reducing overcapacity issues. In other words, the results in Table 4, Table 5, and Table 6 show the minimum BESS configuration at a nominal system duration required to eliminate the hosting capacity issues.

3.2.2 Energy Arbitrage Value Methodology

The objective of the energy arbitrate value assessment was to estimate the differential value across the relevant data time period pulled from market data to guide the operation of the energy storage system beyond solely discharging the battery at times when the adjacent solar generation was expected to no longer be present. This model was used to understand the potential operating characteristics of the BESS systems capturing the proposed benefits in the system capacity value portion of the assessment with perfect economic foresight on energy pricing. This would allow PNM to quantify the average potential economic performance for each system for 2020 using PNM's provided solar data and energy value estimate derived from market data. This approach would be used to recommend BESS configurations with the greatest opportunity for positive economic screening. The same general siting assumptions, round trip efficiencies, and generic performance inputs were used for this portion of the assessment as the system capacity value analysis.

In order to be able to complete this portion of the assessment, some estimate of the value of energy for PNM had to be prepared for the relevant time period and projected for the future value of energy. There are several potential approaches to do so – from simple arithmetic means for specific market settlement points (for example, the Energy Imbalance Market could be a proxy given PNM's recent approval to join) or stipulated values based on public information on local seasonal electricity demand (for example, identifying seasonal electric demand from publicly available data and potentially adjusting for the proximity to the existing solar asset) and others to consider. BMcD approached this issue by sampling nearby sampled market points from SPP and CAISO and fit a surface from that sampling using bicubic interpolation in order to receive the benefits on market determined pricing that consider the input costs to electrical generation, temporal variability in electrical demand (both hourly and seasonally), and to receive an average and hourly granularity energy price profile that smooths the difference in value from a single market source considering the distance of the solar generation from both CAISO and SPP. This was performed using R's akima library for interpolation of irregularly and regularly space data based on the LMP values and geographic locations sampled. The sampled market points are illustrated over an outline of the state of New Mexico in Figure 5 and a snapshot of the energy value at a selected point in time is shown for May 2020 in Figure 6 following the bicubic surface interpolation.

All locational marginal pricing (LMP) for energy was sourced from CAISO and SPP for the day ahead market at hourly intervals from 2018 through 2021. BMcD acknowledges that data from the period of 2020 through 2021 might have limited predictive value for the future value of energy due to the COVID-19 pandemic as shown in the changes in energy value volatility from 2018 through 2021 shown in Appendix C. However, the main purpose of determine energy value proxies within the PNM service territory is understand how the BESS system might be able to be dispatch strategically within a day in order to maintain its capacity value and also capture the difference of energy pricing throughout a day. These estimates for energy value are only intended to be used for informational purposes in evaluating the

BESS configurations that are most likely to meet portfolio targets and monetize additional revenue streams.

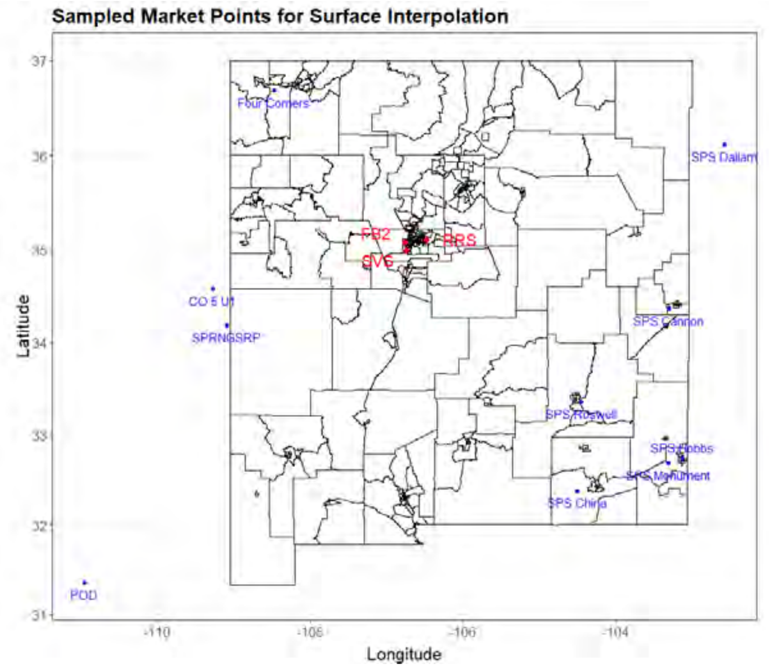


Figure 5: Sample Points in CAISO and SPP for Surface Interpolation

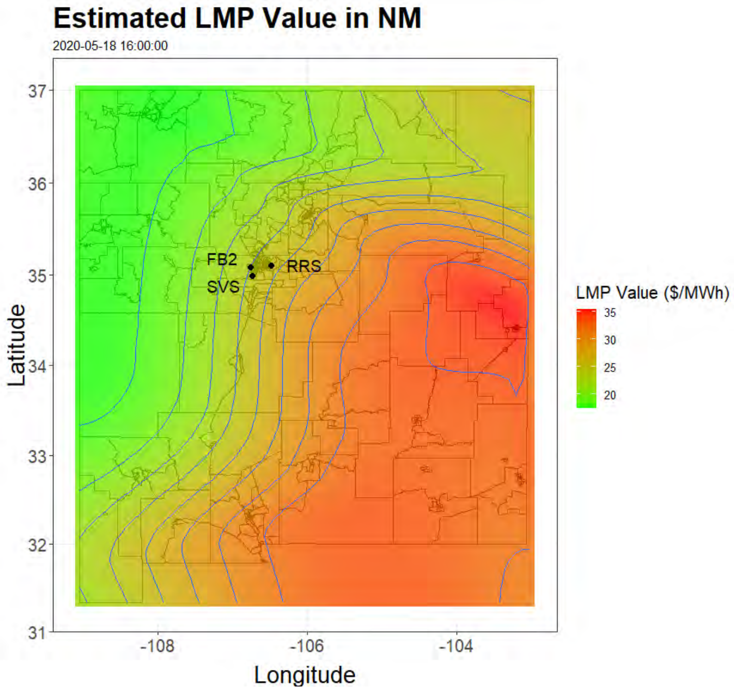


Figure 6: Snapshot of Surface Interpolation Sample Result with Site Locations

A distribution of energy values for each year and each site is presented in graphical form in Appendix C for PNM's review. This data was energy value data was used to determine that maximum potential value possible to attain by a BESS based on an energy arbitrage methodology (purchasing the energy at the lowest daily prices and then discharging at the highest daily prices) with an assumption of 85% round-trip efficiency. These results are presented in units of $/MW since the BESS would theoretically maximize its value at sizes with this perfect dispatch methodology assuming infinite grid supply and demand, simplifying assumptions to determine the highest potential battery configuration (Figure 7). These estimates in energy revenue creation potential in energy arbitrage operation was generalized and averaged over the collection of data points within each month. The daily sums of energy arbitrage revenue generating potential were averaged by month across the 2018-2021 data period and standard deviations for the range of the total sum for each month informed the upper and lower boundary of expected revenues to be generated from this revenue stream using R's simple linear regression tools.

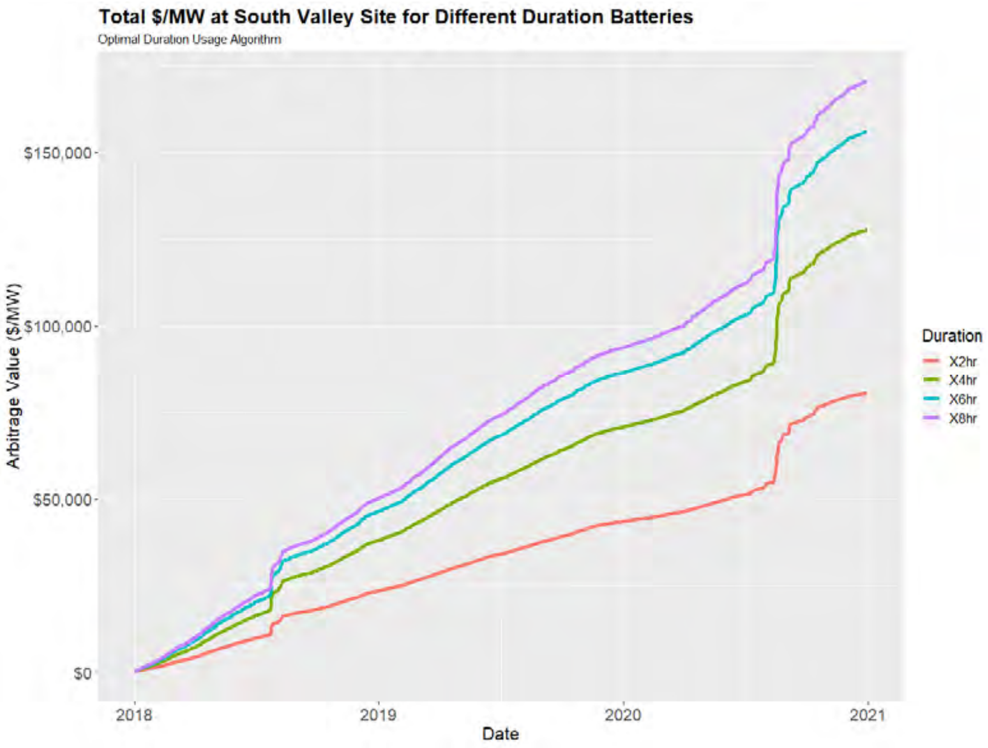


Figure 7: Total $/MW at South Valley Site for Different Duration Batteries

The difference in the cumulative average revenue projections from smallest to the next largest battery system duration was then plotted in a similar fashion (Figure 8) to approximate the marginal value of a longer duration BESS. The declining trend in arbitrage value matches the intuition that the gap between the sum of the highest two energy value hours and the sum of the lowest two energy value hours will be and each proceeding longer storage duration will decrease as the BESS system approaches charging and discharging at the median energy price of the day. To clarify, the marginal revenue point at a two hour duration represents the potential revenue value of installing a two hour duration BESS over not installing any system, the marginal revenue point at a four hour duration represents the increase in potential revenue value of installing a four hour duration BESS over a two hour duration system and so on for the six and eight hour durations systems.

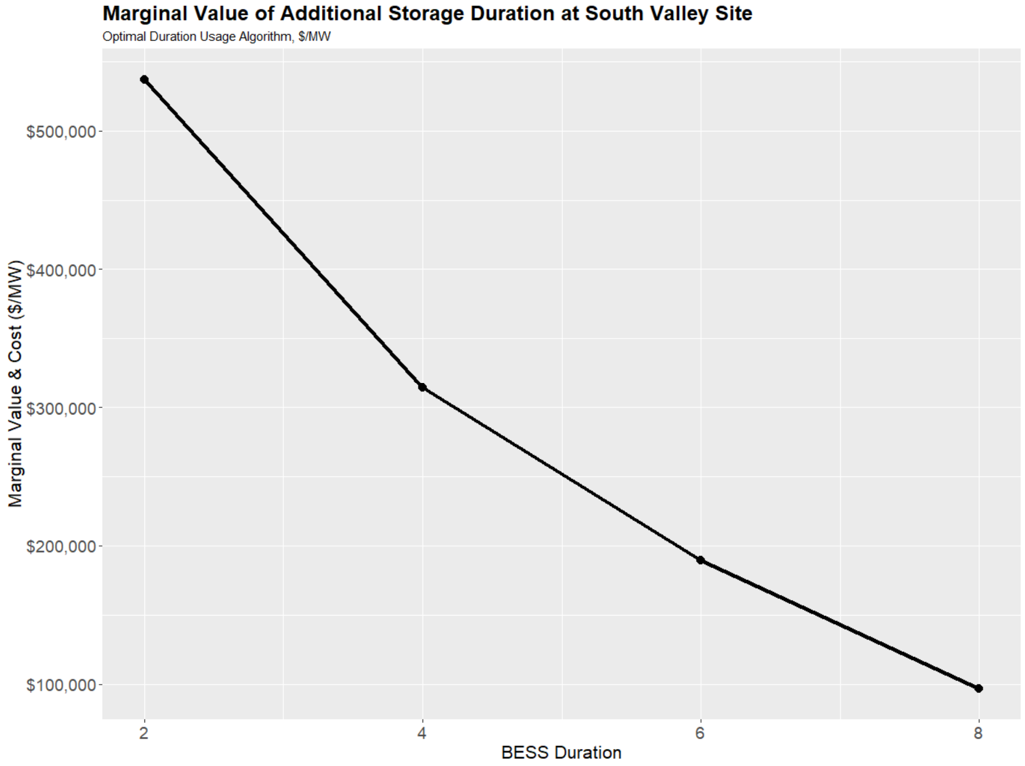


Figure 8: Marginal Value of Additional Storage Durations at South Valley Site

This information was then combined with screening level capital cost information based on BMcD's experience in energy storage system design and estimation and publicly available information to prepare a preliminary expectation on the cost of each of the system configuration. The difference between the cost of each system at increasing durations was then plotted. This calculation presented an approximation for the marginal initial capital cost to install the BESS system. This is presented in Figure 9: Model Results Identifying Economic Sizing with different color lines for different system inverter capacities as indicated on the graphic. While the graphic shows a slight increase in marginal cost for the storage system as the duration increases beyond four hours, BMcD acknowledges that this increase could be artificially created based on latest internal cost data. However, even if the cost trend were to flatten beyond the four hour duration system. The main takeaway from this illustration is that the greatest gap in marginal cost versus marginal revenues occurs at the four hour duration BESS. This means that the relative to the initial capital expense for the installation of the BESS, the four hour duration system has the greatest opportunity for positive economic returns. This data alongside the understanding of the minimum sizes to allow for the potential elimination of feeder overcapacity suggests the inverter capacity and system duration best suited to reach a positive economic return at each site.

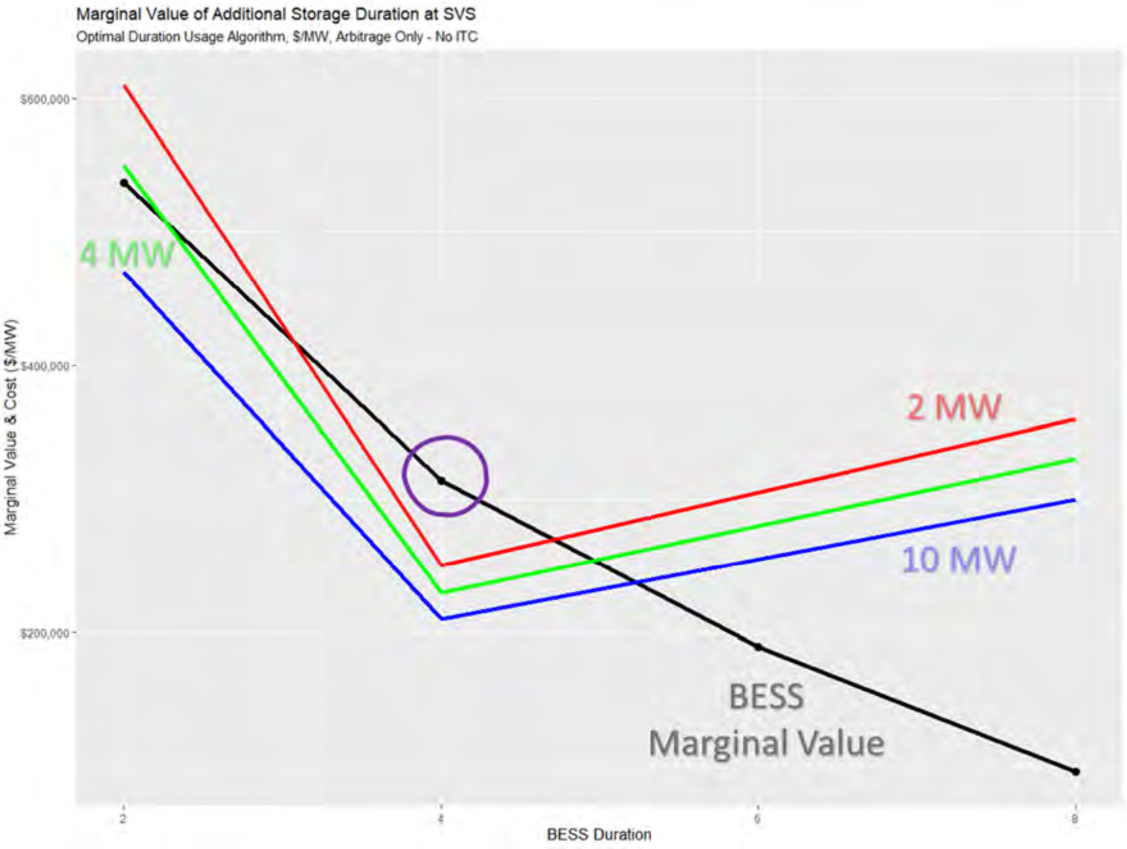


Figure 9: Model Results Identifying Economic Sizing

3.3 Results

This section of the report provides key result summary descriptions for selected portions of Appendix B and Appendix C.

3.3.1 System Capacity Value Results

The system capacity analysis model resulted in the generation of curves recording the frequency of solar generation over the circuit capacity rating for each system duration configuration input into the time-series model. Accordingly, Appendix B includes four different sets of curves where each point represents the total number of hours within the provided data for which the feeder was exposed to generation greater than its capacity with the BESS installed. Each set of curves for each site is color coded based on the system duration and also includes vertical lines noting the feeder's rated capacity and 50% of that capacity for illustrative purposes only. The x-axis ("Imposed Circuit Maximum") is an independent assumption in the model of the controlled generation allowed in the feeder at any given time. For example, while the feeder might be rated for 8.3 MW for the South Valley Solar site, the x-axis notes the potential incidence of generation above this limit Imposed Circuit Maximum with a range of BESS systems. The diamond points in each of the graphics also show the total instances of over feeder capacity events without the BESS system installed. This information is summarized in Figure 10.

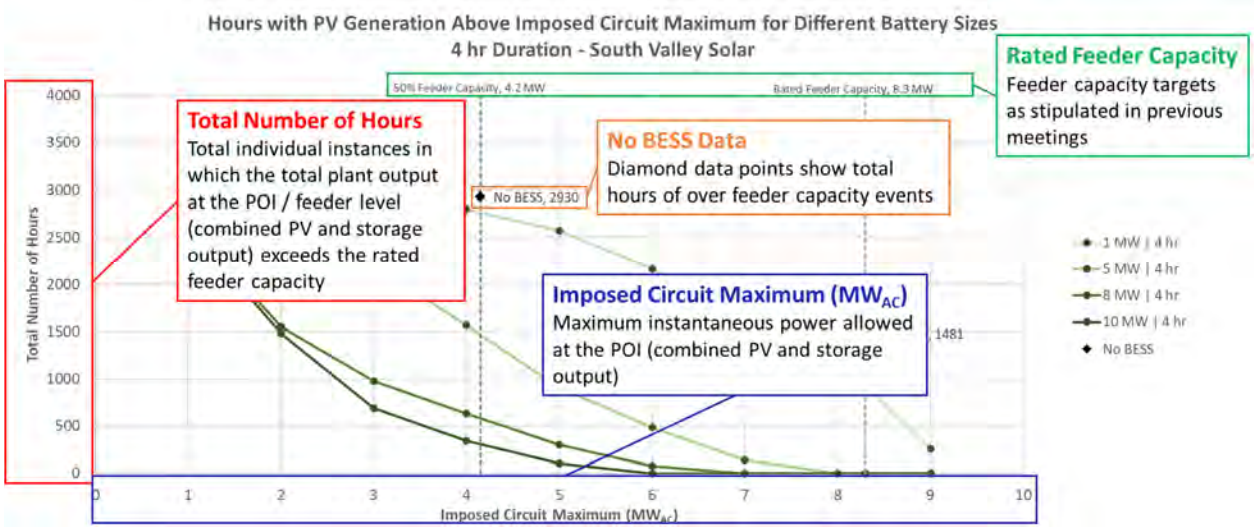
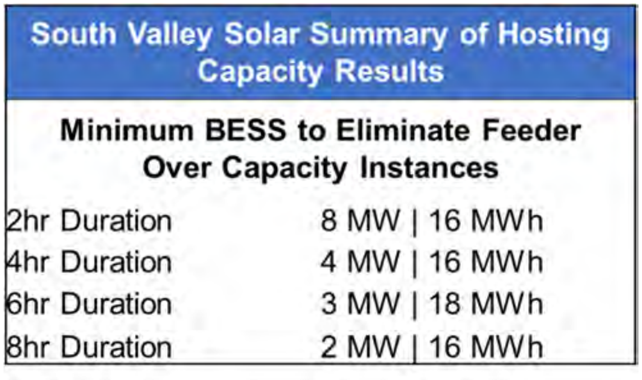


Figure 10: Sample Illustration of System Sizing Curves

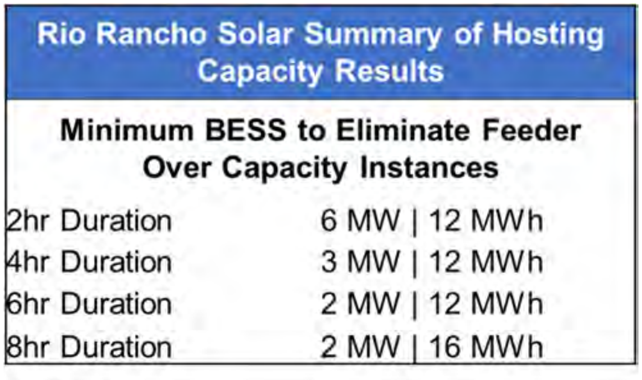
This information is also summarized in Table 4, Table 5, and Table 6 showing the minimum BESS to eliminate feeder over capacity instances at each duration for each site. The results in each of these tables indicate the smallest battery in terms of capacity (and thereby lowest expected capital expense) at each system duration that accomplishes the model's goal. As noted on Table 6, Facebook 2's feeder capacity of 10.1 MW exceeded the maximum solar generation recorded in the PNM supplied data for 2020. Accordingly, no BESS system would be required to avoid any instance of solar generation above the feeder capacity. Instead, as was requested by PNM, Facebook 2 and the other sites offer the opportunity to install a BESS system in order to enable to future installation of distributed generation, especially in the form of additional non-dispatchable solar generation, onto the same feeders.

Table 4: Minimum BESS Configuration to Eliminate Solar Generation over Feeder Capacity at South Valley Solar



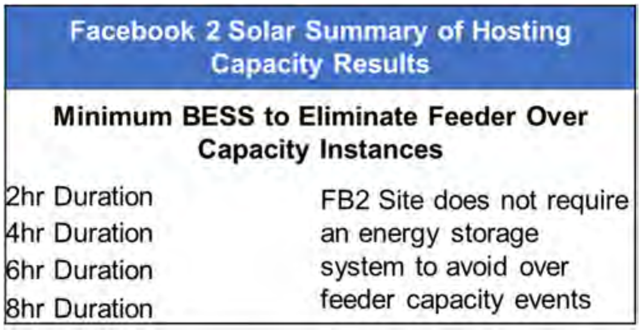
South Valley Solar Summary of Hosting Capacity Results	
Minimum BESS to Eliminate Feeder Over Capacity Instances	
2hr Duration	8 MW | 16 MWh
4hr Duration	4 MW | 16 MWh
6hr Duration	3 MW | 18 MWh
8hr Duration	2 MW | 16 MWh

Table 5: Minimum BESS Configuration to Eliminate Solar Generation over Feeder Capacity at Rio Rancho Solar



Rio Rancho Solar Summary of Hosting Capacity Results	
Minimum BESS to Eliminate Feeder Over Capacity Instances	
2hr Duration	6 MW | 12 MWh
4hr Duration	3 MW | 12 MWh
6hr Duration	2 MW | 12 MWh
8hr Duration	2 MW | 16 MWh

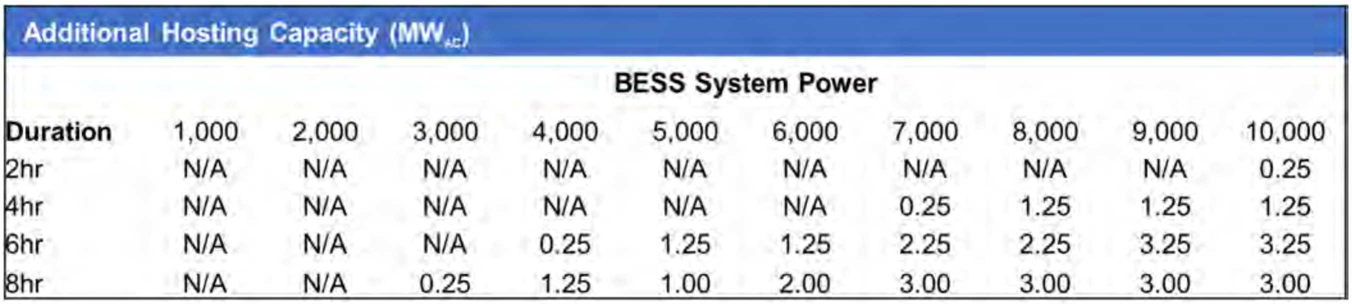
Table 6: Minimum BESS Configuration to Eliminate Solar Generation over Feeder Capacity at Facebook 2 Solar



Facebook 2 Solar Summary of Hosting Capacity Results	
Minimum BESS to Eliminate Feeder Over Capacity Instances	
2hr Duration	FB2 Site does not require an energy storage system to avoid over feeder capacity events
4hr Duration	
6hr Duration	
8hr Duration	

The potential additional hosting capacity is a result of the same analysis highlighted in Figure 10. The potential is calculated as the difference between the minimum BESS configuration to eliminate feeder over capacity instances and the higher available imposed circuit maximums below the rated feeder capacity rounded to the nearest 250 kW. For example, South Valley Solar would require a 4 MW | 16 MWh battery to eliminate potential over capacity instances. For every other larger configuration than this minimum, there would be an imposed maximum below the rated capacity for which it would be expected that over capacity instances would also be eliminated. For an 8 MW | 32 MWh system, there is a gap of approximately 1.25 MW for which the maximum circuit capacity could be increased, and the BESS would still be expected to be capable to eliminating generation over this capacity if its operation is controlled to achieve that goal. This operational strategy would require foresight in ensuring that the theoretical load addition does not have instantaneous excursions above the expected feeder capacity and that it does not prevent the BESS system from discharging at opportune times to allow it to serve its function in future time periods. All further results for this portion of the analysis can be found in Appendix B.

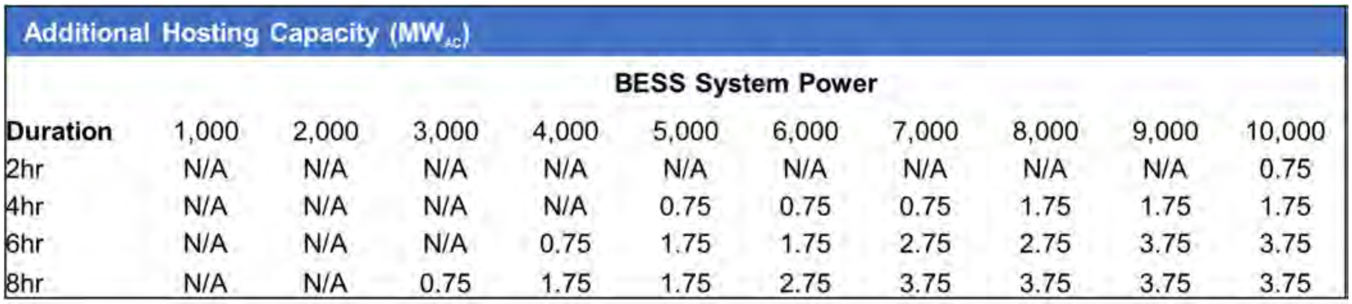
Table 7: Additional Hosting Capacity Potential at South Valley Solar



Additional Hosting Capacity (MW$_{AC}$)

	BESS System Power									
Duration	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
2hr	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
4hr	N/A	N/A	N/A	N/A	N/A	N/A	0.25	1.25	1.25	1.25
6hr	N/A	N/A	N/A	0.25	1.25	1.25	2.25	2.25	3.25	3.25
8hr	N/A	N/A	0.25	1.25	1.00	2.00	3.00	3.00	3.00	3.00

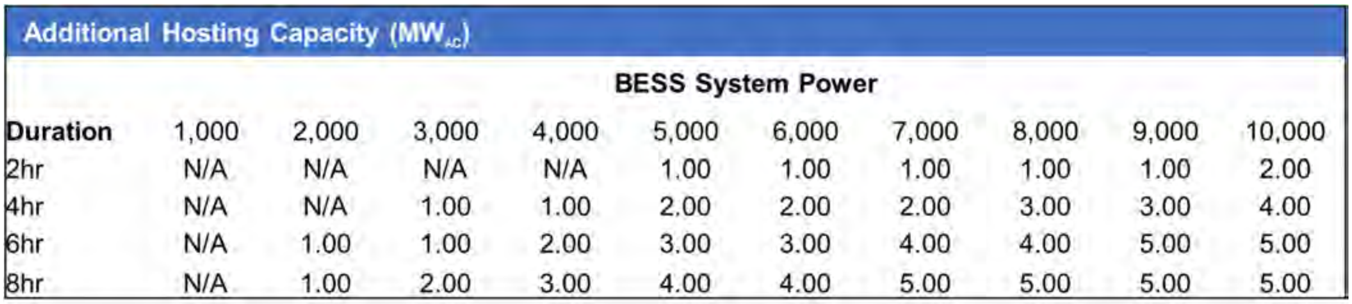
Table 8: Additional Hosting Capacity Potential at Rio Rancho Solar



Additional Hosting Capacity (MW$_{AC}$)

	BESS System Power									
Duration	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
2hr	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
4hr	N/A	N/A	N/A	N/A	0.75	0.75	0.75	1.75	1.75	1.75
6hr	N/A	N/A	N/A	0.75	1.75	1.75	2.75	2.75	3.75	3.75
8hr	N/A	N/A	0.75	1.75	1.75	2.75	3.75	3.75	3.75	3.75

Table 9: Additional Hosting Capacity Potential at Facebook 2 Solar



Additional Hosting Capacity (MW$_{AC}$)

	BESS System Power									
Duration	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
2hr	N/A	N/A	N/A	N/A	1.00	1.00	1.00	1.00	1.00	2.00
4hr	N/A	N/A	1.00	1.00	2.00	2.00	2.00	3.00	3.00	4.00
6hr	N/A	1.00	1.00	2.00	3.00	3.00	4.00	4.00	5.00	5.00
8hr	N/A	1.00	2.00	3.00	4.00	4.00	5.00	5.00	5.00	5.00

3.3.2 Energy Arbitrage Value Results

In addition to the method to identify the highest likelihood to reach a positive economic result identified by the utilization of the market data, the proxy for energy value calculated in this step of the analysis was also used to quantify the value of the average BESS dispatch value by system capacity and duration. A similar BESS integration model to that used for the system capacity value determination was prepared in this portion of the assessment. However, in this instance, the BESS Integration Model was influenced to account for the relative value in charging and discharging at specific times. A few sample 24-hour periods at the South Valley Solar site are included in this report to illustrate how the BESS system would charge and discharge based on to meet both economic and overcapacity instance reduction benefits (Figure 13, Figure 14). Lastly, sample results for each model for the expected value of the energy under the perfect dispatch algorithm are included in Figure 11 and Figure 12. A complete set of average energy dispatch values can be found in Appendix C.

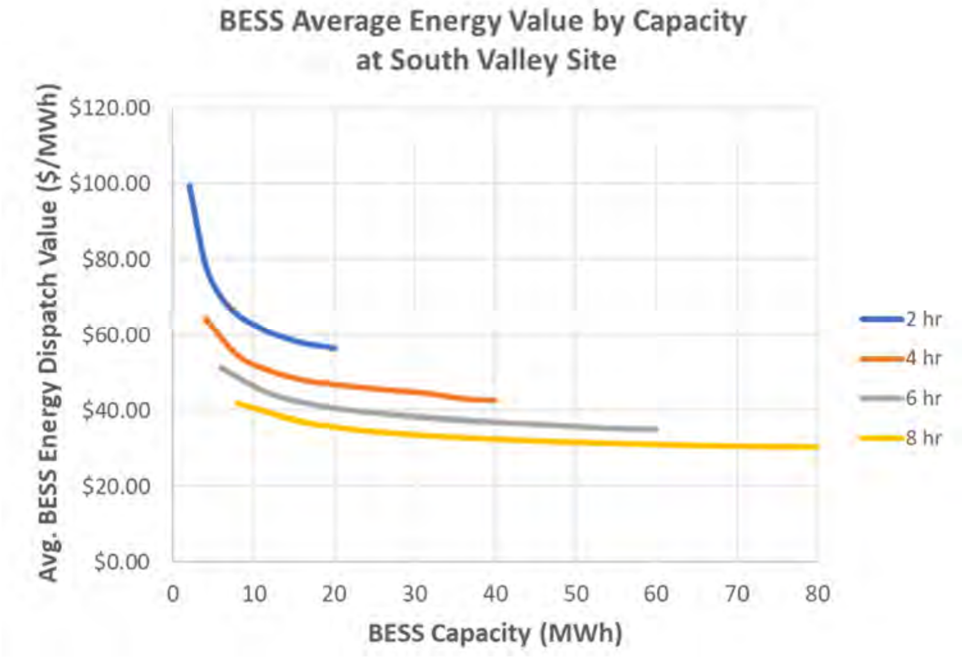


Figure 11: BESS Average Energy Value by Capacity at South Valley Solar

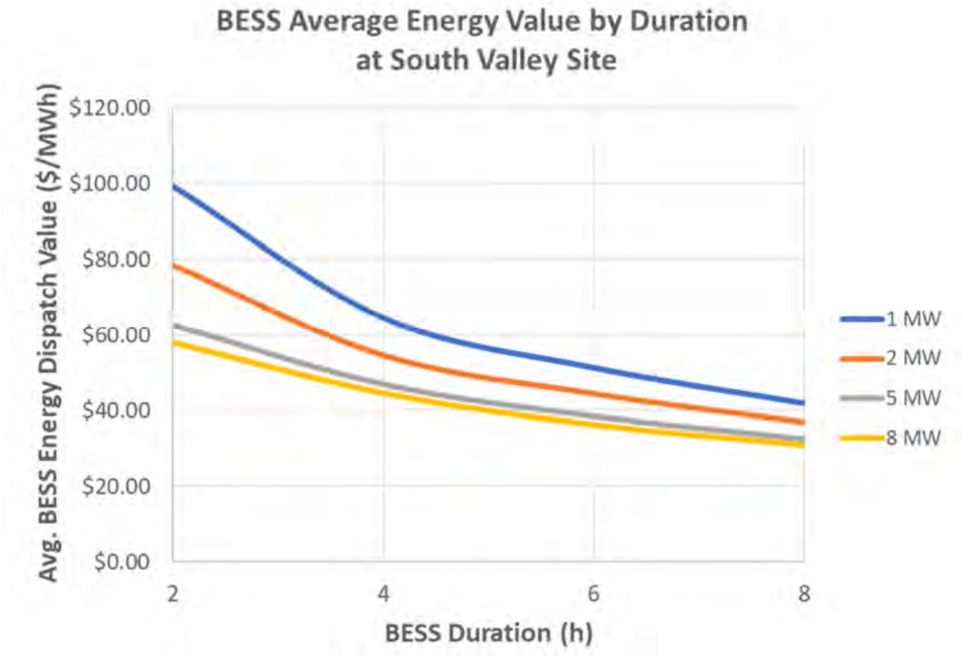
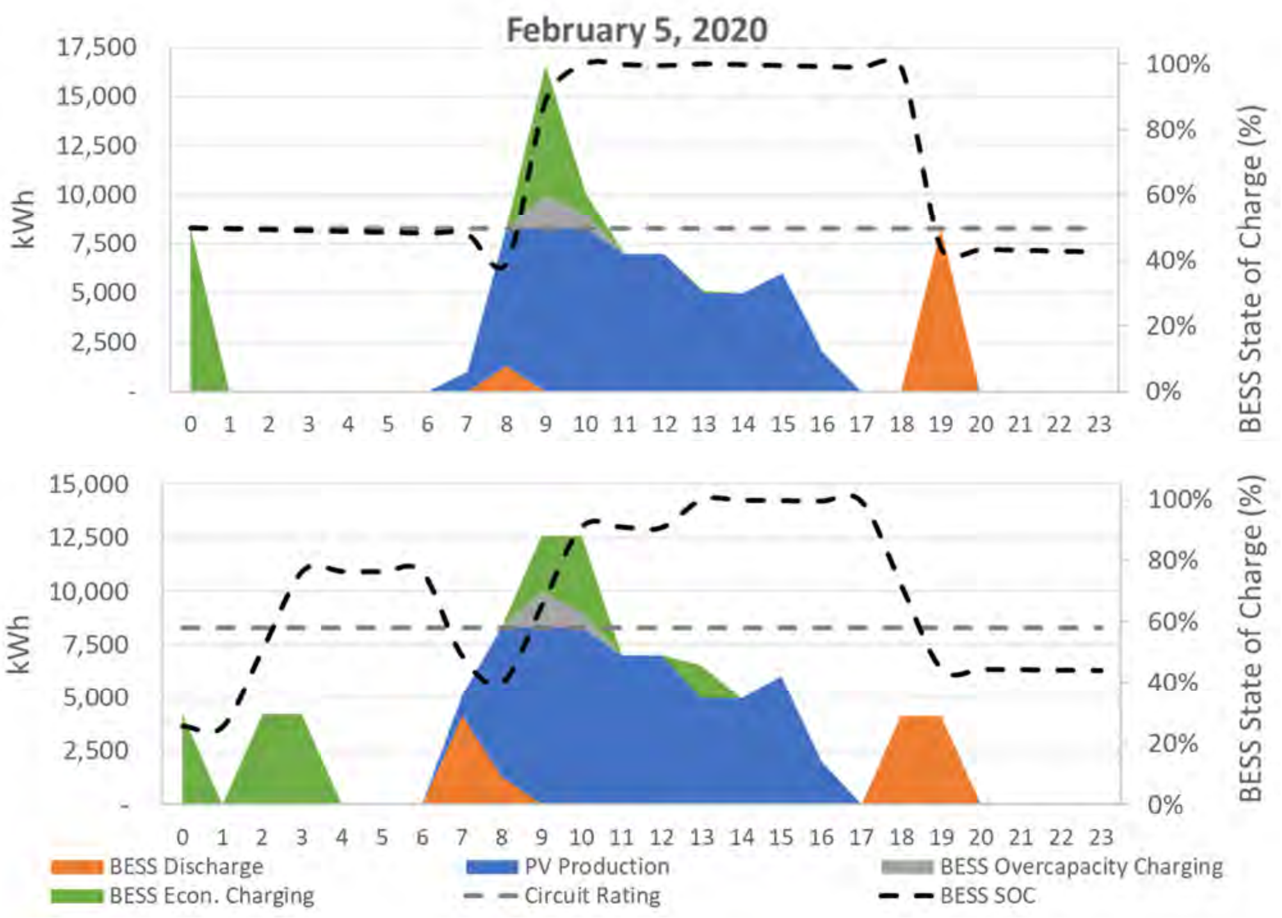


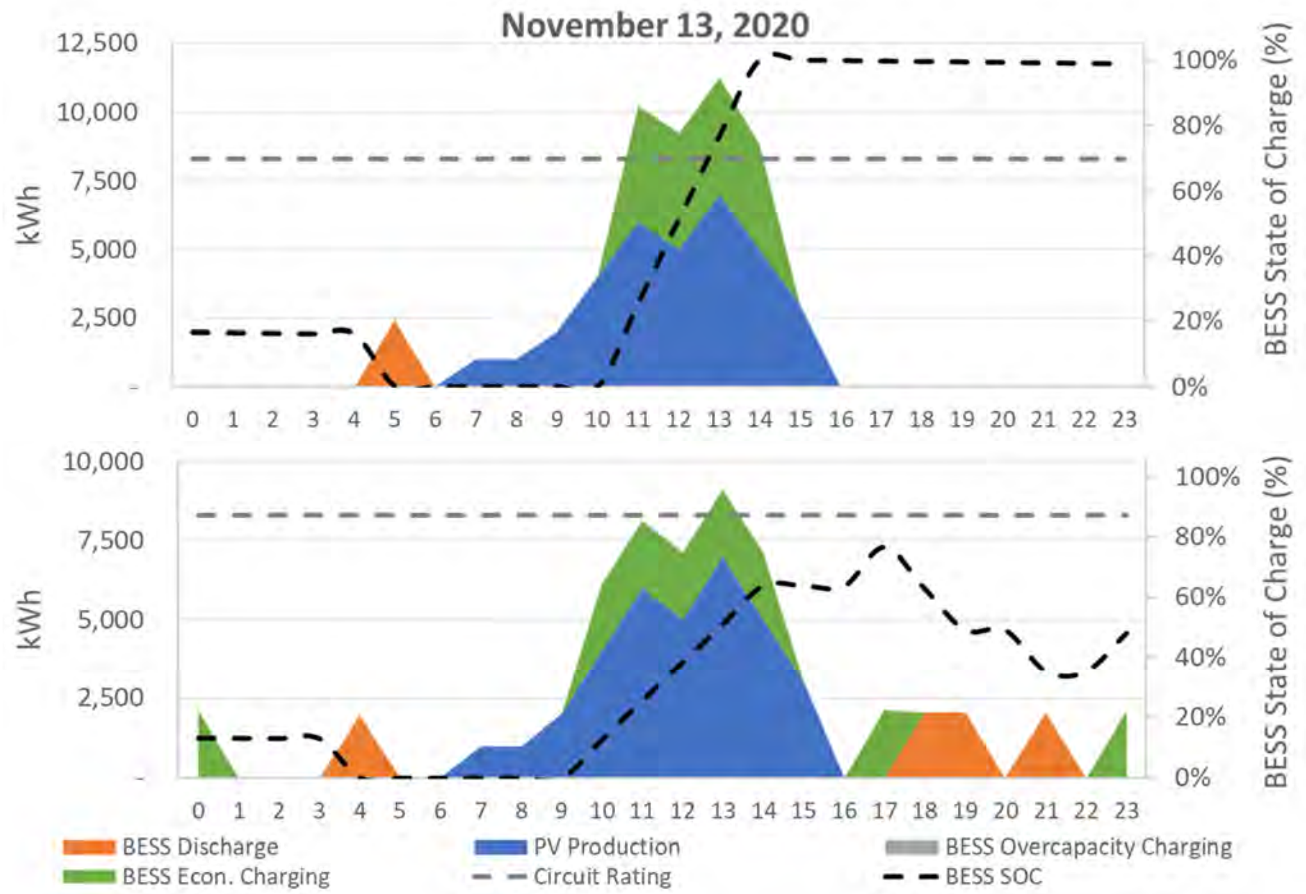
Figure 12: BESS Average Energy Value by Duration at South Valley Site



BESS Configuration
8 MW | 2 hr

BESS Configuration
4 MW | 4 hr

Figure 13: Sample Model Results for BESS Utilization - Feb. 5



BESS Configuration

4 MW | 4 hr

BESS Configuration

2 MW | 8 hr

Figure 14: Sample Model Results for BESS Utilization - Nov. 13

4.0 CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the analysis presented to PNM through several meetings with their distribution planning and generation teams to identify the benefits of BESS systems for the sites selected by PNM. First, a prioritization of the systems within the analysis was prepared and whose results are presented in Table 3 and Appendix A. Next, the system configuration to achieve elimination of solar generation above the feeder capacity was determined using BMcD's GridBEAST and using PNM provided solar generation data and feeder capacities. Lastly, the optimal duration of the BESS was determined by determining a proxy value of energy within the PNM service territory and this data was used to model the performance of the BESS when having to meet both its system capacity purpose and taking advantage of spreads in energy value. Based on this analysis, the following battery configurations were recommended for further study:

- South Valley Solar: 4 MW | 16 MWh
- Rio Rancho Solar: 3 MW | 12 MWh
- Facebook 2 Solar: 3 MW | 12 MWh
    - Facebook 2 does not appear to have any instances of solar generation resulting above the feeder's capacity. The recommendation above represents the minimum BESS capacity to reach an increase in hosting capacity.

As was noted in Section 1.3.2, PNM's transmission planning team did not expect any individual or combination of these projects to enable deferral of transmission level projects. However, in case a future combination of sites is considered, it is recommended that this viewpoint is revisited – especially if the overall capacity size for the BESS totals a multiple of three or greater of the current 10 MW of maximum BESS capacity proposed. BMcD also recommends that this analysis is continued and evaluated in a continuous process as future generation addition, retirements, and transmission projects are considered as PNM sees further integration with the Energy Imbalance Market or sees greater demand for distributed solar.

Appendix A - **BESS DISTRITBUTION PORTFOLIO PRESENTATION**

AGENDA

01 **PV Sites Overview**

02 **Initial Model Observations**

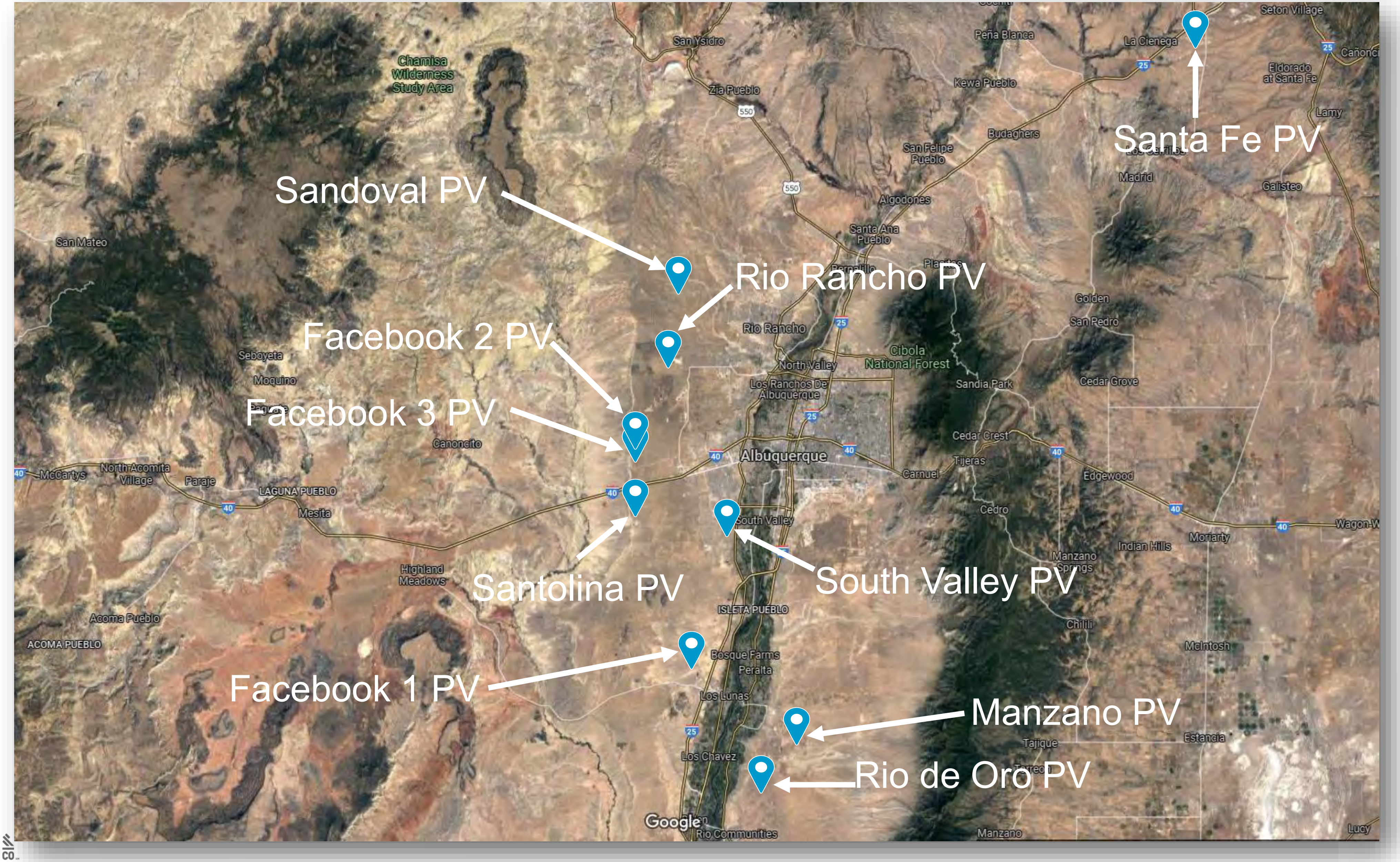
03 **Prioritization Analysis**

04 **Summary**

PV Sites Overview

#	PV Site	Substation	Feeder	Generation
1	**Facebook 3 Solar**	Lost Horizon	LOHO-12	9.9 MW
2	**Santolina Solar**	Lost Horizon	LOHO-13	11.0 MW
3	**Facebook 2 Solar**	Lost Horizon	LOHO-14	11.0 MW
4	**Rio Rancho Solar**	Scenic	SCEN-12	9.1 MW
5	**South Valley Solar**	South Coors	SOCO-12	10.3 MW
6	**Rio de Oro Solar**	Tome	TOME-12	9.9 MW
7	**Manzano Solar**	College	COLL-12	8.4 MW
8	**Facebook 1 Solar**	Los Morros	LSMO-12	10.0 MW
9	**Sandoval Solar**	Progress	PROG-13	6.4 MW
10	**Santa Fe Solar**	State Pen	STPE-12	9.5 MW

PV Site Locations



AGENDA

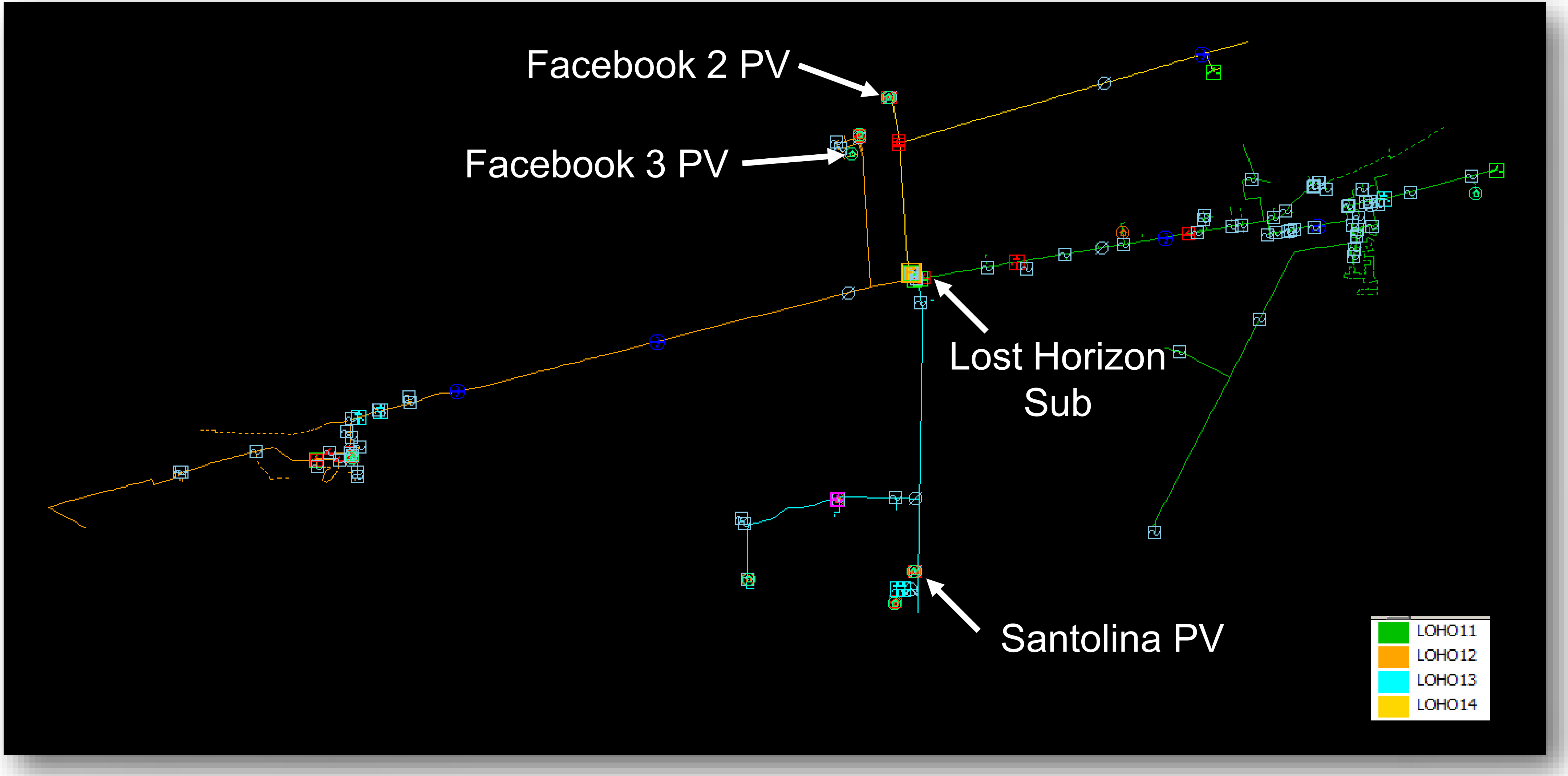
01 PV Sites Overview

02 Initial Model Observations

03 Prioritization Analysis

04 Summary

Lost Horizon Substation - PV Sites



Facebook 2 PV

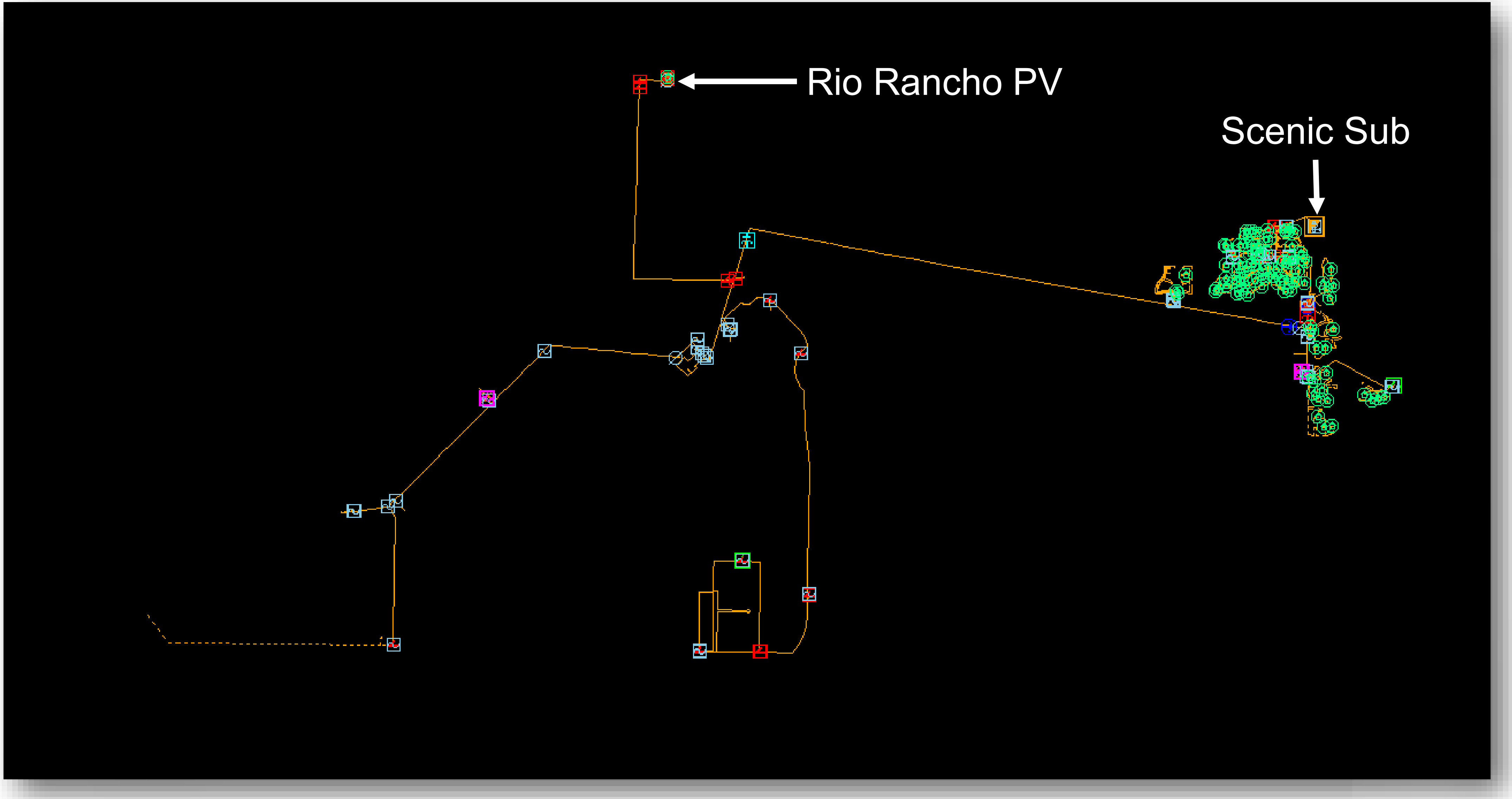
Facebook 3 PV

Lost Horizon Sub

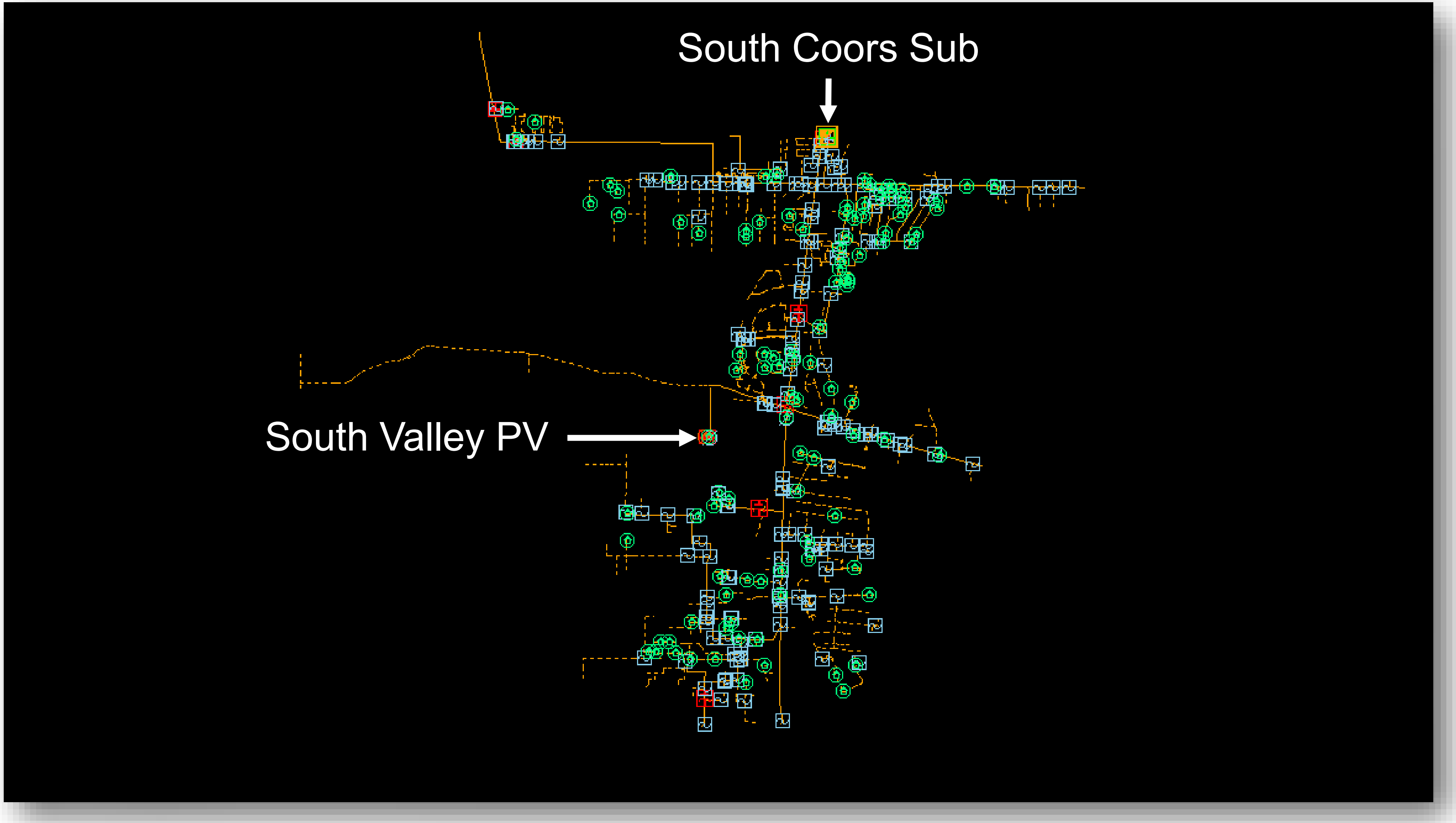
Santolina PV

🟩	LOHO11
🟧	LOHO12
🟦	LOHO13
🟨	LOHO14

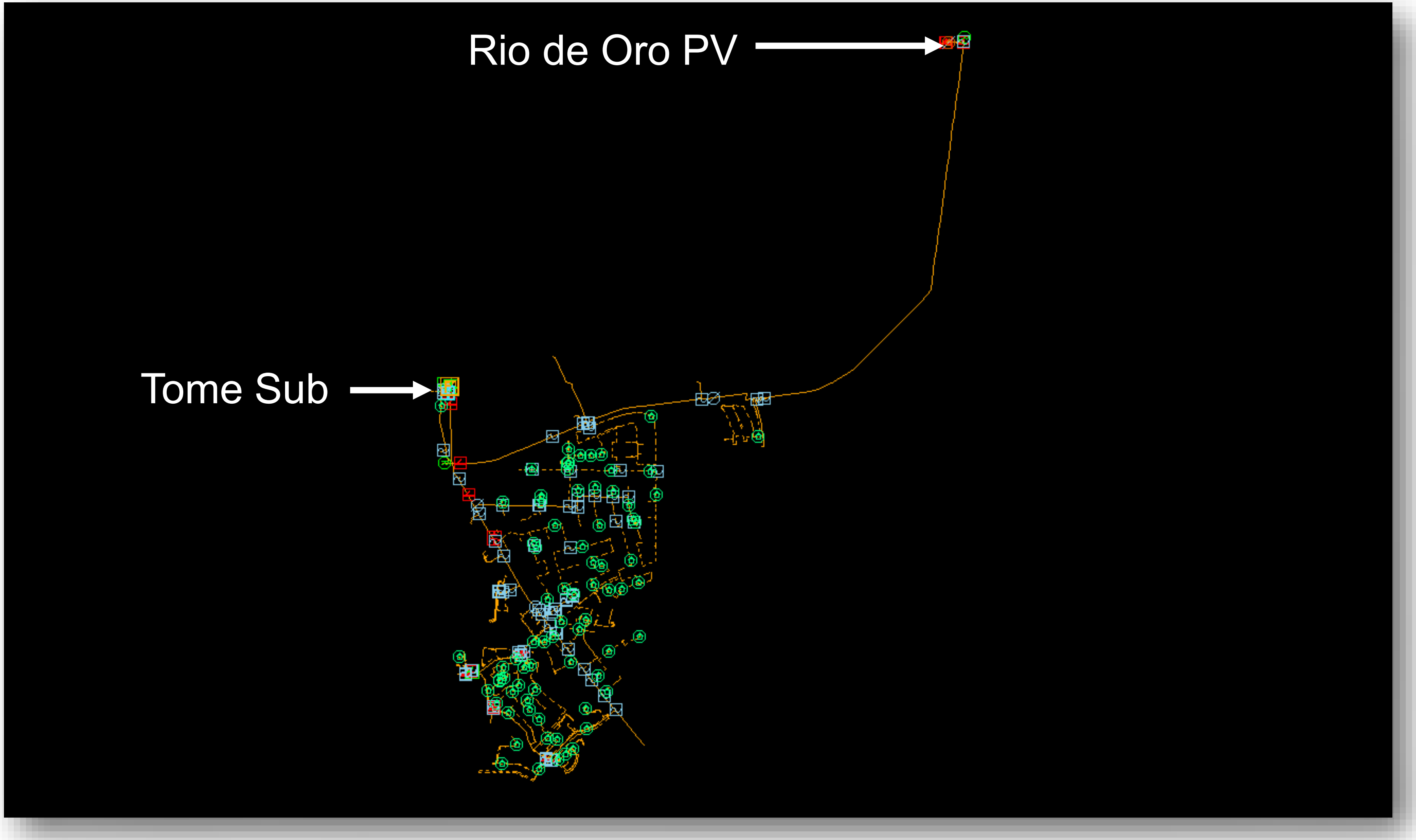
Scenic Substation - PV Site



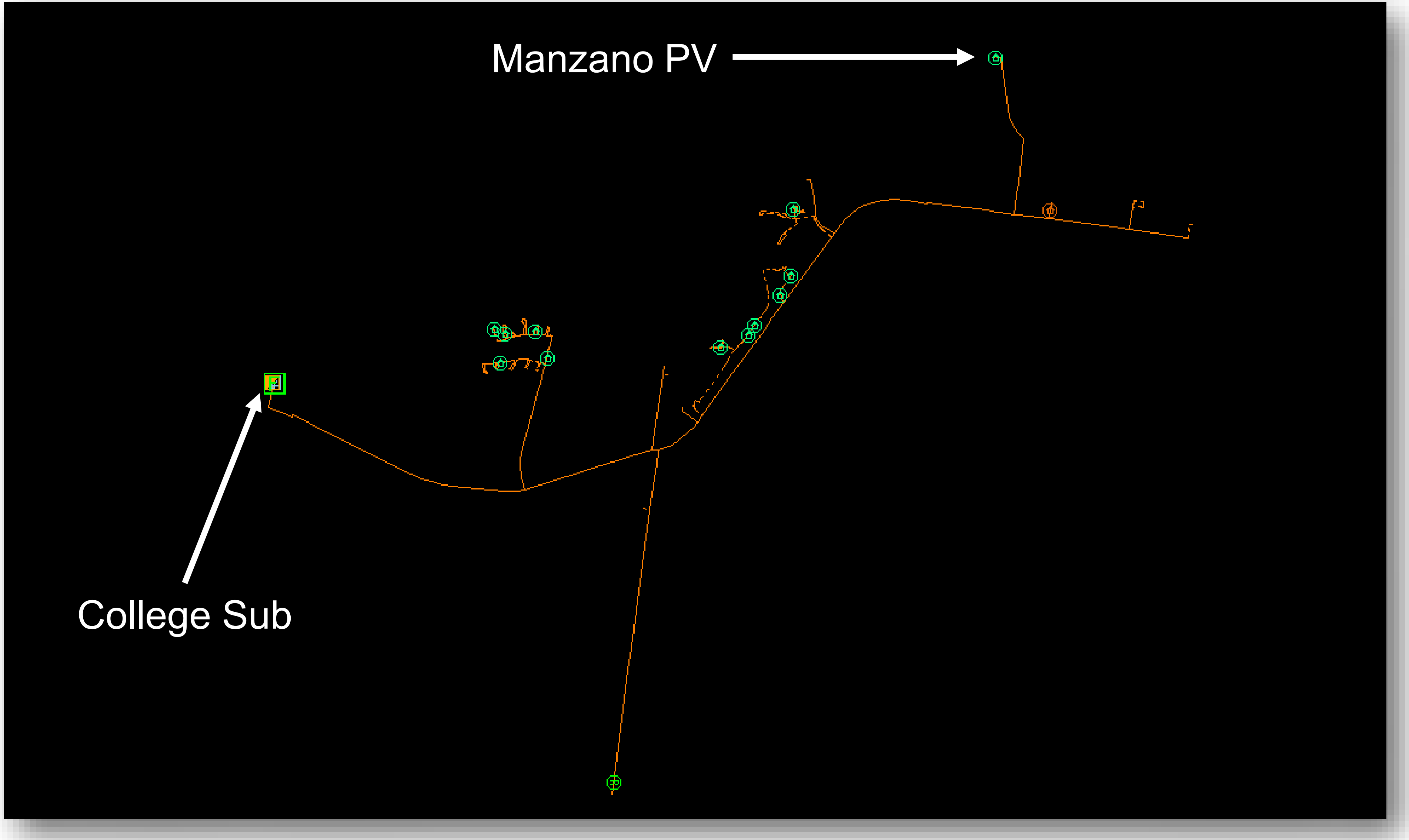
South Coors Substation - PV Site



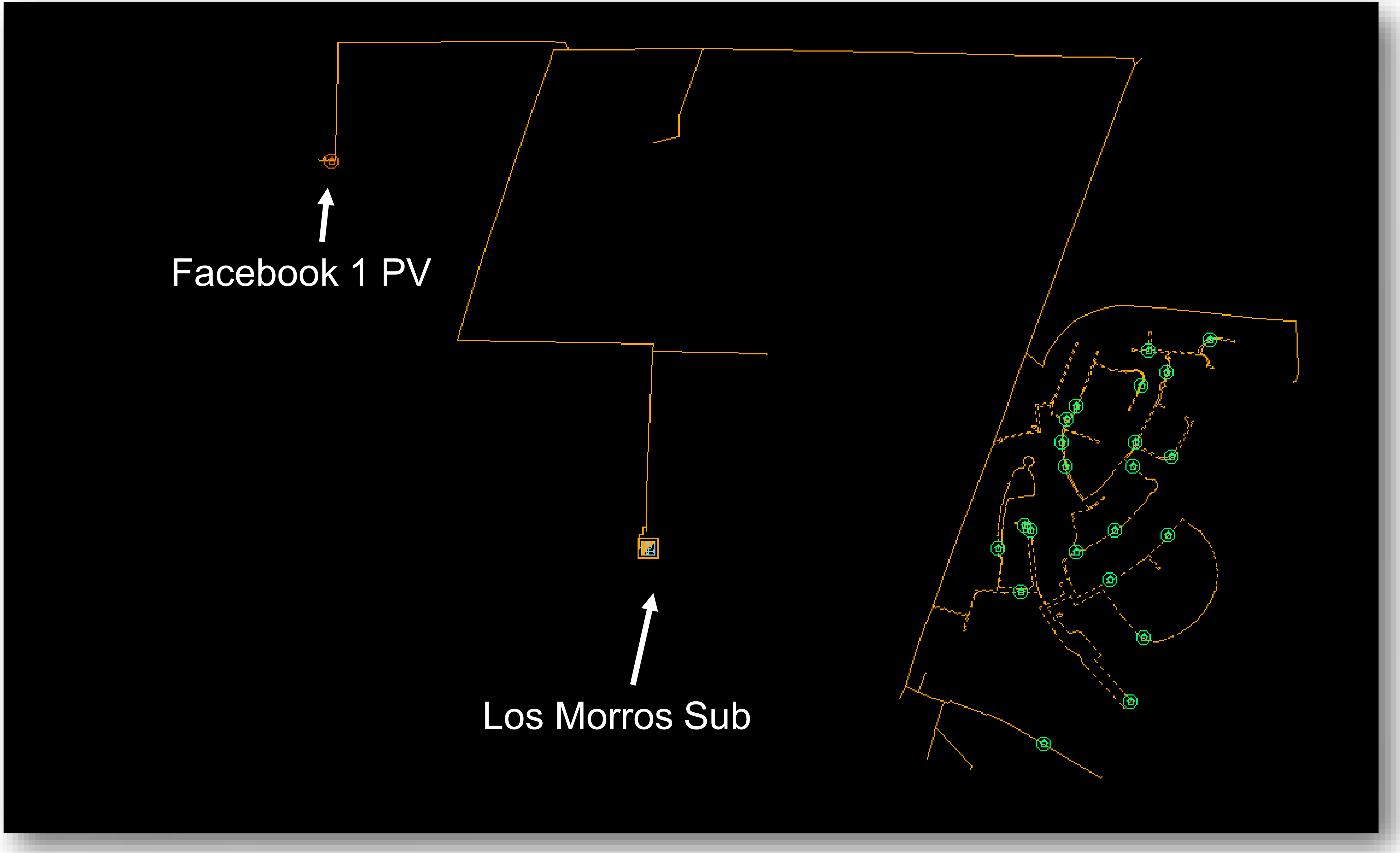
Tome Substation - PV Site



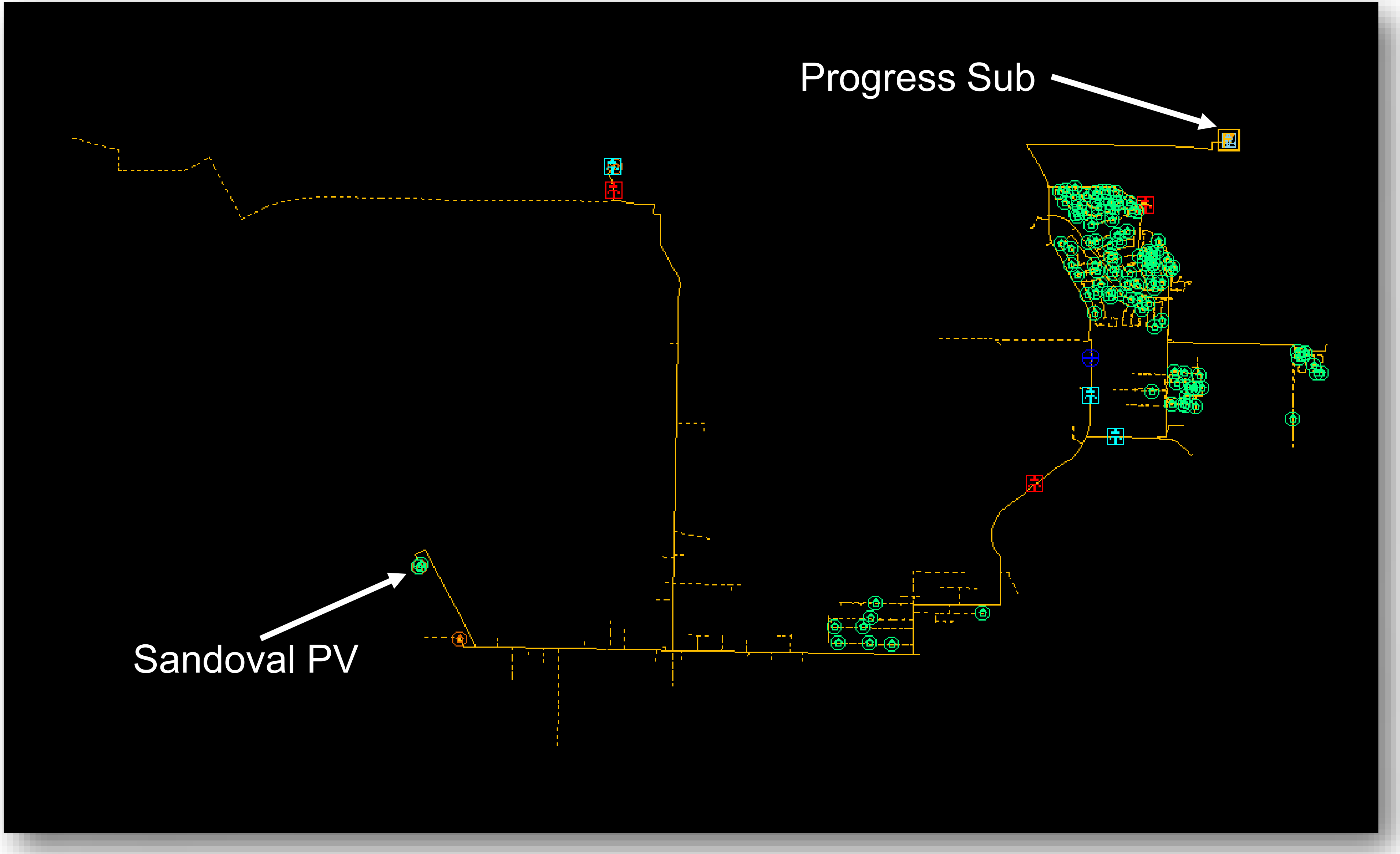
College Substation - PV Site



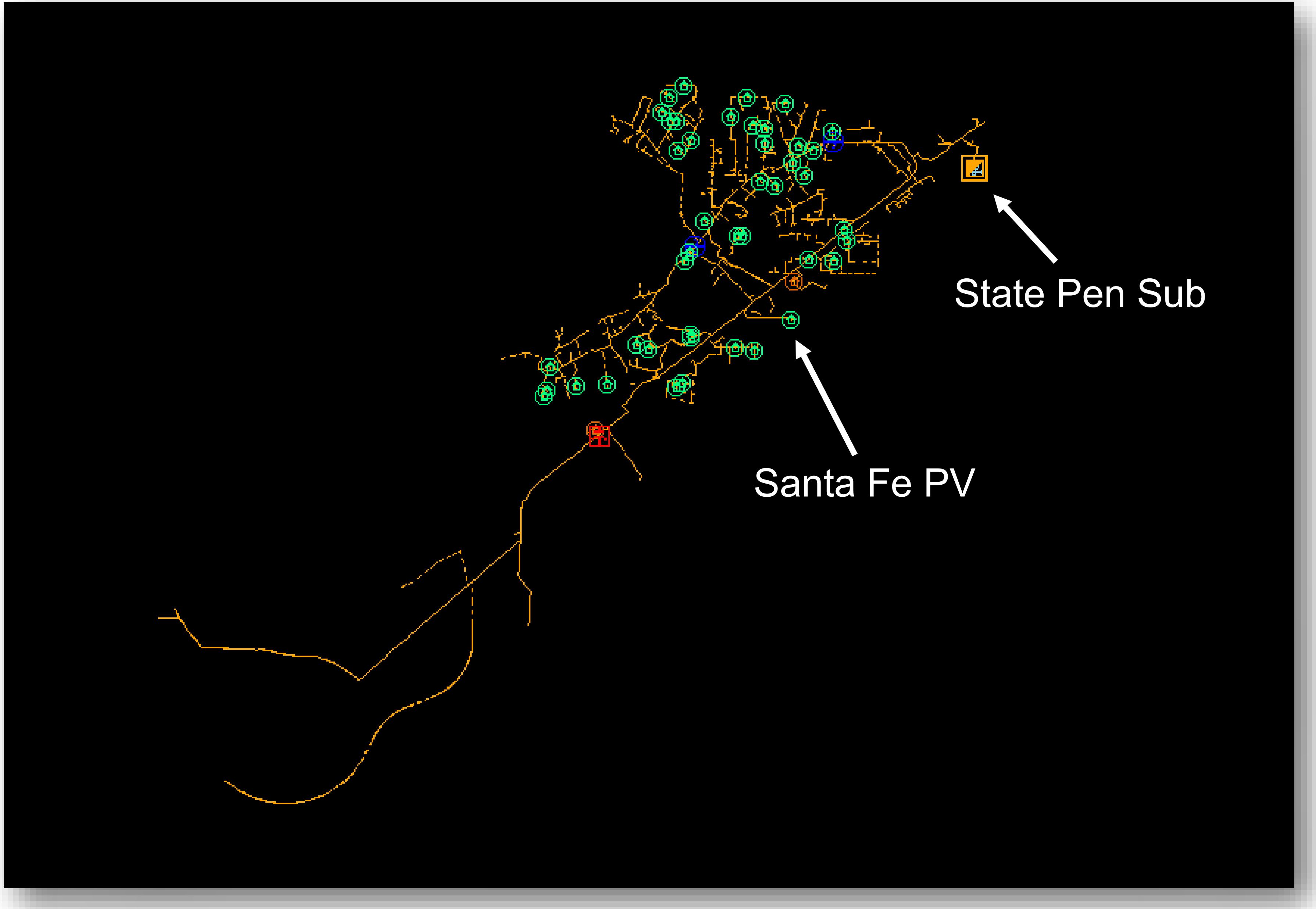
Los Morros Substation - PV Site



Progress Substation - PV Site



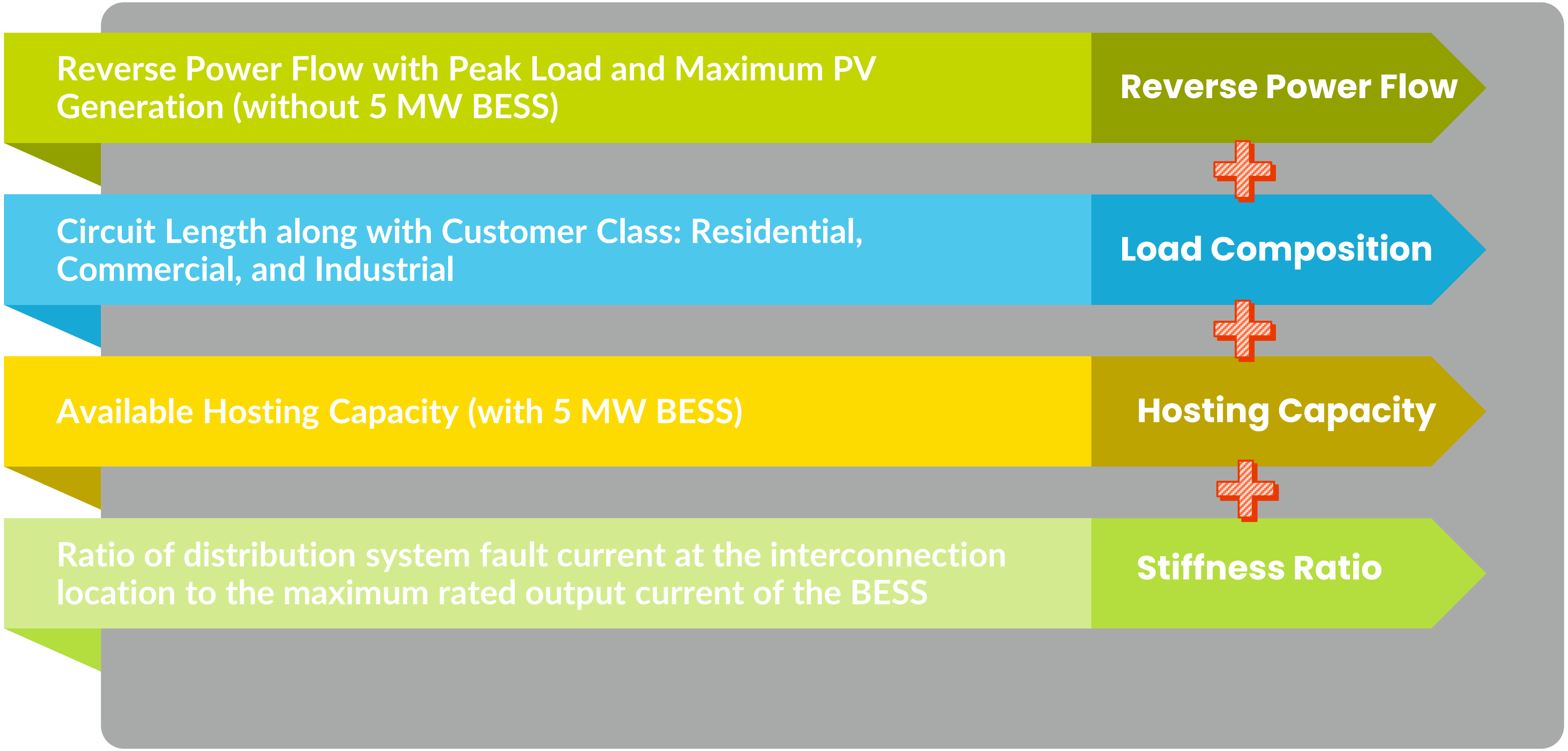
State Pen Substation - PV Site



AGENDA

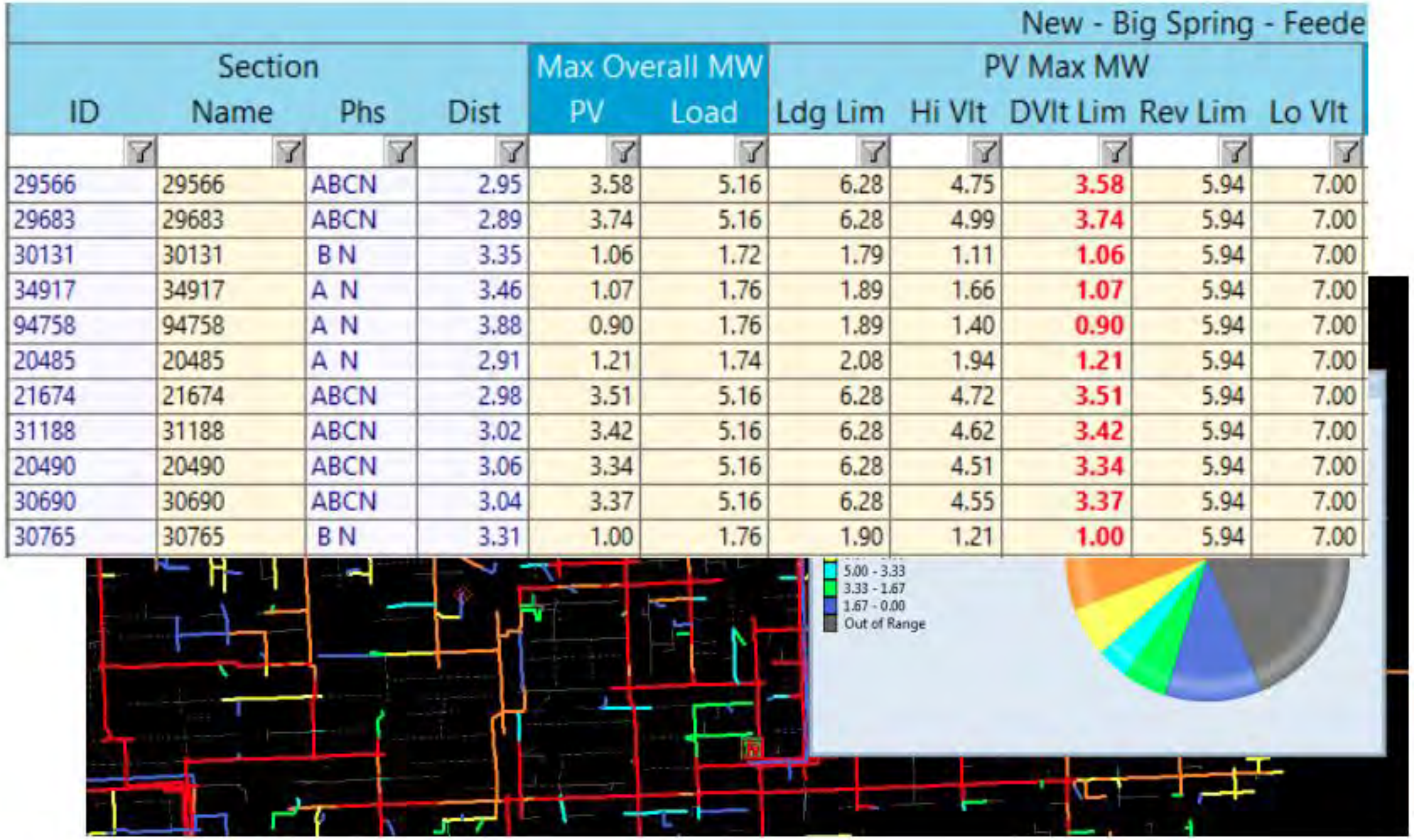
- 01 PV Sites Overview
- 02 Initial Model Observations
- 03 Prioritization Analysis
- 04 Summary

Scoring Methodology



Reverse Power Flow with Peak Load and Maximum PV Generation (without 5 MW BESS)	**Reverse Power Flow**
	+
Circuit Length along with Customer Class: Residential, Commercial, and Industrial	**Load Composition**
	+
Available Hosting Capacity (with 5 MW BESS)	**Hosting Capacity**
	+
Ratio of distribution system fault current at the interconnection location to the maximum rated output current of the BESS	**Stiffness Ratio**

Hosting Capacity - Overview



New - Big Spring - Feede

Section				Max Overall MW		PV Max MW				
ID	Name	Phs	Dist	PV	Load	Ldg Lim	Hi Vlt	DVlt Lim	Rev Lim	Lo Vlt
29566	29566	ABCN	2.95	3.58	5.16	6.28	4.75	3.58	5.94	7.00
29683	29683	ABCN	2.89	3.74	5.16	6.28	4.99	3.74	5.94	7.00
30131	30131	B N	3.35	1.06	1.72	1.79	1.11	1.06	5.94	7.00
34917	34917	A N	3.46	1.07	1.76	1.89	1.66	1.07	5.94	7.00
94758	94758	A N	3.88	0.90	1.76	1.89	1.40	0.90	5.94	7.00
20485	20485	A N	2.91	1.21	1.74	2.08	1.94	1.21	5.94	7.00
21674	21674	ABCN	2.98	3.51	5.16	6.28	4.72	3.51	5.94	7.00
31188	31188	ABCN	3.02	3.42	5.16	6.28	4.62	3.42	5.94	7.00
20490	20490	ABCN	3.06	3.34	5.16	6.28	4.51	3.34	5.94	7.00
30690	30690	ABCN	3.04	3.37	5.16	6.28	4.55	3.37	5.94	7.00
30765	30765	B N	3.31	1.00	1.76	1.90	1.21	1.00	5.94	7.00

Checks for:

- Thermal loading limit
- High voltage
- Delta voltage
- Reverse flow
- Low voltage

The overall minimum forms the heat map.

Hosting Capacity - Criteria

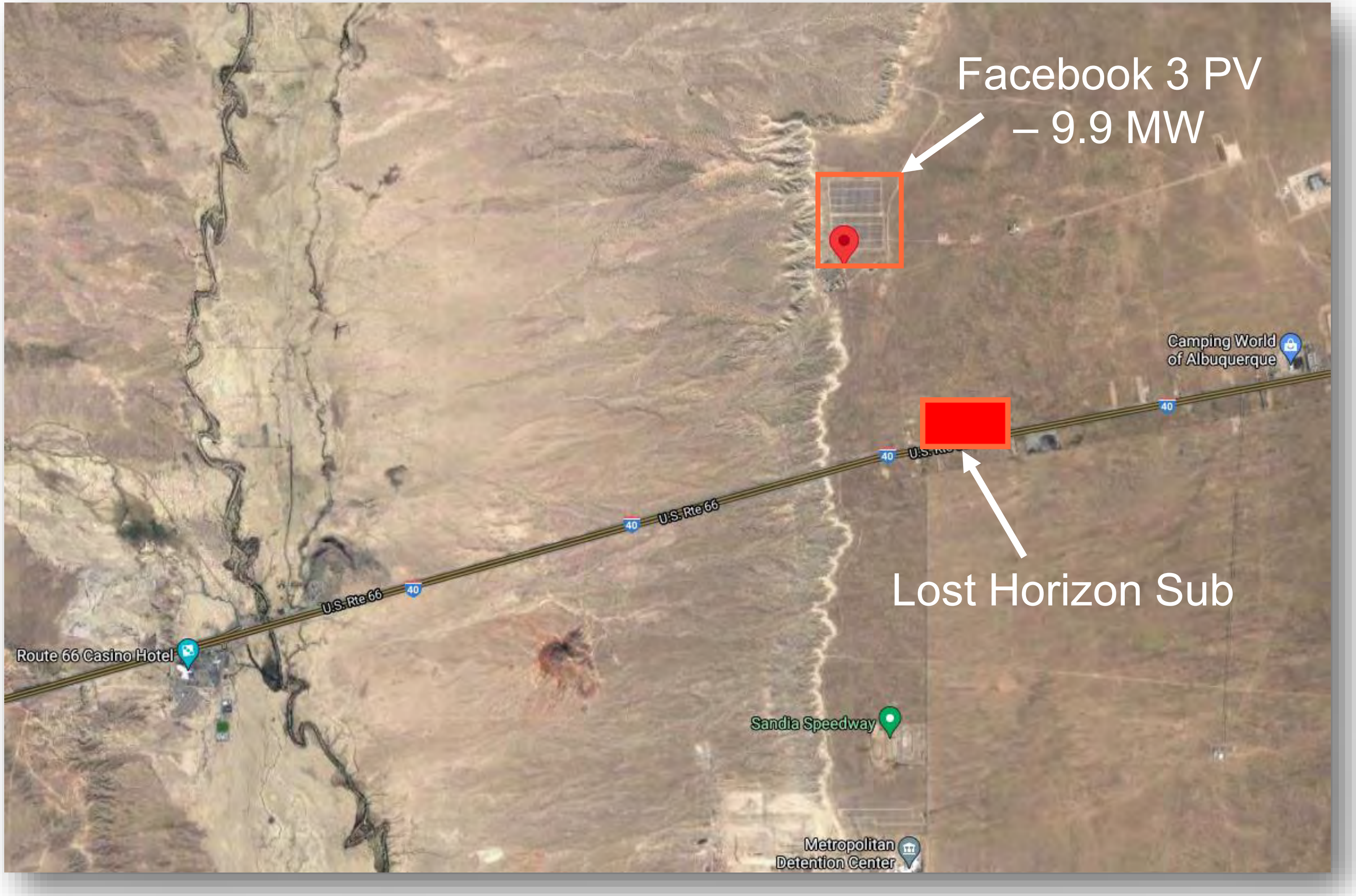
No aggregate generation per circuit more than 90% or 100% of feeder equipment loading

No single generation installation larger than 50% of feeder equipment loading

Facebook 3 Solar

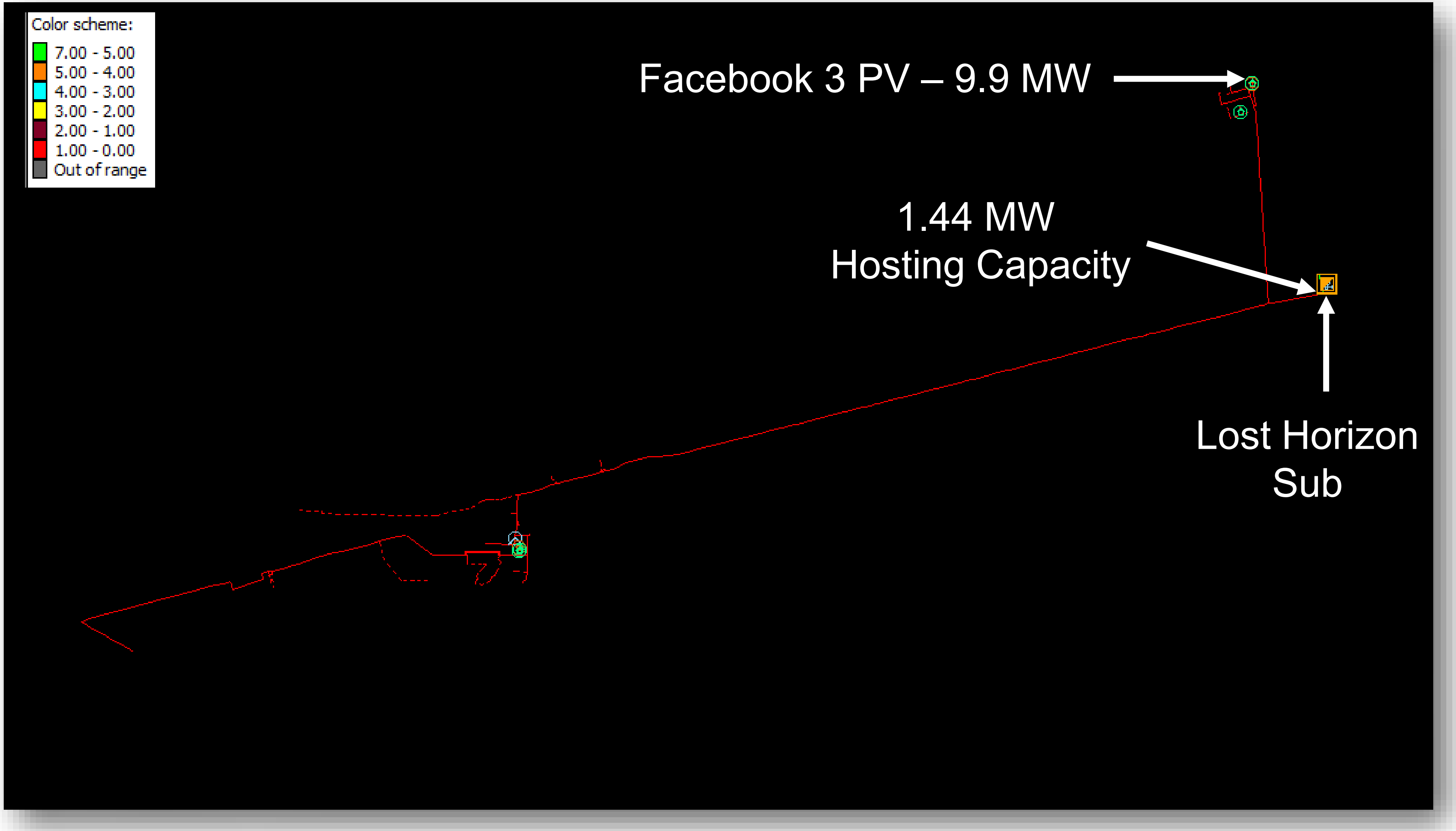
Lost Horizon 12

Lost Horizon 12 – Facebook 3 Solar



- **9.9 MW$_{ac}$** PV site
- Getaway Conductor **750Cu**(riser)
- **16** miles long Feeder
- Rated Feeder Capacity **10.1 MW**
- Limiting Factor between PV site and Substation – **750 Cu UG**(10.1 MW)

Lost Horizon 12 – Hosting Capacity

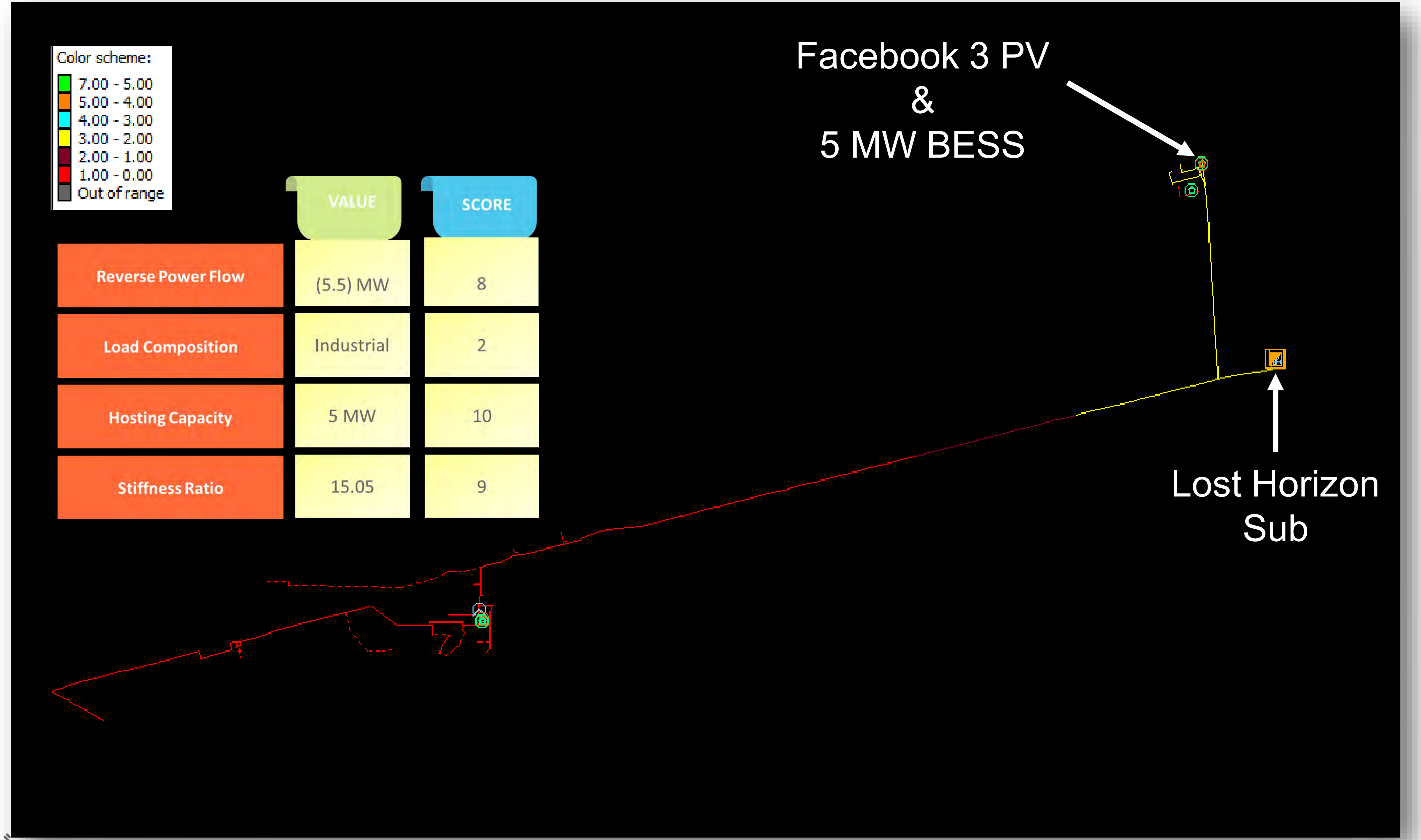


Facebook 3 PV – 9.9 MW

1.44 MW
Hosting Capacity

Lost Horizon
Sub

Lost Horizon 12 – Hosting Capacity (w/ BESS)



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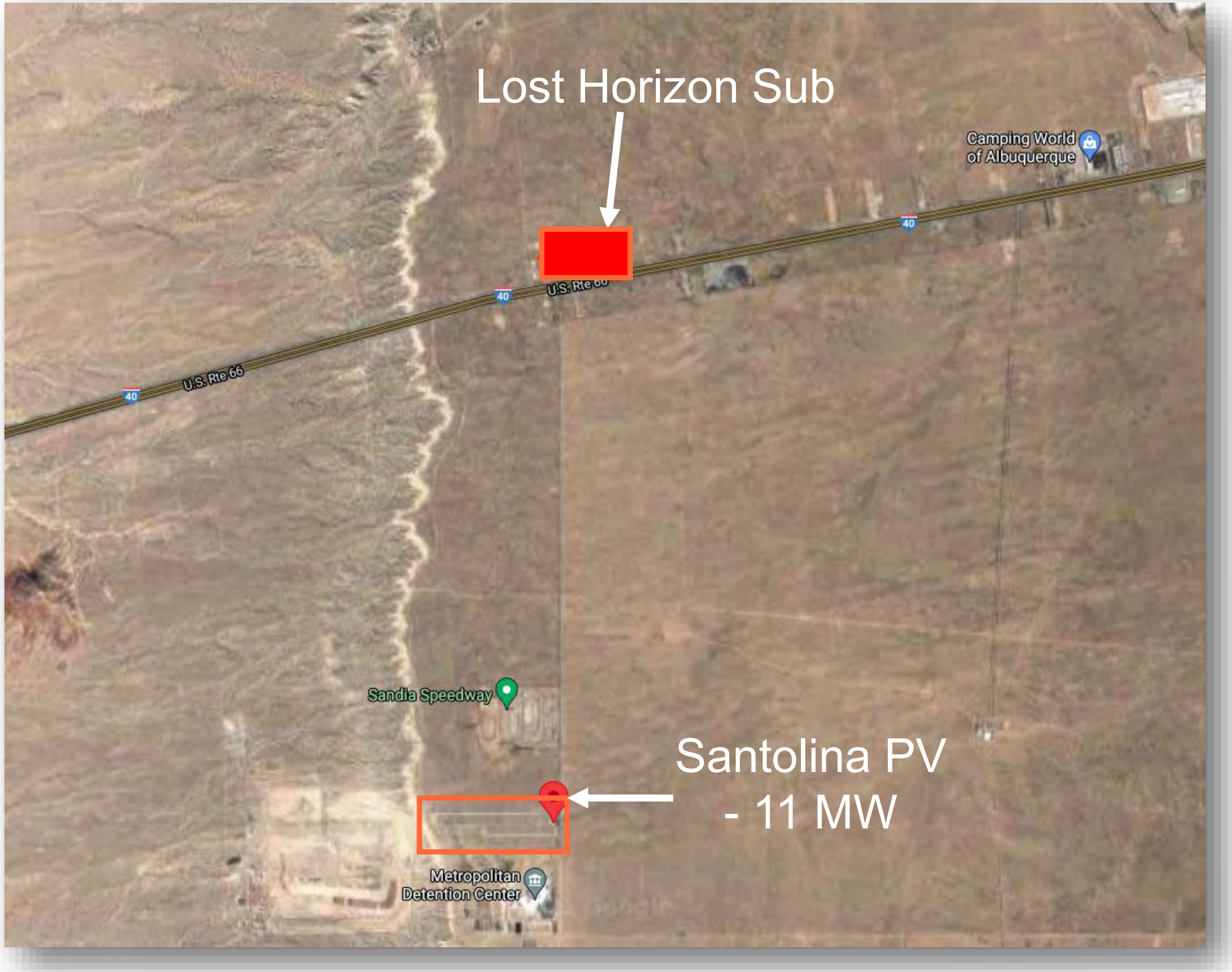
- ⬛ Out of range

	VALUE	SCORE
Reverse Power Flow	(5.5) MW	8
Load Composition	Industrial	2
Hosting Capacity	5 MW	10
Stiffness Ratio	15.05	9

Santolina Solar

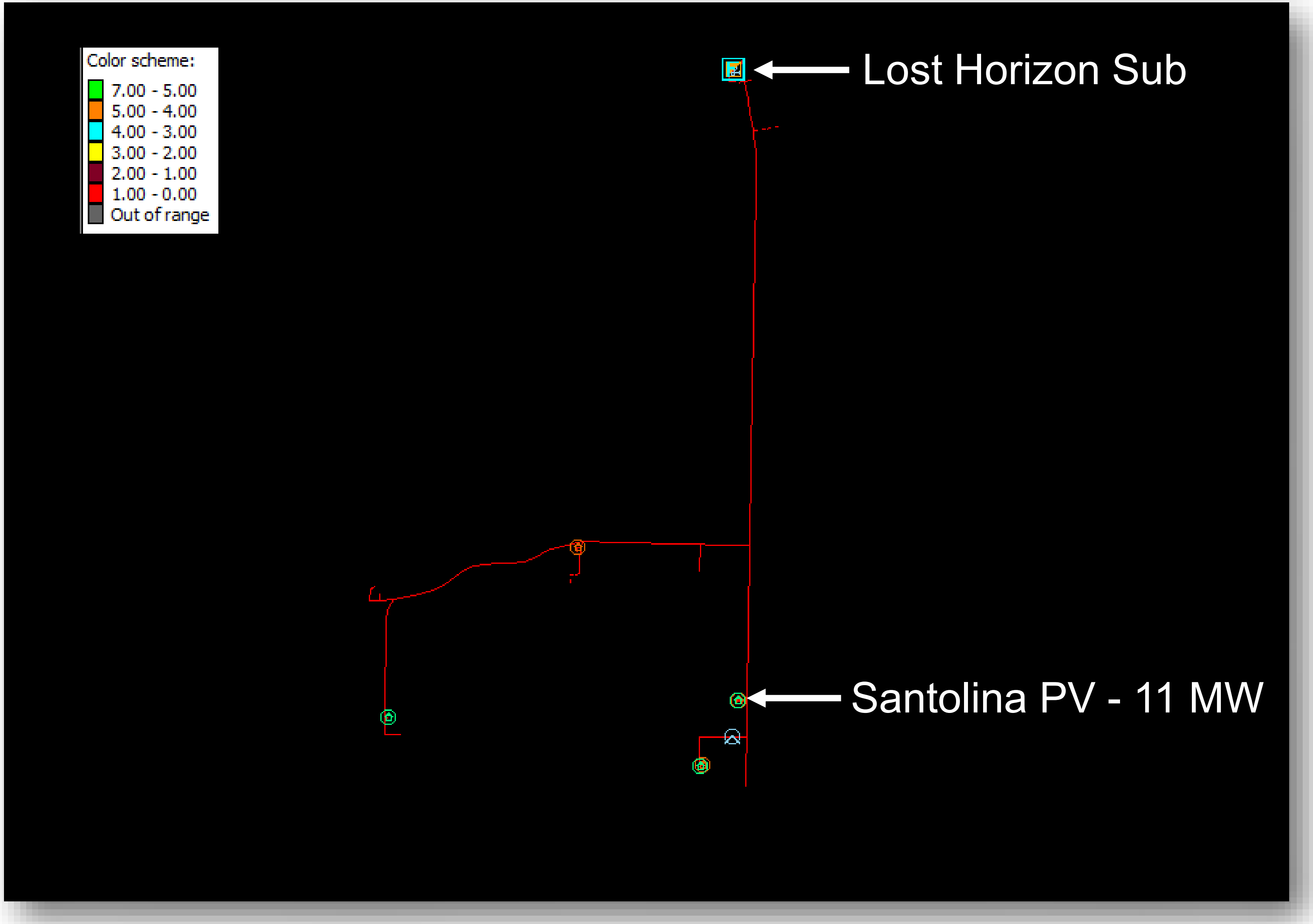
Lost Horizon 13

Lost Horizon 13 – Santolina Solar



- **11 MW$_{ac}$** PV site
- Getaway Conductor **750 Cu(riser)**
- **7** miles long feeder
- Rated Feeder Capacity – **10.1 MW**
- Limiting Factor between PV site and Substation – **750 Cu UG** – Rated **10.1 MW**

Lost Horizon 13 – Hosting Capacity



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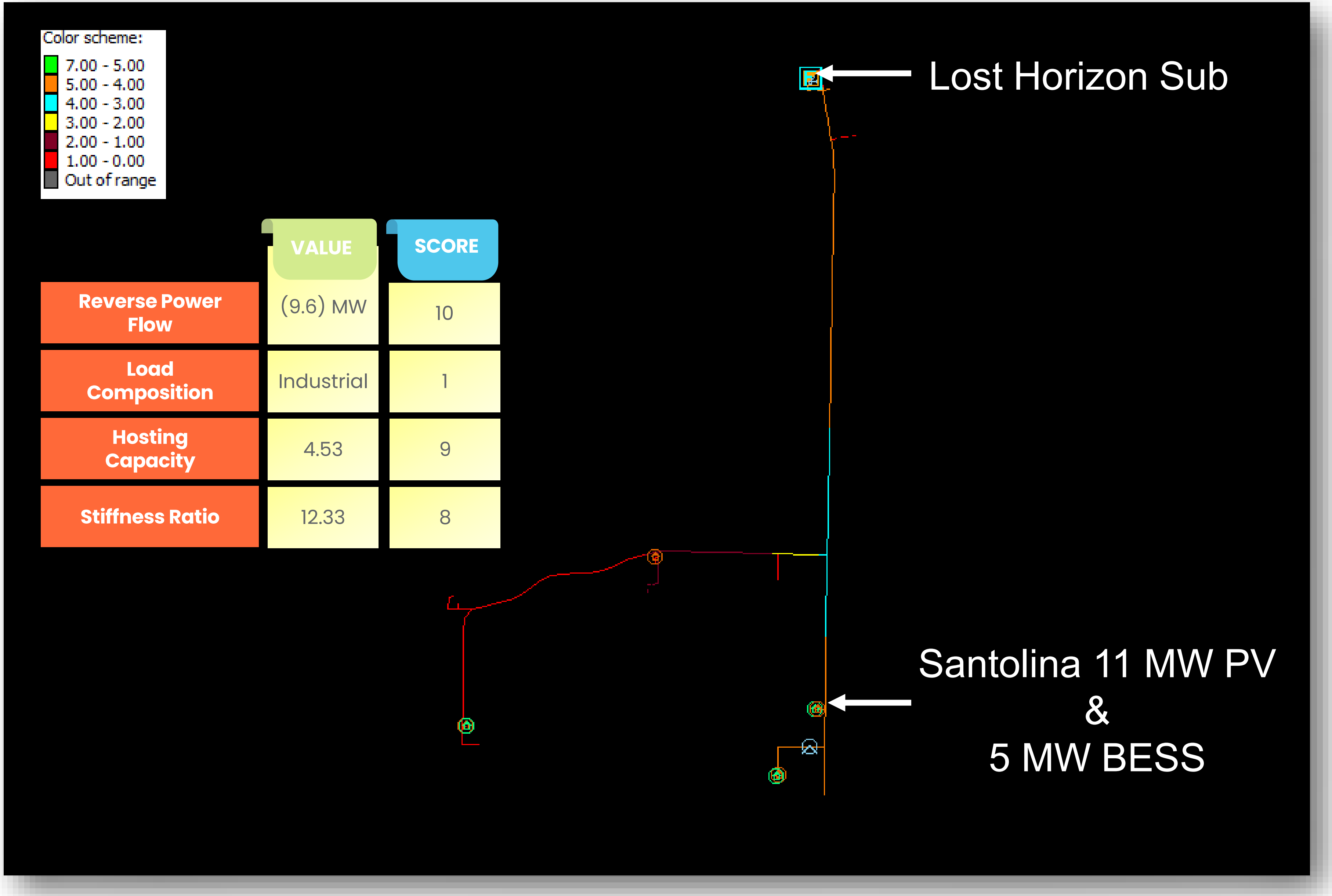
- ⬛ Out of range

Lost Horizon 13 – Hosting Capacity (w/ BESS)

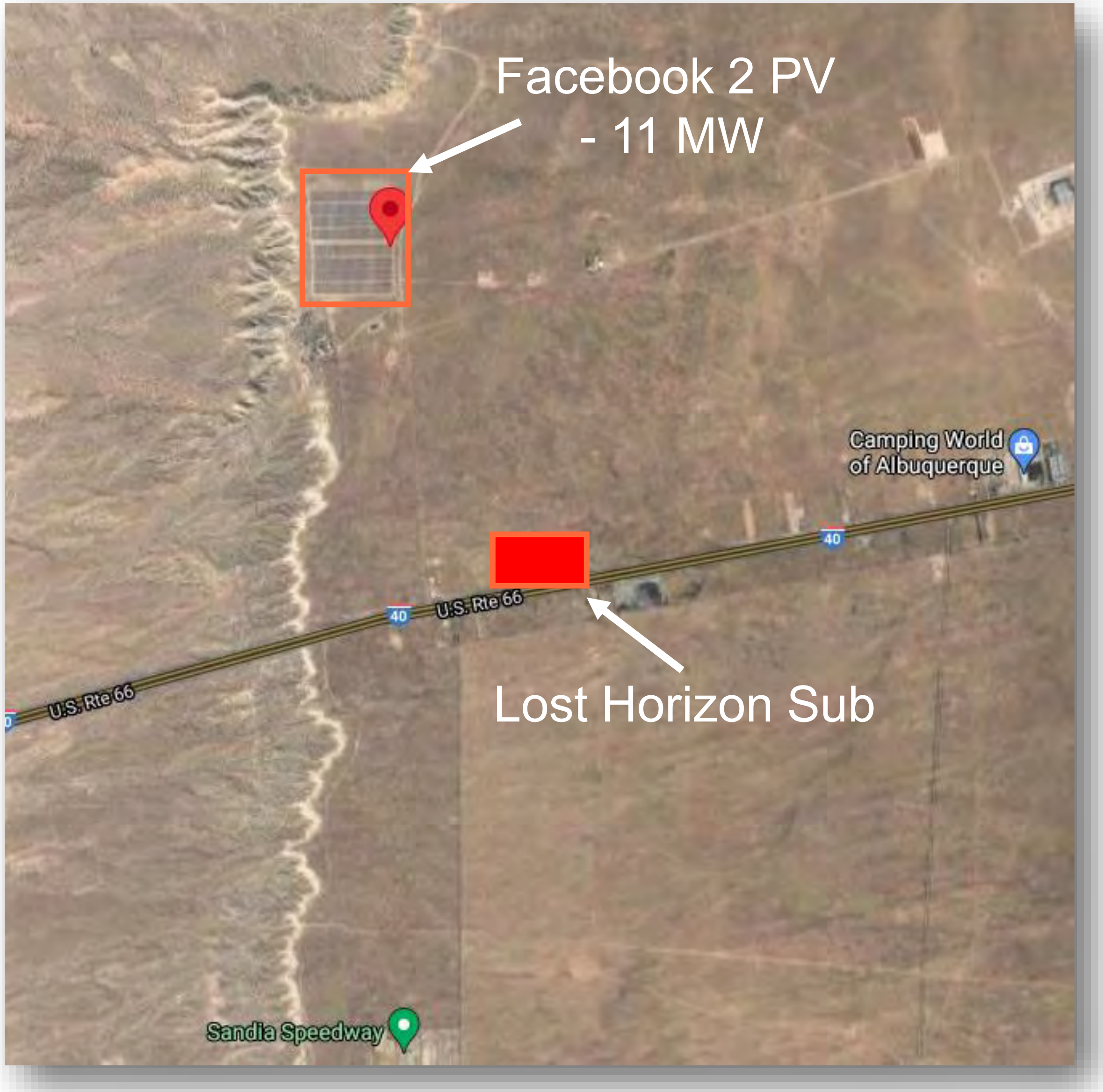


	VALUE	SCORE
Reverse Power Flow	(9.6) MW	10
Load Composition	Industrial	1
Hosting Capacity	4.53	9
Stiffness Ratio	12.33	8

Facebook 2 Solar

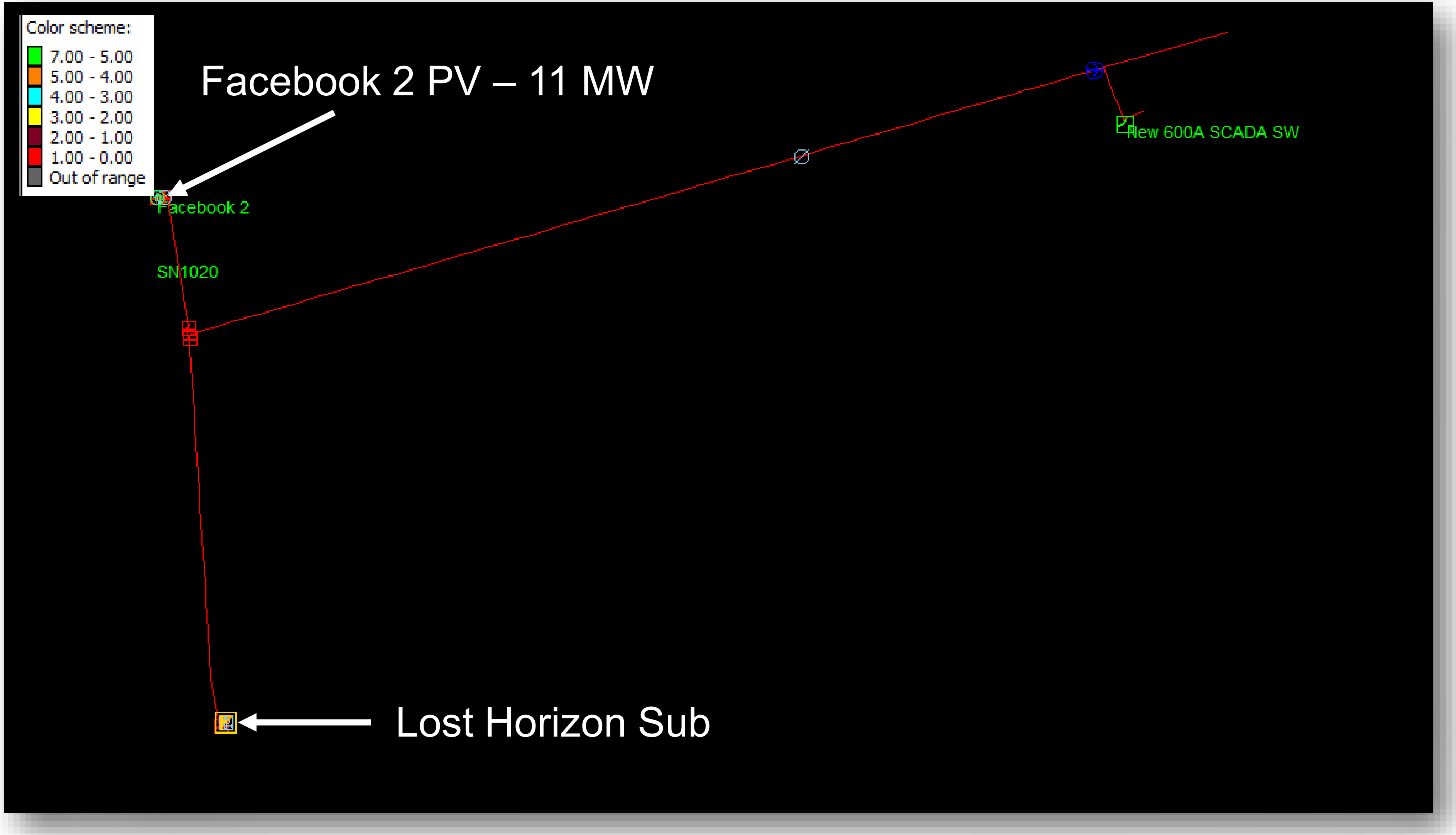
Lost Horizon 14

Lost Horizon 14 – Facebook 2 Solar



- **11 MW$_{ac}$** PV site
- Getaway Conductor **750 Cu(riser)**
- **5** miles long feeder
- Rated Feeder Capacity – **10.1 MW**
- Limiting Factor between PV site and Substation – **750 Cu UG** – Rated **10.1 MW (520 A)**

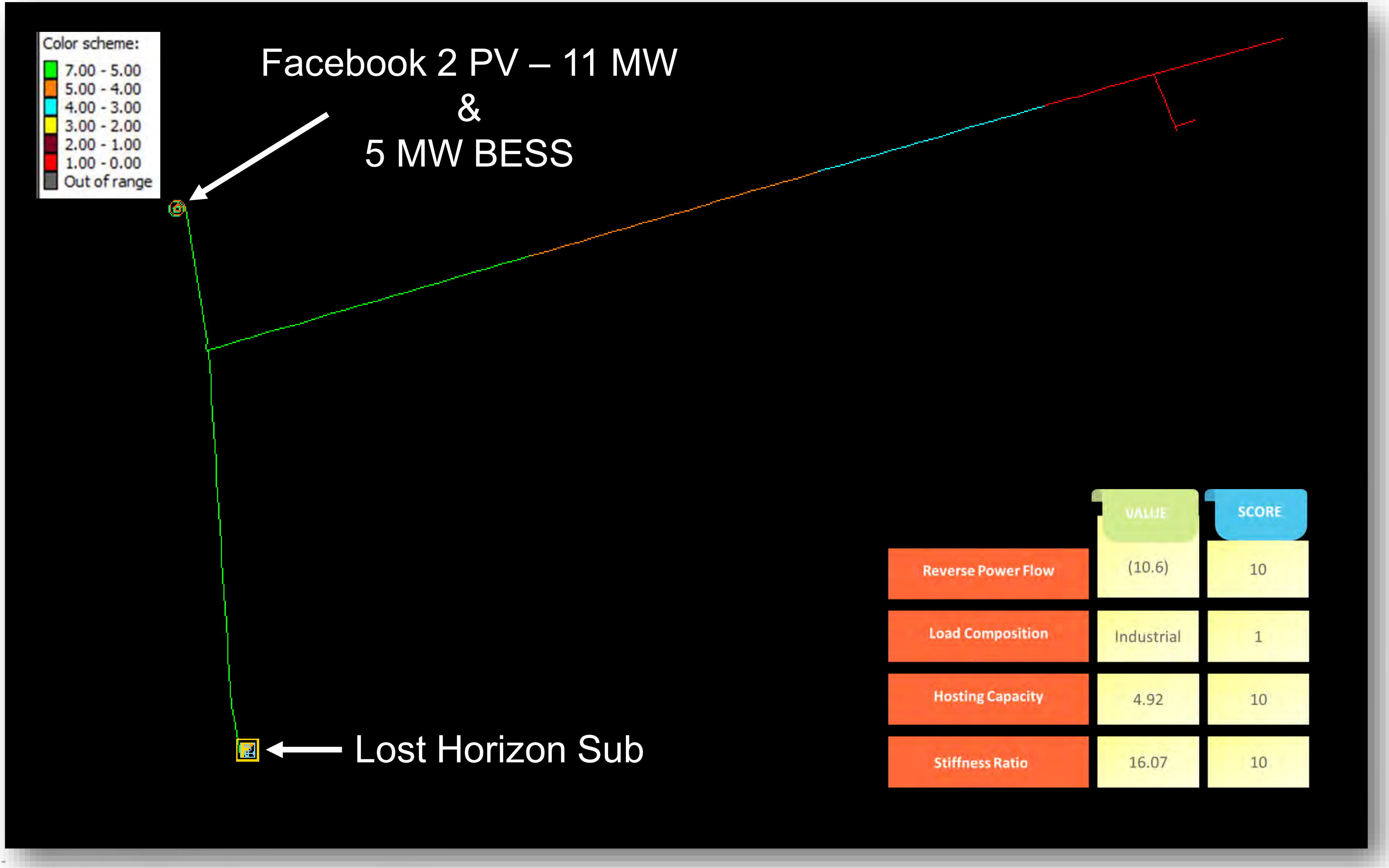
Lost Horizon 14 – Hosting Capacity



Facebook 2 PV – 11 MW

Lost Horizon Sub

Lost Horizon 14 – Hosting Capacity (w/ BESS)



Facebook 2 PV – 11 MW
&
5 MW BESS

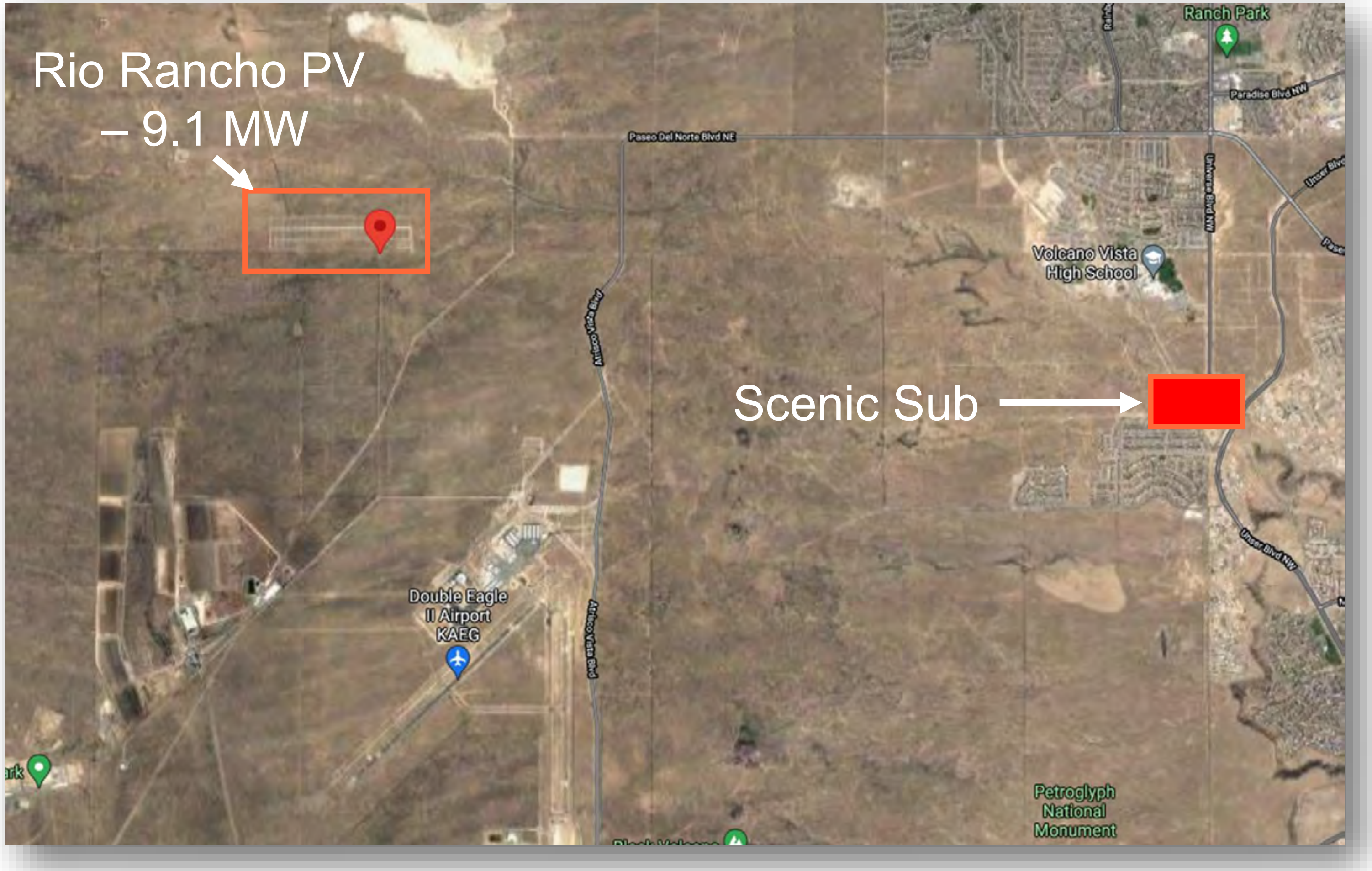
Lost Horizon Sub

	VALUE	SCORE
Reverse Power Flow	(10.6)	10
Load Composition	Industrial	1
Hosting Capacity	4.92	10
Stiffness Ratio	16.07	10

Rio Rancho Solar

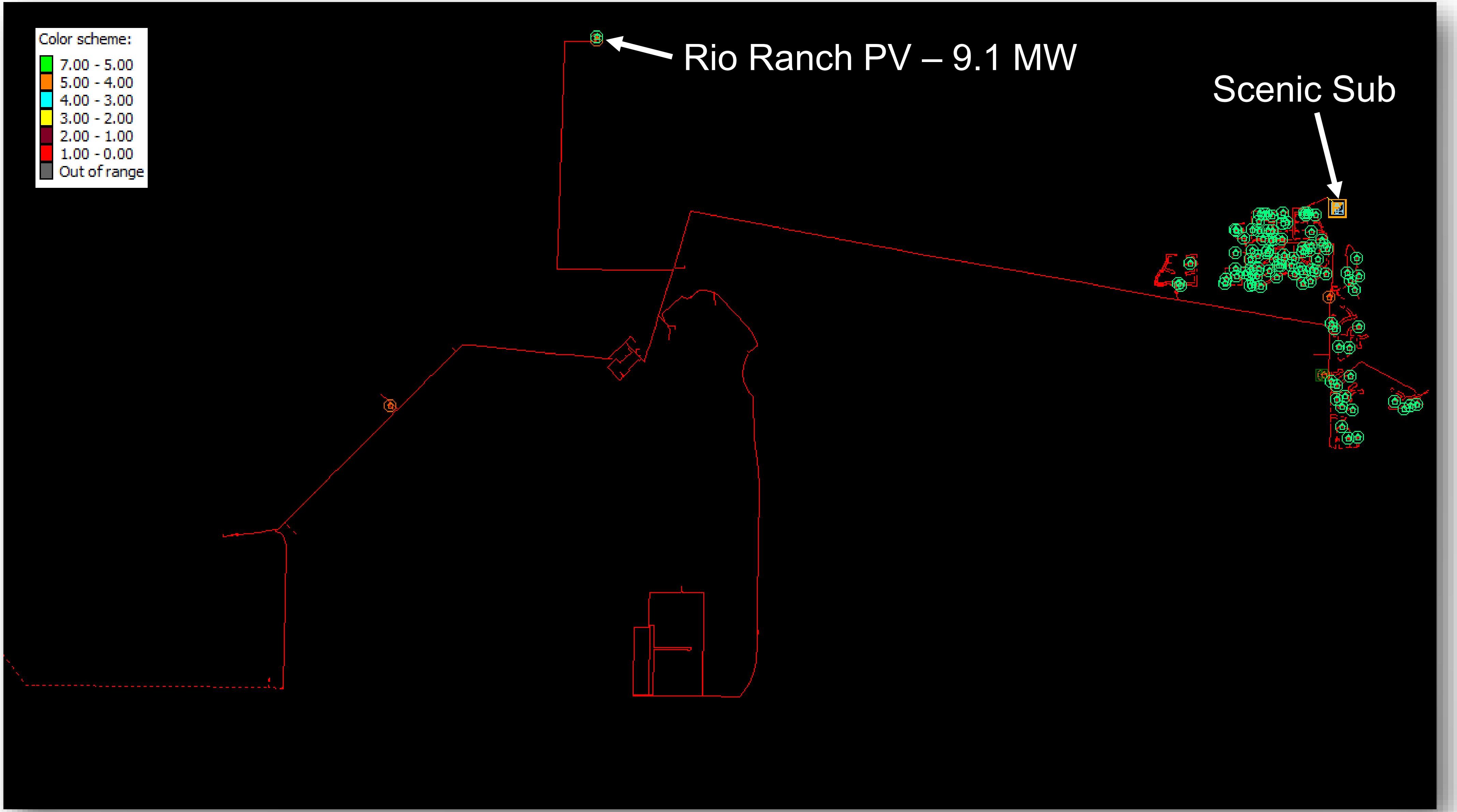
Scenic 12

Scenic 12 – Rio Rancho Solar



- **9.1 MW$_{ac}$** PV site
- Getaway Conductor **750 AL/db (460 A)**
- **45** miles long feeder
- Rated Feeder Capacity **– 8.9 MW**
- Limiting Factor between PV site and Substation **– 750 AL/db**– Rated **8.9 MW**

Scenic 12 – Hosting Capacity



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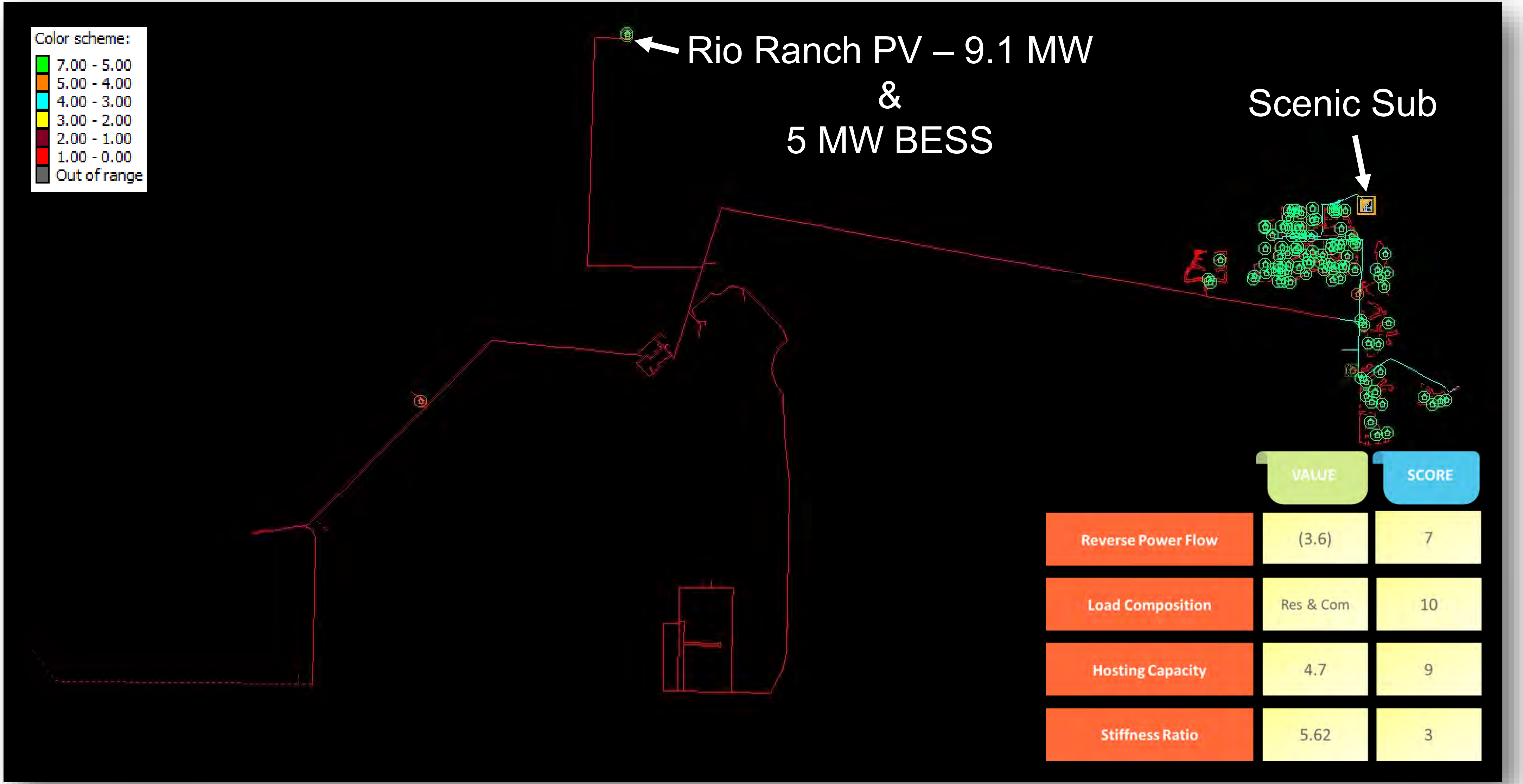
- ⬛ Out of range

Rio Ranch PV – 9.1 MW

Scenic Sub

Scenic 12 – Hosting Capacity (w/ BESS)

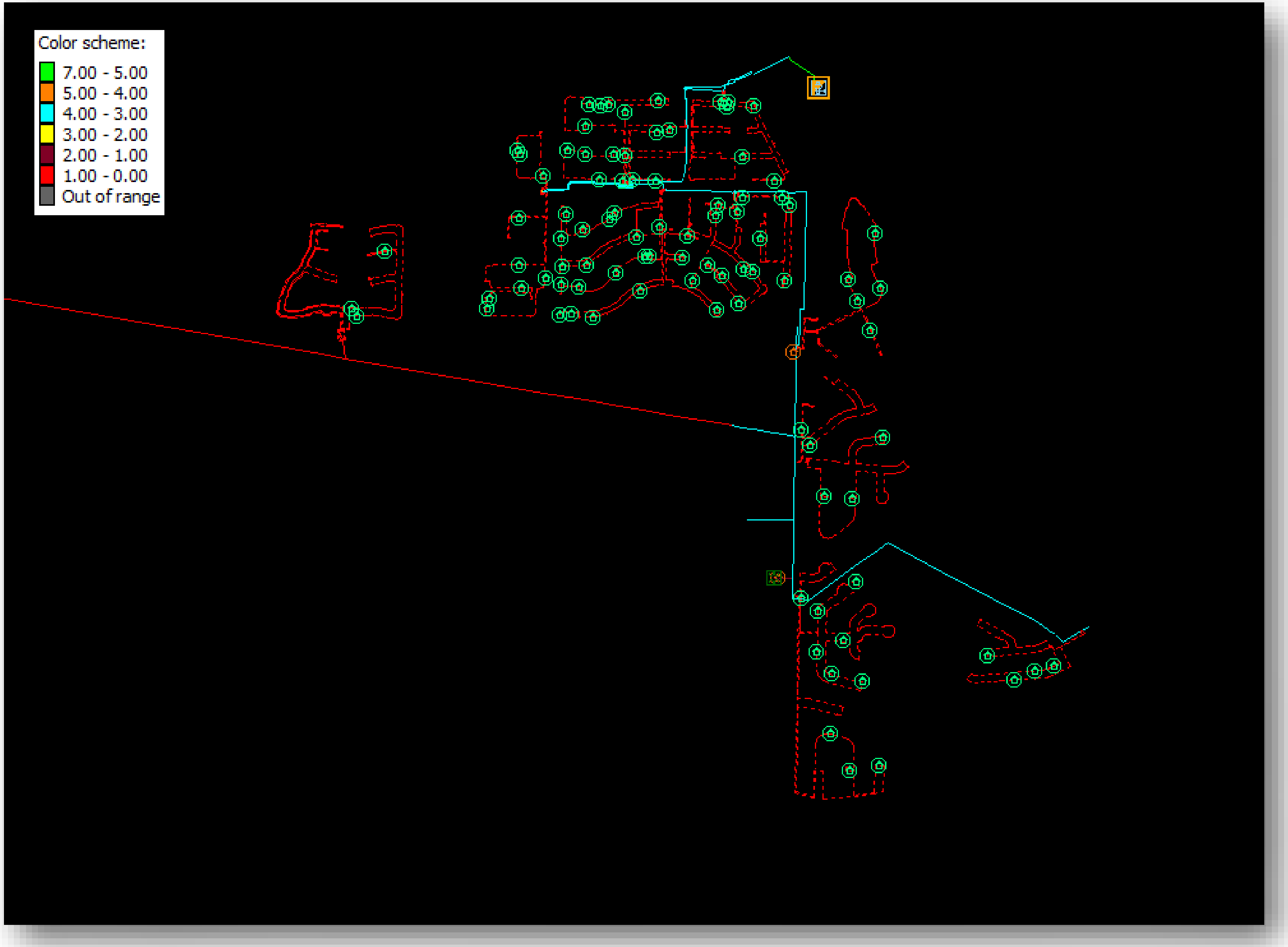


Rio Ranch PV – 9.1 MW
&
5 MW BESS

Scenic Sub

	VALUE	SCORE
Reverse Power Flow	(3.6)	7
Load Composition	Res & Com	10
Hosting Capacity	4.7	9
Stiffness Ratio	5.62	3

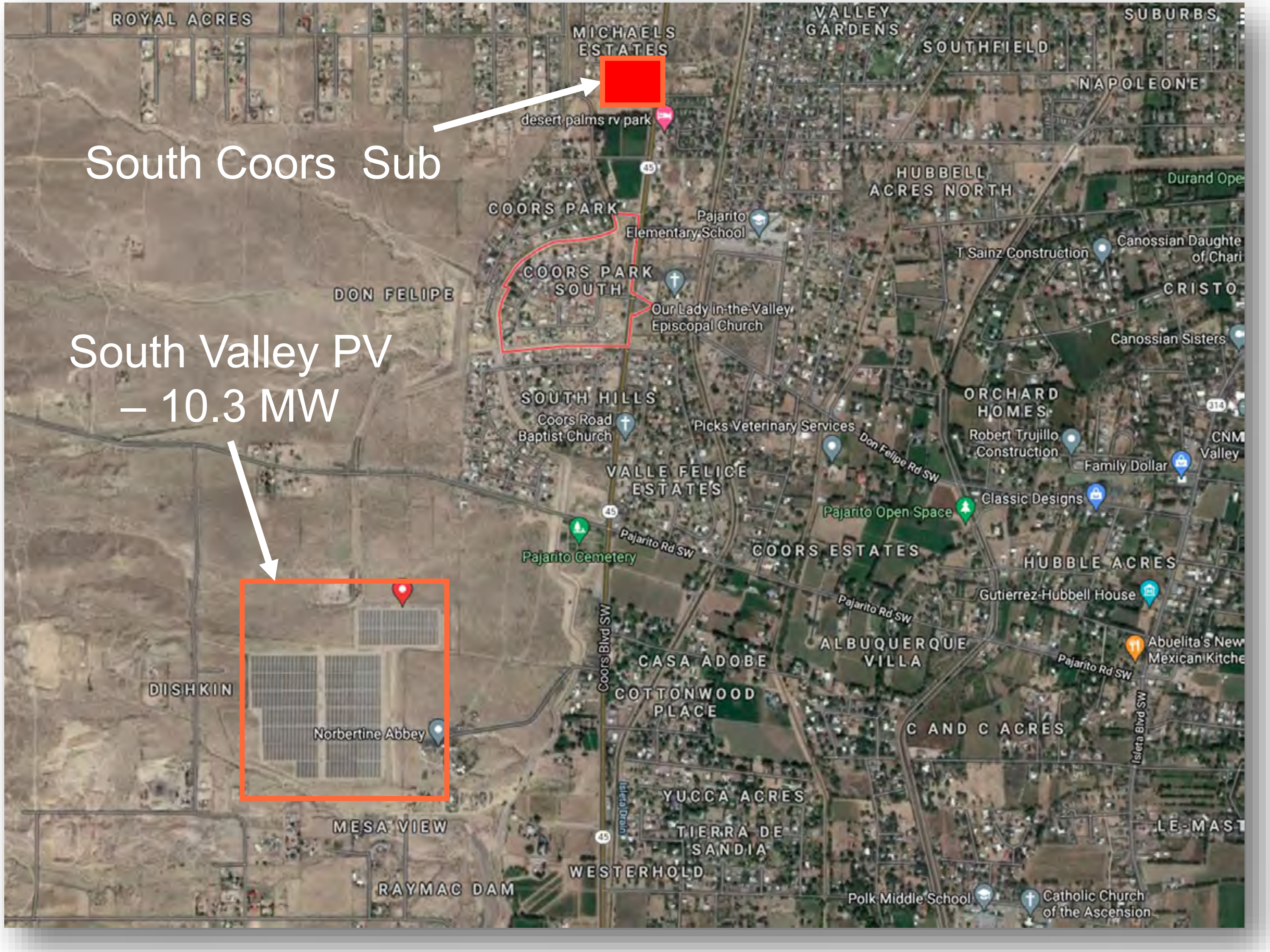
Scenic 12 – Hosting Capacity (w/ BESS)



South Valley Solar

South Coors 12

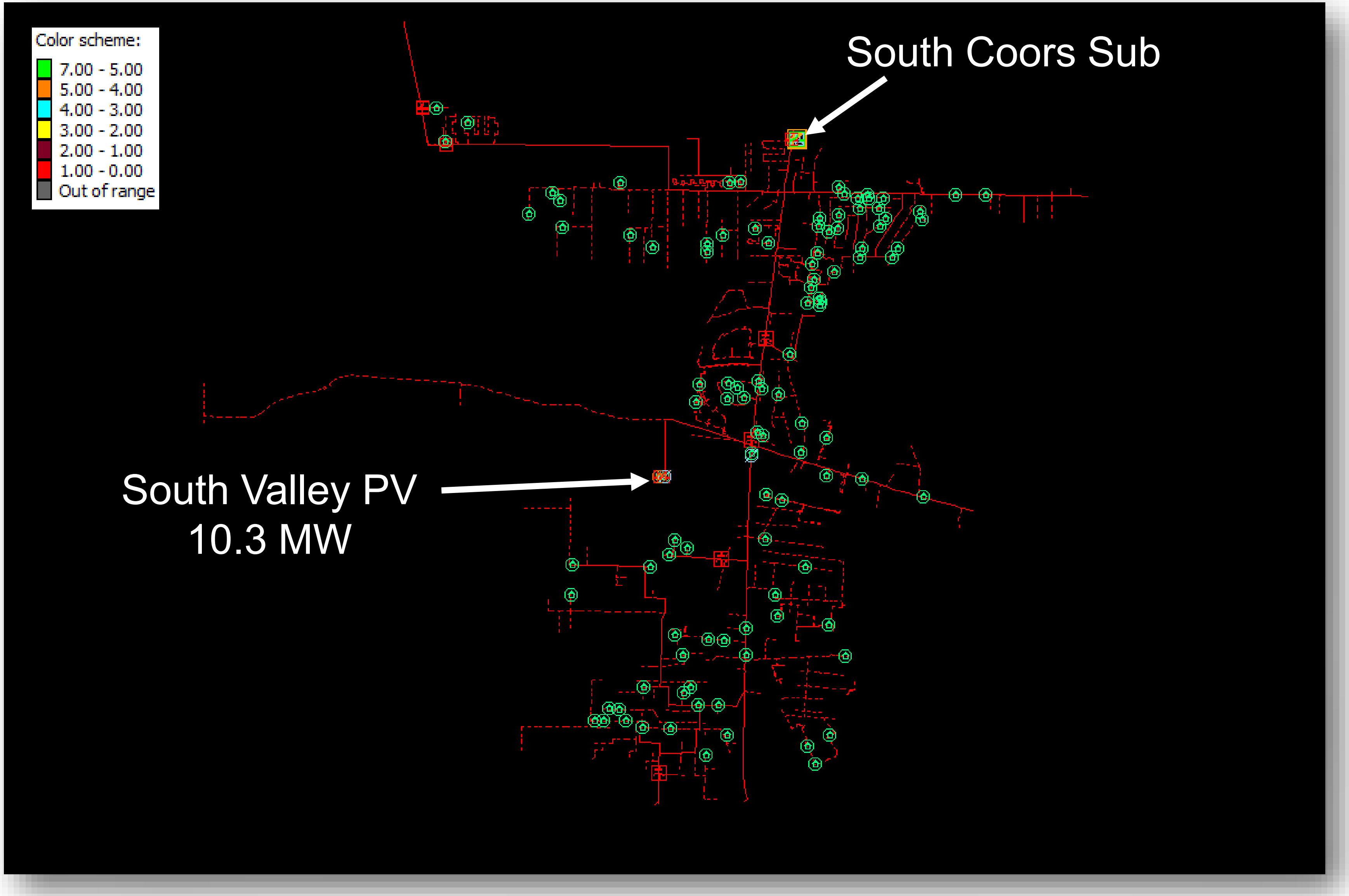
South Coors 12 – South Valley Solar


South Coors Sub

South Valley PV – 10.3 MW

- **10.3 MW$_{ac}$** PV site
- Getaway Conductor **750 AL(riser)(430 A)**
- **65** miles long feeder
- Rated Feeder Capacity – **8.3 MW**
- Limiting Factor between PV site and Substation – **750 AL(Riser).** Rated **8.3 MW**

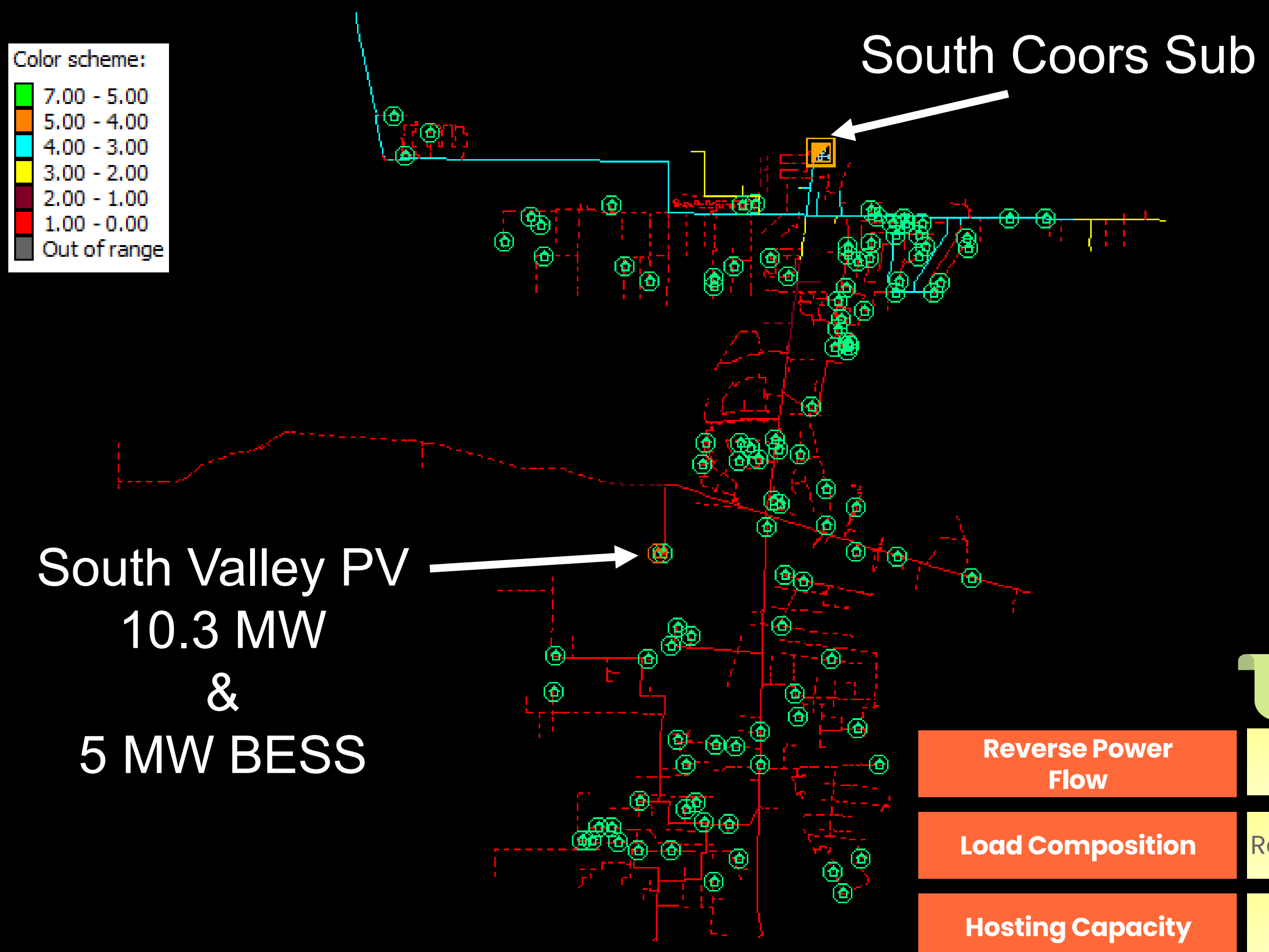
South Coors 12 – Hosting Capacity



South Coors Sub

South Valley PV
10.3 MW

South Coors 12 – Hosting Capacity (w/ BESS)



South Coors Sub

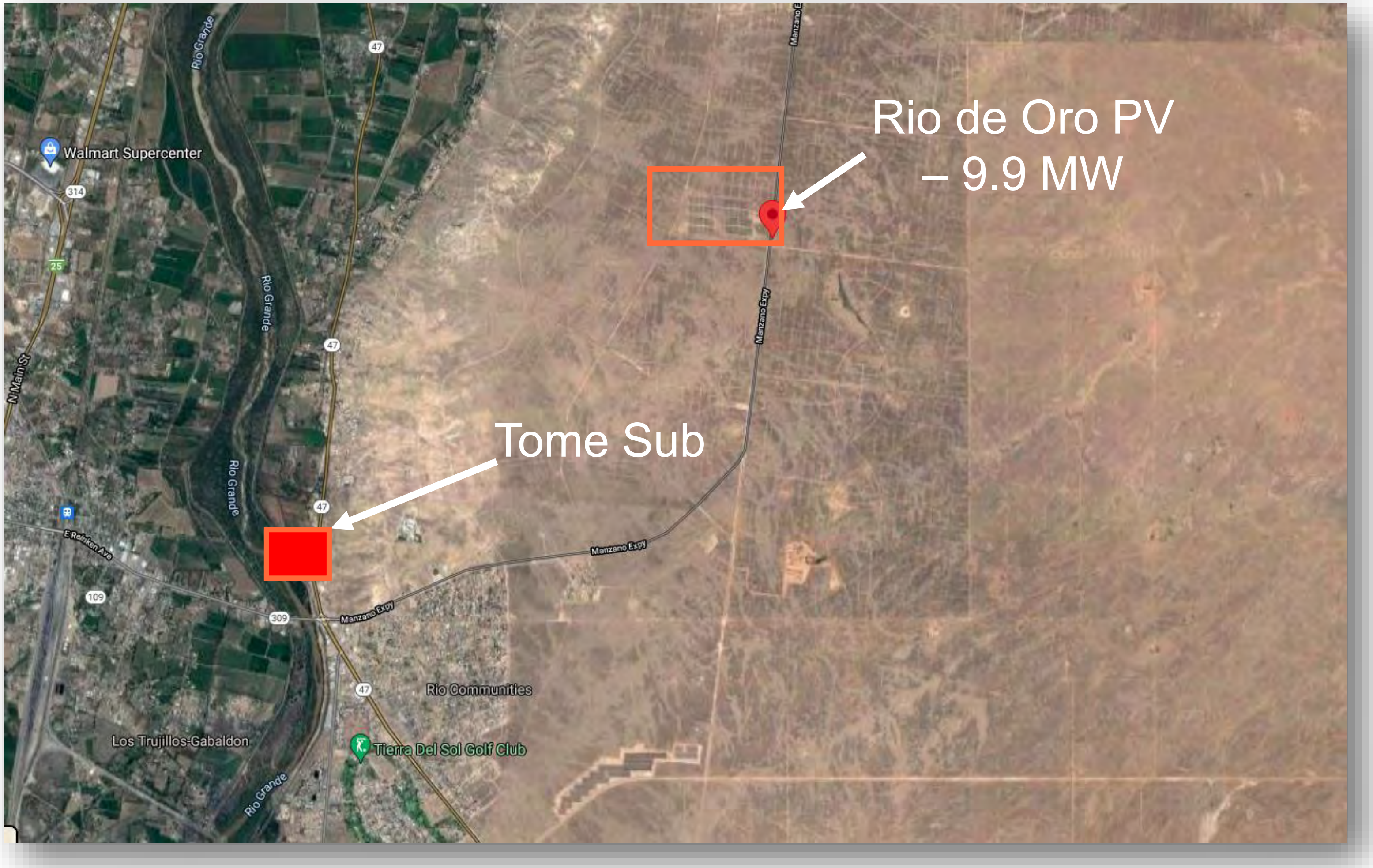
South Valley PV
10.3 MW
&
5 MW BESS

	VALUE	SCORE
Reverse Power Flow	(3.5)	7
Load Composition	Res & Com	10
Hosting Capacity	3.14	6
Stiffness Ratio	11.12	7

Rio de Oro Solar

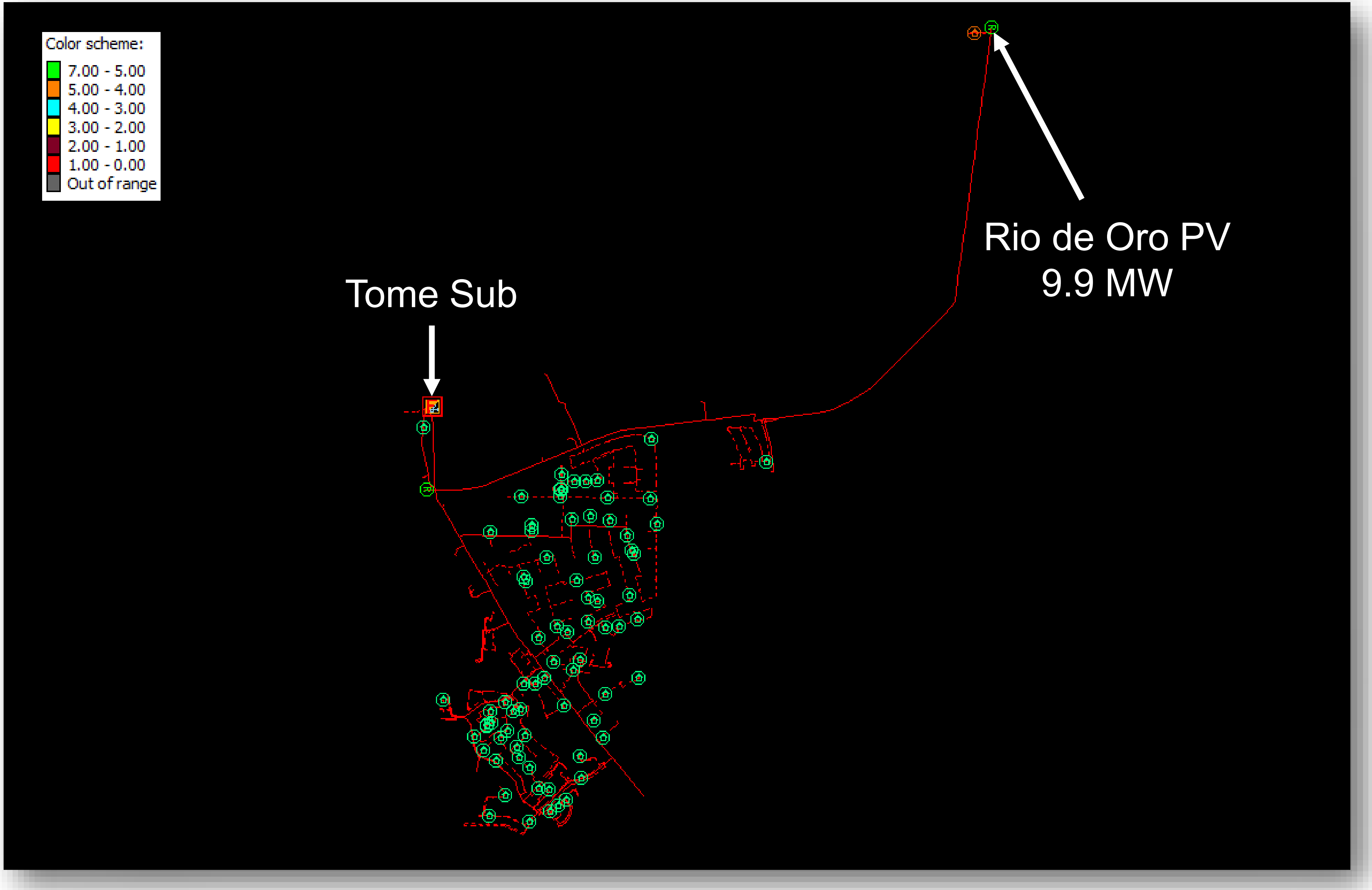
Tome 12

Tome 12 – Rio de Oro Solar

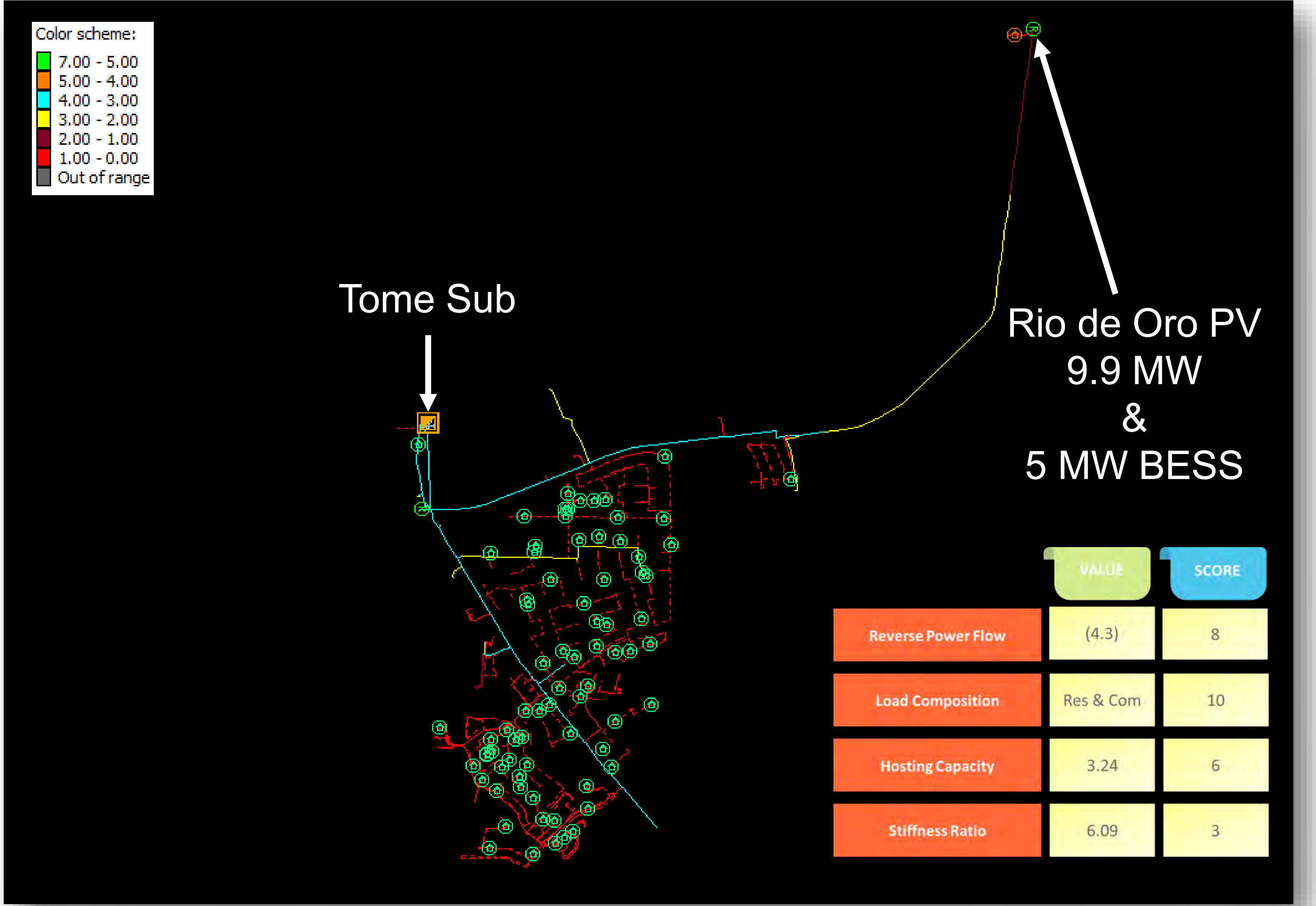


- **9.9 MW$_{ac}$** PV site
- Getaway Conductor **750 AL(riser)(430 A)**
- **45** miles long feeder
- Rated Feeder Capacity **– 8.3 MW**
- Limiting Factor between PV site and Substation **– 750 AL(Riser).** Rated **8.3 MW**

Tome 12 – Hosting Capacity



Tome 12 – Hosting Capacity (w/ BESS)



	VALUE	SCORE
Reverse Power Flow	(4.3)	8
Load Composition	Res & Com	10
Hosting Capacity	3.24	6
Stiffness Ratio	6.09	3

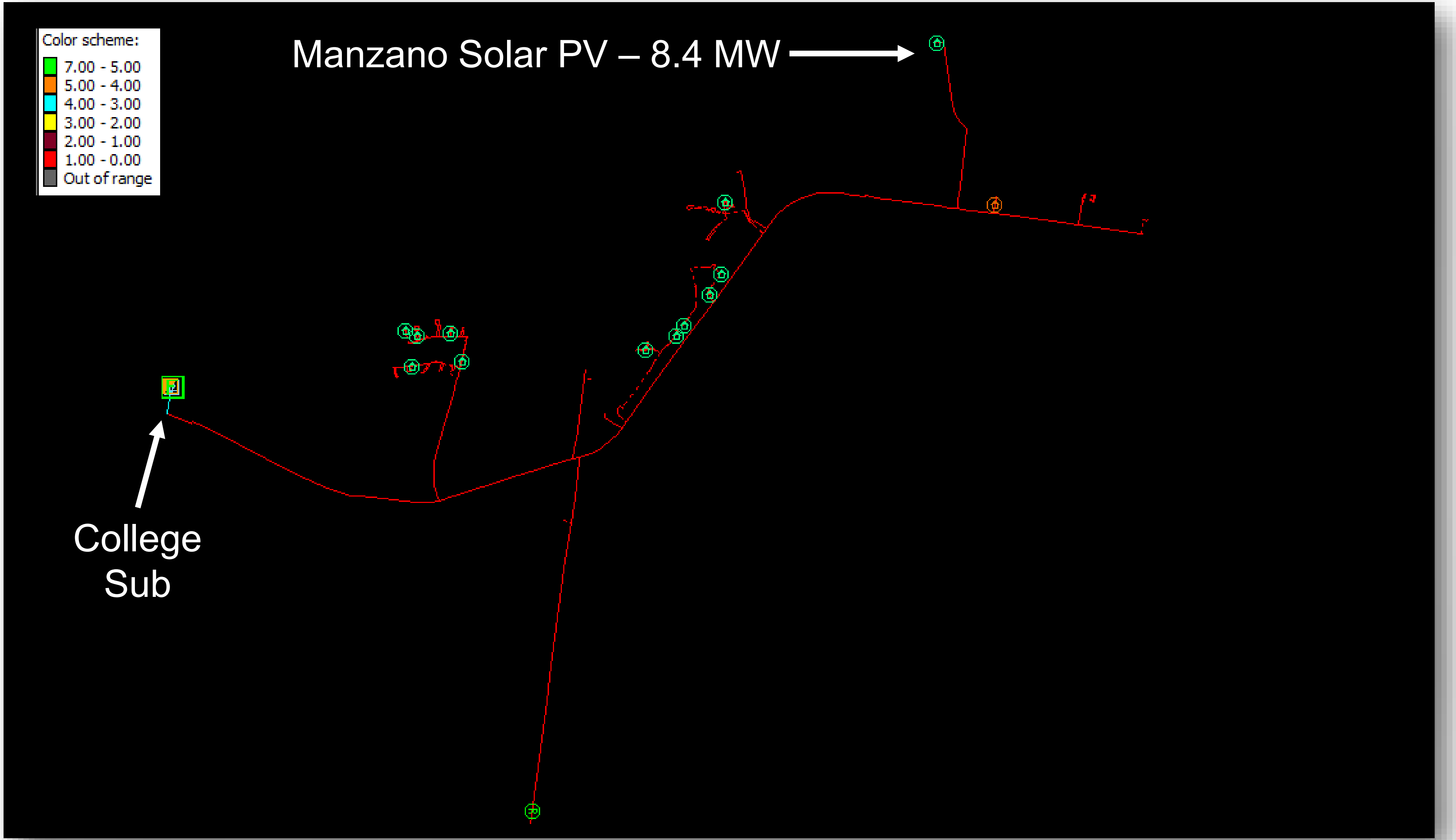
Manzano Solar

College12

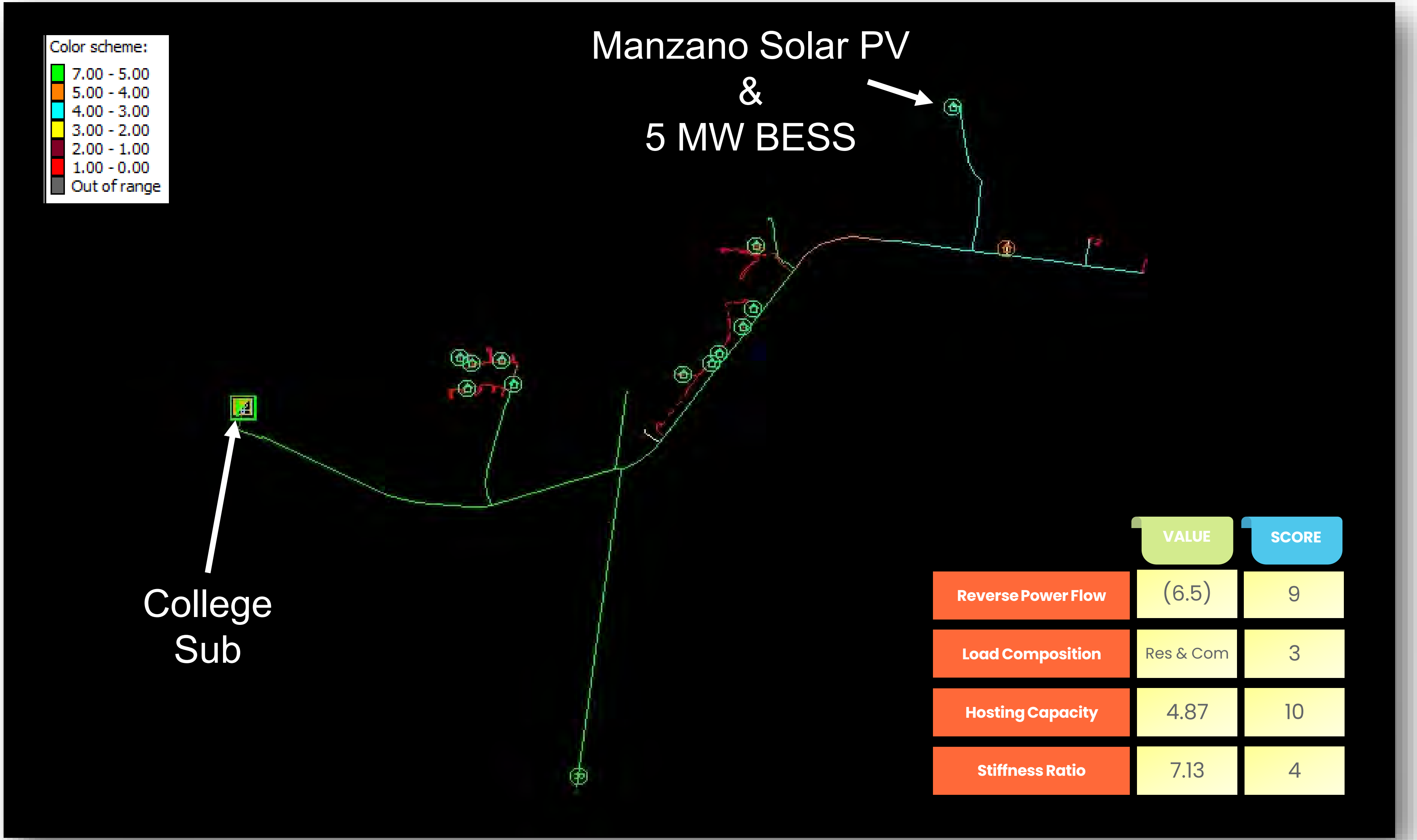
College 12– Manzano Solar

- **8.4 MW$_{ac}$** PV site
- Getaway Conductor **750Cu**(Conduit)
- **14** miles long Feeder
- Rated Feeder Capacity **10.1 MW**
- Limiting Factor between PV site and Substation – **750 Cu UG**(10.1 MW)

College 12 – Hosting Capacity



College 12 – Hosting Capacity (w/ BESS)



	VALUE	SCORE
Reverse Power Flow	(6.5)	9
Load Composition	Res & Com	3
Hosting Capacity	4.87	10
Stiffness Ratio	7.13	4

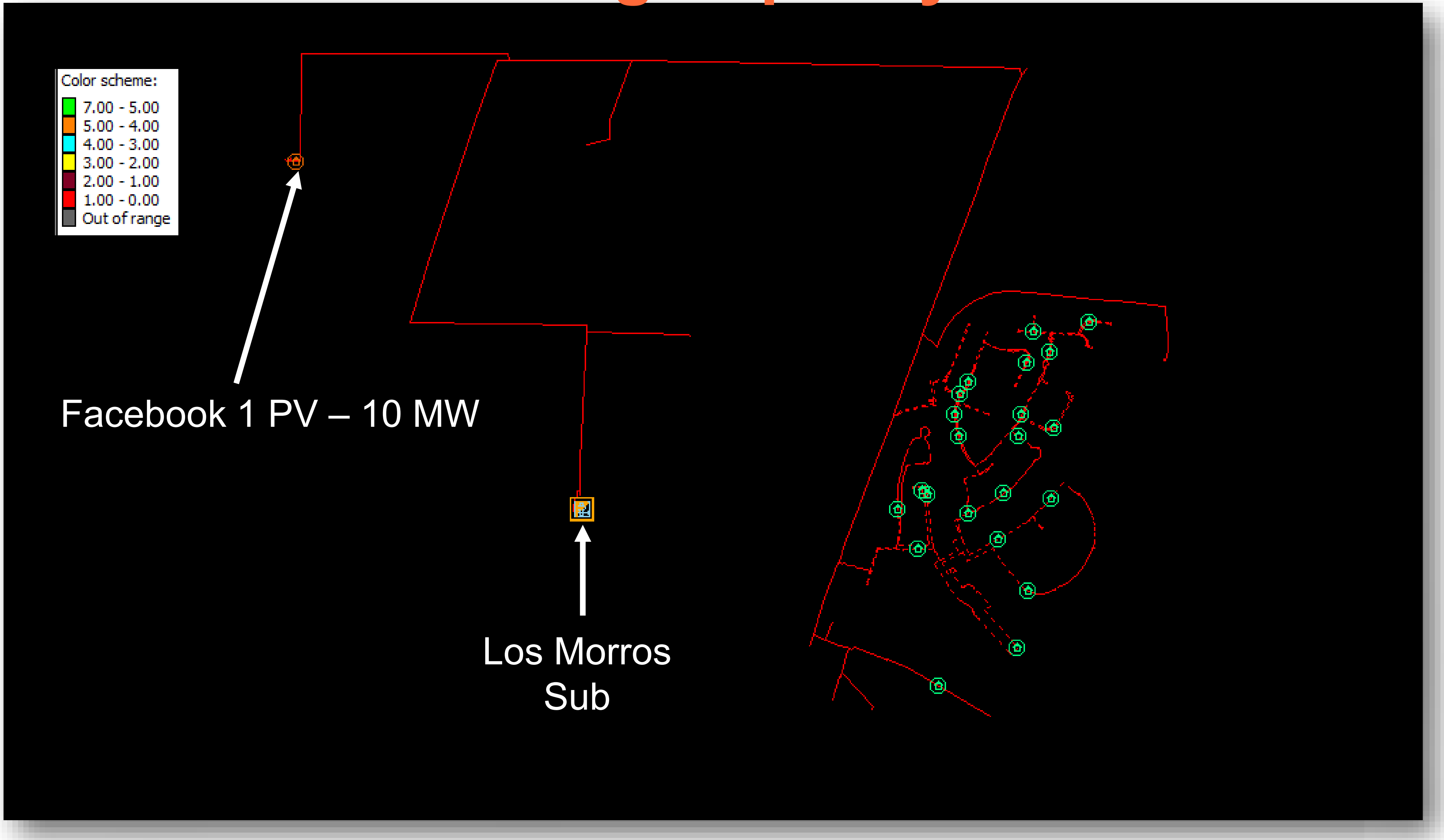
Facebook 1 Solar

Los Morros 12

Los Morros 12 – Facebook 1 Solar

- **10.0 MW$_{ac}$** PV site
- Getaway Conductor **750Cu**(riser)
- **12** miles long Feeder
- Rated Feeder Capacity **8.3 MW**
- Limiting Factor between PV site and Substation – **397AAC** (8.3 MW)

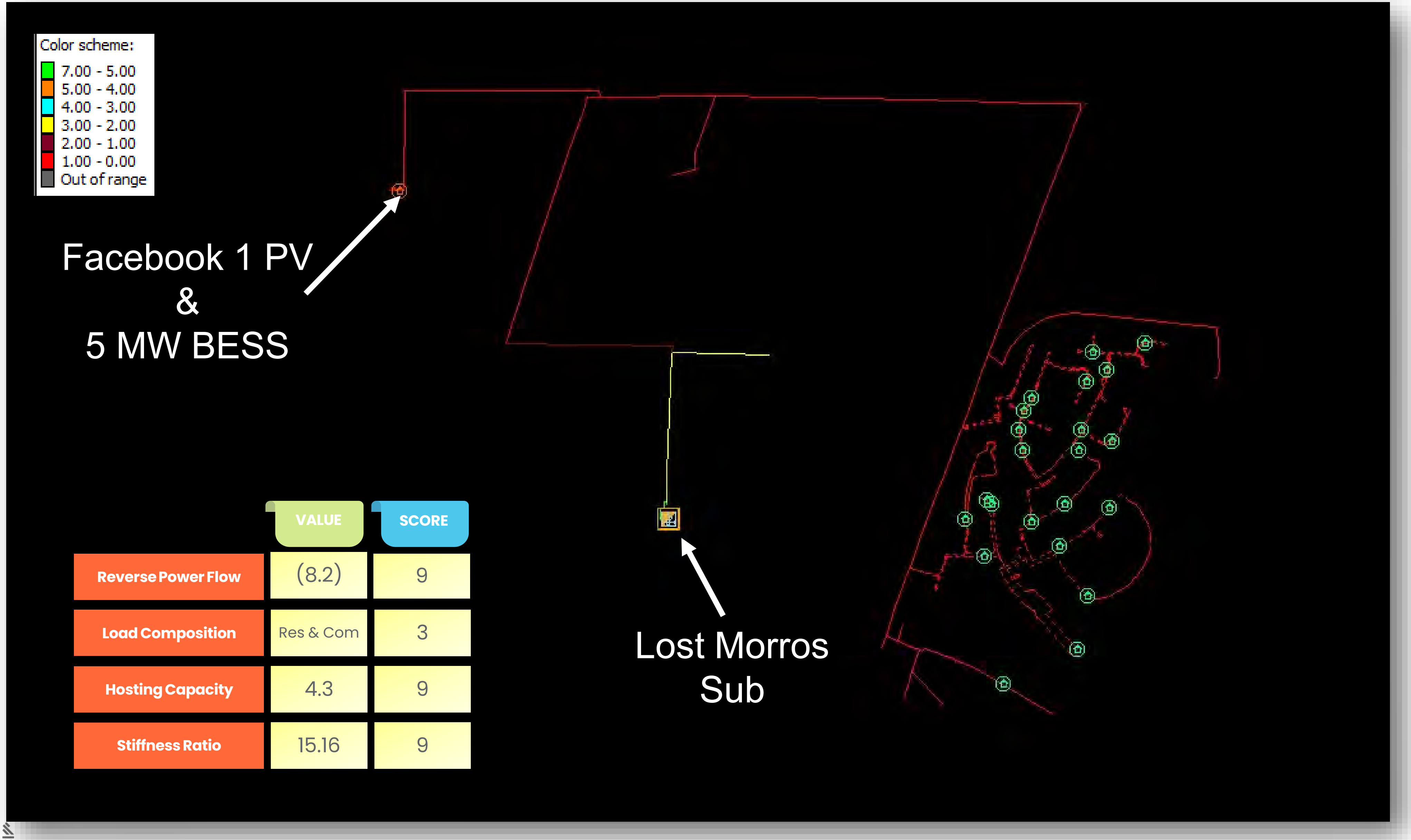
Los Morros 12 – Hosting Capacity



Facebook 1 PV – 10 MW

Los Morros Sub

Los Morros 12 – Hosting Capacity (w/ BESS)



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- 🟥 1.00 - 0.00
- ▨ Out of range

Facebook 1 PV
&
5 MW BESS

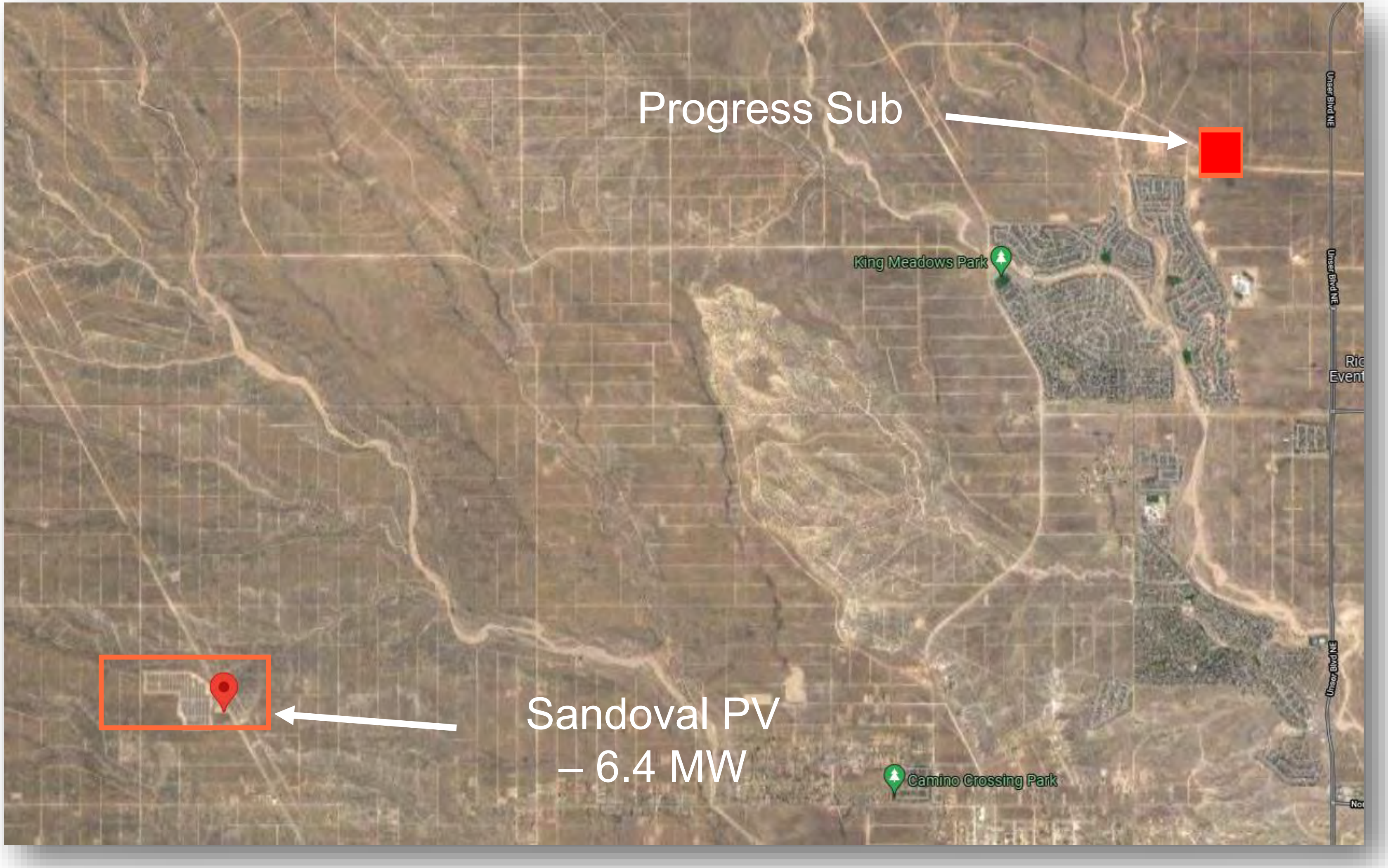
Lost Morros
Sub

	VALUE	SCORE
Reverse Power Flow	(8.2)	9
Load Composition	Res & Com	3
Hosting Capacity	4.3	9
Stiffness Ratio	15.16	9

Sandoval Solar

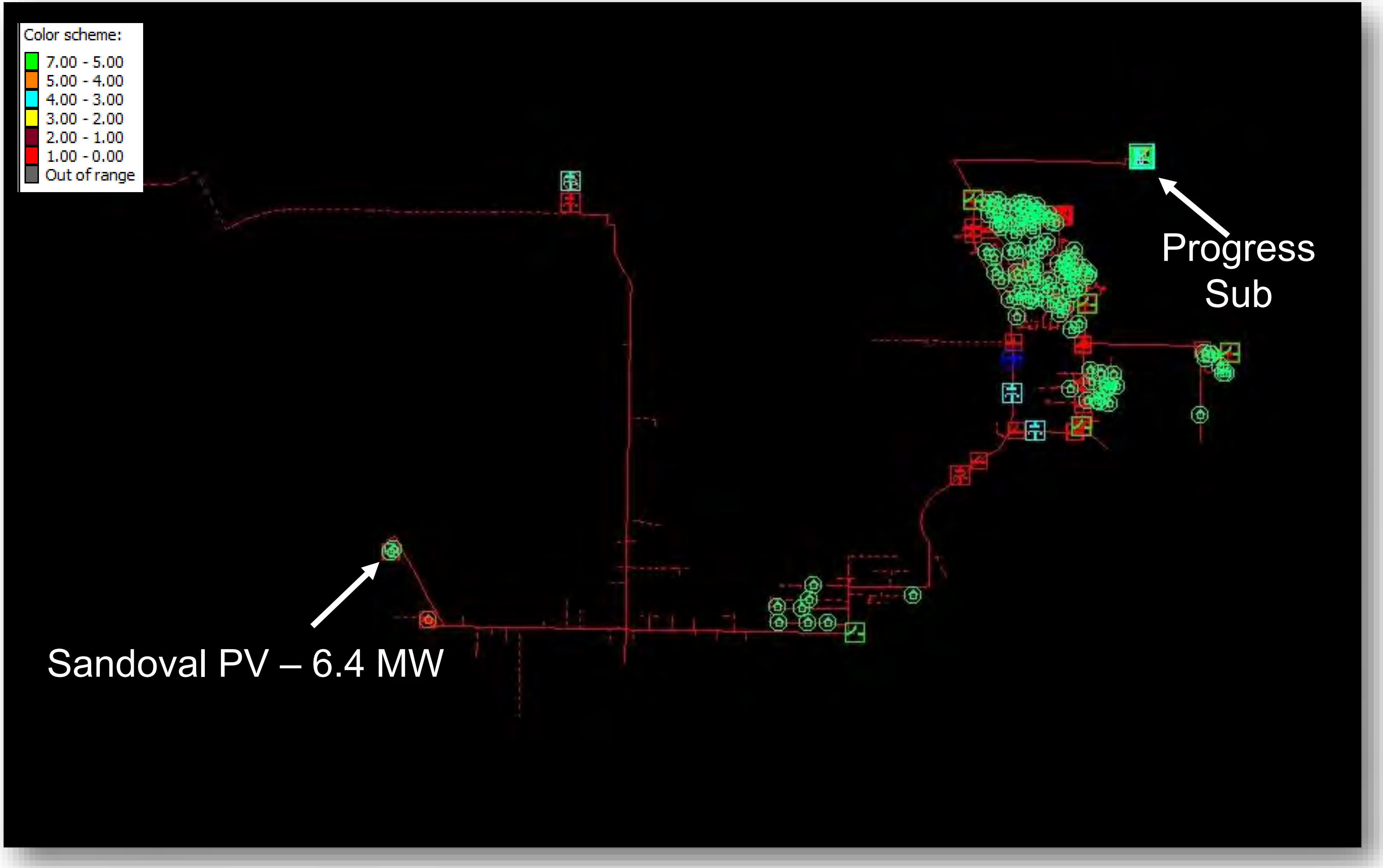
Progress 13

Progress 13 – Sandoval Solar



- **6.4 MW$_{ac}$** PV site
- Getaway Conductor **750Cu**(Db/Ckt)
- **63** miles long Feeder
- Rated Feeder Capacity **8.9 MW**
- Limiting Factor between PV site and Substation – **750AL/db** (8.9 MW)

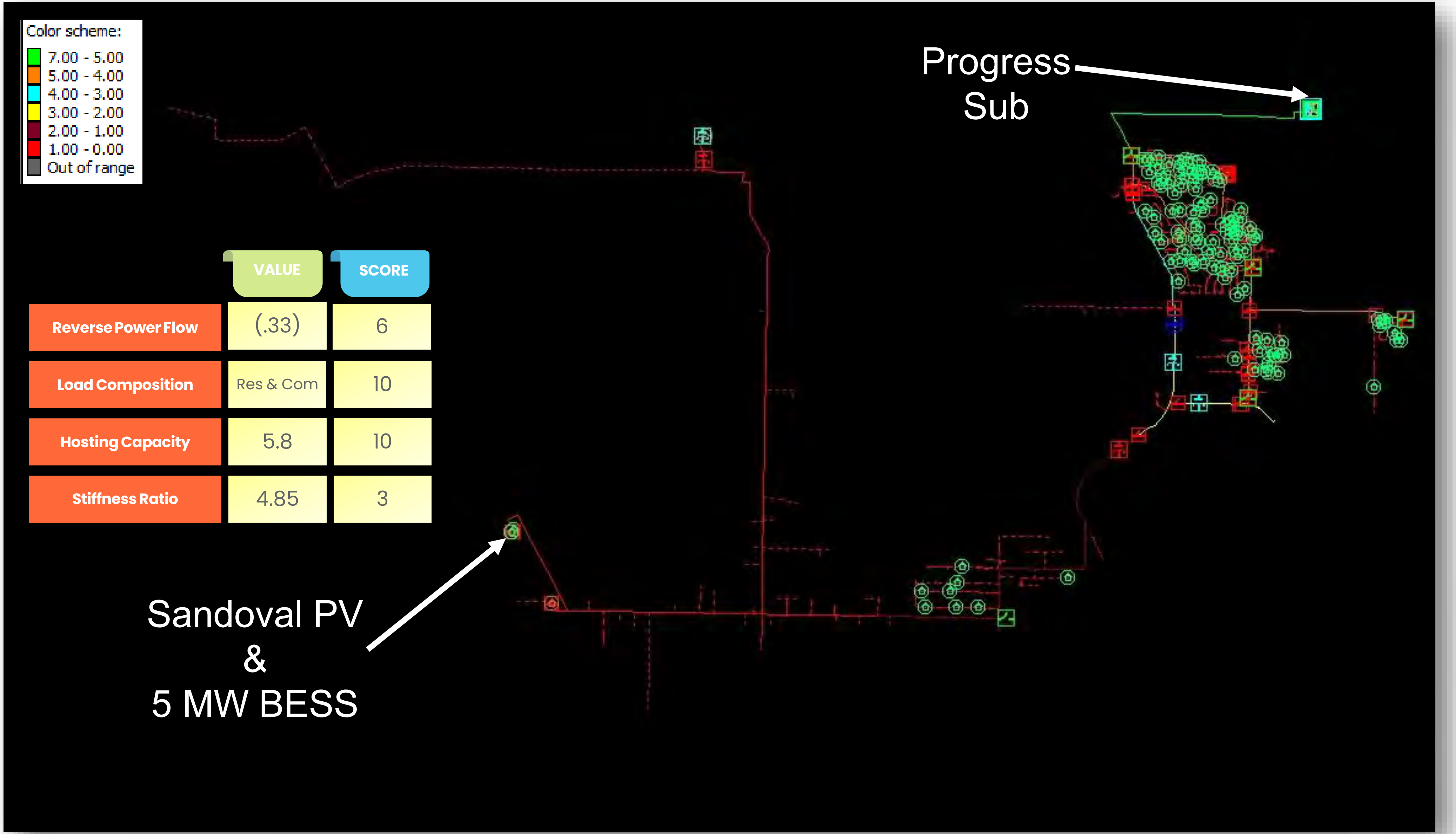
Progress 13 – Hosting Capacity



Progress Sub

Sandoval PV – 6.4 MW

Progress 13 – Hosting Capacity (w/ BESS)



	VALUE	SCORE
Reverse Power Flow	(.33)	6
Load Composition	Res & Com	10
Hosting Capacity	5.8	10
Stiffness Ratio	4.85	3

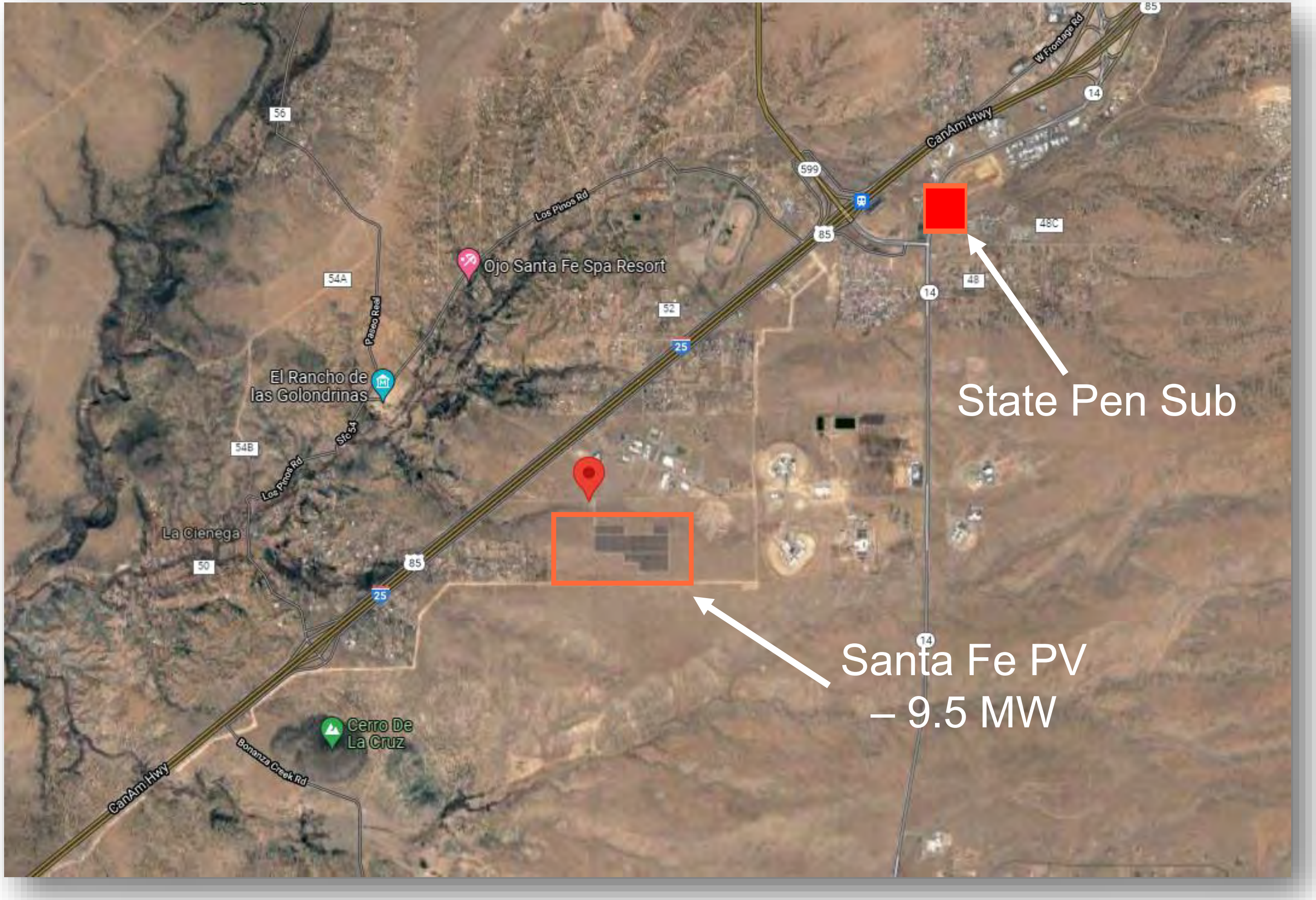
Progress Sub

Sandoval PV
&
5 MW BESS

Santa Fe Solar

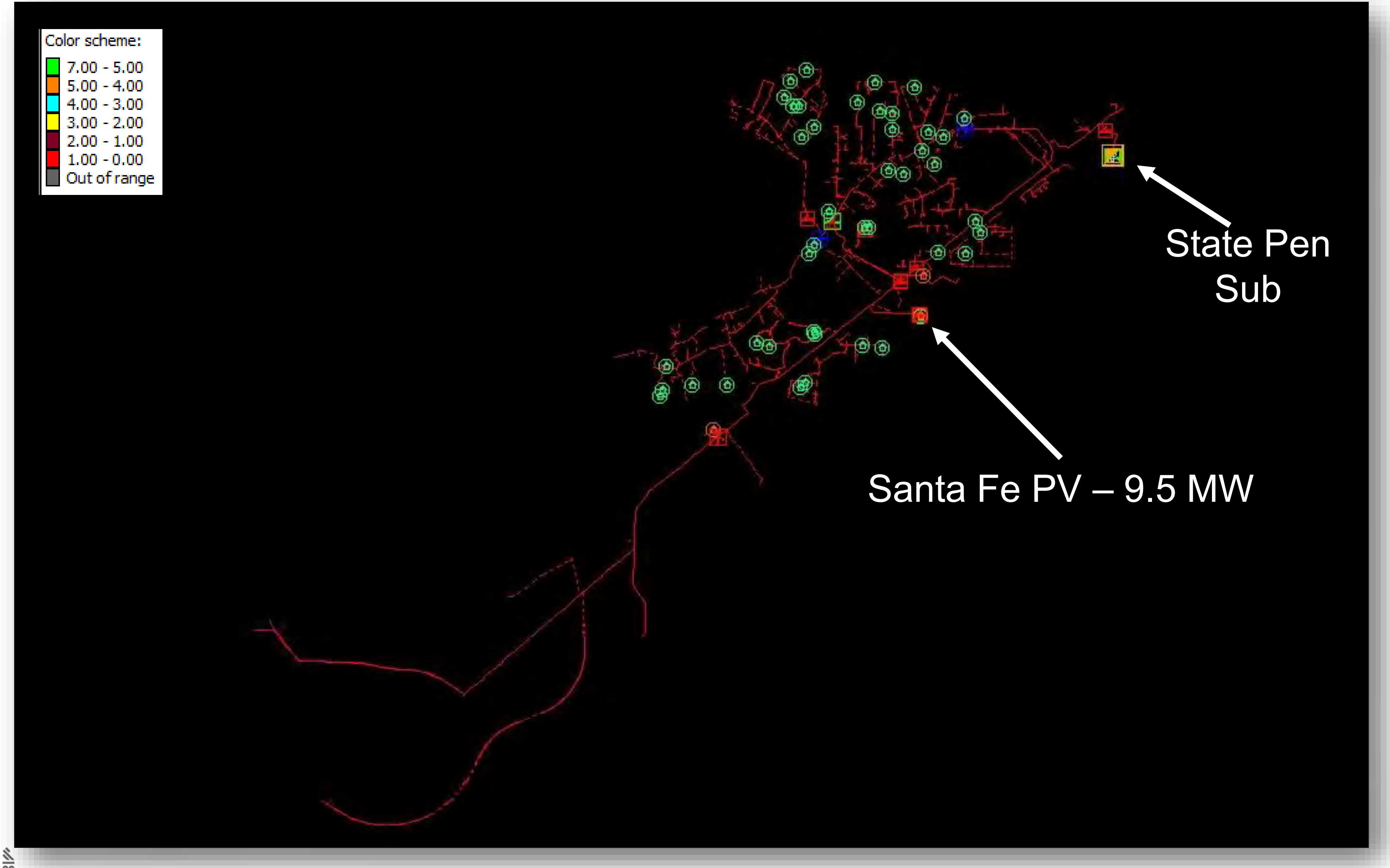
State Pen 12

State Pen – Santa Fe Solar



- **9.5 MW$_{ac}$** PV site
- Getaway Conductor **750AL**(Double Circuit)
- **98** miles long Feeder
- Rated Feeder Capacity **7.3 MW**
- Limiting Factor between PV site and Substation – **750AL**(Double Circuit**)**(7.3 MW)

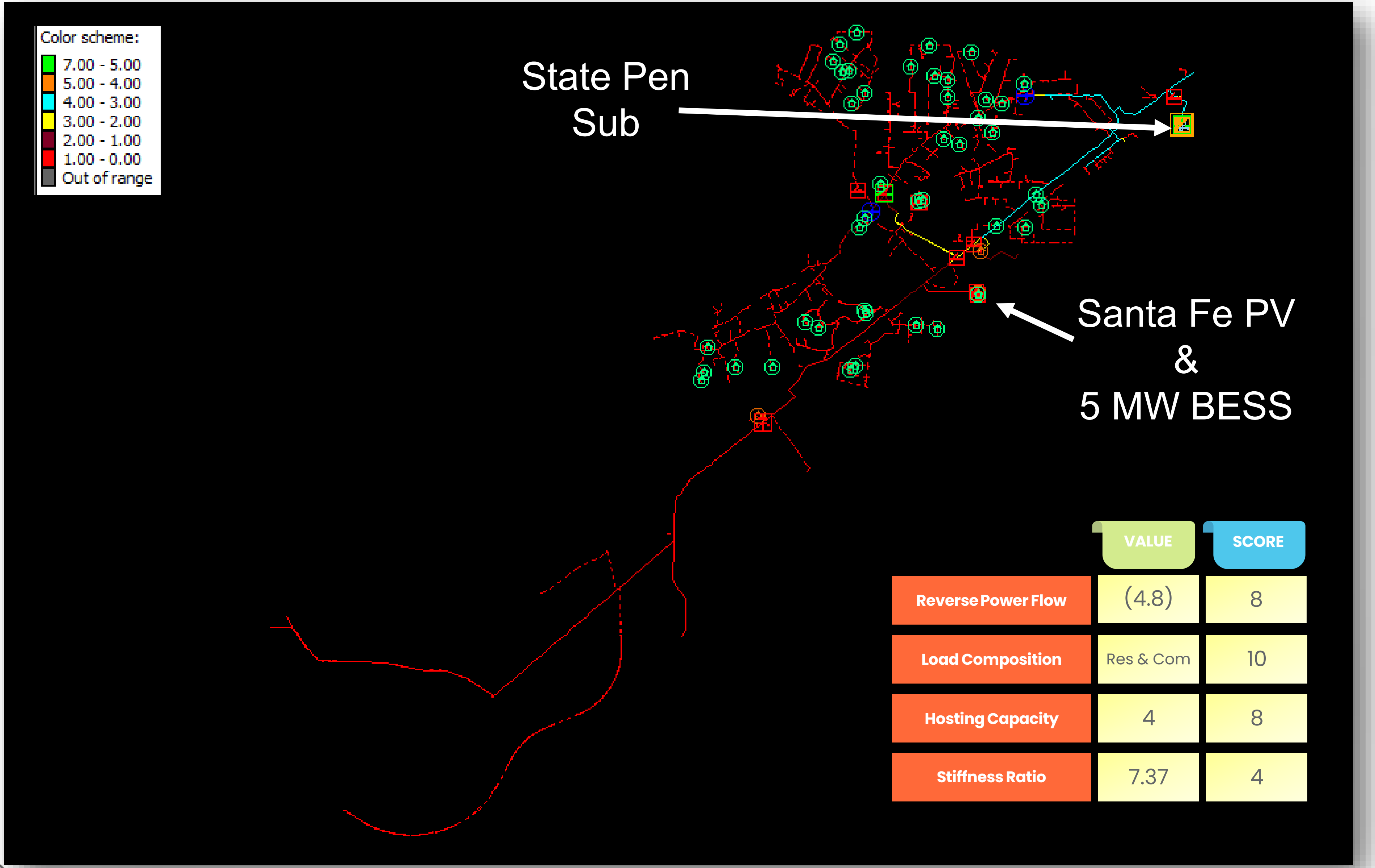
State Pen 12 – Hosting Capacity



State Pen Sub

Santa Fe PV – 9.5 MW

State Pen 12 – Hosting Capacity (w/ BESS)



State Pen
Sub

Santa Fe PV
&
5 MW BESS

	VALUE	SCORE
Reverse Power Flow	(4.8)	8
Load Composition	Res & Com	10
Hosting Capacity	4	8
Stiffness Ratio	7.37	4

AGENDA

- 01 PV Sites Overview
- 02 Initial Model Observations
- 03 Prioritization Analysis
- 04 Summary

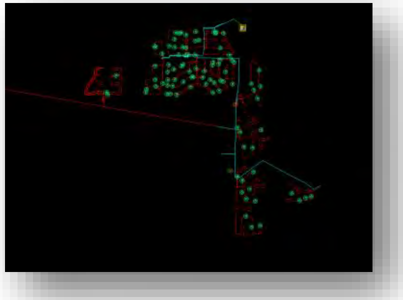
Scoring Matrix

	Reverse Power Flow 10%	Load Composition 30%	Hosting Capacity 30%	Stiffness Ratio 30%	Weighted Overall 100%
South Valley Solar South Coors 12	7	10	6	7	30.4
Sandoval Solar Progress 13	6	10	10	3	30.0
Santa Fe Solar State Pen 12	8	10	8	4	29.6
Facebook 2 Solar Lost horizon 14	10	1	10	10	29.2
Rio Rancho Solar Scenic 12	7	10	9	3	29.2
Facebook 1 Solar Los Morros 12	9	3	9	9	28.8
Facebook 3 Solar Lost horizon 12	8	2	10	9	28.4
Rio De Oro Solar Tome 12	8	10	6	3	26.0
Santolina Solar Lost horizon 13	10	1	9	8	25.6
Manzano Solar College12	9	3	10	4	24.0

Conclusion

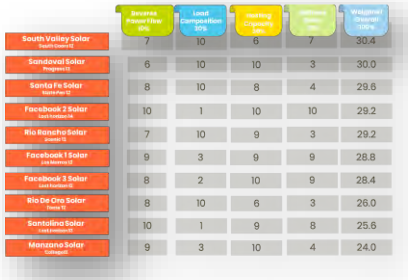
Question: Does adding a BESS improve Hosting Capacity?

1898 & Co. simulated Hosting Capacity analysis and the results showed DER enablement for all Ten (10) solar sites tested.



Question: Which site(s) would a BESS be most beneficial?

The initial prioritization analysis showed the South Valley Solar and Sandoval Solar sites received the highest scores out of the ten (10) sites tested based on the factors of reverse power flow, load composition, hosting capacity, and stiffness ratio.



	Reverse Power Flow 10%	Load Composition 30%	Hosting Capacity	[illegible]	Weighted Overall 100%
South Valley Solar	7	10	6	7	30.4
Sandoval Solar	6	10	10	3	30.0
Santa Fe Solar	8	10	8	4	29.6
Facebook 2 Solar	10	1	10	10	29.2
Rio Rancho Solar	7	10	9	3	29.2
Facebook 1 Solar	9	3	9	9	28.8
Facebook 3 Solar	8	2	10	9	28.4
Rio De Oro Solar	8	10	6	3	26.0
Santolina Solar	10	1	9	8	25.6
Manzano Solar	9	3	10	4	24.0

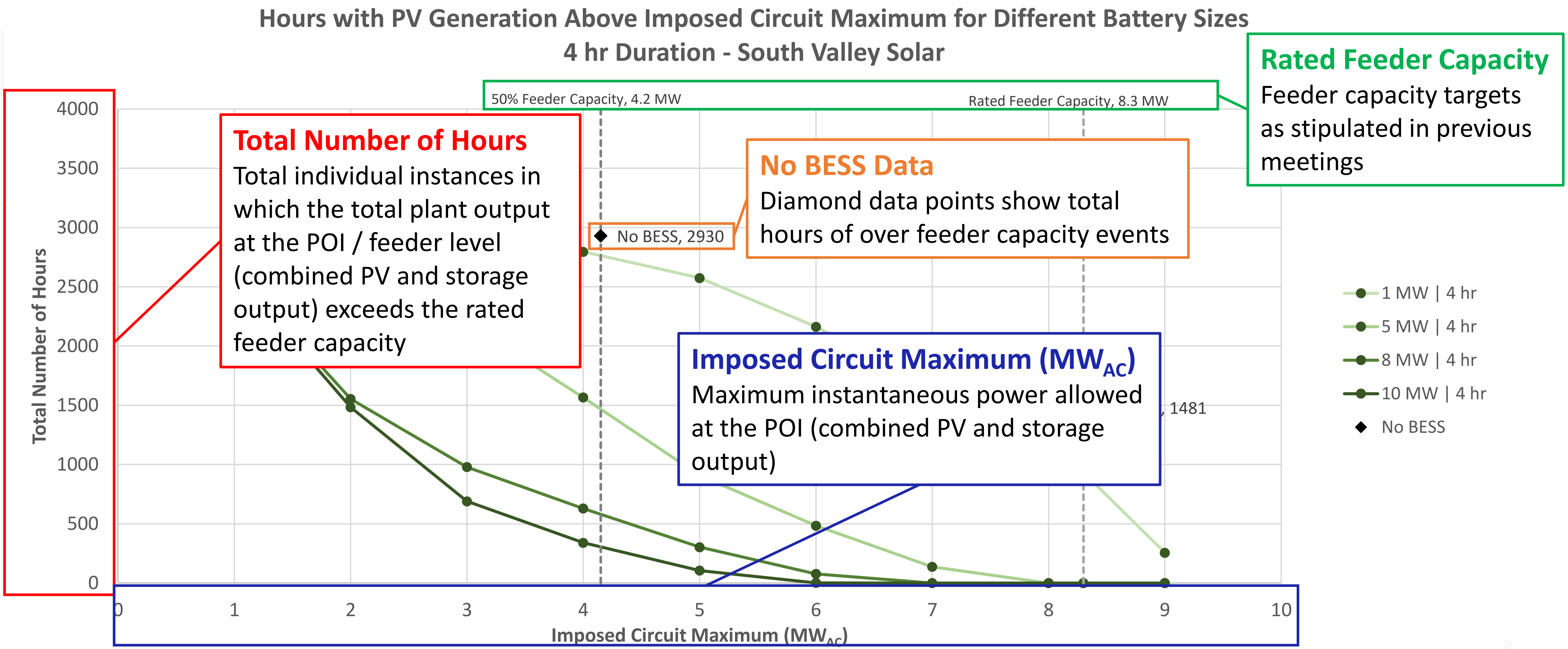
Prioritization Analysis Limitations

Analysis included locating a single 5 MW BESS at each of the ten (10) solar sites. The prioritization analysis did not consider multiple distributed BESS locations per circuit, potential reliability benefits, nor deferred distribution investments.

Appendix B – **HOSTING CAPACITY PRESENTATION**

Hosting Capacity – System Sizing

South Valley Solar



Total Number of Hours
Total individual instances in which the total plant output at the POI / feeder level (combined PV and storage output) exceeds the rated feeder capacity

No BESS Data
Diamond data points show total hours of over feeder capacity events

Rated Feeder Capacity
Feeder capacity targets as stipulated in previous meetings

Imposed Circuit Maximum (MW_{AC})
Maximum instantaneous power allowed at the POI (combined PV and storage output)

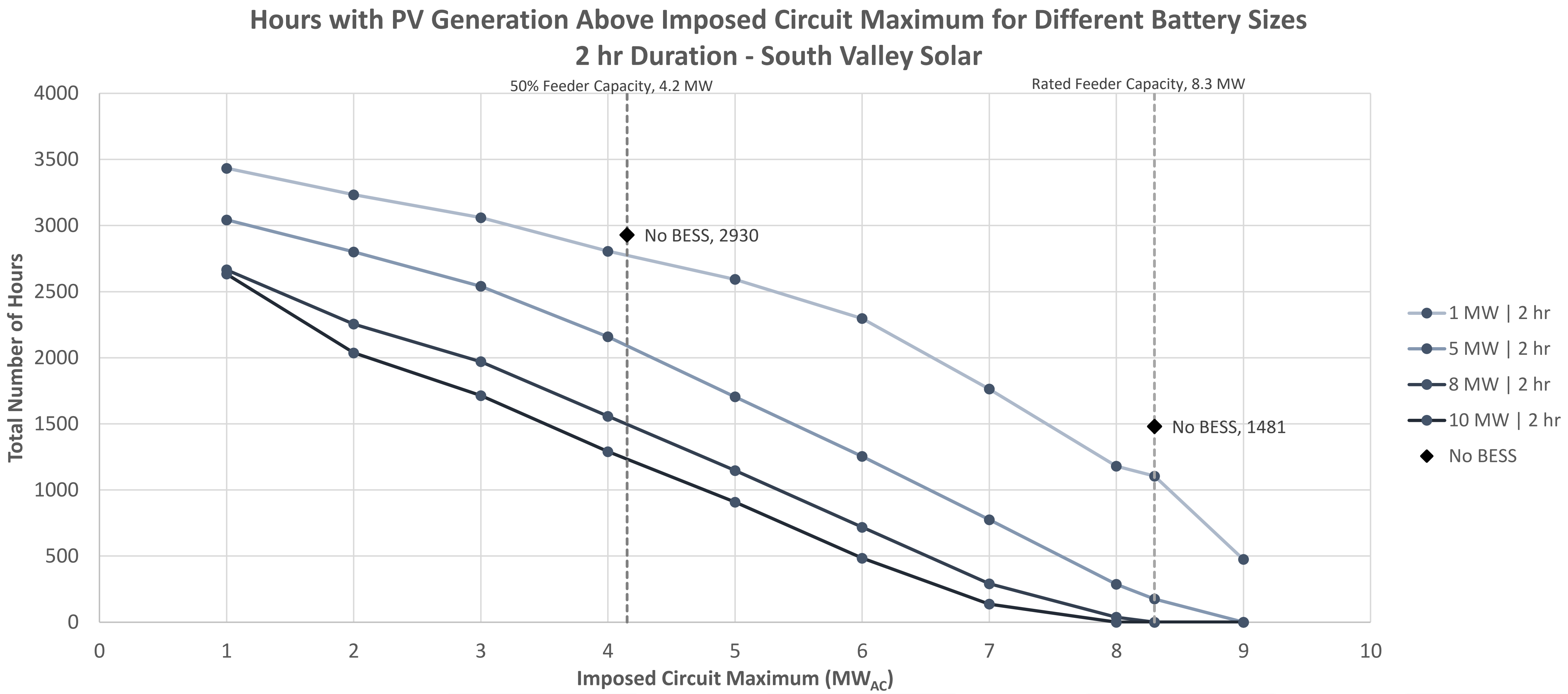
HOSTING CAPACITY GRAPHS

South Valley Solar

South Coors Substation

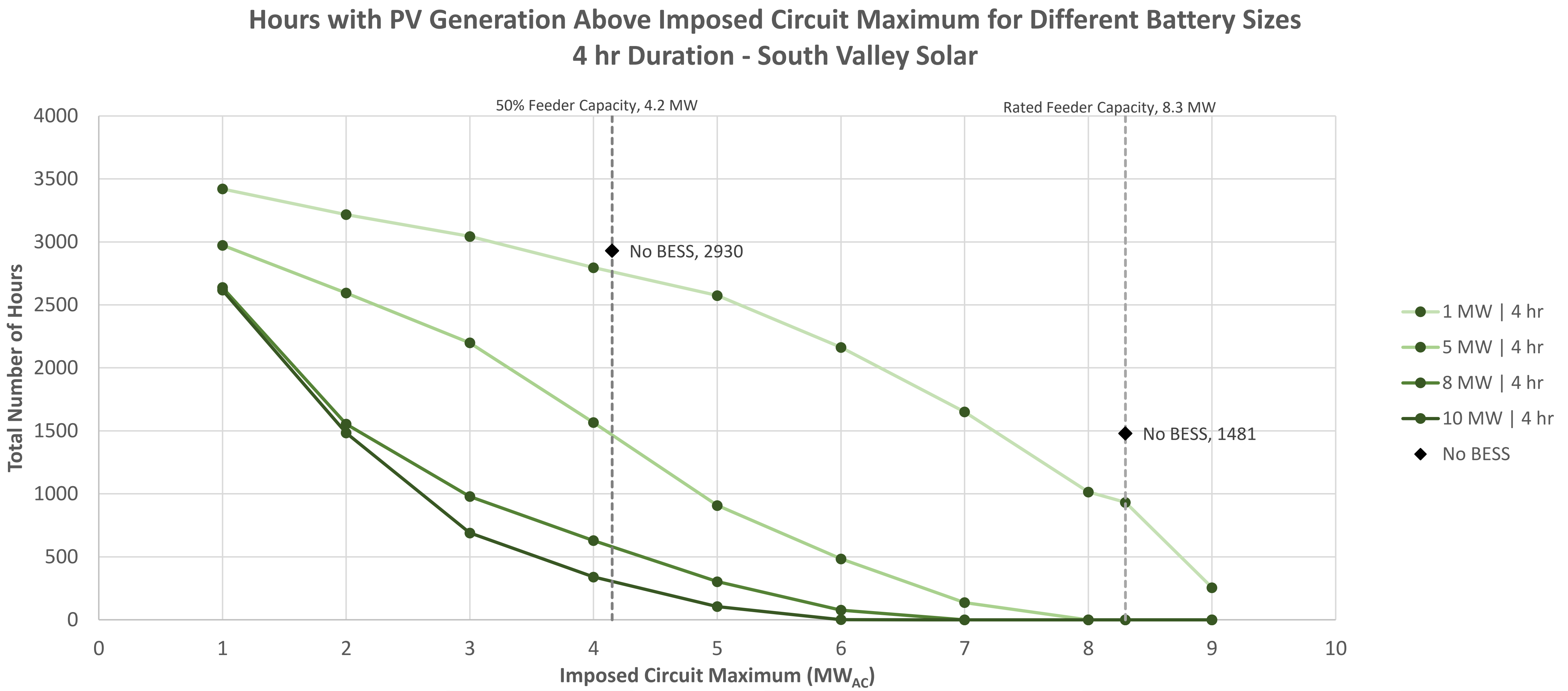
Hosting Capacity – System Sizing

South Valley Solar



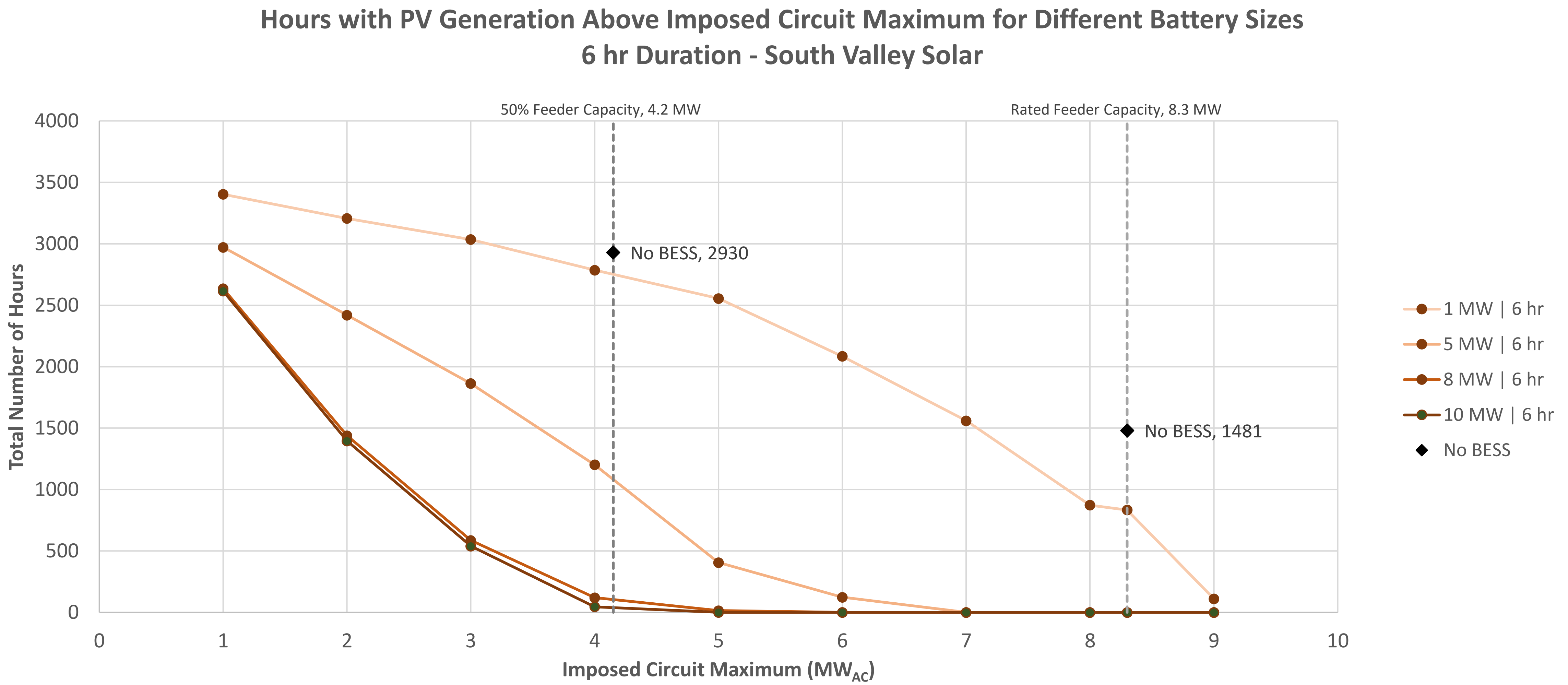
Hosting Capacity – System Sizing

South Valley Solar



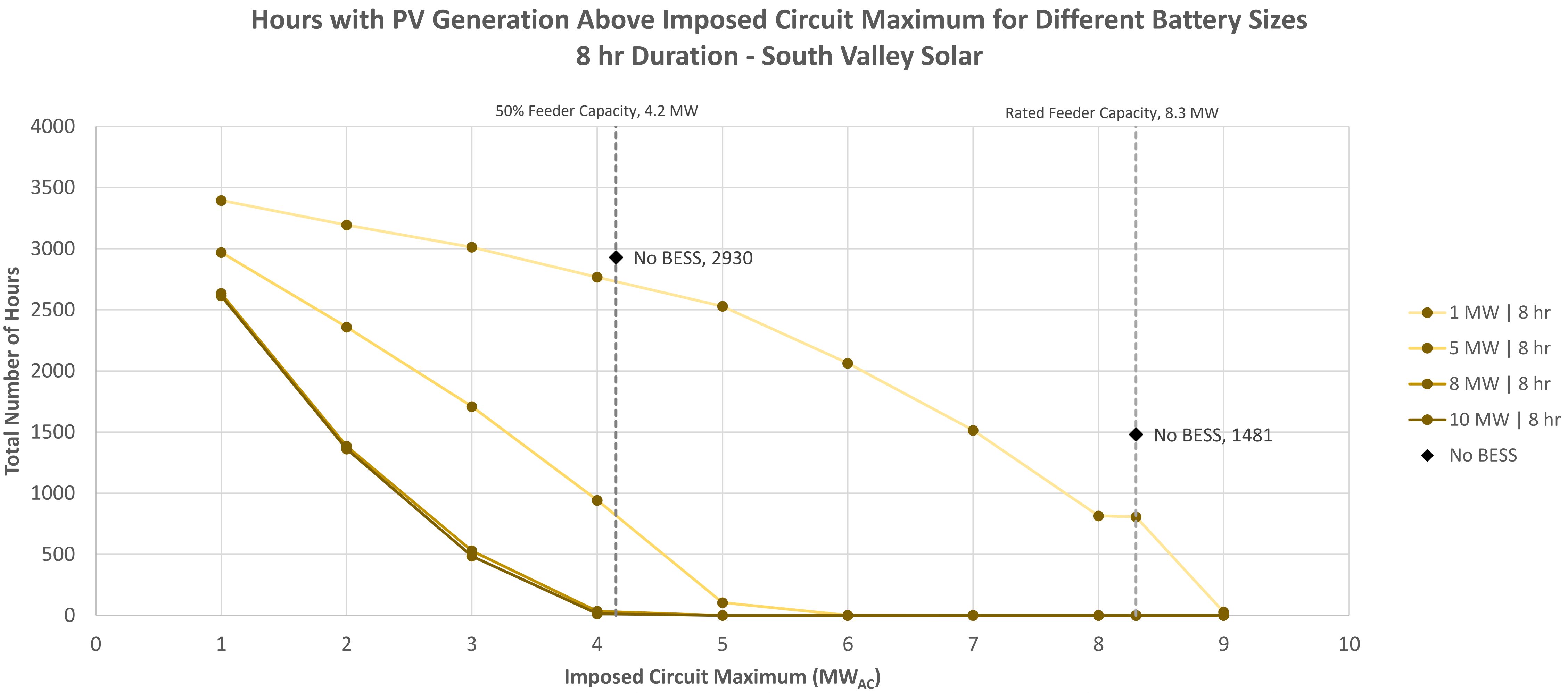
Hosting Capacity – System Sizing

South Valley Solar



Hosting Capacity – System Sizing

South Valley Solar



Hosting Capacity – System Sizing

South Valley Solar

South Valley Solar Summary of Hosting Capacity Results	
Minimum BESS to Eliminate Feeder Over Capacity Instances	
2hr Duration	8 MW | 16 MWh
4hr Duration	4 MW | 16 MWh
6hr Duration	3 MW | 18 MWh
8hr Duration	2 MW | 16 MWh

Additional Hosting Capacity (MW$_{AC}$)

	BESS System Power									
Duration	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
2hr	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4hr	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1
6hr	N/A	N/A	N/A	N/A	1	1	2	2	3	3
8hr	N/A	N/A	N/A	1	1	2	3	3	3	3

- Solar production based on 2020 operating data provided by PNM. Hosting capacity estimates representative of provided solar performance and a BESS system with no performance degradation.

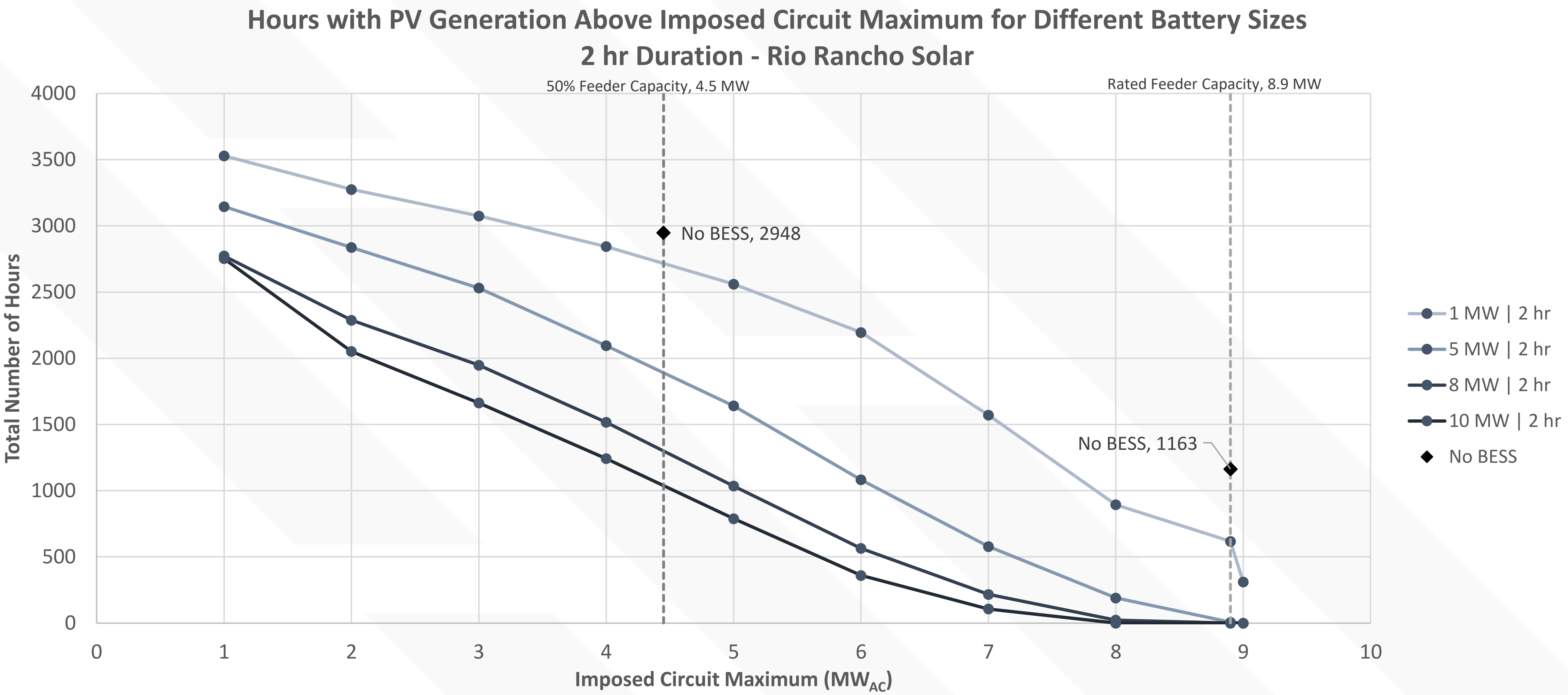
HOSTING CAPACITY GRAPHS

Rio Rancho Solar

Scenic Substation

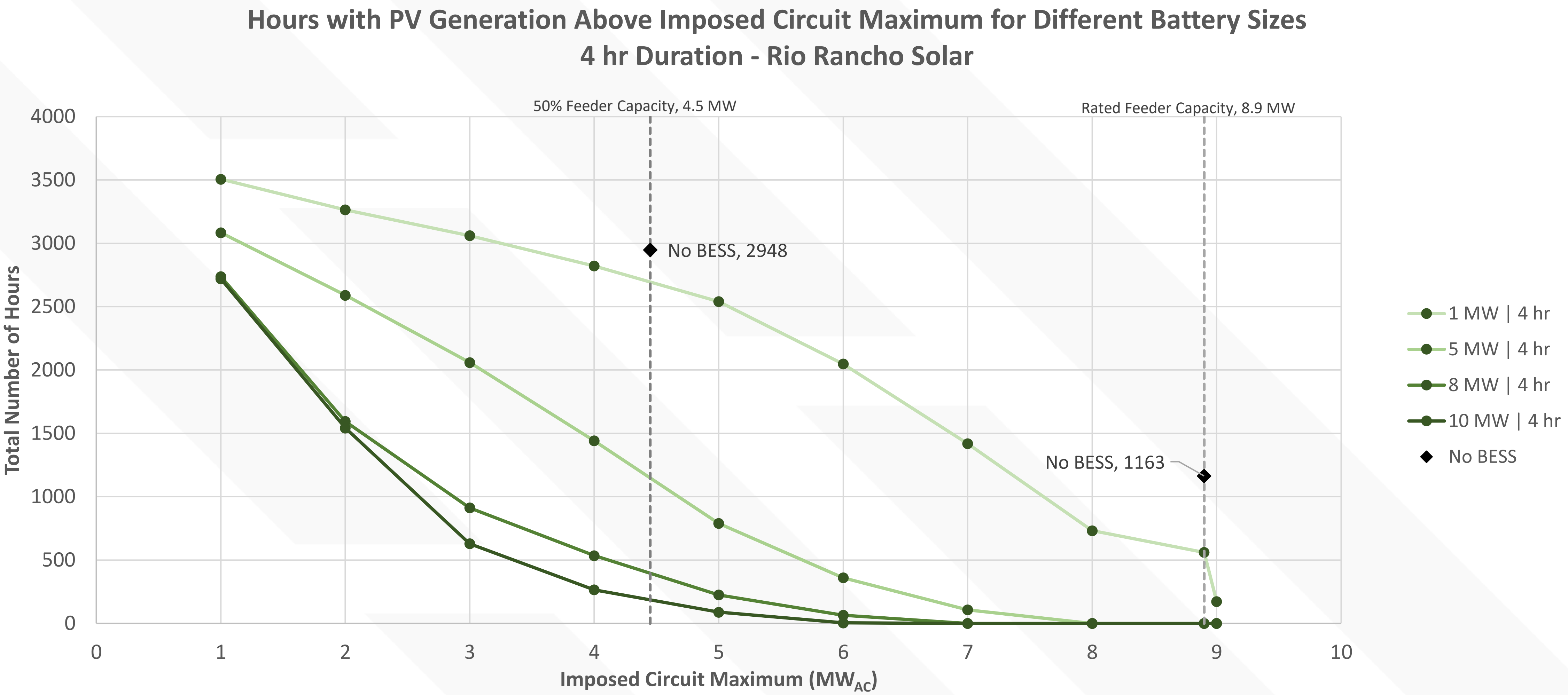
Hosting Capacity – System Sizing

Rio Rancho Solar



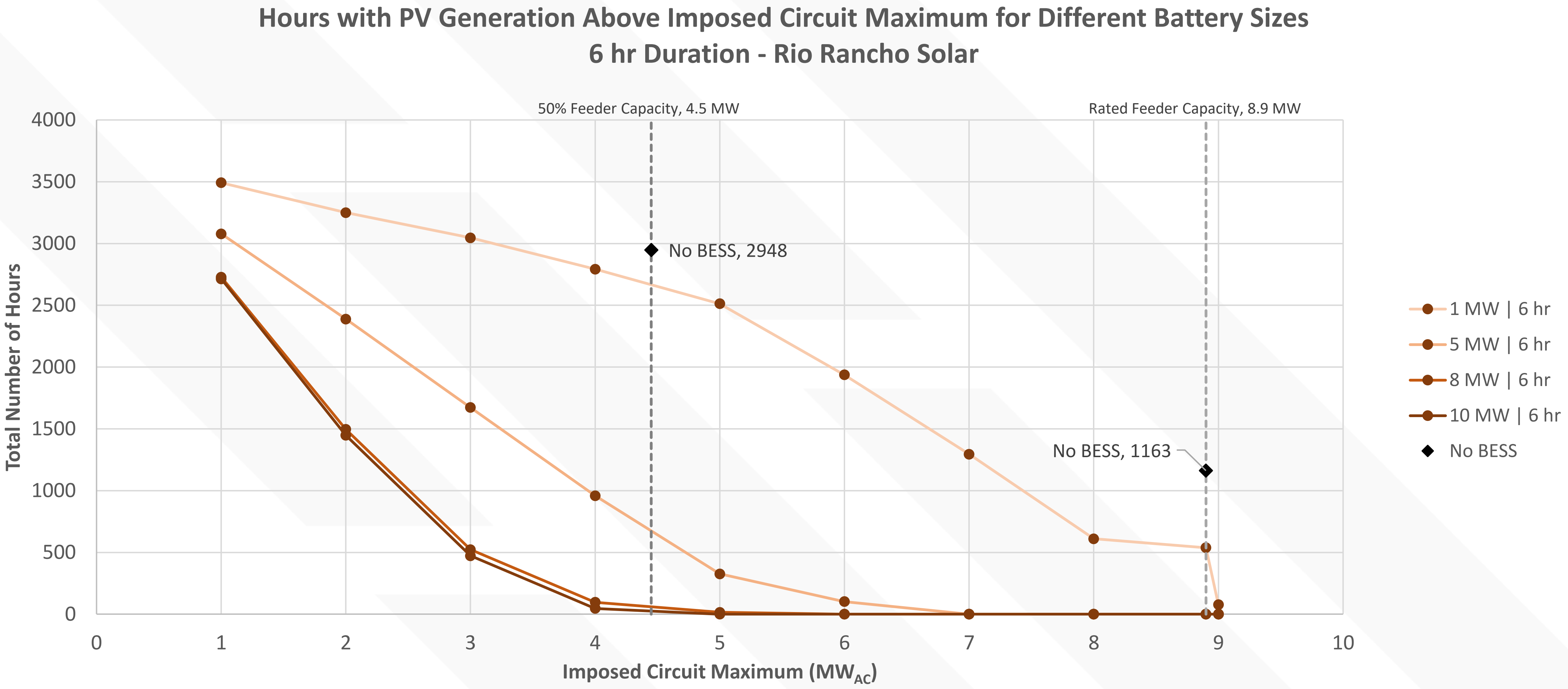
Hosting Capacity – System Sizing

Rio Rancho Solar



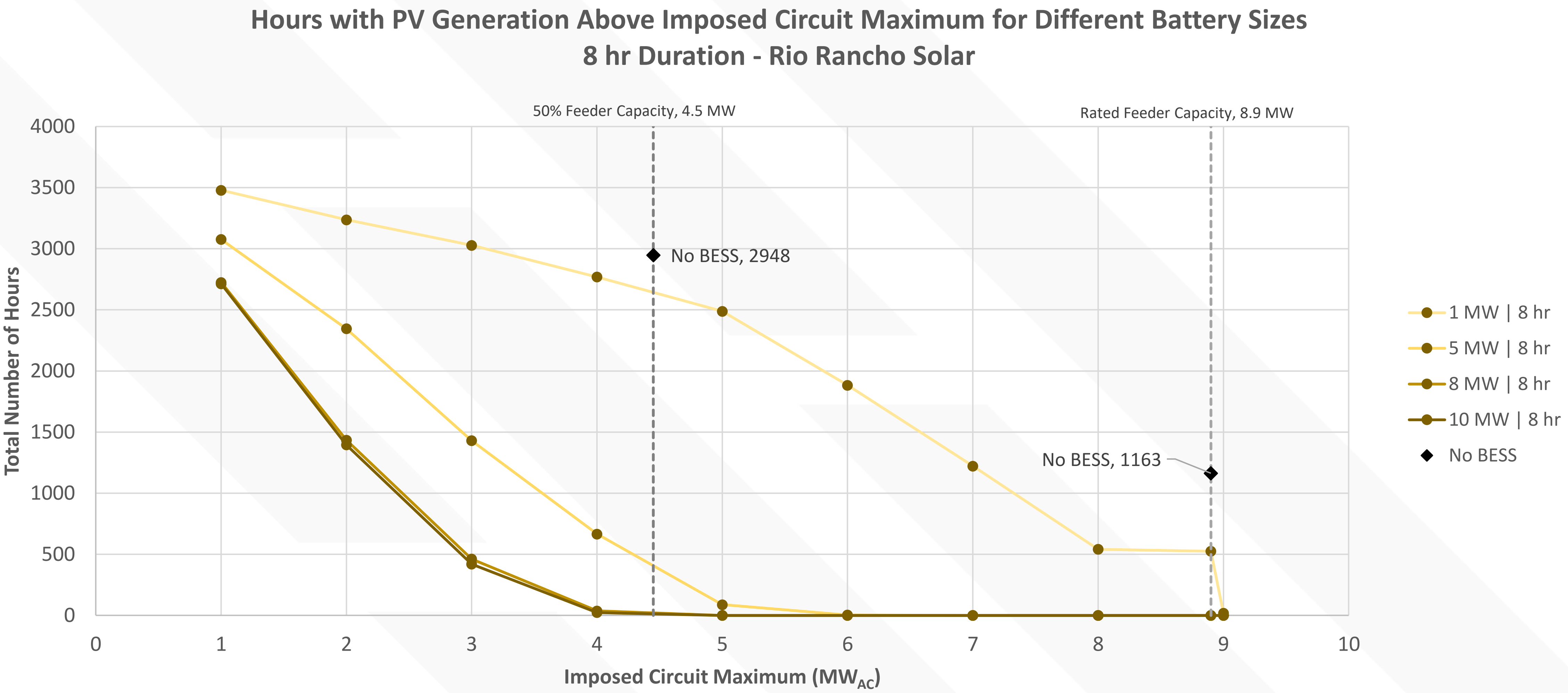
Hosting Capacity – System Sizing

Rio Rancho Solar



Hosting Capacity – System Sizing

Rio Rancho Solar



Hosting Capacity – System Sizing

Rio Rancho Solar

Rio Rancho Solar Summary of Hosting Capacity Results	
Minimum BESS to Eliminate Feeder Over Capacity Instances	
2hr Duration	6 MW | 12 MWh
4hr Duration	3 MW | 12 MWh
6hr Duration	2 MW | 12 MWh
8hr Duration	2 MW | 16 MWh

Additional Hosting Capacity (MW_{AC})

	BESS System Power									
Duration	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
2hr	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
4hr	N/A	N/A	N/A	N/A	0.5	0.5	0.5	1.5	1.5	1.5
6hr	N/A	N/A	N/A	0.5	1.5	1.5	2.5	2.5	3.5	3.5
8hr	N/A	N/A	0.5	1.5	1.5	2.5	3.5	3.5	3.5	3.5

- Solar production based on 2020 operating data provided by PNM. Hosting capacity estimates representative of provided solar performance and a BESS system with no performance degradation.

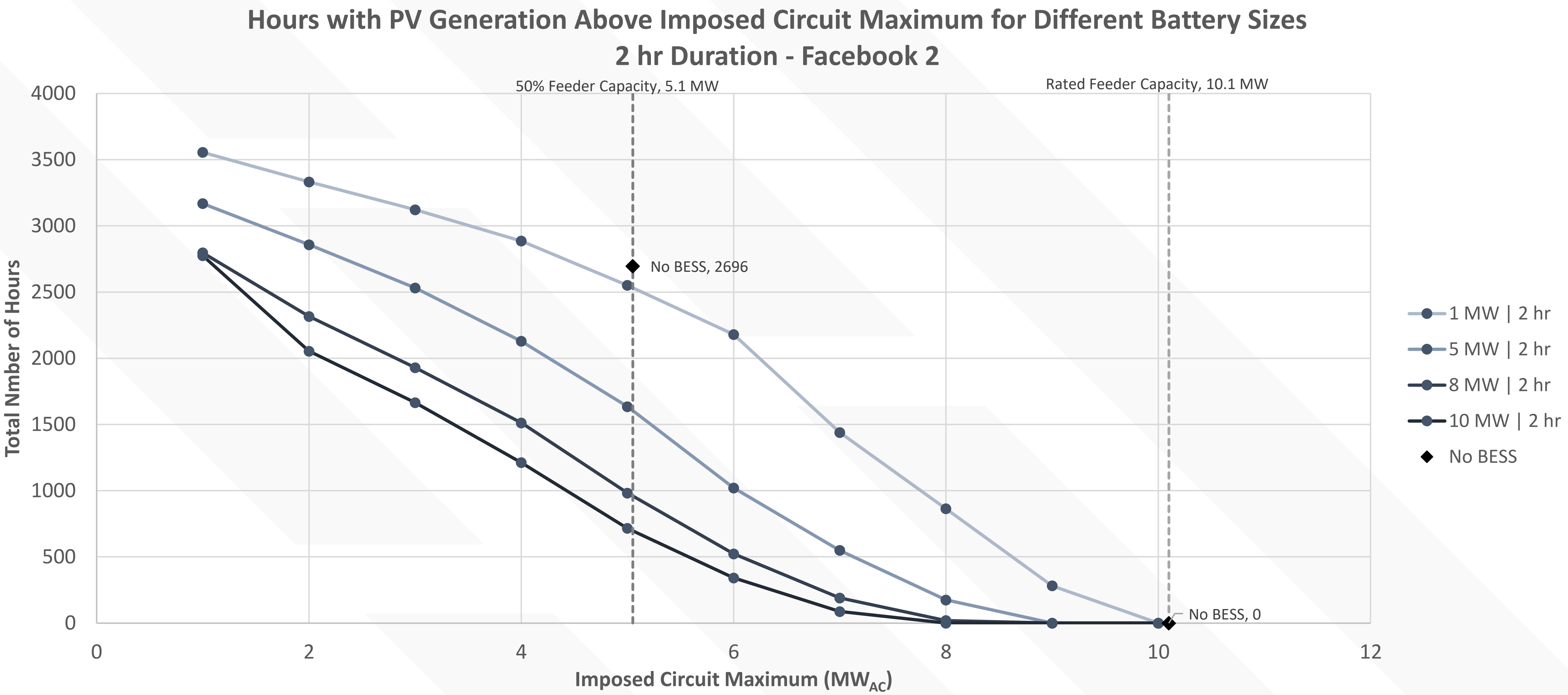
HOSTING CAPACITY GRAPHS

Facebook 2 Solar

Lost Horizon Substation

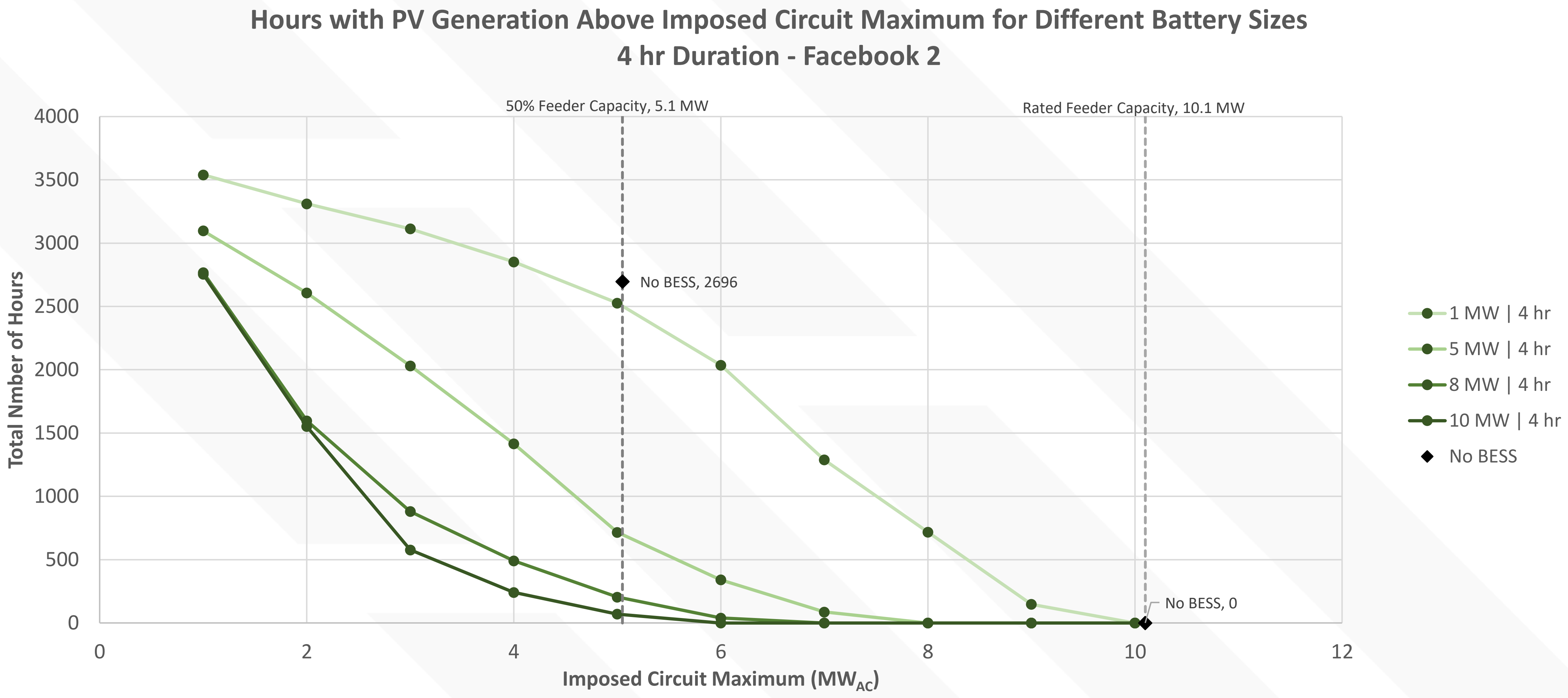
Hosting Capacity – System Sizing

Facebook 2



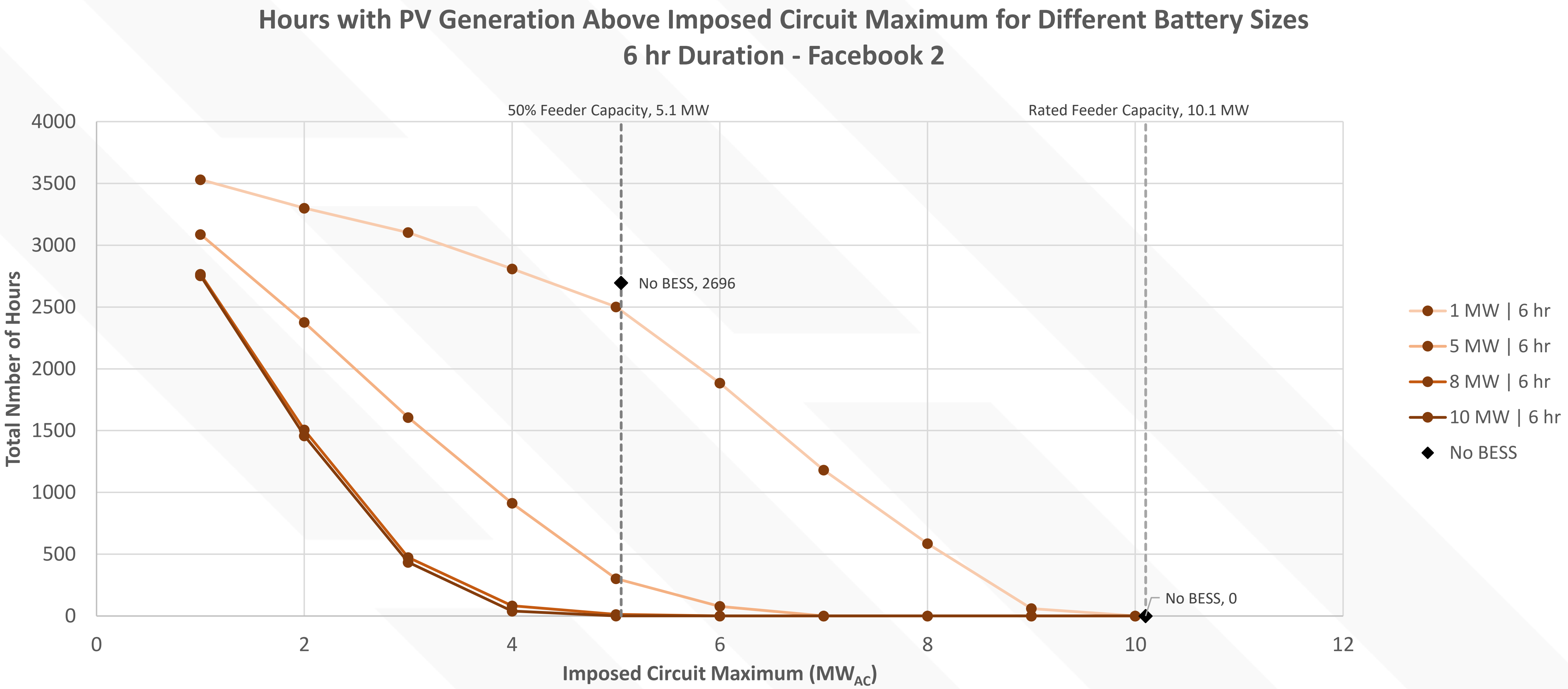
Hosting Capacity – System Sizing

Facebook 2



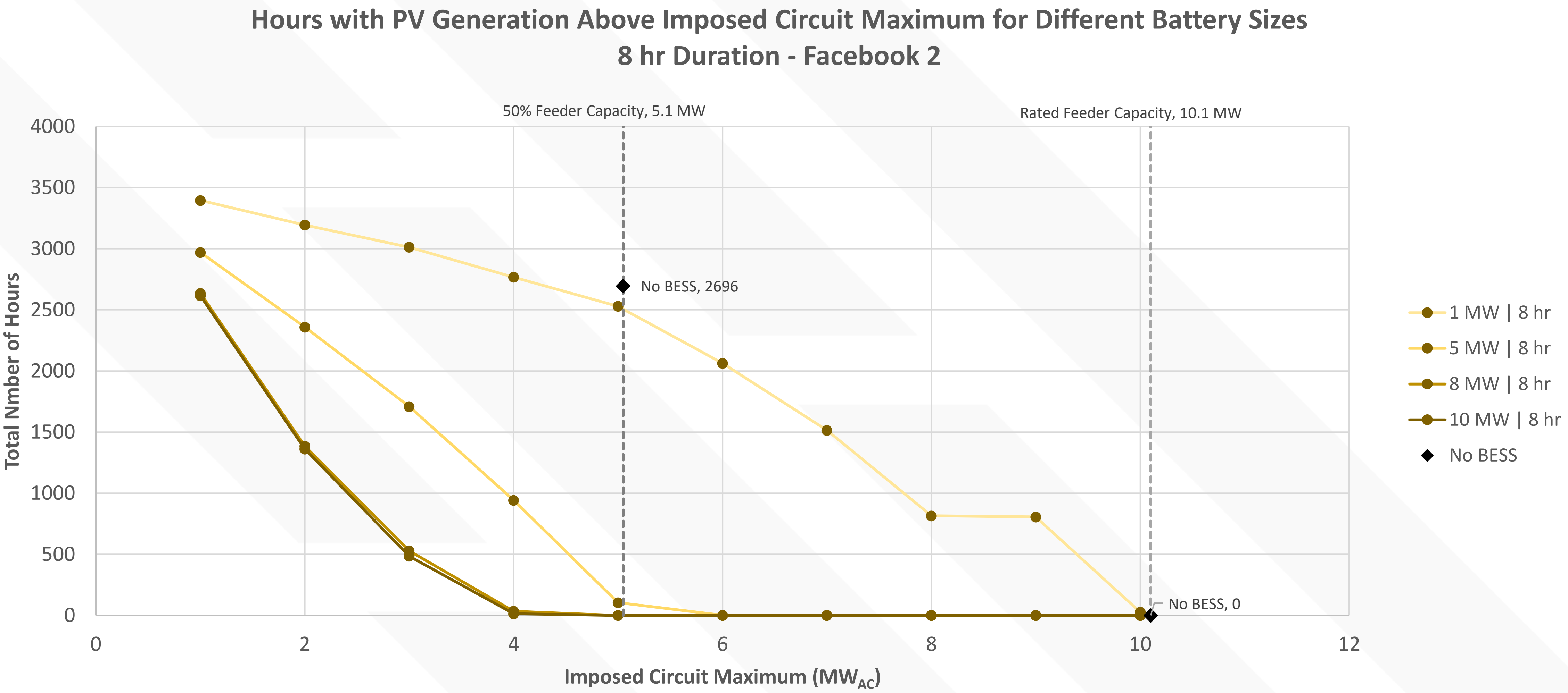
Hosting Capacity – System Sizing

Facebook 2



Hosting Capacity – System Sizing

Facebook 2



Hosting Capacity – System Sizing

Facebook 2

Facebook 2 Solar Summary of Hosting Capacity Results	
Minimum BESS to Eliminate Feeder Over Capacity Instances	
2hr Duration	FB2 Site does not require an energy storage system to avoid over feeder capacity events
4hr Duration	
6hr Duration	
8hr Duration	

Additional Hosting Capacity (MW_{AC})

	BESS System Power									
Duration	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
2hr	N/A	N/A	N/A	N/A	1	1	1	1	1	2
4hr	N/A	N/A	1	1	2	2	2	3	3	4
6hr	N/A	1	1	2	3	3	4	4	5	5
8hr	N/A	1	2	3	4	4	5	5	5	5

- Solar production based on 2020 operating data provided by PNM. Hosting capacity estimates representative of provided solar performance and a BESS system with no performance degradation.

Appendix C – ENERGY ARBITRAGE PRESENTATION

Preliminary Economic Analysis

Methodology

- **Objective:**
  - **Estimate** the differential value of energy across the relevant time period to guide the operation of the energy storage system
  - **Model** the storage system operation at each candidate site using a perfect dispatch algorithm that avoids circuit overloading
  - **Quantify** average economic performance for each system for 2020 using PNM provided solar data, and for 2018-2021 using energy value estimates
  - **Recommend** configurations with the greatest opportunity for positive economic screening
- **How:**
  - Surface interpolation of market-based energy price
  - Processing of energy data in R
  - Time-series modeling of energy storage performance in GridBEAST

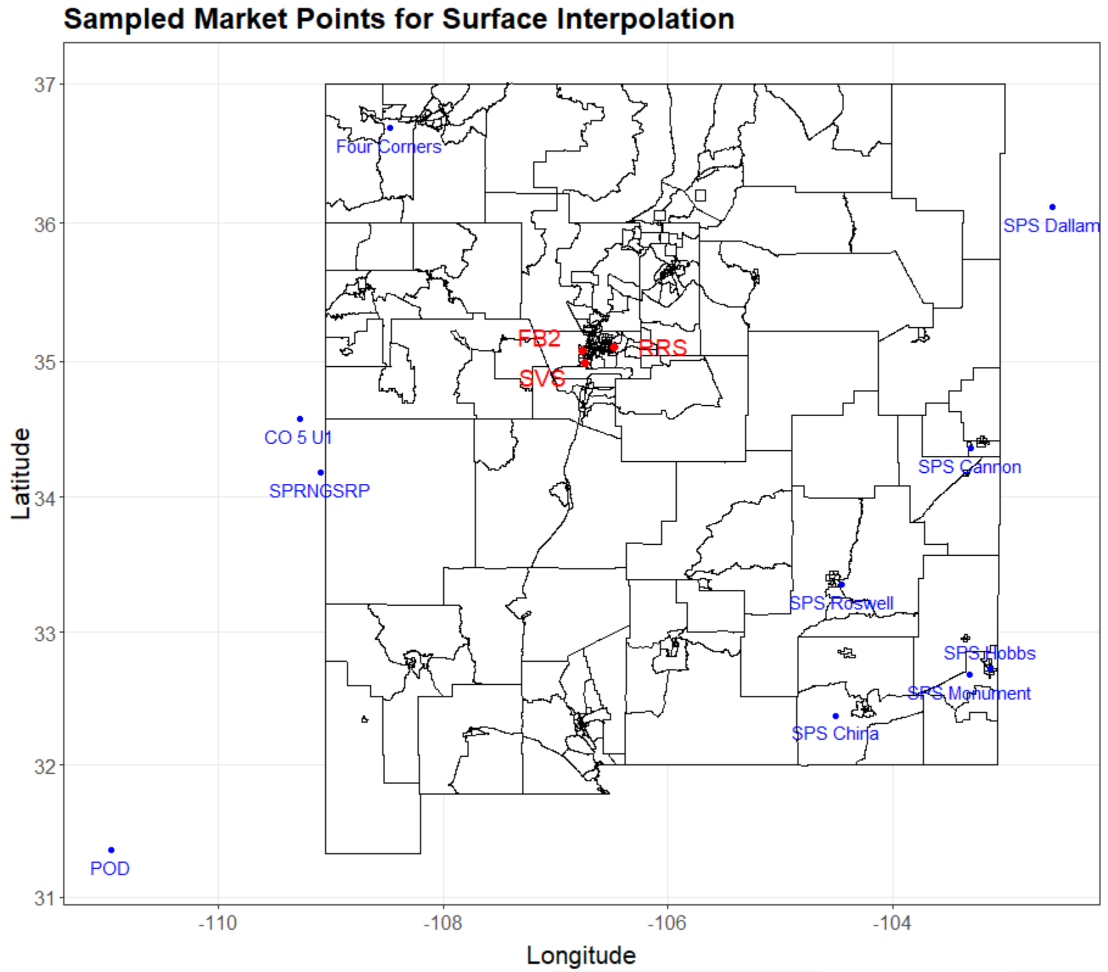
Preliminary Economic Analysis

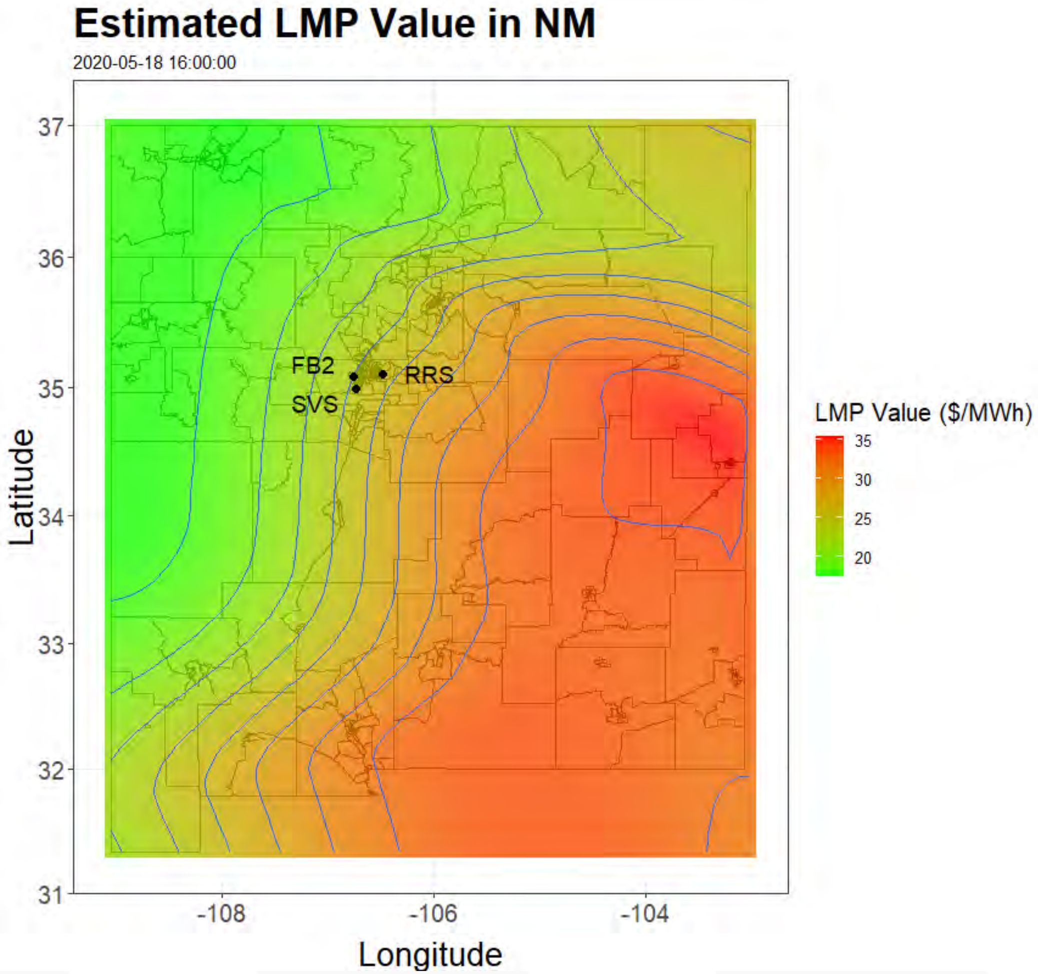
Methodology

- Initial Model Inputs & Assumptions:
  - PV performance data input into GridBEAST model without adjustment following summarization in data query (no data type errors found)
  - PV and BESS performance assume no degradation (first year performance)
  - BESS losses resulting in ~87-88% round-trip efficiency
  - BESS is a separate installation from privately owned PV installation, BESS system is assumed to be connected to same circuit as each PV installation
  - BESS configurations tested from 1 MW_{AC} – 10 MW_{AC} at 2, 4, 6 and 8 hr capacities
  - Economic data are based on Day Ahead hourly values from both CAISO & SPP
- Additional Modeling Assumptions:
  - Model assumes that the battery charges from grid energy
  - Perfect dispatch algorithm is based on differential energy value analysis to identify greatest potential arbitrage value and preserves space to capture energy to prevent circuit overloading events
  - Maximum BESS discharge is set to circuit capacity rating

Preliminary Economic Analysis

Methodology

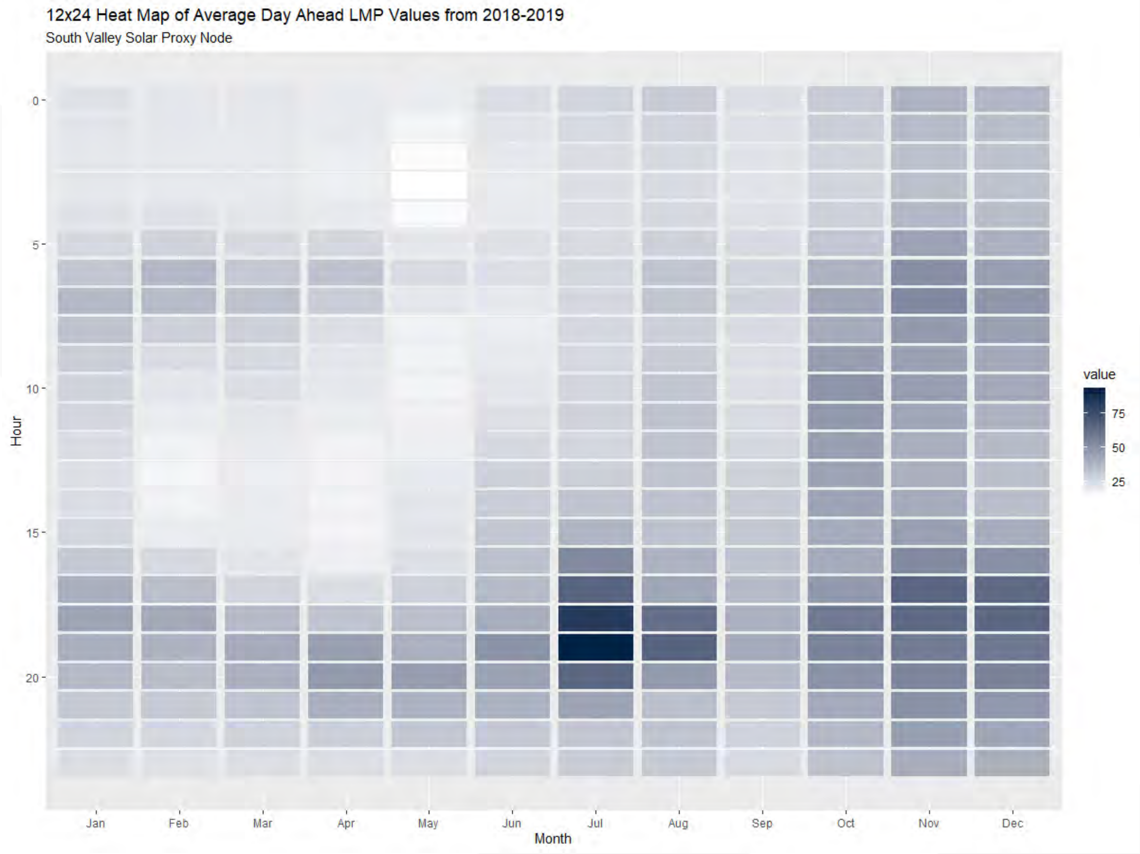


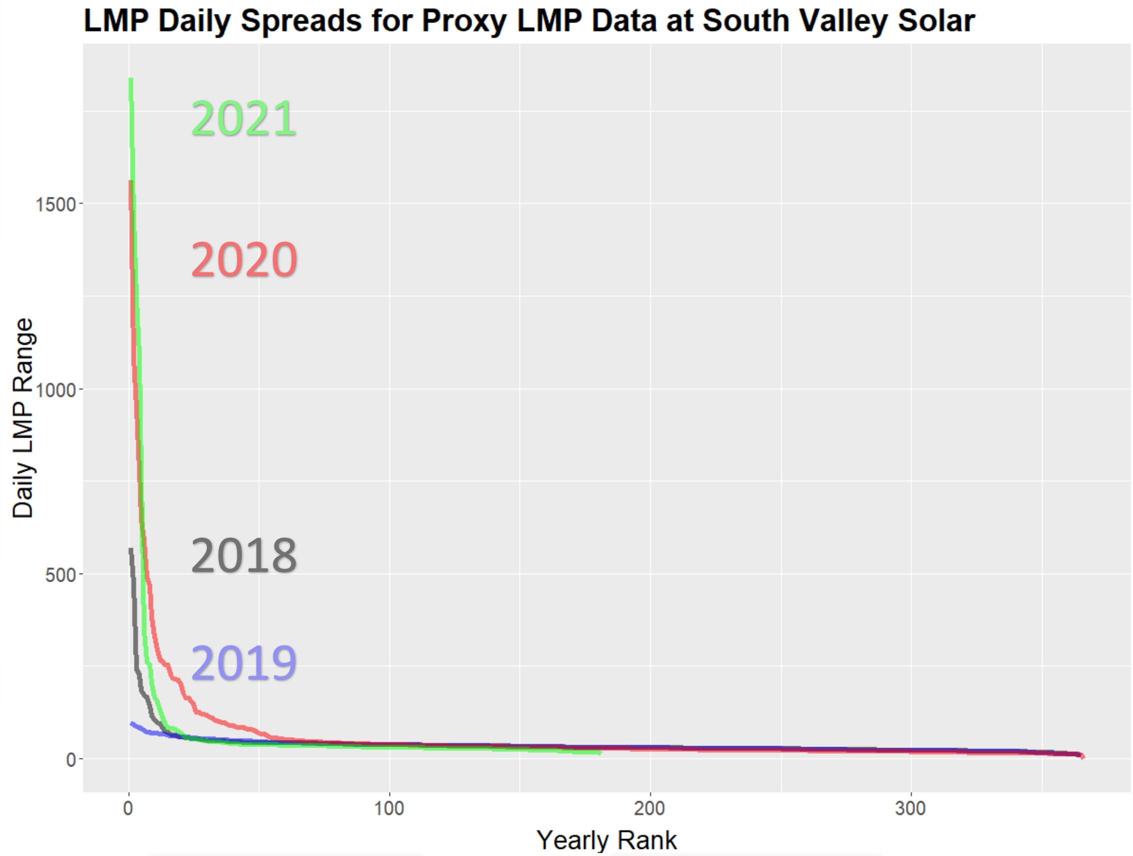


- **Data sources:**
  - Day Ahead Market (DAM) hourly LMP values sourced from CAISO and SPP sampled from 10 points from 2018-2021
  - Data from 2020-2021 might have limitations in predictive value for future years

Preliminary Economic Analysis

Model Inputs

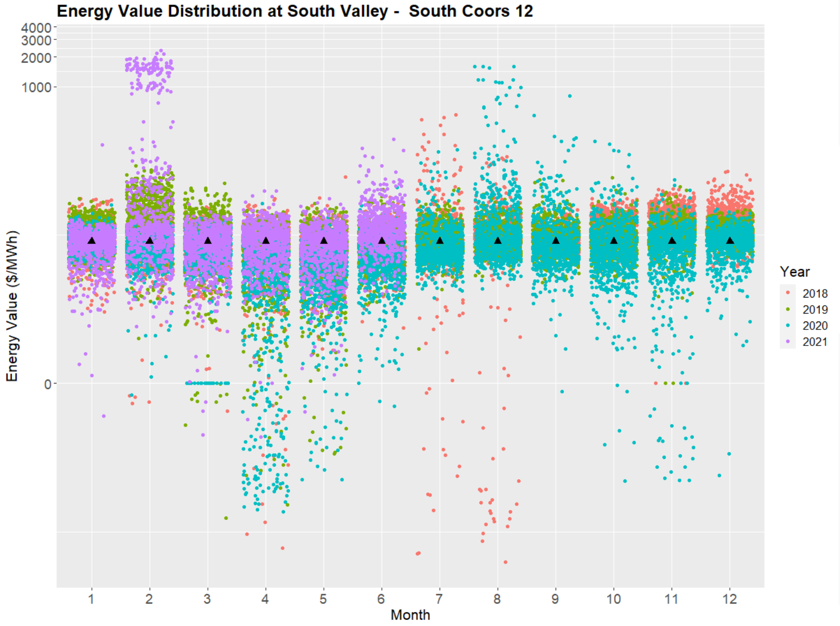

12x24 Heat Map of Average Day Ahead LMP Values from 2018-2019
South Valley Solar Proxy Node


LMP Daily Spreads for Proxy LMP Data at South Valley Solar

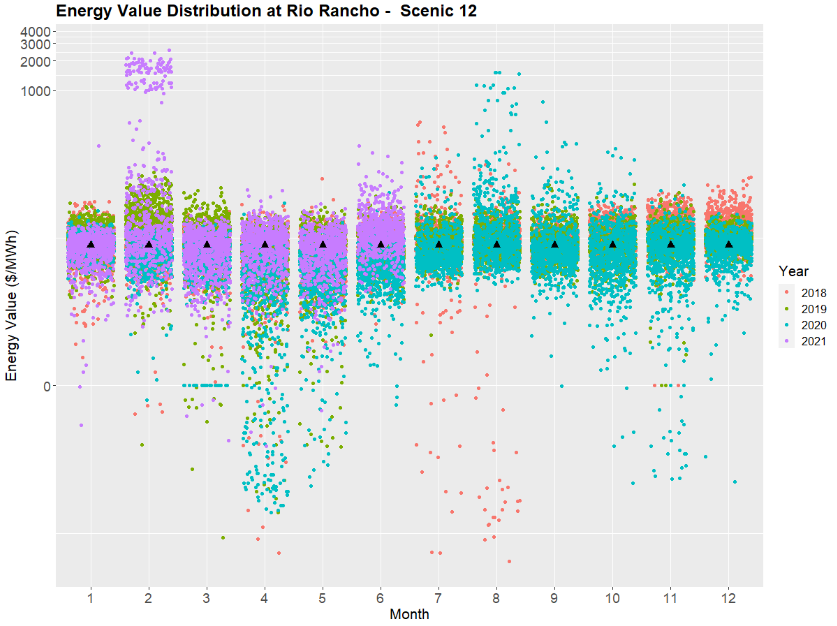
- Data reveals increasing volatility in energy value, with 2020 pandemic and 2021 winter events in ERCOT & SPP skewing results

Preliminary Economic Analysis

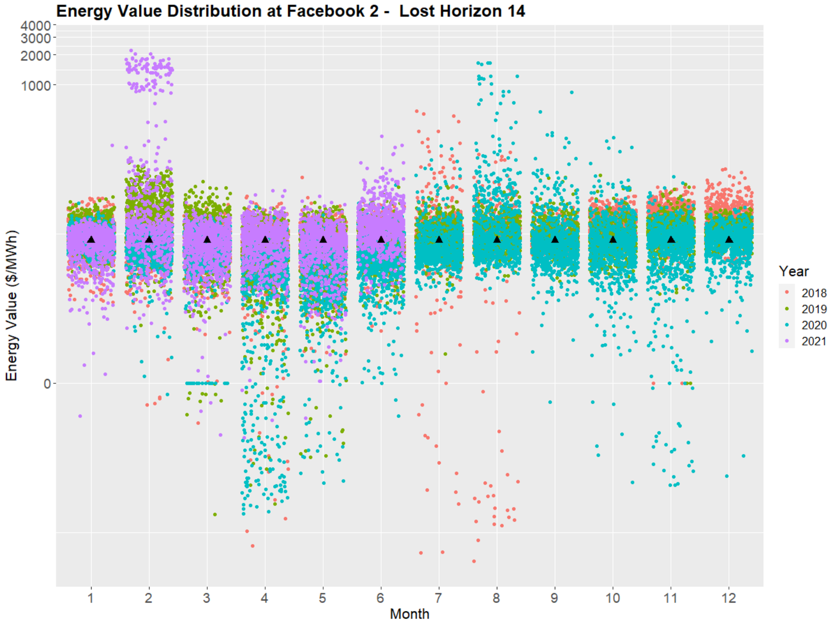
Model Inputs



Energy Value Distribution at South Valley - South Coors 12



Energy Value Distribution at Rio Rancho - Scenic 12



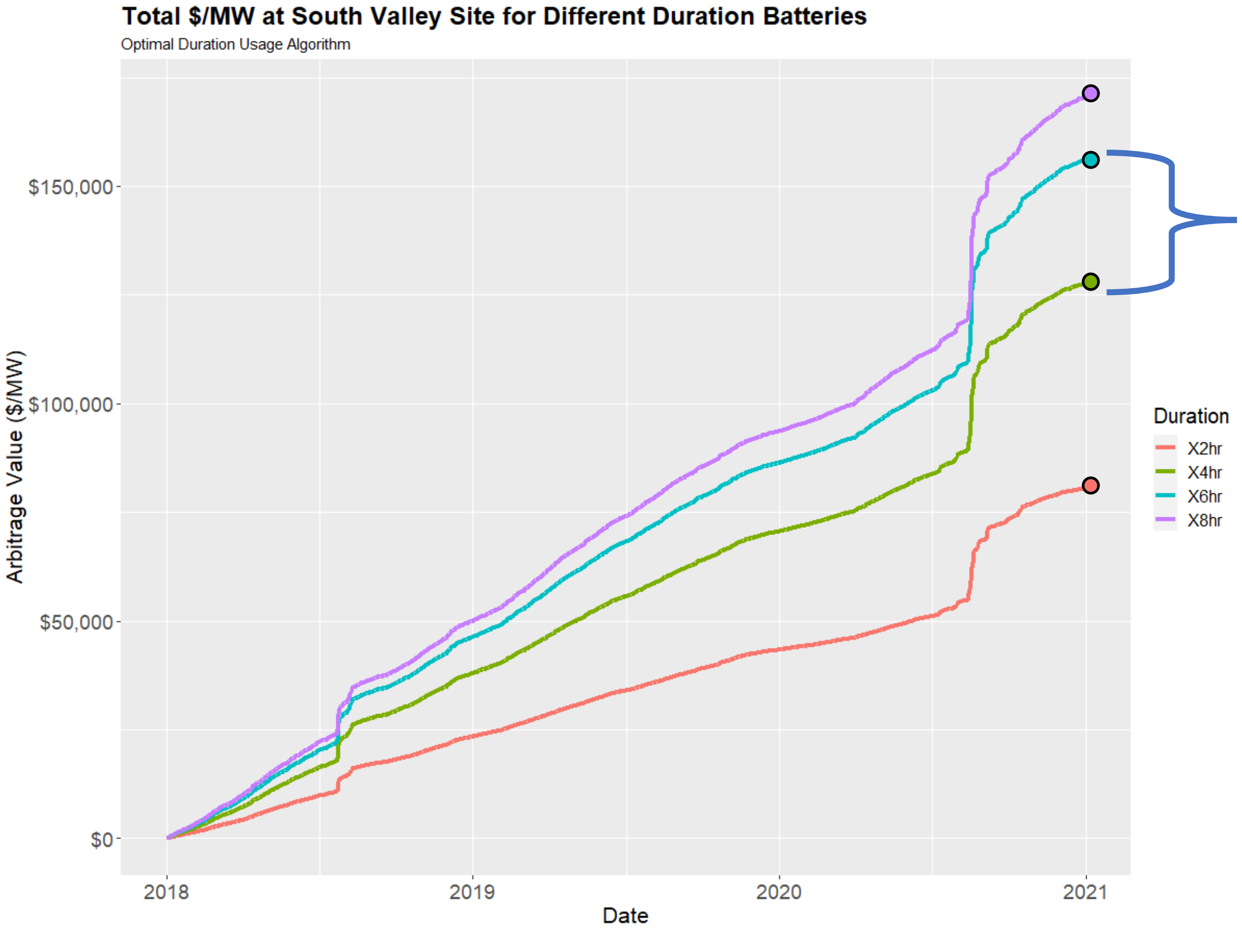
Energy Value Distribution at Facebook 2 - Lost Horizon 14

Average Energy Value by Site ($/MWh) Weighted by PV Production	
South Valley / South Coors 12	$21.02
Rio Rancho / Scenic 12	$22.14
Facebook 2 / Lost Horizon 12	$22.10

Preliminary Economic Analysis

Model Results – LMP Data Analysis

The maximum potential value attained by a BESS based on energy arbitrage by duration over the historical period is show. Units are $/MW since BESS would theoretically maximize value at larger sizes under perfect dispatch, but at greater cost

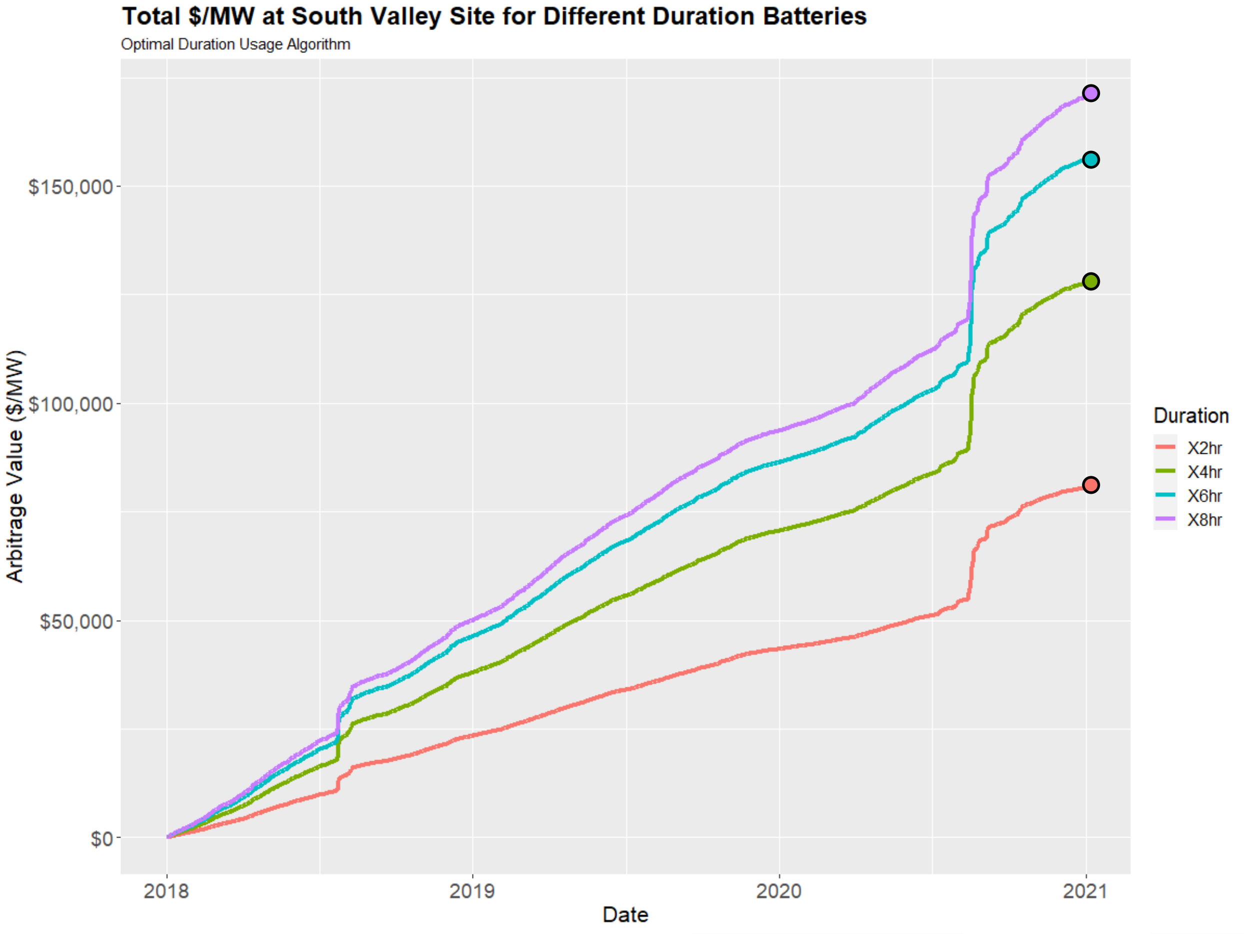


The difference between each line is the marginal value of an additional hour of storage, generalized at any capacity assuming a perfect dispatch algorithm

Data shown in the graph above are based on hourly historical DAM data interpolated as discussed in the previous slides

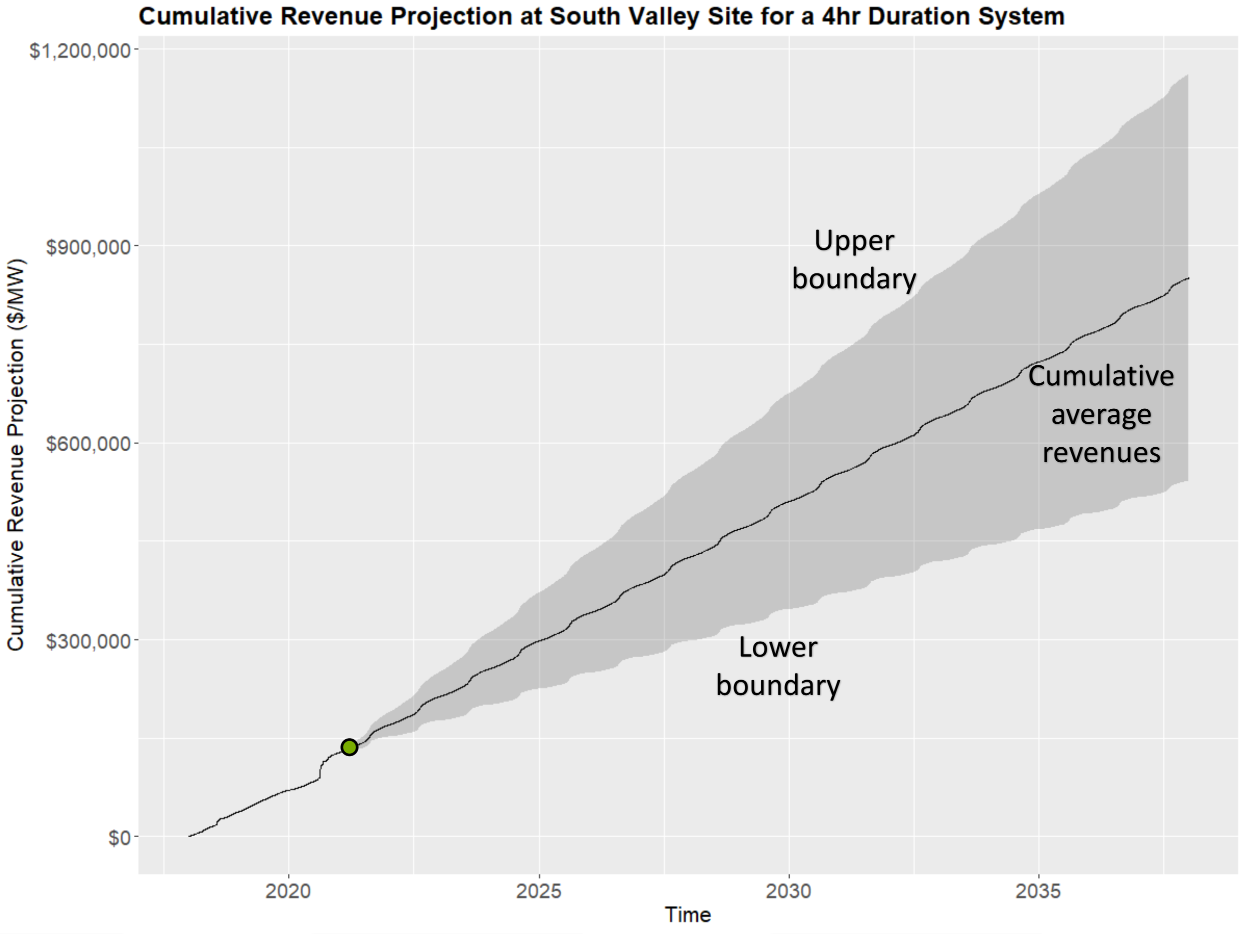
Preliminary Economic Analysis

Model Results – LMP Data Analysis



Total $/MW at South Valley Site for Different Duration Batteries

Optimal Duration Usage Algorithm

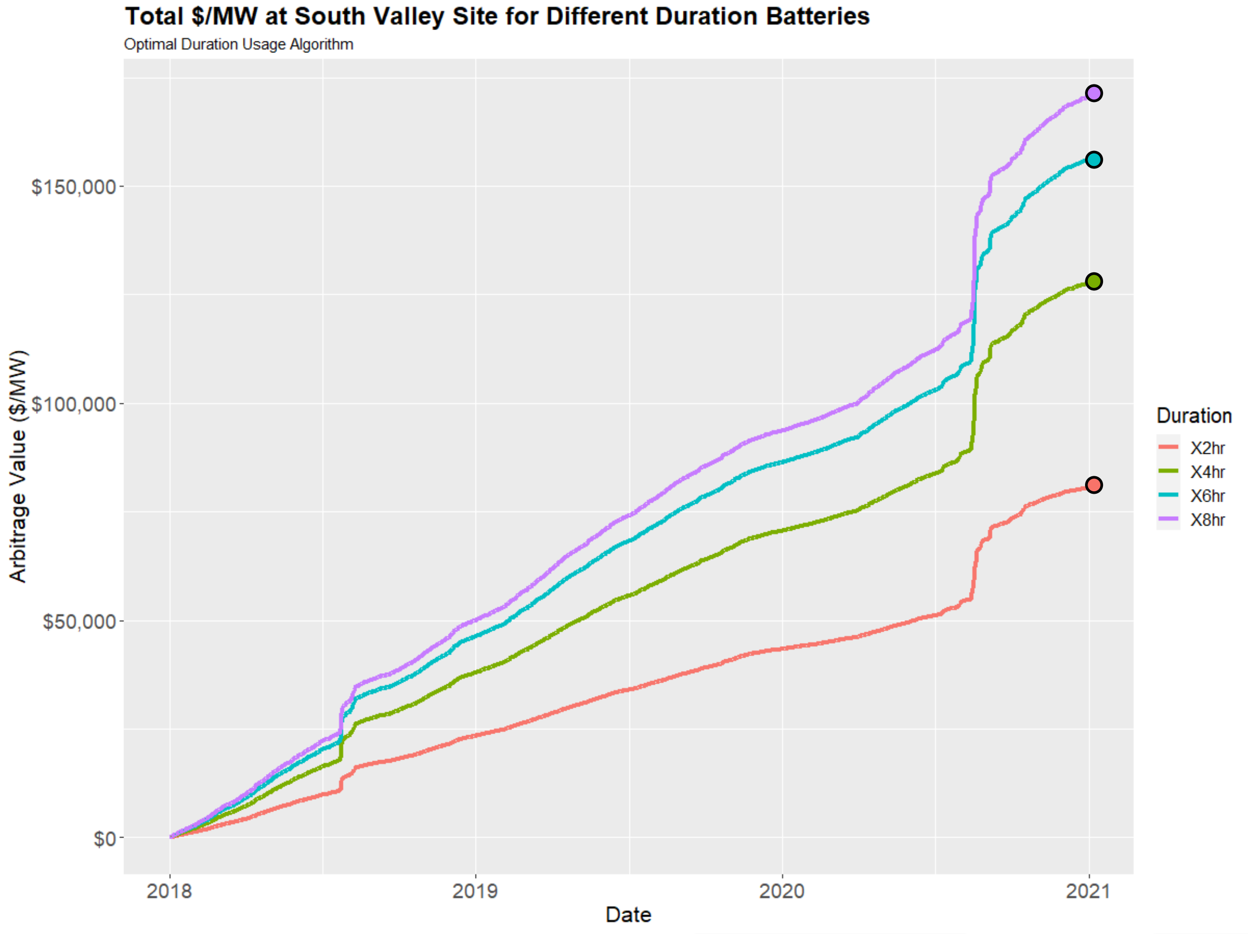


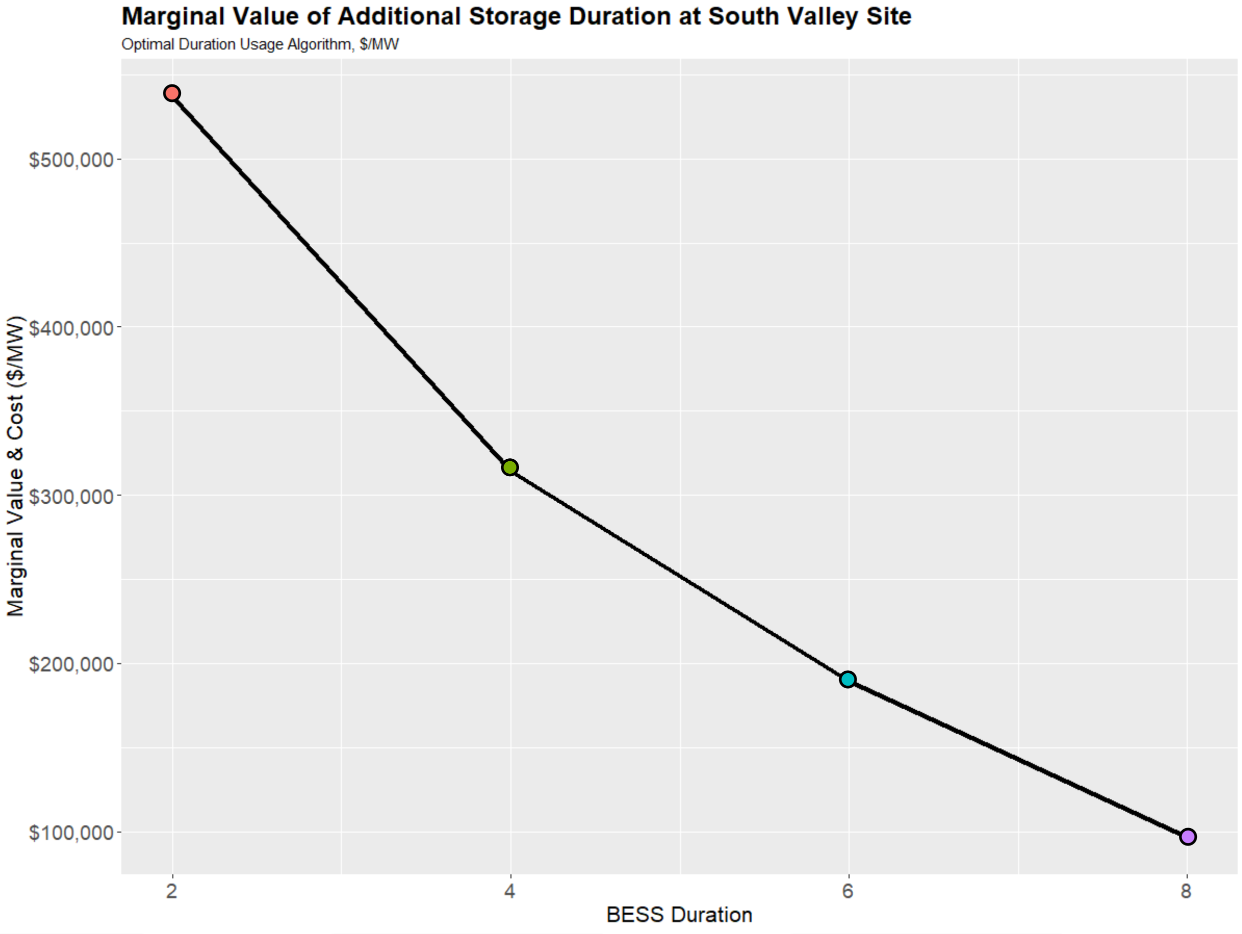
Cumulative Revenue Projection at South Valley Site for a 4hr Duration System

A simplified model of future revenue projections can be built by simple linear regression with each month as a factor that calculates the average expected daily revenue for each duration system as well as the lower and upper confidence boundary

Preliminary Economic Analysis

Model Results – LMP Data Analysis

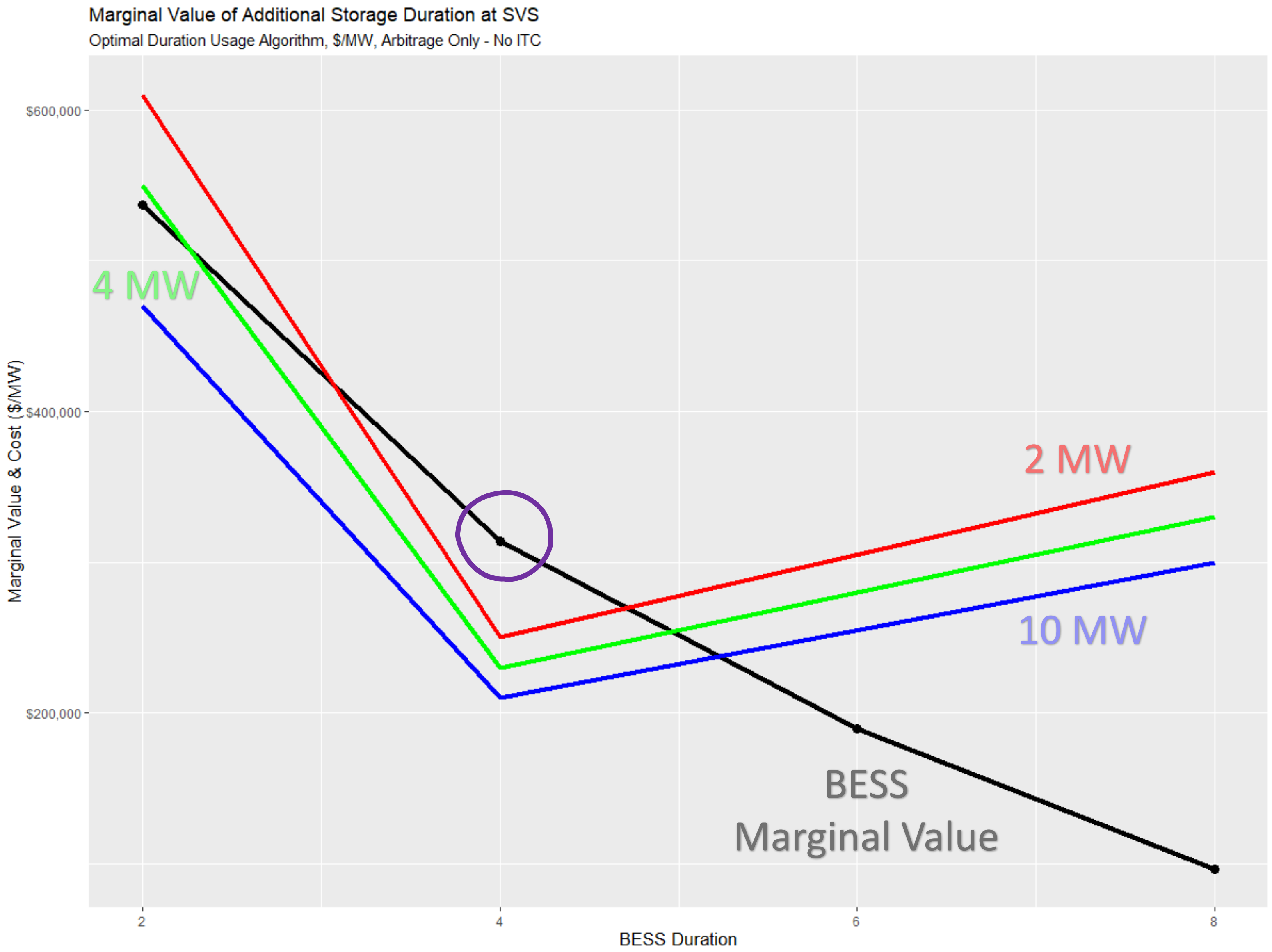




The difference in the cumulative average revenue projects for each battery duration shows the decrease in marginal value as the battery duration increases

Preliminary Economic Analysis

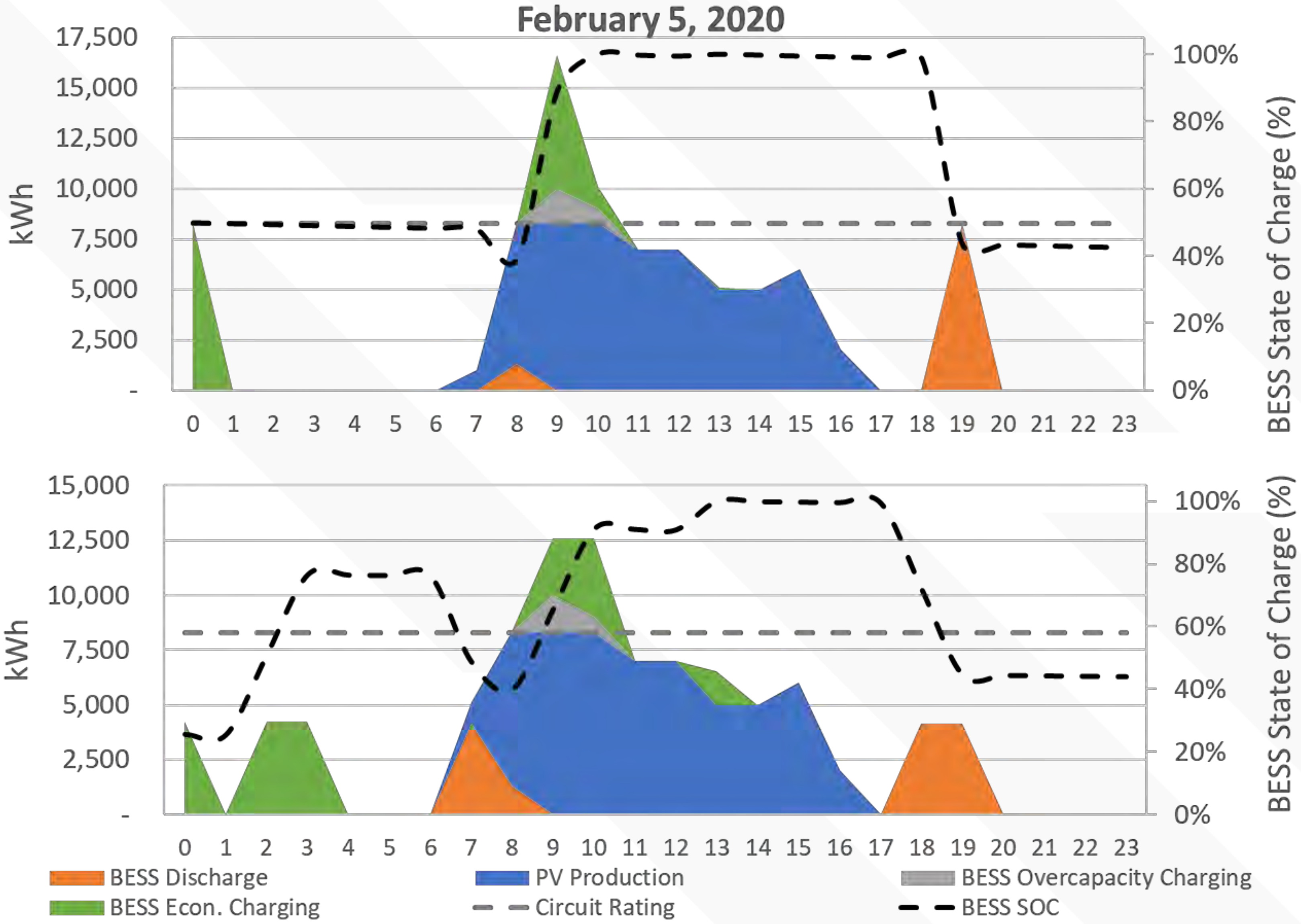
Model Results – LMP Data Analysis



- Black line shows the declining marginal value of storage assuming a perfect arbitrage operation of the BESS at the South Valley site.
- The different color lines show the cost of different BESS systems across the Duration x-axis, with the lowest cost per kWh of storage for larger systems.
- The greatest gap in cost vs value occurs at a 4-hour BESS – which implies that the best opportunity to reach a positive return economic return on the storage system, using arbitrage only, should occur at this system duration.
- This data, alongside with the understanding of the minimum sizes to allow for the potential elimination of feeder overcapacity suggests the MW & MWh sizing best suited to reach economic return at each site.
- Data from 2018 to 2020

Preliminary Economic Analysis

Model Results – Time Series Model

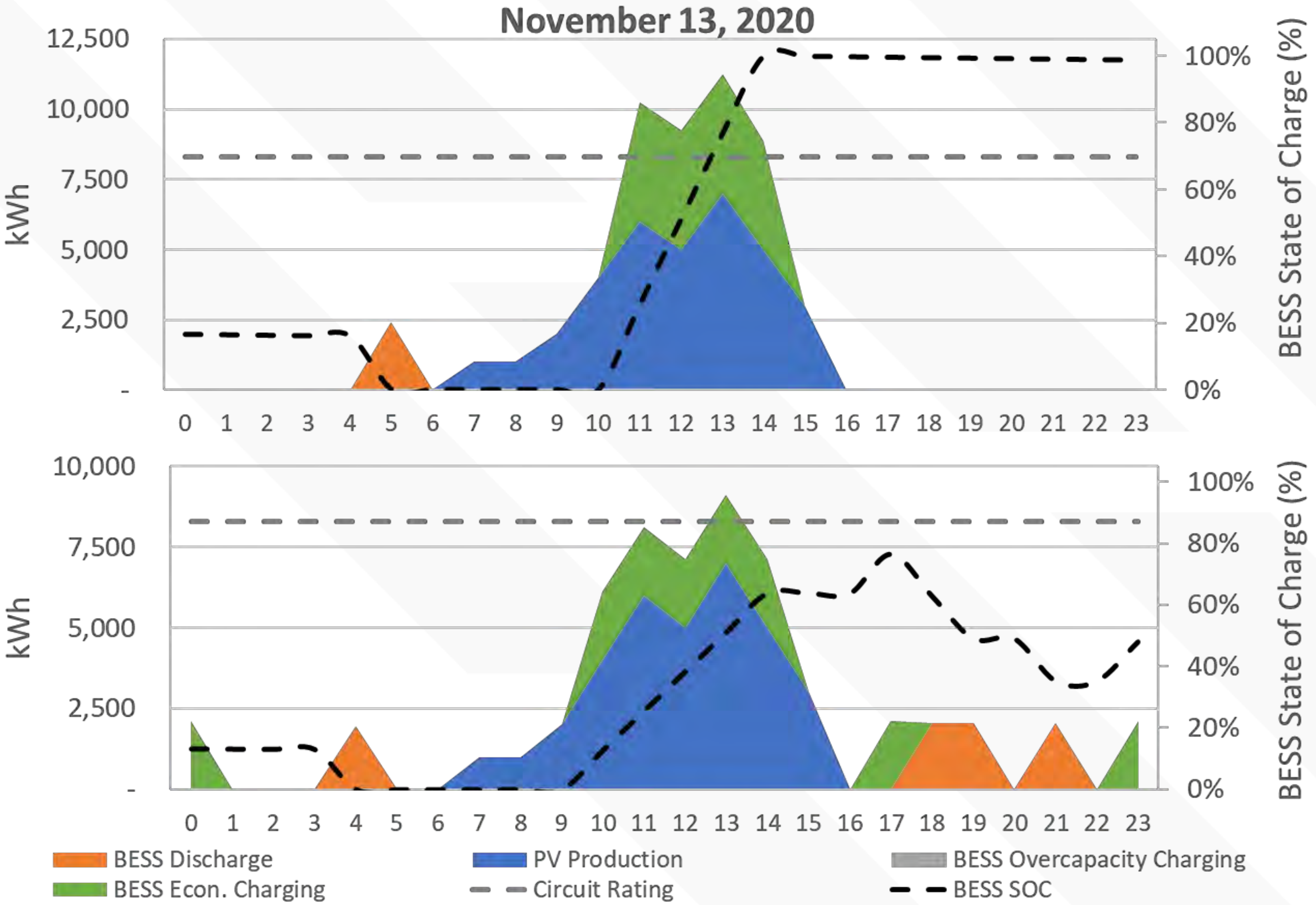


BESS Configuration
8 MW | 2 hr

BESS Configuration
4 MW | 4 hr

Preliminary Economic Analysis

Model Results – Time Series Model



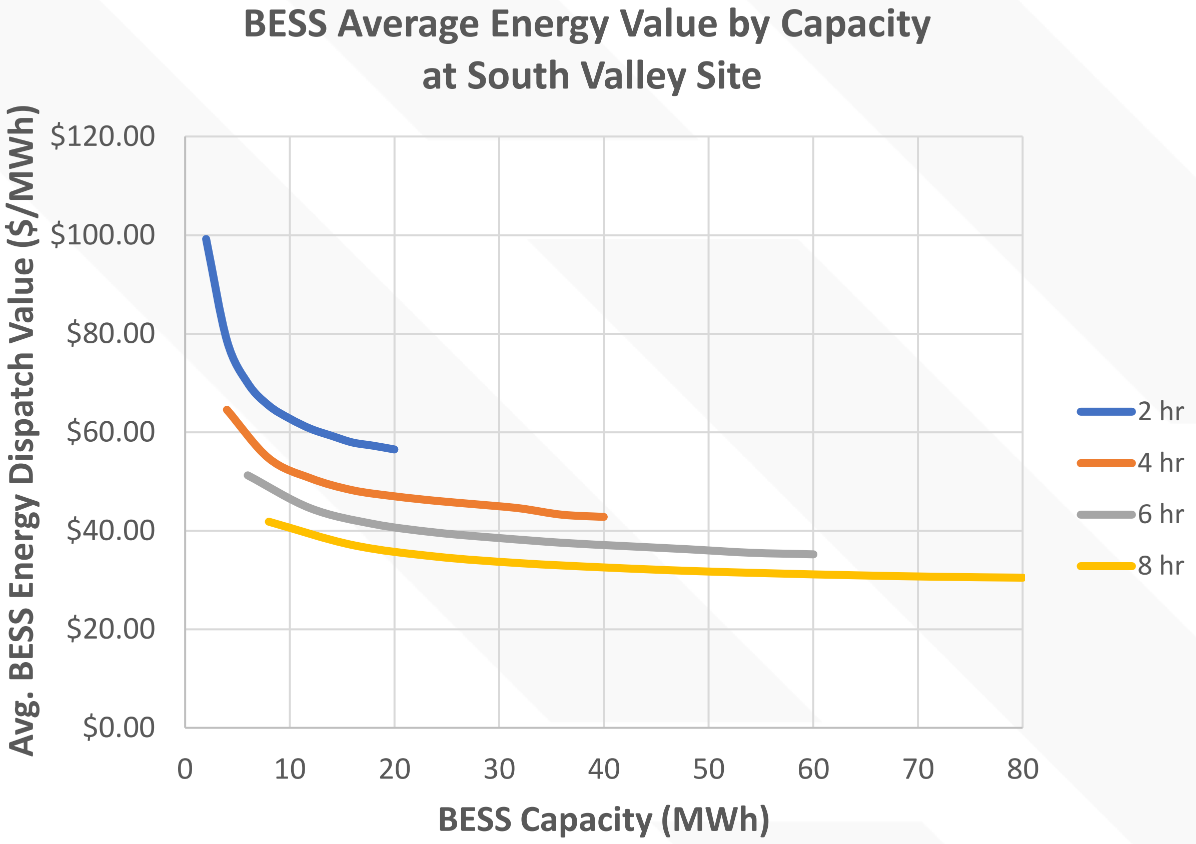
BESS Configuration
4 MW | 4 hr

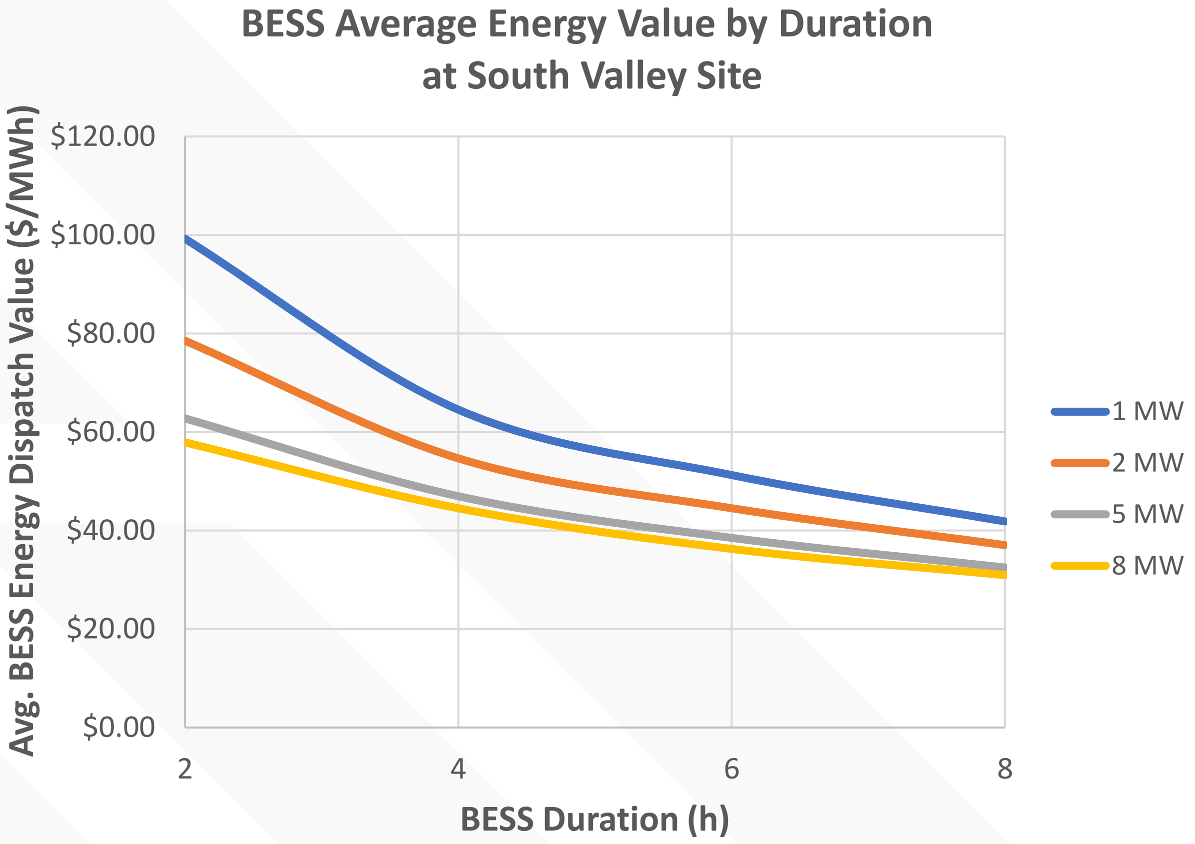
BESS Configuration
2 MW | 8 hr

Preliminary Economic Analysis

Model Results – Time Series Model

South Valley / South Coors 12

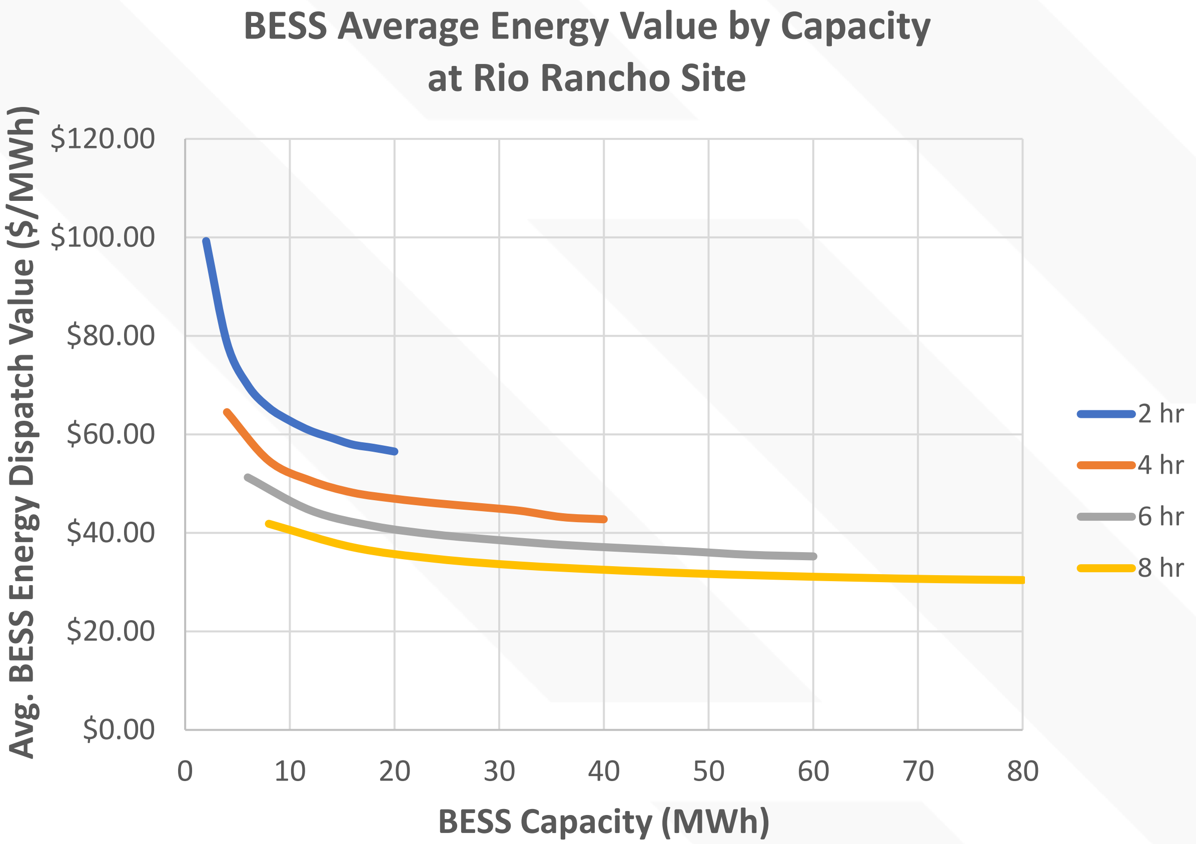


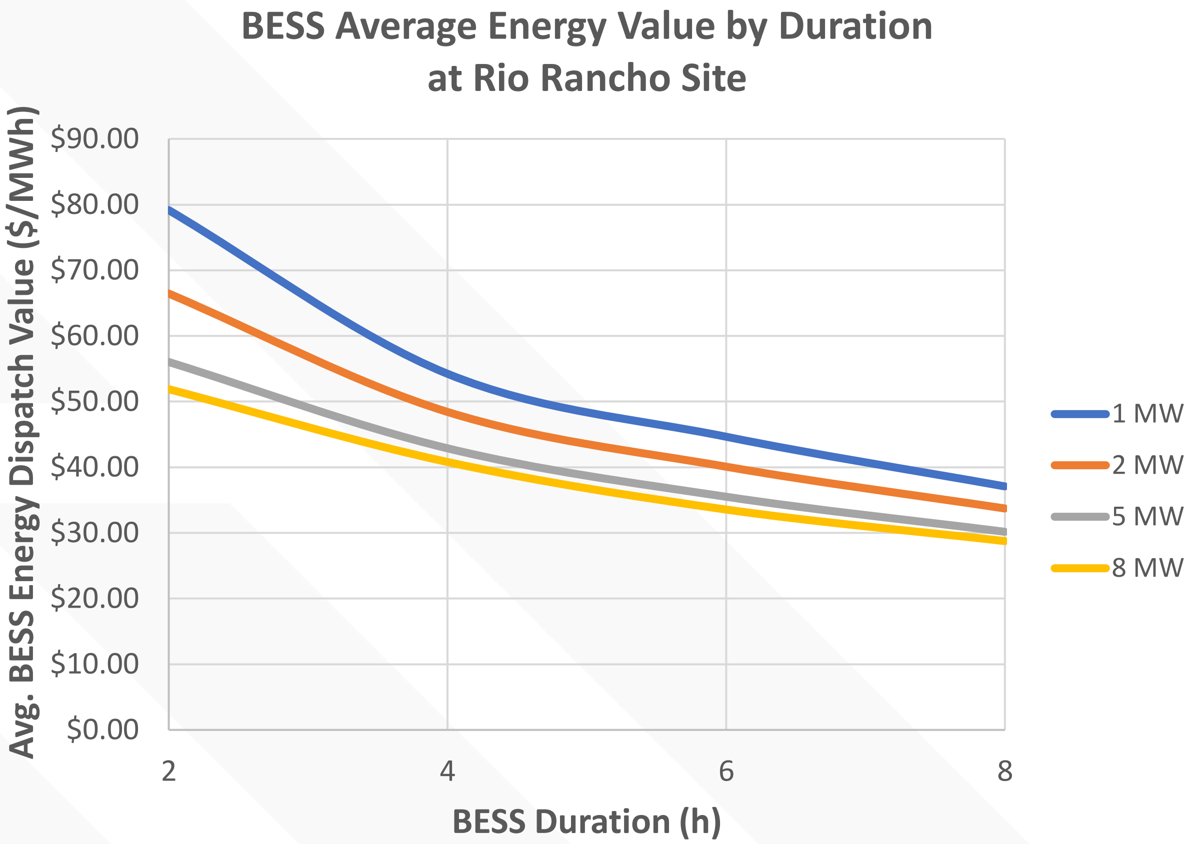


Preliminary Economic Analysis

Model Results – Time Series Model

Rio Rancho / Scenic 12

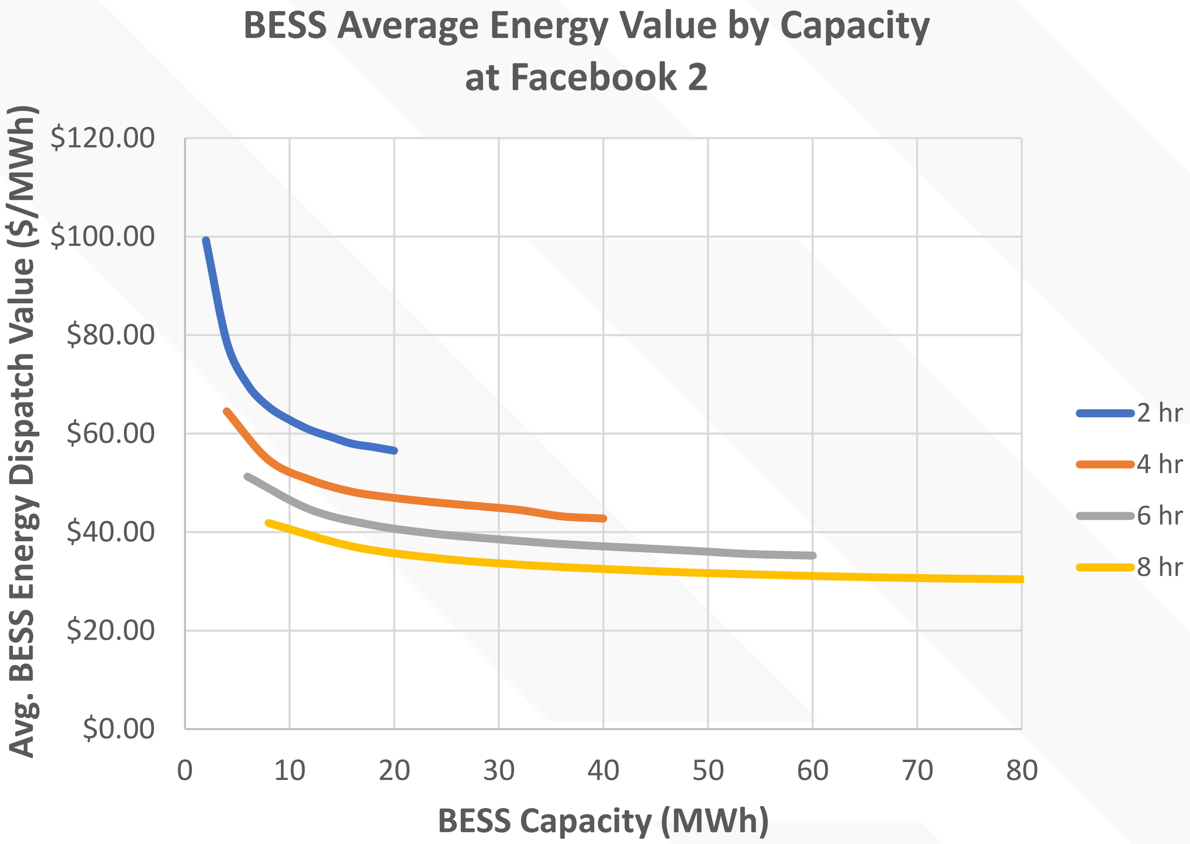


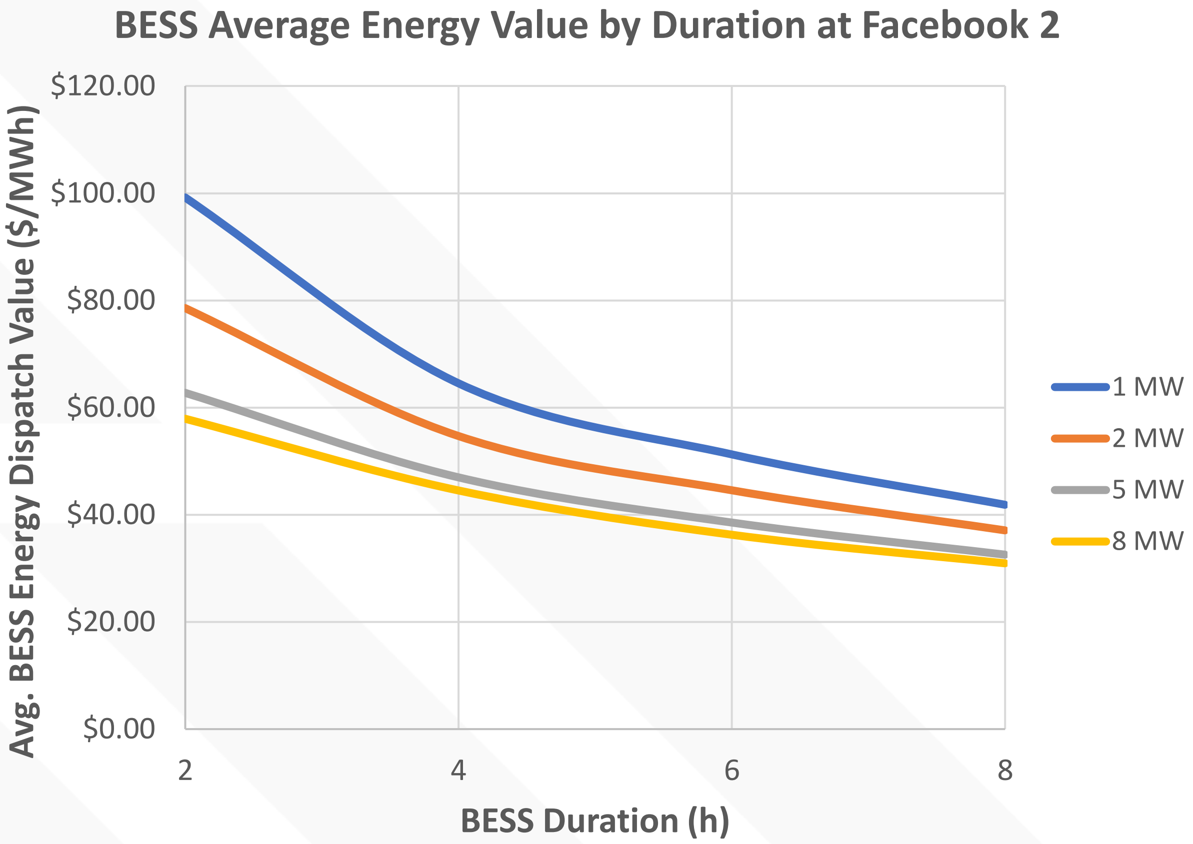


Preliminary Economic Analysis

Model Results – Time Series Model

Facebook 2 / Lost Horizon 12

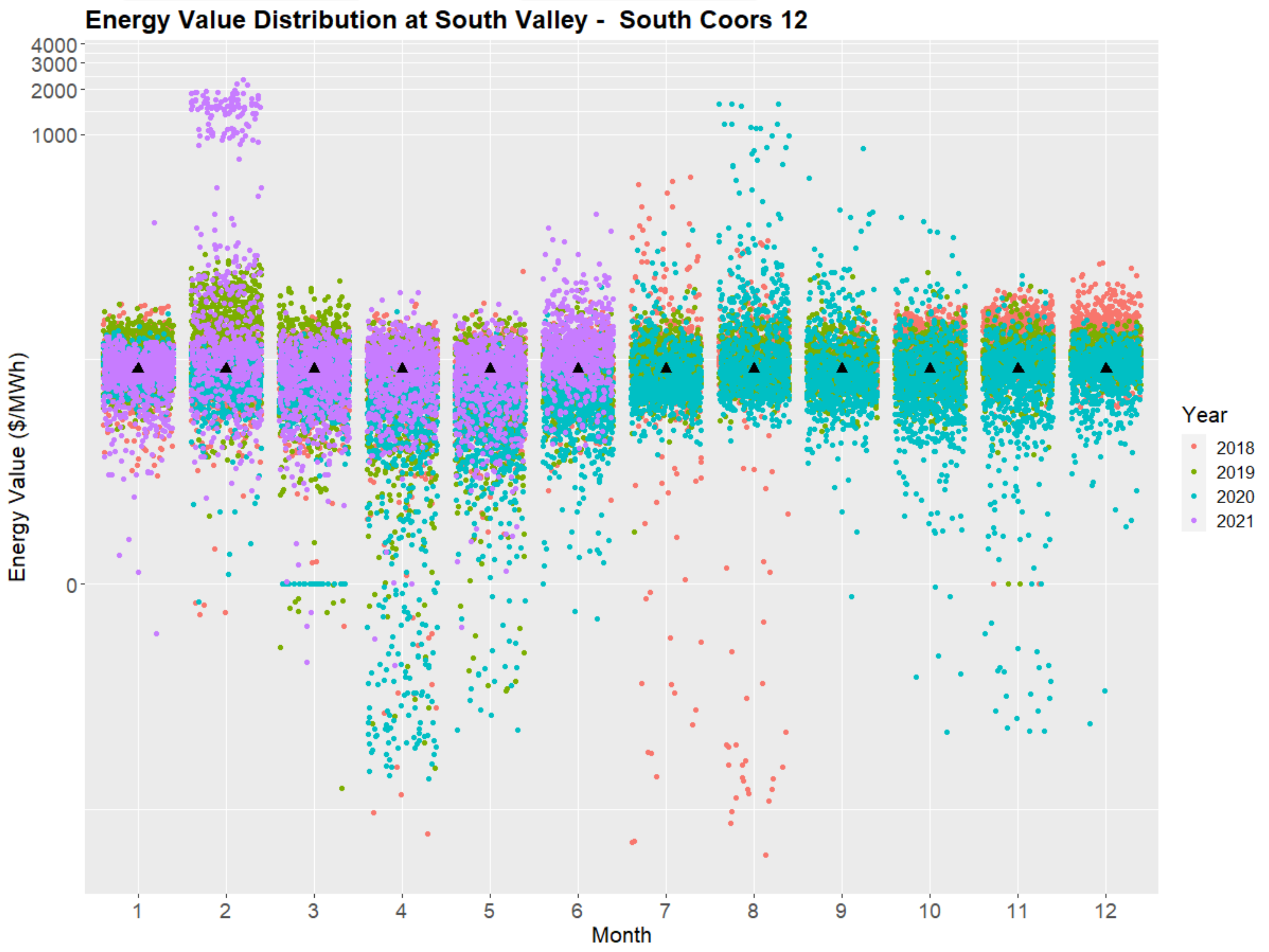




GRAPHICS APPENDIX

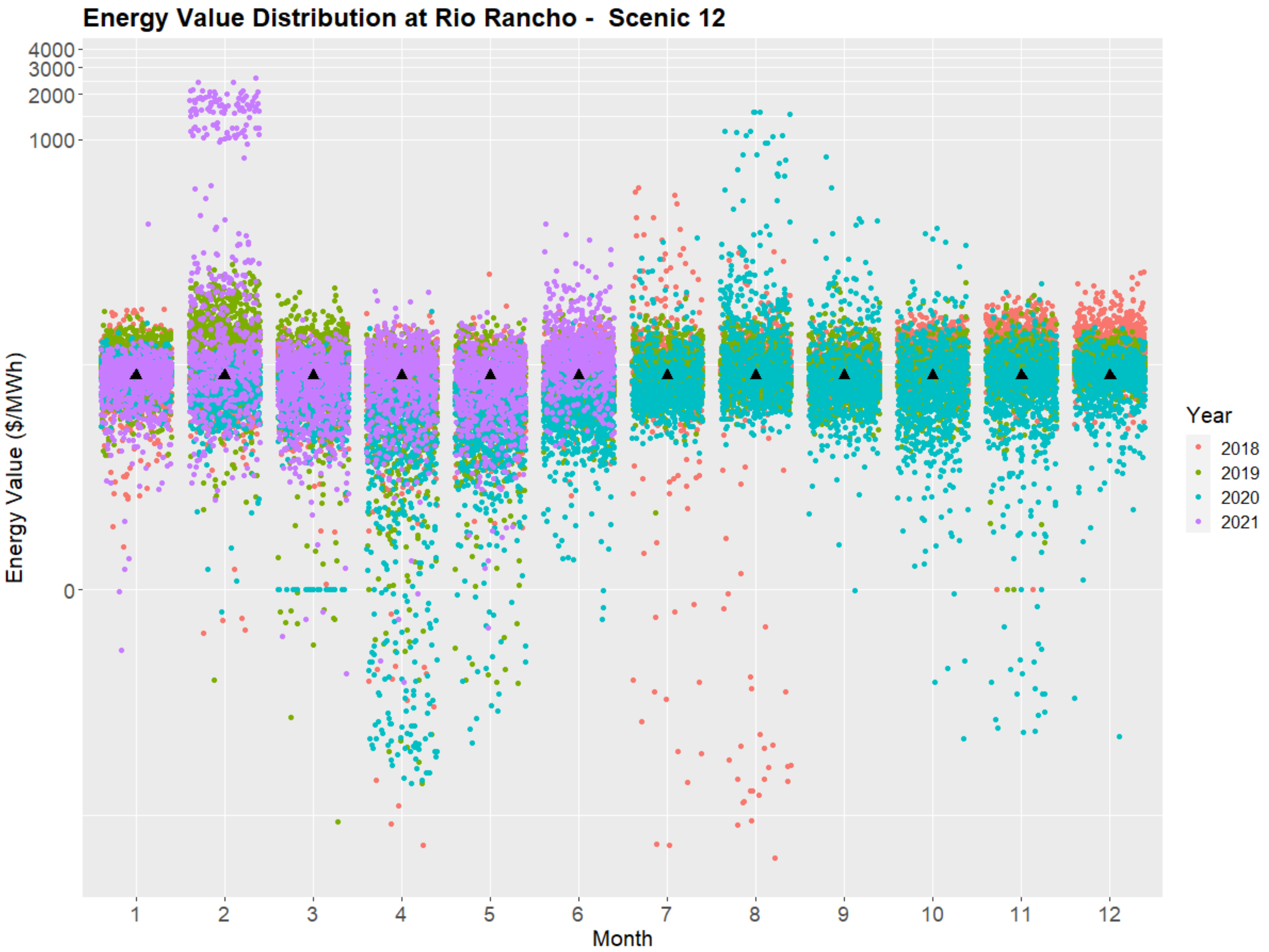
Preliminary Economic Analysis

Model Inputs



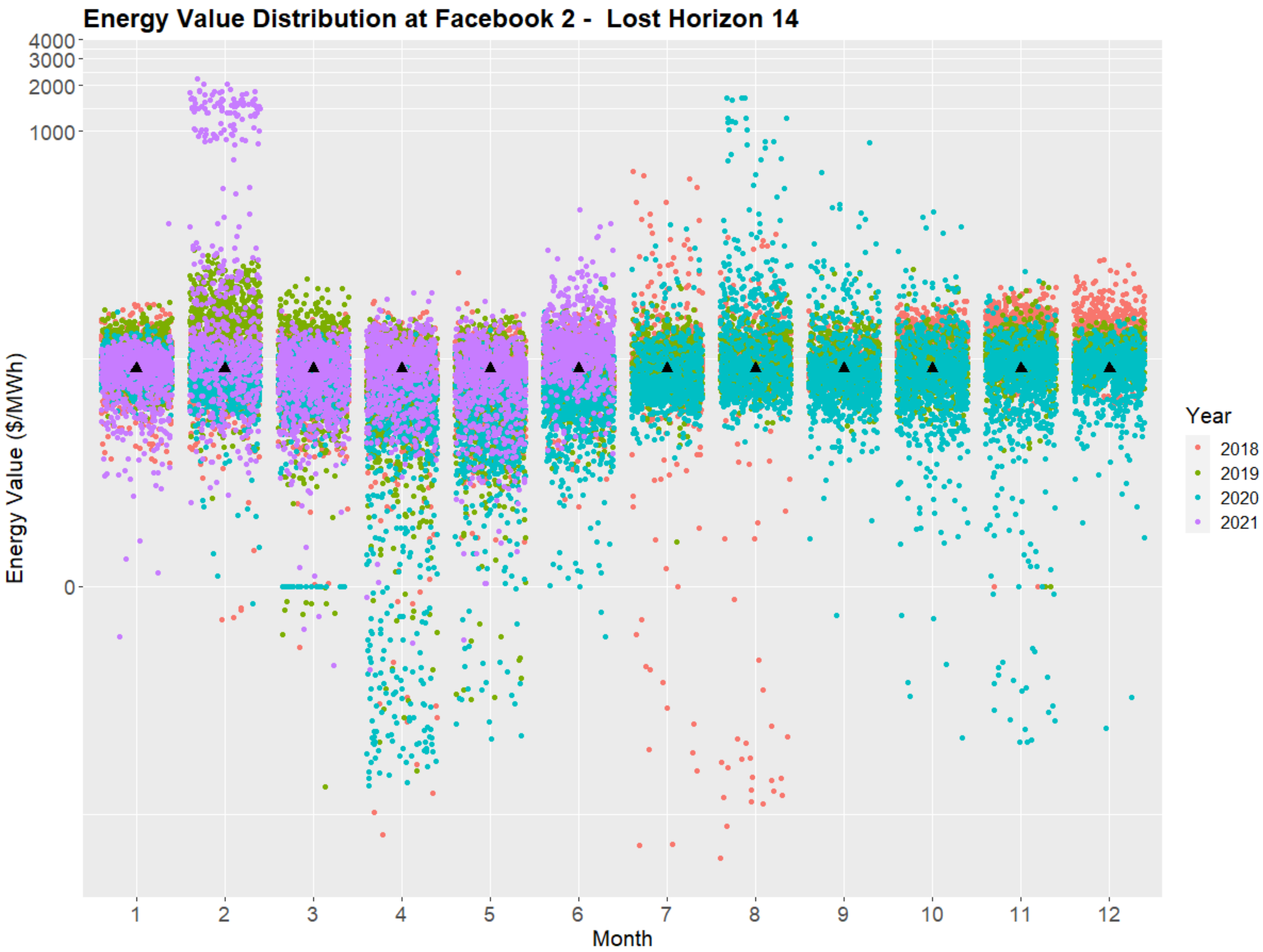
Preliminary Economic Analysis

Model Inputs



Preliminary Economic Analysis

Model Inputs



CREATE AMAZING.

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F 816-333-3690
www.burnsmcd.com

PNM Exhibit LM-3

Is contained in the following 6 pages.

PNM 6MW/24MWh BESS Cost Estimate

PNM

6MW/24MWh BESS
Greater Albuquerque

Project No. 147387

19 August 2022

CLASS 4 CAPITAL COST ESTIMATE
PNM
BESS
6MW/24MWH BESS
Greater Albuquerque Area, New Mexico
BMcD #147387

Area / Discipline	Total Cost
Engineered Equipment	$169,000
Civil, Structural & Architectural	$593,000
Electrical & I&C	$627,000
Total Direct Cost	**$1,389,000**
Engineering, CM, Start-up, Commercial	$1,066,000
Total Indirect Cost	**$1,066,000**
Total Project Cost	**$2,455,000**

Rev.	**Rev. Date**
0	08/19/22

BURNS McDONNELL

V 4.0

BESS EPC Cost Estimate
Scope Assumptions/Clarifications

General Project Information	
Project Description:	6MW / 24MWh Li-Ion Battery Energy Storage System
Site Location:	Valencia, Bernalillo, Sandoval and Santa Fe Counties, New Mexico
Battery Manufacturer:	Powin Stack750 Centipede procurement not included. Installation only.
PCS Manufacturer:	SMA PCS procurement not included. Installation only.
Escalation:	No escalation on material nor labor.
Labor Agreement/PLA:	Open shop
Scope Basis / Assumptions	
General:	Pricing includes engineering, procurement, and construction.
	Estimates, schedules, forecasts, and projections prepared by BMcD are opinions based on BMcD's experience, qualifications, reference projects, historical information, and judgement as a professional. Since BMcD has no control over weather, labor or material availability or cost, and other factors affecting such estimates or projections, BMcD does not guarantee the actual rates, costs, quantities, performance, schedules, etc. will not vary significantly from estimates and projections prepared by BMcD. BMcD estimates shall not be offers to sell.
	This cost estimate applies to a single 6 MW / 24 MWh BESS located at one of the following sites in the New Mexico counties listed below on an individual basis: Rio Del Oro in Valencia County. South Valley in Bernalillo County. Manzano in Valencia County. Rio Rancho in Bernalillo County. Sandoval in Sandoval County. Sante Fe in Sante Fe County. Santolina in Bernalillo County.
Schedule:	No provisions have been made nor allowances included in the pricing for any unexpected work stoppages due to pandemics, executive orders, etc.
	Pricing is based upon Contractor being provided full and clear access to the work areas, assuming no restrictions as a result of Owner permitting or other Owner requirements.
	Pricing is based upon one move in with work being continuous throughout the course of the project.
Equipment:	Batteries, PCS, and EMS equipment not included in pricing. No tariff is included in battery price.
	The basis of the engineering fee for equipment and materials procurement is Contractor's standard specifications, procurement documents, tracking processes, etc.
	Painting is in accordance with Contractor and subcontractor standards. Shop painting of equipment will be manufacturer's standard.
	In general, vendor standard equipment will be supplied (options, color, materials, etc.).
Safety:	Assumes Contractor will have site control and will be responsible for safety at the construction site. Safety individual will not be on site until underground trenching begins and will be on site periodically until the completion of the project.
Permits:	
	Permits excluded.
Environmental:	Excludes identification, relocation, protection or rehabilitation of archeological, cultural or historical artifacts, wetlands, fish and wildlife or wildlife habitats, or threatened and endangered species in price.
	Price does not account for delays or costs associated with delays resulting from archeological or biological remediation or construction activity restrictions.
Zoning:	Excluded.
	Pricing assumes appropriate easements will be provided. Land acquisition is excluded.
Maintenance Equipment:	Mobile maintenance equipment and safety gear for Owner staff during construction is excluded.
Warranty:	Pricing is based on a 12 month Materials and Workman warranty from Substantial Completion.
	Extended warranty on equipment is excluded.
Overbuild:	Excluded.
Augmentation:	Excluded.
General:	
Tie-ins:	
Water Supply:	Excluded.
Construction Facilities:	
Construction Power:	Pricing assumes that temporary 480V power will be supplied by the Owner. Owner will be responsible for the cost of purchasing utility power. Contractor will be responsible for distributing power as needed to support construction activities and will supply construction power transformers, distribution boards, and cable.
Construction Water:	Pricing assumes adequate construction water source is available at perimeter of site.
Spare Parts:	Excluded.
Permanent Cranes:	Permanent cranes, hoists, and/or mobile lifting equipment are excluded.
Civil:	
	Civil pricing includes foundation excavations, utility excavations, fine grade and finish stone, laydown area, bollards, and erosion control. Estimate assumes a flat site; preliminary civil design has not been incorporated.
Surveys:	Included.
Existing Facilities:	Demo/removal of existing facilities is excluded.
Disposal of Spoils:	Excavated soils not used for site grading or backfill will be stockpiled on site or disposed of by Owner.
Soil Conditions / Stability:	Suitable fill and backfill material are assumed to be available onsite. Imported offsite material is excluded.

BESS EPC Cost Estimate
Scope Assumptions/Clarifications

Shoring:	It is assumed that side slopes of excavations can be safely sloped without the use of shoring. Costs for shoring are excluded.
Underground Obstructions:	No provisions have been made or allowance included for the modification, removal, repair or relocation of any unidentified underground obstructions at the site: nor for any delays or loss of productivity due to any such obstructions.
Soil Contamination:	No cost has been included for offsite disposal of any contaminated/non-contaminated soils or other hazardous material, including asbestos, lead paint, and any fluids in existing lines.
Subsurface Rock:	It is assumed that excavation of soils, rock and other material encountered can be completed with conventional construction equipment. Blasting of rock or removal of any other underground obstructions is excluded. It is assumed the use of rock coring equipment or tools will not be required.
Dewatering:	The water table is assumed to be below the bottom of all foundations, and underground utilities. An engineered dewatering system is excluded. Dewatering with temporary sump pumps located in excavations is assumed to be adequate. Discharge permits and testing is excluded.
Permanent Project Stormwater Control:	Stormwater collection, monitoring, and detention is excluded.
Oil Water Separator:	Excluded.
Transformer Containment:	Excluded.
Site Access:	Assume site has legal, improved access from freeways or major roadways with no size or weight restrictions for type of equipment expected. Assumes no improvements to existing roads will be required for site access.
Roads/Surfacing:	Roads included assumed to be crushed rock. Area around BESS and project substation assumed to have crushed rock surfacing
Construction Parking & Laydown:	Assumes Owner provides adequate area for parking and laydown. Assumed that entire areas for construction laydown, parking and other temporary facilities required for execution of the Work will be available solely for Contractor's use.
Site Security:	
Permanent Fencing:	Excluded.
Background Checks:	It is assumed that project labor will not be subject to background checks, obtaining a security clearance, or other screening not typical on a commercial construction site.
NERC/CIP:	It is assumed that this site is not governed by NERC/CIP. No considerations to CIP cyber or physical security have been included.
Landscaping:	No provisions for landscaping have been provided.
Retaining Walls:	Excluded.
Stabilization:	Native re-vegetation is assumed considering Landscaping comment above.
Structural:	
Steel Structures:	N/A.
BESS Foundations:	A frost depth of 1'-6" has been assumed. Each battery string is assumed to be supported on a 2'-0" thick concrete mat foundation. Each PCS skid and switchgear is assumed to be supported by individual 2'-0" thick mat foundations. An equipment pad 2'-0" thick is also provided. Flooding was assumed to not be a design consideration.
Soil Bearing Capacity:	Maximum allowable soil bearing capacity for shallow foundations is assumed to be 1,500 psf with total settlement of 1 inch or less and differential settlement of 1/2 inch or less across 50 ft.
Soil Conditions:	Assumed that site soil conditions are non-expansive and will not require over-excavation or stabilization to provide a suitable, stable bearing surface. Soil remediation or soil improvement programs are excluded. Ground water is assumed to be located greater than 17 ft below existing grade. Low to moderate sulfate corrosion potential relative to concrete. Moderate corrosion potential to ferrous metal.
Geotechnical:	
Site Investigation:	Existing geotechnical reports titled *Geotechnical Investigation & Pile Load Testing* by Earthworks Engineering Group, LLC dated May 1, 2015 (EEG project number A15-193) and *Geotechnical Engineering Report*, Pajarito 345kV Substation Cut-In Project, Bernalillo County, New Mexico, September 8, 2021, Terracon Project No. 66215074 are referenced.
Concrete:	Concrete is normal weight with minimum compressive strength of 4,500 psi and Type I, II, or I/II cement.
Liquefaction:	Liquefaction and lateral spread have been assumed to not be design considerations and any mitigation or design impact is excluded.
Wind Loading:	Risk Category II assumed. Wind speed per ASCE 7-16 wind maps. Exposure C assumed.
Architectural:	
Building:	N/A.
Access Doors:	N/A.
Occupancy Classification:	N/A.
Access/Egress Requirements:	N/A.
Temporary Office Space:	N/A.
Warehouse Facilities:	N/A.
Maintenance Shop:	N/A.
Mechanical:	
Fire Hydrants:	Underground fire piping and hydrants is excluded.
Fire Protection:	Excluded. Fire protection assumed to be integral to the Powin products.
Water Storage:	
Service/Fire Water Storage:	Excluded.
Potable Water Storage	Excluded.
Noise Control:	
Noise Control:	Excluded.

BESS EPC Cost Estimate
Scope Assumptions/Clarifications

Electrical:	
Inverter Step-up Transformers:	Excluded. PNM to provide SMA PCS skid.
Grounding:	A grounding system consisting of ground rods and interconnecting copper conductors is included.
Lighting:	Street lighting included.
Lightning Protection:	Not included.
Aux Power:	Aux power will be provided via collector substation for charging and BESS for discharging. Station service transformers and 480V switchboards will distribute aux power to all necessary equipment.
Site Conditions:	It is assumed that the soil will have sufficient thermal and electrical conductivity that underground conductors and grounding system will not be required to be oversized beyond the minimum NEC and IEEE requirements.
Testing:	Insulation resistance testing is included.
Existing Facilities:	None assumed.
Cables:	Copper conductors are used for all cables.
Cables:	Copper windings are assumed for all transformers.
Cables:	Assumes pre-cut cables (2 kV dc cables, aux power cable and comms cable) will be provided by Powin for all cables connecting from the collector segment to each of the battery segments. Cost estimate only includes installation for these cables.
Controls:	
Plant Control System:	EMS hardware, is assumed be integral to the Powin Centipede and provided by owner. Not included.
Meteorological Station:	Excluded.
Dispatch:	Excluded.
Off-Site Monitoring:	Excluded.
Switchyard Control:	Excluded.
Transmission / Interconnection:	
Substation:	Project substation (engineering, procurement, construction) costs are excluded.
Interconnection to Project Substation:	No additional cabinet provided. Assumes existing switchgear lineup will contain meter and networking switches.
Commissioning:	
Factory Acceptance Testing:	Excluded.
Commissioning/Support:	EPC Contractor support and oversight included in estimate pricing for equipment provided by EPC Contractor. BESS commissioning, including EMS, assumed to be by Powin and is not included in this estimate.
Performance Testing/Support:	BESS performance testing is assumed to be by Powin/PNM, and is not included in this estimate.
	Performance Testing per NETA ATS is excluded.
BESS:	
Number of Racks (BOL):	19 Battery Segments per Centipede, two Centipedes.
Number of Racks (EOL):	19 Battery Segments per Centipede, two Centipedes.
Number of Inverters (BOL):	1 SMA inverter per Centipede, two Centipedes.
Number of Inverters (EOL):	1 SMA inverter per Centipede, two Centipedes.
Other:	
Tax/Duty/Insurance:	Taxes, duties, and builder's all risk insurance has been excluded from the estimate.
Freight:	Includes freight for all material to site.
O&M:	Excluded.
Miscellaneous:	
	No allowances have been included for Hazards Analysis and/or Operability Studies.
	No allowances have been included for any harmonics studies or the addition of any filtration required to compensate for system harmonics.
	Revenue metering excluded.
	No allowance has been included for grounding transformers (zig zag transformers).
	Power factor at the AC terminals of the inverter has been assumed to be acceptable based on a 0.95 power factor requirement at the POI. No allowance has been made for capacitor banks.
	Scope assumes a location outside of flood zones and volcanic zones, and assumes the location is not contaminated with any hazardous substances or pollutants.
	Redundancies are excluded.
	Special inspections are excluded.

BURNS & McDONNELL

CREATE AMAZING.

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PNM Exhibit LM-4

Is contained in the following 31 pages.

STATEMENT OF QUALIFICATIONS

ENERGY STORAGE

Whether technology advancements, regulations or incentives are driving you to an energy storage solution, you need a capable energy partner that can meet your growing needs.

Completing more than 100,000 megawatt hours (MWhs) of battery storage projects, **Burns & McDonnell is that partner**. We use time-tested approaches to weigh any and all technologies to find the solution that meets your needs. We approach projects through a construction lens. As a full-service integrated EPC contractor, we utilize our vertically integrated, in-house team to execute the engineering, environmental, procurement and direct-hire construction of energy storage and substation scopes. Our integrated EPC team has knowledge and experience in all facets of project execution and development including environmental evaluations, interconnection studies, and project execution.


HV ROOM

RANKED NO. 1 IN POWER

Experience leveraged on your projects

With ***Engineering News-Record (ENR)*** **ranking us No. 1 in Power**, we have experienced professionals for virtually every aspect of your project. We have led groundbreaking projects, including **leading some of the largest battery storage projects in the World**. As one of only a few firms offering the full suite of services to take energy storage projects from conception to energization to transmission while completing everything in between, we will leverage our lessons learned, mitigate risks and solve your challenges with a big-picture approach. We bring that experience and tailor our processes to operate as an extension of your staff to achieve solutions that solve your challenges and meet your energy storage needs.

INTEGRATED EPC FIRM

Integrated approach streamlines project delivery

With the diverse technical knowledge and capabilities of our engineers and construction professionals, all in house, you will receive an efficient, holistic plan for optimizing your energy storage assets that also incorporates your systemwide goals. With **significant in-house construction, engineering, thermal management, fire protection and retrofit experience**, we are your single source to complete your project each step of the way. Our integrated EPC team has knowledge and experience in all facets of project execution and development including environmental evaluations, interconnection studies, and project startup and commissioning.

BATTERY STORAGE EXPERIENCE

Vendor agnostic system integrator

Completing more than 100,000 MWhs of battery storage projects, we have the experience to design long-term assets for you that are tailored to your use case and your site constraints. We work with tier one manufacturers day in and day out to integrate different storage solutions for a wide range of applications and customers. Because we are vendor-agnostic with no loyalty to a specific manufacturer, we can help you choose the right technology for your project.

TOP SAFETY RECORD

No incidents; everyone goes home safely

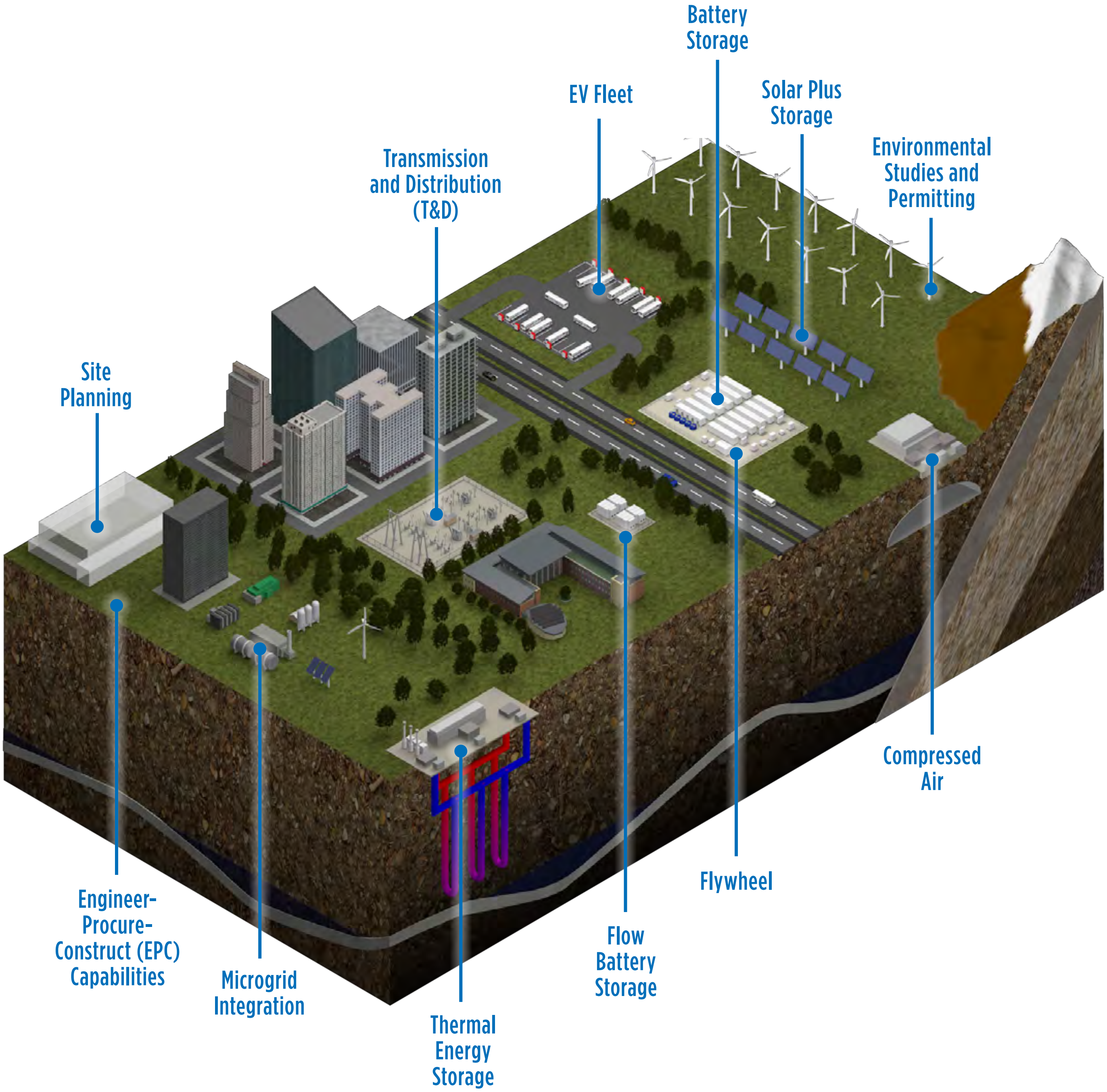
Our safety commitment goes beyond reporting the numbers. It is our intrinsic expectation that everyone working on a project goes home safely to their families every night — our employee-owners, subcontractors and those who work with our partners. This core belief and integrated Corporate Safety & Health Program has resulted in **more than 92 million man hours over the past five years with a total recordable incident rate of 0.16**. By choosing our team with a demonstrated commitment to the safety of the craft, staff, subcontractors, city and public, you can be confident your project will be delivered on schedule and within budget.

RANKED
#1
IN POWER
BY *ENR* 2021

RANKED
#1
IN ELECTRICAL DESIGN
BY *ELECTRICAL CONSTRUCTION AND MAINTENANCE*

RANKED
#2
TOP SOLAR & STORAGE INSTALLLERS BY SOLAR POWER WORLD

RANKED
#9
TOP 500 DESIGN FIRMS BY *ENR*


Battery Storage
EV Fleet
Solar Plus Storage
Transmission and Distribution (T&D)
Environmental Studies and Permitting
Site Planning
Compressed Air
Flywheel
Engineer-Procure-Construct (EPC) Capabilities
Flow Battery Storage
Microgrid Integration
Thermal Energy Storage

OWNER'S ENGINEER (OE)

It takes broad experience to see projects from a variety of perspectives. And knowing where to look is the first step in identifying areas of risk. By analyzing potential risks, we help you make the best decisions and investments possible. As owner's engineer, we serve as an extension of your staff to see that your plans are followed, and that your needs and expectations are met.

EPC

Ideal for fast-track projects, our integrated EPC delivery reduces owner risk, shortens project schedules, provides a single point of contact, increases cooperation, reduces owner staffing, and establishes an environment for design and construction innovation. We leverage our direct hire construction capabilities from our union and non-union subsidiaries AZCO and Ref-Chem as well as long-term relationships with trusted vendors and contractors to keep the project moving.

DETAILED DESIGN

From lithium-ion (li-ion) to compressed-air energy storage to flow batteries, we can support the design of your next energy storage facility. We will see your projects from preliminary design through construction, creating comprehensive and quality design products. We're familiar with a variety of storage options and have developed designs for projects up to 1,000 megawatts (MW).

SYSTEM INTEGRATION

Our advanced technology integration lab enables hands-on testing of various scenarios, including installation of new battery and inverter controls and integration of specific controls with the existing station. Such lab testing gives you intimate knowledge of operation, energy management systems and communications before going live, allowing you to meet aggressive schedules with the confidence that your system will function as planned, now and well into the future.

PROGRAM MANAGEMENT

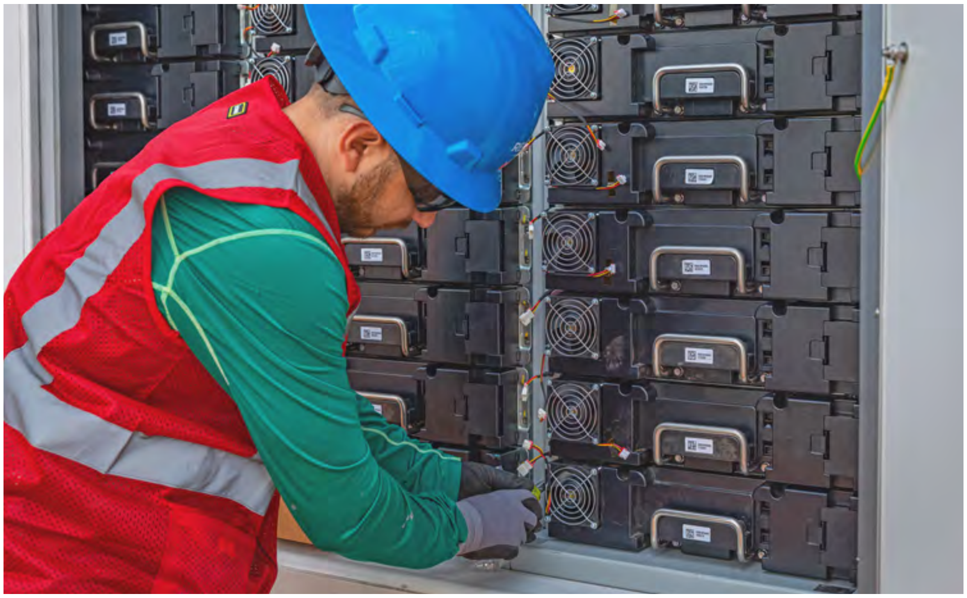
Through program management, our team integrates with yours as a trusted partner and extension of your staff. We'll help you coordinate project planning, design and construction services at all stages so you can remain focused on your core business. We work with you to select consultants and subcontractors, administer contracts, track schedules and budgets, assist with labor relations, implement safety programs, coordinate with federal, state and local agencies, and manage public relations.

ENVIRONMENTAL AND INTERCONNECTION SUPPORT

Understanding how your project interacts with and effects the environment is key to meeting the various federal and local regulations/policies. Our team has worked with various agencies across the country and knows how to meet environmental needs for any type of project, performing mitigation, surveying, siting studies and permitting services. We'll continue to monitor the status throughout the construction and startup phases.

LI-ION BATTERY STORAGE

With Li-ion battery prices dropping, more clients are realizing the flexibility of this technology for power generation, T&D and behind-the-meter systems. You can pair Li-ion battery storage systems with wind, solar or gas generation to provide you flexibility and optimize your facility's operation or provide black start capabilities to restore the grid when the power goes out or provide ancillary services to the grid. When considering a T&D upgrade, batteries can defer these costs or provide alternative benefits in a given area. Lastly, whether you are looking at demand charge reduction, backup power for outages, power quality improvement or any number of benefits, pairing storage at a facility can be useful for many owners.



FLOW BATTERY STORAGE

As the energy storage market is looking for eight-hour, 12-hour, or even days of storage, other technologies, such as flow batteries are being considered for these applications. Given their capacity for high cycle counts, potential decoupling of power and energy ratings of the storage device, and limited or no degradation, flow batteries are beginning to be considered in applications where they fit the use case. We have worked with various original equipment manufacturers (OEMs), chemistries and owners on conceptual scaling up and design for large flow batteries systems that fit utility-scale applications.

THERMAL MANAGEMENT AND COMPUTATIONAL FLUID DYNAMIC ANALYSIS

Thermal management for any battery energy storage system is essential for both for the day-to-day operation and of the system, including adherence to manufacturer warranties. However, thermal management systems can also be expensive to implement at large scale battery energy storage sites. Designing the right system for your batteries can be challenging due to the variety of cooling requirements from different battery manufacturers. With our extensive experience designing thermal management system for battery racks from all of the major battery manufacturers and designing systems for everything from single rack enclosures to full scale buildings, we help determine the best performing and most cost effective solution for your application. We leaverage in-house computational fluid dynamics (CFD) analysis capabilities to develop customized thermal management solutions and to identify and address potential HVAC performance issues long before the site is operational.

OTHER STORAGE OPTIONS

While the energy storage market grows rapidly, we are leveraging our diverse client base to understand the future of energy storage. While we may not know the exact technology that will be utilized in the future, we are actively working on pilot projects and understanding the development of new storage technologies including pumped hydro, compressed air, cryogenic or liquid air, thermal energy storage, hydrogen and gravitational energy storage systems.

BURNS McDONNELL

BESS PROJECT **EXPERIENCE MATRIX**

Energy Storage Experience Matrix

							Services Provided												
Client Name	**Project Name**	**Project Location**	**Technology**	**System Type**	**ESS (MW)**	**ESS (MWh)**	DEVELOPMENT	TECHNOLOGY ASSESSMENT / REVIEW	COST ESTIMATE / FINANCIAL ANALYSIS	RFP PREPARATION / EVALUATION	SPECIFICATIONS DEVELOPMENT	OWNER'S ENGINEER	FIELD SUPPORT	ENVIRONMENTAL STUDIES / PERMITTING	PRELIMINARY DESIGN / SITE LAYOUTS	ENGINEERING AND DETAILED DESIGN	EPC	**ISO**	**Project COD**
Confidential	Confidential	Kern County, CA	Lithium	BESS+PV	300	600						•							2023
Confidential	Confidential	Tulare County, CA	Lithium	BESS	180	540						•			•	•			2022
Confidential	Confidential	Kern County, CA	Lithium	BESS	500	2000						•			•	•			2022
Confidential	Confidential	Kern County, CA	Lithium	BESS	50	150						•			•	•			2022
Confidential	Confidential	Moorpark, CA	Lithium	BESS	500	2000	•	•	•						•			CAISO	TBD
Confidential	Confidential		Lithium	BESS	100	400			•						•				N/A
Confidential	Confidential	Clark County, NV	Lithium	BESS	80	330	•								•	•			TBD
Confidential	Confidential	Banning, CA	Lithium	BESS	65	130	•								•	•		CAISO	2022
Confidential	Confidential	Yonkers, NY	Lithium	BESS	100	200		•	•	•					•			NYISO	2025
Confidential	Confidential	Brooklyn, NY	Lithium	BESS	300	1200		•	•	•					•			NYISO	2025
Confidential	Confidential	Milford, CT	Lithium	BESS	200	400	•								•				TBD
Confidential	Confidential	Catskill, NY	Lithium	BESS	100	400	•								•				TBD
Confidential	Confidential	Caroline County, VA	Lithium	BESS	200	800	•								•				TBD
Confidential	Confidential	Prince William County, VA	Lithium	BESS	200	800	•								•				TBD
Confidential	Confidential	Botetourt County, VA	Lithium	BESS	100	400	•								•				TBD
Confidential	Confidential	Hidalgo County, TX	Lithium	BESS	200	250						•						ERCOT	2021
Confidential	Confidential	West Medway, MA	Lithium	BESS	250	500	•								•			ISO-NE	2024
Confidential	Confidential	Salt Lake City, UT	Lithium	BESS	400	800	•								•				
Confidential	Confidential	Eagle Mountain, UT	Lithium	BESS	400	800	•								•				
Confidential	Confidential	Mona, UT	Lithium	BESS	400	800	•								•				
Confidential	Confidential	West Jordan, UT	Lithium	BESS	400	800	•								•				
Confidential	Confidential	Romoland, CA	Lithium	BESS	150	187.5	•								•				2023
Confidential	Confidential	Anaconda, MT	Lithium	BESS	150	600	•								•				
Confidential	Confidential	Big Sky, MT	Lithium	BESS	30	150	•								•				
Confidential	Confidential	Billings, MT	Lithium	BESS	30	150	•								•				
Confidential	Confidential	Bozeman, MT	Lithium	BESS	30	150	•								•				
Confidential	Confidential	Great Falls, MT	Lithium	BESS	150	600	•								•				
Confidential	Confidential	Helena, MT	Lithium	BESS	30	150	•								•				
Confidential	Confidential	Missoula, MT	Lithium	BESS	30	150	•								•				
Confidential	Confidential	Wareham, MA	Lithium	BESS	150	300	•								•				2023
Confidential	Confidential	Buffalo, NY	Lithium	BESS	150	300	•		•					•	•				2023
Confidential	Confidential	Frederickson, WA	Lithium	BESS	100	400	•								•				
Confidential	Confidential	Danvers, MA	Lithium	BESS	150	300	•								•				N/A
Confidential	Confidential	Billerica, MA	Lithium	BESS	150	300	•		•						•				2023
Confidential	Confidential	Licking County, OH	Lithium	BESS	200	800	•								•				2024
Confidential	Confidential	Dallas, TX	Lithium	BESS	100	100					•								TBD
Confidential	Confidential	Dallas, TX	Lithium	BESS	100	100						•						ERCOT	2021
AEP	Energy Storage Warehouse	Columbus, OH	Lithium	BESS	0.25	5										•		PJM	N/A
AEP	Ohio BESS	Athens, OH	Lithium	BESS	1	5	•				•				•	•		PJM	2021
AEP/Mid American	Cat K Battery Storage Facility (NaS)	Presidio, TX	NaS	BESS	4	32										•	•	ERCOT	2010
AES	Salt River Project	Gilbert, AZ	Lithium	BESS	10	40						•	•						2019

Energy Storage Experience Matrix

							Services Provided												
Client Name	**Project Name**	**Project Location**	**Technology**	**System Type**	**ESS (MW)**	**ESS (MWh)**	DEVELOPMENT	TECHNOLOGY ASSESSMENT / REVIEW	COST ESTIMATE / FINANCIAL ANALYSIS	RFP PREPARATION / EVALUATION	SPECIFICATIONS DEVELOPMENT	OWNER'S ENGINEER	FIELD SUPPORT	ENVIRONMENTAL STUDIES / PERMITTING	PRELIMINARY DESIGN / SITE LAYOUTS	ENGINEERING AND DETAILED DESIGN	EPC	**ISO**	**Project COD**
AES	Alamitos	Long Beach, CA	Lithium	BESS	100	400						•						CAISO	2020
Confidential	Confidential	, AZ	Lithium	BESS+PV								•				•			
Confidential	Confidential	, AZ	Lithium	BESS+PV								•				•			
Confidential	Confidential	, TX		BESS	200	400	•	•	•						•				N/A
Arizona State University	Polytechnic Quad III Microgrid	Mesa, AZ	Lithium	BESS+PV		0.2	•				•					•			2018
Confidential	Confidential	,	Lithium	BESS	N/A	N/A	•												N/A
Confidential	Confidential	Itasca, TX	Lithium	BESS+PV	30	30	•								•			ERCOT	2023
Confidential	Confidential	Lemoore, CA	Lithium	BESS	75	300	•	•			•	•	•		•	•			2021
Confidential	Confidential	Blythe, CA	Lithium	BESS	150	600	•	•				•			•	•			2022
Confidential	Confidential	,	Lithium	BESS															
Capital Dynamics	Townsite	Boulder, NV	Lithium	BESS+PV	90	360	•			•	•							CAISO	2021
Capital Dynamics	Cal Flats	Monterey, CA	Lithium	BESS+PV	60	240	•			•	•							CAISO	2021
Capital Dynamics	Switch Core	Moapa, NV	Lithium	BESS+PV	51	204	•			•	•							CAISO	2022
Capital Dynamics	Saticoy	Ventura, CA	Lithium	BESS+PV	100	400	•			•	•							CAISO	2020
Capital Dynamics	Switch Citadel	McCarran, NV	Lithium	BESS+PV	60	240	•			•	•							CAISO	2022
Confidential	Confidential	Inyo County, CA	Lithium	BESS	60	240	•			•	•	•						CAISO	2021
Confidential	Confidential	, TX	Lithium	BESS	9.9	20	•								•			ERCOT	
Confidential	Confidential	McClellanville, SC	Lithium/Flow	BESS	2.5	20	•	•	•					•				N/A	2021
Confidential	Confidential	Santa Margarita, CA	Lithium	BESS	125	500	•								•			CAISO	TBD
Confidential	Confidential	Los Angeles County, CA	Lithium	BESS	80	320	•								•			CAISO	TBD
Confidential	Confidential	Kern County, CA	Lithium	BESS	150	600	•								•			CAISO	TBD
Confidential	Confidential	,	Lithium	BESS+PV	N/A	N/A					•								N/A
Confidential	Confidential	Valley View, TX	Lithium	BESS	300	1200	•								•			ERCOT	TBD
Confidential	Confidential	Iron County, UT	Lithium	BESS	50	250	•								•				TBD
Confidential	Confidential	Iron County, UT	Lithium	BESS	80	400	•								•				TBD
Confidential	Confidential	Iron County, UT	Lithium	BESS	80	400	•								•				TBD
Confidential	Confidential	Beaver County, UT	Lithium	BESS	80	400	•								•				TBD
Confidential	Confidential	Beaver County, UT	Lithium	BESS	80	400	•								•				TBD
Confidential	Confidential	Beaver County, UT	Lithium	BESS	80	400	•								•				TBD
Confidential	Confidential	Iron County, UT	Lithium	BESS	80	400	•								•				TBD
Confidential	Confidential	Kern County, CA	Lithium	BESS	137	548	•								•				TBD
Confidential	Confidential	Stark County, IL	Lithium	BESS	325	2600	•								•				TBD
Confidential	Confidential	Winnebago County, IL	Lithium	BESS	125	1000	•								•				TBD
Confidential	Confidential	Hopkins County, TX	Lithium	BESS	285	570	•								•			ERCOT	TBD
Confidential	Confidential	Kern County, CA	Lithium	BESS	125	500									•			CAISO	TBD
Confidential	Confidential	Los Angeles County, CA	Lithium	BESS	80	320									•			CAISO	TBD
Confidential	Confidential	Kern County, CA	Lithium	BESS	150	600									•			CAISO	TBD
Confidential	Confidential	Galveston County, TX	Lithium	BESS	300	600	•								•			ERCOT	TBD
Confidential	Confidential	Suffolk County, NY	Lithium	BESS	104	416	•								•			NYISO	
Confidential	Confidential	Suffolk County, NY	Lithium	BESS	565	2260	•								•			NYISO	

BESS PROJECT **EXPERIENCE MATRIX**

Energy Storage Experience Matrix

							Services Provided												
Client Name	**Project Name**	**Project Location**	**Technology**	**System Type**	**ESS (MW)**	**ESS (MWh)**	DEVELOPMENT	TECHNOLOGY ASSESSMENT / REVIEW	COST ESTIMATE / FINANCIAL ANALYSIS	RFP PREPARATION / EVALUATION	SPECIFICATIONS DEVELOPMENT	OWNER'S ENGINEER	FIELD SUPPORT	ENVIRONMENTAL STUDIES / PERMITTING	PRELIMINARY DESIGN / SITE LAYOUTS	ENGINEERING AND DETAILED DESIGN	EPC	**ISO**	**Project COD**
Confidential	Confidential	Pima County, AZ	Lithium	BESS	350	2800	•								•				
Confidential	Confidential	Pima County, AZ	Lithium	BESS	320	2650	•								•				
Confidential	Confidential	Galveston County, TX	Lithium	BESS	300	600	•								•				
Confidential	Confidential	Kern County, CA	Lithium	BESS	92	368	•								•				
Confidential	Confidential	Chicago, IL	Lithium	BESS	0.1	0.1						•							2020
Confidential	Confidential	El Centro, CA	Lithium/Flow	BESS	2000	8000	•	•	•									CAISO	2025
Confidential	Confidential	Middletown, NY	Lithium	BESS	10	40	•	•	•					•					2022
Confidential	Confidential	Eagle Ford, TX	Lithium	BESS+PV	45	360		•	•						•			ERCOT	N/A
Confidential	Confidential	Hampton, IA	Lithium	BESS	1.425	8.55					•	•			•	•			2022
Confidential	Confidential	Jug Fork, MS	Lithium	BESS	20	80	•	•	•						•			N/A	2024
Confidential	Confidential	Columbia, SC	Lithium	BESS	2	8	•		•						•				
Confidential	Confidential	Charleston, SC	Lithium	BESS	2	8	•		•						•				
Confidential	Confidential	Detroit, MI	Lithium	BESS+PV+Recip	1	4		•	•			•						MISO	N/A
Duke	2020 Generic Unit Study (Storage)	Charlotte, NC	Lithium/Flow	BESS	50	200		•	•			•						N/A	N/A
Duke	2021 Generic Unit Study (Storage)	Charlotte, NC	Lithium/Flow	BESS	50	200		•	•			•						N/A	N/A
Confidential	Confidential	Owensville, IN	Lithium	BESS	7.5	11.3		•	•						•				N/A
Confidential	Confidential	New York, NY	Lithium	BESS	90	360	•	•	•						•			N/A	2025
Confidential	Confidential	Desert Center, CA	Lithium	BESS+PV	35	140	•	•	•			•			•			CAISO	2021
Confidential	Confidential	Oahu, HI	Lithium	BESS	100	600	•	•	•						•			N/A	2023
Confidential	Confidential	,	Lithium	BESS+PV								•							
Entergy	Perryville Blackstart	Monroe, LA	Lithium	BESS+GT	7.5	7.5				•	•	•	•						2020
Entergy	Searcy	Search, AR	Lithium	BESS+PV	10	30						•	•						2022
Evergy	Wichita BESS	Wichita, KS	Lithium	BESS	1	4						•	•		•			SPP	2022
Confidential	Confidential	, MA	Lithium	BESS+PV			•	•	•						•				TBD
Confidential	Confidential	Urbana, MD	Lithium	BESS								•							2022
Confidential	Confidential	Mexicali, Mexico	Lithium	BESS	500	2000	•	•	•	•	•	•			•				2022
Confidential	Confidential	Mexicali, Mexico	Lithium	BESS	500	2000	•	•	•	•	•	•			•			CAISO	2024
KCPL	Smart Grid Demonstration Project	Kansas City, MO	Lithium	BESS	1	1				•	•	•	•		•	•			2015
LG Chem	Texas Trio Snyder	Snyder, TX	Lithium	BESS	10	20	•	•					•		•	•	•	ERCOT	2021
LG Chem	Texas Trio Sweetwater	Sweetwater, TX	Lithium	BESS	10	20	•	•					•		•	•	•	ERCOT	2022
LG Chem	Texas Trio Westover	Odessa, TX	Lithium	BESS	10	20	•	•					•		•	•	•	ERCOT	2023
Confidential	Confidential	Alpine County, CA	Lithium	BESS+PV	2	12	•	•	•						•			N/A	2022
Confidential	Confidential	, MO	Lithium	BESS+PV	TBD	TBD		•	•						•			SPP	2023
Confidential	Confidential	Cambridge, MA	Flow	BESS	10	100	•	•	•						•			N/A	N/A
Confidential	Confidential	Long Beach, CA	Lithium	BESS+GT	10.35	20.7			•						•				N/A
MN Power	GRPU BESS	Grand Rapids, MN	Lithium	BESS	2	5				•	•	•							2021
Confidential	Confidential	Glendive, MT		BESS	3	12	•		•					•	•				
Confidential	Confidential	Goose Pond, MA	Lithium	BESS+PV	1	2										•			TBD
Confidential	Confidential	Fort Lauderdale, FL	Lithium	BESS+GT	11.5	46					•					•		FRCC	2020
Confidential	Confidential	,	Lithium	BESS	N/A	N/A						•				•			N/A

BESS PROJECT **EXPERIENCE MATRIX**

Energy Storage Experience Matrix

							Services Provided												
Client Name	**Project Name**	**Project Location**	**Technology**	**System Type**	**ESS (MW)**	**ESS (MWh)**	DEVELOPMENT	TECHNOLOGY ASSESSMENT / REVIEW	COST ESTIMATE / FINANCIAL ANALYSIS	RFP PREPARATION / EVALUATION	SPECIFICATIONS DEVELOPMENT	OWNER'S ENGINEER	FIELD SUPPORT	ENVIRONMENTAL STUDIES / PERMITTING	PRELIMINARY DESIGN / SITE LAYOUTS	ENGINEERING AND DETAILED DESIGN	EPC	**ISO**	**Project COD**
Confidential	Confidential	Live Oak, FL	Lithium	BESS+PV	30	75					•					•		FRCC	2021
Confidential	Confidential	Pueblo, CO	Lithium	BESS+PV	125	500					•					•			2022
Confidential	Confidential	Pueblo, CO	Lithium	BESS+PV	100	400					•					•			2022
Confidential	Confidential	Alameda County, CA	Lithium	BESS	700	2800	•								•				2024
Confidential	Confidential	Valencia County, NM	Lithium	BESS	50	200										•			2023
Confidential	Confidential	Duvall County, TX		BESS	10	40	•								•				
Confidential	Confidential	Haskell, TX		BESS	10	50	•								•				
Confidential	Confidential	, CA	Lithium	BESS	130	520										•		CAISO	2023
Confidential	Confidential	, CA	Lithium	BESS	32	128										•			2023
Confidential	Confidential	Blythe, CA	Lithium	BESS								•	•						N/A
NRG	Mobile BESS	New York, NY	Lithium	BESS	1.5	3.9										•		NYISO	2022
NRG	Astoria	New York, NY	Lithium	BESS	66	264	•											NYISO	TBD
NRG	Arthur Kill	New York, NY	Lithium	BESS	80	320	•											NYISO	TBD
Confidential	Confidential	Las Vegas, NV	Lithium	BESS	24	96		•							•				2018
NYISO	Demand Curve Reset	New York, NY	Lithium	BESS	200	800		•	•									NYISO	N/A
Confidential	Confidential	Ewell, MD	Lithium	BESS	2	5					•					•			2022
Confidential	Confidential	Hot Springs, VA	Lithium	BESS	5	10					•					•			2022
Confidential	Confidential	Ocean Pines, MD	Lithium	BESS	6	12					•					•			2022
Confidential	Confidential	Sussex County, DE	Lithium	BESS	8	16					•					•			2022
Confidential	Confidential	Hopewell, VA	Lithium	BESS	5	10					•					•			2022
Confidential	Confidential	,	Lithium	BESS	26	53		•	•	•	•	•			•				2022
Confidential	Confidential	, VA	Lithium	BESS					•	•	•				•				N/A
Confidential	Confidential	Harriman, TN	Lithium	BESS	300	1200	•								•				N/A
Confidential	Confidential	Harriman, TN	Lithium	BESS	300	1200	•								•				N/A
Confidential	Confidential	Clarksville, TN	Lithium	BESS	250	1000	•								•				N/A
Confidential	Confidential	Clarksville, TN	Lithium	BESS	250	1000	•								•				N/A
Confidential	Confidential	Chesapeak County, VA	Lithium	BESS	300	1200	•								•				TBD
Confidential	Confidential	Chesapeak County, VA	Lithium	BESS	300	1200	•								•				TBD
Confidential	Confidential	Virginia Beach, VA	Lithium	BESS	300	1200	•								•				TBD
Confidential	Confidential	Loudoun County, VA	Lithium	BESS	47	188	•								•				TBD
Confidential	Confidential	Loudoun County, VA	Lithium	BESS	28	112	•								•				TBD
Confidential	Confidential	Anderson County, TN	Lithium	BESS	200	800	•								•				
Confidential	Confidential	Anderson County, TN	Lithium	BESS	100	400	•								•				
Confidential	Confidential	,	Lithium	BESS	N/A	N/A					•								N/A
Confidential	Confidential	Carver, MA	Lithium	BESS	150	300											•		2024
Confidential	Confidential	Albuquerque, NM	Lithium	BESS	150	300						•							2022
Confidential	Confidential	Albuquerque, NM	Lithium	BESS	30	120						•							2022
Confidential	Confidential	Farmington, NM	Lithium	BESS+PV	10	40							•		•	•			
Confidential	Confidential	Bernalillo County, NM	Lithium	BESS	6	24			•						•				
Confidential	Confidential	Valencia County, NM	Lithium	BESS	6	24			•						•				

BURNS McDONNELL.

BESS PROJECT **EXPERIENCE MATRIX**

Energy Storage Experience Matrix

							Services Provided												
Client Name	Project Name	Project Location	Technology	System Type	ESS (MW)	ESS (MWh)	DEVELOPMENT	TECHNOLOGY ASSESSMENT / REVIEW	COST ESTIMATE / FINANCIAL ANALYSIS	RFP PREPARATION / EVALUATION	SPECIFICATIONS DEVELOPMENT	OWNER'S ENGINEER	FIELD SUPPORT	ENVIRONMENTAL STUDIES / PERMITTING	PRELIMINARY DESIGN / SITE LAYOUTS	ENGINEERING AND DETAILED DESIGN	EPC	ISO	Project COD
Port of LA	Green Omni Microgrid	Los Angeles, CA	Lithium	BESS	1	2.6										•	•	CAISO	2019
Confidential	Confidential	Salem, OR	Lithium	BESS	15	30		•	•						•				N/A
Confidential	Confidential	Clark County, NV	Lithium	BESS+PV	380	1406						•	•						2023
Confidential	Confidential	Kings County, CA	Lithium	BESS+PV	140.25	561						•						CAISO	2022
Recurrent	Garland BESS	Garland, CA	Lithium	BESS	88	352						•						CAISO	2021
Recurrent	Traquility BESS	Tranquility, CA	Lithium	BESS	72	288						•						CAISO	2021
Confidential	Confidential	New York, NY	Lithium	BESS	75	300	•	•	•						•			NYISO	2025
Confidential	Confidential	Hermleigh, TX	Lithium	BESS	30	30										•	•		2023
Samsung	BESS Evaluation	Seoul, South Korea	Lithium	BESS	N/A	N/A										•			N/A
Confidential	Confidential	, WA	Lithium	BESS	30	120				•									N/A
SDG&E	Escondido	Escondido, CA	Lithium	BESS	30	120						•	•					CAISO	2018
SDG&E	Miramar Top Gun	Miramar, CA	Lithium	BESS	30	120						•	•					CAISO	2021
Confidential	Confidential	Campo, CA	Flow	BESS+PV	0.5	2	•	•	•			•			•	•		CAISO	2021
Confidential	Confidential	Palm Springs, CA	Lithium	BESS	25	300										•	•	CAISO	2023
Confidential	Confidential	Desert Center, CA	Lithium	BESS+PV	200	800	•	•										CAISO	2022
Confidential	Confidential	Camden, NJ	Lithium	BESS	20	40	•	•	•			•		•	•	•		PJM	2024
Confidential	Confidential	York, PA	Lithium	BESS	170	340	•	•	•			•		•	•	•		PJM	2024
Confidential	Confidential	Kleberg County, TX	Lithium	BESS+PV	150	300	•	•	•			•		•	•	•		ERCOT	2024
Confidential	Confidential	Tampa, FL	Lithium	BESS+Recip	20	40	•	•	•	•	•	•							
Confidential	Confidential	Calexico, CA	Lithium	BESS	200	800	•								•				2022
Confidential	Confidential	Calexico, CA	Lithium	BESS	200	800	•								•				2022
Confidential	Confidential	San Clemente, CA	Lithium	BESS	200	800	•								•				2022
Confidential	Confidential	City of Industry, CA	Lithium	BESS	200	800	•								•				2023
Confidential	Confidential	City of Industry, CA	Lithium	BESS	200	800	•								•				2023
Confidential	Confidential	Brisbane, CA	Lithium	BESS	250	1000	•								•				2023
Confidential	Confidential	City of Grand Terrace, CA	Lithium	BESS	200	800	•								•				2023
Confidential	Confidential	Carson, CA	Lithium	BESS	200	800	•								•				2022
Confidential	Confidential	King County, WA	Lithium	BESS	200	800	•								•				TBD
Confidential	Confidential	King County, WA	Lithium	BESS	200	800	•								•				TBD
Confidential	Confidential	Skagit County, WA	Lithium	BESS	200	800	•								•				TBD
Confidential	Confidential	Thurston County, WA	Lithium	BESS	150	600	•								•				TBD
Confidential	Confidential	King County, WA	Lithium	BESS	250	1000	•								•				TBD
Confidential	Confidential	,	Lithium	BESS	50	200	•		•	•	•				•				N/A
Confidential	Confidential	,	Lithium	BESS	50	200	•		•		•				•				N/A
Confidential	Confidential	Kern County, CA	Lithium	BESS+PV	332	1247						•	•					CAISO	2022
Confidential	Confidential	San Diego, CA	Lithium	BESS+PV	345	984						•						CAISO	2022
Confidential	Confidential	San Diego County, CA	Lithium	BESS+PV	139	428.5						•						CAISO	2021
Confidential	Confidential	Mojave, CA	Lithium	BESS	179	518						•						CAISO	2022
Confidential	Confidential	San Bernadino County, CA	Lithium	BESS+PV	153	306						•	•					CAISO	2023
Confidential	Confidential	Tuscon, AZ	Lithium	BESS	50	200	•	•	•		•				•			N/A	2024

BESS PROJECT **EXPERIENCE MATRIX**

Energy Storage Experience Matrix

							DEVELOPMENT	TECHNOLOGY ASSESSMENT / REVIEW	COST ESTIMATE / FINANCIAL ANALYSIS	RFP PREPARATION / EVALUATION	SPECIFICATIONS DEVELOPMENT	OWNER'S ENGINEER	FIELD SUPPORT	ENVIRONMENTAL STUDIES / PERMITTING	PRELIMINARY DESIGN / SITE LAYOUTS	ENGINEERING AND DETAILED DESIGN	EPC		
							Services Provided												
Client Name	**Project Name**	**Project Location**	**Technology**	**System Type**	**ESS (MW)**	**ESS (MWh)**												**ISO**	**Project COD**
US DOE/DOD	SPIDERS (ZnBr Flow and Li-ion) Microgrid	Honolulu, HI	Lithium/Flow	BESS	0.625	0.65	•	•	•	•	•	•				•			2018
Confidential	Confidential	Los Angeles, CA	Lithium	BESS	150	600	•	•	•						•				TBD
Confidential	Confidential	Rancho Corvoda, CA	Lithium	BESS	105	420	•	•	•						•				TBD
Confidential	Confidential	Rancho Corvoda, CA	Lithium	BESS	165	660	•	•	•						•				TBD
Confidential	Confidential	Fort Dodge, IA	Lithium	BESS+Wind	20	80	•	•	•						•			MISO	2026
Confidential	Confidential	Victoria, TX	Lithium	BESS+PV	25	100						•						ERCOT	2021
Confidential	Confidential	Henderson, TX	Lithium	BESS+PV	25	100	•	•							•			ERCOT	2022
Confidential	Confidential	Worchester, MA	Lithium	BESS	100	400	•	•							•			ISO-NE	2022
Confidential	Confidential	Windham, CT	Lithium	BESS	100	400	•	•							•			ISO-NE	2022
Confidential	Confidential	Belleville, IL	Lithium	BESS+PV	17	68	•	•							•			MISO	2021
Confidential	Confidential	Putnam, IL	Lithium	BESS+PV	6	24	•	•							•			MISO	2021
Confidential	Confidential	Litchfield, IL	Lithium	BESS+PV	11	44	•	•							•			MISO	2021
Confidential	Confidential	Canton, IL	Lithium	BESS+PV	5	20	•	•							•			MISO	2021
Confidential	Confidential	Newton, IL	Lithium	BESS+PV	13	52	•	•							•			MISO	2021
Confidential	Confidential	Oglesby, IL	Lithium	BESS	75	300	•	•							•			MISO	2022
Confidential	Confidential	Chicago, IL	Lithium	BESS	10	40	•	•							•			PJM	2020
Confidential	Confidential	Masontown, PA	Lithium	BESS+PV	10	40	•	•							•			PJM	2022
Confidential	Confidential	Sicily, IL	Lithium	BESS+PV	15	60	•	•							•			PJM	2022
Confidential	Confidential	Media, PA	Lithium	BESS	10	40	•	•							•			PJM	2020
Confidential	Confidential	Elizabethtown, OH	Lithium	BESS	10	40	•	•							•			PJM	2020
Confidential	Confidential	Ontelaunee, PA	Lithium	BESS	10	40	•	•							•			PJM	2020
Vistra	Moss Landing	Moss Landing , CA	Lithium	BESS	100	400	•						•		•	•	•	CAISO	2021
Confidential	Confidential	,	Lithium	BESS+PV	N/A	N/A					•								N/A
Confidential	Confidential	Moss Landing , CA	Lithium	BESS	350	1400										•	•		2023
Confidential	Confidential	Moss Landing , CA	Lithium	BESS	300	1200										•	•		2022

MOSS LANDING 100MW/400MWH BESS EXPANSION

Monterey County, California

Burns & McDonnell was selected to provide **Engineering, Procurement, and Construction (EPC) services for a 100MW / 400MWh** Li-ion stand-alone Battery Energy Storage System (BESS) in Monterey County, California. The project consisted of Owner provided LG Chem battery racks populated with their JH4 modules. **Burns & McDonnell's union direct-hire construction subsidiary, AZCO**, was utilized for erecting the pre-engineered metal building and installing more than 1,500 battery racks. The racks were double stacked to increase energy density and optimize usage of the available site.

The HVAC design consists of DX cooling units to provide cooled and conditioned air to the building and to the face of the battery racks to maintain temperatures consistent with the manufacture's recommendations. During both conceptual engineering and detailed design, Burns & McDonnell utilized its in-house thermal management team to build a computational fluid dynamics (CFD) model to confirm the air flow and temperature distribution at the battery racks and throughout the building.

LG Chem provided their 9540A compliant rack with rack-based fire suppression system containing water nozzles at the back of each battery module. Burns & McDonnell's scope included building-based fire detection and suppression system in addition to providing water to the tie-in location for each battery rack.

The Moss Landing battery energy storage expansion, which went online in July, brings the system's capacity to 400 megawatts/1,600 megawatt-hours, making it the largest battery storage facility in the world. The energy storage facility is located on the same site as an existing natural gas plant and multiple retired fossil generation assets and leverages the existing interconnection.

CLIENT

- *Vistra Energy*

KEY DATES

- *LNTP 5/15/2020*
- *FNTP 7/15/2020*
- *COD 7/3/2021*

SERVICES

- Engineering, Procurement and Construction (EPC)

PROJECT FEATURES

- *LG Chem JH4 Modules*
- *Air Cooled HVAC Design*
- *Pre-Engineered Building*
- *Double-Stacked Racks*

Burns & McDonnell completed construction in just 10 months — three months faster than originally anticipated. The project was completed ahead of schedule despite many challenges associated with the market conditions, supply chain and shipping disruptions, and COVID-19.

CONFIDENTIAL STORAGE EPC PROJECT

California

Burns & McDonnell was selected to provide Engineering, Procurement, and Construction (EPC) services for a 350MW / 1400MWh Li-ion stand-alone Battery Energy Storage System (BESS) in California. The project consists of Owner provided LG Chem battery racks populated with LG JH4-4P modules inside of custom-built enclosures. Burns & McDonnell's union, direct-hire construction subsidiary, AZCO, was utilized for loading the battery modules into the 5,124 battery racks as well as mechanical construction of the site. The racks were double stacked in the enclosures to increase energy density and optimize usage of the available site.

Burns & McDonnell worked with AZZ Enclosure Systems located in Pittsburg, KS to construct the 122 custom-built battery enclosures for this project. This design involved 32-tons of air-cooled HVAC capacity, thermal management system, double-pre action thermal runaway mitigation (TRM) system, VESDA smoke & gas detection systems, as well as auxiliary electrical design. AZZ received, assembled, and installed the battery racks and associated controls systems provided by LG Energy Solutions. Enclosures are shipped to the Project Site without battery modules installed, measuring 55'-3" L x 12'-4" W x 15'-1" H, and weighing over 70,000lbs.

CLIENT

- Confidential Client

KEY DATES

- LNTP 10/25/2021
- FNTP 1/26/2022
- COD 6/1/2023

SERVICES

- Engineering, Procurement and Construction (EPC)

PROJECT FEATURES

- Custom Built Battery Enclosures
- LG Chem JH4-4P Modules
- Air Cooled HVAC Design
- Pre-Engineered Building
- Double-Stacked Racks

This project is scheduled to reach commercial operation in summer of 2023, and will bring the facilities energy storage capacity to 750 megawatts/3,000 megawatt-hours, making it the largest battery storage facility in the world. The energy storage facility is located on the same site as an existing natural gas plant and multiple retired fossil generation assets and leverages the existing interconnection.

CONFIDENTIAL ENERGY STORAGE EPC PROJECT

Massachusetts

Burns & McDonnell has been awarded a Limited Notice to provide **Engineering, Procurement, and Construction (EPC) services for a** stand-alone lithium-ion Battery Energy Storage System (BESS) in Massachusetts. The project consists of installation of 82 Owner-provided Tesla Megapack 2 XL enclosures, civil and structural site works, balance of plant electrical, fire detection, SCADA, and a 115kV air-insulated collector substation.

Burns & McDonnell is providing balance of plant (BOP) engineering design, substation design, procurement of BOP and substation equipment, and construction services.

CLIENT

- *Confidential*

KEY DATES

- *LNTP 4/15/2022*
- *FNTP 6/1/2023 (anticipated)*
- *COD 5/1/2025 (anticipated)*

SERVICES

- Engineering, Procurement and Construction (EPC)

PROJECT FEATURES

- *Tesla Megapack 2 XL BESS Enclosures*
- *115kV Collector Substation*

CONFIDENTIAL ENERGY STORAGE EPC PROJECT

Arizona

Burns & McDonnell has been awarded a Limited Notice to provide **Engineering, Procurement, and Construction (EPC) services for a** stand-alone lithium-ion Battery Energy Storage System (BESS) in Arizona. The project consists of installation of 276 Owner-provided Tesla Megapack 2 XL enclosures, civil and structural site works, balance of plant electrical, fire detection, SCADA, and a 230kV air-insulated collector substation.

Burns & McDonnell is providing balance of plant (BOP) engineering design, substation design, procurement of BOP and majority of substation equipment, along with construction services.

CLIENT

- *Confidential*

KEY DATES

- *LNTP 9/26/2022*
- *FNTP 6/1/2023 (anticipated)*
- *COD 6/1/2024 (anticipated)*

SERVICES

- Engineering, Procurement and Construction (EPC)

PROJECT FEATURES

- *Tesla Megapack 2 XL BESS Enclosures*
- *230kV Collector Substation*

RWE RENEWABLES 30MW/30MWH BESS

West Texas

Burns & McDonnell was selected to provide **Engineering, Procurement, and Construction (EPC) services for a 30MW / 30MWh** Li-ion stand-alone Battery Energy Storage System (BESS) in Scurry County, Texas. The project consisted of Owner provided CATL EnerOne battery racks populated with their LFP 1P416S battery modules. **Burns & McDonnell's non-union direct-hire construction subsidiary, Burns & McDonnell Constructors**, was utilized for installing the batteries. The containers were wired directly to the inverters with no DC combiners. Distribution for BMS and chiller power came from custom designed AC auxiliary panels. EnerOne racks came with battery modules pre-installed.

Each EnerOne container includes a self-contained chiller for cooling and heating of the containers and integrated fire detection. The site presented many challenges to construction including proximate natural gas pipelines and existing buried 35kV feeder cables. Burns & McDonnell's design prioritized logical site organization and minimization of construction costs and impacts to existing infrastructure.

Burns & McDonnell's scope included modifications to the existing collection substation to relocate an existing capacitor bank to make room for addition of another feeder breaker for connection of one half of the BESS system as well as modification of an existing feeder breaker to accommodate the other half of the BESS system. Burns & McDonnell was responsible for all design, installation and commissioning activities prior to including protective relaying and metering upgrades.

KEY DATES

- *LNTP 12/22/2021*
- *FNTP 2/28/2022*
- *COD 9/23/2022*

SERVICES

- *Engineering, Procurement and Construction (EPC)*

PROJECT FEATURES

- *CATL EnerOne with 1P416S Modules*
- *Substation Expansion*
- *Containerized Solution*

LG CHEM 3X10MW/20MWH BESS

West Texas

Burns & McDonnell was selected to provide **Engineering, Procurement, and Construction (EPC) services for three 10MW / 20MWh** Li-ion stand-alone Battery Energy Storage System (BESS) in the Odessa, Texas area. The project consisted of Owner provided LG Chem battery racks populated with their JH3 and JH4 modules. **Burns & McDonnell's non-union direct-hire construction subsidiary, Burns & McDonnell Constructors**, was utilized for installing the batteries. Containers were shipped to site with the empty racks pre-wired to DC combiner panels and AC auxiliary panels. The modules were installed once the containers had been installed on their foundations at site.

The HVAC design consisted of DX cooling units to provide cooled and conditioned air to the building and to the face of the battery racks to maintain temperatures consistent with the manufacture's recommendations. During the bid process Burns & McDonnell built a computational fluid dynamics (CFD) model to confirm the air flow and temperature distribution at the battery racks and throughout the building.

LG Chem provided their 9540a compliant rack with the rack-based fire suppression system containing water nozzles at the back of each rack. Burns & McDonnell's scope included fire detection and suppression system in addition to providing water to the tie-in location for each battery rack.

KEY DATES

- *LNTP 5/15/2020*
- *FNTP 7/15/2020*
- *COD 9/1/2021*

SERVICES

- *Engineering, Procurement and Construction (EPC)*

PROJECT FEATURES

- *LG Chem JH3 and JH4 Modules*
- *Air Cooled HVAC Design*
- *Containerized Solution*

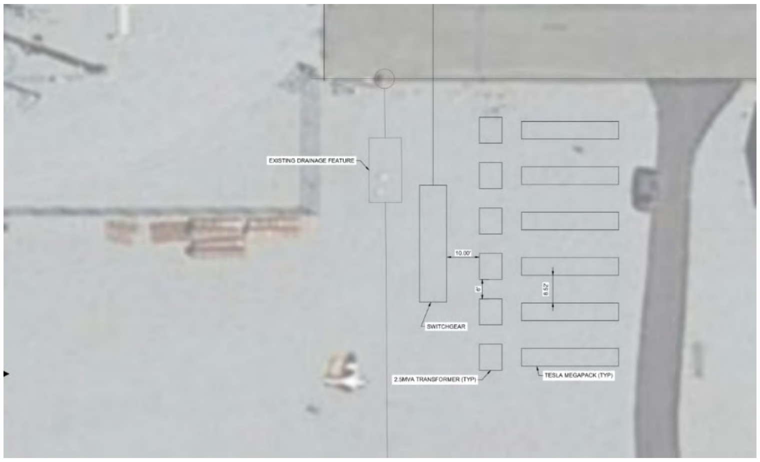
23MWH BESS BLACK START

North Desert Springs, California

Burns & McDonnell was selected to provide **Engineering, Procurement, and Construction (EPC) services for a Black Start** Battery Energy Storage System (BESS) in North Desert Springs, California. The project consisted of Owner provided batteries. **Burns & McDonnell's union direct-hire construction subsidiary, AZCO**, was utilized for all electrical construction.

The 23MWh BESS is located on the same site as an existing natural gas plant and leverages the existing interconnection. The batteries were used to add Black Start capabilities to the facility's existing eight LMS100 gas turbines to support grid restoration. This was the first BESS Black Start installation for LMS100 turbines in the world.

The project's planned COD is at the end of 2023.



CLIENT

- *Confidential Client*

KEY DATES

- *LNTP 2/8/2022*
- *FNTP 12/1/2022*
- *COD 12/31/2023*

SERVICES

- Engineering, Procurement and Construction (EPC)

GREEN OMNI TERMINAL PROJECT

Southern California

CLIENT

- *Port of Los Angeles/Pasha Stevedoring and Terminals*

PROJECT TEAM

- *Project Manager: Sean Kenny*

SERVICES

- *Grant application development*
- *Design*
- *Construction*
- *Management*

PROJECT FEATURES

- *Installation of new electrical Infrastructure and EV charging stations*
- *Microgrid and renewable technology integration*

As the premier gateway for international commerce, the Port of Los Angeles consists of more than 7,500 acres of land and water stretching along 40 miles of waterfront. This busy seaport terminal features both passenger and cargo terminals, including automobile, breakbulk, container, dry and liquid bulk, and warehouse facilities. North America's leading seaport by container volume and cargo value, the Port of Los Angeles has a strong commitment to developing sustainable operations that benefit Southern California's quality of life, including the elimination of pollution from seaport operations.

Together with Pasha and the California Air Resources Board, the Port of Los Angeles launched the Green Omni Terminal Demonstration Project, designed to showcase how sustainable, clean energy solutions can revolutionize marine terminal operations. The project is a proving ground for how zero and near-zero emissions technologies can dramatically reduce pollutants and improve energy resiliency at marine terminals and industrial facilities all around the world.

We served as the engineering, procurement, and construction contractor for this $27 million project to design and build the microgrid's associated electrical infrastructure. Deliverables included a 1MW solar photovoltaic system combined with a 2.6-Mwh battery storage system and microgrid/energy management control system. Our team incorporated zero and near zero emissions cargo-handling equipment, all while maintaining facility operations for finite periods of time when isolated from the electrical grid in the event of power outages.

Funded in part by a grant from the California Air Resources Board, which is a result of our written grant application and expedited design approval process to meet the demonstration deadline required by the grant, the project will feature a clean energy microgrid that allows terminal operations to continue in the event of a widespread power outage.

We designed and constructed the electric infrastructure that supports the deployment of heavy-duty electric vehicle and cargo handling equipment as a component of the renewable and storage-based microgrid. Construction included

GREEN OMNI TERMINAL PROJECT

(CONTINUED)

retrofits to and expansion of the terminal's existing substation, installation of new switchgear, transformers, conduit, and structural foundations to support nine electric vehicle chargers and the two battery storage systems. As the program manager, we will oversee the testing and deployment of the electric 21-ton forklifts, yard tractors, and Class-8 drayage trucks.

Another key feature of the project will be the installation of the ShoreCat Marine Exhaust Treatment System, which has the ability to capture more than 90 percent of emissions, including CO2 emissions, from stacks of berthed ships at the terminal. Berthed ships are the largest sources of greenhouse gases and priority pollutants at marine ports worldwide.

EDWARDS & SANBORN PV + STORAGE

Kern County, California

Burns & McDonnell has been selected to provide Owner's Engineering (OE) services for two solar photovoltaic (PV) and battery energy storage system (BESS) projects in Kern County, California. The two projects are comprised of various offtake agreements between PV, DC coupled, AC coupled, and standalone storage. Additionally, there are two project collection substations, a double circuit 230kV transmission line, and a project switching station. Both projects are broken into two phases (1A and 1B) for design and construction.

The Edwards project consists of 650MW of solar generation and a 345MW/984MWh combined behind the meter and in front of the meter DC coupled BESS.

The Sanborn project consists of 241MW of solar generation, a 132MW/528MWh combined behind the meter and in front of the meter DC coupled BESS, and a 200MW/719MWh AC coupled standalone BESS.

The projects will consist of LG Chem and Samsung battery racks. The battery racks will be housed in containers fabricated by either IE or Sabre. Power Electronics inverters will also be utilized.

CLIENT

- *Terra-Gen*

KEY DATES

- *BESS Standalone COD: 8/1/2021*
- *Phase 1A PV + BESS COD: 6/1/2022*
- *Phase 1B PV + BESS COD: 11/1/2022*

SERVICES

- *Owner's Engineer*
- *Design & As-Built Reviews*
- *Construction Support*

PROJECT FEATURES

- *LG Chem and Samsung Batteries*
- *Power Electronics Inverters*
- *IE and Sabre Containers*

As part of the owner's engineer scope, Burns & McDonnell is responsible for reviewing design packages. Packages will be reviewed for engineering and drafting best practices, along with confirming that project codes and standards are being followed. Also included in the design reviews are evaluations of substation and BESS reports and studies, such arc flash, load flow, short circuit, etc. Burns & McDonnell will perform as-built reviews once construction of the projects is completed. Due to the complexity of the battery storage portion of these projects, the Client is relying on Burns & McDonnell to provide support and perform additional scope outside the typical design reviews for the BESS. This additional scope includes review of the battery sizing, thermal CFD results of the containers, EMS and SCADA integration, fire suppression and code compliance, delivery considerations, and confirming performance requirements and operation parameters comply with offtake and modeling assumptions.

Burns & McDonnell will also provide support during construction to review requests for information (RFI's), change orders, and re-submittals. Throughout the design and construction of the project, Burns & McDonnell will attend EPC Contractor-Owner meetings, and during construction will have team members travel to the project sites for monthly in person meetings.

GEMINI DC COUPLED PV + STORAGE

Clark County, Nevada

CLIENT

- *Primergy*

KEY DATES

- *COD: 8/1/2023*

SERVICES

- *Owner's Engineer*
- *Design Reviews*
- *LTSA, LGIA, & EPC Contract Reviews*

PROJECT FEATURES

- *CATL EnerOne Batteries*
- *Power Electronics Inverters and DC-DC Converters*

Burns & McDonnell has been selected to provide Owner's Engineering (OE) services for a solar photovoltaic (PV) and battery energy storage system (BESS) project in Clark County, Nevada. Additionally, there is a collection substation and an overhead 230kV transmission line.

The Gemini project consists of 967MW of solar generation and a DC coupled, front of the meter, 400MW BESS.

The projects will consist of CATL EnerOne battery racks. The battery racks will be housed in containers fabricated by CATL. Power Electronics inverters and DC-DC converters will also be utilized.

As part of the owner's engineer scope, Burns & McDonnell is responsible for reviewing design packages. Packages will be reviewed for engineering and drafting best practices, along with confirming that project codes and standards are being followed. Also included in the design reviews are evaluations of substation and BESS reports and studies, such arc flash, load flow, short circuit, etc. Due to the complexity of the battery storage portion of these projects, the Client is relying on Burns & McDonnell to provide support and perform additional scope outside the typical design reviews for the BESS. This additional scope includes review of the EMS and SCADA integration, fire suppression, NERC CIP and code compliance, and confirming performance requirements and operation parameters comply with offtake and modeling assumptions.

Throughout the design of the project, Burns & McDonnell will attend EPC Contractor-Owner meetings, integrator-Owner meetings, and CATL-Owner meetings.

OE SERVICES FOR BESS PROJECTS

Various Locations (United States)

Burns & McDonnell provides Owner's Engineering (OE) services for various battery energy storage system (BESS) projects across the United States that are in various stages of development. Burns & McDonnell's responsibilities include overall lithium-ion battery chemistry, OEM, and deployment strategies, preliminary sizing with the chosen technology, preliminary general arrangements, and optimization given certain constraints such as available land area, wetland mitigation, required power/energy, etc. Burns & McDonnell also develops the deliverables required for town/county approvals and/or the permitting process.

Burns & McDonnell services are ongoing, but to date, the following projects have been completed:

- Confidential Project – 250MW/500MWh BESS project located in Massachusetts.
- Confidential Project – 150MW/300MWh BESS project located in New York.
- Confidential Project – 150MW/300MWh BESS project located in Massachusetts.
- Confidential Project – 150MW/300MWh BESS project located in Massachusetts.
- Confidential Project – 200MW/400MWh BESS project located in Ohio.

CLIENT

- *Able Grid*

SERVICES

- *Technology Selection*
- *Preliminary Lithium-Ion BESS Sizing*
- *Preliminary General Arrangements*
- *Site Energy Optimization*

PROJECT FEATURES

- *Preliminary design*
- *Development engineering services*
- *"On-call" engineering services*

In addition to development services for the specific projects listed above, Burns & McDonnell also provides "on-call" engineering services for various BESS projects located across the United States, including California, Utah, Montana, and Washington. "On-call" engineering services vary from project to project, but these services generally include providing technical guidance related to a BESS and/or developing single line diagrams.

As part of the owner's engineer scope for development engineering services, Burns & McDonnell is responsible for developing preliminary site plans for public planning or permitting, depending on the town's/county's approval process. The site plans include a general arrangement of the major equipment necessary for the BESS, general arrangement of the project substation and associated gen-tie routes, civil items (roads, fences, etc.), and fire suppression items (fire hydrants, etc.). Burns & McDonnell will evaluate different BESS technical solutions for the specific project and, based on a given technology, will take into consideration items including safety, energy density, auxiliary loads, location, project size, and usable land area. During site development, Burns & McDonnell will also evaluate any wetland delineation boundaries and adjust the site plans as needed to avoid or minimize impacts to wetlands and other waters. Burns & McDonnell will determine the general requirement for construction and post-construction periods for each site, and should a stormwater pond be required, it will be included in the final site plan.

Depending on the town/county approval or permitting process, Burns & McDonnell may also provide additional civil and fire protection services. A Stormwater Pollution Prevention Plan (SWPPP) may be developed, and additional civil designs, such as a grading plan, drainage plan, erosion control plan, site finishing plan, etc. may also be provided. Burns & McDonnell can also tailor a specific fire protection plan for the site that includes a Fire Safety Plan and/or utility plan.

Burns & McDonnell also provides cost estimates, as needed, for specific projects to assist the client with future planning.

GALLOWAY 1 & 2

West Texas

The Galloway Solar Projects, 250 MWAC and 110 MWAC respectively, are located just east of San Angelo Texas. The projects are adjacent to each other and use the same substation. Burns & McDonnell (BMcD) assisted 8Minute Energy (8me) in reviewing design, engineering studies, factory test plans, and other documents during the design phase and quality and milestone verification during the construction phase. BMcD held the projects to requirements of the project contract and applicable codes and standards and industry best practices. BMcD also assisted with substation commissioning dealing with the Electric Reliability Council of Texas (ERCOT).

The projects showcase how sustainable, clean energy solutions can be built quickly and inexpensively while maintaining high quality standards. The project is a proving ground for how renewable energy technologies can dramatically reduce pollutants and improve energy resiliency while preventing degradation or harmful impacts to the land.

CLIENT

- *8minute Solar Energy*

SERVICES

- *Contract development*
- *Design review*
- *Construction review*
- *ERCOT Management*

RELEVANCE

- *Installation of one of the largest PV plants in Texas*
- *Rapid and seamless construction in a challenging environment*

We served as the owner's engineer for these $360 million projects providing oversight of the design and build of the PV power plants. Scope of work included contract evaluation, design review, factory and field test review, field quality monitoring, and mechanical completion review summaries. A special service provided was certification of substation foundation completion to allow 8me to qualify for ITC.

The project incorporated bifacial modules with and expected improved energy production of approximately 14%. Pile driving was accomplished with predrilling to facilitate sound foundations in the rugged soil.

SGIP BATTERY STORAGE PROJECTS (COMMERCIAL/INDUSTRIAL FACILITIES)

Southern California

Burns & McDonnell partnered with Tesla to manufacturer to permit, design, and construct 1MW battery energy storage systems (BESS) capable of providing multiple customers with 2 hours of electricity for their facilities. Our clients are using these batteries daily to avoid expensive demand charges and reduce the amount of grid power needed during times of the highest electricity rates. These systems can also be used to provide power quality services in the case of grid disruptions. Burns & McDonnell provided civil, structural, and electrical balance of plant design, as well as, permitting, procurement, and construction management. Each BESS was located on a raised slab and interconnected to the customers' existing building medium-voltage switchgear (or SES) located behind-the-meter. Each BESS was protected from vehicular impact by strategic placement in either parking lots or garages and then surrounded by concrete bollards.

Installing new technology on these commercial properties presented Burns & McDonnell with challenging design and permitting questions. Burns & McDonnell had to convey information to the issuing authority which proved difficult since the manufacturer had not completely defined some of the specifications of their product and the issuing authorities had no prior experience with battery storage. Through consistent and professional communication with the manufacturer and the issuing authority, the projects were able to be approved with minimal re-design efforts. Additional challenges included the interconnection requirements of the local utility to ensure no back feeding occurred on the distribution line during outage events. This required upgrades to some of the medium voltage switchgear at the customer sites with additional relay protection added. Close coordination between the battery manufacturer and the local utility were necessary to ensure a safe and successful interconnection.

CLIENT

- *Tesla*

KEY DATES:

- *Completed: Q2 2016*

SERVICES

- *Permitting with the city and/or county*
- *Detailed design of electrical, civil, and structural components*
- *Procurement and construction management*

PROJECT HIGHLIGHTS

- *Integration of cutting edge battery storage technology that meet California SGIP requirements.*
- *Installations count towards CPUC energy storage mandate for utilities.*

ENERGY STORAGE PROJECTS

San Diego, CA

In 2016, the California Public Utilities Commission approved to expedite two energy storage projects proposed by San Diego Gas & Electric, the result of a directive from regulators that utilities seed battery projects to boost regional reliability and guard against natural gas storage. In an effort to avoid potential blackouts in the state, related to gas losses at the Aliso Canyon natural gas storage facility, SDG&E recently installed 30 MW of lithium-ion battery storage, supplied by AES Energy Solutions, at its Operations Center in Escondido, CA and a smaller 7.5 MW array, also supplied by AES Energy Solutions, at a facility in El Cajon, CA. AES's Advancion arrays provide 37.5 MW of power for four continuous hours and serve as a 75 MW of flexible resource to the grid. The batteries charge when there is an abundance of solar and wind energy, and supply higher-priced load when demand spikes. The Escondido array is the largest lithium-ion battery-based energy storage project in operation in the United States and was recently selected as the winner of *Energy Storage North America's* 2017 Energy Innovation Award.

SDG&E worked with an aggressive construction schedule to have the two facilities operational by the end of January 2017. To monitor and control all activity sequencing and completion, SDG&E relied on the expertise of the Burns & McDonnell project controls team – who developed and updated the schedule in Primavera 6 schedule environment. Burns & McDonnell performed owner's engineer services - providing project controls, electrical inspections, and QA/QC over the course of four months on the expedited projects. In addition, Burns & McDonnell completed as-built reviews of the constructed project.

Quality Assurance of electrical installations was necessary for both energy storage projects as they are composed of complex and sensitive electrical equipment such as switchgears, transformers, electrical panels and multiple electrical cable connections. SDG&E again relied on the expertise of Burns and McDonnell and its network of qualified partners to provide quality assurance and electrical Code related inspections and fire protections systems.

CLIENT

- *SDG&E*
- *Contact:*
  Kelli Fitzgerald
  8315 Century Park Ct., San Diego, CA
  P: 760.791.2979

KEY DATES:

- Design Start: July 2016
- Design Complete: November 2016
- Construction Start: August 2016
- Construction Complete: March 2017

PROJECT TEAM

- *Project Manager: Carlos Larios*
- *Lead Project Controls: Mike McShea*
- *Team: Dan Clark, Dustin Weaver, Pride Resources, Bureau Veritas*

SERVICES

- Owner's Engineer
- Project Controls
- Scheduling
- Electrical Inspections
- QA/QC
- As-Built Reviews

AWARDS

2017 – Energy Innovation Award,
Energy Storage North America

15MW PV + BATTERY EVALUATION

Las Vegas, NV

Burns & McDonnell teamed with our client to develop two 24MW solar photovoltaic (PV) power plants each paired with a 24MW, 96MWh energy storage system. In the initial phase of the project a thorough evaluation was completed of current energy storage technologies. Once the appropriate energy storage technologies were chosen, one-lines, plan drawings, energy storage sizing analysis and PV energy production models were created in support of determining the optimum project size. From there, the team developed a PSLF model of the projects and submitted them to the California Independent System Operator (CAISO) along with completed Interconnection Requests. The projects were accepted by CAISO and were included in the Cluster 9 study queue.

CAISO typically requires dynamic models to be provided in ".dyd" formats using PSLF library models that have been approved by the Western Electricity Coordinating Council (WECC). However, no appropriate energy storage models were approved at the time of our modeling. To solve this issue, the team worked with CAISO to create a user defined dynamic model that was acceptable for the Interconnection Request submission.

The team continues to provide support during the CAISO study phases by reviewing CAISO results, creating responses, and attending meetings on behalf of our client. We are also assisting the client in developing bid packages for both projects by providing technical data and graphs for inclusion in the proposal documents.

CLIENT

- *Confidential*

KEY DATES:

- *Design Start: Design 2017*
- *Design Complete: February 2018*

PROJECT TEAM

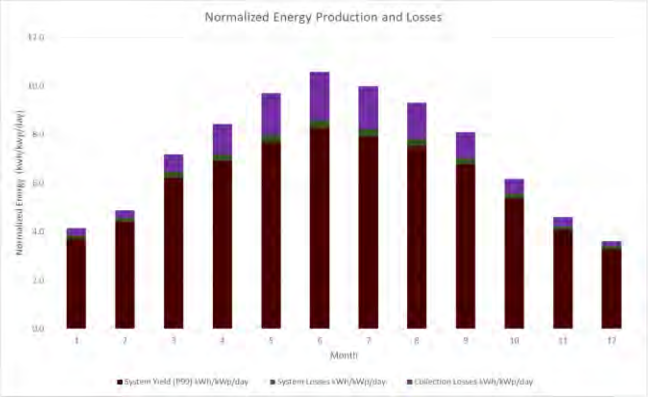
- *PM: Robert Healy*
- *Lead Electrical: Daniel Clark*
- *Team: Hyung Shin, Jon Lim, Patrick Durkee*

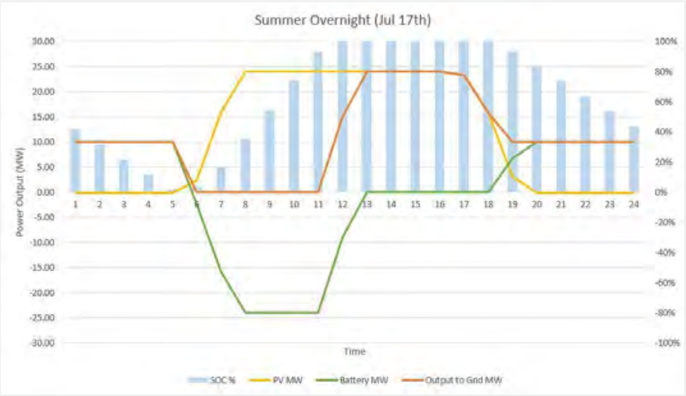
SERVICES

- *Technology Assessment*
- *Sizing Analysis*
- *Energy Production Analysis*
- *One-lines*
- *Site Plan*
- *Interconnection Plan*
- *PSLF Modeling*
- *CAISO Interconnection Request*
- *Bid Support*

15MW PV + BATTERY EVALUATION

Las Vegas, NV





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CLIENT

- *Confidential*

KEY DATES:

- *Design Start: February 2016*
- *Design Complete: July 2016*
- *Construction Start: 2018 Estimated*

PROJECT TEAM

- *PM: Robert Healy*
- *Lead Electrical: Daniel Clark*
- *Team: Hyung Shin, Jon Lim, Patrick Durkee*

SERVICES

- *Technology Assessment*
- *Sizing Analysis*
- *Energy Production Analysis*
- *One-lines*
- *Site Plan*
- *Interconnection Plan*
- *PSLF Modeling*
- *CAISO Interconnection Request*
- *Bid Support*

Chris Ruckman, PE | Energy Storage Director | 816-822-3826 | cruckman@burnsmcd.com