

Introduction

PSE secured the third-party expert, Black & Veatch (“B&V”), to research, produce, and provide a report on the cost and market potential, in MWs, for each DER program concept considered for potential inclusion in PSE’s preferred portfolio. The purpose of PSE securing a third-party for the purposes of producing cost and market potential for its DER program concepts is to ensure that the assumptions, analysis, and outputs benefit from an experienced subject matter expert in the industry, who brings direct experience across many energy markets, clients, and programs. Black & Veatch was selected through a competitive process that focused on experience with developing and deploying distributed energy resources and distributed energy resource programs.

The cost data and market potential by B&V is intended to provide PSE with an independently researched and accurate resource for program costs and market potential of potential DER program concepts. B&V leveraged its proprietary experience and sourcing of market information to develop costs, as well as internal proprietary assessments of technical potential, in order to develop market potential. In addition to the cost and market potential report, B&V also prepared an appendix to support the development of the cost and market potential for each DER program concept, detailing the approach, basis, and assumptions utilized.

B&V’s selection and engagement was scoped to produce the cost and market potential report to align with PSE’s obligations and timeline for filing its CEIP.

B&V’s cost and market potential report is provided herein to the CEIP, as well as being preceded by B&V’s appendix in support of its cost and market potential report.

DRAFT

DER COST AND MARKET POTENTIAL ASSESSMENT

B&V PROJECT NO. 409474

PREPARED FOR
Puget Sound Energy

20 AUGUST 2021

Table of Contents

1.0	Executive Summary	1
1.1	Overview of Scope of Work.....	1
1.2	Summary Results	1
1.2.1	Programmatic and Resource Cost.....	1
1.2.2	Achievable Market Potential	4
1.3	Organization of Report	5
2.0	Programmatic and Resource Cost	6
2.1	Scope of Analysis and Approach.....	6
2.1.1	Programmatic Costs.....	6
2.1.2	Resource Costs	6
2.1.3	Fixed and Variable Operating and Maintenance Costs.....	7
2.1.4	General and Administrative Costs.....	7
2.1.5	Additional Information and Assumptions	7
2.2	Program Concepts and Cost Drivers	8
2.2.1	Concept #1 – Third-Party Customer-Sited Distributed Battery PPA.....	8
2.2.2	Concept #2 – Third Party Utility-Scale Distributed Battery PPA	8
2.2.3	Concept #3 – C&I Battery Install Incentive	8
2.2.4	Concept #4 – C&I Space Leasing for Batteries	9
2.2.5	Concept #5 – Multifamily Unit Battery Program	9
2.2.6	Concept #6 – PSE Mobile Batteries.....	9
2.2.7	Concept #7 – PSE Substation Batteries.....	10
2.2.8	Concept #8 – PSE Utility-Scale Distributed Battery Storage.....	10
2.2.9	Concept #9 – Residential Battery Install Incentive.....	10
2.2.10	Concept #10 – Residential PSE Battery Leasing	10
2.2.11	Concept #11 – Residential PSE Battery Leasing - Vulnerable Population/Low Income	11
2.2.12	Concept #12 – PSE Shared Solar.....	11
2.2.13	Concept #13 – PSE Shared Solar – Vulnerable Population/Low Income	11
2.2.14	Concept #14 – Third-Party Distributed Solar PPA.....	11
2.2.15	Concept #15 – C&I Rooftop Solar Incentive.....	12
2.2.16	Concept #16 – C&I Rooftop Solar Leasing	13
2.2.17	Concept #17 – Multifamily Solar Partnership.....	13
2.2.18	Concept #18 – Multifamily Rooftop Solar Incentive	13
2.2.19	Concept #19 – Customer-Sited Solar Plus Storage Offering.....	13
2.2.20	Concept #20 – Residential Rooftop Solar Leasing.....	14
2.2.21	Concept #21 – Residential Rooftop Solar Leasing, Vulnerable Population/Low Income	14

2.2.22	Concept #22 – C&I Bring Your Own Battery.....	14
2.3	Summary of Results	15
3.0	Achievable Market Potential.....	18
3.1	Scope of Analysis and Approach.....	18
3.2	Key Drivers and Constraints	19
3.3	Summary of Results	21
3.3.1	Battery Energy Storage Systems.....	21
3.3.2	Solar Systems.....	23
3.3.3	Solar Plus Battery Energy Storage Systems.....	24
4.0	References	25

LIST OF TABLES

Table 1-1	Program Concept Overview.....	1
Table 1-1-2	Overview of Programmatic and Resource Cost Per Site, by Program Concept.....	2
Table 1-3	BESS Program Concepts, Annual Achievable Market Potential (MW-AC)	4
Table 1-4	Solar Program Concepts, Annual Achievable Market Potential (MW-AC)	4
Table 1-5	Concept #21, Solar Plus Storage Annual Achievable Market Potential (MW- AC).....	5
Table 2-1	Overview of Programmatic and Resource Cost Per Site, by Concept.....	16
Table 3-1	Overview of PSE Customer and Building Stock	19
Table 3-2	BESS Program Concepts, Annual Achievable Market Potential (MW-AC)	21
Table 3-2	BESS Concepts Cumulative Market Potential, 2021-2030 (MW-AC)	22
Table 3-4	Solar Program Concepts, Annual Achievable Market Potential (MW-AC)	23
Table 3-5	Solar Concepts Cumulative Market Potential, 2021-2030 (MW-AC)	23
Table 3-6	Concept #21, Solar Plus Storage Annual Achievable Market Potential (MW- AC).....	24
Table 3-7	Solar Plus BESS Cumulative Market Potential (MW-AC).....	24

LIST OF FIGURES

Figure 3-1	Overview of Market Potential Approach.....	18
Figure 3-2	BESS Customer Payback by Program Concept, Sample	20
Figure 3-3	Solar Customer Payback by Program Concept, Sample	20

Acronyms and Abbreviations

Acronym	Definition
BESS	Battery Energy Storage System. References to “battery” and “storage” are synonymous.
BTM	Behind the Meter
C&I	Commercial & Industrial
CAPEX	Capital Expense
CEIP	Clean Energy Implementation Plan
CETA	Clean Energy Transformation Act
DER	Distributed Energy Resource, for the purposes of this study this represents solar and battery energy storage systems
EMP	Energy Market Perspectives
FOTM	Front of the Meter
IFC	International Fire Code
IRP	Integrated Resource Plan
ITC	Investment Tax Credits
kW	Kilowatt
kWh	Kilowatt-Hour
MW	Megawatt
O&M	Operating and Maintenance
OPEX	Operating Expense
PPA	Power Purchase Agreement
PSE	Puget Sound Energy

1.0 Executive Summary

Black & Veatch Management Consulting, LLC (Black & Veatch) was engaged by Puget Sound Energy (PSE) to provide an independent assessment of programmatic costs and market potential for a set of 22 distributed renewable generation and distributed Battery Energy Storage System (BESS) concepts collectively referred to as program concepts from 2021 to 2030. This assessment was developed to support PSE's effort to select an optimal portfolio of distributed energy resources (DER) and programs to be included in PSE's Clean Energy Implementation Plan (CEIP), which details PSE's plans for achieving Clean Energy Transformation Act (CETA) compliance from 2022 to 2025.

1.1 Overview of Scope of Work

To develop and assess the potential program concepts, Black & Veatch leveraged its expertise and past experience in the engineering, design, and construction of DER applications and assessments of similar resources previously prepared in PSE's territory. Black & Veatch prepared cost estimates for the programmatic and resource costs of 22 program concepts prepared by PSE. The cost estimates included capital costs, programmatic costs, operating and maintenance (O&M) costs, and administrative costs. Equipment and installation cost declines were also identified through 2030.

Black & Veatch assessed the achievable market potential for each program concept from 2021 through 2030. The technical potential for a program concept is defined as the resource capacity if all technically feasible resources were captured, including building orientation, shading, and appropriate spacing. Achievable potential is defined as resource capacity based on customer economic criteria and market and program ramp rates. Black & Veatch provided PSE with forecasts of achievable resource potential for use in PSE's quantitative analysis, performed through AURORA, an electric modeling software tool.

The program concepts evaluated include solar systems and lithium-ion BESS in applications directed to residential, multifamily, vulnerable population/low income residential and multifamily, and commercial customers, as well as aggregators and the utility itself. Table 1-1 provides an overview of each program concept.

Table 1-1 Program Concept Overview

Concept	Name	Description	Resource Type	Application Type	Ownership	Target Customer	Incentive Type
1	Third-Party Customer-Sited Distributed Battery Power Purchase Agreement (PPA)	"Third-Party C&I BESS PPA" Third party installs and manages network of customer-sited batteries that provide backup power and renewable energy integration for customers. Third party will aggregate a network of batteries to respond to dispatch signal from PSE to help integrate renewables and manage system/local peak.	BESS	Behind the Meter (BTM)	Third Party	Commercial	Periodic – Performance
2	Third-Party Utility-Scale Distributed Battery PPA	"Third-Party Utility-Scale BESS PPA" Third party installs and manages single/network of batteries to respond to dispatch signal from PSE to help increase power quality and/or resiliency, as well as manage system/local peak.	BESS	Front of the Meter (FOTM)	Third Party	N/A	Periodic – Performance
3	Commercial & Industrial (C&I) Battery Install Incentive	"C&I BESS Incentive" PSE offers upfront incentive to C&I customer to install their own BESS, with terms for operating modes that lead to manage system/local peak.	BESS	BTM	Customer	Commercial	One-Time Upfront
4	C&I Space Leasing for Batteries	"C&I BESS Space Lease" PSE leases space from/at C&I customers to deploy BESS to improve power quality and/or resiliency and manage system/local peak. Backup power for host customer may be offered as additional integration.	BESS	FOTM	PSE	Commercial	Lease Payment
5	Multifamily Unit Battery Program	"Multifamily BESS Incentive" PSE partners with multifamily unit owner/developer to deploy and deploy in-unit BESSs. Multifamily unit renters benefit from backup power and PSE uses batteries to help manage system/local peaks.	BESS	BTM	PSE	Multifamily	One-Time Upfront

Concept	Name	Description	Resource Type	Application Type	Ownership	Target Customer	Incentive Type
6	PSE Mobile Batteries	"PSE Mobile BESS" PSE deploys mobile batteries to support outages, as well as to help manage system/local peak. Batteries can serve at distribution level.	BESS	FOTM	PSE	N/A	N/A
7	PSE Substation Batteries	"PSE Substation BESS" PSE installs batteries at its substations that can support renewables integration, increase power quality and/or resiliency, and manage system or local peak.	BESS	FOTM	PSE	N/A	N/A
8	PSE Utility-Scale Distributed Battery Stations	"PSE Utility-Scale BESS" PSE installs distributed batteries locally, communally, and/or in urban settings (i.e., outside of substations). Batteries help to improve power quality and/or resiliency, integrate renewables, or manage system/local peak.	BESS	FOTM	PSE	N/A	N/A
9	Residential Battery Install Incentive	"Residential BESS Incentive" PSE offers upfront incentive to residential customers to install their own BESS, with terms for operating modes that lead to optimal load behavior.	BESS	BTM	Customer	Residential	One-Time Upfront
10	Residential PSE Battery Leasing	"Residential BESS Lease" PSE installs batteries in customer homes. Customers pay a monthly fee for backup power services; PSE uses battery to manage system/local peaks.	BESS	BTM	PSE	Residential	N/A
11	Residential PSE Battery Leasing - Vulnerable Population/Low Income	"Residential BESS Lease – Vulnerable Population/Low Income" PSE provides targeted deployment of batteries for vulnerable population/low income customers.	BESS	BTM	PSE	Residential	N/A

Concept	Name	Description	Resource Type	Application Type	Ownership	Target Customer	Incentive Type
		Customers benefit from back-up power and PSE can use batteries to manage system/local peaks.					
12	PSE Shared Solar	“PSE Shared Solar” PSE offers customers the ability to subscribe to the output of solar panels deployed throughout the service territory. Customers pay a monthly fee and receive a monthly credit for generation.	Solar	FOTM	PSE	Residential and Multifamily	N/A
13	PSE Shared Solar – Vulnerable Population/Low Income	“PSE Shared Solar – Vulnerable/Low Income” PSE offers customers the ability to subscribe to the output of solar panels deployed throughout the service territory. Subscribing customers receive a monthly credit for the generation. The customer’s monthly fee is discounted.	Solar	FOTM	PSE	Residential and Multifamily	N/A
14	Third-Party Distributed Solar PPA	“Third-Party C&I Solar PPA” Third party installs/provides rooftop solar panels to C&I customers throughout service territory. PSE off-takes renewable energy via PPA while the third party is responsible for managing the program and financing equipment.	Solar	FOTM	Third Party	Commercial	Periodic - Performance
15	C&I Rooftop Solar Incentive	“C&I Solar Incentive” PSE offers upfront incentives to commercial customers, discounting their upfront cost to install and own distributed solar generation throughout the service territory.	Solar	BTM	Customer	Commercial	One-Time Upfront
16	C&I Rooftop Solar Leasing	“C&I Solar Roof Lease” PSE leases commercial customers' rooftop space to install solar. Customer receives a monthly lease payment; PSE generates renewable energy to supply the grid.	Solar	FOTM	PSE	Commercial	Lease Payment

Concept	Name	Description	Resource Type	Application Type	Ownership	Target Customer	Incentive Type
17	Multifamily Solar Partnership	"Multifamily Solar Partnership" PSE facilitates installation of solar at multifamily buildings by connecting with technology providers and/or billing support to share production across units.	Solar	BTM	Customer	Multifamily	Periodic - Fixed
18	Multifamily Rooftop Solar Incentive	"Multifamily Solar Incentive" PSE offers incentives to multifamily building owners, discounting their upfront cost to install and own solar in PSE's service territory.	Solar	BTM	Customer	Multifamily	One-Time Upfront
19	Customer-Sited Solar Plus Storage Offering	"Residential Solar and BESS Incentive" PSE enrolls customers through an incentive program to both install solar plus BESS and respond to operating settings or dispatch signals from PSE.	Solar and BESS	BTM	Customer	Residential	One-Time Upfront
20	Residential Rooftop Solar Leasing	"Residential Solar Roof Lease" PSE offers to lease residential customers' rooftop space to install solar. Customer receives a monthly lease payment; PSE generates renewable energy to supply grid.	Solar	FOTM	PSE	Residential	Lease Payment
21	Residential Rooftop Solar Leasing - Vulnerable Population/Low Income	"Residential Solar Roof Lease – Vulnerable Population/Low Income" PSE targets lease to vulnerable population/low income and/or impacted residential customers for access to rooftop space to install solar. Customer receives a monthly lease payment; PSE generates renewable energy to supply grid.	Solar	FOTM	PSE	Residential	Lease Payment
22	C&I Bring Your Own Battery	"C&I BYOB" PSE offers an incentive targeted at existing/new commercial battery owners that encourages optimal load behavior, charge/discharge, and/or	BESS	BTM	Customer	Commercial	One-Time Upfront

Concept	Name	Description	Resource Type	Application Type	Ownership	Target Customer	Incentive Type
		PSE access that helps PSE to manage system/local peak.					

1.2 Summary Results

1.2.1 Programmatic and Resource Cost

Black & Veatch prepared cost estimates for the programmatic and resource costs for the 22 program concepts identified by PSE.

Black & Veatch leveraged its experience in designing and constructing solar and BESS along with a review of existing PSE solar and BESS installations to identify system sizes and site parameters that adequately characterize and cost a representative system applicable to each program concept. As a result, a representative system was defined for each program concept according to assumed parameters such as capacity, duration, system footprint, installation location, building type, applicable rate schedule, mounting system, building vintage and site conditions, use case, system life, and operating parameters.

Based on the characterization of each representative system, Black & Veatch prepared cost estimates for a single representative system for each program concept. Each cost estimate included both programmatic and resource costs and identified responsible party for each cost category.

An overview of the programmatic and resource costs identified for each program concept is shown in Table 1-1-2. Capital expenses (CAPEX), including the cost to procure and install, were largely consistent across technology, customer segment, and corresponding capacity. Variations in BESS costs of similar capacity were due to different specified durations.

The cost to administer and incentivize the concepts were included in programmatic costs, which varied based on program concept design elements such as incentives, PPA costs, and program overhead. The operating expense (OPEX) for the DER system, including equipment O&M costs, incremental insurance, and technology, also varied based on program design with major variations due to assumptions on land ownership and leasing costs.

Table 1-1-2 Overview of Programmatic and Resource Cost Per Site, by Program Concept

Concept	Description	Rated Capacity (kW-AC)	BESS Duration (hours)	Program Life (yr)	Utility Cost (\$/kW-Yr)			Participant Cost (\$/kW-Yr)		
					CAPEX	OPEX	Programmatic ¹	CAPEX	OPEX	Participant
#1	Third-Party C&I BESS PPA	200	2	10	\$0	\$0	\$5	\$3,072	\$265	Third Party
#2	Third-Party Utility-Scale BESS PPA	5,000	4	10	\$0	\$0	\$5	\$2,292	\$67	Third Party
#3	C&I BESS Incentive	200	2	10	\$0	\$0	\$63	\$3,072	\$23	Customer
#4	C&I BESS Space Lease	200	4	10	\$4,802	\$217	\$77	\$0	\$0	-
#5	Multifamily BESS Incentive	250	3	10	\$3,782	\$11	\$61	\$0	\$0	Customer
#6	PSE Mobile BESS	500	2	10	\$1,784	\$19	\$28	\$0	\$0	-
#7	PSE Substation BESS	3,300	2	10	\$1,339	\$20	\$18	\$0	\$0	-
#8	PSE Utility-Scale BESS	1,000	2	10	\$1,365	\$92	\$26	\$0	\$0	-
#9	Residential BESS Incentive	5	3	10	\$0	\$0	\$70	\$3,782	\$42	Customer
#10	Residential BESS Lease	5	3	10	\$3,782	\$42	\$96	\$0	\$60	Customer
#11	Residential BESS Lease - Vulnerable Population/Low Income	5	3	10	\$3,782	\$42	\$96	\$0	\$10	Customer

¹ Programmatic costs listed include marketing and administration costs incurred by PSE

Concept	Description	Rated Capacity (kW-AC)	BESS Duration (hours)	Program Life (yr)	Utility Cost (\$/kW-Yr)			Participant Cost (\$/kW-Yr)		
					CAPEX	OPEX	Program-matic ¹	CAPEX	OPEX	Participant
#12	PSE Shared Solar (Existing/Modeled)	3,850	-	15	\$1,408	\$21	\$20	\$0	\$164/\$31	Customer
#13	PSE Shared Solar – Vulnerable Population/Low Income	3,850	-	15	\$1,408	\$21	\$20	\$0	\$0	Customer
#14	Third-Party C&I Solar PPA	308	-	10	\$0	\$0	\$6	\$2,165	\$87	Third Party
#15	C&I Solar Incentive	308	-	10	\$0	\$0	\$8	\$2,165	\$32	Customer
#16	C&I Solar Roof Lease	308	-	10	\$2,162	\$45	\$31	\$0	\$0	-
#17	Multifamily Solar Partnership	83	-	10	\$0	\$0	\$47	\$4,027	\$119	Customer
#18	Multifamily Solar Incentive	83	-	10	\$0	\$0	\$172	\$4,027	\$119	Customer
#19	Residential Solar and BESS Incentive	6 (Solar) 5 (BESS)	3	10	\$0	\$0	\$176	\$6,601	\$77	Customer
#20	Residential Solar Roof Lease	6	-	10	\$3,449	\$163	\$45	\$0	\$0	-
#21	Residential Solar Roof Lease - Vulnerable Population/Low Income	6	-	10	\$4,315	\$203	\$45	\$0	\$0	-
#22	C&I BYOB	200	2	10	\$0	\$0	\$7	\$3,072	\$23	Customer

1.2.2 Achievable Market Potential

Battery Energy Storage Systems

Twelve of the 22 program concepts assessed for achievable market potential were related to BESS. The achievable potential was assessed based on customer economics and market and program ramp rates applied against the technical potential. Table 1-3 indicates the annual achievable potential from BESS program over the study period. Concept #6, PSE Mobile Batteries; #7, PSE Substation Batteries; and #8, PSE Utility Scale, were not assessed for market potential by Black & Veatch because these concepts are utility-led and utility-owned efforts.

Table 1-3 BESS Program Concepts, Annual Achievable Market Potential (MW-AC)

Concept	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
#1 Third-Party C&I BESS PPA	6.6	6.8	7	7.2	7.4	7.4	7.6	7.6	7.8	7.8
#2 Third-Party Utility-Scale BESS PPA	0	0	0	0	0	0	0	5	5	5
#3 C&I BESS Incentive	0.4	0.4	0.6	0.8	1.2	1.6	2.0	2.4	2.8	3.4
#4 C&I BESS Space Lease	1.8	3.6	7.2	7.2	7.2	14.4	14.4	28.8	36	36
#5 Multifamily BESS Incentive	0.25	0.5	0.75	0.75	0.75	1.75	1.75	3.25	4.25	4.25
#6 PSE Mobile BESS	Not Specified									
#7 PSE Substation BESS	Not Specified									
#8 PSE Utility-Scale BESS	Not Specified									
#9 Residential BESS Incentive	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8
#10 Residential BESS Lease	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3
#11 Residential BESS Lease - Vulnerable Population/Low Income	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
#22 C&I BYOB	0.2	0.2	0.4	0.4	0.6	0.8	1.0	1.2	1.4	1.8

Solar Systems

The achievable potential for each solar program concept was assessed based on customer economics and market and program ramp rates applied against the technical potential. Table 1-4 indicates the annual achievable potential from the solar program concepts over the study period.

Table 1-4 Solar Program Concepts, Annual Achievable Market Potential (MW-AC)

Concept	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
#12 PSE Shared Solar	19.0	19.0	19.0	19.0	19.0	19.0	22.8	22.8	22.8	22.8

#13 PSE Shared Solar – Vulnerable Population/ Low Income	0	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
#14 Third-Party C&I Solar PPA	0	2.8	2.8	2.8	2.8	4.8	6.8	8.8	11.2	13.2
#15 C&I Solar Incentive	0.9	5.2	5.2	5.2	5.2	7.1	8.6	10.1	11.7	13.2
#16 C&I Solar Roof Lease	4.4	8.4	12.8	17.2	21.6	21.6	21.6	21.6	21.6	21.6
#17 Multifamily Solar Partnership	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3
#18 Multifamily Solar Incentive	0.2	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.7
#20 Residential Solar Roof Lease	0.5	0.6	1.0	1.4	1.8	2.5	3.3	4.2	5.3	6.7
#21 Residential Solar Roof Lease - Vulnerable Population/Low Income	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.6	0.8	0.9

Solar and Battery Energy Storage System

The achievable potential for the co-located solar and BESS concept was assessed based on customer economics and market and program ramp rates applied against the technical potential. Table 1-5 outlines the annual achievable potential from Concept #19 Customer-Sited Solar Plus Storage Offering, over the study period.

Table 1-5 Concept #19, Solar Plus Storage Annual Achievable Market Potential (MW-AC)

Technology	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Solar	2.4	2.9	3.5	4.1	4.8	5.6	6.5	7.4	8.4	9.5
Storage	2.0	2.4	2.9	3.4	4.0	4.7	5.4	6.2	7.0	7.9

1.3 Organization of Report

This report is organized into two sections to address the scope of work. Each section will outline the scope of analysis and methodology, key drivers and constraints, and a summary of results.

- Programmatic and Resource Cost
- Achievable Market Potential

2.0 Programmatic and Resource Cost

2.1 Scope of Analysis and Approach

Black & Veatch prepared cost estimates for the programmatic and resource costs of 22 program concepts identified by PSE.

Black & Veatch leveraged its experience in designing and constructing solar and BESS along with a review of existing PSE solar and BESS installations to identify system sizes and site parameters that adequately characterize and cost a representative system applicable to each program concept. As a result, a representative system was defined for each program concept according to parameters such as capacity, duration, system footprint, installation location, building type, applicable rate schedule, mounting system, building vintage and site conditions, use case, system life, and operating parameters.

Based on the characterization of each representative system, Black & Veatch prepared cost estimates for a single representative system for each program concept. Each cost estimate included both programmatic and resource costs and the identified responsible party for each cost category. As the assessed costs were used as an input to perform additional quantitative analysis including AURORA modeling and the determination of market potential, no expectation of implementation volume and corresponding economies of scale were included in this cost assessment. Cost categories and estimation approach is outlined as follows:

2.1.1 Programmatic Costs

Black & Veatch assessed programmatic costs for PSE to implement and administer program concepts on a unit-site basis, including applicable incentives, PPAs, marketing, and processing costs. These costs were estimated through the review of past program costs published by utilities located in the Pacific Northwest^{2,3,4}, including California^{5,6,7}, and similar programs in operation at PSE. Programmatic costs for a limited set of concepts was determined to yield favorable customer or third party project economics, including concepts targeting vulnerable populations/low income customers or concepts specifically identified by PSE. Based on the program concept design, incentives were captured as a one-time cost or as a reoccurring annual or monthly payment by the utility.

2.1.2 Resource Costs

Black & Veatch identified capital costs to install the representative system defined for each program concept on a unit-site basis. These capital costs include equipment procurement and delivery, design and construction, taxes, development, and financing and, in instances of third party ownership, anticipated profits required by the third party. Minor roof repair costs were included for some solar concepts anticipated to occur prior to the installation of the solar panels.

² Puget Sound Energy, 2020.

³ Puget Sound Energy, 2021.

⁴ Pacific Power & Light Company, 2021.

⁵ Pacific Gas and Electric Company, 2021.

⁶ San Diego Gas and Electric, 2020.

⁷ Southern California Edison, 2021.

Black & Veatch leveraged past design and construction experience for similar installations in PSE's service territory and in the Pacific Northwest. Where necessary and for purposes of confirming pricing applicability to service territory and application, Black & Veatch leveraged project estimators and requested budgetary estimates and quotes from vendors to develop cost estimates.

2.1.3 Fixed and Variable Operating and Maintenance Costs

Black & Veatch assessed operating costs, including equipment O&M, insurance, technology fees, land/lease costs, and subscription costs on a unit-site basis. Annual operating costs were estimated using Black & Veatch's internal benchmarking database and market reports and studies published by the U.S. Department of Energy⁸, Lawrence Building National Laboratory⁹, and the National Renewable Energy Laboratory^{10,11}. Black & Veatch did not assess information technology or operational technology costs associated with program concept enablement by PSE.

2.1.4 General and Administrative Costs

Black & Veatch assessed general and administrative costs to include personnel salaries, rent, and other overhead costs not already included in O&M costs, allocated on a unit-site basis. These costs were estimated at 12 percent of anticipated revenues for the third-party participant (e.g., developer or aggregator), consistent with anticipated general and administrative costs in similar businesses.

2.1.5 Additional Information and Assumptions

The following outlines additional estimating details and assumptions:

- As costs were estimated in real 2020 dollars. An annual escalation of 2 percent was assumed as indicated by the Producer Price Index¹².
- Equipment and installation cost declines were included and were derived from technology cost curves developed by Black & Veatch's Energy Market Perspectives (EMP) for solar and BESS. The decline curve for BESS was assumed consistent for each BESS concept applications. Similarly the decline curve for solar was applied across all solar concepts.
- Black & Veatch assumed that no changes to programmatic, O&M, and general and administrative costs, on a real-dollar basis, would occur through the study period.
- Costs were determined for the program life of the installation. For example, replacement costs were not included beyond the life of the program.
- Black & Veatch separated costs according to those borne by the utility, the customer and the third party participant as applicable to the program concept.
- Investment Tax Credits (ITCs) were not incorporated into costs.

⁸ U.S. Department of Energy, July 2019.

⁹ Piette M.A. et al., Lawrence Berkeley National Laboratory, May 2016.

¹⁰ National Renewable Energy Laboratory, Q1 2020.

¹¹ Cole, W. and Frazier, A.W, National Renewable Energy Laboratory, 2019.

¹² Producer Price Index, 2021.

2.2 Program Concepts and Cost Drivers

2.2.1 Concept #1 – Third-Party Customer-Sited Distributed Battery PPA

Overview: Concept #1 is a program concept where a third party installs a BESS at a C&I property to provide the utility with resources capable of demand response and/or assist in renewables integration and may provide the C&I building owner the ability to manage demand charges and provide backup power. This BESS is characterized as a 200 kilowatt (kW) with a 2-hour duration and a system life of 10 years, cycling twice per day. The third party owns and manages the BESS and executes a PPA with the C&I customer. PSE provides the performance payments according to the third party's participation in demand response events.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the third party. Operating costs anticipated for the third party include equipment O&M, technology, insurance, administration, and land costs. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including PPA payments. PPA rates were estimated to sufficiently incentivize distributed BESS deployment.

2.2.2 Concept #2 – Third Party Utility-Scale Distributed Battery PPA

Overview: Concept #2 is a program concept where a third-party installs a utility-scale BESS to respond to dispatch signals from PSE, help increase power quality, resiliency, and/or manage system or local peak. This BESS is characterized as a 5 megawatt (MW), 4-hour duration and a system life of 10 years, cycling twice per day. The third-party owns and manages the BESS. PSE executes a PPA with the third-party. PPA costs were established according to equivalent demand response value as outlined in PSE's previous IRP¹³.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the third party. The resource costs outline costs associated with the installation cost paid by the third party. Operating costs anticipated for the third party include equipment O&M, technology, insurance, administration, and land costs. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the annual power purchase payments.

2.2.3 Concept #3 – C&I Battery Install Incentive

Overview: Concept #3 is a program concept to provide an incentive for C&I buildings to install BESS. PSE would include terms for operating modes that would lead to would result in system and local peak management. This BESS is characterized as a 200 kW with a 2-hour duration and a system life of 10 years, cycling twice per day. The C&I customer owns and manages the BESS. In addition to responding to operating modes as specified by PSE, the C&I customer may use the BESS to manage their demand charges. PSE provides a one-time incentive payment to the C&I customer upon program enrollment and commissioning of installed BESS.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the customer. Operating costs anticipated for the customer include equipment O&M, technology, and additional insurance. Existing land was assumed sufficient to site the BESS and no customer cost was included for this purpose. Utility program costs include any costs incurred by

¹³ Puget Sound Energy, April 2021.

the utility for administration and implementation of the program, including the one-time incentive payment, estimated at levels offered by peer utilities for similar systems.

2.2.4 Concept #4 – C&I Space Leasing for Batteries

Overview: Concept #4 is a program concept where PSE installs BESS at a C&I customer location. PSE operates and controls the BESS to improve power quality and/or resiliency and to manage local or system peak. PSE provides a lease payment to the C&I customer. This BESS is characterized as a 200 kW with a 4-hour duration and a system life of 10 years, cycling twice per day.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by PSE. Operating costs anticipated for the utility include equipment O&M, technology, and additional insurance. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the annual leasing cost paid to the C&I customer, assessed at an average leasing cost for the BESS footprint and easement access in PSE's service territory.

2.2.5 Concept #5 – Multifamily Unit Battery Program

Overview: Concept #5 is a program concept where PSE installs individual BESS systems in multifamily units that are used to manage system or local peaks. The multifamily unit customer benefits from backup power and the aggregator is incentivized for performance. This system is characterized as 50 residential BESS, each rated at 5 kW, 13.5 kilowatt-hours (kWh) and a system life of 10 years, cycling twice per day. PSE owns and operates the BESS.

Cost Assumptions: The resource cost includes all costs associated with the installation of a 50-unit system borne by PSE. Operating costs anticipated for the utility include equipment O&M, technology, and additional insurance. Existing space was assumed sufficient to site the BESS and no customer cost was included for this purpose. Utility program costs include any costs incurred by the utility for administration and implementation of the program.

2.2.6 Concept #6 – PSE Mobile Batteries

Overview: Concept #6 is a program concept where PSE owns a mobile BESS unit to help integrate renewables, increase power quality, resiliency, and/or manage system or local peak. This mobile system is characterized as a 500 kW, 2-hour duration with a system life of 10 years, cycling twice per day. PSE owns and manages the BESS.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by PSE. Black & Veatch received budgetary estimates from providers of these units to inform resource cost. Operating costs anticipated for the utility include equipment O&M and technology. Utility program costs include costs incurred by the utility for the administration and implementation of the program.

2.2.7 Concept #7 – PSE Substation Batteries

Overview: Concept #7 is a program concept where PSE owns a BESS located at a PSE substation to help integrate renewables, increase power quality, resiliency, and/or manage system or local peak. This BESS is characterized as a 3.3 MW, 2-hour duration with a system life of 10 years, cycling twice per day. PSE owns and manages the BESS.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by PSE. Operating costs anticipated for the utility include equipment O&M, technology, and insurance. Utility program costs include costs incurred by the utility for the administration and implementation of the program.

2.2.8 Concept #8 – PSE Utility-Scale Distributed Battery Storage

Overview: Concept #8 is a program concept where PSE owns a BESS located on property that is not owned by PSE. The BESS helps integrate renewables, increase power quality, resiliency, and/or manage system or local peak. This BESS is characterized as a 1.0 MW, 2-hour duration with a system life of 10 years, cycling twice per day. PSE owns and manages the BESS.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by PSE. Operating costs anticipated for the utility include equipment O&M, technology, insurance, and land costs. Utility program costs include costs incurred by the utility for the administration and implementation of the program.

2.2.9 Concept #9 – Residential Battery Install Incentive

Overview: Concept #9 is a program concept to provide an incentive to residential customers to install BESS. PSE would include terms for operating modes that would lead to manage system peak. This BESS is characterized as a 5 kW, 13.5 kWh system with a system life of 10 years, cycling twice per day. The customer owns and manages the BESS. PSE provides a one-time incentive payment to the customer upon program enrollment and commissioning of installed system.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the customer. Operating costs anticipated for the customer include equipment O&M, technology, and additional insurance. Existing land was assumed sufficient to site the BESS and no customer cost was included for this purpose. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the one-time incentive payment, estimated at levels offered by peer utilities for similar systems.

2.2.10 Concept #10 – Residential PSE Battery Leasing

Overview: Concept #10 is a program concept where PSE installs BESS at a residential customer's home. PSE owns and manages the BESS to manage local or system peak. The customer pays a monthly subscription cost to PSE for the backup services. BESS is characterized as a 5 kW, 13.5 kWh system with a system life of 10 years, cycling twice per day.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne PSE. Operating costs anticipated for the utility include equipment O&M and technology. In this concept, the customer also incurs the operating cost of the subscription fee paid to the utility; however, it is assumed that no additional land costs are required. The subscription fee used in this assessment was first identified through benchmarks of similar initiatives and then refined by PSE. Utility program costs include any costs incurred by the utility for administration and implementation of the program.

2.2.11 Concept #11 – Residential PSE Battery Leasing - Vulnerable Population/Low Income

Overview: Concept #11 is a similar program as Concept #11, where PSE installs BESS targeted to vulnerable population/low income customers. PSE owns and maintains the BESS to manage local or system peak. The customer pays a monthly subscription cost, at a more accessible rate than in Concept #11, to PSE for the backup services. BESS is characterized as a 5 kW, 13.5 kWh unit with a system life of 10 years, cycling twice per day.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne PSE. Operating costs anticipated for the utility include equipment O&M and technology. In this concept, the customer also incurs the operating cost of the subscription fee paid to the utility; however, it is assumed that no additional land costs is required. The subscription fee used in this assessment was first identified through benchmarks of similar initiatives and then refined by PSE to ensure annual subscription costs to the customer were offset by annual system benefits. Utility program costs include any costs incurred by the utility for administration and implementation of the program.

2.2.12 Concept #12 – PSE Shared Solar

Overview: Concept #12 is a program concept where PSE installs ground-mount solar system in its service territory and allows customers to subscribe to the output of the solar generation. PSE operates and maintains the system to supply the grid with renewable energy. This solar system is characterized as a 3,850 kW monofacial system mounted on single-axis trackers. The program life is 10 years. Customers pay a monthly fee and receive a monthly credit for generation.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne PSE. Modeled operating costs anticipated for the utility include equipment O&M, land leasing costs, technology, and insurance. Utility program costs include any costs incurred by the utility for administration and implementation of the program. Subscription fees and credits were estimated through benchmarks of similar initiatives.

2.2.13 Concept #13 – PSE Shared Solar – Vulnerable Population/Low Income

Overview: Concept #13 is a program concept where PSE installs ground-mount solar system in its service territory and allows customers to subscribe to the output of the solar generation. PSE operates and maintains the system to supply the grid with renewable energy. This solar system is characterized as a 3,850 kW monofacial system mounted on single-axis trackers. The program life is 10 years. Customers receive a monthly credit for generation. The subscription fee is discounted for qualifying customers.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne PSE. Operating costs anticipated for the utility include equipment O&M, land leasing costs, technology, and insurance. Utility program costs include any costs incurred by the utility for administration and implementation of the program. Credits were estimated through benchmarks of similar initiatives.

2.2.14 Concept #14 – Third-Party Distributed Solar PPA

Overview: Concept #14 is a program concept where a third party installs rooftop solar at a C&I property. This solar system is characterized as a 400 kW system with a program life of 10 years. The third party owns and manages the system. PSE executes a PPA with the third-party to offtake the renewable energy.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the third party. Operating costs anticipated for the third party include equipment O&M, technology, insurance, administration, and land costs. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the annual power purchase payments. The PPA rate was estimated at rates consistent with regional benchmarks.

2.2.15 Concept #15 – C&I Rooftop Solar Incentive

Overview: Concept #15 is a program concept to provide an incentive for C&I buildings to install rooftop solar. This solar system is characterized as a 400 kW system with a program life of 10 years. The C&I customer owns and maintains the solar system. PSE provides a one-time incentive payment to the C&I customer upon program enrollment and commissioning of system.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the customer. Operating costs anticipated for the customer include equipment O&M, technology, and additional insurance. No leasing costs were assumed necessary for the customer to site the solar system. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the one-time incentive payment, estimated at levels offered by peer utilities for similar systems.

2.2.16 Concept #16 – C&I Rooftop Solar Leasing

Overview: Concept #16 is a program concept where PSE installs rooftop solar at a C&I customer location. PSE operates and maintains the system to supply the grid with renewable energy. PSE provides a lease payment to the C&I customer. This solar system is characterized as a 400 kW system with a program life of 10 years.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne PSE. Operating costs anticipated for the utility include equipment O&M, technology, and additional insurance. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the annual leasing cost paid to the C&I customer. Rooftop lease costs were estimated based on Black & Veatch benchmarks.

2.2.17 Concept #17 – Multifamily Solar Partnership

Overview: Concept #17 is a program concept where PSE facilitates the installation of solar systems on a multifamily building rooftop by enabling the building with technology that allows sharing of production and benefits across units. The multifamily building customer(s) or landlord owns and maintains the system. PSE is responsible for the technology subscription fees and enablement costs. The representative multifamily building is characterized as a 50-unit, low-rise building. The resulting solar system is sized as a 100 kW system with a program life of 10 years.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the customers or landlord. Costs reflect minor roof repair costs were included at the time of installation. Operating costs anticipated for the customer(s) include equipment O&M, technology, and additional insurance. Utility program costs include costs incurred by the utility for administration and implementation of the program including the subscription fees for the enablement technology. Black & Veatch received budgetary estimates from providers to inform technology costs.

2.2.18 Concept #18 – Multifamily Rooftop Solar Incentive

Overview: Concept #18 is a program concept to provide an incentive for multifamily buildings to install rooftop solar. The multifamily building customer(s) or landlord owns and maintains the system. The representative multifamily building is characterized as a 50-unit low-rise building. The resulting solar system is sized as a 100 kW system with a program life of 10 years. PSE provides a one-time incentive payment to the C&I customer upon program enrollment and commissioning of installed system.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the customers or landlord. Costs reflect minor roof repair costs were included at the time of installation. Operating costs anticipated for the customer(s) include equipment O&M, technology, and additional insurance. No leasing costs were assumed necessary for the customer to site the solar system. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the one-time incentive payment, estimated at levels offered by peer utilities for similar systems.

2.2.19 Concept #19 – Customer-Sited Solar Plus Storage Offering

Overview: Concept #19 is a program concept to provide an incentive to residential customers to install both a co-located BESS and solar system. Customers may use this system to offset load with renewable energy and are incentivized to respond to operating settings and/or dispatch settings from PSE. This BESS is characterized as a 5 kW, 13.5 kWh system, cycling twice per day, while the

solar system is characterized as a 6 kW system. The program life for this system would be 10 years. The customer owns and manages the system. PSE provides a one-time incentive payment and an annual reoccurring performance payment to the customer.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by the customer. Operating costs anticipated for the customer include equipment O&M, technology, and additional insurance. Existing land was assumed sufficient to site the BESS and no customer cost was included for this purpose. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the incentive payments, estimated at levels offered by peer utilities for similar systems.

2.2.20 Concept #20 – Residential Rooftop Solar Leasing

Overview: Concept #20 is a program concept where PSE installs rooftop solar at a residential customer's home. PSE owns and maintains the solar system to supply renewable energy to the grid. PSE provides a lease payment to the customer for the roof space. This solar system is characterized as a 6 kW system with a program life of 10 years.

Cost Assumptions: The resource cost includes all costs associated with the installation of one site borne by PSE. Costs to reflect minor roof repair costs were included at the time of installation. Operating costs anticipated for the utility include equipment O&M, technology, and additional insurance. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the leasing cost paid to the customer. Rooftop leasing costs were estimated leveraging Black & Veatch past experience.

2.2.21 Concept #21 – Residential Rooftop Solar Leasing, Vulnerable Population/Low Income

Concept #21 is a program concept similar to #20 where PSE installs rooftop solar, targeted towards the vulnerable population/low income residential customers. PSE owns and maintains the solar system to supply renewable energy to the grid. PSE provides a lease payment to the customer for the roof space. This solar system is characterized as a 6 kW system with a program life of 10 years.

The resource cost includes all costs associated with the installation of one site including roof repairs borne by PSE. Operating costs anticipated for the utility include equipment O&M, technology, and additional insurance. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the leasing cost paid to the customer. Rooftop leasing payments were assessed to provide a higher rate to customers than those in Concept #20.

2.2.22 Concept #22 – C&I Bring Your Own Battery

Concept #22 is a program concept where a C&I customer installs the BESS and is offered an incentive designed to help PSE manage system and local peak. The incentive payments are periodic and will be based on terms and conditions of program participation defined by PSE. This BESS is characterized as a 200 kW with a 2-hour duration and a system life of 10 years, cycling twice per day. The C&I customer owns and manages the BESS. PSE provides an incentive payment to the C&I customer when the BESS participates, including, but not limited to, when the BESS responds to a dispatch request by PSE.

The resource cost includes all costs associated with the installation of one site borne by the customer. Operating costs anticipated for the customer include equipment O&M, technology, and additional insurance. Existing land was assumed sufficient to site the BESS and no customer cost

was included for this purpose. Utility program costs include any costs incurred by the utility for administration and implementation of the program, including the incentive payment, estimated at levels offered by peer utilities for similar applications.

2.3 Summary of Results

Table 2-1 outlines programmatic and resource costs identified for each program concept for a single site.

Resource costs include equipment procurement and delivery, design and construction, taxes, development, and financing and, in instances of third-party ownership, anticipated profits required by the third party. The resource cost of BESS concepts varied by size and duration, with larger systems yielding greater cost efficiencies. Similarly, concepts characterized by larger solar systems also yielded greater cost efficiencies. Resource costs for solar systems were consistent across concepts that targeted the same customer segment.

Programmatic costs, including the cost to administer, market, and incentivize each site, varied largely based on program concept design elements such as ownership structure, incentives, power purchase costs, and program overhead. With the exception of Concept #5, Multifamily Unit Battery Program, concepts that included PSE-owned systems generally had the lowest programmatic costs due to limited participant incentives associated.

The operating cost for the DER system, including equipment O&M costs, incremental insurance, and technology also varied based on program design. While O&M costs were largely consistent across similar applications, major variations in operating costs were attributed to assumptions on land ownership and leasing costs for each concept.

Table 2-1 Overview of Programmatic and Resource Cost Per Site, by Concept

Concept	Description	Rated Capacity (kW-AC)	BESS Duration (hours)	Program Life (yr)	Utility Cost (\$/kW-Yr)			Participant Cost (\$/kW-Yr)		
					CAPEX	OPEX	Programmatic ¹⁴	CAPEX	OPEX	Participant
#1	Third-Party C&I BESS PPA	200	2	10	\$0	\$0	\$5	\$3,072	\$265	Third Party
#2	Third-Party Utility-Scale BESS PPA	5,000	4	10	\$0	\$0	\$5	\$2,292	\$67	Third Party
#3	C&I BESS Incentive	200	2	10	\$0	\$0	\$63	\$3,072	\$23	Customer
#4	C&I BESS Space Lease	200	4	10	\$4,802	\$217	\$77	\$0	\$0	-
#5	Multifamily BESS Incentive	250	3	10	\$3,782	\$11	\$61	\$0	\$0	Customer
#6	PSE Mobile BESS	500	2	10	\$1,784	\$19	\$28	\$0	\$0	-
#7	PSE Substation BESS	3,300	2	10	\$1,339	\$20	\$18	\$0	\$0	-
#8	PSE Utility-Scale BESS	1,000	2	10	\$1,365	\$92	\$26	\$0	\$0	-
#9	Residential BESS Incentive	5	3	10	\$0	\$0	\$70	\$3,782	\$42	Customer
#10	Residential BESS Lease	5	3	10	\$3,782	\$42	\$96	\$0	\$60	Customer
#11	Residential BESS Lease - Vulnerable Population/Low Income	5	3	10	\$3,782	\$42	\$96	\$0	\$10	Customer
#12	PSE Shared Solar (Existing/Modeled)	3,850	-	10	\$1,408	\$21	\$20	\$0	\$164/\$31	Customer
#13	PSE Shared Solar – Vulnerable Population/Low Income	3,850	-	10	\$1,408	\$21	\$20	\$0	\$0	Customer

¹⁴ Programmatic costs listed include marketing and administration costs incurred by PSE

Concept	Description	Rated Capacity (kW-AC)	BESS Duration (hours)	Program Life (yr)	Utility Cost (\$/kW-Yr)			Participant Cost (\$/kW-Yr)		
					CAPEX	OPEX	Program-matic ¹⁴	CAPEX	OPEX	Participant
#14	Third-Party C&I Solar PPA	308	-	10	\$0	\$0	\$6	\$2,165	\$87	Third Party
#15	C&I Solar Incentive	308	-	10	\$0	\$0	\$8	\$2,165	\$32	Customer
#16	C&I Solar Roof Lease	308	-	10	\$2,162	\$45	\$31	\$0	\$0	-
#17	Multifamily Solar Partnership	83	-	10	\$0	\$0	\$47	\$4,027	\$119	Customer
#18	Multifamily Solar Incentive	83	-	10	\$0	\$0	\$172	\$4,027	\$119	Customer
#19	Residential Solar and BESS Incentive	6 Solar 5 BESS	3	10	\$0	\$0	\$176	\$6,601	\$77	Customer
#20	Residential Solar Roof Lease	6	-	10	\$3,449	\$163	\$45	\$0	\$0	-
#21	Residential Solar Roof Lease - Vulnerable Population/Low Income	6	-	10	\$4,315	\$204	\$45	\$0	\$0	-
#22	C&I BYOB	200	2	10	\$0	\$0	\$7	\$3,072	\$23	Customer

3.0 Achievable Market Potential

3.1 Scope of Analysis and Approach

Black & Veatch assessed the technical and achievable potential for each program concept from 2021 through 2030. The technical potential was defined as the resource capacity if all technically feasible resources were captured. Achievable potential was defined as resource capacity based on customer economic criteria and market and program ramp rates. Black & Veatch provided PSE with forecasts of achievable resource potential for use in their IRP modeling.

First, Black & Veatch identified the target market segment of each program concept and identified the number of sites for which each concept would be technically feasible to locate the DER system. Black & Veatch utilized previously developed information to identify market information such as total number of customers by sector, including past DER potential studies¹⁵, building stock assessments^{16,17}, and market characterization reports¹⁸. Second, site quantities were then applied against applicability factors to reflect the percentage of sites that would be technically feasible, leveraging the above listed reports along with Regional Stock Assessments.

Finally, the achievable number of sites was determined by multiplying the technical potential against anticipated program ramp rates based on a number of criteria. Program concepts that were identified as driven by customer economics were determined by bass diffusion modeling and applied against past and current adoption rates. Program concepts that were identified as determined by programmatic efforts such as those that were particularly novel were determined based on benchmarks. Black & Veatch did not assess market potential for select program concepts that were identified to be utility-owned and utility-operated, including Concept #6 PSE Mobile BESS, #7 PSE Substation BESS and #8 PSE Utility-Scale BESS. The forecasted achievable potential was then calculated by multiplying the identified number of achievable sites against the system capacity previously identified as representative during the concept characterization process.

Figure 3-1 provides an overview of the approach taken to assess the market potential for each program concept.

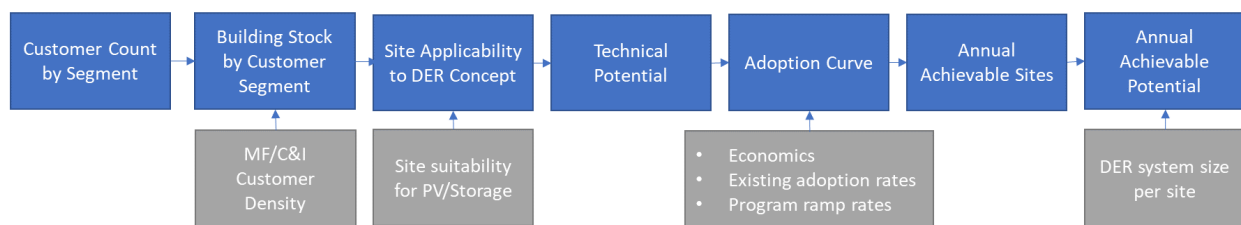


Figure 3-1 Overview of Market Potential Approach

¹⁵ Cadmus, Dec 2020.

¹⁶ Northwest Energy Efficiency Alliance, 2014.

¹⁷ Northwest Energy Efficiency Alliance, 2021.

¹⁸ Cadmus, Oct 2020.

3.2 Key Drivers and Constraints

Building stock by customer segment was first determined based on customer count by segment as outlined in the 2020 demand-side potential report¹⁹ and informed by building stock assessments^{20,21}. An overview of PSE customers and building stock is outlined in Table 3-1.

Table 3-1 Overview of PSE Customer and Building Stock^{22,23}

Customer Type	Customer Count	Building Stock
Commercial	160,000	130,000
Single Family	750,000	750,000
Single Family Low Income	135,000	135,000
Multifamily	270,000	9,000
Multifamily Low Income	85,000	3,400

The suitability of the building stock was incorporated to inform technical feasibility. For solar, this factored orientation, shading, and obstructions and compliance with the 2012 International Fire Code (IFC) 605.11.3. Black & Veatch leveraged the technical constraint assumptions outlined in the 2020 demand-side potential report²⁴ for these factors. This constraint was assumed at 25 percent for residential buildings and 51 percent for commercial buildings.

Multifamily buildings were further constrained based on owned versus renter properties and the ability to add solar or BESS to rental units. Based on previous market characterization reports, 60 percent of households in PSE territory were assumed to be owned, while 36 percent of vulnerable population/low income households were assumed to be owned²⁵. The technical potential available within the remaining rental buildings is large. To date, the primary method for multifamily tenants to participate in solar programs has been through shared solar initiatives, such as those proposed in Concepts #12 and #13. Programs that have effectively targeted the adoption of BESS in tenant-occupied multifamily buildings has been limited to pilots and demonstrations.

Achievable potential was assessed considering participant economics, existing technology adoption, and programmatic ramp rates. For concepts that were driven by market factors, customer or third-party payback under each program concept were evaluated over the study period, incorporating participant resource and operating costs, technology cost curves, customer rates, and any incentives or ITCs available through the PSE’s programmatic efforts or government policies. Figure

¹⁹ Cadmus, Dec 2020.

²⁰ Northwest Energy Efficiency Alliance, 2014.

²¹ Northwest Energy Efficiency Alliance, 2021.

²² Northwest Energy Efficiency Alliance, 2014.

²³ Northwest Energy Efficiency Alliance, 2021.

²⁴ Cadmus, Dec 2020.

²⁵ Cadmus, Oct 2020.

3-2 and Figure 3-3 show customer payback across sample BESS and solar concepts based on installation year. Installation costs are forecast to decline over time resulting in a corresponding decrease in payback years over time.

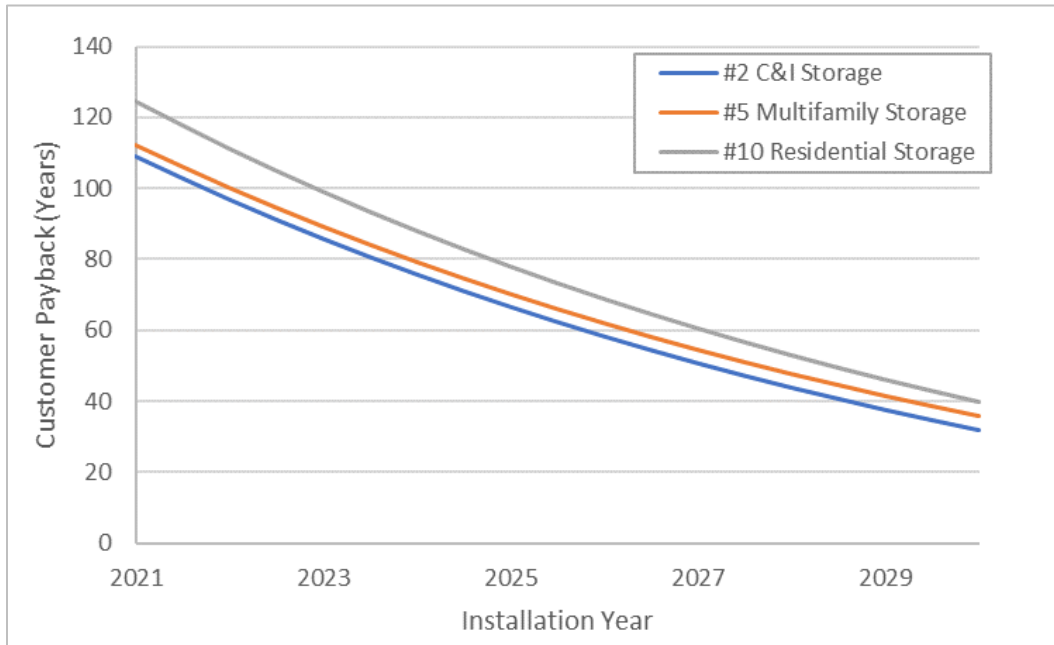


Figure 3-2 BESS Customer Payback by Program Concept, Sample

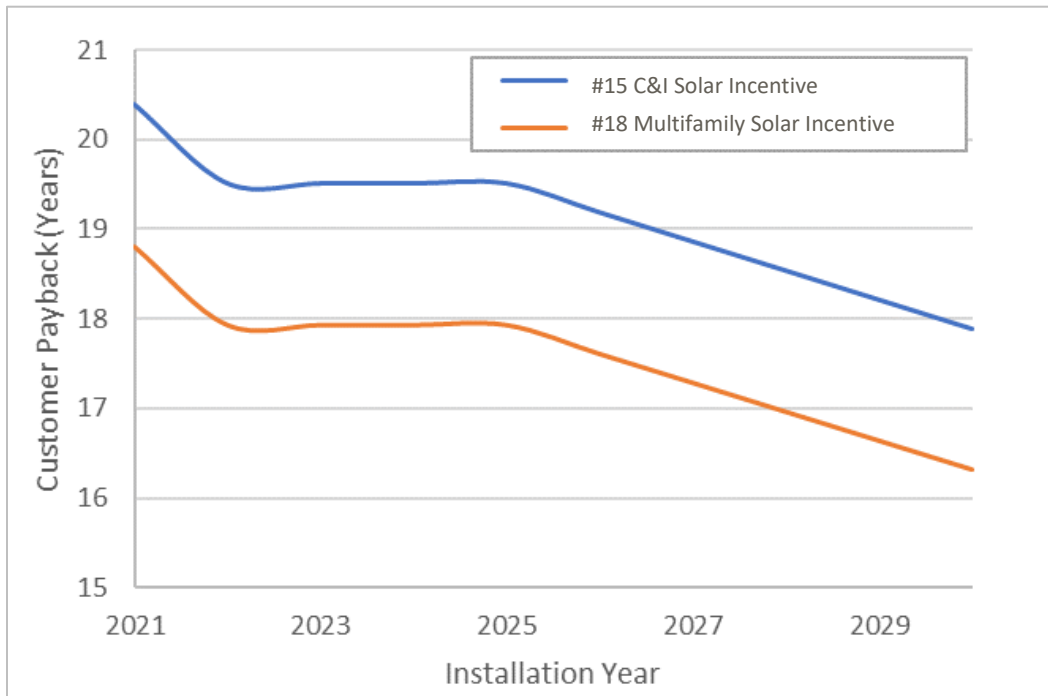


Figure 3-3 Solar Customer Payback by Program Concept, Sample

Market adoption rates were calculated as a function of customer payback and fit to a curve based on historic installation rates. Available data included net-metered solar installation rates in PSE’s territory, PSE Solar Choice program historical adoption rates, interconnection queue data, standalone BESS installation rate, and solar plus BESS installation rates.

Concept #19, Customer-Sited Solar Plus Storage Offering, had a more aggressive adoption curve than similar standalone BESS due to two factors. First, the value of ITCs were incorporated into the installation cost of solar when coupled with BESS, thus improving customer economics. Second, historic installation rates of solar plus BESS and new BESS added to existing solar systems in PSEs territory were notably higher than standalone BESS.

3.3 Summary of Results

3.3.1 Battery Energy Storage Systems

Table 3-2 indicates the annual achievable potential from BESS program concepts over the study period. Concept #6 PSE Mobile Batteries; #7 PSE Substation Batteries; and #8 PSE Utility Scale BESS were not assessed for market potential by Black & Veatch because these concepts are utility-led and utility-owned efforts.

Table 3-2 BESS Program Concepts, Annual Achievable Market Potential (MW-AC)

Concept	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
#1 Third-Party C&I BESS PPA	6.6	6.8	7	7.2	7.4	7.4	7.6	7.6	7.8	7.8
#2 Third-Party Utility-Scale BESS PPA	0	0	0	0	0	0	0	5	5	5
#3 C&I BESS Incentive	0.4	0.4	0.6	0.8	1.2	1.6	2.0	2.4	2.8	3.4
#4 C&I BESS Space Lease	1.8	3.6	7.2	7.2	7.2	14.4	14.4	28.8	36	36
#5 Multifamily BESS Incentive	0.25	0.5	0.75	0.75	0.75	1.75	1.75	3.25	4.25	4.25
#6 PSE Mobile BESS	Not Specified									
#7 PSE Substation BESS	Not Specified									
#8 PSE Utility-Scale BESS	Not Specified									
#9 Residential BESS Incentive	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8
#10 Residential BESS Lease	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3
#11 Residential BESS Lease - Vulnerable Population/Low Income	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
#22 C&I BYOB	0.2	0.2	0.4	0.4	0.6	0.8	1.0	1.2	1.4	1.8

Table 3-2 indicates the cumulative market potential between 2021 to 2030 for BESS concepts, segmented by customer type. Program interactions and overlap considerations were not included in this analysis, and therefore potential estimates may not be additive.

Table 3-3 BESS Concepts Cumulative Market Potential, 2021-2030 (MW-AC)

Customer Segment	BESS Concept	Cumulative Available Potential (MW-AC)
C&I	#1 Third-Party C&I BESS PPA	73
	#3 C&I BESS Incentive	16
	#4 C&I BESS Space Lease	157
	#22 C&I BYOB	8.0
Multifamily	#5 Multifamily BESS Incentive	18
Utility	#2 Third-Party Utility-Scale BESS PPA	15
	#6 PSE Mobile BESS	Not Specified
	#7 PSE Substation BESS	Not Specified
	#8 PSE Utility-Scale BESS	Not Specified
Residential	#9 Residential BESS Incentive	4.7
	#10 Residential BESS Lease	12
	#11 Residential BESS Lease - Vulnerable Population/Low Income	1.1

3.3.2 Solar Systems

Table 3-4 indicates the annual achievable potential from Solar Program Concepts over the study period.

Table 3-4 Solar Program Concepts, Annual Achievable Market Potential (MW-AC)

Concept	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
#12 PSE Shared Solar (Modeled)	19.0	19.0	19.0	19.0	19.0	19.0	22.8	22.8	22.8	22.8
#13 PSE Shared Solar – Vulnerable Population/ Low Income	0	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
#14 Third-Party C&I Solar PPA	0	2.8	2.8	2.8	2.8	4.8	6.8	8.8	11.2	13.2
#15 C&I Solar Incentive	0.9	5.2	5.2	5.2	5.2	7.1	8.6	10.1	11.7	13.2
#16 C&I Solar Roof Lease	4.4	8.4	12.8	17.2	21.6	21.6	21.6	21.6	21.6	21.6
#17 Multifamily Solar Partnership	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3
#18 Multifamily Solar Incentive	0.2	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.7
#20 Residential Solar Roof Lease	0.5	0.6	1.0	1.4	1.8	2.5	3.3	4.2	5.3	6.7
#21 Residential Solar Roof Lease - Vulnerable Population/Low Income	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.6	0.8	0.9

Table 3-5 indicates the cumulative market potential between 2021 to 2030 for solar concepts, segmented by customer type. Program interactions and overlap considerations were not included in this analysis, and therefore potential estimates may not be additive.

Table 3-5 Solar Concepts Cumulative Market Potential, 2021-2030 (MW-AC)

Customer Segment	Solar Concept	Cumulative Available Potential (MW-AC)
C&I	#14 Third-Party C&I Solar PPA	56
	#15 C&I Solar Incentive	72
	#16 C&I Solar Roof Lease	172

Customer Segment	Solar Concept	Cumulative Available Potential (MW-AC)
Multifamily	#17 Multifamily Solar Partnership	1.4
	#18 Multifamily Solar Incentive	4.8
Residential	#20 Residential Solar Roof Lease	27
	#21 Residential Solar Roof Lease - Vulnerable Population/Low Income	3.8
Residential/ Multifamily	#12 PSE Shared Solar	205
	#13 PSE Shared Solar – Vulnerable Population/Low Income	83

3.3.3 Solar Plus Battery Energy Storage Systems

Table 3-6 indicates the annual achievable potential from Concept #19, Customer-Sited Solar Plus Storage Offering, over the study period.

Table 3-6 Concept #19, Solar Plus Storage Annual Achievable Market Potential (MW-AC)

Technology	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Solar	2.4	2.9	3.5	4.1	4.8	5.6	6.5	7.4	8.4	9.5
Storage	2.0	2.4	2.9	3.4	4.0	4.7	5.4	6.2	7.0	7.9

Table 3-7 indicates the cumulative market potential between 2021 to 2030 for co-located solar and BESS concepts, segmented by customer type. Program interactions and overlap considerations were not included in this analysis, and therefore potential estimates may not be additive.

Table 3-7 Solar Plus BESS Cumulative Market Potential (MW-AC)

Customer Segment	Solar Concept	Cumulative Available Potential (MW-AC)
Residential	#19. Customer-Sited Solar Plus Storage Offering	Solar: 55 BESS: 46

4.0 References

Cadmus. PSE Low-Income Household Needs Assessment: Final Report. October 2020.

Cadmus. Comprehensive Assessment of Demand-Side Resource Potentials (2022-2045). Prepared for Puget Sound Energy. December 4, 2020.

https://oohpseirp.blob.core.windows.net/media/Default/Reports/2021/Final/Appendix/16.%20RP21_AppE_033021_FileUpdate%20with%20report.pdf

Cole, W. and Frazier, A.W. National Renewable Energy Laboratory. Cost Projections for Utility-Scale Battery Storage. 2019. <https://www.nrel.gov/docs/fy19osti/73222.pdf>

National Renewable Energy Laboratory. U.S. Solar Photovoltaic BESS System Cost Benchmark Q1 2020 Report. Q1 2020. <https://data.nrel.gov/submissions/158>

Northwest Energy Efficiency Alliance. 2014 Northwest Commercial Building Stock Assessment: Appendix AAA Combined CBSA Building Characteristic Summary Tables. December 16, 2014. <https://neea.org/resources/appendix-aaa-combined-cbsa-building-characteristic-summarytables>

Northwest Energy Efficiency Alliance. 2016-2017 RBSA Supporting Documentation: RBSA II Combined Database. Accessed May 2021. <https://neea.org/resources/rbsa-ii-combined-database>

Pacific Gas and Electric Company. 2020 Energy Efficiency Annual Report. May 3, 2020. <https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442469299>

Pacific Power & Light Company. 2020-2021 Conservation Report to Department of Commerce. Filing UE – 190908. June 1, 2021. <https://www.utc.wa.gov/casedocket/2019/190908/docsets>

Piette, M.A. et al. Lawrence Berkeley National Laboratory. Comparison of Actual Costs to Integrate Commercial Buildings with Grid. May 2016. <https://eta.lbl.gov/publications/comparison-actual-costs-integrate>

Producer Power Index. PPI Industry Data for Electric Power Generation. Accessed May 2021. <https://beta.bls.gov/dataViewer/view/timeseries/PCU22111-22111->

Public Utilities Commission of the State of California. San Diego Gas & Electric Company 2017 Demand Response Program Proposals. Rulemaking 13-09-011. February 1, 2016. <https://www.sdge.com/sites/default/files/regulatory/R.13-09-011-SDGE-2017-Demand-Response-Program-Proposal.pdf>

Puget Sound Energy. 2020 Annual Report of Energy Conservation Accomplishments. Filing UE – 190905. April 9, 2021. <https://www.utc.wa.gov/casedocket/2019/190905/docsets>

Puget Sound Energy. 2021 PSE Integrated Resource Plan. April 2021. <https://pse-irp.participate.online/2021-irp/reports>.

San Diego Gas and Electric. SDG&E 2019 Annual Report. May 25, 2020. <ftp://ftp.cpuc.ca.gov/energy/EEfficiencyRpts/SDGE/SDGE.AnnualNarrative.2019.1.pdf>

Southern California Edison. SCE 2020 Annual Report. May 24, 2021. <https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442469298>

U.S. Department of Energy. Energy Storage Technology and Cost Characterization Report. July 2019.
https://www.energy.gov/sites/default/files/2019/07/f65/Storage%20Cost%20and%20Performance%20Characterization%20Report_Final.pdf