SANTA CATALINA ISLAND REPOWER FEASIBILITY STUDY APPENDIX

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Prepared For:

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APPENDIX

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APPENDIX A – POWER PLANT GENERATION COST ESTIMATES

COST ESTIMATE DETAIL

Disclaimer: The cost estimates within this document are preliminary and based on the best information available at the time of this report. The estimates are subject to change as plans are developed or modified.

Electrical

2.4 kV System

	Bay 7				Site Adjustment	Site Adjusted Cost	
	Number	Units	$/Unit	Total		High	Low
Underground raceway to 2,400V Swgr, LV and MV							
Demolition				$ 80,800	Y	$ 242,400	$ 161,600
Pavement removal and repair	1	LT	$ 21,500	$ 21,500	Y	$ 64,500	$ 43,000
Trench, 2.5 FT x 2 FT	325	LF	$ 4.40	$ 1,500	Y	$ 4,500	$ 3,000
Reinforced concrete ductbank	50	CY	$ 4,310	$ 215,500	Y	$ 215,500	$ 215,500
four 4 IN PVC	1400	LF	$ 21.60	$ 30,300	Y	$ 90,900	$ 60,600
four 2 IN PVC	1400	LF	$ 8.70	$ 12,200	Y	$ 36,600	$ 24,400
4/0 bare CU ground wire in ductbank	360	LF	$ 8.70	$ 3,200	Y	$ 9,600	$ 6,400
Cable							
500 kcmil, 5 kV, EPR/PVC shld, 2/PH	2400	LF	$ 21.60	$ 51,900	Y	$ 155,700	$ 103,800
15 kV terminations	12	EA	$ 351	$ 4,300	Y	$ 12,900	$ 8,600
Circuits/Controls							
LV power, control, metering and relaying circuits	1	LT	$ 161,600	$ 161,600	Y	$ 484,800	$ 323,200
Relay settings, relays and equipment testing	1	LT	$ 32,400	$ 32,400	Y	$ 97,200	$ 64,800
Rework raceways to plant	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
Grounding	1	LT	$ 10,800	$ 10,800	Y	$ 32,400	$ 21,600
Comm circuits and Ovation Integration	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
			Total	$ 773,800		$ 1,770,400	$ 1,252,100

2.4 kV System, continued

	Bay 8				Site	Site Adjusted Cost	
	Number	Units	$/Unit	Total	Adjustment	High	Low
Underground raceway to 2,400 Swgr, LV and MV							
Demolition				$ 80,800	Y	$ 242,400	$ 161,600
Pavement removal and repair	1	LT	$ 21,500	$ 21,500	Y	$ 64,500	$ 43,000
Trench, 2.5 FT x 2 FT	100	LF	$ 4.40	$ 440	Y	$ 1,500	$ 1,000
Reinforced concrete ductbank	12	CY	$ 4,310	$ 51,800	N	$ 51,800	$ 51,800
four 4 IN PVC	400	LF	$ 21.60	$ 8,700	Y	$ 26,100	$ 17,400
four 2 IN PVC	400	LF	$ 8.70	$ 3,500	Y	$ 10,500	$ 7,000
4/0 bare CU ground wire in ductbank	120	LF	$ 8.70	$ 1,100	Y	$ 3,300	$ 2,200
Cable							
500 kcmil, 5 kV, EPR/PVC shld, 2/PH	750	LF	$ 21.60	$ 16,200	Y	$ 48,600	$ 32,400
15 kV terminations	12	EA	$ 351	$ 4,300	Y	$ 12,900	$ 8,600
Circuits/Controls					Y		
LV power, control, metering and relaying circuits	1	LT	$ 134,700	$ 134,700	Y	$ 404,100	$ 269,400
Relay settings, relays and equipment testing	1	LT	$ 32,400	$ 32,400	Y	$ 97,200	$ 64,800
Rework raceways to plant	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
Grounding	1	LT	$ 10,800	$ 10,800	Y	$ 32,400	$ 21,600
Comm circuits and Ovation Integration	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
			Total	$ 474,100		$ 1,318,700	$ 896,400

2.4 kV System, continued

	Bay 10				Site	Site Adjusted Cost	
	Number	Units	High	High	Adjustment	High	Low
Underground raceway to 2,400 Swgr, LV and MV							
Demolition				$ 80,800	Y	$ 242,400	$ 161,600
Pavement removal and repair	1	LT	$ 21,500	$ 21,500	Y	$ 64,500	$ 43,000
Trench, 2.5 FT x 2 FT	150	LF	$ 4.40	$ 700	Y	$ 2,100	$ 1,400
Reinforced concrete ductbank	23	CY	$ 4,310	$ 99,200	Y	$ 99,200	$ 99,200
four 4 IN PVC	600	LF	$ 21.60	$ 13,000	Y	$ 39,000	$ 26,000
four 2 IN PVC	600	LF	$ 8.70	$ 5,300	Y	$ 15,900	$ 10,600
4/0 bare CU ground wire in ductbank	200	LF	$ 8.70	$ 1,800	Y	$ 5,400	$ 3,600
Cable							
500 kcmil, 5 kV, EPR/PVC shld, 2/PH	1125	LF	$ 21.60	$ 24,300	Y	$ 72,900	$ 48,600
15 kV terminations	12	EA	$ 351	$ 4,300	Y	$ 12,900	$ 8,600
Circuits/Controls							
LV power, control, metering and relaying circuits	1	LT	$ 161,600	$ 161,600	Y	$ 484,800	$ 323,200
Relay settings, relays and equipment testing	1	LT	$ 32,400	$ 32,400	Y	$ 97,200	$ 64,800
Rework raceways to plant	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
Grounding	1	LT	$ 10,800	$ 10,800	Y	$ 32,400	$ 21,600
Comm circuits and Ovation Integration	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
			Total	$ 563,500		$ 1,492,100	$ 1,027,800

2.4 kV System, continued

	Bay 12				Site	Site Adjusted Cost	
	Number	Units	$/Unit	Total	Adjustment	High	Low
Underground raceway to 2,400 Swgr, LV and MV							
Demolition				$ 80,800	Y	$ 242,400	$ 161,600
Pavement removal and repair	1	LT	$ 21,500	$ 21,500	Y	$ 64,500	$ 43,000
Trench, 2.5 FT x 2 FT	300	LF	$ 4.40	$ 1,400	Y	$ 4,200	$ 2,800
Reinforced concrete ductbank	46	CY	$ 431	$ 198,300	Y	$ 198,300	$ 198,300
four 4 IN PVC	1200	LF	$ 21.60	$ 26,000	Y	$ 78,000	$ 52,000
four 2 IN PVC	1200	LF	$ 8.70	$ 10,500	Y	$ 31,500	$ 21,000
4/0 bare CU ground wire in ductbank	340	LF	$ 8.70	$ 3,000	Y	$ 9,000	$ 6,000
Cable							
500 kcmil, 5 kV, EPR/PVC shld, 2/PH	2160	LF	$ 21.60	$ 46,700	Y	$ 140,100	$ 93,400
15 kV terminations	12	EA	$ 351	$ 4,300	Y	$ 12,900	$ 8,600
Circuits/Controls					Y		
LV power, control, metering and relaying circuits	1	LT	$ 161,600	$ 161,600	Y	$ 484,800	$ 323,200
Relay settings, relays and equipment testing	1	LT	$ 32,400	$ 32,400	Y	$ 97,200	$ 64,800
Rework raceways to plant	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
Grounding	1	LT	$ 10,800	$ 10,800	Y	$ 32,400	$ 21,600
Comm circuits and Ovation Integration	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
			Total	$ 705,100		$ 1,718,700	$ 1,211,900

12 kV System

	Bay 14				Site	Site Adjusted Cost	
	Number	Units	$/Unit	Total	Adjustment	High	Low
Underground raceway to 12kV Swgr, LV and MV							
Demolition				$ 80,800	Y	$ 242,400	$ 161,600
Pavement removal and repair	1	LT	$ 32,300	$ 32,300	Y	$ 96,900	$ 64,600
Trench, 2.5 FT x 2 FT	250	LF	$ 4.40	$ 1,100	Y	$ 3,300	$ 2,200
Reinforced concrete ductbank	38	CY	$ 4,310	$ 163,800	Y	$ 163,800	$ 163,800
four 4 IN PVC	1700	LF	$ 21.60	$ 36,800	Y	$ 110,400	$ 73,600
four 2 IN PVC	1700	LF	$ 8.70	$ 14,800	Y	$ 44,400	$ 29,600
4/0 bare CU ground wire in ductbank	425	LF	$ 8.70	$ 3,700	Y	$ 11,100	$ 7,400
Cable							
#3/0 15 kV, EPR/EPC shld	950	LF	$ 21.60	$ 20,600	Y	$ 61,800	$ 41,200
15 kV terminations	6	EA	$ 351	$ 2,200	Y	$ 6,600	$ 4,400
Circuits/Controls							
15 kV Switchgear							
LV power, control, metering and relaying circuits	1	LT	$ 134,700	$ 134,700	Y	$ 404,100	$ 269,400
Relay settings, relays and equipment Testing	1	LT	$ 32,400	$ 32,400	Y	$ 97,200	$ 64,800
Rework raceways to plant	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
Grounding	1	LT	$ 10,800	$ 10,800	Y	$ 32,400	$ 21,600
Comm circuits and Ovation Integration	1	LT	$ 53,900	$ 53,900	Y	$ 161,700	$ 107,800
			Total	$ 641,800		$ 1,597,800	$ 1,119,800

240 V Plant Auxiliary System

Replace Existing SLP Transformer and Swbrd BA	Number of Units	Unit of Measure	Total	Site Adjustment	Site Adjusted Cost	
					High	Low
Demolish existing electric equipment and work	1	LT	$ 107,700	Y	$ 323,100	$ 215,400
450 kW diesel engine-gen, installed	1	LT	$ 215,400	Y	$ 646,200	$ 430,800
Air compressor 4 VFD and Electric Work	1	LT	$ 107,700	Y	$ 323,100	$ 215,400
Switchboard BA and transformer, installed	1	EA	$ 510,500	Y	$ 1,531,500	$ 1,021,000
Electric work	1	LT	$ 161,600	Y	$ 484,800	$ 323,200
240 V Plant Auxiliary System Total			$ 1,102,900		$ 3,308,700	$ 2,205,800

Note: Needed to support electrical requirements for propane or LNG options.

Engine Generator Sets

	Cummins		Site ADJ	Site Adjusted Cost			
				High	Low	High	Low
Capacity: kW/kV	2,127/12	2,127/2.4		2,127/12	2,127/12	2,127/2.4	2,127/2.4
Engine Generator Set	$ 2,320,000	$ 2,270,000	N	$ 2,320,000	$ 2,320,000	$ 2,270,000	$ 2,270,000
Spare/Parts/Tools	$ 5,000	$ 5,000	N	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Freight/Delivery	$ 328,500	$ 328,500	N	$ 328,500	$ 328,500	$ 328,500	$ 328,500
Structural							
Foundations: Concrete Work	$ 150,000	$ 150,000	N	$ 150,000	$ 150,000	$ 150,000	$ 150,000
Supports and Platforms: Steel Works	$ 25,000	$ 25,000	Y	$ 75,000	$ 50,000	$ 75,000	$ 50,000
Mechanical: Final Connections	$ 15,000	$ 15,000	Y	$ 45,000	$ 30,000	$ 45,000	$ 30,000
Controls/Controls Integration	$ 10,000	$ 10,000	Y	$ 30,000	$ 20,000	$ 30,000	$ 20,000
Start-up	$ 30,000	$ 30,000	Y	$ 90,000	$ 60,000	$ 90,000	$ 60,000
Crane Rental	$ 10,000	$ 10,000	Y	$ 30,000	$ 20,000	$ 30,000	$ 20,000
Placement/Installation	$ 515,000	$ 515,000	Y	$ 1,545,000	$ 1,030,000	$ 1,545,000	$ 1,030,000
Contingency, 15%	$ 113,000	$ 113,000	Y	$ 339,000	$ 226,000	$ 339,000	$ 226,000
Engine Generator Total	$ 3,521,500	$ 3,471,500		$ 4,957,500	$ 4,239,500	$ 4,907,500	$ 4,189,500

Engine Generator Sets, continued

	EMD		Site ADJ	Site Adjusted Cost			
				High	Low	High	Low
Capacity: kW/kV	2,983/12	2,237/2.4		2,983/12	2,983/12	2,237/2.4	2,237/2.4
Engine Generator Set	$ 2,623,400	$ 2,435,000	N	$ 2,623,400	$ 2,623,400	$ 2,435,000	$ 2,435,000
Spare/Parts/Tools	$ 5,000	$ 5,000	N	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Freight/Delivery	$ 350,000	$ 328,500	N	$ 350,000	$ 350,000	$ 328,500	$ 328,500
Structural							
Foundations: Concrete Work	$ 200,000	$ 150,000	N	$ 200,000	$ 200,000	$ 150,000	$ 150,000
Supports and Platforms: Steel Works	$ 30,000	$ 25,000	Y	$ 90,000	$ 60,000	$ 75,000	$ 50,000
Mechanical: Final Connections	$ 15,000	$ 15,000	Y	$ 45,000	$ 30,000	$ 45,000	$ 30,000
Controls/Controls Integration	$ 10,000	$ 10,000	Y	$ 30,000	$ 20,000	$ 30,000	$ 20,000
Start-up	$ 30,000	$ 30,000	Y	$ 90,000	$ 60,000	$ 90,000	$ 60,000
Crane Rental	$ 10,000	$ 10,000	Y	$ 30,000	$ 20,000	$ 30,000	$ 20,000
Placement/Installation	$ 515,000	$ 515,000	Y	$ 1,545,000	$ 1,030,000	$ 1,545,000	$ 1,030,000
Contingency, 15%	$ 95,000	$ 93,000	Y	$ 366,000	$ 244,000	$ 339,000	$ 226,000
Engine Generator Total	$ 3,910,400	$ 3,636,500		$ 5,374,400	$ 4,462,400	$ 5,072,500	$ 4,354,500

Engine Generator Sets, continued

	EMD	Site ADJ	Site Adjusted Cost	
			High	Low
Capacity: kW/kV	1,491/2.4		1,491/2.4	1,491/2.4
Engine Generator Set	$ 2,340,000	N	$ 2,340,000	$ 2,340,000
Spare/Parts/Tools	$ 5,000	N	$ 5,000	$ 5,000
Freight/Delivery	$ 328,500	N	$ 328,500	$ 328,500
Structural				
Foundations: Concrete Work	$ 120,000	N	$ 120,000	$ 120,000
Supports and Platforms: Steel Works	$ 25,000	Y	$ 75,000	$ 50,000
Mechanical: Final Connections	$ 15,000	Y	$ 45,000	$ 30,000
Controls/Controls Integration	$ 10,000	Y	$ 30,000	$ 20,000
Start-up	$ 30,000	Y	$ 90,000	$ 60,000
Crane Rental	$ 10,000	Y	$ 30,000	$ 20,000
Placement/Installation	$ 515,000	Y	$ 1,545,000	$ 1,030,000
Contingency, 15%	$ 109,000	Y	$ 327,000	$ 218,000
Engine Generator Total	$ 3,507,500		$ 4,935,500	$ 4,221,500

Engine Generator Sets, continued

	Caterpillar, Propane	Site ADJ	Site Adjusted Cost	
			High	Low
Capacity: kW/kV	1,382/2.4		1,382/2.4	1,382/2.4
Engine Generator Set	$ 1,950,000	N	$ 1,950,000	$ 1,950,000
Spare/Parts/Tools	$ 5,000	N	$ 5,000	$ 5,000
Freight/Delivery	$ 328,500	N	$ 985,500	$ 657,000
Structural				
Foundations: Concrete Work	$ 150,000	N	$ 150,000	$ 150,000
Supports and Platforms: Steel Works	$ 25,000	Y	$ 75,000	$ 50,000
Mechanical: Final Connections	$ 15,000	Y	$ 45,000	$ 30,000
Controls/Controls Integration	$ 15,000	Y	$ 45,000	$ 30,000
Start-up	$ 30,000	Y	$ 90,000	$ 60,000
Crane Rental	$ 10,000	Y	$ 30,000	$ 20,000
Placement/Installation	$ 475,000	Y	$ 1,425,000	$ 950,000
Contingency, 15%	$ 108,000	Y	$ 324,000	$ 216,000
Engine Generator Total	$ 3,111,500		$ 5,124,500	$ 4,118,000

Engine Generator Sets, continued

	Caterpillar, Propane	Site ADJ	Site Adjusted Cost	
			High	Low
Capacity: kW/kV	1,382/12		1,382/12	1,382/12
Engine Generator Set	$ 2,000,000	N	$ 2,000,000	$ 2,000,000
Spare/Parts/Tools	$ 5,000	N	$ 5,000	$ 5,000
Freight/Delivery	$ 328,500	N	$ 985,500	$ 657,000
Structural				
Foundations: Concrete Work	$ 150,000	N	$ 150,000	$ 150,000
Supports and Platforms: Steel Works	$ 25,000	Y	$ 75,000	$ 50,000
Mechanical: Final Connections	$ 15,000	Y	$ 45,000	$ 30,000
Controls/Controls Integration	$ 15,000	Y	$ 45,000	$ 30,000
Start-up	$ 30,000	Y	$ 90,000	$ 60,000
Crane Rental	$ 10,000	Y	$ 30,000	$ 20,000
Placement/Installation	$ 475,000	Y	$ 1,425,000	$ 950,000
Contingency, 15%	$ 108,000	Y	$ 324,000	$ 216,000
Engine Generator Total	$ 3,161,500		$ 5,174,500	$ 4,168,000

Engine Generator Sets, continued

	Jenbacher, Propane	Site ADJ	Site Adjusted Cost	
			High	Low
Capacity: kW/kV	1,382/2.4		2,983/12	2,237/2.4
Engine Generator Set	$ 1,214,000	N	$ 1,214,000	$ 1,214,000
Spare/Parts/Tools	$ 5,000	N	$ 5,000	$ 5,000
Freight/Delivery	$ 100,000	N	$ 300,000	$ 200,000
Structural				
Foundations: Concrete Work	$ 150,000	n	$ 150,000	$ 150,000
Supports and Platforms: Steel Works	$ 62,000	Y	$ 186,000	$ 124,000
Mechanical: Final Connections	$ 34,000	Y	$ 102,000	$ 68,000
Controls/Controls Integration	$ 12,000	Y	$ 36,000	$ 24,000
Start-up	$ 30,000	Y	$ 90,000	$ 60,000
Crane Rental	$ 10,000	Y	$ 30,000	$ 20,000
Placement/Installation	$ 387,000	Y	$ 1,161,000	$ 774,000
Contingency, 15%	$ 83,000	Y	$ 249,000	$ 166,000
Engine Generator Total	$ 2,107,000		$ 3,583,000	$ 2,845,000

Fuel Delivery / Urea Systems

	Unit Price Containment	Number of Units	Unit of Measure	Total	Site Adjustment	Site Adjusted Cost	
						High	Low
Fuel Delivery							
Pipe Diameter (inches)							
6	$ 280	570	LF	$ 159,600	Y	$ 478,800	$ 319,200
4	$ 200	150	LF	$ 30,000	Y	$ 90,000	$ 60,000
3	$ 100	65	LF	$ 6,500	Y	$ 19,500	$ 13,000
Fittings & Valves			15%	$ 29,400	Y	$ 88,200	$ 58,800
Urea System							
Pipe Diameter (inches)							
3	$ 120	410	LF	$ 49,200	Y	$ 147,600	$ 98,400
2.5	$ 100	180	LF	$ 14,500	Y	$ 43,500	$ 29,000
1.5	$ 80	190	LF	$ 15,200	Y	$ 45,600	$ 30,400
Fittings & Valves			15%	$ 11,800	Y	$ 35,500	$ 23,700
Concrete Demolition: 6" deep	$ 16.00	1,370	SF	$ 21,900	N	$ 21,900	$ 21,900
Demolition Waste: 6" deep	$ 19.60	25	CY	$ 5,000	N	$ 5,000	$ 5,000
Demolition Waste: Pipe removal	$ 28.90	15	CY	$ 4,300	N	$ 4,300	$ 4,300
Trench & Backfill: 24" x 36" deep	$ 47.00	685	LF	$ 32,200	N	$ 32,200	$ 32,200
Asphaltic Concrete Paving	$ 47.00	1,370	SF	$ 64,400	N	$ 64,400	$ 64,400
Unknown Detail			25%	$ 111,000	Y	$ 269,000	$ 190,000
			Fuel Delivery/Urea Systems Total	$ 555,000		$ 1,345,500	$ 950,300

Propane Storage—100% Propane Engine Generator Scenario

	Nominal Cost	Location Adjustment		
			High	Low
Propane Tanks	$ 800,000	N	$ 800,000	$ 800,000
Vaporizer	$ 300,000	N	$ 300,000	$ 300,000
Delivery	$ 250,000	N	$ 250,000	$ 250,000
Site work	$ 975,000	Y	$ 2,925,000	$ 1,950,000
Installation/Concrete	$ 990,000	Y	$ 2,970,000	$ 1,980,000
Propane Office	$ 675,000	Y	$ 2,025,000	$ 1,350,000
Water Deluge Tank	$ 4,500,000	Y	$ 13,500,000	$ 9,000,000
Deluge Piping/Pump	$ 425,000	Y	$ 1,275,000	$ 850,000
Distribution to Plant	$ 2,157,000	Y	$ 6,471,000	$ 4,314,000
Back-up Generator	$ 375,000	N	$ 375,000	$ 375,000
Fencing/Security	$ 188,000	Y	$ 564,000	$ 376,000
Electrical/Controls	$ 1,080,000	Y	$ 3,240,000	$ 2,160,000
Contingency	$ 1,660,000	Y	$ 4,577,000	$ 3,119,000
Construction Cost	$ 14,375,000		$ 39,272,000	$ 26,824,000
Engineering	$ 1,222,000	N	$ 1,222,000	$ 1,222,000
Bid Support	$ 216,000	N	$ 216,000	$ 216,000
Cx	$ 288,000	Y	$ 864,000	$ 576,000
Project Cost	$ 16,101,000		$ 41,574,000	$ 28,838,000

CONSOLIDATED COST ESTIMATES WITH LOCATION ADJUSTMENTS

Option 1 – All Engine Replacement

	Cummins	Location Adjustment		
	One 2,127 kW/12 kV Four 2,127 kW/2.4 kV		High	Low
Engine Gen-Sets	$ 11,400,000	N	$ 11,400,000	$ 11,400,000
Spare Parts/Tools	$ 25,000	N	$ 25,000	$ 25,000
Freight/Delivery	$ 1,642,500	Y	$ 4,927,500	$ 3,285,000
Crane Rental	$ 50,000	Y	$ 150,000	$ 100,000
Engine Placement/Installation	$ 2,575,000	Y	$ 7,725,000	$ 5,150,000
Plant Renovations				
Engine Removal/Demolition	$ 1,250,000	Y	$ 3,750,000	$ 2,500,000
Structural				
Foundations: Concrete Work	$ 750,000	N	$ 750,000	$ 750,000
Supports/Access Platforms	$ 125,000	Y	$ 375,000	$ 250,000
Mechanical Connections	$ 75,000	Y	$ 225,000	$ 150,000
Electrical				
2.4 kV Modifications	$ 2,476,500	Y	$ 6,299,900	$ 4,388,200
12 kV Modifications	$ 641,800	Y	$ 1,597,800	$ 1,119,800
240V Plant Auxiliary Upgrade		Y		
Controls/Controls Integration	$ 50,000	Y	$ 150,000	$ 100,000
Fuel/Urea System	$ 555,000	Y	$ 1,345,500	$ 950,300
Start-Up	$ 150,000	Y	$ 450,000	$ 300,000
Contingency, 15%	$ 3,264,900		$ 5,875,600	$ 4,570,200
Construction Cost	$ 25,030,700		$ 45,046,300	$ 35,038,500
Engineering	$ 2,127,600	N	$ 2,127,300	$ 2,127,300
Bid Support	$ 375,500	N	$ 375,500	$ 375,500
Commissioning	$ 500,600	Y	$ 1,126,500	$ 751,000
Project Cost	$ 28.034,400		$ 48,675,900	$ 38,292,600

CONSOLIDATED COST ESTIMATES WITH LOCATION ADJUSTMENTS, CONTINUED

Option 1 – All Engine Replacement

	EMD	Location Adjustment		
	Two 2,237 kW/2.4 kV Two 1,491 kW/2.4 kV One 2,983 kW/12 kV		High	Low
Engine Gen-Sets	$ 12,173,400	N	$ 12,173,400	$ 12,173,400
Spare Parts/Tools	$ 25,000	N	$ 25,000	$ 25,000
Freight/Delivery	$ 1,642,500	Y	$ 4,927,500	$ 3,285,000
Crane Rental	$ 50,000	Y	$ 150,000	$ 100,000
Engine Placement/Installation	$ 2,575,000	Y	$ 7,725,000	$ 5,150,000
Plant Renovations				
Engine Removal/Demolition	$ 1,250,000	Y	$ 3,750,000	$ 2,500,000
Structural				
Foundations: Concrete Work	$ 740,000	N	$ 740,000	$ 740,000
Supports/Access Platforms	$ 130,000	Y	$ 390,000	$ 260,000
Mechanical Connections	$ 75,000	Y	$ 225,000	$ 150,000
Electrical				
2.4 kV Modifications	$ 2,476,500	Y	$ 6,299,900	$ 4,388,200
12 kV Modifications	$ 641,800	Y	$ 1,597,800	$ 1,119,800
240V Plant Auxiliary Upgrade		Y		
Controls/Controls Integration	$ 50,000	Y	$ 150,000	$ 100,000
Fuel/Urea System	$ 555,000	Y	$ 1,345,500	$ 950,300
Start-Up	$ 150,000	Y	$ 450,000	$ 300,000
Contingency, 15%	$ 3,380,100		$ 5,992,400	$ 4,686,300
Construction Cost	$ 25,914,300		$ 45,941,500	$ 35,928,000
Engineering	$ 2,202,700	N	$ 2,202,700	$ 2,202,700
Bid Support	$ 388,700	N	$ 388,700	$ 388,700
Commissioning	$ 518,300	Y	$ 1,554,900	$ 1,036,600
Project Cost	$ 29,024,000		$ 50,087,800	$ 39,556,000

CONSOLIDATED COST ESTIMATES WITH LOCATION ADJUSTMENTS, CONTINUED

Option 1 – All Engine Replacement, 100% Propane

	Caterpillar	Location Adjustment		
	Three 1,382 kW/12 kV Four 1.382 kW/2.4 kV		High	Low
Engine Gen-Sets	$ 13,800,000	N	$ 13,800,000	$ 13,800,000
Spare Parts/Tools	$ 35,000	N	$ 35,000	$ 35,000
Freight/Delivery	$ 2,299,500	Y	$ 6,898,500	$ 4,599,000
Crane Rental	$ 70,000	Y	$ 210,000	$ 140,000
Engine Placement/Installation	$ 3,325,000	Y	$ 9,975,000	$ 6,650,000
Plant Renovations				
Engine Removal/Demolition	$ 1,500,000	Y	$ 4,500,000	$ 3,000,000
Structural				
Foundations: Concrete Work	$ 1,050,000	N	$ 1,050,000	$ 1,050,000
Supports/Access Platforms	$ 175,000	Y	$ 525,000	$ 350,000
Mechanical Connections	$ 105,000	Y	$ 315,000	$ 210,000
Electrical				
2.4 kV Modifications	$ 2,476,500	Y	$ 7,429,500	$ 4,953,000
12 kV Modifications	$ 1,845,300	Y	$ 5,535,900	$ 3,690,600
240V Plant Auxiliary Upgrade	$ 1,102,900	Y	$ 3,308,700	$ 2,205,800
Controls/Controls Integration	$ 105,000	Y	$ 315,000	$ 210,000
Fuel/Urea System	$ 555,000	Y	$ 1,665,000	$ 1,110,000
Start-Up	$ 210,000	Y	$ 630,000	$ 420,000
Contingency, 15%	$ 944,200		$ 2,832,600	$ 1,888,400
Propane Storage	$ 14,375,000		$ 39,272,000	$ 26,824,000
Construction Cost	$ 43,973,400		$ 98,297,200	$ 71,135,800
Engineering	$ 3,737,900	N	$ 3,737,900	$ 3,737,900
Bid Support	$ 660,000	N	$ 660,000	$ 660,000
Commissioning	$ 880,000	Y	$ 2,044,500	$ 1,462,200
Project Cost	$ 49,251,300		$ 104,739,600	$ 76,995,900

CONSOLIDATED COST ESTIMATES WITH LOCATION ADJUSTMENTS, CONTINUED

Option 2 – Two Engine Replacement

	EMD	Location Adjustment		
	Two 2,237 kW/2.4 kV		High	Low
Engine Gen-Sets	$ 4,870,000	N	$ 4,870,000	$ 4,870,000
Spare Parts/Tools	$ 10,000	N	$ 10,000	$ 10,000
Freight/Delivery	$ 657,000	Y	$ 1,971,000	$ 1,314,000
Crane Rental	$ 20,000	Y	$ 60,000	$ 40,000
Engine Placement/Installation	$ 1,030,000	Y	$ 3,090,000	$ 2,060,000
Plant Renovations				
Engine Removal/Demolition	$ 500,000	Y	$ 1,500,000	$ 1,000,000
Structural				
Foundations: Concrete Work	$ 300,000	N	$ 300,000	$ 300,000
Supports/Access Platforms	$ 50,000	Y	$ 150,000	$ 100,000
Mechanical Connections	$ 30,000	Y	$ 90,000	$ 60,000
Electrical				
2.4 kV Modifications	$ 1,037,600	Y	$ 2,810,800	$ 1,924,200
12 kV Modifications				
240V Plant Auxiliary Upgrade		Y		
Controls/Controls Integration	$ 20,000	Y	$ 60,000	$ 40,000
Fuel/Urea System				
Start-Up	$ 60,000	Y	$ 180,000	$ 120,000
Contingency, 15%	$ 1,287,700		$ 2,263,800	$ 1,775,700
Construction Cost	$ 9,872,300		$ 17,355.600	$ 13,613,900
Engineering	$ 839,100	N	$ 839,100	$ 839,100
Bid Support	$ 148,100	N	$ 148,100	$ 148,100
Commissioning	$ 197,400	Y	$ 592,200	$ 394,800
Project Cost	$ 11,0565,900		$ 18,935,000	$ 14,995,900

CONSOLIDATED COST ESTIMATES WITH LOCATION ADJUSTMENTS, CONTINUED

Option 2 – Two Engine Replacement

	Caterpillar, Propane	Location Adjustment		
	Two 1,382 kW/2.4 kV		High	Low
Engine Gen-Sets	$ 3,800,000	N	$ 3,800,000	$ 3,800,000
Spare Parts/Tools	$ 10,000	N	$ 10,000	$ 10,000
Freight/Delivery	$ 657,000	Y	$ 1,971,000	$ 1,314,000
Crane Rental	$ 20,000	Y	$ 60,000	$ 40,000
Engine Placement/Installation	$ 1,030,000	Y	$ 3,090,000	$ 2,060,000
Plant Renovations				
Engine Removal/Demolition	$ 500,000	Y	$ 1,500,000	$ 1,000,000
Structural				
Foundations: Concrete Work	$ 300,000	N	$ 300,000	$ 300,000
Supports/Access Platforms	$ 50,000	Y	$ 150,000	$ 100,000
Mechanical Connections	$ 30,000	Y	$ 90,000	$ 60,000
Electrical				
2.4 kV Modifications	$ 1,037,600	Y	$ 2,810,800	$ 1,924,200
12 kV Modifications		Y	$ -	$ -
240V Plant Auxiliary Upgrade	$ 1,102,900	Y	$ 3,308,700	$ 2,205,800
Controls/Controls Integration	$ 30,000	Y	$ 90,000	$ 60,000
Fuel/Urea System			$ -	$ -
Start-Up	$ 60,000	Y	$ 180,000	$ 120,000
Contingency, 15%	$ 1,294,100		$ 2,604,100	$ 1,949,100
Construction Cost	$ 9,921,600		$ 19,964,600	$ 14,943,100
Engineering	$ 843,300	N	$ 843,300	$ 843,300
Bid Support	$ 148,800	N	$ 148,800	$ 148,800
Commissioning	$ 198,400	Y	$ 595,200	$ 396,800
Project Cost	$ 11,112,100		$ 21,551,900	$ 16,332,000

CONSOLIDATED COST ESTIMATES WITH LOCATION ADJUSTMENTS, CONTINUED

Option 2 – Two Engine Replacement

	Jenbacher, Propane	Location Adjustment		
	Two 1,025 kW/2.4 kV		High	Low
Engine Gen-Sets	$ 2,428,000	N	$ 2,428,000	$ 2,428,000
Spare Parts/Tools	$ 10,000	N	$ 10,000	$ 10,000
Freight/Delivery	$ 200,000	Y	$ 600,000	$ 400,000
Crane Rental	$ 20,000	Y	$ 60,000	$ 40,000
Engine Placement/Installation	$ 773,000	Y	$ 2,319,000	$ 1,546,000
Plant Renovations				
Engine Removal/Demolition	$ 500,000	Y	$ 1,500,000	$ 1,000,000
Structural				
Foundations: Concrete Work	$ 300,000	N	$ 300,000	$ 300,000
Supports/Access Platforms	$ 123,000	Y	$ 369,000	$ 246,000
Mechanical Connections	$ 67,000	Y	$ 201,000	$ 134,000
Electrical				
2.4 kV Modifications	$ 1,037,600	Y	$ 2,810,800	$ 1,924,200
12 kV Modifications		Y		
240V Plant Auxiliary Upgrade	$ 1,102,900	Y	$ 3,308,700	$ 2,205,800
Controls/Controls Integration	$ 24,000	Y	$ 72,000	$ 48,000
Fuel/Urea System				
Start-Up	$ 58,000	Y	$ 174,000	$ 116,000
Contingency, 15%	$ 997,400		$ 2,125,600	$ 1,561,500
Construction Cost	$ 7,646,900		$ 16,296,100	$ 11,971,500
Engineering	$ 650,000	N	$ 650,000	$ 650,000
Bid Support	$ 114,700	N	$ 114,700	$ 114,700
Commissioning	$ 152,900	Y	$ 458,700	$ 305,800
Project Cost	$ 8,564,500		$ 17,519,500	$ 13,042,000

APPENDIX B – FOSSIL FUEL GENERATION ELECTRICAL DRAWINGS

ABBREVIATIONS

ABBRV.	DESCRIPTION	ABBRV.	DESCRIPTION
		kW	KILOWATT
AFF	ABOVE FINISHED FLOOR	KO	KNOCK OUT
A/C	AIR CONDITIONING	LTG	LIGHTING
AHU	AIR HANDLING UNIT	LOC	LOCATION
AC	ALTERNATING CURRENT	LOR	LOCK OUT RELAY
AL	ALUMINUM	LV	LOW VOLTAGE
AWG	AMERICAN WIRE GAUGE	MCB	MAIN CIRCUIT BREAKER
A, AMP	AMPERES	MLO	MAIN LUGS ONLY
APPROX.	APPROXIMATE	MSB	MAIN SWITCHBOARD
ARCH	ARCHITECT	MH	MAINTENANCE HATCH
AUTO	AUTOMATIC	MAN	MANUAL
ATS	AUTOMATIC TRANSFER SWITCH	MTS	MANUAL TRANSFER SWITCH
AVG	AVERAGE	MFR	MANUFACTURER
BKR	BREAKER	MAX	MAXIMUM
BLDG	BUILDING	MECH	MECHANICAL
CAB	CABINET	MIN	MINIMUM
CAT	CATALOG	M, MTR	MOTOR
CLG	CEILING	MCC	MOTOR CONTROL CENTER
CKT	CIRCUIT	MCP	MOTOR CONTROL PANEL
CB	CIRCUIT BREAKER	MTD	MOUNTED
CCTV	CLOSED CIRCUIT TELEVISION	MTG	MOUNTING
COL	COLUMN	NEC	NATIONAL ELECTRIC CODE
COMB	COMBINATION	N	NEUTRAL
C	CONDUIT	NF	NON-FUSED
CONN	CONNECTION	NORM	NORMAL
CONST	CONSTRUCTION	NC	NORMALLY CLOSED
CONTR	CONTRACTOR	NO	NORMALLY OPEN
CTRL	CONTROL	NIC	NOT IN CONTRACT
CS	CONTROL SWITCH	NTS	NOT TO SCALE
CU	COPPER	OC	ON CENTER
CLF	CURRENT LIMITING FUSE	OH	OVERHEAD
DET	DETAIL	PNL	PANEL
DIA	DIAMETER	PTZ	PAN, TILT, ZOOM
DC	DIRECT CURRENT	PH, Ø	PHASE
DISC	DISCONNECT	PL	PILOT LIGHT
DIST	DISTRIBUTION	P	POLE
DN	DOWN	PVC	POLYVINYL CHLORIDE
DWG	DRAWING	PWR	POWER
EA	EACH	PDU	POWER DISTRIBUTION UNIT
ETC	ELAPSED TIME CONTROLLER	PF	POWER FACTOR
ELEC	ELECTRICAL	PP	POWER POLE
EHU	ELECTRIC HEATING UNIT	PB	PUSH BUTTON
EMT	ELECTRICAL METALLIC TUBING	RECEPT	RECEPTACLE
EWH	ELECTRIC WATER HEATER	REFRIG	REFRIGERATOR
EL	ELEVATION	REQ'D	REQUIRED
EMERG	EMERGENCY	RGS	RIGID GALVANIZED STEEL
ELR	END OF LINE RESISTOR	RM	ROOM
ENG	ENGINEER	RND	ROUND
EQUIP	EQUIPMENT	SS	SAFETY SWITCH OR SYNC SWITCH
EXIST	EXISTING	SEC	SECOND
FDR	FEEDER	SPEC	SPECIFICATION
F/A	FIRE ALARM	SQ	SQUARE
FAAP	FIRE ALARM ANNUNCIATOR PANEL	STR	STARTER
FACP	FIRE ALARM CONTROL PANEL	STRUCT	STRUCTURAL
FIXT	FIXTURE	SW	SWITCH
FL	FLOOR	SWBD	SWITCHBOARD
FLUOR	FLUORESCENT	SWGR	SWITCHGEAR
FT	FOOT	SYM	SYMMETRICAL
FR	FRAME	TEL	TELEPHONE
FLA	FULL LOAD AMPS	TV	TELEVISION
GEN	GENERATOR	TS	TEMPERATURE SWITCH
G, GND	GROUND	TERM	TERMINAL
GFI	GROUND FAULT INTERRUPTER	TT	THERMAL SWITCH
HOA	HAND - OFF - AUTOMATIC	kCMIL	THOUSAND CIRCULAR MILS
HTR	HEATER	T, XFMR	TRANSFORMER
HVAC	HEATING, VENTILATING AND AIR CONDITIONING	TYP	TYPICAL
HZ	HERTZ	UFD	UNDERFLOOR DUCT
HID	HIGH INTENSITY DISCHARGE	UG	UNDERGROUND
HV	HIGH VOLTAGE	UL	UNDERWRITER'S LAB
HORZ	HORIZONTAL	UPS	UNINTERRUPTABLE POWER SOURCE
HP	HORSEPOWER	UH	UNIT HEATER
INCAND	INCANDESCENT	VFD	VARIABLE FREQUENCY DRIVE
IMC	INTERMEDIATE METALLIC CONDUIT	VENT	VENTILATION
IG	ISOLATED GROUND	VERT	VERTICAL
JCT	JUNCTION	V	VOLT
JB	JUNCTION BOX	VA	VOLT AMPERE
kV	KILOVOLT	W	WATT
kVA	KILOVOLT AMPERES	WP	WEATHER PROOF

PLAN SYMBOLS

LIGHTING

SYMBOL	DESCRIPTION	MOUNTING HEIGHT AFF
	FIXTURE TYPE/CIRCUIT NUMBER	
	RECESSED FLUORESCENT FIXTURE	
	RECESSED EMERGENCY FLUORESCENT FIXTURE	
	SURFACE MOUNT FLUORESCENT FIXTURE	
	SURFACE MOUNT EMERGENCY FLUORESCENT FIXTURE	
	LINEAR PENDANT	
	STRIP LIGHT	
	EMERGENCY STRIP LIGHT	
	RECESSED DOWNLIGHT FIXTURE	
	SURFACE MOUNTED DOWNLIGHT FIXTURE	
	DOWNLIGHT FIXTURE - EMERGENCY CIRCUIT	
	DIRECTIONAL DOWNLIGHT FIXTURE	
	WALL MOUNTED LIGHT FIXTURE	
	WALL MOUNTED EMERGENCY LIGHT FIXTURE	
	EMERGENCY LIGHT FIXTURE	
	EMERGENCY SINGLE REMOTE LIGHT FIXTURE	
	EXIT LIGHT	
	WALL MOUNTED EXIT LIGHT	
	POLE MOUNTED LIGHT FIXTURE	
	POLE MOUNTED DOUBLE LIGHT FIXTURE	
	LIGHT POLE WITH SINGLE LUMINAIR	
	LIGHT POLE WITH DOUBLE LUMINAIR	
	LIGHT POLE WITH QUADRUPLE LUMINAIR	
P	PHOTO CELL	
R	RELAY	
	SURFACE WALL PACK	

COMMUNICATION

SYMBOL	DESCRIPTION	MOUNTING HEIGHT AFF
C	CLOCK	
S	SPEAKER OUTLET	
S	CEILING SPEAKER	
M	MICROPHONE OUTLET	
TV	VIDEO OUTLET	18"
	VOICE OUTLET	18"
	VOICE AND DATA OUTLET	18"
	INTERCOM	
CCTV	CLOSED CIRCUIT TV CAMERA	
TMGB	TECHNOLOGY MAIN BUS BAR	
— COMM —	COMMUNICATIONS WIRING	

FIRE ALARM

SYMBOL	DESCRIPTION	MOUNTING HEIGHT AFF
FACP	FIRE ALARM CONTROL PANEL	60"
FAAP	FIRE ALARM ANNUNCIATOR PANEL	60"
F_H	HEAT DETECTOR	
F_S	SMOKE DETECTOR (PRODUCTS OF COMBUSTION DETECTOR)	
F_{DS}	DUCT SMOKE DETECTOR (PRODUCTS OF COMBUSTION DETECTOR)	
F	MANUAL PULL STATION	42"
F_{FS}	SPRINKLER FLOW SWITCH	
F_{DH}	MAGNETIC DOOR HOLDER	
F TS	TAMPER SWITCH	
F_{SV}	SOLENOID VALVE	
F_{RL}	REMOTE INDICATOR LIGHT	
F	FIRE ALARM SPEAKER	
F	FIRE ALARM STROBE ONLY	
F	FIRE ALARM HORN ONLY	
F_{CM}	CONTROL MODULE	
F_{MM}	MONITOR MODULE	

RACEWAY

SYMBOL	DESCRIPTION	MOUNTING HEIGHT AFF
	CABLE TRAY	
	CONDUIT TURNING UP	
	CONDUIT TURNING DOWN	
	TEE TYPE CONDUIT FITTING	
	LB TYPE CONDUIT FITTING	
	CONDUIT EXPOSED WITH WIRE COUNT	
	CONDUIT CONCEALED IN CEILING OR WALLS WITH WIRE COUNT	
	CONDUIT CONCEALED IN OR UNDER FLOOR WITH WIRE COUNT	
LP1 1	CIRCUIT HOME RUN LP1 = PANEL IDENTIFIER 1 = CIRCUIT NUMBER	
J	JUNCTION BOX	
J	WALL MOUNTED JUNCTION BOX	
P	PULL BOX	
— —	CONCEALED OR UNDERGROUND RACEWAY	

DEVICES

SYMBOL	DESCRIPTION	MOUNTING HEIGHT AFF
	SINGLE RECEPTACLE	18"
	DUPLEX RECEPTACLE	
	CEILING MOUNTED RECEPTACLE	18"
	COMBINATION RECEPTACLE	18"
	SPECIAL PURPOSE RECEPTACLE	18"
GFI WP	GFI RECEPTACLE	18"
IG	ISOLATED GROUND RECEPTACLE	18"
	QUAD RECEPTACLE	18"
	EMERGENCY POWER OFF	
	SINGLE POLE SWITCH	42"
3	3-WAY SWITCH	42"
4	4-WAY SWITCH	42"
T	THERMAL SWITCH	
K	KEY OPERATED SWITCH	
P	PILOT LIGHT SWITCH	
MC	MOMENTARY CONTACT SWITCH	
LV	LOW VOLTAGE SWITCH	
OS	OCCUPANCY SENSOR SWITCH	42"
D	DIMMER SWITCH	42"
OS	OCCUPANCY SENSOR	
OS	WALL MOUNTED OCCUPANCY SENSOR	
DL	DAYLIGHT SENSOR	
DL	WALL MOUNTED DAYLIGHT SENSOR	
	MOTOR	
B	DISCONNECT SWITCH B = CIRCUIT BREAKER F = FUSED SWITCH BLANK = NON FUSED	
B	COMBINATION STARTER DISCONNECT SWITCH	
	MOTOR STARTER	
	CONTROL DEVICE	
	CIRCUIT PANEL - FLUSH MOUNTED	
	CIRCUIT PANEL - SURFACE MOUNTED	
	CIRCUIT/CONTROL PANEL SPECIAL SYSTEMS	
MGBB	MAIN GROUNDING BUS BAR	

MISCELLANEOUS

SYMBOL	DESCRIPTION
A	FLOOR BOX =WITH RECEPTACLE =WITH VOICE/DATA A =TYPE (SEE SPEC)
A	PLUGSTRIP (SEE SPEC FOR TYPE)
4/0	GROUND CONDUCTOR WITH WIRE SIZE
	GROUND ROD
/////	INDICATED ITEMS TO BE DEMOLISHED
ITSXXXX	CIRCUIT NUMBER - REFER TO CIRCUIT TABULATION
O | C INSTALLED BY FURNISHED BY	CONTRACT BOX O = OWNER C = CONTRACTOR

ONE-LINE/RISER AND SCHEMATIC SYMBOLS

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
		RL	REMOTE-LOCAL SELECTOR SWITCH
	CIRCUIT BREAKER		TEST SWITCH
	DRAWOUT MOUNTED CIRCUIT BREAKER LOW VOLTAGE	A	AMMETER
	DRAWOUT MOUNTED CIRCUIT BREAKER MEDIUM VOLTAGE	V	VOLTMETER
	FUSE	PFM	POWER FACTOR METER
	FUSE - DRAWOUT MOUNTED	VAR	VAR METER
	FUSED DISCONNECT SWITCH	WHM	WATT-HOUR METER
	DRAWOUT MOUNTED EQUIPMENT	WM	WATT METER
	AUTOMATIC TRANSFER SWITCH	SYNC	SYNCHROSCOPE
	CURRENT LIMITING REACTOR	A	TRANSDUCER (LETTER INDICATES TYPE)
	CABLE TERMINATOR		TOGGLE SWITCH
	GROUND		FUSED SWITCH
	TRANSFORMER		CONTACT - NORMALLY OPEN
	SUBSTATION TRANSFORMER WITH LTC		CONTACT - NORMALLY CLOSED
	VOLTAGE REGULATOR	G	INDICATOR LIGHT (LETTER INDICATES LIGHT COLOR)
	WYE / GROUNDED WYE		TRIP SIGNAL
	GROUNDED WYE / GROUNDED WYE		DEVICE TERMINAL POINT
	DELTA / GROUNDED WYE		TERMINAL BLOCK POINT
	DELTA / WYE		WIRING CONNECTION POINT
	DELTA / DELTA		TEST SWITCH/BLOCK
	GENERATOR (WYE CONFIGURED WINDINGS)		BUSWAY
	GENERATOR NEUTRAL		
	RESISTOR		
CAPACITOR BANK	CAPACITOR		
	ZERO SEQUENCE CURRENT TRANSFORMER		
	CURRENT TRANSFORMER		
	POTENTIAL TRANSFORMER		
	MULTI RATIO CURRENT TRANSFORMER		
	SURGE ARRESTER		
AS	AMMETER SWITCH		
CS	CONTROL SWITCH		
GS	GOVERNOR SWITCH		
SS	SYNCHRONIZING SWITCH		
TS	TEMPERATURE SWITCH		
VS	VOLTMETER SWITCH		
AM	AUTO-MANUAL SELECTOR SWITCH		
LR	LOWER-RAISE SELECTOR SWITCH		
K	KEY INTERLOCK		
E	ELECTRICAL INTERLOCK		
	BATTERY		
PM	POWER METER		

MARKERS

PLAN/DETAIL TITLE MARKER

DRAWING NUMBER

1 E1 DRAWING TITLE

SCALE:

DRAWING SHEET

SECTION MARKER

SECTION NUMBER

1 E1

SHEET WHERE SHOWN

MATCHLINE

MATCHLINE FOR CONTINUATION SEE SHEET E1 — MATCHLINE FOR CONTINUATION SEE SHEET E1

SHEET INDEX

• REVISE ON AUTOCAD SYSTEM ONLY •

REFERENCE DRAWINGS	REFERENCE DRAWINGS	NO.	REVISIONS	DATE	SAP WO	SUPV	APPROVED	ENGR	CK'D	MADE	P.E.

NO.	REVISIONS	DATE	SAP WO	SUPV	APPROVED	ENGR	CK'D	MADE	P.E.
A	PRELIMINARY	05-06-20		XXX	XX	XX	XX	M.DAY	

LOCATION: PEBBLY BEACH GENERATING STATION

ELECTRICAL SYMBOLS AND ABBREVIATIONS

SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company

SHEET NO. -

SCALE: AS SHOWN

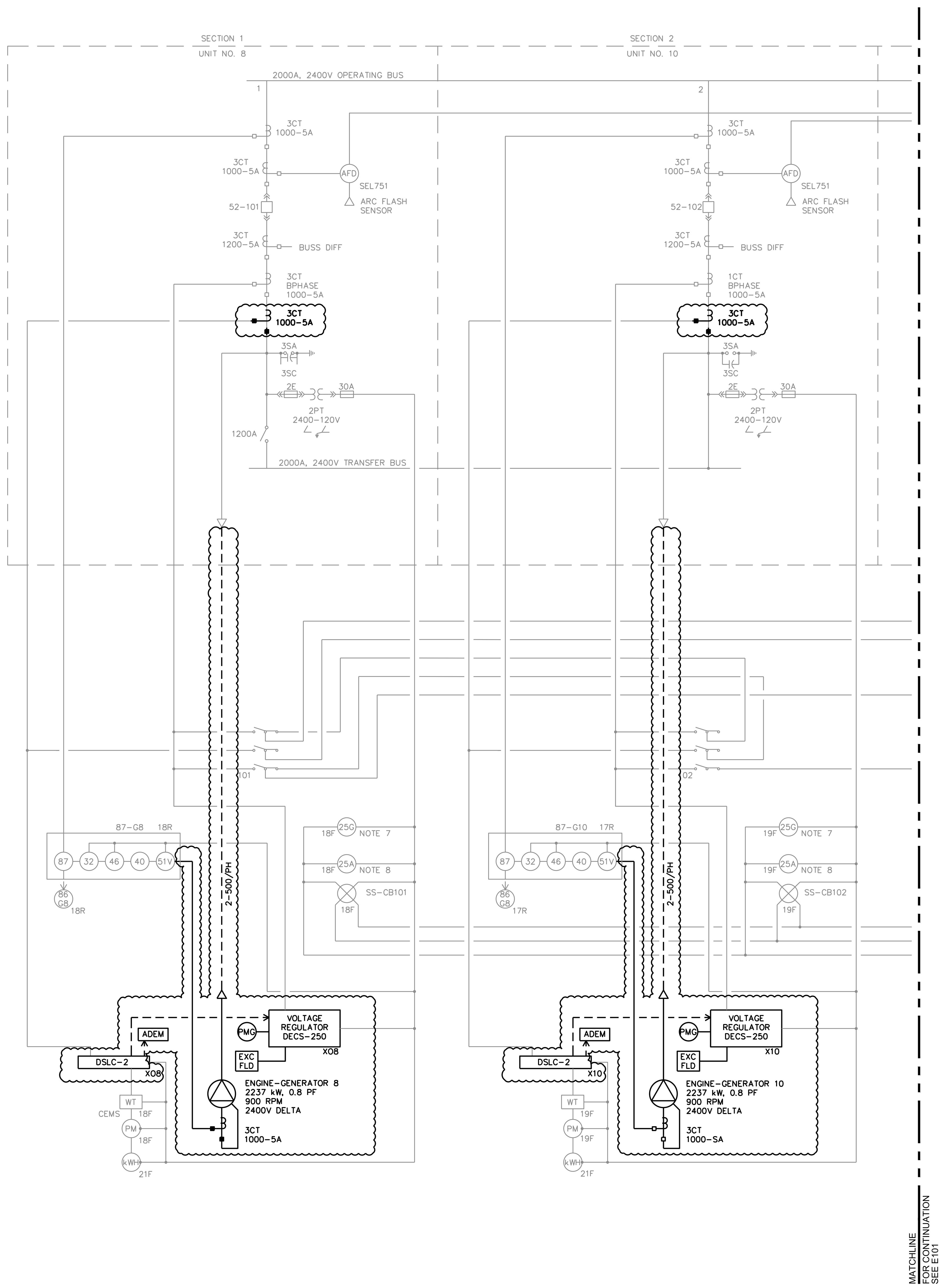
1 OF 1 SHTS.

SOUTHERN CALIFORNIA EDISON
2016 - 5 SIZE

PRELIMINARY NOT FOR CONSTRUCTION

REVISE ELECTRONICALLY ONLY

E001



* REVISE ON AUTOCAD SYSTEM ONLY *

NO.	REVISIONS	DATE	SAP WO	SUPV	APPROVED	ENGR	CK'D	MADE	P.E.
A	PRELIMINARY	05-06-20		XXX	XX	XX		XX	M.DAY

REFERENCE DRAWINGS

REFERENCE DRAWINGS

LOCATION: PEBBLY BEACH GENERATING STATION

2400V SWITCHGEAR ONE-LINE DIAGRAM

SOUTHERN CALIFORNIA EDISON — An EDISON INTERNATIONAL Company

SHEET NO. -

SCALE: AS SHOWN

1 OF 1 SHTS.

SOUTHERN CALIFORNIA EDISON
2016 - 5 SIZE

PRELIMINARY NOT FOR CONSTRUCTION

REVISE ELECTRONICALLY ONLY

E100

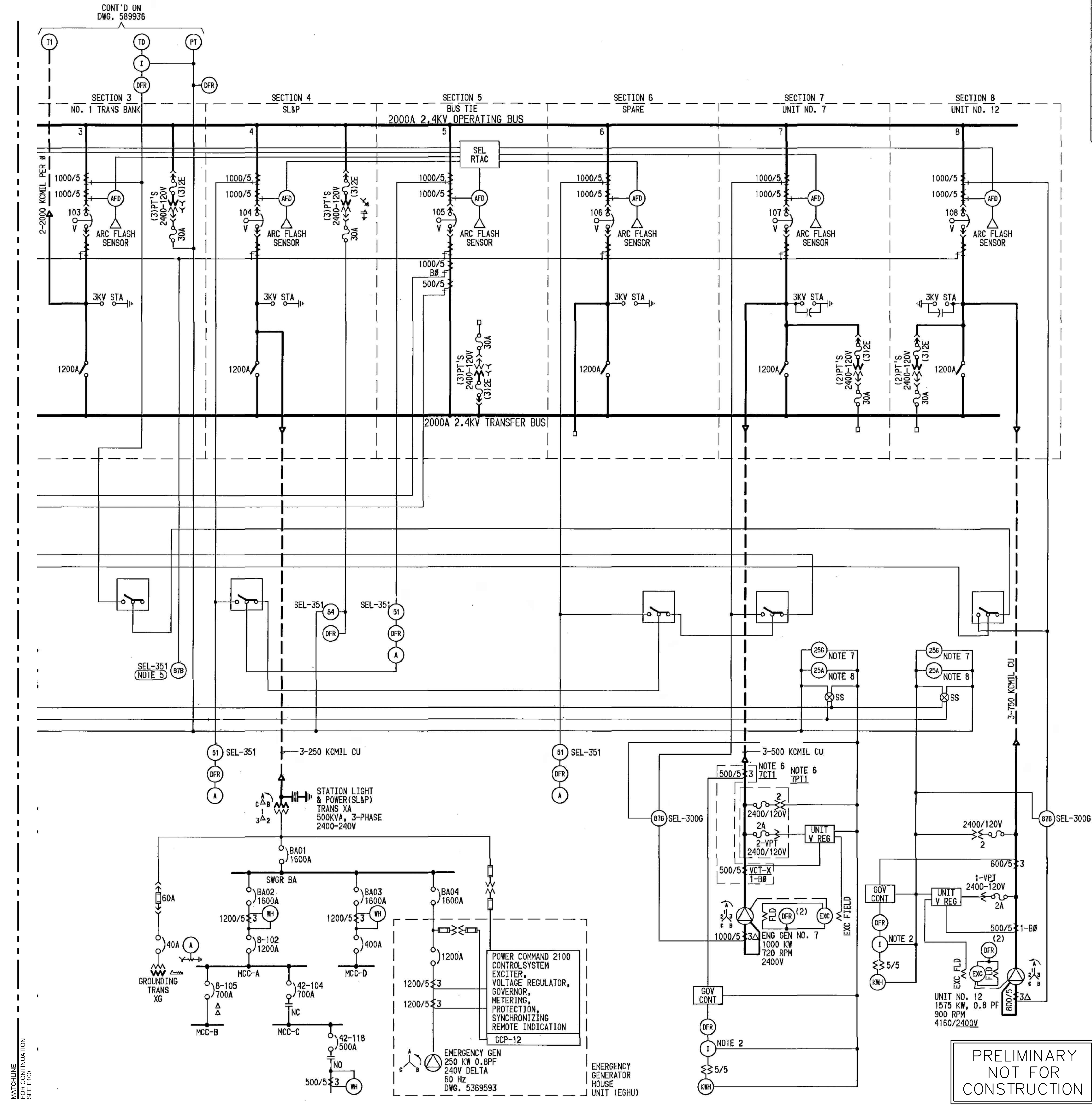


TABLE OF CB'S							
NUMBER	KV	MAKE	TYPE	AMP	BCT'S LINE SIDE	BCT'S BUS SIDE	DUTY
101,102	2.5			1200	3-2000/5 4-1200/5	6-1200/5	40KA
104,106,107,108	2.5			1200	3-2000/5	6-1200/5	40KA
103	2.5			2000	3-2000/5	6-2000/5	40KA
105	2.5			2000	3-2000/5 4-1200/5	6-2000/5	40KA

TRIP SCHEDULE		
PROTECTION	RELAY FUNCTION	CB'S TRIPPED & TRIP FUNCTION
2.4 KV BUS DIFF SEL-351 (LOR AUX)	87B	101, 102, 103. 105. 106. 107. 108 LOCKOUT & MANUAL RESET
GENERATOR DIFF SEL-300G	87G	101, 102, 107 & 108 LOCKOUT & MANUAL RESET

NOTES:

1. MAIN BATTERY-60 CELL.
2. 3Ø DIGITAL MULTI-FUNCTION METER W/ 3Ø AMPS, MW, MVARS, POWER FACTOR, FREQUENCY AND KWH.
3. PGBS SYSTEM PHASE ROTATION IS A-B-C COUNTERCLOCKWISE
4. ARC FLASH DEVICE (SEL-751), RUN FIBER SENSORS ON BREAKER COMPARTMENT, POWER CABLE TERMINATION, LINE PT'S & TRANSFER SWITCHES.
5. 2.4KV BUS DIFFERENTIAL CT RATIO IS 1200/5.
6. PT'S AND CT'S ARE MOUNTED IN UNIT 7 GENERATOR ENCLOSURE.
7. GENERATOR SYNC-CHECK RELAY (BECKWITH M-3410A) ALLOWS MANUAL OR AUTOMATIC CLOSE ONLY WHEN GENERATOR IS IN SYNC.
8. GENERATOR AUTOMATIC SYNCHRONIZER (WOODWARD SPH-010 25A) INITIATES REMOTE CLOSING OF GENERATOR CB VIA PBGS OVATION DCS AUTOMATION
9. REMOTE (SUPERVISORY) CONTROL, STATUS INDICATION, ALARMS AND TELEMETRY VIA PBGS OVATION DCS AUTOMATION
10. NEW DFR IS USI (UTILITY SYSTEMS INC) MODEL 2002 W/ 72 ANALOG CHANNELS AND 96 DIGITAL EVENT MARKERS
11. EACH BREAKER PROVIDED WITH A CONTROL SWITCH AND RED & GREEN STATUS INDICATING LIGHTS.

PRELIMINARY NOT FOR CONSTRUCTION

* REVISE ON AUTOCAD SYSTEM ONLY *

NO.	REVISIONS	DATE	SAP WO	SUPV	APPROVED	ENGR	CK'D	MADE	P.E.
A	PRELIMINARY	05-06-20		XXX	XX	XX		XX	M.DAY

REFERENCE DRAWINGS | REFERENCE DRAWINGS

LOCATION: PEBBLY BEACH GENERATING STATION

2400V SWITCHGEAR ONE-LINE DIAGRAM

SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company

SHEET NO. –

SCALE: AS SHOWN

1 OF 1 SHTS.

SOUTHERN CALIFORNIA EDISON 2016 - 5 SIZE

PRELIMINARY NOT FOR CONSTRUCTION | REVISE ELECTRONICALLY ONLY

E101

APPENDIX C – RENEWABLE ENERGY SITE MATRIX

Site Number	Energy Type	Regulatory Complexity Rank 1=Low 10=High	Size (acres)	Biological Sensitivity Rank	Wetland Sensitivity Rank	Mitigation Requirement Rank	Grading Complexity Rank	New Road Length Estimate (Miles)	New Power Line Estimated Length (miles)	Electric System Gen-tie Cost Estimate	Approximate Power Generation (MW)	Team Comments	Site Visit Comments (August 2019)	Site Summary	Notes from 9-25-19	Tiered Ranking - Individual Use	Grouped With	Tiered Ranking - When Grouped	Land Owner
1	PV	5	10	2	8	2-8	TBD	TBD	0.1	TBD	2	Resource availability, land type, zoning, potential power delivery (size), Mitigation dependent on Jurisdictional drainage and presence of wetland or riparian habitat (100ft buffer per CDFW), smaller drainages without vegetation may only have 10ft buffer. Sites would likely require JD to 401, 404 and 1600 permits to establish setbacks and impacts.	a) Preferred areas would be located near water body. Due to wetland features, overall size would be reduced and fragmented for avoidance. Steeper terrain would require grading. b) Disturbed habitat areas interlaced with some natural habitat. c) 12kV line located next to site.	This site is steeply pitched on towards a wetland. Although close to two distribution circuits, the substantial grading and environmental constraints may be prohibitive. This site is not feasible.	LOCATION: BESIDE PATRICK RESERVOIR SLIGHTLY NORTH OF THE RESERVOIR.	Low		Low	Conservancy
2	PV	5	6.4	2	8	2-8	TBD	TBD	0.05	TBD	1.28	Acceptability to landowner, land user, recreational user, gather info via charrette, mitigation dependent on jurisdictional drainage and presence of wetland or riparian habitat (100ft buffer per CDFW), smaller drainages without vegetation may only have 10ft buffer. Sites would likely require JD to 401, 404 and 1600 permits to establish setbacks and impacts.	a) Preferred areas would be located near water body. Due to wetland features, overall size would be reduced and fragmented for avoidance. Steeper terrain would require grading. b) Disturbed habitat areas interlaced with some natural habitat. c) 12kV line located next to site. 3 to 4 poles expected to connect to 12kV line.	This site is steeply pitched on both sides towards a natural drainage and into a wetland. Although close to two distribution circuits, the substantial grading and environmental constraints may be prohibitive. This site is not feasible.	LOCATION: BESIDE HAYPRESS RESERVOIR SLIGHTLY NORTH WEST OF THE RESERVOIR.	Low		Low	Conservancy
3	PV	5	15	2	2-6	1	TBD	TBD	0.05	TBD	3	Mitigation dependent on Jurisdictional drainage and presence of wetland or riparian habitat (100ft buffer per CDFW), smaller drainages without vegetation may only have 10ft buffer. Sites would likely require JD to 401, 404 and 1600 permits to establish setbacks and impacts.	a) Flat rectangular sites. b) Site appears to have been previously used for agriculture, but abandoned and reverting to natural area. c) Bordered to the south with steep ridge, winter shading should be evaluated. d) Riparian Arroyo borders northern boundary with native flora and fauna. e) Central portion of site contains riparian features which may affect use areas. f) Minor site restoration of scrub oak communities by Island Conservancy may be incompatible. g) 12kV line located near site.	This location shows promise because of the available size. Site has been previously disturbed. A long, narrow solar array is possible, keeping in mind the shading from the ridge and the incized channel. Due to such constraints, approximately 5 acres could be available for PV. The site has existing distribution. This site is feasible as a Tier 1 option.	LOCATION: BESIDE MIDDLE RANCH RESERVOIR SLIGHTLY SOUTH EAST OF THE RESERVOIR AND SLIGHTLY SOUTH EAST OF MIDDLE RANCH WELLS.	High		High	Conservancy
4	PV	7	2.4	2-6	2	4-8	TBD	TBD	1	TBD	0.48	Bio sensitivity related to presence of coastal scrub and rare plants. Mitigation needs tied to vegetation impacts. No significant wetland habitat but drainages may exist. Power lines contributes to both bio sensitivity and mitigation rankings as transmission path has substantial veg habitat and potential tree impacts.	No site visit.	No site visit.	LOCATION: WEST OF EAGLES NEST SLIGHTLY NORTH WEST OF MIDDLE RANCH RESERVOIR.	Medium		Medium	Conservancy
5	PV	3	6	2	0	1	TBD	TBD	0.01	TBD	1.2	Bio sensitivity related to presence of coastal scrub and rare plants. Mitigation needs tied to potential vegetation impacts and historical view scape. Potential cultural resources maybe present and would alter rankings appropriately. No significant wetland habitat but drainages may exist.	a) Mostly non-native grasses, slope 5% or less, steady low speed breeze. b) General Plan shows future residential. c) 12kV line passes through site.	On Catalina Island Company land. Site has gentle slopes although it's north facing and may require civil or other construction work. The site has existing distribution. Near barge locations, making the site easier to access than remote sites. This site is feasible as a Tier 2 option.	LOCATION: SOUTH EAST OF TWO HARBORS ON A SLOPE.	High		High	Island Company
6	PV	3	7.22	2	0	1	TBD	TBD	0.01	TBD	1.444	Bio sensitivity related to presence of coastal scrub and rare plants. Mitigation needs tied to potential vegetation impacts and historical view scape. Potential cultural resources maybe present and would alter rankings appropriately. No significant wetland habitat but drainages may exist.	a) Mostly non-native grasses, slope 5% or less, steady low speed breeze. b) General Plan shows future residential. c) Moderate wind in area may be suitable for low speed wind energy production. d) 12kV line passes through site.	On Catalina Island Company land. Site has gentle slopes although it's north facing and may require civil or other construction work. The site has existing distribution. Near barge locations, making the site easier to access than remote sites. This site is feasible as Tier 2 option.	LOCATION: SOUTH OF TWO HARBORS ON FLAT LAND.	Medium		Medium	Island Company
7	PV	5	13.8	3	0	2	TBD	TBD	0.2	TBD	2.76	Avoid Scrub, Bio sensitivity related to presence of coastal scrub and rare plants. Mitigation needs tied to vegetation impacts. No significant wetland habitat but drainages may exist. Switchyard contributes to both bio sensitivity and mitigation rankings as does transmission path.	a) Gentle slope. Suitable with minimal grading. b) Site is previously disturbed with non-native grasses. c) Rectangular shape. Two parcels, each either side of main road. d) 12kV line located nearby to the west. e) Visual impact to newly upgraded Ranch may be an issue. PV would be visible from key Ranch viewpoints, disturbing natural backdrop to ocean.	On Catalina Island Company land. Visual impacts to vineyard and B&B are likely. The site is flat, constructable with minimal grading expected. The site has existing distribution. Adding battery storage would provide optional ability to 'microgrid island' this area and support the wells/commercial facility. Although the Catalina Island Company may eventually prohibit use, the site from a feasibility perspective is a Tier 1 option.	LOCATION: WRIGLEY-RUSACK PROPERTY.	High		High	Conservancy
8	Wind	8	0.25				TBD	TBD	0.36	TBD	N/A	No analysis outside of wind zone.	No site visit.	No site visit.		No site visit.		No site visit.	
9	Wind	8	0.25				TBD	TBD	1.1	TBD	N/A	No analysis outside of wind zone.	No site visit.	No site visit.		No site visit.		No site visit.	
10	Thermo Incline	9	500	5	7	5	TBD	TBD	10.9	TBD	N/A	Offshore sites would require anchored and or suspended or floating infrastructure that contribute to biological, waters and mitigation rankings, avoid of hard substrate rock influences mitigation needs, USCG and Coastal commission contribute to water impacts/mitigation associated with recreation. NFMS is expected to have concerns about EFH and marine mammals. Fill associated with anchoring under USACE would also need to be mitigated.	No site visit.	No site visit.	LOCATION: IN THE OCEAN SOUTH OF THE ISLAND SOUTH OF BINNACLE ROCK.	No site visit.		No site visit.	Ocean unknown
11	Wave Energy	9	360	5	7	5	TBD	TBD	6.2	TBD	N/A	Offshore sites would require anchored and or suspended or floating infrastructure that contribute to biological, waters and mitigation rankings, avoid of hard substrate rock influences mitigation needs, USCG and Coastal commission contribute to water impacts/mitigation associated with recreation. NFMS is expected to have concerns about EFH and marine mammals. Fill associated with anchoring under USACE would also need to be mitigated. However, less constraints are expected compared to Site 10 due to depth, habitat and rugosity.	No site visit.	No site visit.	LOCATION: IN THE OCEAN SOUTH OF THE ISLAND SOUTH EAST OF SOUTHEAST ROCK AUXILIARY.	No site visit.		No site visit.	Ocean unknown
12	Thermo cline	9	412	5	7	5	TBD	TBD	TBD	TBD	N/A	Offshore sites would require anchored and or suspended or floating infrastructure that contribute to biological, waters and mitigation rankings, avoid of hard substrate rock influences mitigation needs, USCG and Coastal commission contribute to water impacts/mitigation associated with recreation. NFMS is expected to have concerns about EFH and marine mammals. Fill associated with anchoring under USACE would also need to be mitigated. However, less constraints are expected compared to Site 10 due to depth, habitat and rugosity.	No site visit.	No site visit.	LOCATION: IN THE OCEAN SOUTH OF THE ISLAND SOUTH OF SOUTHEAST ROCK AUXILIARY.	No site visit.		No site visit.	Ocean unknown
13	Floating Solar	9	8.75 (4 ac usable)	8	5	7	TBD	TBD	TBD	TBD	0.8	Biological sensitivity tied to Eagles foraging on fish species or nesting in shoreline trees, input of fill (USACE) contributes to mitigation ranking as does proximity to shoreline riparian habitat. Potential impacts to riparian habitat could be negotiated out since infrastructure not likely to directly impact habitat.	a) Lake level was at peak during site visit. Peak level offers large viable floating PV area. b) Typical lake level ranges significantly in height. Lower years provide approximately 1/3 of current surface. c) Two Bald Eagle nests are currently occupied. Documented observations include eagles fishing at lake. Island Conservancy has observation records that may affect a regulatory decision. d) Steady moderate wind passes over dam. No wind turbine foundations allowed in earthen dam (structure just meets safety standards). e) 12kV line located near site.	Regulatory factors would likely guide decision-making for this site. Assuming environmental constraints are minimized, this site shows some promise for floating PV and could also reduce natural evaporation. Due to use of water for domestic purposes, drought and evaporation, the lake's east end dries out seasonally. Floating PV pontoons could be placed in the shallow areas, allowing the system to settle on the lakebed when drying occurs. It is unknown if the lakebed is flat enough to support this and if the pontoons can handle being mired in subsequent mud. Positioning in the shallow side of the lake may also allow wildlife to remain relatively undisturbed when foraging in the deeper parts of the lake. An additional ½ acre on land would be needed for collection and inversion of energy produced by wave generators. This site is feasible as a Tier 2 option.	LOCATION: MIDDLE RANCH RESERVOIR.	Medium		Medium	Conservancy
14	Floating Solar	9	0.39	6	5	7	TBD	TBD	TBD	TBD	0.078	Biological sensitivity tied to Eagles foraging on fish species or nesting in shoreline trees, input of fill (USACE) contributes to mitigation ranking as does proximity to shoreline riparian habitat. Potential impacts to riparian habitat could be negotiated out since infrastructure not likely to directly impact habitat.	a) Lake level fluctuates, limited surface area available. b) Regulating agencies would require assessment to evaluate impacts to riparian flora and fauna. c) 12kV line located next to site. d) Approx. 1/2 acre would be needed for power collection and inversion.	The lake is narrow and supports native species. Additionally, floating PV generation and required equipment on land may disrupt animal life including federally protected species includign migratory birds. This location, when compared to other potential generation sites, is deemed to have too many constraints for reasonable level of pursuit. This site is not feasible.	LOCATION: HAYPRESS RESERVOIR.	Not feasible.		Not feasible.	Conservancy
15	PV (other)	9	0.6	0	0	0	TBD	TBD	TBD	TBD	0.12	Existing reservoir likely already permitted so no additional mitigation or bio/waters constraints expected.	a) The site is owned by SCE and there are no natural environmental issues related to using the site. b) Due to water quality management practices, the site utilizes a rubber bladder (cover) that expands and contracts. Floating PV is not practical due to cover. c) Construction of a roof structure to support PV over the pool is complex. The reservoir pool is an engineered concrete basin with regulated berms. Penetration of the concrete or installation of roof supporting piers is likely to exceed the net benefit of energy production. d) 12kV line passes next to site.	This site could provide generation of reasonable amounts of energy. The challenge is that mounting of panels would require innovation for the mounting/racking design. State drinking water regulations apply to the surrounding dams. This site is feasible as a Tier 3 option.	LOCATION: WRIGLEY RESERVOIR.	Low		Low	SCE
16	Rooftop PV	2	0.28	0	0	0	TBD	TBD	TBD	TBD	0.056	No constraints expected (Built Environment).	a) SCE controls two buildings at the Pebbly Beach Generation Station with rooftop area (warehouse and office). b) A third warehouse building near the Generation Station has been leased to a commercial enterprise. c) All three rooftops offer some areas for rooftop PV. d) Each structure would need to be evaluated for structural integrity. e) No natural environmental resources would be impacted.	Construction would require tie-in to customer meter.	LOCATION: PEBBLY BEACH GENERATING STATION OFFICE BUILDING ROOF.	Medium		Medium	SCE

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17	Rooftop PV	2	0.09	0	0	0	TBD	TBD	TBD	TBD	0.018	No constraints expected (Built Environment).	a) SCE controls two buildings at the Pebbly Beach Generation Station with rooftop area (warehouse and office). b) A third warehouse building near the Generation Station has been leased to a commercial enterprise. c) All three rooftops offer some areas for rooftop PV. d) Each structure would need to be evaluated for structural integrity. e) No natural environmental resources would be impacted.	Construction would require tie-in to customer meter.	LOCATION: CONNEX BOXES BESIDE THE PEBBLY BEACH GENERATING STATION SLIGHTLY NORTH OF THE STATION.	Medium		Medium	Catalina Island Company
18	Wind	8	112	8	1	8	TBD	TBD	TBD	TBD	N/A	Bio sensitivity related to presence of coastal scrub and rare plants. Mitigation needs tied to potential vegetation in selected sites. No significant wetland habitat but drainages may exist. Mitigation related to potential impacts to raptors and migratory birds contributes to high ranking.	a) Wind energy maps show lower annual speed range. b) Most vegetation can be classified as native coastal sage scrub. c) Road access is steep and narrow. Construction may require helicopter support. d) Suitable wind turbine pad locations are limited. e) Site is dominated by FAA facility located at 2,100-foot island peak. f) A 12kV line services the FAA facility, but would require upgrade for renewable production.	The data in this area indicates historically low, sporadic wind. This, with the additional challenge of finding suitable locations to support large wind generation and equipment foundations, essentially eliminates this site as a location for wind generation at this time. This site is not feasible.	LOCATION: SOUTH OF THE AIRPORT ON THE RIDGELINE TOWARD MOUNT ORIZABA.	Not feasible.		Not feasible.	Conservancy
19	Wind	8	232	8	1	8	TBD	TBD	TBD	TBD	N/A	Bio sensitivity related to presence of coastal scrub and rare plants. Mitigation needs tied to potential vegetation in selected sites. No significant wetland habitat but drainages may exist. Mitigation related to potential impacts to raptors and migratory birds contributes to high ranking	a) Very narrow ridge limits wind turbine site locations. Possible 1 or 2 locations at the eastern site. b) Native habitat along both sides of ridge. c) 12kV line located near eastern side ridge.	The data in this area indicates historically low, sporadic wind. This, with the additional challenge of finding suitable locations to support large wind generation and equipment foundations, essentially eliminates this site as a location for wind generation at this time. This site is not feasible.	LOCATION: ALONG DIVIDE ROAD SOUTH OF WRIGLEY RESERVOIR.	Not feasible.		Not feasible.	
20	Floating Solar	9	12.92	7	N/A	7	TBD	TBD	TBD	TBD	2.584	Offshore sites would require anchored and or suspended or floating infrastructure that contribute to biological, waters and mitigation rankings, Avoidance of hard substrate rock influences mitigation needs, USCG and Coastal commission contribute to water impacts/mitigation associated with recreation. NFMS is expected to have concerns about EFH and marine mammals. Fill associated with anchoring under USACE would also need to be mitigated	No site visit.	No site visit.	LOCATION: WHITE'S LANDING.	No site visit.		No site visit.	Conservancy
21	Floating Solar	9	0.53	7	N/A	7	TBD	TBD	TBD	TBD	0.106	Offshore sites would require anchored and or suspended or floating infrastructure that contribute to biological, waters and mitigation rankings, Avoidance of hard substrate rock influences mitigation needs, USCG and Coastal commission contribute to water impacts/mitigation associated with recreation. NFMS is expected to have concerns about EFH and marine mammals. Fill associated with anchoring under USACE would also need to be mitigated	No site visit.	No site visit.	LOCATION: JUST OFFSHORE SLIGHTLY EAST OF CATALINA BEVERAGE.	No site visit.		No site visit.	State Lands Commission?
22	Rooftop PV	2	0.25		N/A		TBD	TBD	TBD	TBD	0.05	Located on roof of Catalina Beverage.	a) SCE controls two buildings at the Pebbly Beach Generation Station with rooftop area (warehouse and office). b) A third warehouse building near the Generation Station has been leased to a commercial enterprise. c) All three rooftops offer some areas for rooftop PV. d) Each structure would need to be evaluated for structural integrity. e) No natural environmental resources would be impacted.	Construction would require tie-in to customer meter.	LOCATION: CATALINA BEVERAGE ROOF. Would need a lot of analysis to understand if something can work on the roof. ROI is likely to be very high relative to cost versus energy produced.	Low		Low	City of Avalon
23	Floating Solar	5	0.1		N/A		TBD	TBD	TBD	TBD	0.02	Located on man-made reservoir near cruise ship dock.	No site visit.	No site visit.	LOCATION: MOUNT ADA RESERVOIR?	Low		Low	City of Avalon
24	Rooftop PV	2	2.95		N/A		TBD	TBD	TBD	TBD	0.59	Located on roof of future building owned by others.	a) Existing roof structure would need to be evaluated for integrity. b) Historic resources/visual could prohibit upgrades or infrastructure placement.	Construction would require tie-in to customer meter.	LOCATION: FUTURE DEVELOPMENT BESIDE THE AVALON FIRE DEPARTMENT JUST EAST OF THE FD BUILDING AND SLIGHTLY SOUTH EAST OF AVALON CITY HALL.	Low		Low	City of Avalon
25	Rooftop PV	2	0.4		N/A		TBD	TBD	TBD	TBD	0.08	Located on Von's store roof.	a) Sloped roof not ideal for panel placement and angle. b) Existing infrastructure on roof would need redesign to accommodate panels.	Construction would require tie-in to customer meter.	LOCATION: HOTEL ATWATER.	Low		Low	City of Avalon
26	Rooftop PV	2	0.11		N/A		TBD	TBD	TBD	TBD	0.022	Located on SCE's former reservoir.	a) The site is owned by SCE and there are no natural environmental issues related to using the site. b) Site sits on top of natural hill and is surrounded by residential with limited public view into site. c) Equipment still operates to drain pool. d) 12kV line passes through site.	Options exist for this property. Pool could be used as floating hydro pilot project. Site could be used for battery storage.	LOCATION: WHITLEY RESERVOIR. More of an "icing on the cake" site when all else is done or has been considered.	Low		Low	SCE
27	Floating Solar	5	0.14		N/A		TBD	TBD	TBD	TBD	0.028	Located on SCE's man-made reservoir located near Avalon Cemetery.			LOCATION: CITY OF AVALON RESERVOIR SLIGHTLY WEST OF THE HOLIDAY INN EXPRESS.	No site visit.		No site visit.	City of Avalon
28	PV	7	54.6				TBD	TBD	TBD	TBD	10.92	Located on Island quarry mining operation near Two Harbors.			LOCATION: EMPIRE QUARRY EAST OF TWO HARBORS. Steep terrain, access to existing distribution is far away.	Low		Low	Connelly Pacific Quarry lease
29	PV	7	4.72				TBD	TBD	TBD	TBD	0.944	Located on USC land above North Two Harbors. Area likely subject to Coastal Commission jurisdiction may need additional permitting and mitigation needs to address sea level rise. Also this site should be investigated for Cultural resource conflicts.	a) Site is currently used as storage yard. b) Site is valley shaped with steep west slope and moderate east slope. Valley portion with moderate upward slope 8% from campus. c) Blue line stream (potentially jurisdictional) parallels western boundary, but could be avoided. Setbacks would be expected. d) Site can be expanded to the south by grading to fence line. e) Geology is expected to be hard subsurface volcanic rock. Past grading efforts approximately 4 times initial expected cost. f) Renewable facilities can be designed to avoid impacting coastal views. g) 12kV line located at USC Campus require an extension to reach renewable site.	USC seems to be a positive, willing stakeholder to increase renewable power availability for their operations. The site is north facing, but with minimal grading required, if at all. Near barge location, providing good access. Construction of the OH or UG line segment would require that USC and SCE collaborate on the design. This site is feasible and a Tier 1 option.	LOCATION: USC WRIGLEY	High		High	Island Company
30	Wave Power	9	0.09				TBD	TBD	TBD	TBD	N/A	Site located on existing ship dock at Avalon Harbor Area subject to Coastal Commission jurisdiction may need additional permitting and mitigation needs to address sea level rise and coastal access. Limited wave energy at this location.			LOCATION: ATTACHED TO THE EAST SIDE OF CATALINA LANDING. (NOTE THAT THERE ARE TWO SIGHT # 30's; THE OTHER ONE IS THE ROOF OF THE DUMP / RECYCLING CENTER BUILDING.)	No site visit.		No site visit.	City of Avalon
31	Wave Power	9	0.4				TBD	TBD	TBD	TBD	N/A	Site located existing jetty at Avalon Harbor. Encroaches into Marine Preserve used for habitat conservation and recreational diving. Area subject to Coastal Commission jurisdiction will need additional permitting and mitigation needs to address sea level rise and coastal access. Development of shore based infrastructure a concern as Casino is historical building and site has limited space. Jetty will likely require significant structural amendments that will likely trigger USACE and RWQCB permitting.			LOCATION: BESIDE CASINO SLIGHTLY EAST OF CASINO.	No site visit.		No site visit.	City of Avalon
32	Wave Power	3	0.14				TBD	TBD	TBD	TBD	N/A	Site on existing pier. Pier to be rebuilt with Equipment below pier. New structure done for residents at no cost. Area subject to Coastal Commission jurisdiction would need additional permitting and address sea level rise and coastal access.	a) Steep and windy road access. b) 12kV line is two phase only. Would require rebuild. c) Pier/dock appears in good shape; lowers opportunity to rebuild. d) Dock surroundings support recreational uses. e) Ocean areas are designated Area of Biological Significance. f) Wave action low due to sheltered east side island shadow.	Eastern location on island and reduced wave heights/action. This site is not feasible.	LOCATION: GALLAGHER CANYON COVE.	Not feasible.		Not feasible.	Conservancy
33	Wave Power	9	12	9	9	8	TBD	TBD	TBD	TBD	N/A	Shark Harbor/Little Harbor Wave Power site - located in coastline, designated Area of Biological Significance.	a) Located in Area of Biological Significance (ocean layer) b) Two primitive recreational camps nearby c) Multiple recreational uses; ie. beach, surfing, snorkeling, fishing, etc. d) Boat anchorages e) 12kV line approximately 5 spans to east.	This west-facing shoreline site would require extensive foundations along the coastline, triggering myriad environmental, stakeholder, and other issues. In addition, construction to the grid would require building distribution lines up a steep slope from the cliffs below. A ½ to 1 acre site on land would be needed for collection and inversion of energy produced by wave generators. This site is not feasible at this time.	LOCATION: SHARK HARBOR	Not feasible.		Not feasible.	Conservancy
34	PV	2	0.33	0	0	0	TBD	TBD	TBD	TBD	0.066	Flat unused substation land within fence.	a) Two Harbors Substation could accommodate battery storage and some PV. Approximately 1.5 acres with 25-foot setback to substation equipment. b) Good vehicular access to sites. c) Sites are visible to Two Harbors. d) 12kV line passes through site.	Substation owned by SCE. Fenced area, close to roads with barge access. Generation and/or storage would be intended to support Two Harbors community.	LOCATION: TWO HARBORS SUBSTATION Great site for storage. Some potential for PV, although small	High		High	Island Company
35	PV	3	0.76	0	4	3	TBD	TBD	TBD	TBD	0.152	Sloping non-native grassland NE of substation.	a) North of Two Harbors substation is a smaller non-native grassland, with 10% or less slope, square shape. b) Grading would be required. c) Good vehicular access to sites. d) Sites are visible to Two Harbors. e) 12kV line passes through site.	Land is likely owned by Catalina Island Company. Site is relatively flat but would require grading. Site is not in line-of-site from habitable structures or planned communities. Generation and/or storage would be intended to support Two Harbors community.	LOCATION: BESIDE TWO HARBORS SUBSTATION SLIGHTLY NORTH WEST This is a good site for a small array to support the larger concept of a north microgrid.	High		High	Island Company

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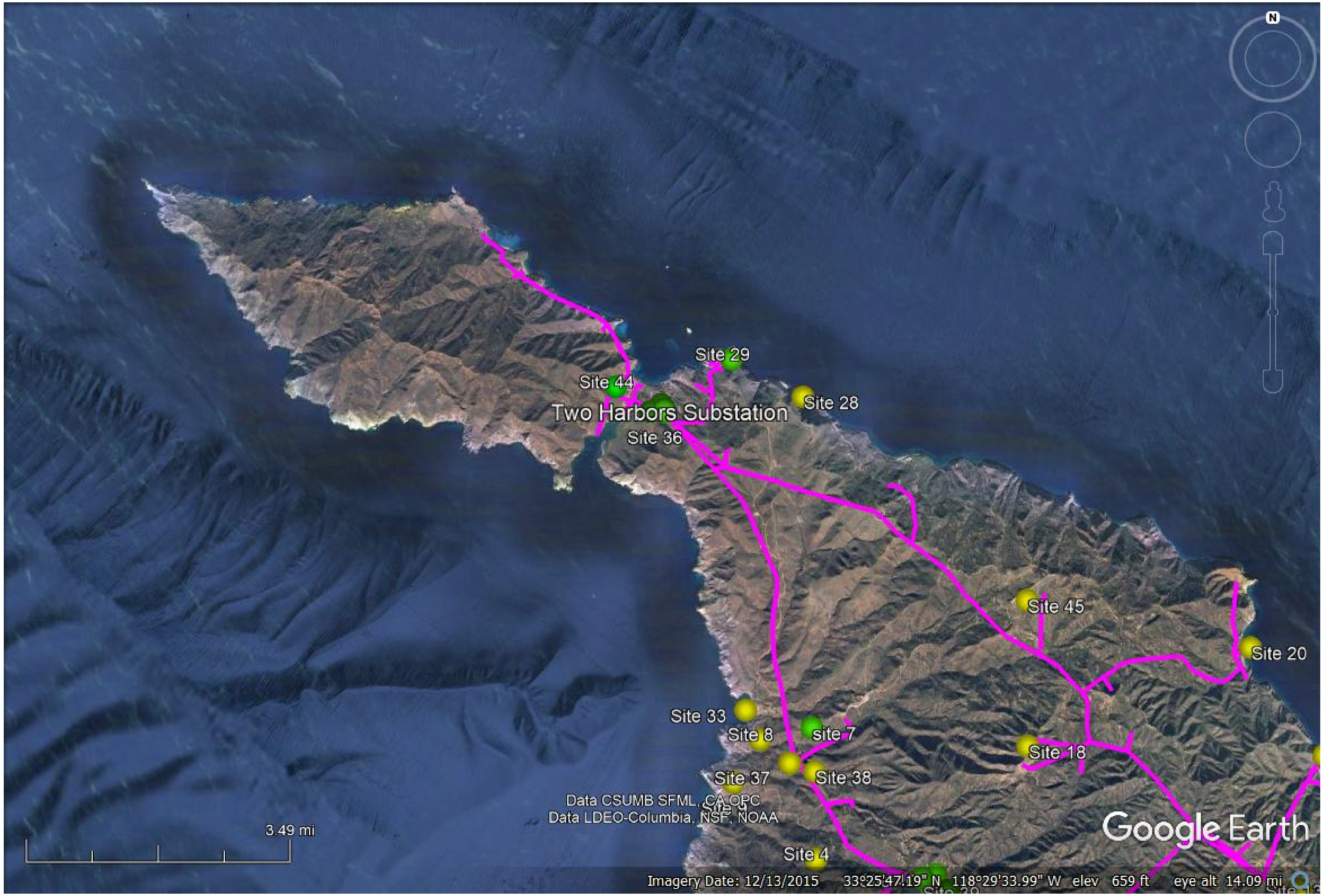
36	PV	3	0.55	0	4	3	TBD	TBD	TBD	TBD	0.11	Sloping non-native grassland SW of substation.	a) South of Two Harbors substation is a 1 acre non-native grassland, with 10% or less slope, rectangular shape. b) Grading would be required. c) Good vehicular access to sites. d) Sites are visible to Two Harbors. e) 12kV line passes through site.	Land is likely owned by Catalina Island Company. Site is relatively flat but would require grading and has a northerly facing slope. Site is not in line-of-site from habitable structures or planned communities. Generation and/or storage would be intended to support Two Harbors community.	LOCATION: BESIDE TWO HARBORS SUBSTATION SLIGHTLY SOUTH EAST This is a good site for a small array to support the larger concept of a north microgrid. Land looks like it may have been cleared in the past. Native vegetation was minimal	High		High	Island Company
37	PV	7	4.79	0	7	6	TBD	TBD	TBD	TBD	0.958	El Rancho native land west of El Rancho.	a) Evaluated site to southwest approximately 2 miles away from El Rancho. b) Expect hard subsurface. Slopes to the north, approximately 10% grade. c) Some disturbed grassland areas mixed with native coastal sage scrub. d) Public trails pass through or near both sites. e) Site presents visual impact to El Rancho, although located outside of El Rancho boundaries. f) 12kV line passes through or nearby.	Initially viewed from Site 7 and upon arrival, determined not feasible due to potential impacts to natural habitat.	LOCATION: SOUTH OF WRIGLEY-RUSACK PROPERTY EAST OF COTTONWOOD BEACH SOUTH EAST OF SHARK HARBOR.	Not feasible		Not feasible.	
38	PV	7	3.5	0	7	6	TBD	TBD	TBD	TBD	0.7	El Rancho native land west of El Rancho.	a) Evaluated site to southwest approximately 2 miles away from El Rancho. b) Expect hard subsurface. Slopes to the north, approximately 10% grade. c) Some disturbed grassland areas mixed with native coastal sage scrub. d) Public trails pass through or near both sites. e) Site presents visual impact to El Rancho, although located outside of El Rancho boundaries. f) 12kV line passes through or nearby.	Initially viewed from Site 7 and upon arrival, determined not feasible due to potential impacts to natural habitat.	LOCATION: SOUTH OF WRIGLEY-RUSACK PROPERTY EAST OF COTTONWOOD BEACH SOUTH EAST OF SHARK HARBOR.	Not feasible		Not feasible.	Conservancy
39	PV	2	3.02	O	1	0	TBD	TBD	TBD	TBD	0.604	Conservancy site 1	a) Disturbed grassland unused by Conservancy b) Gentle slope c) 12kV line located nearby	This site and neighboring Conservancy sites are relatively flat and have access to existing distribution. Land is disturbed with no major known environment hurdles. Site development is relatively straight forward and location is free from obstructions such as trees and ridgelines. The potential challenge is the Conservancy is said to be planning development in this area. However, one or more of area sites may be available for a long-term lease or other arrangement and is worthy of conversations with the Conservancy. This site is feasible as a Tier 1 option.	LOCATION: BESIDE MIDDLE RANCH RESERVOIR SLIGHTLY NORTH AND EAST OF THE RESERVOIR.	High		High	Conservancy
40	PV	2	2.1	O	1	0	TBD	TBD	TBD	TBD	0.42	Conservancy site 2	a) Disturbed grassland unused by Conservancy b) Gentle slope c) 12kV line located nearby	This site and neighboring Conservancy sites are relatively flat and have access to existing distribution. Land is disturbed with no major known environment hurdles. Site development is relatively straight forward and location is free from obstructions such as trees and ridgelines. The potential challenge is the Conservancy is said to be planning development in this area. However, one or more of area sites may be available for a long-term lease or other arrangement and is worthy of conversations with the Conservancy. This site is feasible as a Tier 1 option.	LOCATION: BESIDE MIDDLE RANCH RESERVOIR SLIGHTLY NORTH AND EAST OF THE RESERVOIR.	High		High	Conservancy
41	PV	2	2.17	O	1	0	TBD	TBD	TBD	TBD	0.434	Conservancy site 3	a) Disturbed grassland unused by Conservancy b) Gentle slope c) 12kV line located nearby	This site and neighboring Conservancy sites are relatively flat and have access to existing distribution. Land is disturbed with no major known environment hurdles. Site development is relatively straight forward and location is free from obstructions such as trees and ridgelines. The potential challenge is the Conservancy is said to be planning development in this area. However, one or more of area sites may be available for a long-term lease or other arrangement and is worthy of conversations with the Conservancy. This site is feasible as a Tier 1 option.	LOCATION: BESIDE MIDDLE RANCH RESERVOIR SLIGHTLY NORTH AND EAST OF THE RESERVOIR.	High		High	Conservancy
42	PV	2	1.23	3	3	3	TBD	TBD	TBD	TBD	0.246	Conservancy site 4	a) Disturbed grassland unused by Conservancy a) Gentle slope b) 12kV line located nearby	This site and neighboring Conservancy sites are relatively flat and have access to existing distribution. Land is disturbed with no major known environment hurdles. Development on this site would potentially occur near a natural drainage and there are smaller ridges on two sides that may create morning and afternoon shade. Additionally, the Conservancy may be relocating a historic lodge and barn to this site. Based on this information, this site is feasible as a Tier 2 option.	LOCATION: BESIDE MIDDLE RANCH RESERVOIR SLIGHTLY EAST OF THE RESERVOIR.	High		High	Conservancy
43	PV	2	0.75	6	5	2	TBD	TBD	TBD	TBD	0.15	SCE storage site	a) Relatively flat. b) Native riparian habitat on 3 sides c) Steep south facing slope may affect winter shadow d) 12kV line located nearby	This site is relatively small but appears to be disturbed land with invasive species. The proximity to feasible generation sites makes this site ideal for battery storage. Additionally, battery storage in this area may be leveraged to provide 'microgrid island' capabilities for the nearby communities and water pumps. This site is feasible as a Tier 1 option for battery storage.	LOCATION: MIDDLE RANCH WELLS BESIDE MIDDLE RANCH RESERVOIR SLIGHTLY EAST OF THE RESERVOIR.	High (battery)		High (battery)	SCE
44	PV	3	4	2	0	1	TBD	TBD	TBD	TBD	0.8	Across the valley from Sites 5 and 6.	a) Mostly non-native grasses, slope 5% or less, steady low speed breeze. b) South facing slope	On Catalina Island Company land. Site has gentle slopes although it's north facing and may require civil or other construction work. The site has existing distribution. Near barge locations, making the site easier to access than remote sites. This site is feasible as a Tier 2 option.	LOCATION: TWO HARBORS SLIGHTLY NORTH WEST FROM SITE 6.	High		High	Across
45	PV	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Airport	Was a quick (unplanned) look while resting at the airport. Will assess once decided if there is an opportunity to include in the feasibility study.	This site is currenly being considered by SCE for a separate project. The proximity to load and distribution lines makes this appealing. Reflection may be an issue for pilots. Will consider for the study once the scope of SCE's project is known and if there is room to expand scope to support the bigger Catalina picture.	LOCATION: AIRPORT.	No-Go		No-Go	Conservancy
46	PV	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	South Quarry	Did not visit. Will further analyze once the availability of land is known.	Did not visit. Will further analyze once the availability of land is known.	LOCATION: CONNOLLY PACIFIC SOUTH QUARRY. Heavily dependent on permitting/use. Blasting in the area would probably prohibit	No-Go		No-Go	
																			Total Generation

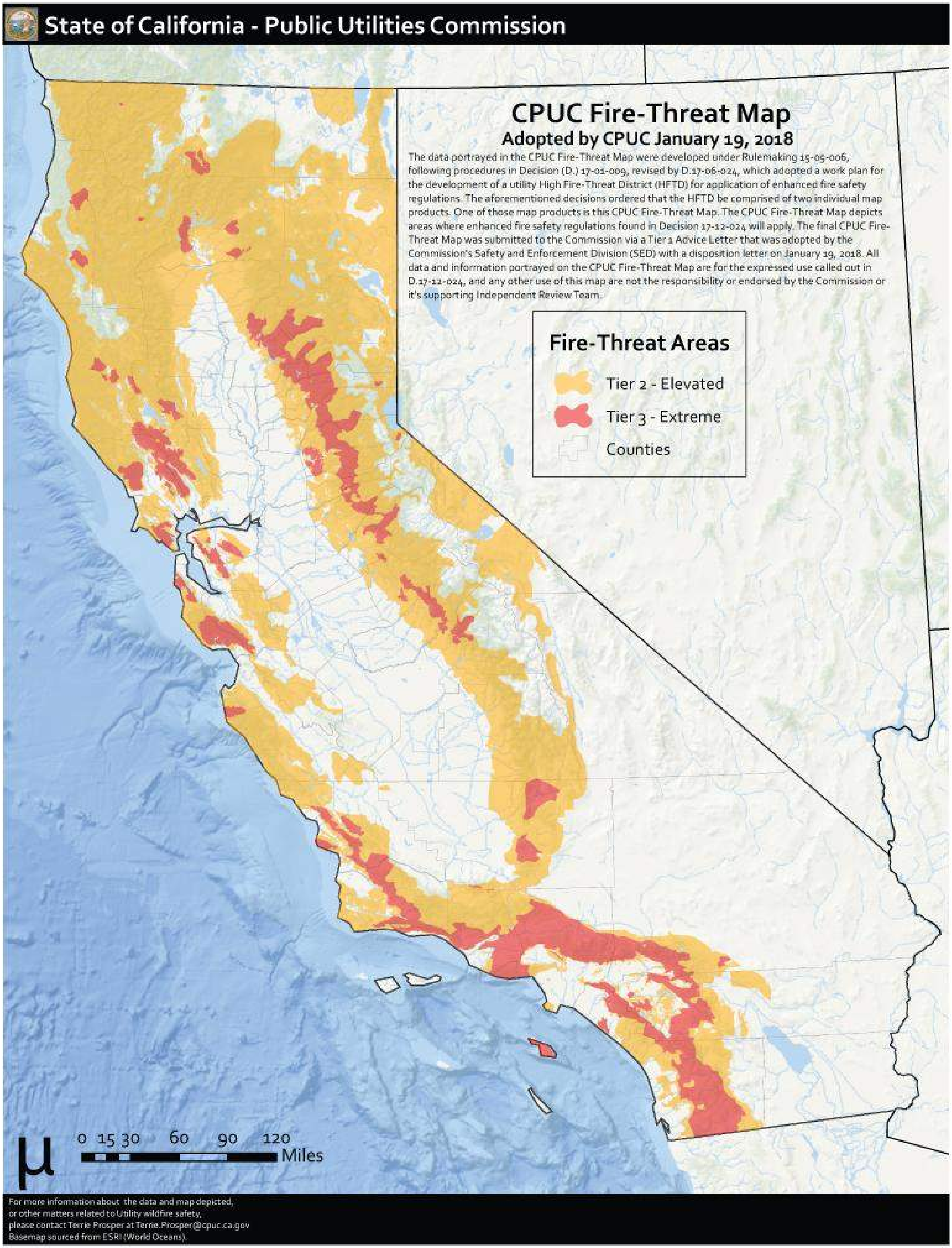

Two Harbors Substation
SCE Pebbly Beach Generation Site
5.32 mi
Data CSUMB SFML, CA OPC
Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth
33°23'20.75" N 118°25'51.15" W elev 712 ft eye alt 22.14 mi


Site 20
Site 33
Site 8
site 7
Site 18
Site 38
Site 37
Site 9
Site 32
Site 4
Site 40
Site 39
Site 41
Site 43
Site 42
Site 3
Site 2
Site 15
Site 14
Site 1
Site 31
Site 27
Site 25
site 26
Site 24
Site 19
SCE Pebbly Beach Generation Site
Site 46
Site 10
Site 11
Site 12
Data CSUMB SFML, CA OPC
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data LDEO-Columbia, NSF, NOAA
2.93 mi
Google Earth
Imagery Date: 1/4/2015 33°19'44.19" N 118°22'33.90" W elev 1146 ft eye alt 12.04 mi



Site 29
Site 44
Two Harbors Substation
Site 36
Site 28
Site 45
Site 20
Site 33
Site 8
site 7
Site 18
Site 37
Site 38
Data CSUMB SFML, CA OPC
Data LDEO-Columbia, NSF, NOAA
3.49 mi
Site 4
Google Earth
Imagery Date: 12/13/2015 33°25'47.19" N 118°29'33.99" W elev 659 ft eye alt 14.09 mi

APPENDIX D – CPUC FIRE THREAT MAP AND SCE OVERHEAD DISTRIBUTION LINE STANDARDS



State of California - Public Utilities Commission
CPUC Fire-Threat Map
Adopted by CPUC January 19, 2018
The data portrayed in the CPUC Fire-Threat Map were developed under Rulemaking 15-05-006, following procedures in Decision (D.) 17-01-009, revised by D.17-06-024, which adopted a work plan for the development of a utility High Fire-Threat District (HFTD) for application of enhanced fire safety regulations. The aforementioned decisions ordered that the HFTD be comprised of two individual map products. One of those map products is this CPUC Fire-Threat Map. The CPUC Fire-Threat Map depicts areas where enhanced fire safety regulations found in Decision 17-12-024 will apply. The final CPUC Fire-Threat Map was submitted to the Commission via a Tier 1 Advice Letter that was adopted by the Commission's Safety and Enforcement Division (SED) with a disposition letter on January 19, 2018. All data and information portrayed on the CPUC Fire-Threat Map are for the expressed use called out in D.17-12-024, and any other use of this map are not the responsibility or endorsed by the Commission or it's supporting Independent Review Team.
Fire-Threat Areas
Tier 2 - Elevated
Tier 3 - Extreme
Counties
0 15 30 60 90 120
Miles
For more information about the data and map depicted,
or other matters related to Utility wildfire safety,
please contact Terrie Prosper at Terrie.Prosper@cpuc.ca.gov
Basemap sourced from ESRI (World Oceans).

NOTE SCE's Primary Distribution System shall be designed to Grade A and Grade B construction only. All joint pole attachments shall be designed to Grade A construction.

Refer to DOH, PO 100, for wood pole installation details.

B. Composite Poles

Composite poles are fiber-reinforced polymer (FRP) structures. They are non-conductive, corrosion, wildlife, rot and flame resistant. Composite poles are lighter in weight and have the capacity to carry more load when compared to wood poles of the same class and size.

In general, composite poles are preferred in lieu of wood poles when one or more of the following conditions exist:

- Areas of restricted vehicle access (applies to sectional composite poles)
- Areas of severe or accelerated pole degradation due to animals, insects, fungus, moisture, and other severe environmental conditions.
- Areas subject to pole shrinkage and constant winds
- Load weights or distances that exceed helicopter and/or crane capabilities

SCE previously installed single-piece octagonal, non-tapered composite poles manufactured by Creative Pultrusion (previously known as Powertrusion) and round, tapered composite poles manufactured by Shakespeare and Newmark. Consult Distribution Apparatus Engineering for equipment installation or third party attachments on Creative Pultrusion, Shakespeare and Newmark poles.

There are presently two types of composite poles that are approved for use on the Edison system: (1) Intelli-pole® and (2) Resin Systems (RS) sectional composite poles. Refer to DOH PO 112 for SAP codes, dimensions, weights and installation details of the sectional composite poles.

1. Intelli-Pole® Sectional Composite Poles

The Intelli-Pole® is only available in a length of 45 feet. Transformer and equipment weights on the Intelli-Pole® are limited to 4,000 pounds.

2. RS Sectional Composite Poles

The RS sectional composite poles are available in lengths from 35 feet to 65 feet. For additional heights or classes, consult Distribution Apparatus Engineering. The standard color is brown, but they are also available in gray (contact DAE for details).

COMPOSITE POLES IN HIGH FIRE HAZARD AREAS (HFHA)

Composite poles with protective shields shall be evaluated and considered as an option for use in new construction and rebuilds in HFHAs. Contact Distribution Apparatus Engineering for appropriate application and material availability before proceeding with the planning process. Composite poles with protective shields are not recommended for locations that have been developed and void of flammable vegetation.

Composite poles with protective shields will use the same construction practices as the RS sectional composite poles with the exception of the protective shield embedment. The shield will be embedded 12 inches below the ground line (refer to DOH Figure PO 112-3, for details).

Composite poles with protective shields are available in lengths 45 feet and 50 feet. They can be ordered as partially preassembled or fully preassembled poles. In partially preassembled poles, the manufacturer will preassemble the bottom two sections with the protective shield. The remaining section(s) will be assembled in the field. Refer to horizontal assembly of RS sectional composite poles in DOH PO 112 for details. The partially preassembled pole with the protective shield can be used where road access is available or for helicopter sets. In a fully preassembled pole, pole sections and the protective shield will be preassembled by the manufacturer. The fully preassembled composite poles with protective shields can be used for helicopter sets when warranted.

SECTIONAL COMPOSITE POLES IN REAR PROPERTY LINE AREAS

Sectional composite poles will be used to replace wood poles when the existing pole is located in rear property line and when the existing pole is not truck accessible.

For composite pole material (such as composite crossarms, climbing steps, and guying hardware), refer to DOH PO 370.

Refer to PLM-2 for pole loading requirements on composite poles.

3.3 Routing and Location of Overhead Lines

When planning the construction of any overhead lines, the following shall be carefully considered:

- ☐ Will the city allow overhead construction
- ☐ Could this line become a future Rule 20 conversion
- ☐ When developing the routing of the line, has the restriction pertaining to Scenic Highways been considered
- ☐ Has the routing of future transmission been taken into consideration
- ☐ Is the route in a heavily vegetated area
- ☐ Is the route within 1 mile of coastal area or area known to have unique accelerated corrosion

The route should be selected so that the total cost of the completed line will be at a minimum, while at the same time consideration is given to (1) accessibility for maintenance, and (2) the effect of local climate conditions on insulators and other parts of the structures.

When a line is to be built or rebuilt, either adjacent to, or crossing any transmission line, the SCE's Transmission division must be advised during the planning stages. This will allow time to eliminate any possible clearance problems between Transmission and Distribution prior to construction.

Tree hazards should be avoided unless permission can be obtained to cut or trim, and keep trimmed, all trees that will be an obstruction to the line. The probable future extension of the circuits and additional circuits on poles should be kept in mind when selecting the route. Temporary routes should be avoided.

5.0 Design Criteria

5.1 Conductors

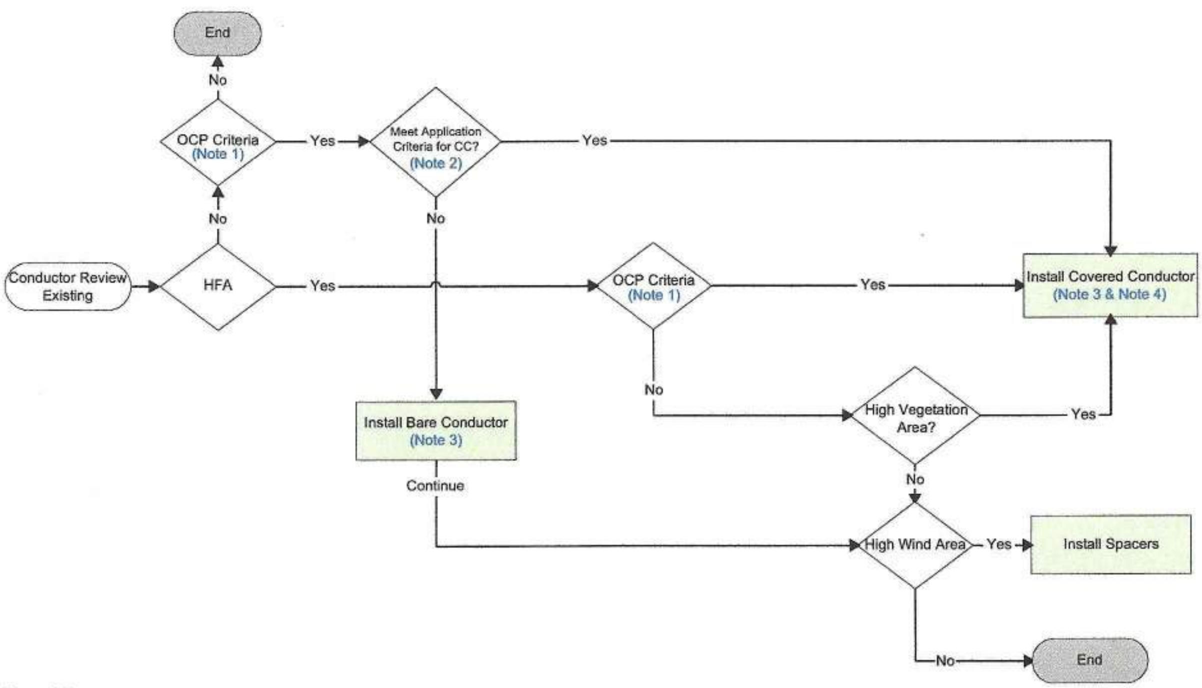
Primary conductor sizes are determined by the economic loading limits (DDS–9), and mainline conductor sizes are reviewed by FE. Secondary conductors are sized based on customer demand, voltage drop, flicker, and motor starting load (DDS–8).

The number, size, height requirements, pole loading, and dead-ending tension of conductors, supported by an overhead pole, are the primary factors used in determining the pole-strength requirements.

Typical overhead construction will utilize crossarm construction for primary voltages and rack or multiplex construction for secondary voltages. The maximum span lengths for various conductors and the type of construction necessary to provide adequate support are found in DOH. General conductor information (for example, use of copper wire in beach areas, weight, amperage, and diameter) may be found in DOH, Section CO.

The following decision tree shall be used to decide on the appropriate conductor type or conductor apparatus to install:

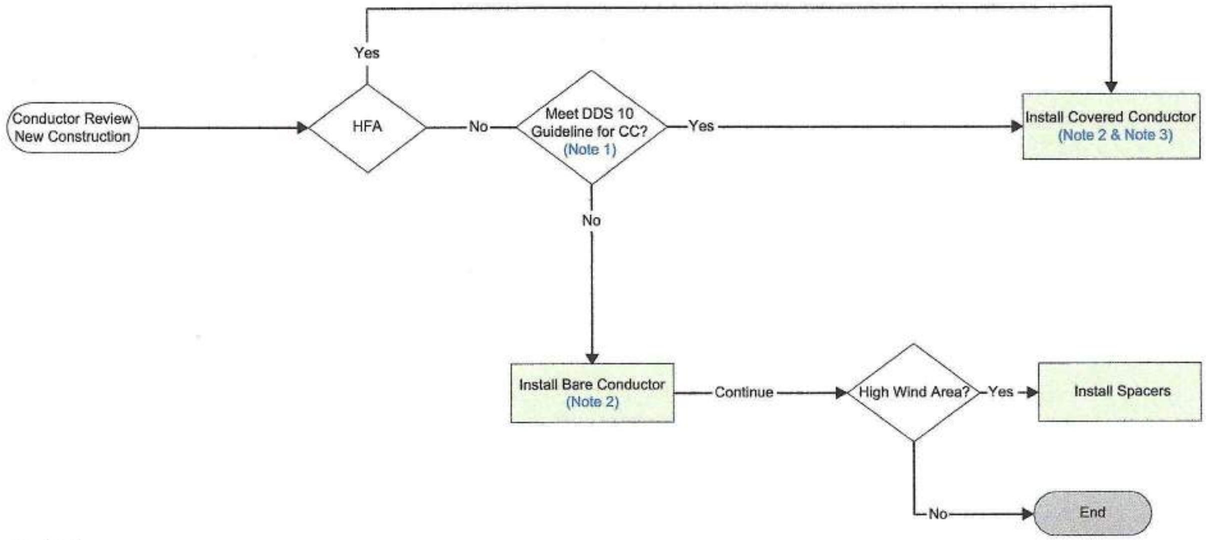
Figure 10–2: Decision Tree for Appropriate Conductor Use for Existing Construction or Rebuild/Reconductor



Note(s):

1. Refer to OCP criteria found in DDS–13, Subsection 5.11.
2. Refer to Covered Conductor Application criteria.
3. If not feasible, consider undergrounding.
4. If conductors are being installed in coastal areas within one mile of the ocean, then copper-covered conductor shall be used.

Figure 10–3: Decision Tree for Appropriate Conductor Use for New Construction



Note(s):

1. Refer to Covered Conductor Application criteria.
2. If not feasible, consider converting to underground.
3. If conductors are being installed in coastal areas within one mile of the ocean, then copper covered conductor shall be used.

COVERED CONDUCTOR

Covered Conductor, also known as tree wire, is a conductor that is protected by layers of insulating material. There are four components in the covered conductor: the conductor, a conductor shield, an inner layer, and an outer layer.

The conductor can be Aluminum Conductor Steel-Reinforced (ACSR) or Hard Drawn Copper (HDCU). Copper covered conductor is for coastal applications due to copper being more resistant to corrosion than ACSR.

The conductor shield is made out of a semi-conducting thermoset polymer. Its purpose is to reduce stress concentrations caused by flux lines from the individual conductor strands. By encircling the strands, it effectively transforms the strands into a single uniform conducting cylinder. The conductor shield can increase the life of the covered conductor by reducing the electrical stress on the contact area, therefore increasing the time to failure when an object makes contact with the covered conductor.

The inner layer is Crosslinked Low Density Polyethylene (XL-LDPE), which is an insulating material. The insulation contributes to the high impulse strength of the cover and protects the conductor from phase to phase and phase to ground contact.

The outer layer is Crosslinked High Density Polyethylene (XL-HDPE), which is an insulating material as well. It has the same insulating function as the inner layer. However, due to being high density, it is also a tougher layer, making it abrasion and impact resistant. The outer layer is also track resistant, which limits the charging current flowing on its surface. This track resistant property will help maintain the integrity of the insulation surface over time by significantly reducing electrical tracking that could lead to erosion of the insulation. Additionally, the XL-HDPE layer is specified for UV stability, making it less susceptible to UV degradation.

Overall, covered conductor can improve reliability by preventing faults due to contact from objects such as tree branches, palm fronds, metallic balloons, or other conductors. Because of this advantage, covered conductors will be useful in areas that regularly or have a high probability of experiencing faults due to contact from object.

By decreasing the chance of faults due to contact from objects through the use of covered conductors, the chance of ignition can be substantially reduced. Therefore, covered conductors shall be used in High Fire Areas (HFA).

The conductor covering can also protect the conductor from corrosion, especially in coastal environments. Therefore, covered conductors may benefit installations in coastal areas (within one mile of the coast). Because the conductor may be exposed in certain areas, such as dead-ends, copper covered conductor shall be used due to being more resistant to corrosion than aluminum.

Unguyed spans have lower sags, therefore increasing the chance of conductor to conductor contact. Therefore, covered conductor shall be used in unguyed spans.

Covered conductor shall be installed in areas that meet the following application criteria:

1. HFA - System Operating Bulletin 322 areas[1/]
2. Vegetation with potential tree-to-wire contacts, which can include the following[2/]:
   - Vegetation that regularly sheds branches or fronds (for example, palm trees, eucalyptus)
   - Vegetation that is in proximity to fall into lines if they uproot (for example, oak, sycamore, and pine)
3. Areas with known metallic balloon contacts causing circuit outages
4. Areas with outages due to known intermittent contacts
5. Coastal areas within one mile of the ocean
6. Unguyed spans
7. Any specific area that experiences accelerated corrosion, in which Field Engineering should be contacted for review

1/ Covered conductor shall be used in Bulletin 322 areas, per Figure 10–2 and Figure 10–3.

2/ Consider topography when evaluating whether a tree poses a threat to overhead lines. If the tree is located upslope of the line, distance from which the tree can threaten the overhead line is increased.

Covered conductor shall be used for the spans which are identified meeting the above application criteria. Additionally, spans shall be constructed with covered conductor either to extend to existing dead-ends or extend to new dead-end locations.

Covered conductor shall be treated and worked on as a bare conductor. Furthermore, covered conductor does not exempt tree trimming requirements.

Refer to DOH, Section CC, for all construction standards for covered conductor.

INSULATED OVERHEAD WIRE SPACERS

The purpose of insulated overhead wire spacers is to prevent wires from coming in contact with each other.

The application of the overhead insulated wire spacers for horizontal and vertical configuration are as follows, respectively:

A. Horizontal Configuration:

   Any span, including reduced tension spans, that meet both of the following criteria shall have line spacers installed

   1. Three feet or more of conductor sag.
   2. Conductor separation of 36 inches or less.

B. Vertical Configuration:

   Any span where conductors are subjected to uplifting wind forces due to any of the following criteria shall have line spacers installed:

   1. Ice formation (heavy loading areas) that can result in traveling waves or line galloping.
   2. Extreme changes in terrain (pole line on apex of ridge) that can result in traveling waves or galloping.

Insulated spacers can only be installed in areas with bucket access.

For installation instructions and line guard or armor rod material codes, refer to the DOH manual, Section CO.

Overhead wire spacers shall not be used on covered conductor systems.

SPIRAL VIBRATION DAMPERS

Use of the Spiral Vibration Dampers is intended to reduce Aeolian vibration. Aeolian vibration is high frequency, low amplitude vibration that is caused by low wind velocities (below 15 mph) blowing across overhead conductors. Spiral vibration dampers shall be installed on spans 300ft or greater for new construction or during planned maintenance activities. They are limited for use up to 336 ACSR and 4/0 Cu and are not placement specific. Spiral vibration dampers are generally not needed in heavy loading areas due to low conductor tensions. Additionally, they are not needed for covered conductor. Refer to DOH, Section CO 460 for installation instructions, quantity of dampers per span length, and SAP codes.

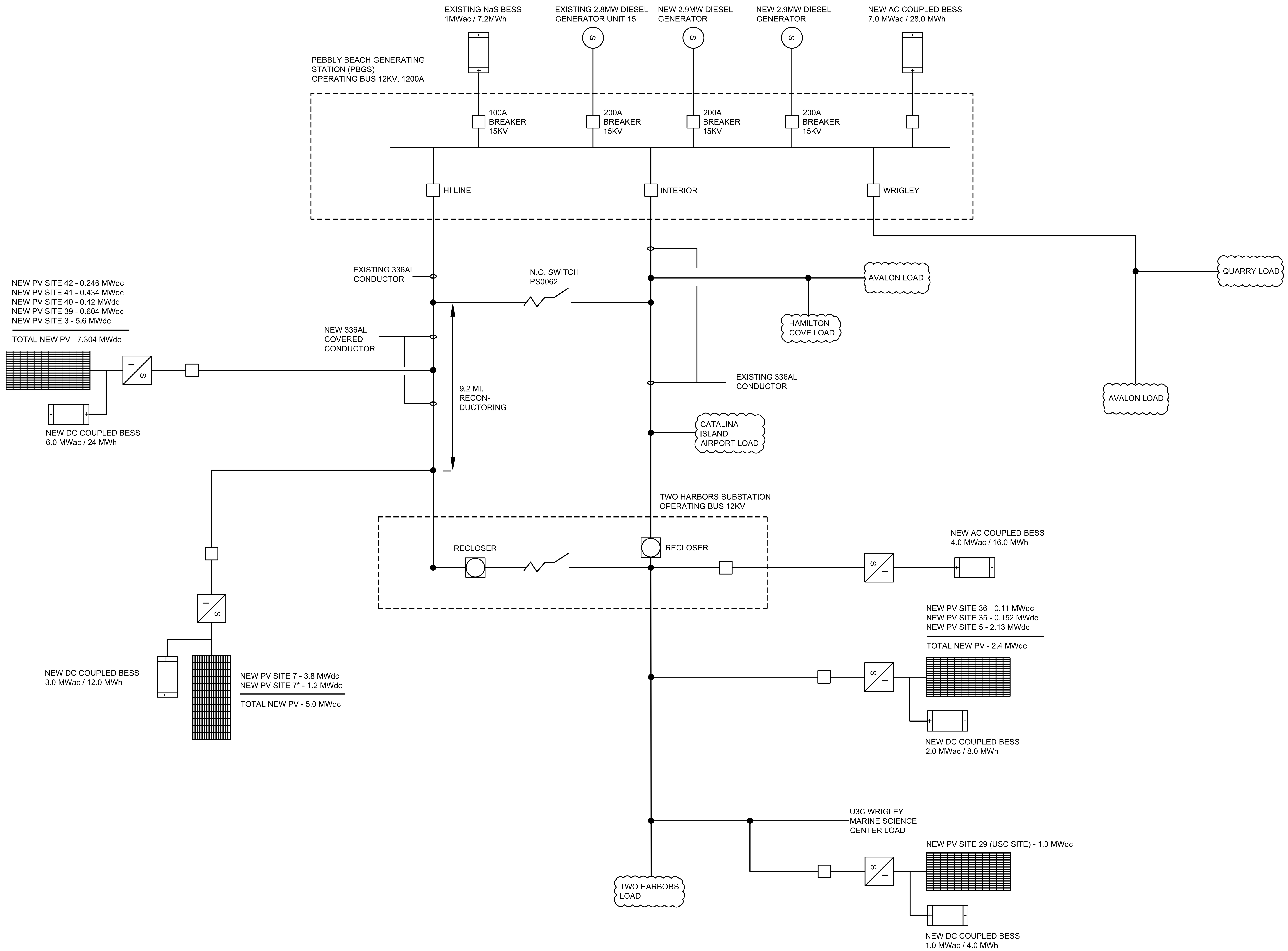
APPENDIX E – GRID UPGRADES COST ESTIMATE

COST ESTIMATE DETAIL

Disclaimer: The cost estimates within this document are preliminary and based on the best information available at the time of this report. The estimates are subject to change as plans are developed or modified.

Catalina Island Reconductoring and Pole Installation Cost Estimate				
Task	Quantity	$/Unit	Total	Comments
Pole	45	$25,000	$1,125,000	
Conductor	23,760 LF	$15	$356,400	
Subtotal			$1,481,400	
Catalina Multiplier			$1,481,400	2x multiplier, includes copper
Subtotal			$2,962,800	
SCE Overhead, Labor			$1,333,260	45% planning/design and management
Subtotal			$4,296,060	
Contingency			$859,212	20% Contingency
Total			**$5,155,272**	
Cost per Mile			**1,096,866**	**4.7 mile estimate**

APPENDIX F – 60% RENEWABLE MICROGRID SINGLE-LINE DIAGRAM



SAMPLE 60% RENEWABLE MICROGRID. FINAL FOSSIL-FUEL AND RENEWABLE GENERATION CONFIGURATION MAY DIFFER FROM WHAT IS SHOWN HERE.

NV5
703.522.3800 www.NV5.com

NOT FOR CONSTRUCTION

Revision: Date:

Date: Reg. No.:

Project No.: 226818-0432.02
Checked By: S.SWERN
Designed By: J.GARDNER
Drawn By: B.VASKE
Date: 01/13/2020
Scale: NTS
Site Address:

Project Title

SOUTHERN CALIFORNIA EDISON CATALINA ISLAND FEASIBILITY STUDY

xxx

Sheet Title

60% RENEWABLE MICROGRID SLD

Sheet No.

E-200

APPENDIX G – UNDERSEA CABLE ROM OPC

COST ESTIMATE DETAIL

Disclaimer: The cost estimates within this document are preliminary and based on the best information available at the time of this report. The estimates are subject to change as plans are developed or modified.

HUNTINGTON BEACH GENERATING STATION UPGRADES (HBGS)

UNDERSEA CABLE ROM OPC (ROUGH ORDER OF MAGNITUDE OPINION OF PROBABLE COST)					
ITEM	**UNIT COST**	**UNIT**	**QUANTITY**	**TOTAL COST**	**COMMENTS**
HUNTINGTON BEACH GENERATING STATION UPGRADES (HBGS)					
Mobilization / Demobilization	$ 330,000.00	LS	1	$ 330,000.00	1
Set of gang operated 1200A 66kV rated GOAB Disconnect Switches (HBGS)	$ 5,750.00	EA	4	$ 23,000.00	2
Set of gang operated 1200A 66kV rated GOAB Disconnect Switches - Foundation & Structure (HBGS)	$ 17,822.22	EA	4	$ 71,288.89	3
Medium Voltage Circuit Breaker - 66kv 1200A 50KA (HBGS)	$ 28,770.00	EA	2	$ 57,540.00	2
Medium Voltage Circuit Breaker - 66kv 1200A 50KA Foundation (HBGS)	$ 8,911.11	EA	2	$ 17,822.22	3
Potential Transformer - 66kV (HBGS)	$ 10,000.00	EA	1	$ 10,000.00	2
Potential Transformer - 66kV Foundation (HBGS)	$ 8,911.11	EA	1	$ 8,911.11	3
66kv to 33kv 10MVA OTC step down transformers (with LTC) - Huntington Beach Generating Station (HBGS)	$ 410,000.00	EA	2	$ 820,000.00	2
66kv to 33kv 10MVA OTC transformers (with LTC) - Foundation (HBGS)	$ 76,388.89	EA	2	$ 152,777.78	3
Medium Voltage Circuit Breaker - 33kv 1200A 50KA (HBGS)	$ 28,770.00	EA	1	$ 28,770.00	2
Medium Voltage Circuit Breaker - 33kv 1200A 50KA Foundation (HBGS)	$ 8,911.11	EA	1	$ 8,911.11	3
Set of gang operated 1200A 38kV rated GOAB Disconnect Switches (HBGS)	$ 5,750.00	EA	2	$ 11,500.00	2
Set of gang operated 1200A 38kV rated GOAB Disconnect Switches - Foundation (HBGS)	$ 17,822.22	EA	2	$ 35,644.44	3
Potential Transformer - 33kV (HBGS)	$ 10,000.00	EA	3	$ 30,000.00	2
Potential Transformer - 33kV Foundation (HBGS)	$ 6,527.78	EA	3	$ 19,583.33	3
33kV 3-Phase Fused Bypass Switch 250A (HBGS)	$ 7,500.00	EA	1	$ 7,500.00	2
33kV 3-Phase Fused Bypass Switch 250A - Foundation (HBGS)	$ 17,822.22	EA	1	$ 17,822.22	3
Miscellaneous Bus, Cable Raceway, Foundations, Grounding, Earthwork, BMPs, etc. (HBGS)	$ 575,000.00	LS	1	$ 575,000.00	4
SUB-TOTAL HBGS UPGRADES				**$ 2,226,071.11**	
Risk Contingency			20.00%	$ 445,214.22	
TOTAL HBGS UPGRADES				**$ 2,671,285.33**	
COMMENTS:					
1) Assumes $150k mob/demob with 12M @ $15k/M (Facilities & Supervision)					
2) Does not include GC mark-up or logistics					
3) Considers Substructure and Concrete					
4) As described					

PEBBLY BEACH GENERATING STATION UPGRADES (PBGS)

UNDERSEA CABLE ROM OPC (ROUGH ORDER OF MAGNITUDE OPINION OF PROBABLE COST)					
ITEM	**UNIT COST**	**UNIT**	**QUANTITY**	**TOTAL COST**	**COMMENTS**
PEBBLY BEACH GENERATING STATION UPGRADES (PBGS)					
Mobilization / Demobilization	$ 650,000.00	LS	1	$ 650,000.00	1
Set of gang operated 1200A 38kV rated GOAB Disconnect Switches (PBGS)	$ 5,750.00	EA	2	$ 11,500.00	2
Set of gang operated 1200A 38kV rated GOAB Disconnect Switches - Foundation (PBGS)	$ 59,111.11	EA	2	$ 118,222.22	3
Potential Transformer - 33kV (PBGS)	$ 10,000.00	EA	1	$ 10,000.00	2
Potential Transformer - 33kV Foundation (PBGS)	$ 17,638.89	EA	1	$ 17,638.89	3
Medium Voltage Circuit Breaker - 33kv 1200A 50KA (PBGS)	$ 28,770.00	EA	1	$ 28,770.00	2
Medium Voltage Circuit Breaker - 33kv 1200A 50KA Foundation (PBGS)	$ 29,555.56	EA	1	$ 29,555.56	3
33kV 3-Phase Fused Bypass Switch 250A (PBGS)	$ 7,500.00	EA	1	$ 7,500.00	2
33kV 3-Phase Fused Bypass Switch 250A - Foundation (PBGS)	$ 41,111.11	EA	1	$ 41,111.11	3
33kv to 12kv 10MVA OTC step down transformers - Pebbly Beach Generating Station (PBGS)	$ 225,000.00	EA	2	$ 450,000.00	2
33kv to 12kv 10MVA OTC transformers - Foundation (PBGS)	$ 381,944.44	EA	2	$ 763,888.89	3
Set of gang operated 1200A 15.5kV rated GOAB Disconnect Switches (PBGS)	$ 4,500.00	EA	3	$ 13,500.00	2
Set of gang operated 1200A 15.5kV rated GOAB Disconnect Switches - Foundation (PBGS)	$ 41,111.11	EA	3	$ 123,333.33	3
Medium Voltage Circuit Breaker - 12kv (17kV) 1200A 50KA (PBGS)	$ 28,770.00	EA	1	$ 28,770.00	2
Medium Voltage Circuit Breaker - 12kv (17kV) 1200A 50KA Foundation (PBGS)	$ 29,555.56	EA	1	$ 29,555.56	3
Miscellaneous Bus, Cable Raceway, Foundations, Grounding, Earthwork, BMPs, etc. (PBGS)	$ 475,000.00	LS	1	$ 475,000.00	4
SUB-TOTAL PBGS UPGRADES				**$ 2,798,345.56**	
Risk Contingency			20.00%	$ 559,669.11	
TOTAL PBGS UPGRADES				**$ 3,358,014.67**	
COMMENTS:					
1) Assumes $350k mob/demob with 12M @ $25k/M (Facilities & Supervision)					
2) Does not include GC mark-up or logistics					
3) Considers Substructure and Concrete					
4) As described					

UNDERSEA CABLE PLUS O&M, UG TRENCHING & SUBSTRUCTURES PLUS HDD

UNDERSEA CABLE ROM OPC (ROUGH ORDER +A65:F87OF MAGNITUDE OPINION OF PROBABLE COST)

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL COST	COMMENTS
UG TRENCHING & SUBSTRUCTURES PLUS HDD					
Underground Trenching Including Cable and Accessories (HB to HBGS)	$ 1,300.00	LF	2,500	$ 3,250,000.00	1
Horizontal Directional Drilling (PBGS)	$ 15,000,000.00	LS	1	$ 15,000,000.00	2
UNDERSEA CABLE PLUS O&M					
Undersea Cable (Manufacture and Supply)	$ 60,000,000.00	LS	1	$ 60,000,000.00	3
Undersea Cable (Delivery / Installation)	$ 100,000,000.00	LS	1	$ 100,000,000.00	4
Undersea Cable (Yearly Operations and Maintenance)	$ 500,000.00	YR	10	$ 5,000,000.00	5
SUB-TOTAL UNDERSEA CABLE WITH O&M, HDD, AND TRENCHING				**$ 183,250,000.00**	
Risk Contingency			20.00%	$ 36,650,000.00	
TOTAL UNDERSEA CABLE WITH O&M, HDD, AND TRENCHING				**$ 225,929,300.00**	

COMMENTS:

1) For the mainland tie-in from the abandoned 24-inch diameter pipe at Huntington Beach to the nearest overhead (OH) transmission pole tying into HBGS, an underground (UG) costing of $1,300.00 per lineal foot will be evaluated for alignment to the OH riser pole located on Beach Boulevard (Huntington Beach-Wave 66kV).

2) Shall be considered for the shore crossing from PBGS into the Pacific Ocean. HDD at Huntington Beach Not Yet Considered - 24" Abandoned Pipe to be Used Until Deemed Unavailable.

3) A three core, 33kV armored submarine cable with 400kcmil per phase. ROM costing on manufacture and supply for the cable is roughly $60,000,000.00

4) ***Assumption for Cable Installation Work***

A. Cable burial is assumed at a depth of 2m. Any special cable protection is not included in the pricing.

B. Marine survey cost is not included in the pricing.

C. Cable burial and cable installation shall be done in continuous work.

D. Cable route and environmental permission shall not be included in Seller's scope of work.

E. The furnishing and installation of the civil infrastructure are not included in Seller's scope of work.

F. Existing cable or debris removal and disposal work are not included in the above pricing.

5) Estimated annual costing over the first 10 years. Maintenance does not include any major repairs.

UNDERSEA CABLE PLUS O&M, UG TRENCHING & SUBSTRUCTURES PLUS HDD

UNDERSEA CABLE ROM OPC (ROUGH ORDER OF MAGNITUDE OPINION OF PROBABLE COST)

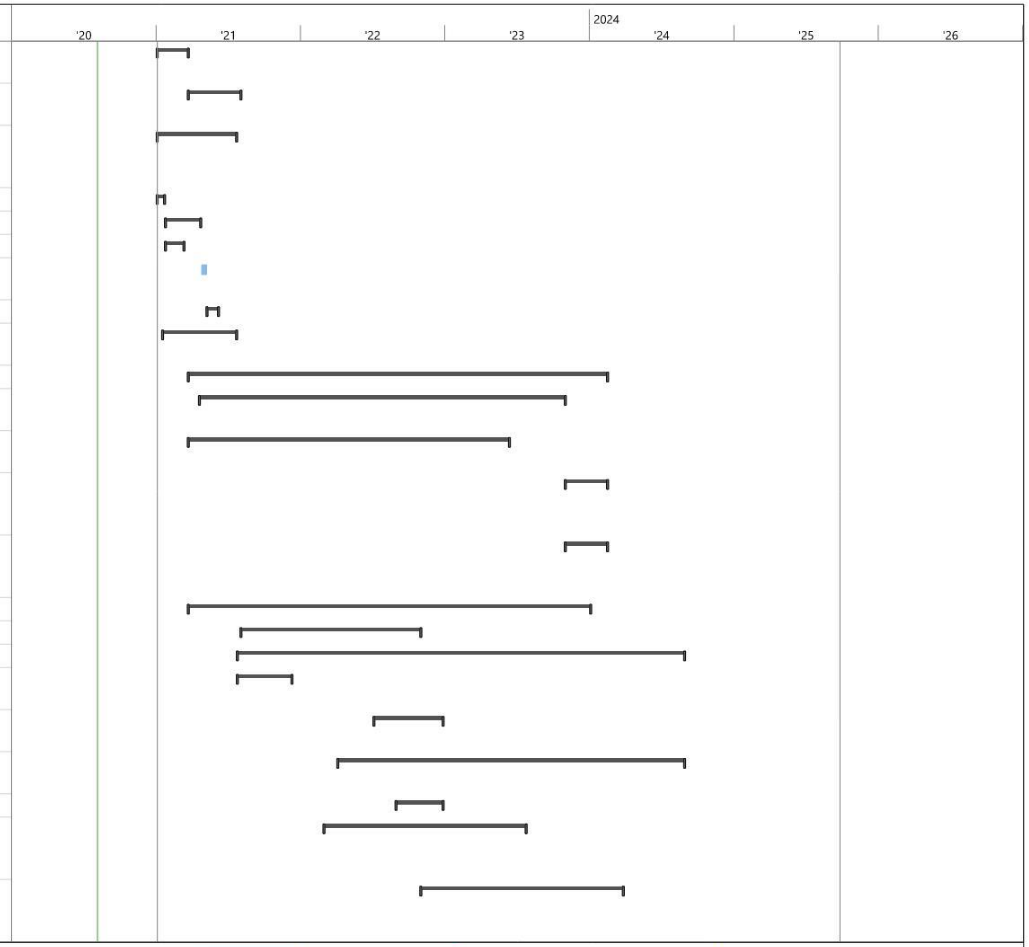
ASSUMPTIONS / CLARIFICATIONS - OPC COSTING NOT CURRENTLY CONSIDERED FOR THE FOLLOWING:

SWPPP preparation
QSP work related to SWPPP maintenance
Fees associated with submitting and renewing the NOI, annual reporting to the Regional Board, inspections and sampling required by the SWPPP's Monitoring Program, preparing the Notice of Termination and accompanying documentation, any changes made necessary by plan checks or changes in site conditions (SWPPP Amendments), and soil monitoring and/or
Stormwater Quality Management Plan
Storm water quality analysis
Storm water Management Plan
Drainage Study
Drainage analysis
Traffic control or phasing plans
Traffic analysis
Traffic Control Permits
Easement plat and legal description for RR License
Easement acquisition
Right of Way/Encroachment Permits
Environmental studies or documentation
Excavation permit processing
Municipal or Agency Permitting
Landscape and irrigation plans
Geological / Geotechnical design conditions are to be provided by SCE.
Geotechnical investigations and testing
Seismic analysis
Construction inspection and construction management
No material ordering or processing will be required of NV5
As-built documentation and subsidence monitoring
NV5 is to be provided with any SCE as-built documentation (if available), standards and/or bulletins necessary to complete the OPC
SCE shall provide utility and right-of-way AutoCAD drawings
SCE shall provide phasing diagram for connection to existing facilities, vaults, cable poles, etc.
SCE shall provide any relevant as-built information for electrical work in the vicinity of this project
NV5 will provide scheduling support for the feasibility phases of this project, supplemental to the master SCE schedule only (design, construction, and as-built phases excluded)

APPENDIX H – UNDERSEA CABLE SCHEDULE

N|V|5

ID	Task Name	Duration	Start	Finish	Predecessors	Successors
1	**Preliminary Permit Applications**	**57 days**	**Mon 1/4/21**	**Tue 3/23/21**		**77,67,61,72**
6	**Environmental Consultant**	**95 days**	**Wed 3/24/21**	**Tue 8/3/21**		
12	**Preliminary Survey and Geotechnical Sampling**	**145 days**	**Mon 1/4/21**	**Fri 7/23/21**		**102**
13	**Survey RFQ**	**15 days**	**Mon 1/4/21**	**Fri 1/22/21**		**18,25**
17	**Marine Survey**	**65 days**	**Mon 1/25/21**	**Fri 4/23/21**		**29**
24	**Land Survey**	**35 days**	**Mon 1/25/21**	**Fri 3/12/21**		**29,82**
29	Complete Preliminary Survey	10 days	Mon 4/26/21	Fri 5/7/21	17,24	31
30	**Route Selection**	**21 days**	**Mon 5/10/21**	**Mon 6/7/21**		
35	**Geotechnical Sampling**	**135 days**	**Mon 1/18/21**	**Fri 7/23/21**		
47	**Permitting**	**758 days**	**Wed 3/24/21**	**Fri 2/16/24**		
48	**State Lands Commission (SLC)**	**661 days**	**Wed 4/21/21**	**Wed 11/1/23**		
60	**Army Corp or Engineers**	**580 days**	**Wed 3/24/21**	**Tue 6/13/23**		
66	**Regional Water Quality Control Board**	**77 days**	**Thu 11/2/23**	**Fri 2/16/24**		
71	**Costal Commission Permits**	**77 days**	**Thu 11/2/23**	**Fri 2/16/24**		
76	**Local Permits**	**727 days**	**Wed 3/24/21**	**Thu 1/4/24**		
81	**Engineering**	**325 days**	**Wed 8/4/21**	**Tue 11/1/22**		
100	**Procurement**	**809 days**	**Mon 7/26/21**	**Thu 8/29/24**		
101	**Pipeline Agreement**	**100 days**	**Mon 7/26/21**	**Fri 12/10/21**		
105	**General Civil Construction**	**125 days**	**Wed 7/6/22**	**Tue 12/27/22**		
110	**Vault Procurement**	**627 days**	**Wed 4/6/22**	**Thu 8/29/24**		
117	**HDD Construction**	**85 days**	**Wed 8/31/22**	**Tue 12/27/2**		
122	**Switchyard Equipment Procurement**	**365 days**	**Wed 3/2/22**	**Tue 7/25/23**		
128	**Power Cable Furnish and Install**	**366 days**	**Wed 11/2/22**	**Wed 3/27/24**		

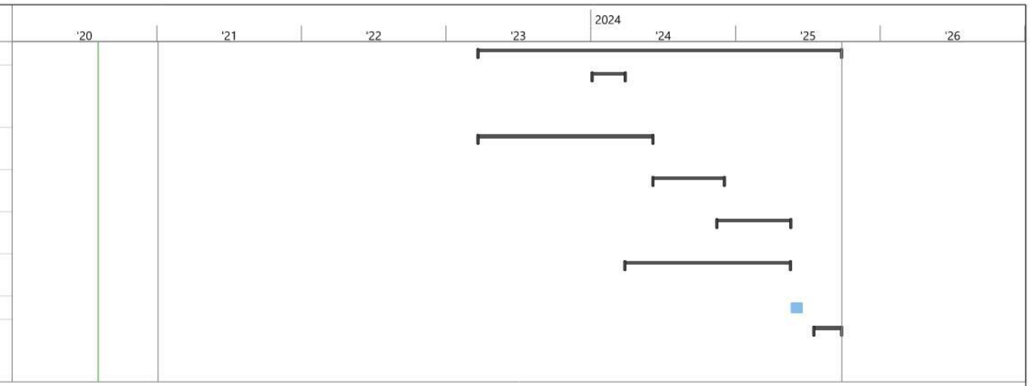


Project: Catalina Island Feasibili
Date: Thu 8/6/20

Task; Split; Milestone; Summary; Project Summary; Inactive Task; Inactive Milestone; Inactive Summary; Manual Task; Duration-only; Manual Summary Rollup; Manual Summary; Start-only; Finish-only; External Tasks; External Milestone; Deadline; Progress; Manual Progress

Page 1

ID	Task Name	Duration	Start	Finish	Predecessors	Successors
144	**Construction**	**656 days**	**Thu 3/23/23**	**Thu 9/25/25**		
145	**Confirm Preliminary Site Survey**	**60 days**	**Fri 1/5/24**	**Thu 3/28/24**		
152	**Construction Engineering**	**316 days**	**Thu 3/23/23**	**Thu 6/6/24**		
159	**Huntington Beach Civil Construction**	**128 days**	**Fri 6/7/24**	**Tue 12/3/24**		
174	**Catalina Island Civil Construction**	**133 days**	**Fri 11/15/24**	**Tue 5/20/25**		**207**
195	**Lay Submarine Cable**	**298 days**	**Thu 3/28/24**	**Mon 5/19/25**		**207**
207	Clean Up Site	20 days	Wed 5/21/25	Tue 6/17/25	174,195,206	209FS+22 days
208	**Commissioning and Post Lay Survey**	**50 days**	**Fri 7/18/25**	**Thu 9/25/25**		



Project: Catalina Island Feasibili
Date: Thu 8/6/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

APPENDIX I – UNDERSEA CABLE MISCELLANEOUS

HDD FRACTION MITIGATION CONTINGENCY PLAN

Introduction and Purpose

Directional drilling operations have a potential to release fluids into the surface through frac-outs. Frac-outs occur when drilling fluid is released through fractured bedrock into the surrounding rock and sand and eventually travels toward the surface or ocean bottom. Drilling fluid (mud) consists of bentonite clay, which is a naturally mined mineral, so it does not classify as a hazardous substance.

Frac-outs can occur in any area of a directional bore. However, they are most likely to occur near the entry and exit pits of the bore due to the shallow depths at these points. This Frac-Out Contingency Plan establishes operating procedures and responsibilities for prevention, containment, clean up, and disposal of drilling fluid if a frac-out does occur. All Boring Contractor personnel and sub-contractors must follow this plan during the directional drilling operation.

The objectives of this plan are:

1. Minimize the potential for a frac-out associated with directional drilling activities;
2. Provide the timely detection of frac-outs;
3. Protect any environmentally sensitive areas;
4. Ensure an organized, timely, and minimum impact response;
5. Ensure that all appropriate notifications are made.

Description of work

Southern California Edison (SCE) Submarine Electrical Power Cable Project. SCE's proposed Submarine Electrical Power Cable Horizontal Directional Drill (HDD) Project at Catalina Island's Pebbly Beach Generating Station consists of installing 800 feet through a new 10" diameter HDD from the seafloor bed at a depth of approximately 75 to 80 feet to the area of the station currently occupied by the micro turbines.

During the drilling operation, a frac-out has the potential to occur during any stage of the drilling process. More than likely the frac-out will occur during the pilot process since the mud will only have one direction to go, back to the drill entry point.

In the event a frac-out occurs, the drilling crew will halt drilling operations immediately. Once the stop-work has occurred, the cleanup shall begin straightaway. The site-supervisor shall notify management and safety personnel immediately. A spill kit will be on site and used if a frac-out occurs. A vacuum truck will be on site at all times during the drilling operation. Containment materials such as straw waddles may be used to help contain the frac-out. The Boring Contractor's site supervisor will evaluate the situation and direct the crew with exact actions that need to be taken.

1. If a frac-out is of a minor nature and can be easily contained. The proper precautions shall be taken in order to ensure that when drilling does resume, the frac-out will be contained. A fluid-loss drilling additive will be used to help seal off any fluid loss that has already occurred.
2. If a frac-out has been classified as a major incident, the site supervisor will stop the drilling operation and begin the containment process. Once the frac-out has been contained, the drill rod will be tripped back toward the drill to alleviate in-hole pressure. Once the frac-out has been contained, the Boring Contractor's vacuum truck will begin the cleanup process. After the frac-out is contained and cleaned up, the drilling operation will begin again making sure that flow is

constant to the bore pit and fluid pressures closely monitored.

Site Supervisor/ Foremen Responsibilities

The site supervisor/foremen will have the responsibility for implementing this Frac-Out Contingency Plan. The supervisor will ensure that all members of the Boring Contractor's drill crew are properly trained for implementation of the contingency measures and briefed prior to drilling. The site supervisor/foremen will be responsible for ensuring that the safety department and management are made aware in the event that a frac-out occurs. They will also be responsible for the response, cleanup, and notification to the customer if a frac-out occurs. The site supervisor/foreman will ensure that all bentonite is cleaned up, properly transported, and disposed of at a legal dumpsite.

The site supervisor/foremen shall be familiar with all aspects of the drilling process, the Frac-Out Contingency Plan contents, and the conditions of approval under which the activity is permitted to take place. The site supervisor/foremen will have the authority to stop work and commit the appropriate resources to implement this plan. The site supervisor/foremen will have a copy of this plan on site at all times and ensure that all Boring Contractor employees on site are familiar with this plan.

Equipment

The Site Supervisor shall ensure that:

1. All Boring Contactor equipment and vehicles are checked daily for any hazardous leaks.
2. Spill kits and spill containment materials are available on site at all times and that the equipment is in good working order.
3. Equipment required to clean up a frac-out shall be available on site at all times during the drilling operation, or at a maximum of 10 minutes away at an off-site yard.
4. If equipment is required to enter into a riverbed, area absorbent pads shall be placed under any motorized equipment while it is in operation to ensure that no fluids contaminate the riverbed.

Training

Prior to the start of work, the site supervisor must ensure that all Boring Contractor's crewmembers have received training in the following:

1. The provisions of the Frac-out Contingency Plan, equipment maintenance and site-specific requirements.
2. Inspection procedures for release prevention and containment equipment and materials.
3. Contractor/crew obligation to immediately stop drilling operations upon first detection of a frac-out.
4. Contractor/crewmember responsibilities during the event of a frac-out.
5. Operation of release prevention and control equipment and location of release control materials.

Drilling Procedures

The following procedures shall be followed each day, prior to the start of work. The Frac-Out Contingency Plan shall be available on-site during all construction. The site supervisor/foreman shall be on-site at any time that the drilling is occurring or is planned to occur. The site supervisor/foremen shall ensure a job briefing meeting is held at the start of each day of drilling to review the appropriate procedures to be followed in the event of a frac-out.

Drilling pressures shall be monitored closely so they do not exceed what is required to successfully drill through the formation. The operator shall monitor pressure levels randomly throughout the day. If available, the machine pressure levels shall be set to a minimum to minimize the potential for a frac-out event to occur.

A spill kit shall be on-site and used if a frac-out occurs. A vacuum truck shall be readily available on-site prior to, and during, all drilling operations. Containment materials (straw, silt fencing, sand bags, and frac-out spill kits.) shall be staged on-site at a location that is easily accessible. Silt fencing shall be set up at any storm drains prior to drilling.

Once the drilling operation has commenced, the operator shall notify the site supervisor/foremen if any drops or spikes in pressure occur, or if there is a lack of fluid returns into the entry pit. The site shall be monitored for frac-outs at this point. It is important to realize that just because fluid returns may be minimal does not mean a frac out is occurring. It is common for the bentonite drilling fluid to escape into the surrounding soil where it will eventually form a filter cake to seal off voids. If this occurs a fluid loss additive will be added to help reduce the amount of fluid loss.

Vacuum Truck

A vacuum truck will be on site or staged at a near-by location so it can be easily mobilized in the event that a frac-out occurs. The vacuum truck will suck up the contained frac-out and will dump at a legal dumpsite or into the entry pit so the fluid can be recycled.

Field Response to a Frac-Out occurrence

The response of the field crew to a frac-out release shall be immediate and in accordance with procedures identified in this plan. All appropriate actions that do not pose an additional threat to the surrounding area should be taken as follows:

1. Directional boring will stop immediately.
2. The drill rod will be tripped back to relieve the down hole pressure.
3. The site supervisor/foremen will be notified to ensure that management and the safety department is notified, as well as an SCE foremen.
4. The site supervisor/foremen shall evaluate the situation and recommend the type and level of response required.
5. If the frac-out is minor and easily contained, a leak-stopping compound will be added to help seal the frac-out.
6. If the frac-out has reached the surface, a berm will be constructed and the vacuum truck will be mobilized to suck up any drilling fluid that has escaped.

Response Close-out Procedures

When the release has been contained and cleaned up, response closeout activities will be conducted under the direction of the site supervisor/foremen and will include the following:

1. The recovered drilling fluid will either be disposed of legally or taken over to the entry pit to

be recycled.

2. All containment measures will be removed and cleaned up to the state prior to the frac- out.

Construction Re-start

For small releases not requiring external notification, drilling may continue if 100 percent containment is achieved through the use of a fluid loss compound. A clean-up crew shall remain at the frac-out location under the direction of the foremen.

For releases requiring external notification, drilling will not continue until SCE gives Boring Contractor notice to proceed.

Notification

In the event of a frac-out, the site supervisor will notify the safety department and the management team. The following information must be documented with 24 hours of a frac-out and given to SCE:

1. Name and telephone number of person reporting.
2. Location of the frac-out.
3. Date and time of the frac-out.
4. Estimated quantity of drilling fluid released.
5. How the release occurred.
6. The type of activity that was occurring during the frac-out.
7. Description of the methods used to clean up or secure the site.

Communication with Customer (SCE)

The site supervisor/foremen will contact Customer when there is a frac-out. They will follow up with the above-mentioned documentation. If it is a major frac-out, the Boring Contractor will wait for the approval of SCE to resume the drilling operation. Only the site supervisor/foremen are to communicate with Customer over the frac-out.

Documentation

The site supervisor/foremen shall record the frac-out event in his daily log. The log will include the following information:

1. Details on the frac-out.
2. Estimate of fluid loss.
3. Location and time of release.
4. Size of the affected area.
5. Sources used to clean up.

   The log report shall also include:

6. Name and telephone number of the person reporting.
7. Date.

8. How the release occurred.
9. The type of activity that was occurring when the frac-out happened.
10. A description of the method used for clean-up.

This daily log will can be copied and given to Customer upon request.

CABLE BURIAL BY HAND JETTING PROCEDURE

The section of cables in bundle configuration from the position where the jet plow stops its work to the HDD conduit exit, or abandoned 24-inch pipeline exit, will be buried by divers using hand-jetting systems and/or post burial systems. Hand-jetting shall be performed as follows:

Site Location and Vessel Mooring

The Dive vessel will anchor over the portion of the cable to be hand jetted. A DGPS navigation/survey system, or equivalent, will be used to locate the area and to place the anchors in a 4-point moor. The surveyor will determine a safe position when using spuds for remedial work. The stern of the vessel will be positioned over the end of the exposed cable where the cable enters or exits the jet plow burial trench.

Diving to Locate Jet Plow Burial Transition

A small clump weight attached to a down line will be lowered to the seabed from the stern of the dive vessel. The diver will descend this line and begin a search for the cable on the seabed. When the cable is located the diver will proceed to the point where the cable exits /enters the jet plow burial trench. This beginning location will be recorded by the surveyor.

Hand Jetting Burial

Once the transition point is located, a balanced head-jetting wand will be lowered to the diver. This is a T-shaped burial jet, which provides a 5/8” jet nozzle for jetting and an identical nozzle to provide counter thrust in the opposite direction. This jetting wand is supplied by a 3-inch water hose and diesel power jetting pump. The diver will begin to jet the seabed soil from under the cable bundle at the jet plow transition. Once the bundle is buried to the full depth at the transition, the diver will continue to jet the bundle along the portion where the bundle is laying on the seabed surface. This transition from full burial to seabed surface is a slope approximately 15 to 25 feet long. The diver will progressively jet as this slope is shifted along until the entire exposed section of cable bundle is buried. The ending point will be recorded by the surveyor.

Burial Depth Verification

The burial depth will be verified using a diver’s pneumo tube and a 6.5 foot (2 meter) probe. The diver will place the probe on top of the cable bundle; a pneumo depth will be recorded at the top of the probe. A second pneumo depth will be recorded at natural seabed adjacent to the cable trench. A comparison will be made to determine the cable depth below natural seabed.

INSTALLATION VESSEL CABLE EQUIPMENT

General Vessel Layout: The cable lay vessel general arrangement includes the main undersea cabling coiled in the center of the vessel, the laying and burial systems located at the stern, the main control room at the stern to control and direct all shipping operations, with the balance of equipment placed in space around these main components.

Cable Tubs

The power cable will be coiled in a conventional static tub. The tub is a circular containment structure that provides an internal ring and external ring of specific dimension. The cable is coiled in layers within these rings using a coiling arm.

Cable Towers

The cable towers are an overhead structure that allows the cables to drop into or be pulled out of the cable tubs. This overhead configuration allows the cable to transition from the coil to the linear cableway and cable traction machines.

Cable Linear Machines

The cable will be run through a linear machine on the vessel deck. The machine has a pair of powered tracks that grip the cable and moves the cable off or on to the vessel. The machine is controlled to provide a coordinated movement of cable.

Figure 1 - Linear Cable Machine & Remote Total Control Console

Cable Chute

The cable chutes (elephant trunks) are radiused structures generally located at the stern of the vessel that controls the bending of the cable in vertical and horizontal position as it is laid from or recovered to the installation vessel.

Dive Systems on the Installation Vessel

Where applicable, a dive system will be mobilized aboard the cable installation vessel. This will allow all phases of the project diving to be performed as the cable is installed. The dive system is capable of supporting a hard-hat diver and diver work tasks. The dive system includes a diver with underwater video and voice communications. An umbilical provides this link along with divers breathing air. Air compressors, video, communication links, supervision, coordination, and observation are all provided from the dive station.

APPENDIX J – NREL PHASES I & II SUMMARY REPORT

Catalina Repower Feasibility Study: NREL Phases I & II Summary Report

Kathleen Krah, Michael Callahan, and James Elsworth

Suggested Citation
Krah, Kathleen, Michael Callahan, and James Elsworth. 2020. *Catalina Repower Feasibility Study: NREL Phases I & II Summary Report*. Golden, CO: National Renewable Energy Laboratory.

Technical Report
Issued to Client 08/6/2020

NOTICE

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by Southern California Edison and the U.S. Environmental Protection Agency (EPA) under Agreement IAG-16-2012. Work incorporates inputs and assumptions developed by and independent project partner NV5. The views expressed herein do not necessarily represent the views of the DOE or the U.S. Government.

Acknowledgments

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List of Acronyms

AC	alternating current
ACF	area cost factor
ATB	Annual Technology Baseline
BESS	battery energy storage system
BTU	British thermal units
CA	California
CAISO	California Independent System Operator
CAPEX	capital expenditure or capital costs
CO_2	carbon dioxide
COD	commercial operation date
DC	direct current
ECM	energy conservation measures
EE	energy efficiency
EIA	U.S. Energy Information Association
EPA	Environmental Protection Agency
FF-1	fossil fuel scenario #1
FF-2	fossil fuel scenario #2
FF-3	fossil fuel scenario #3
FF-4	fossil fuel scenario #4
FF-5	fossil fuel scenario #5
FF-6	fossil fuel scenario #6
FF-EE	fossil fuel scenario with energy efficiency sensitivity
gal	gallons
gm	gram
GWh	gigawatt-hours
HP	horsepower
hr	hour
ITC	Investment Tax Credit
kV	kilovolts
kW	kilowatts
LC-1	minimize lifecycle cost scenario #1
LC-CAP	minimize lifecycle cost scenario with lower PV/BESS capital cost sensitivity
LCC	lifecycle costs
LNG	liquified natural gas
M	million
MACRS	Modified Accelerated Cost Recovery System
MERRA	Modern-Era Retrospective analysis for Research and Applications
MMBTU	million British thermal units
MW	megawatts
MWh	megawatt-hours
NaS	sodium-sulfur
NASA	National Aeronautics and Space Administration
NOx	nitrogen oxide
NREL	National Renewable Energy Laboratory

NSRDB	National Solar Radiation Database
O&M	operations & maintenance
PBGS	Pebbly Beach Generating Station
PV	photovoltaics
PVRR	present value of revenue required
RE	renewable energy
RE60-1	60% renewable energy scenario #1
RE100-1	100% renewable energy scenario #1
RE60-2	60% renewable energy scenario #2
RE60-3	60% renewable energy scenario #3
RE60-CAP	60% renewable energy scenario with lower PV/BESS capital cost sensitivity
RE100-CAP	100% renewable energy scenario with lower PV/BESS capital cost sensitivity
RE60-EE	60% renewable energy scenario with energy efficiency sensitivity
REopt	Renewable Energy Optimization and Integration tool
ROM	rough order of magnitude
S.B.	Senate Bill
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
tmy	typical meteorological year
UC-1	undersea cable scenario #1
W	watts
WIND Toolkit	Wind Integration National Database Toolkit

Executive Summary

Engineers at the National Renewable Energy Laboratory (NREL) supported Southern California Edison (SCE) and the United States Environmental Protection Agency (EPA) by conducting technical and economic analyses for energy systems at Santa Catalina (Catalina) Island, which is located 22 miles off the coast of Long Beach, California. This effort was part of a broader Repower Catalina Feasibility Study that was also supported by NV5, an engineering consulting firm and project partner to NREL for this analysis. This document describes NREL's techno-economic modeling and optimization analysis for the first two phases of this project which focus on supply-side generation and energy storage options for Catalina.

SCE's goal for this analysis is to determine a strategy for electricity generation on Catalina Island that results in lower energy costs, improved energy resiliency, and reduced air emissions. The U.S. Environmental Protection Agency's (EPA) goals for this effort are to reduce emissions of air pollution and encourage renewable energy development on current and formerly contaminated lands when such development is aligned with the community's vision for the site.

Currently, an on-island SCE power plant serves the Catalina Island electrical load with six reciprocating diesel generators totaling 9.4 MW, 23 propane-fueled microturbines totaling 1.5 MW, and a 1 MW, 7.2 MWh sodium sulfur (NaS) battery energy storage system (BESS). In 2017, the electricity consumption on the island was 29.1 GWh, with an average load of 3.3 MW and peak load ~5.5 MW.

Considering new environmental standards on diesel generator emissions from California's South Coast Air Quality Management District (SCAQMD), a 60% renewable energy target for 2030 laid out in California's Senate Bill 100, SCE's Clean Power Electrification Pathway, and the characteristics of the island's existing diesel generators, SCE is seeking to evaluate the technical and economic implications of different energy technology options to determine a path forward. Phases I and II of the Repower Catalina Feasibility Study summarized in this document, evaluated the following:

- Interconnection with the mainland via an undersea cable
- On-island fossil-fuel generation, including diesel, propane, and/or liquified natural gas (LNG)
- On-island renewable energy (RE) technologies, including solar photovoltaics (PV), wind turbines, and wave energy devices
- Battery energy storage systems to support the above generation technologies
- Initial analysis of the potential impacts of implementing energy efficiency measures

Thus far, results indicate strong techno-economic potential for a mix of on-island diesel and/or propane generators, solar PV, BESS and energy efficiency measures, to help SCE and Catalina achieve their goals compliant with California's emissions and clean energy standards while minimizing electricity lifecycle costs (LCC) over the 30-year analysis period. The following bullet points summarize key takeaways from phase I and II of this analysis:

- An **undersea cable** does not appear cost-competitive with the other options assessed, largely due to its capital cost along with capital costs required to support redundancy in the form of a second undersea cable or on-island generators.

- On-island emissions compliant diesel generators or a diesel/propane hybrid generator option could cost-effectively support generation and reliability goals for any of the scenarios considered.

  - **Diesel generators** each ranging in capacity from 1.49 MW to 2.98 MW were considered and LCC do not significantly vary between these options.

  - An all-**propane generators** scenario has an ~50% higher LCC than all-diesel generators but reduces NOx emissions by over 75%. This higher cost is largely driven by the need for additional fuel storage on the island. However, even once emissions associated with additional barge shipments of fuel are considered, propane options are still likely to have lower total NOx emissions than diesel. It seems plausible that at least one propane generator could be used to replace the propane microturbines with the existing fuel storage and fire suppression system. Moreover, if propane usage for buildings on Catalina is eventually converted to electricity usage, there may be increased flexibility to add or convert to more propane generators for electrical generation. Additionally, despite its lower heat content than diesel, propane fuel benefits from a low shipping cost since the barge delivery tariffs are significantly based of weight.

  - A combined **diesel and propane hybrid** could serve as a cost-effective option that reduces NOx emissions by nearly 25% over an all-diesel scenario and provides fuel flexibility for price hedging. Generator fuel-switching or dual-fuel generators could facilitate this option.

  - **LNG generators** appears to be the most costly generator option evaluated, with an LCC 63% higher than an all-diesel option. This higher LCC is largely driven by higher capital costs for generators and infrastructure upgrades. Additional feasibility studies for this option would be required to more accurately estimate the costs of fuel shipping and infrastructure upgrades.

- **Solar PV and BESS** could cost-effectively reduce fossil fuel and emissions on Catalina.

  - **Minimizing LCC:** Even without considering a RE target, PV is cost-effective on Catalina. Adding 1.2 MW-DC of PV (covering ~8 acres) cost-effectively achieves 5% annual RE without changing the LCC of electricity relative to an all-diesel scenario.

  - **60% annual RE target:** A 60% annual RE target on Catalina Island could be met with approximately 15.6 MW-DC of PV (covering ~100 acres) and 12 MW / 90 MWh (~7.5-hr) of additional BESS. Compared to an all-diesel scenario, the LCC could increase by $71M (47%).

- **100% annual RE target:** To meet 100% of the electrical load on Catalina with RE, approximately 44 MW-DC of PV (covering ~280 acres) and 36 MW, 340 MWh of BESS could be required. Compared to an all-diesel scenario, overall LCC would increase by $290M+ (>275%) and would likely require additional distribution system upgrades and integration costs not included in this estimate.

- **PV and BESS costs assumptions** include higher transportation and labor costs associated with Catalina. If lower PV/BESS capital costs can be achieved, in line with mainland U.S. costs, understandably overall system LCC decreases for all PV/BESS scenarios and cost optimal PV/BESS systems size could be larger. For a 60% annual RE target, the overall system LCC could decrease by 13%. PV and BESS capital costs are likely to continue to decrease over the coming years, making projects more cost effective as they are developed in phases.

- **Wind turbines** do not appear cost effective versus other options due to the estimated island's low wind resource, ~9.9% capacity factor. Wind resource data for potential site specific wind turbines locations was not available but was estimated using "measure-correlate-predict" analysis.

- **Wave energy devices** are in an earlier stage of technology readiness and do not appear as cost-effective for Catalina versus other options considered. As the technology matures and costs decrease, SCE could re-evaluate the potential for using this technology at Catalina. A pilot demonstration could be considered but is unlikely to reduce lifecycle costs of electricity on Catalina at this time.

- An initial example of **energy efficiency impacts** suggests that a 21% decrease in modeled electrical load could yield 15-25% reductions in the LCC of electricity, excluding the cost of energy conservation measures (ECMs). Considering a 60% annual RE target, such ECMs could also reduce the PV capacity and land requirements to achieve this goal on-island by 21%.

Concurrent with this analysis, NV5 conducted a preliminary energy efficiency (EE), demand response (DR), demand side management (DSM), and deferrable loads (DL) evaluation for Catalina. The results of this NV5 analysis were not yet available at the time that NREL completed this techno-economic analysis. SCE has indicated additional follow-on analysis phases could include more detailed analysis and optimization of these demand-side energy options, water systems, electric transportation, and building electrification, among others.

This document summarizes the considerations and findings of Phases I and II, focusing on high-level takeaways from Phase I and more detailed results from Phase II, and discusses a potential path forward for Phase III.

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1 Introduction

This section provides an overview of Catalina Island, including its electricity consumption, generation strategy, and factors driving this analysis. The scope and approach of NREL's techno-economic analysis for Phases I and II are also described in the context of the overall Catalina Repower Feasibility Study.

1.1 Island Overview

Catalina Island, located just over 20 miles off the coast of southern California, is home to roughly 4,000 year-round residents, but tourists increase the summer and weekend population to over 10,000 with over 1 million visitors per year.[1] The island is roughly 48 thousand acres of land including over 50 miles of coastline; 88% of this land is protected by the Catalina Island Conservancy.[1] Figure 1 shows a map of the island including SCE's electric generation facilities and distribution system, described below.

Figure 1. Map of Catalina Island's generation facility and electric distribution system.[2]

As a part of Los Angeles County, the island's electricity requirements are served by Southern California Edison (SCE). The hourly electrical load profile for Catalina is shown in Figure 2. In 2017, the island consumed 29.1 GWh of electricity, with an average load of 3.3 MW and peak load ~5.5 MW.

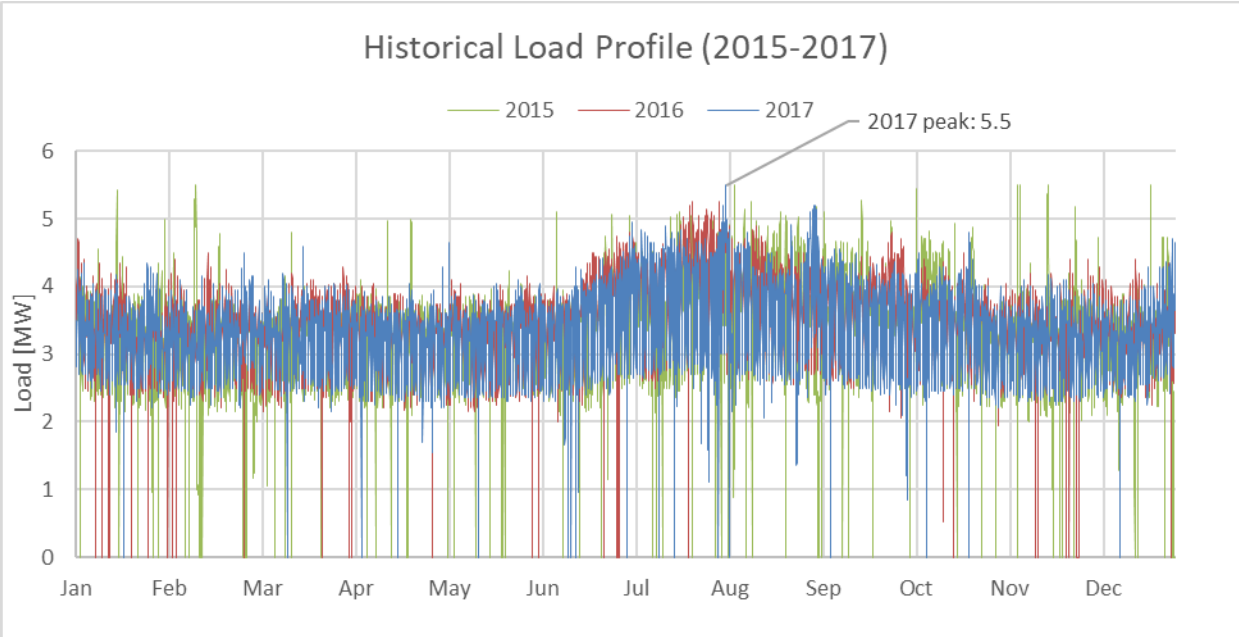

Figure 2. Historical hourly electrical load profile, 2015-2017, per SCE.

Currently, SCE generates Catalina's electricity on-island at Pebbly Beach Generating Station (PBGS), which is approximately one mile southeast of the city of Avalon. PBGS consists of six reciprocating diesel generators totaling 9.4 MW, 23 propane microturbines totaling 1.5 MW, and a 1 MW, 7.2 MWh sodium sulfur (NaS) battery energy storage system (BESS), as summarized in Table 1. Other known on-island generation is customer-sited and privately-owned, the largest being 23 kW of solar photovoltaics (PV) located at the University of Southern California's Wrigley Marine Science Center. Electricity is distributed across the island via three 12 kV circuits. A second substation is located in the city of Two Harbors.

Table 1. Existing Generation and Storage Systems

Unit	Type	Rated Capacity	Annual NOx Emissions (2017) [tons]
Unit 7	Diesel generator	1 MW	10.3
Unit 8	Diesel generator	1.5 MW	13.2
Unit 10	Diesel generator	1.125 MW	13.8
Unit 12	Diesel generator	1.575 MW	21.5
Unit 14	Diesel generator	1.4 MW	13.0
Unit 15	Diesel generator	2.8 MW	3.3
Microturbines	Propane microturbines	23 @ 65 kW = 1.5 MW	0.3
BESS	NaS BESS	1 MW / 7.2 MWh	0
TOTAL	**TOTAL**	**11.9 MW**	**75.4**

Diesel and propane fuel for these generators is delivered to the island by barge. Table 2 summarizes fuel consumption and costs for 2017; costs include the cost of fuel transport. See the Appendix for more information about fuel delivery and costs. Of the 800k gallons (gal) of propane delivered, ~20% (150k gal) was consumed by the microturbines. (SCE also distributes propane to facilities in the Avalon area via a pipeline.)

Table 2. 2017 Delivered Fuel Consumption and Costs

Fuel	Diesel	Propane
Annual consumption	2.03M gal	0.80M gal
Annual total cost	$5.5M	$1.3M
Average cost	$2.73/gal = $18.93/MMBTU	$1.27/gal = $17.35/MMBTU

Of the six diesel generators currently operating at PBGS, five are in the range of 33-61 years of age and do not comply with California's South Coast Air Quality Management District's (SCAQMD's) nitrogen oxide (NOx) emissions standards as described in Rule 1135, which defines several compliance options with deadlines ranging from 2022 to 2026.[3] Per SCE, the sixth generator, 2.8 MW Unit 15, is exempt from Rule 1135 and could remain operational, but all other existing generators would need to be replaced with new compliant generation. Note that although this analysis focuses on NOx emissions, SCAQMD Rule 1135 also stipulates requirements for other emissions.

Additionally, in 2017, SCE released its Clean Power Electrification Pathway detailing a blueprint to achieving California's environmental goals.[4] In 2018, California's Senate Bill 100 (S.B.100) set a 60% renewable energy target for the year 2030. The characteristics of the existing generators and generation plant, SCAQMD's Rule 1135, California's S.B.100, and SCE's clean power goals serve as the impetus for this analysis.

1.2 Scope and Approach

The overall Catalina Repower Feasibility Study evaluated options for Catalina's electric system to provide reliable power to the island while complying with emissions requirements. The team, comprised of SCE, EPA, NV5, and NREL, evaluated the following generation and storage technology options:

- Interconnection with the mainland via an undersea cable
- On-island fossil-fuel generation, including diesel, propane, and/or liquified natural gas (LNG)
- On-island renewable energy (RE) technologies, including solar photovoltaics (PV), wind turbines, and wave energy devices
- Battery energy storage systems (BESS)

- Initial analysis of the potential impacts of implementing energy efficiency measures

Concurrent with this analysis, NV5 conducted a preliminary energy efficiency (EE), demand response (DR), demand side management (DSM), and deferrable loads (DL) evaluation for Catalina. The results of this NV5 analysis were not yet available at the time that NREL completed this techno-economic analysis. SCE has indicated additional follow-on analysis phases could include more detailed analysis of these demand-side energy options, water systems, electric transportation, and building electrification, among others.

NREL is using the Renewable Energy Optimization and Integration (REopt)[5,6] software tool to evaluate the potential of various energy technology options to power Catalina over a 30-year analysis period. This document describes NREL's techno-economic analysis and discusses the lifecycle cost-effectiveness and other factors of various energy system configurations evaluated. Given the collaborative nature of this effort, the techno-economic analysis both utilizes results of NV5 analysis as techno-economic inputs and feeds techno-economic results into NV5's analysis.

2 Methodology

This section provides an overview of NREL's REopt software tool and of the phased approach taken for this iterative techno-economic analysis.

2.1 REopt Overview

REopt[5,6] is a techno-economic time series optimization modeling tool to support distributed energy systems planning decisions. Formulated as a mixed integer linear software program, REopt identifies the cost-optimal mix of candidate technologies, their respective sizes, and dispatch strategies.

Typically, the objective function is to minimize the present value of lifecycle costs (LCC) of energy over the analysis period by adjusting modeled system sizes and dispatch. The model can optionally incorporate specific RE targets to identify cost-effective pathways to achieve such targets. The LCC modeled includes capital costs (CAPEX) of new energy generation and storage capacity, the present value of all operating expenses such as fuel costs and operations and maintenance (O&M) costs, and the present value of any financial incentives and depreciation.

The model achieves a balance between energy demand and generation in every time step of the year (hourly time steps were used for this analysis) by sizing and dispatching a cost-optimal combination of power purchases (via a potential sub-sea cable in this case), renewable generation, fossil fuel generation and energy storage. The model also includes specific constraints for each of the identified technology options that define how they can operate.

2.2 Analysis Phases

Due to the interdependencies of NREL and NV5 sub-tasks, the techno-economic analysis was performed iteratively, with results informing the next phase of analysis to facilitate comprehensive understanding of options and convergence on recommendations for a path forward.

- **Phase I: Preliminary Analysis.** The preliminary analysis considered initial technical and cost assumptions based on inputs from SCE, EPA, NV5, and NREL. Results were presented in October 2019.

- **Phase II: Refined Analysis.** Scenarios and technologies considered in Phase II were informed by the results of Phase I and discussion between SCE, EPA, NV5, and NREL. Some technical and cost assumptions were also updated based on Phase I findings, especially where Phase I findings could inform assumptions provided by NV5. Initial results were presented in March 2020.

- **Phase III: Refined Analysis including Demand-Side Factors.** A future phase of this analysis could fully assess the impact of demand-side considerations on generation-side planning. A Phase III techno-economic analysis could be informed by findings from this Phase II REopt analysis and NV5's initial analysis of potential load increases, load reductions, and controllable loads. This is discussed in more depth in Section 4.

This document summarizes the considerations and findings of Phases I and II, focusing on high-level takeaways from Phase I and more detailed results from Phase II, and discusses a potential path forward for Phase III.

3 Results

3.1 Phase I High-Level Summary

A goal of Phase I was to evaluate a range of options at a high level to facilitate team discussions, improve inputs and assumption for Phase II, and inform selection of scenarios to be assessed in Phase II. Phase I scenarios were collaboratively identified with input from SCE, EPA, NREL, and NV5.

Phase I results yielded the following takeaways:

- **Solar PV** appears to be cost effective on Catalina.

- **Wind turbines** do not appear cost effective on Catalina, due to the relatively low estimated capacity factor of 9.9% predicted from the geospatial wind data and the high capital costs associated with distributed wind on an island with complex terrain. Site-specific wind resource measurements for possible wind turbines locations was not available but NREL wind experts used "measure-correlate-predict" analysis to identify areas of the island with the strongest resource.

- **Additional BESS** could stabilize high penetrations of renewables on the island's electric grid.

- Per SCE, **microturbines** will be decommissioned once they reach end of life in the next several years.

- An **undersea cable** interconnecting with the mainland appears more expensive on a lifecycle basis than when compared with on-island generation. This is in part driven by its high estimated capital cost of $220M for a single undersea cable, per NV5. A second cable or on-island generation would also be required to provide redundancy, further increasing costs.

3.2 Phase II Detailed Results

Based on the findings of and feedback on Phase I, the Phase II analysis incorporated refined techno-economic assumptions, additional technologies and scenarios, and pertinent sensitivity analyses. This section describes the scenarios, considerations, and sensitivities included in the Phase II analysis; for additional details about techno-economic assumptions, see the Appendix.

The load profile used for these analyses is based on the 2017 load profile, which peaks at 5.5 MW, scaled to a peak load of 7 MW per SCE's estimates of load growth. To model this estimated load increase, the electric demand in each hourly timestep was increased by 27% (since 7 MW is a 27% increase over 5.5 MW peak demand). In future work, additional demand-side analysis could be performed to more accurately capture temporal variations in load impacted by future load increases, load reductions, and controllable loads.

To ensure system reliability, spinning reserve requirements and N+2 redundancy requirements were specified as constraints. Spinning reserve requirements are detailed in the Appendix. N+2 redundancy requires that if the two largest generators are offline during the peak load that the remaining generators could still cover the peak load. Renewables and BESS were not assumed to contribute to the N+2 requirement, but could support redundancy albeit at higher risk of unavailability.

Table 3 summarizes the scenarios evaluated and the high-level results for Phase II, organized into five categories:

- Undersea Cable (UC)
- Fossil Fuel Only (FF)
- Minimize LCC (LC)
- 60% RE Annually (RE60)
- 100% RE Annually (RE100)

The FF and RE100 options serve as analysis bookends. RE60 is predicated on California's S.B.100 target of 60% RE by 2030; however, off-island options could also support this goal. In order to reduce lifecycle costs in LC scenarios, REopt identified the cost-optimal mix of energy technologies to serve Catalina Island's electricity requirements, without considering any renewable energy targets.

Within each of these five categories in Table 3, the individual scenarios listed (in order of increasing LCC) consider different generator configurations and sensitivity analyses.

- Enumerated (1,2,3, etc.) scenarios vary generator type, number, and size but otherwise use the same load and technology assumptions, as described in the Appendix.

- Lower PV/BESS CAPEX (CAP) scenarios assume PV and BESS cost are equal to mainland U.S. price points, rather than in the enumerated scenarios where PV and BESS costs are assumed to be higher on Catalina.

- The energy efficiency (EE) scenarios assume that energy conservation measures (ECMs) are implemented to bring the electrical load profile back to 2017 values, essentially a 21% decrease in demand applied to all hours of the year. This EE case is intended as one simple example to demonstrate the impact demand-side considerations could have on SCE's generation strategy on Catalina. An additional analysis to include potential load changes and their impact on electricity requirements and generation strategy is recommended and is planned as a Phase III of techno-economic analysis as discussed in Section 4.

Unless otherwise noted, all scenarios assume that the existing 2.8 MW diesel generator (Unit 15) and 1 MW, 7.2 MWh NaS BESS are available for use, with the NaS BESS being replaced at end of life, estimated ~2032.

Table 3. Phase II Scenarios and Results Summary

Scenario		Generator / Fuel Type	Sensitivity Analysis	New Generators[7] [MW]	New BESS Capacity[7]	PV Capacity	Estimated PV Footprint	Annual % RE	Estimated Annual NOx Emissions[8]	Estimated CAPEX[9]	Present Value of Estimated LCC
Under-sea Cable[10]	**UC**	Diesel (larger)	---	4 x 2.98	N/A	N/A	N/A	N/A	N/A	$263M	**$334M**
Fossil Fuel Only	**FF-EE**	Diesel (larger)	EE	3 x 2.98	N/A	N/A	N/A	N/A	20 tons	$32M	**$128M**
	FF-1	Diesel (smaller)	---	6 x 1.49					25 tons	$32M	**$152M**
	FF-2	Diesel (larger) + Propane	---	3 x 2.98 + 1 x 1.38					19 tons	$44M	**$165M**
	FF-3	Diesel (larger)	---	4 x 2.98					25 tons	$43M	**$168M**
	FF-4	Diesel (mixed), no unit #15 (2.8 MW)	---	2 x 1.49 + 2 x 2.23 + 2 x 2.98					25 tons	$48M	**$169M**
	FF-5	Propane	---	7 x 1.38					6 tons	$108M	**$230M**
	FF-6	LNG[11]	---	4 x 2.5					3 tons	$132M+	**$247M+**
Minimize LCC	**LC-CAP**	Diesel (larger)	Lower PV/BESS CAPEX	4 x 2.98	2.2 MW, 1.1 MWh	3.8 MW-DC	24 acres	16%	21 tons	$50M	**$165M**
	LC-1	Diesel (larger)	---	4 x 2.98	0	1.2 MW-DC	8 acres	5%	24 tons	$46M	**$168M**
60% RE Annually	**RE60-EE**	Diesel (larger)	EE	3 x 2.98	9 MW, 71 MWh	12.3 MW-DC	78 acres	60%	8 tons	$127M	**$194M**
	RE60-CAP	Diesel (larger)	Lower PV/BESS CAPEX	4 x 2.98	12 MW, 90 MWh	15.6 MW-DC	99 acres		10 tons	$126M	**$211M**
	RE60-1	Diesel (smaller)	---	6 x 1.49					10 tons	$149M	**$223M**
	RE60-2	Diesel (larger)	---	4 x 2.98					10 tons	$159M	**$243M**
	RE60-3	Propane	---	7 x 1.38					2 tons	$224M	**$302M**
100% RE[12] Annually	**RE100-CAP**	Diesel (larger)	Lower PV/BESS CAPEX	4 x 2.98	36 MW, 340 MWh	44 MW-DC	279 acres	100%	0 tons	$291M+	**$354M+**
	RE100-1	Diesel (larger)	---	4 x 2.98					0 tons	$395M+	**$458M+**

3.2.1 Undersea Cable

The capital ($220M) and O&M costs ($5M) of the undersea cable were evaluated by NV5. California Independent System Operator (CAISO) day-ahead (DA) electricity costs from the Huntington Beach substation were used to estimate the cost of mainland generation that would supply Catalina Island through the cable. The undersea cable is assumed to be backed up by on-island diesel generators in this scenario (see UC) which adds additional capital and O&M costs to this scenario. The LCC of electricity with an undersea cable is nearly 200% of the LCC of electricity in an all-diesel scenario (see FF-3).

3.2.2 Generator and Fuel Options

In order to satisfy N+2 redundancy requirements, all scenarios evaluated have on-island fossil fuel generation to cover the full peak load even if the two largest generators go offline. Three fuel types (diesel, propane, and LNG) and several generator sizes and configurations were evaluated. Note that additional factors beyond those included in the techno-economic analysis, including generator footprint, renewables integration, part load operations, ramp rates, implementation schedule, and spare parts requirements, may also influence generator selection and are not included in this results table.

3.2.2.1 Diesel Generators

Results suggest diesel generation as a lower life-cycle cost option than the other fossil fuel generator options, with a small difference in LCC between smaller (1.49 MW; see FF-1), larger (2.98 MW; see FF-3), or mixed-capacity (1.49 MW, 2.23 MW, and 2.98 MW; see FF-4) generators.

The higher LCCs shown in Table 3 can be attributed to the difference in total generator capacity between the scenarios because diesel generator capital and O&M costs were estimated on a constant $/kW basis, as well as the fact that Unit 15 was excluded from the mixed-capacity scenario (see FF-4) per request from SCE which therefore required additional new generation capacity to be purchased. However, the larger generators operate at a slightly higher efficiency than the smaller generators. Note that the full range of diesel generators evaluated appear flexible enough in their partial load and minimum loading requirements to be able to facilitate at least 60% RE according to input provided by NV5.

3.2.2.2 Propane Generators

An all-propane scenario (see FF-5) has a ~40% higher LCC than all-diesel generators but reduces NOx emissions by over 75%. A combined diesel and propane option (see FF-2) could serve as a cost-effective system that reduces NOx emissions by nearly 25% over an all-diesel scenario and provides fuel flexibility for price hedging.

Potential generator fuel-switching or dual fuel options could be considered to facilitate this option; it could be possible to convert the diesel generators to 95% propane. Having multiple fuel options and generators could also provide a hedge against cost increases for either propane or diesel fuel.

Even once emissions associated with additional barge shipments of fuel to the island are considered, propane options are still likely to have total lower NOx emissions. Propane has a higher energy intensity by weight and although it has a lower energy intensity by volume. Thus, Catalina's weight-based fuel shipping rates give propane an shipping cost advantage over diesel. See the Appendix for more details on fuel shipments and emissions implications.

One challenge is that propane fuel storage on the island may be limited by fire suppression requirements and other factors. Nevertheless, it seems plausible that at least one propane generator could be used to replace the propane microturbines with the existing fuel storage and fire suppression system. Additionally, if the propane usage in buildings on Catalina is eventually converted to electricity usage, there may be increased flexibility to add or convert to more propane generators to generate electricity.

3.2.2.3 LNG Generators

LNG (see FF-6) appears to be the most expensive generator option evaluated, with an LCC 63% higher than an all-diesel option. This higher LCC is largely driven by higher capital costs for generators and infrastructure upgrades. Additional feasibility studies for this option would be required to more accurately estimate the costs of fuel shipping and infrastructure upgrades.

3.2.3 Solar PV + BESS

Solar PV and BESS appear to be cost effective technologies on Catalina. This section discusses the recommended PV and BESS systems and their economics for scenarios seeking to minimize LCC, achieve 60% or 100% RE annually, and considering capital cost and land lease cost sensitivities.

NV5 conducted an analysis to estimate the costs to accommodate increased variable RE generation and potential locations and configurations (e.g. AC-connected vs DC-connected, distributed vs centralized) on Catalina's electric system. These distribution system upgrade cost estimates are included in the capital costs and LCCs listed in Table 3; additional details are provided in the Appendix.

3.2.3.1 Minimizing LCC

PV is cost-effective on Catalina. Initial analysis suggests that 1.2 MW-DC could be supported by the existing NaS BESS (see LC-1) without changing the LCC of electricity relative to an all-diesel scenario (see FF-3) and assuming 76.5% higher PV capital costs and 31.5% higher BESS capital costs on Catalina vs. the mainland. Such a system could achieve a 5% annual RE penetration and reduce annual NOx emissions by 4-5% relative to the all-diesel scenario (see FF-3). The actual most cost-effective size of a PV system will depend on actual PV pricing and project costs.

3.2.3.2 60% Annual RE Target

A 60% annual RE target on Catalina Island could be achieved with approximately 15.6 MW-DC of PV and 12 MW / 90 MWh (~7.5-hr) of additional BESS (see RE60-1). This PV system could require ~100 acres of land. Compared to an all-diesel scenario (see FF-3), NOx emissions would decrease by 15 tons/yr to 10 tons/yr, but the lifecycle cost could increase by $71M (47%). This system represents a high contribution of RE, nearly 200% of the 7 MW peak load on a capacity basis and would require controls and communications systems to integrate with the power system. Rough cost estimates for integration are included but could be higher than estimated.

If mainland PV and BESS capital costs could be achieved on Catalina, capital costs could be reduced by $33M leading to a 13% reduction in system LCC (see RE60-CAP and Section 3.2.3.4).

3.2.3.3 100% Annual RE Target

A 100% annual RE target was assessed for this analysis. To meet 100% of the electrical load on Catalina with RE, approximately 44 MW-DC of PV and 36 MW, 340 MWh of BESS could be required. This PV system would require ~280 acres of land but could reduce NOx emissions to 0. Relative to an all-diesel scenario (see FF-3), overall LCC increase by $290M+ to over $458M, which is $215M+ more than the 60% annual RE scenario (see RE60-1). These estimates only include NV5's distribution system upgrade cost estimate to facilitate 60% RE; additional distribution system upgrades are likely required to achieve 100% RE but these costs were not calculated or included.

If mainland-based PV and BESS capital costs can be achieved, capital costs could be reduced by $104M leading to a 23% reduction in system LCC (see RE100-CAP and Section 3.2.3.4).

Note that REopt was given the option of identifying a combination of solar PV, wind turbines, wave energy devices, and BESS to achieve this 100% RE target, but only selected PV and BESS to achieve the target at lowest lifecycle cost. See Section 3.2.4 for further discussion of wave and wind energy potential and challenges on Catalina.

3.2.3.4 PV + BESS Capital Cost Sensitivity

As mentioned in sections 3.2.3.1-3.2.3.3, a PV and BESS capital cost sensitivity study was performed to evaluate the impact of capital costs on recommended systems and estimated lifecycle costs. Because the base case PV and BESS capital cost assumptions include an area cost factor (ACF) to account for the costs of transportation to and labor on Catalina Island, this sensitivity analysis assessed the implications of achieving mainland costs. PV and BESS capital costs are likely to continue to decrease over the coming years, making projects more cost effective as they are developed in phases.

Removing the ACF from PV and BESS cost assumptions has the following impacts:

- When minimizing LCC without considering any RE target (see LC-CAP), the cost-effective RE annual contribution increases from 5% to 16%. The system size is constrained by NV5-estimated distribution system upgrade costs rather than the cost of the PV/BESS systems themselves. Without considering the distribution system upgrade cost estimates provided by NV5, the estimated PV system size increases to up to 7.6 MW-DC, which could achieve an annual RE contribution of 30%.

- Overall system LCC for the 60% RE scenario (see RE60-CAP) could decrease by 9%.

- Overall system LCC for the 100% RE scenario (see RE100-CAP) could decrease by 23%.

3.2.3.5 Land Lease Cost

A sensitivity analysis on land lease costs was conducted to help inform land use planning for PV arrays.

3.2.4 Wind Turbines and Wave Energy Devices

Wind turbines and wave energy devices were considered in all the scenarios listed in Table 3 but were not found to be as lifecycle cost effective when compared to other options. These technologies and their challenges for Catalina Island are discussed below.

3.2.4.1 Wind Turbines

Wind turbines did not appear cost effective on Catalina given the assumptions used for this analysis. This is due to the relatively low capacity factor of 9.9% observed from the geospatial wind data and the high capital costs associated with distributed wind on an island with complex terrain. Wind resource data for specific possible wind turbines locations was not available but was estimated using "measure-correlate-predict" analysis.

A sensitivity on wind resource and turbine capital costs was performed to consider uncertainty in these values. The wind resource was varied across a range of profiles with average wind speeds up to 2.2x those in available data. Capital costs were reduced up to 50%. As shown in Table 4, wind may become cost-effective on Catalina with a 2.2x increase in average wind speed for the sites identified with the highest wind resource on Catalina supplemented by a 50% reduction in capital costs.

Table 4. Sensitivity to Higher Wind Resource and Lower Wind Turbine CAPEX.

Legend: × = not cost-effective; ✔ = cost-effective.

		Average Wind Speed [m/s]				
		3.52	**4.05**	**5.32**	**6.59**	**7.82**
Capital Cost Reduction	**0%**	×	×	×	×	×
	10%	×	×	×	×	×
	20%	×	×	×	×	×
	30%	×	×	×	×	×
	40%	×	×	×	×	×
	50%	×	×	×	×	✔

3.2.4.2 Wave Energy Devices

Wave energy does not appear to be lifecycle cost effective on Catalina compared to the other options evaluated and given the assumptions used for this analysis. However, wave energy is an emerging technology with less MW deployed vs. the other options considered which has several implications for this analysis and future planning.

Cost and technical assumptions used in this analysis are based on numbers provided by a wave energy vendor. These costs and performance assumptions were not able to be verified by NREL;

the costs appear lower and performance appears higher than other wave energy devices NREL has assessed. Even using the vendor's assumptions, wave power was not found to be lifecycle cost-effective compared to the other options at Catalina. Moreover, concerns have been expressed with siting the wave energy infrastructure at Catalina.

However, given its early stage of technology readiness, wave energy could potentially become feasible or even cost effective in the future, pending developments in technology and reductions in costs.

Additional due diligence and evaluation of pilot projects could reduce the risks and confirm costs and generation assumptions. Wave energy device performance is highly device-specific (the industry has not converged to a particular technology) and site-specific. If wave energy is of interest for Catalina island, a smaller pilot demonstration could be considered to de-risk the reliability concerns associated with a technology that is considerably less mature than PV.

3.2.5 Energy Efficiency (EE): Initial Example

Phase III of the techno-economic analysis can focus on the impact of demand-side factors, including load increases, load reductions, and controllable loads. However, leading into Phase III, NREL conducted an initial scenario analysis to demonstrate how demand-side considerations could impact SCE's generation strategy on Catalina. For this example of EE impacts, the electric load in each timestep was decreased by 21% to reduce it to 2017 values.

The assumed load reduction could yield $25-40M (15-25%) reductions in LCC, achieved by reducing the number of generators required to support the load and by reducing annual fuel consumption (see FF-EE). Additionally, it could reduce the PV capacity required to meet the 60% annual RE goal by 3.3 MW-DC, reducing LCC by $49M (20%) and PV footprint by 21 acres (see RE60-EE).

This high-level analysis assumes a constant percent reduction in energy consumption throughout all hours of the year and does not consider the costs of the ECMs. Actual energy efficiency measures are likely to impact the load profile in different ways, as are other demand-side factors, to be assessed in Phase III.

4 Discussion: Potential Next Steps Incorporating Load Increases, Load Reductions, and Deferrable Loads

Especially for an island energy system like Catalina, effectively managing energy loads and consumption can have a significant impact on energy generation strategies and assets, provide an opportunity to lower overall lifecycle cost, and facilitate meeting environmental protections. For example, implementation of energy conservation measures (ECMs) could reduce the amount of generation capacity needed and possibly the distribution infrastructure required as illustrated in the initial energy efficiency scenario described in section 3.2.5 above and many other actual examples from the energy efficiency and demand response industry. Additionally, controls to manage deferrable loads on the island could be resources for the island electricity system. Integration of these controllable deferrable loads could result in more optimal cost-effective generation strategies and selection of capital infrastructure. On the other hand, the potential for increasing loads from cruise ships, building and transportation electrification, can also have a significant impact on future power generation scenarios.

The techno-economic analysis described in this document is primarily focused on supply-side generation options, except for the one energy efficiency example listed above. A potential future phase III could incorporate additional techno-economic analysis to evaluate how the energy system could be optimized with consideration of both demand and supply-side considerations.

NV5 has conducted a high-level analysis on the energy efficiency (EE) and demand reduction (DR) potential on Catalina Island to assess opportunities to cost-effectively reduce load and emissions and positively influence the island's load profile. The results of this assessment completed by NV5 could be used as technical inputs for a techno-economic EE and DR model to determine the impact to the generation options. Additional utility systems data inputs from SCE and others could also be used to evaluate other load increases and deferrable loads as outlined in Table 5.

Table 5. Potential Future Load Changes for Phase III

Load Increases	Load Reductions	Deferrable Loads
• Building electrification • Electrification of vehicles • Cruise ship shore power	• Energy efficiency measures	• Demand response • Load shifting • Water desalination plant • Island-wide water pumping • Electric crane and rock crusher

Moreover, future analyses could evaluate the impacts to the generation strategies resulting from the ability to control deferrable loads (e.g. such as grid interactive hot water heaters, air conditioning, ice storage for air conditioning, water pumps, and water desalination) to determine their impact on energy generation strategies. The impact of deferrable loads on the load profile may be stacked in addition to the EE and DR impact described above.

Because SCE is also the potable water utility for Catalina island managing a system of groundwater wells and an existing and expanding desalination plant, they are in a good position to invest in operational and infrastructure improvements to enhance the efficiency of the energy and water systems. This water energy nexus scenario warrants attention and analysis to provide additional insights for SCE consideration to improve the scheduling, operation and construction of desalination, water treatment, and water distribution assets. (Another entity manages the wastewater system).

A key to improving energy generation strategies associated with water treatment and conveyance is to separate the operation of the treatment plant from the water demand that it is serving. This could be achieved by expanding the size of the treatment plant and adding storage in the form of water tanks. Storing water in tanks is very similar in concept to storing energy in batteries, except it is lossless and can be accomplished at much lower cost. Moreover, the variable nature of renewable energy can be synergistic with such dispatchable loads – water could also be treated during periods of high renewable energy production and stored for later use.

A techno-economic analysis could evaluate this water energy nexus scenario. Modeling would help identify cost-effective technologies, sizes, and operational strategies for reducing overall system ownership costs.

Future Phase III analyses could also consider the impact of generation strategies resulting from increases to the load profile. One significant impact to the load profile could be cruise ships using shore power. A second potential impact could be the development of an electric transportation (ET) (vehicle / boat) charging program. This analysis could also evaluate how an ET charging program could impact and be complimentary to the generation strategy. A third potential load increase could be from the complete removal of propane from buildings replacement with electricity. Similarly, the impact of the increases to loads on the load profile may be stacked in addition to the other load impacts described above.

In summary, a phase III techno-economic analysis and modeling of load increases, decreases, and deferrable loads could provide useful information to facilitate decisions on programs, policies, operational practices, and infrastructure investments on Catalina Island to improve to overall effectiveness and efficiency of the energy, water, buildings, and transportation systems.

5 Summary

Phases I and II of NREL's techno-economic analysis of generation and storage options for Catalina Island suggests that a mix of on-island diesel and/or propane generators, solar PV, and BESS could provide the island with cost-effective electricity in alignment with emissions standards and SCE's clean and reliable energy goals.

The results for Phases I and II of this primarily generation-side analysis can inform SCE's planning and permitting decisions for near-term regulatory compliance and can inform future decisions and/or a phased implementation of technologies. Further techno-economic analysis of the generation-side implications of demand-side considerations, including load increases, load reductions, and deferrable/controllable loads is warranted.

Glossary

Capital and replacement costs: Capital and replacement cost estimates attempt to capture the fully burdened installed cost of the system, including purchased assets, infrastructure, and installation. The Appendix and text throughout this document attempt to capture the degree of certainty/uncertainty about each individual technology's capital/replacement costs at Catalina and whether the estimates used are average, liberal, or conservative. Replacement costs are only considered for technologies with expected lives shorter than the 30-year analysis period.

Present Value of Revenue Requirement (PVRR) factor: PVRR is an SCE metric similar to NPV that incorporates the costs and value to rate payers over the project life. PVRR capital cost scaling factors were provided by SCE to account for the way rate payers pay for a project. These scaling factors are technology-specific, calculated by SCE based on assumptions about capital cost, number of years required to permit and build each technology, build year (assumed 2021), land costs (none included in this analysis since Phase II analysis assumes land is leased), incentives (i.e. ITC and MACRS depreciation), and decommissioning costs.

Area cost factor: The ACF applies to capital and non-fuel O&M costs to account for the increased costs associated with doing business on an island rather than the U.S. mainland.

Fuel costs: Fuel costs attempt to incorporate both the cost of the fuel and transport of the fuel to the island. There is still an element of uncertainty about fuel transport costs.

Non-fuel operations & maintenance (O&M) costs: Non-fuel O&M costs attempt to capture the cost of operating and maintaining the energy systems at Catalina. Note that the O&M costs included in the techno-economic analysis capture costs that scale with increased generation and storage capacity ($/kW) or production ($/kWh), as specified in the Appendix. Additional fixed O&M costs such as those to operate and maintain the electricity distribution system may exist as well but are not included.

Lifecycle costs (LCC): Lifecycle costs include the present value of capital costs, replacement costs, fuel costs, non-fuel O&M costs, and mainland electricity purchase costs as defined here and throughout the Appendix. REopt's optimization seeks to minimize the lifecycle costs of electricity at Catalina Island by identifying cost-optimal generation and storage system sizes and dispatch to achieve a given energy goal.

Appendix

This Appendix describes the techno-economic assumptions used in NREL's energy systems analysis for Catalina Island. The assumptions listed in this section were used for each scenario of Phase II except in sensitivity analyses where assumptions were varied, such as in the Lower PV and BESS CAPEX Sensitivity scenario and in the Land Lease Cost Sensitivity scenario.

A.1 General Economic Assumptions

This section describes the general economic assumptions used to evaluate the lifecycle cost of the various scenarios and configurations described in the body of the report.

Table 6. Economic Assumptions

Input	Assumption	Reference
Ownership model	Direct ownership by SCE	Per SCE
Analysis period	30 years	NREL ATB 2019[13] and to match previous SCE analysis for Catalina
Discount rate (nominal)	10%	Per SCE
Inflation rate	2.5%	NREL ATB 2019[13]

A.2 Technology Assumptions

Table 8 summarizes the technical and cost assumptions for the undersea cable, diesel, propane, and LNG generators, solar PV, wind turbines, and BESS. Wave cost and performance assumptions are not listed because they were provided to SCE by a wave energy device vendor and could not be verified by NREL.

Included in this breakout of costs are two cost multipliers, the area cost factor (ACF) and the present value of revenue requirement (PVRR) factor:

- The ACF is a multiplier applied to capital and O&M costs to account for increases in costs because of higher labor costs and transportation/shipment costs to complete capital construction projects on Catalina Island. To determine the ACF for each technology, it was assumed that on-island construction costs 2.5x mainland costs, but engineering services and materials can be purchases at mainland costs. For the undersea cable and generators, NV5 explicitly identified line items that would likely incur this 2.5x multiplier, and these costs were included in the estimate provided by NV5. For PV and wind, it was assumed that 51% of estimated mainland capital costs would incur this 2.5x multiplier, for an overall ACF of 1.765. For BESS, it was assumed that only 21% of estimated mainland costs would incur this 2.5x multiplier, for an overall ACF of 1.315.

- SCE's PVRR factors apply only to capital and replacement costs and help capture the cost of these technologies to the rate payer, considering that rate payers pay for capital expenses over a number of years rather than the year the costs are incurred to the utility. PVRR multipliers are technology-specific and calculated by SCE based on capital cost, land purchase costs (none included in PVRR factor calculation for this analysis because

Phase II analysis assumes land is leased at $200/acre rather than purchased), incentives (such as the federal Investment Tax Credit (ITC) and Modified Accelerated Cost Recovery System (MACRS) depreciation available to RE and BESS technologies), ACF, estimated build year, estimated number of years required to permit and build each technology, and, if available, estimated decommissioning costs.

Distribution system upgrade costs required to facilitate higher variable RE penetrations were estimated by SCE at $1.2M/mile. NV5 estimated how much distribution line would require upgrades to facilitate different levels of variable RE penetration, based on representative site selection, and estimated costs for new distribution line poles. These costs, listed in Table 7, were included in REopt analysis and results.

Table 7. Representative Distribution System Upgrade Cost Estimate, per NV5

Maximum PV Capacity [kW-DC]	Distance to upgrade [miles]	Estimated distribution system upgrade costs, per NV5
3.8 MW-DC	0	$0
6.2 MW-DC	4.7	$5.64M
9.5 MW-DC	8.4	$10.08M
15.6 MW-DC (60% RE annually)	9.2	$11.04M

Table 8. Summary of Techno-Economic Assumptions

		Undersea Cable	Diesel Generators	Propane Generators	LNG Generators	Solar PV	Wind Turbines	Existing BESS	New BESS
Capital costs	Before multipliers [$/W-AC, unless otherwise noted]	---	$3.294[14]	$6.920 standalone, $9.393 for all-propane[14]	$11.283[14]	$1.612/ W-DC[15]	$3.500[16]	---	$401/kWh + $688/kW[17]
	ACF	---	Included in capital cost estimate[14]			1.765	1.765	---	1.315
	PVRR factor	---	1.04[18]	1.17[19]	1.17[19]	0.93[20]	1.08[21]	---	0.87[22]
	Including multipliers [$/W-AC, unless otherwise noted]	$220M[23]	$3.426	$8.166 standalone, $10.990 for all-propane	$13.201	$2.646/ W-DC	$6.672	---	$459/kWh + $787/kW
Replacement costs	Year	---	---	---	---	---	---	Year 10[24]	Year 10[25]
	Cost before multipliers	---	---	---	---	---	---	$213/kWh + $1,700/kW[26]	$193/kWh + $332/kW[27]
	ACF	---	---	---	---	---	---	1.315	1.315
	PVRR factor	---	---	---	---	---	---	0.37[22]	0.37[22]
	Including multipliers	---	---	---	---	---	---	$104/kWh + $827/kW	$94/kWh + $162/kW
O&M costs	Before multipliers [$/kW-AC/year, unless otherwise noted]	---	$150[28]	$150[28]	$150[28]	$16/kW-DC/year[15]	$50[16]	---	---
	ACF	---	1.765	1.765	1.765	1.765	1.765	---	---
	Including multipliers [$/kW-AC/year, unless otherwise noted]	$5M[23]	$265	$265	$265	$28	$88	---	---

		Undersea Cable	Diesel Generators	Propane Generators	LNG Generators	Solar PV	Wind Turbines	Existing BESS	New BESS
Fuel, performance, & emissions	Fuel cost [$/MMBTU, unless otherwise noted]	Average of $40.97/MWh electricity[29]	$18.93[30]	$17.35[30]	$16.93[31]	---	---	---	---
	Heat rate [BTU/kWh]	---	8,854[14]-9,726[32]	9,688[14]	8,645[14]	---	---	---	---
	Fuel cost escalation rate[33] [%/year]	2.76%	3.00%	3.35%	3.69%	---	---	---	---
	Capacity factor for RE resource [%]	---	---	---	---	21.7%[34]	9.9%[35]	---	---
	BESS round-trip efficiency	---	---	---	---	---	---	70%[24]	89.9%[25]
	NOx emissions [gm/HP-hr]	Varies	0.46[14]-0.66[32]	0.10[14]	0.024[14]	---	---	---	---
Land	Installed capacity density	---	---	---	---	9.1 acres/MW-DC[36]	30 acres/MW-AC[37]	---	---
	Land lease cost[38] [$/acre/year]	---	---	---	---	$200	---	---	---
General/Other		---	1.49, 2.23, & 2.98 MW units;[14] Minimum load: 50%[14]-80%[32] of rated capacity	1.38 MW units;[14] Minimum load: 50%[14] of rated capacity	2.5 MW units;[14] Minimum load: 50%[14] of rated capacity	Tilt: latitude (33.4°); Azimuth: South-facing; DC-to-AC ratio: 1.2; Inverter efficiency: 96%; Annual degradation: 0.5%/year	100-275 kW turbines	1 MW, 7.2 MWh NaS;[24] Minimum state of charge: 10%[24]	Li-ion;[39] Minimum state of charge: 20%[25]

A.3 Reliability Requirements

System capacity-based and operational reliability requirements were included in the modeling.

For the capacity-based requirement the model required an N+2 redundancy. To satisfy this requirement, at peak load, if the two largest generators are off-line the remaining generators must be able to carry the peak load. The model conservatively only considers fossil fuel generation capacity towards this required redundancy; RE and BESS were not considered to support N+2 capacity requirements because they are not always available to provide coverage (PV and wind power are dependent on solar or wind resource and a battery at low state of charge may not be able to sustain a load). Nonetheless, RE and BESS could provide additional redundancy to the system.

For the operational reliability requirement of spinning reserve, the analysis required that in each hourly timestep, the spinning reserve be greater than or equal to the sum of the following:

- 10% of the load in the current timestep
- 80% of solar PV output in the current timestep
- 50% of wind output in the current timestep

This spinning reserve could be provided by any of the following:

- Unused capacity of online (operational) fossil fuel generators
- Battery storage, up to the minimum power the BESS could provide for the hour timestep
- A percentage of PV and wind generation that is being curtailed or sent to battery storage (20% for solar PV, 50% for wind)

A.4 Fuel Shipments and Associated Emissions

Current Emissions from Fuel Shipments

SCE currently consumes approximately 2.03M gallons of diesel fuel and 150k gallons of propane to fuel Catalina's electricity generation with diesel reciprocating generators and propane microturbines, respectively. (Per SCE, the microturbines will not be replaced when they reach the end of life in the next several years. Currently, microturbines only consume ~20% of propane delivered to Catalina; the rest is distributed to facilities in the Avalon area.)

SCE imports diesel and propane for energy generation on Catalina Island from a mainland port in Long Beach, CA. Annual shipments in 2017 included 89 propane tankers (9,000 gal/tanker), 282 diesel tankers (7,200 gal/tanker). The fuel is shipped to the island along with other goods (ship fuel, groceries, construction materials, other cargo) by Avalon Freight Services using one of two vessels: the Catalina Provider (primary ship) or the Lucy Franco [40, 41]. Fuel comprises approximately 55% of each shipload by weight[42]. Both vessels run on marine diesel oil (MDO)[43].

Based on the energy intensity and emissions assumptions listed in Table 1, annual NOx and carbon dioxide (CO_2) emissions associated with fuel shipments to Catalina are estimated at 21 tons NOx/year and 569 tons CO_2/year [44, 45, 46].

Table 9. Vessel and Emissions Data for Fuel Shipments to Catalina Island

Vessel	Catalina Provider	Lucy Franco	
Engines	3 C18 tier 3 engines	2 C-32 tier 3 engines	
Horsepower	1800	1200	
Boat Weight	192,000 lbs (96.0 tons)	194,000 lbs (97.0 tons)	
Trips/Year (estimated)	200	60	
MDO Used Per Round Trip	350 (440-660 at max hp)	350 (440-660 at max hp)	
NOx emissions rate (lbs NOx/gal MDO)	0.4655	0.4655	
CO_2 emissions rate (lbs CO_2/gal MDO)	22.747	22.747	**TOTAL:**
Annual NOx emissions (tons)	**16**	**5**	**21**
Annual CO_2 emissions (tons)	**438**	**131**	**569**

Assumptions: 7.8 tankers shipped per week (1.6 tankers/trip, 342,000 lbs/week), four tankers max per vessel, five trips per week, MDO density 0.9 kg/L; MDO heat content: 18,358 BTU/lb,55% of cargo weight is fuel, thus 55% of ship emissions attributed to fuel shipments [47,48,49]. Fuel shipment analysis focuses on delivering equal heat content to the island but does not consider differences in generator efficiency.

Fuel Switching Impact on Emissions from Fuel Shipments

Because propane generators produce lower emissions than diesel generators, switching Catalina's generators to run on propane fuel could yield direct emissions reductions, including, as discussed in the main text, NOx savings amounting to ~19 tons per year. An analysis of the additional indirect emissions impacts of fuel switching includes consideration of emissions from transporting fuel to the island.

To fully replace diesel generation with propane generation, Catalina would need approximately 13 million lbs of propane, or 344 tankers per year in addition to the 89 propane tankers currently shipped (433 total, an increase of 63 tankers per year). Fuel shipping charges are applied primarily by weight, costing approximately $0.052/lb.[50] Because propane has a higher heat content by weight, 1,406,000 fewer pounds would need to be shipped, which could save SCE approximately $73k/year while reducing emissions from fuel shipments by 1.6 tons of NOx and 45 tons of CO_2 annually.[51, 52, 53]

However, because a higher number of propane tankers than diesel tankers would need to be shipped, possibly necessitating more trips to and from Catalina. Assuming the 2 freight vessels currently operate at capacity, it will take approximately 16 additional trips to ship the additional 63 tankers of propane needed.[54] This represents an increase of 1.3 tons NOx/year and 64 tons CO_2/year.[55, 56, 57]

Table 10. Summary of Results from Fuel Switching Shipment Analysis

Current Shipments	371 tankers shipped per year
Current Emissions	21 tons NOx/year
Switching to Propane - Cost	$73k shipping savings
Switching to Propane - Tankers	63 more tankers to ship
Switching to Propane - Emissions	NOx: -1.6 to +1.3 tons/year change CO_2: -45 to +64 tons/year change

Assumptions: 1 diesel tanker holds 7200 gal, 1 propane tanker holds 9000 gal. Densities: Diesel 7.1 lbs/gal. Propane 4.2 lbs/gal. Fuel heat contents: Diesel: 13,900 BTU/gal, 19,553 BTU/lb; Propane: 91,000 BTU/gal, 21,667 BTU/lb[58]

References

[1] https://www.catalinachamber.com/
[2] Map of distribution system provide by NV5.
[3] http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1135.pdf
[4] https://www.edison.com/content/dam/eix/documents/our-perspective/g17-pathway-to-2030-white-paper.pdf
[5] https://www.nrel.gov/docs/fy17osti/70022.pdf
[6] https://reopt.nrel.gov/
[7] Unless otherwise noted, all scenarios assume the existing exempt 2.8 MW diesel generator (Unit 15) and 1 MW, 7.2 MWh NaS BESS are available for use.
[8] Annual NOx emissions listed only account for those emitted during generator operations; they do not include NOx emissions associated with fuel shipments.
[9] CAPEX listed includes upfront capital costs of generation and storage technologies, capital costs for distribution system upgrade costs as estimated by NV5, and capital costs of BESS replacement
[10] Undersea cable and 100% RE scenarios list diesel generators; these generators are included to satisfy N+2 redundancy requirements but only operate as backup.
[11] Additional fuel shipping costs and infrastructure upgrades may be required for LNG; additional feasibility analysis is recommended to refine cost assumptions. LNG infrastructure cost estimates are assumed greater than or equal to propane infrastructure cost estimates.
[12] Additional integration costs are likely for 100% RE scenario.
[13] NREL Annual Technology Baseline (ATB) 2019. https://atb.nrel.gov/
[14] Standardized assumptions based on NV5 study of generator options for Catalina; actual generator capital costs will likely vary based on generator type, capacity, and configuration, as discussed in Section 3.
[15] NREL Annual Technology Baseline (ATB) 2019. https://atb.nrel.gov/
[16] Distributed wind energy cost estimate provided by NREL wind expert.
[17] Wood Mackenzie U.S. Energy Storage Monitor 2019. https://www.woodmac.com/research/products/power-and-renewables/
[18] Provided by SCE; assumes 10/30/30/30 spend in 2020-2023, commercial operation date (COD) 2021-2023
[19] Provided by SCE; assumes 50/50 spend in 2020-2021, COD 2021
[20] Provided by SCE; assumes COD of 2021
[21] Provided by SCE; assumes 50/50 spend in 2020-2021, COD 2021
[22] Provided by SCE; assumes battery is connected to PV installations for tax purposes, COD 2021 with replacement COD 2031
[23] NV5 rough order of magnitude (ROM) cost estimate for undersea cable.
[24] Per SCE, the existing 1 MW, 7.2 MWh NaS BESS has a projected life of 20 years, of which it is currently in year 8; thus it is projected to require replacement circa year 10 of the analysis period. Per SCE, the overall round-trip efficiency is ~70% and it operates with a minimum state of charge of 10%.
[25] https://www.sciencedirect.com/science/article/pii/S2352152X15300335
[26] 2030 NaS BESS replacement costs estimated at 85% of 2019 costs. https://www.sciencedirect.com/topics/engineering/sodium-sulfur-battery
[27] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017.pdf
[28] Capacity-based O&M costs (e.g. $/kW) were estimated as 60% of total recorded O&M costs, in line with numbers NREL has seen elsewhere.
[29] Mainland generation was modeled at California Independent System Operator (CAISO) day-ahead locational marginal pricing for Huntington Beach Substation (08/21/2018-08/20/2019); average of $40.97/MWh, maximum of $255.82/MWh. http://www.caiso.com/PriceMap/Pages/default.aspx
[30] Diesel and propane fuel costs were calculated from SCE 2017 average fuel prices for Catalina Island, including the cost of transportation.
[31] LNG fuel costs were estimated assuming a 60% premium on city gate price (per NV5) of natural gas for CA per the EIA, plus $0.076/lb per historic fuel transport costs to Catalina (estimated by NREL).
[32] The fuel curve and NOx emissions for the existing diesel generator Unit 15 that is exempt from SCAQMD emissions requirements were obtained from SCE historical operational data.
[33] Calculated from EIA Annual Energy Outlook for Pacific region (commercial, 2020-2050). https://www.eia.gov/outlooks/aeo/data/browser/

[34] Hourly solar resource is modeled from a typical meteorological year (TMY2) weather file from the National Solar Radiation Database (NSRDB), for Long Beach, CA. https://nsrdb.nrel.gov/

[35] NREL's Wind Study for Catalina Island overlaid observational interval data from the Catalina Island Airport, the National Aeronautics and Space Administration's (NASA's) Modern-Era Retrospective analysis for Research and Applications (MERRA) dataset, and the NREL Wind Integration National Database (WIND) Toolkit. This techno-economic analysis utilized the resource data for the strongest sites identified at 55m hub height.

NASA's MERRA dataset: https://gmao.gsfc.nasa.gov/reanalysis/MERRA/

NREL's WIND Toolkit: https://www.nrel.gov/grid/wind-toolkit.html

[36] NREL Solar Land Use Study. https://www.nrel.gov/docs/fy13osti/56290.pdf

[37] https://www.nrel.gov/analysis/tech-size.html

[38] SCE provided a cost estimate on market value of land on Catalina. This cost was applied to solar PV because PV has a relatively defined land use requirement. However, land requirements for wind are less certain because direct vs. indirect land access requirements depend on local topography and wind turbine configuration, so land lease costs were not included in the wind cost assumptions. Land requirements for BESS were also not included and may vary with configuration (e.g. distributed vs. centralized BESS), but would likely be necessary.

[39] A Li-ion battery was modeled for the new BESS, but SCE may consider other battery chemistries as well. Per Wood Mackenzie U.S. Energy Storage Monitor 2019[17], Li-ion batteries currently make up >99% of the battery storage market.

[40] Valdez, Abelino, interview by James Elsworth. 2020. *Conversation* (1 15).

[41] USCG. 2020. *United States Coast Guart Merchant Vessels of the United States.* Accessed 2 2020. https://www.dco.uscg.mil/Our-Organization/Assistant-Commandant-for-Prevention-Policy-CG-5P/Inspections-Compliance-CG-5PC-/Office-of-Investigations-Casualty-Analysis/Merchant-Vessels-of-the-United-States/

[42] SCE. 2017. *Fuel Shipment Cost Data Provided*

[43] Valdez, Abelino, interview by James Elsworth. 2020. *Conversation* (1 15).

[44] Winnes, Hulda and Erik Fridell. 2012. "Particle Emissions from Ships: Dependence on Fuel." *Journal of the Air & Waste Management Association* 1391-1398. https://www.tandfonline.com/doi/pdf/10.3155/1047-3289.59.12.1391

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[47] SCE. 2017. Fuel Shipment Cost Data Provided.

[48] Valdez, Abelino, interview by James Elsworth. 2020. *Conversation* (1 15).

[49] Mardesich, Anthony, interview by James Elsworth. 2020. (1 30).

[50] SCE. 2017. Fuel Shipment Cost Data Provided

[51] Olmer, Naya, Bryan Comer, Biswajoy Roy, Xiaoli Mao, and Dan Rutherford. 2017. *Greenhouse Gas Emissions From Global Shipping, 2013-2015.* Washington, DC: The International Council on Clean Transportation

[52] Winnes, Hulda and Erik Fridell. 2012. "Particle Emissions from Ships: Dependence on Fuel." *Journal of the Air & Waste Management Association* 1391-1398. https://www.tandfonline.com/doi/pdf/10.3155/1047-3289.59.12.1391

[53] CarbonTracking.com. 2008. "A study of the carbon footprint of cartransport with Irish Ferries." http://www.carbontracking.com/reports/irish_ferries_emissions_calculation.pdf

[54] Valdez, Abelino, interview by James Elsworth. 2020. *Conversation* (1 15).

[55] Olmer, Naya, Bryan Comer, Biswajoy Roy, Xiaoli Mao, and Dan Rutherford. 2017. *Greenhouse Gas Emissions From Global Shipping, 2013-2015.* Washington, DC: The International Council on Clean Transportation

[56] Winnes, Hulda and Erik Fridell. 2012. "Particle Emissions from Ships: Dependence on Fuel." *Journal of the Air & Waste Management Association* 1391-1398. https://www.tandfonline.com/doi/pdf/10.3155/1047-3289.59.12.1391

[57] CarbonTracking.com. 2008. "A study of the carbon footprint of cartransport with Irish Ferries." http://www.carbontracking.com/reports/irish_ferries_emissions_calculation.pdf

[58] Valdez, Abelino, interview by James Elsworth. 2020. *Conversation* (1 15).

APPENDIX K – DOMESTIC (RESIDENTIAL) ESTIMATES

Existing Electric Domestic customers (No Gas)	Market rate	LMI	TOTAL	Avg annual use (kWh) per home	Avg annual use (kWh) for all homes	Annual EE savings (kWh) per home*	Annual EE savings (kWh) for all homes*	EE % reduction from baseline per home	Full EE package cost ($) per home	EE package cost ($) for all homes*	First Year Gross EE package $/kWh per home and for all homes per year*	Life Cycle Gross EE package $/kWh per home and for all homes*	Total cost for each home size class ($)*
up to 1500 Sq Ft	300	8	**308**	3950	1216600	990	304920	25%	3859	416000	1.36	0.14	1,659,799
1500 - 2500 Sq Ft	58	8	**66**	6991	461406	1165	76890	17%	5618	129776	1.69	0.17	778,766
>2500	42	12	**54**	4677	252558	1302	70308	28%	7423	140295	2.00	0.20	503,962
Unknown (avg #)	46	45	**91**	5205	473655	1152	104832	22%	5633	179411	1.71	0.17	810,620
TOTAL	*446*	*171*	***617***	*20823*	2404219	*4609*	*556950*	*23%*	*22533*	*865482*	*1.29*	*0.13*	3,753,147
*Savings projected at 35% of potential maximum implementation of all ECMs in all homes								(average)↑			(weighted averag	(weighted average)↑	

Existing Mixed Fuel Domestic customers (Electric + Gas)	Market rate	LMI	TOTAL	Avg annual use (kWh) per home	Avg annual use (kWh) for all homes	Annual EE savings (kWh) per home*	Annual EE savings (kWh) for all homes*	EE % reduction from baseline per home	Full EE package cost ($) per home	EE package cost ($) for all homes*	First Year Gross EE package $/kWh per home and for all homes per year*	Life Cycle Gross EE package $/kWh per home and for all homes*	Total cost for each home size class ($)*
up to 1500 Sq Ft	427	34	**461**	3327	1533747	213	98193	6%	340	54859	0.56	0.06	856,882
1500 - 2500 Sq Ft	248	27	**275**	3922	1078550	297	81675	8%	451	43409	0.53	0.05	573,229
>2500	216	70	**286**	3762	1075932	324	92664	9%	602	60260	0.65	0.07	699,688
Unknown (avg #)	108	43	**151**	3670	554170	278	41978	8%	465	24575	0.59	0.06	324,429
TOTAL	*1008*	*174*	***1182***	*14681*	*4242399*	*1112*	*314510*	*8%*	*1858*	*183103*	*0.57*	*0.06*	2,454,228
*Savings projected at 35% of potential maximum implementation of all ECMs in all homes								(average)↑			(weighted averag	(weighted average)↑	

APPENDIX L – WATER SYSTEMS ESTIMATES

FACILITY	ACC'T #	EQUIPMENT	PUMP Ref #	Pump Motor HP	Tariff ($/KWH)	SCE actual ($/KWH)	Annual avg kWh	Annual avg $	Annual EE pot'l (KWH)	EE Implementation Cost ($)	First Year Gross $/kWh	Lifecycle gross $/kWh	New annual kWh	Annual % saved	Annual $ saved	SCE actual $ saved
Potable Water System																
Middle Ranch Wells (GroundWater)	003-6404-80	Thomson Dam Well: Well 1A	33956	50	$ 0.37	$ 0.40	33,870	$ 13,413	5,457	$ 10,000	$ 1.83	$ 0.18	28,413	16%	$ 2,019	2,161
	003-6404-80	Thomson Dam Well: Well 6A	33954	50	$ 0.37	$ 0.40	33,870	$ 13,413	5,939	$ 10,000	$ 1.68	$ 0.17	27,931	18%	$ 2,198	2,352
Pebbly Beach	022-5216-63	Potable Water Pump 1	28472	20	$ 0.22	$ 0.40	43,056	$ 17,050	6,458	$ 4,000	$ 0.62	$ 0.06	36,598	15%	$ 1,421	2,558
Generation Station (Desalination)	022-5216-63	Potable Water Pump 2	28473	20	$ 0.22	$ 0.40	42,504	$ 16,832	6,376	$ 4,000	$ 0.63	$ 0.06	36,128	15%	$ 1,403	2,525
SweetWater Well	009-5297-56	SweetWater Well Pump	1404	5	$ 0.16	$ 0.40	32,448	$ 12,849	9,213	$ 1,000	$ 0.11	$ 0.01	23,235	28%	$ 1,474	3,648
Cottonwood Well 2A	033-6402-13	Cottonwood Well 2A Pump	1420	3	$ 0.20	$ 0.40	23,352	$ 9,247	3,503	$ 600	$ 0.17	$ 0.02	19,849	15%	$ 701	1,387
Howlands Landing	3416-076244	Howlands Well	1429	15	$ 0.01	$ 0.40	21,144	$ 8,373	3,172	$ 3,000	$ 0.95	$ 0.09	17,972	15%	$ 32	1,256
Whites Landing	3416-076338	Whites Landing Well	1480	7.5	$ 0.26	$ 0.40	10,044	$ 3,977	1,715	$ 1,500	$ 0.87	$ 0.09	8,329	17%	$ 446	679
Toyon Well	000-9781-13	Toyon Well	28474	5	$ 0.22	$ 0.40	12,332	$ 4,883	3,289	$ 1,000	$ 0.30	$ 0.03	9,043	27%	$ 716	1,302
Two Pump Station	003-6402-14	Pump Station 2 Pump#3	28496	50	$ 0.23	$ 0.40	29,436	$ 11,657	4,415	$ 10,000	$ 2.26	$ 0.23	25,021	15%	$ 1,016	1,748
Two Pump Station	003-6402-14	Pump Station 2 Pump#4	28470	50	$ 0.23	$ 0.40	29,844	$ 11,818	4,477	$ 10,000	$ 2.23	$ 0.22	25,367	15%	$ 1,030	1,773
Two Pump Station	003-6402-14	Pump Station 2 Pump#5	28471	50	$ 0.23	$ 0.40	29,845	$ 11,819	4,477	$ 10,000	$ 2.23	$ 0.22	25,368	15%	$ 1,030	1,773
Desalination Plant	3729864	Reverse Osmosis, Pumps			$ 0.22	$ 0.40	730,922	$ 289,445	73,092	$ 181,269	$ 2.48	$ 0.25	657,830	10%	$ 16,080	28,945
Waste Water System																
Catherine Lift Station (CLS)	035-8985-00	Flygt centrifugal pump (model 3153) - Catherine	35544	18	$ 0.17	$ 0.40	18,168	$ 7,195	4,142	$ 3,600	$ 0.87	$ 0.09	14,026	23%	$ 703	1,640
	035-8985-00	Flygt centrifugal pump (model 3153) - Catherine	35545	18	$ 0.17	$ 0.40	13,776	$ 5,455	8,789	$ 3,600	$ 0.41	$ 0.04	4,987	64%	$ 1,493	3,480
Pebbly Beach Lift Station (PBLS)		Flygt centrifugal pump (model 3171) - PBLS BST 1														
	035-8985-88	Flygt centrifugal pump (model 3171) - PBLS BST	35542	25	$ 0.17	$ 0.40	54,300	$ 21,503	30,842	$ 17,500	$ 0.57	$ 0.06	23,458	57%	$ 5,190	12,213
	035-8985-88	Flygt centrifugal pump (model 3171) - PBLS BST	35543	25											$ -	
WWTF	na	na	na	na	$ 0.17	$ 0.40	479,865	$ 190,027	186,306	$ 314,803	$ 1.69	$ 0.17	293,559	39%	$ 31,672	73,777
Salt Water System																
Catherine Booster Station	035-8985-00	Main Salt Water Pump #1	35546	100	$ 0.17	$ 0.40	33,696	$ 13,344	13,960	$ 20,000	$ 1.43	$ 0.14	19,736	41%	$ 2,371	5,528
	035-8985-00	Main Salt Water Pump #2	35547	100	$ 0.17	$ 0.40	33,324	$ 13,196	13,472	$ 20,000	$ 1.48	$ 0.15	19,852	40%	$ 2,288	5,335
Hill Street Booster Station		7.5 HP Centrifugal Pump		7.5	$ 0.20	$ 0.40	7,000	$ 2,772	1,050	$ 1,500	$ 1.43	$ 0.14	5,950	15%	$ 210	416
Whittley Booster Station		7.5 HP Centrifugal Pump		7.5	$ 0.20	$ 0.40	7,000	$ 2,772	1,050	$ 1,500	$ 1.43	$ 0.14	5,950	15%	$ 212	416

APPENDIX M – RECEIVED ITEMS LOG

Catalina Island - Received Items Tracking Log

Project Number: 226818-0000432.00
Internal Project Manager: Brian Roppe

No	Item Name	Date Received	Sharepoint Parent Folder	Discpline	Description	Uploaded By	Comments
1	Catalina Feasibility Study Presentation	3/1/2019	Project Management	General	SCE presenation pdf presented during kickoff	Matthew Zents	
2	Link Weather Station Data	3/1/2019	Project Management	General	Email from Matt contating link to weather data	Matthew Zents	
3	NREL SOW Proposal	3/1/2019	Project Management	General	NREL's scope of work	Matthew Zents	Overlaps with our renewable SOW
4	Feasibility Study Reference Dwgs	3/1/2019	Eng	Tier 4	Genaration foundation and enclosure dwgs at Pebbly	Corrine Gentry	
5	Undersea Cable	3/13/2019	Reg-Env-Legal	Underwater	2004, 2005 studies	Tracey Alsobrook	
6	FINAL_Avalon_RW_Study_06.21.16	3/13/2019	Reg-Env-Legal			Tracey Alsobrook	
7	RFI 02	3/19/2019	Eng	Genral	Station layouts for hunington beach and PBGS	Corrine Gentry	
8	Sample Undersea Fiber Optic Projects	3/19/2019	Reg-Env-Legal	Underwater	Sample Fibre optic	Tracey Alsobrook	
9	Catalina Map Package	3/19/2019	Reg-Env-Legal			Tracey Alsobrook	
10	2030 EIR4 Genral Plan Adopted	3/20/2019	Reg-Env-Legal			Tracey Alsobrook	
11	Avalon_2030_General_Plan_Local_Coastal_Plan_Final.pdf-	3/20/2019	Reg-Env-Legal			Tracey Alsobrook	
12	Load Info (Future & Historical Load)	3/21/2019	Eng	Genral		Molham Kayali	
13	Underwater Cable	3/21/2019	Eng	Underwater	Summary of cble project, ppt, permitting	Molham Kayali	
14	Diesel Units	3/21/2019	-	Tier 4		Matthew Zents	Sent to Tom S via email. Stored in discpline folder
15	Circuit Maps	3/26/2019	Eng	Renewable	circuit maps for Avalon, HI line, Interior & wrigley	Matthew Zents	
16	Facility Information Maps (FIM)	3/26/2019	Eng	General	Facility inofrmation (structures etc)	Matthew Zents	
17	Drawings: PDF For Review	3/28/2019	Eng	General	Huntington; one lines, and PBGS; microtuirbines, Onle line	Corrine Gentry	
18	Fugro Catalina Submarine Cable Project Route Surveys.	3/29/2019	Reg-Env-Legal	Underwater	cable route survey	Tracey Alsobrook	
19	Sample Undersea Fiber Optic Projects	3/29/2019	Reg-Env-Legal	Underwater	most recent undersea power cable project in southern California.	Tracey Alsobrook	
20	Senate Bill 100	4/2/2019	Reg-Env-Legal	General	This bill would state that it is the policy of the state that eligible renewable energy resources and zero-carbon resources supply 100% of retail sales of electricity to California end-use customers and 100% of electricity procured to serve all state agencies by December 31, 2045.	Matthew Zents	
21	Solar Pilot Project	4/4/2019	Project Management	General		Matthew Zents	
22	RFI 01, 03, 04	4/5/2019	Eng	General	Initial Responses	Matthew Zents	
23	Charts	4/6/2019	Reg-Env-Legal	General		Luis R Lopez	
24	TGP-101050-DTS-01-00	4/6/2019	Reg-Env-Legal	Underwater	Thales desktop study for a proposed submarine power cable	Luis R Lopez	
25	Presentatio Template	4/12/2019	Project Management	General		Matthew Zents	
26	RFI 03	4/16/2019	Eng	Tier 4	Updated respose	Matthew Zents	
27	CatalinaMarineData.gdb	4/17/2019	Reg-Env-Legal	General	bathymetry, fish migrating ranges, dive sites, sensitive marine habitats, etc.	Tracey Alsobrook	
28		5/2/2019	Reg-Env-Legal	Underwater	map prepared by the Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement (BSEE) that shows existing offshore oil platforms and oil pipelines	Tracey Alsobrook	
29	DCS Historical Data	5/3/2019	Eng			Matthew Zents	
30	Floating Solar Study	5/3/2019	Eng			Molham Kayali	
31	RFI 05 & 06	5/8/2019	Eng	Genral	Initial Responses. RFI 06 comes with a dwgs list	Matthew Zents	
32	NREL RFI 01	5/8/2019	Eng	Genral	NREL RFI 01	Matthew Zents	
33	Substation Drawings	5/13/2019	Eng	General	Dwgs for Hamilton, Lafayette, Wave	Corrine Gentry	
34	USC Solar	5/13/2019	Eng	General	Onyx Renewable Partners	Matthew Zents	
35	BOEM	5/13/2019	Project Management	General	Bureau of Ocean Energy Management	Matthew Zents	
36	Usage for 90704	5/21/2019	Eng	Genral	New load info	Molham Kayali	
37	Presenation slides	5/24/2019	Eng	Genral	Presenation docs	Molham Kayali	
38	Stakeholder Presenation	6/5/2019	Eng	General	Stakeholder Presentation edits	Molham Kayali	
39	Pipeline & Hazardous Materials Safety Admin	6/7/2019	0	Underwater		Molham Kayali	
40	Propoane Gen	6/7/2019	Eng	General		Molham Kayali	
41	PBGS Emission	6/7/2019	Eng	Renewable		Molham Kayali	
42	Load Info - Solar	6/7/2019	Eng	Renewable		Molham Kayali	
43	Added info on RFI 05	6/11/2019	Eng	Renewable		Molham Kayali	
44	Outages	6/21/2019	Eng	Renewable		Molham Kayali	
45	2.4KV Ref Dwgs	6/24/2018	Eng	Renewable		Corrine Gentry	
46	CYME Model	6/25/2019	Eng	Renewable		Molham Kayali	
47	SCAQMD	6/28/2019	Eng	General	rule 1135 and 1110.2 applies to Catalina island to control NOx, CO and VCOs.	Molham Kayali	
48	Wave Energy	7/9/2019	Eng	Wave Power	Locations and enrgy reports	Molham Kayali	
49	CYME reports	7/24/2019	Eng	Renewable		Molham Kayali	
50	Catalina Emissions - Historic	7/24/2019	Eng	Tier 4		Molham Kayali	
51	AES Hunington Beach dwgs	8/24/2019	Eng	Underwater		Matthew Zents	
52	E3 Residential Building Electrification in California April 2019	10/29/2019	Eng	General		Molham Kayali	

APPENDIX N – ADDITIONAL PERMITTING INFORMATION

LAND USE REGULATIONS; LOCAL, STATE, AND FEDERAL

LOCAL REQUIREMENTS

Local land use planning ordinances and permits will be primarily the responsibility of the County of Los Angeles with exception of the proposed submarine cable landing location in the City of Huntington Beach in Orange County and alternatives within the City of Avalon. In nearly all cases CEQA authority over the project will likely be deferred to the County of Los Angeles (Table 1).

Table 1

Land Owner	Local Jurisdiction	Land Use Designation	Zoning Designation	Required Local Actions
Catalina Island Land Company Lands at Two Harbors	**County of Los Angeles**	**Two Harbors Resort Village District (RESORT)[1]**	**Two Harbors Resort Village District (RESORT)[1]**	**GPA, Zone Change, CUP or MCUP, and CDP**
University of California	**County of Los Angeles**	**Utility and Industrial District (U/I)[1]**	**Utility and Industrial District (U/I)[1]**	**GPA, Zone Change, CUP or MCUP, and CDP**
Santa Catalina Conservancy	**County of Los Angeles**	**Open Space/Conservation District (OS/C)[1]**	**Open Space/Conservation District (OS/C)[1]**	**GPA, Zone Change, CUP or MCUP, and CDP**
El Rancho Escondido LLC	**County of Los Angeles**	**Open Space/Conservation District (OS/C)[1]**	**Open Space/Conservation District (OS/C)[1]**	**GPA, Zone Change, CUP or MCUP, and CDP**
Distribution Line	**County of Los Angeles**	**Open Space/Conservation District (OS/C)[1]**	**Open Space/Conservation District (OS/C)[1]**	**CUP**

[1] Per the Santa Catalina Island Specific Plan (County of Los Angeles 1989)

Table 1 - Overview of Local Jurisdiction and Land Use Designations for Key Landowner Parcels

The unincorporated area of Santa Catalina Island falls under a specific plan, which designates land use districts for the unincorporated area of the island. These land use districts serve the same role as zones but supersede the basic zones in Title 22 of the Los Angeles County Code. This has been in effect since the adoption of the Santa Catalina Island Specific Plan, which is a component of the Santa Catalina Island LCP, in 1989. The Santa Catalina Island Specific Plan is located in Los Angeles County Code Sections 22.46.050 through 22.46.750. The four sites are zoned as Open Space/Conservation District (OS/C), Two Harbors Resort Village District (RESORT), or Utility and Industrial District (U/I). The Project is a permitted use within the Utility and Industrial District; however, the Project is not a permitted use within the Open Space/Conservation District and the Two Harbors Resort Village District. In addition, ground-mounted utility-scale solar energy facilities like the Project, are allowed in Zones A-2, C-H, C-1, C-2, C-3, C-M, C-R, C-MJ, C-RU, M-1, M-1.5, M-2, M-4, R-1, R-R, MXD-RU, MXD, and IT, but will require a Conditional Use Permit (CUP) or a Minor Conditional Use Permit (MCUP) (Los Angeles County Code Section 22.140.510[E]).

The Santa Catalina Island Local Coastal Plan (CLCP) was established in 1983 to ensure that majority of Catalina Island remains in its natural state and to comply with the California Coastal Act of 1976 and to recognize and respond to the goals of the Open Space Easement Agreement between County of Los Angeles and the Santa Catalina Island Company. Policies established under the CLCP include:

- Preserve the designated conservation/primitive recreation area in a substantially undisturbed natural condition.
- Minimize impacts or alterations to the topography, vegetation, natural resources, historical and cultural sites, and natural character of the island.
- Improve habitat areas, protect viewsheds, and focus new development in non-sensitive areas.
- Limit new development in scope and carefully design it to be compatible with the unique character of the island.
- Relate new development to the natural character of the island by limiting building heights (except for selected architectural accents approved through design review), specifying types of building materials and sensitively reviewing designs and landscaping materials.
- Mitigate environmental impacts by channeling development into already developed and/or publicly used areas; minimize grading (cut and fill) operations; avoiding steep slopes, tsunami run-up areas, archaeological sites, landslide areas, and view corridors; and by ensuring the provisions of sufficient water resources and solid and liquid waste facilities prior to development approvals.

Under Section 30240(b) of the Coastal Act, environmentally sensitive habitat areas (ESHA) shall be protected against any significant disruption of habitat values, and only uses dependent on such resources shall be allowed within such areas.

Under Section 30240(d) of the Coastal Act, development in areas adjacent to ESHA and parks and recreational areas shall be sited and designed to prevent impacts which would significantly degrade such areas and shall be compatible with the continuance of such habitat areas.

Under Section 30244 of the Coastal Act, where development would adversely impact archaeological or paleontological resources, as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.

Under Section 30251 of the Coastal Act, the scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas. New development in highly scenic areas such as those designated in the California Coastal Preservation and Recreation Plan prepared by the Department of Parks and Recreation and by local government shall be subordinate to the character of its setting.

Under Section 30233(a) of the Coastal Act, the disking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of the Coastal Act, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects.

Under Section 30233(b) of the Coastal Act, dredging and spoils disposal shall be planned and carried out to avoid significant disruption to marine and wildlife habitats and water circulation. Dredge spoils suitable for beach replenishment should be transported for such purposes to appropriate beaches or into suitable longshore current systems.

Under Section 30233(c) of the Coastal Act, in addition to the other provisions of Section 30233, disking, filling, or dredging in existing estuaries and wetlands shall maintain or enhance the functional capacity of the wetland or estuary.

The Significant Ecological Area (SEA) Program is a component of the Los Angeles County Conservation/Open Space Element. This program is a resource identification tool that indicates the existence of important biological resources. SEAs are not preserves but are areas where the county deems it important to facilitate a balance between limited development and resource conservation. Limited development activities are reviewed closely in these areas where site design is a key element in conserving fragile resources such as streams, oak woodlands and threatened or endangered species and their habitat.

As currently zoned/designated, none of the sites permit ground-mounted utility scale facilities. All the sites will require zone changes and a General Plan amendment to allow for the Project. The distribution line can be permitted under a CUP, per Section 22.46.150 of the Los Angeles County Code.

STATE REQUIREMENTS

The proposed alternatives all occur within the State of California (State) and/or within the coastal zone, state tidelands, and/or Waters of the State. Considering the relative sensitivity of the resources and natural setting of the majority of the site alternatives, project permitting will potentially require approvals and/or consultations through some or all the following State agencies:

- California Coastal Commission (CCC)
- California State Lands Commission (CSLC)
- Los Angeles Regional Water Quality Control Board (LARWQCB)
- State Historic Preservation Officer (SHPO)
- California Department of Fish and Wildlife (CDFW)
- California Public Utilities Commission (CPUC)

Sites and project alternatives subject to permitting through each of these agencies are summarized in Table 2. Applicability depends on where the sites are located (marine or terrestrial), presence of sensitive resources, and jurisdiction. For instance, the CSLC has jurisdiction over the tidelands and submerged lands within the 3-mile state limit; thus, some alternatives may require the leasing of such lands.

FEDERAL REQUIREMENTS

The proposed energy generation and supply alternatives with the potential to impact federal lands or federally protected species will potentially require permitting through applicable federal agencies such as:

- United States (U.S.) Army Corps of Engineers (USACE)
- U.S. Fish and Wildlife Service (USFWS)
- National Oceanographic Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS)
- U.S. Environmental Protection Agency (USEPA)

In most cases, the USACE acts as the lead agency for actions within jurisdictional Waters of the U.S. given its authority under Sections 401/404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Depending on the proposed location and activities, permission from the USACE can be issued through various nationwide permits or individual permits. The Nationwide Permit system helps to reduce the permitting time for "routine" operations including general maintenance dredging, power cables, and other recurring activities. The USACE, in many cases, consults with the other federal agencies on the specific resources it oversees.

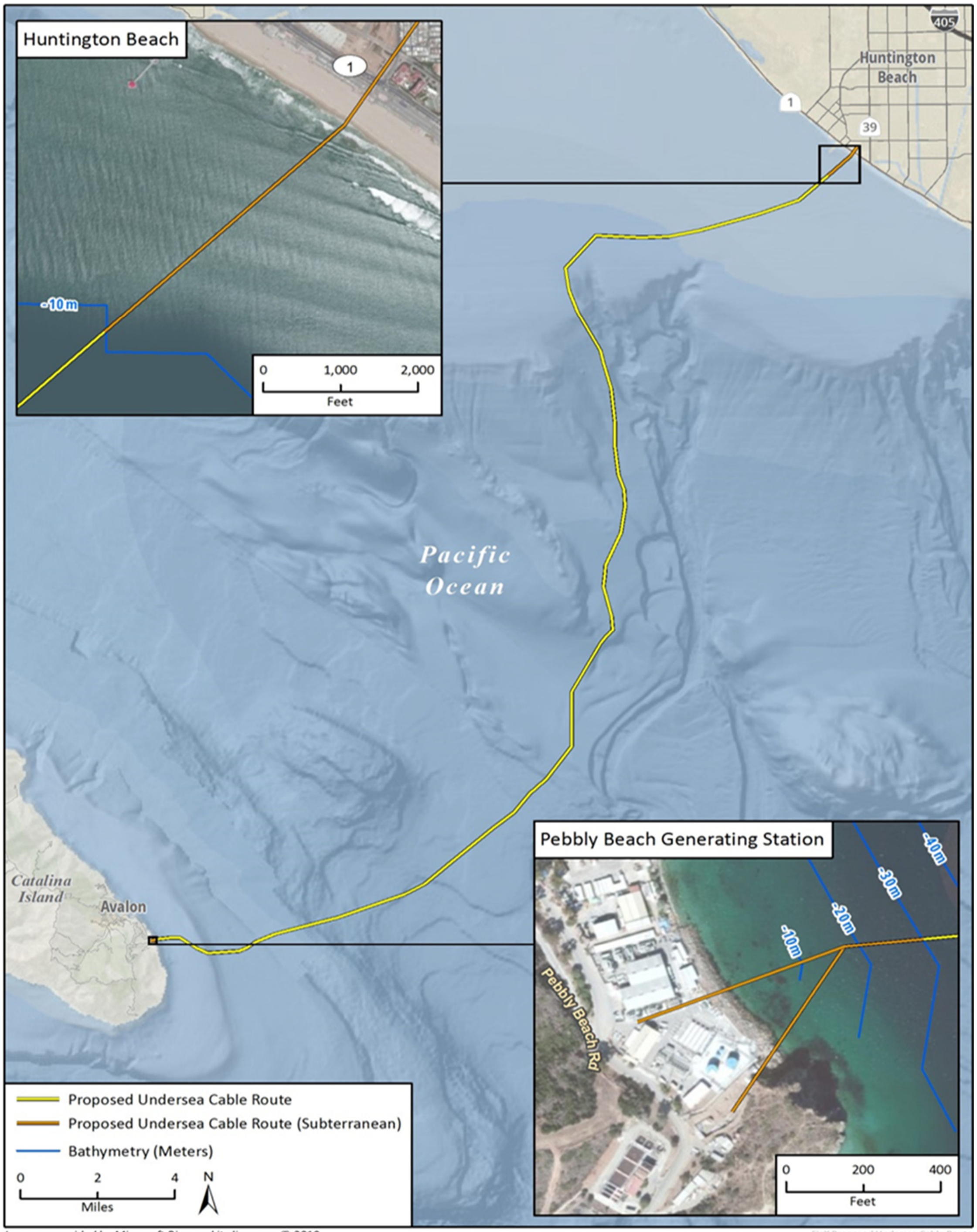
SUBMARINE POWER CABLE PERMITTING OVERVIEW

The installation of a proposed submarine power cable (power cable) connecting Santa Catalina Island (Catalina Island) to the mainland of California was initially evaluated in a desktop study in 1998 (Pelagos, 1998) and subsequent in a desktop study in 2003 (Thales, 2003). The proposed route and landing locations were further refined based on an evaluation of the best available physical and biological resource data and site specific geophysical and biological surveys conducted in 2003 and 2004 and summarized in a Project Execution Plan drafted in May 2005 (SCE, 2005). The identified preferred route proposes source electricity originating from a substation adjacent to the Huntington Beach Generating Station (HBGS) in the City of Huntington Beach (Orange County) and transiting through a subsea 35 kilovolt (KV), three-conductor electrical transmission cable to the existing Pebbly Beach Generating Station (PBGS) Catalina Island (Los Angeles County) (Figure 1).

The proposed mainland (Huntington Beach) shore crossing proposed to be through an abandoned 24-inch (in.) diameter concrete pipeline or alternatively through a steel pipe placed within a new horizontal directional drilling (HDD) bore hole originating from the HBGS and piloting offshore at a depth of approximately 50 feet (ft.) below mean lower low water (MLLW) in consolidated sand substrate. On Catalina Island the power cable will transition the coastal shoreline through a steel pipe placed within a new HDD bore originating from the PBGS property to a water depth of approximately 75 ft. below MLLW in consolidated sand substrate. The 35.5 mile (mi.)-long subsea portion of the cable will transverse the San Pedro Channel with a specified corridor; maximum water depth along that corridor is approximately 2,500 ft. (SCE 2005) (Figure 1).

The proposed construction methods and the existing conditions occurring within the proposed power cable route and shore based facilities are not expected to have significantly changed since the preferred route was identified in 2005. However, it should be expected that regulatory agencies will expect that new geophysical, biological and cultural site specific focus surveys will need to be conducted for the permitting and environmental review process. The environmental concerns remain consistent with those identified in the 2005 Project Execution Plan and include marine habitat and sensitive species, water quality, marine geology, cultural resources, coastal access and recreation. Key concerns to permitting regulatory agencies and the environmental review process are anticipated to be focused on the coastal shoreline transitions of the power cable through pipelines or HDD bores to the proposed shore based facilities and the path of the submarine portion of the cable relative to geologic hazards and sensitive habitat. Including detailed descriptions of the shore based facility construction activities, HDD, and cable installation methods in the project description, including specific avoidance and minimization measures, will be paramount to obtaining endorsement and timely consensus of the selected route from stakeholders and regulatory agencies.

The proposed submarine power cable incorporates an array of sites, jurisdictions and operational activities necessitating environmental planning and permitting processes through various federal, state, and local regulatory agencies. Regulatory authority of the individual agencies includes general land use and resources in the municipalities, regions, coastal zone, and marine waters offshore of California.



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FigX Proposed Undersea Cable Route

Figure 1 - Submarine Power Cable Preferred Route and Shore Based Landing Locations

SCE completed pre-application meetings with the U.S. Army Corps of Engineers (USACE), California State Lands Commission (CSLC), California Coastal Commission (CCC), and the City of Huntington Beach and Avalon as recently as 2005 (SCE, 2005). Future submarine power cable planning and permitting activities are anticipated to benefit significantly from the previous permit discussions. Reinitiating pre-application communications with the regulatory agencies to share the currently proposed submarine power cables route and approach would affirm anticipated environmental review, permit, and site-specific environmental focus study needs.

Federal, state, and local approvals will be needed and environmental review under both the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) should be anticipated. Considering that each of the power cables proposed shore based facilities are located in different Local Coastal Program (LCP) jurisdictions and the power cable will transect nearshore submerged lands under the jurisdiction of the CSLC. Proposed power cable activities in the LCP and CLSC jurisdictions will trigger the CEQA process. The NEPA is anticipated to be led by the USACE with other federal agencies including the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), U.S. Coast Guard, and Bureau of Ocean Energy Management either delegating authority to USACE or providing review and input. The CEQA and NEPA documents will incorporate a detailed project description, existing conditions of potentially impacted resources, and outline and incorporate mitigation measures designed to reduce or eliminate project related impacts that will contribute and facilitate the development of the various permit applications.

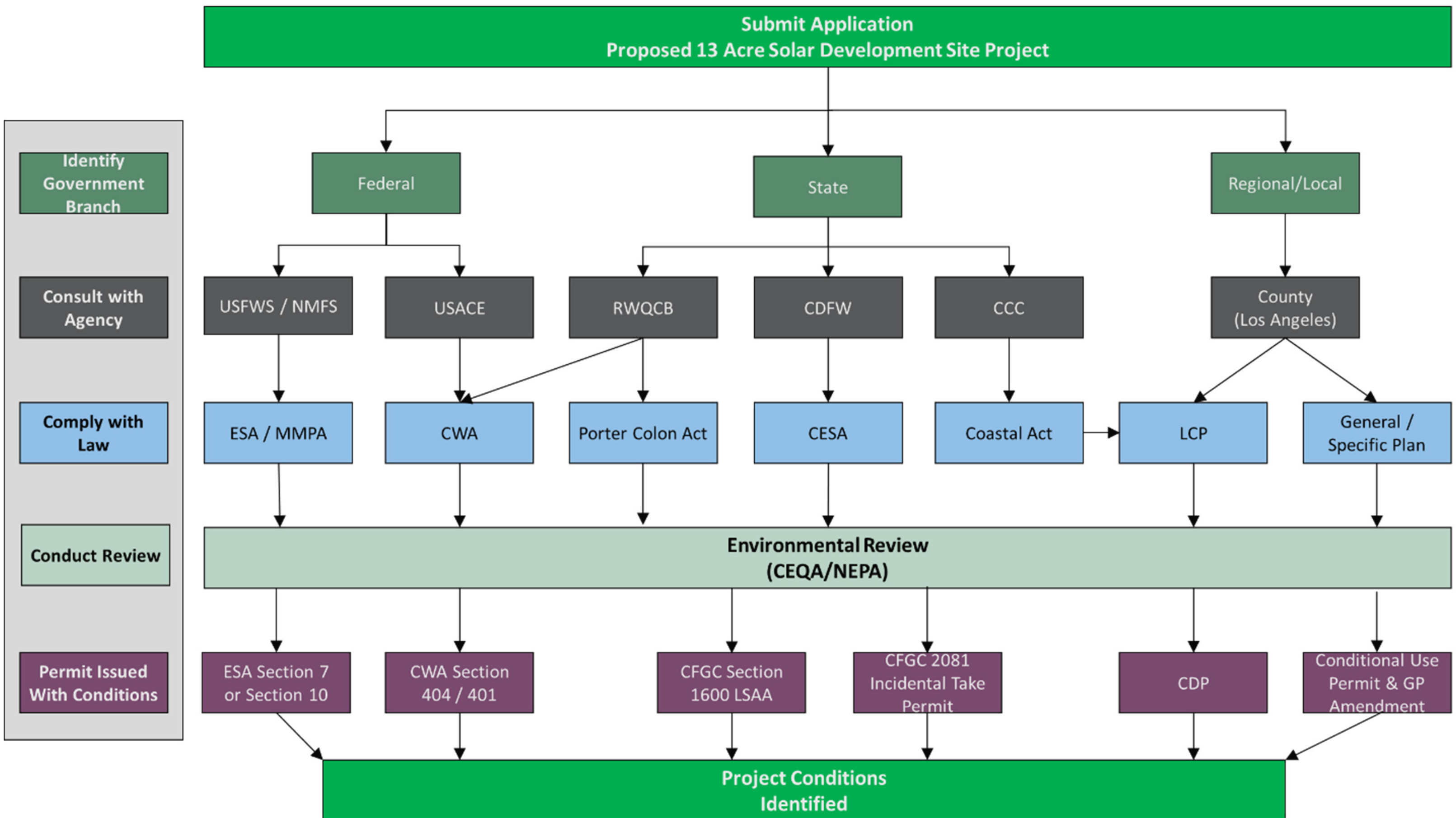
The proposed submarine power cable route will require a considerable amount of federal and state environmental review because of the diversity of resources and number of jurisdictions affected. The environmental planning process could take two years or longer if an Environmental Impact Statement (EIS) and Environmental Impact Report (EIR) are required. However, recent environmental planning documents for fiber optic cable projects prepared in California for the CLSC and federally for the USACE have been Environmental Assessments (EA) for NEPA and Initial Study/Mitigated Negative Declarations (IS/MND) for CEQA, which are prepared more quickly and at lower cost. Federal and state regulatory agencies have recently been actively involved in working groups and developed Memorandums of Understanding to streamline environmental planning and permitting for marine cable installations, although these have been focused on renewable energy options and consolidating marine cable landing locations. For the proposed energy generation and supply preferred alternatives identified in this study including those interfacing with the marine environment an EA and/or IS/NMND may be suitable environmental documents depending on the individual alternatives design, construction activities, resource avoidance, mitigation and regulatory agency precedence.

Planning and permitting anticipated time lines and costs for the submarine power cable are summarized in Table X. Significant preplanning should be anticipated and organized to better inform the presumed schedule and costs of the various site-specific focus surveys, permit applications and environmental planning preparation and review time lines. The permitting process is most effectively initiated after multiple pre-application and informal consultation meetings have been conducted and regulatory agency concurrence relative to the environmental planning document needs has been agreed upon. Once the draft environmental document has been completed and submitted for public review, the permit application packages and consultations should be finalized and submitted for formal consideration. The power cables permit applications, lease hold agreements and protected species consultations will require several months to a year depending on the agency and will likely need to be supported by site specific surveys and information.

Key concerns and challenges of executing the power cable alternative include potential impacts to the nearshore and offshore resources associated with placing, boring or trenching the power cable throughout its extent including cultural resources, sensitive habitat, existing offshore infrastructure (cables, oil rigs, pipelines) and hazards related to geologic formations and HDD boring. Recent concerns by the CCC related to sea level rise associated with resiliency of shore based facilities and recreational use constraints should also be anticipated and addressed.

Table H provides an overview of permit requirements and a cost range to construct the submarine power cable.

PERMITTING FLOW CHART



NOTE: **CCC** – CA Coastal Commission; **CDFW** – California Department of Fish and Wildlife; **CESA** – CA Endangered Species Act; **CDP** – Coastal Development Permit; **CEQA** – CA Environmental Quality Act; **CFGC** – CA Fish and Game Code; **CWA** – Clean Water Act; **ESA** – (federal) Endangered Species Act; **LCP** – Local Coastal Plan; **MMPA** – Marine Mammal Protection Act; **NEPA** – Nation Environmental Policy Act; **NMFS** – National Marine Fisheries Act; **RWQCB** – Regional Water Quality Control Board; **USACE** – U. S. Army Corp of Engineers; **USFWS** – U. S. Fish and Wildlife Service;