



California ISO

# Energy Storage Enhancements State of Charge Implementation Update

Oct 9, 2023

## Housekeeping Reminders:

- This call is engages stakeholders in review of market performance issues and in high level dialogue on release planning, implementation and new market enhancements. This is intended to foster open dialogue and sharing of ideas and perspectives
- This call is being recorded for informational and convenience purposes only. Any related transcriptions should not be reprinted without ISO's permission.
- Please keep comments brief and refrain from repeating any comments previously made.

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- Select the raise hand icon 🙋 located in the lower tool bar. You will hear a beep tone when you are un-muted; at that time please state your name, and question.
- Phone only use #2 when dialed into the meeting.
  - Please remember to **state your name and affiliation** before making your comment.
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California ISO

# ESE SOC Constraint – Revised Implementation

10.9.2023

# Agenda

- Discussion of proposed implementation of ESE SOC constraint solution
- Review of analysis

The revisited implementation is currently in market sim through 10/13/2023

Negative prices for regulation down were observed in the testing environment and ESE constraint implementation was delayed

$$SOC_{i,t} = SOC_{i,t-1} - (P_{i,t}^{(+)} + \eta_i P_{i,t}^{(-)} + \mu_{1,t} RU_{i,t} - \mu_{1,t} \eta_i RD_{i,t})$$

- The market software understands the intertemporal relationship between regulation, energy, and state of charge
  - Negative regulation prices were determined to not be supported by the existing tariff
- The ISO paused implementation of the constraint, published a white paper on results and other potential options, and held a workshop on 8/3/2023
  - Discussed pros/cons of existing constraint, application of envelope equations and PG&E's two constraint solution

# Proposed implementation of AS SOC in the market: Two constraint solution

$$SOC_{i,t}^{AT} = SOC_{i,t-1}^{AT} - (EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)} + ATRU_t RU_{i,t} - ATRD_t \eta_i RD_{i,t}) \frac{\Delta T}{T_{60}}$$

$$\underline{SOC}_{i,t} \leq SOC_{i,t}^{AT} \leq \overline{SOC}_{i,t}$$

$$SOC_{i,t}^{EN} = SOC_{i,t-1}^{EN} - (EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)}) \frac{\Delta T}{T_{60}}$$

$$\underline{SOC}_{i,t} \leq SOC_{i,t}^{EN} \leq \overline{SOC}_{i,t}$$

- Removes the direct coupling of AS and Energy while continuing to manage SOC
  - $SOC^{AT}$  will control for feasibility of energy and reg awards
  - $SOC^{EN}$  will ensure energy dispatch mainly dictated by the results of energy awards
- The ISO believes this largely negates the interaction between regulation and energy within the SOC constraint that lead to the observed negative priced regulation down awards

# Propose Phased Attenuation Factor Implementation

- Separate attenuation factors for each hour and direction
- Start with a smaller attenuation factor, progressively increase until attenuation factor is at data supported level
  - Increase attenuation factors linearly across 4 months, starting at 25% of expected full implementation
  - Attenuation factors will be implemented hourly; values will be published in the BPM
- Allows the ISO and market participants to monitor implementation to ensure market results are as expected



# Testing revised implementation against case where negative prices were observed

HE	Initial Formulation		Revised Formulation	
	MW	RD PRICE	MW	RD PRICE
1	350.00	4.12	350.00	7.14
2	350.00	8.00	350.00	6.33
3	350.00	6.33	350.00	6.33
4	350.00	8.00	350.00	6.33
5	350.00	8.00	350.00	5.15
6	350.00	3.52	350.00	5.91
7	350.00	8.00	350.00	8.56
8	370.00	-3.97	350.00	8.51
9	356.97	0.00	350.00	7.91
10	370.00	0.00	350.00	7.91
11	370.00	0.00	350.00	7.91
12	370.00	-3.16	350.00	7.79
13	370.00	-4.34	350.00	7.93
14	370.00	-4.72	350.00	8.10
15	370.00	-4.99	350.00	8.27
16	370.00	-4.99	350.00	8.29
17	370.00	-5.26	350.00	9.43
18	350.00	6.72	350.00	7.99
19	350.00	6.11	350.00	7.99
20	350.00	6.72	350.00	10.40
21	350.00	8.00	350.00	10.40
22	350.00	8.00	350.00	10.33
23	350.00	8.00	350.00	6.33
24	350.00	6.33	350.00	6.33

HE	Initial Formulation		Revised Formulation	
	MW	RU PRICE	MW	RU PRICE
1	350.00	3.94	350.00	4.55
2	350.00	5.37	350.00	4.37
3	350.00	4.67	350.00	3.48
4	350.00	5.42	350.00	4.40
5	350.00	4.63	350.00	3.57
6	350.00	4.63	350.00	3.94
7	350.00	4.01	350.00	4.00
8	350.00	6.26	350.00	9.54
9	350.00	4.00	350.00	4.00
10	350.00	6.75	350.00	6.75
11	350.00	6.88	350.00	5.36
12	350.00	6.92	350.00	4.92
13	350.00	5.85	350.00	4.23
14	350.00	6.51	350.00	4.76
15	350.00	4.18	350.00	4.59
16	350.00	3.00	350.00	3.61
17	350.00	4.00	350.00	3.48
18	350.00	4.00	350.00	4.00
19	350.00	4.00	350.00	3.36
20	350.00	4.00	350.00	3.36
21	350.00	3.00	350.00	2.83
22	350.00	3.00	350.00	2.81
23	350.00	4.00	350.00	3.40
24	350.00	4.00	350.00	3.40

# Testing revised implementation against case where negative prices were observed

HE	Initial Formulation			Revised Formulation			EN Diff	RD Diff	RU Diff
	EN	RD	RU	EN	RD	RU			
1	105.00	206.00	72.00	105.00	139.00	157.00	0.00	-67.00	85.00
2	48.00	321.00	64.00	92.00	137.00	157.00	44.00	-184.00	93.00
3	-65.00	259.00	40.00	-156.00	166.00	101.00	-91.00	-93.00	61.00
4	-49.00	321.00	18.00	-55.00	72.00	146.00	-6.00	-249.00	128.00
5	60.00	273.00	20.00	55.00	141.00	157.00	-5.00	-132.00	137.00
6	33.00	181.00	70.00	10.00	139.00	146.00	-23.00	-42.00	76.00
7	162.00	266.00	0.00	62.00	174.00	123.00	-100.00	-92.00	123.00
8	-9.00	370.00	148.00	0.00	174.00	170.00	9.00	-196.00	22.00
9	-120.00	356.00	70.00	-97.00	321.00	102.00	23.00	-35.00	32.00
10	-38.00	369.00	144.00	-36.00	321.00	174.00	2.00	-48.00	30.00
11	-87.00	370.00	224.00	-91.00	321.00	224.00	-4.00	-49.00	0.00
12	-119.00	370.00	188.00	-110.00	321.00	270.00	9.00	-49.00	82.00
13	-228.00	370.00	187.00	-234.00	349.00	301.00	-6.00	-21.00	114.00
14	-173.00	370.00	185.00	-169.00	294.00	320.00	4.00	-76.00	135.00
15	-89.00	370.00	152.00	-83.00	266.00	320.00	6.00	-104.00	168.00
16	-38.00	370.00	131.00	-40.00	321.00	160.00	-2.00	-49.00	29.00
17	32.00	370.00	83.00	14.00	213.00	101.00	-18.00	-157.00	18.00
18	543.00	154.00	98.00	175.00	6.00	157.00	-368.00	-148.00	59.00
19	138.00	181.00	96.00	90.00	26.00	98.00	-48.00	-155.00	2.00
20	116.00	154.00	83.00	117.00	75.00	98.00	1.00	-79.00	15.00
21	98.00	229.00	130.00	5.00	128.00	130.00	-93.00	-101.00	0.00
22	-16.00	229.00	126.00	1.00	102.00	130.00	17.00	-127.00	4.00
23	-45.00	266.00	96.00	-48.00	75.00	202.00	-3.00	-191.00	106.00
24	7.00	169.00	114.00	-16.00	52.00	202.00	-23.00	-117.00	88.00

# Testing revised implementation against case where negative prices were observed

	Initial Formulation		Revised Formulation	
HE	MW	EN PRICE	MW	EN PRICE
1	14452.55	87.00	14448.84	88.00
2	14171.17	78.50	14143.17	82.00
3	13974.13	76.80	13974.13	73.77
4	13899.53	79.96	13899.53	76.53
5	14228.03	82.00	14228.03	82.00
6	15042.58	87.37	15058.37	84.98
7	16272.69	90.00	16272.69	90.00
8	17151.96	78.50	17148.96	83.08
9	17336.75	74.08	17336.75	73.92
10	17493.88	80.01	17494.94	80.01
11	17523.77	76.00	17520.73	76.00
12	17317.04	74.90	17317.04	74.90
13	17182.09	69.44	17181.09	69.65
14	17231.65	73.54	17231.65	73.76
15	17316.12	75.98	17316.12	76.00
16	17621.79	79.86	17621.79	79.86
17	17858.06	89.70	17858.06	89.70
18	18683.22	92.02	18648.22	94.55
19	18367.01	91.92	18415.25	91.40
20	18264.31	90.00	18238.31	93.49
21	17723.30	89.70	17710.77	90.00
22	16875.75	89.70	16876.75	88.22
23	15835.40	79.07	15831.48	80.00
24	15226.90	80.77	15226.90	80.77

# Testing on stressed day: August 16, 2023 (45933 MW)

## Prices

HE	Initial Proposal			Revised Proposal			Diff (Revised - initial)		
	Energy	RegUp	RegDN	Energy	RegUp	RegDN	Energy	RegUp	RegDN
1	76	6	9	76	6	10	0	0	1
2	70	2	9	70	2	11	0	0	1
3	70	2	11	69	1	11	-1	-1	0
4	68	2	10	69	1	10	1	-1	0
5	68	2	11	69	0	11	1	-1	0
6	76	2	11	76	1	11	0	-1	0
7	89	6	24	90	8	17	1	2	-7
8	72	4	18	74	0	26	2	-4	8
9	67	3	17	68	3	31	0	0	14
10	68	2	17	68	3	31	0	0	14
11	68	3	19	69	1	28	1	-2	9
12	74	3	18	74	1	25	0	-2	7
13	85	6	23	85	6	21	0	0	-1
14	102	20	20	102	11	20	0	-9	0
15	131	26	9	129	21	9	-1	-5	0
16	200	108	15	200	107	19	0	-1	4
17	300	195	19	310	200	19	10	5	0
18	600	493	30	600	490	30	0	-3	0
19	1000	888	19	1000	886	19	0	-3	0
20	1076	961	19	1084	965	19	8	4	0
21	600	483	32	600	480	32	0	-3	0
22	258	153	8	255	145	19	-3	-9	11
23	110	17	8	110	16	10	0	-1	2
24	95	6	8	94	19	9	-1	13	1

# Testing on stressed day: August 16, 2023 (45933 MW)

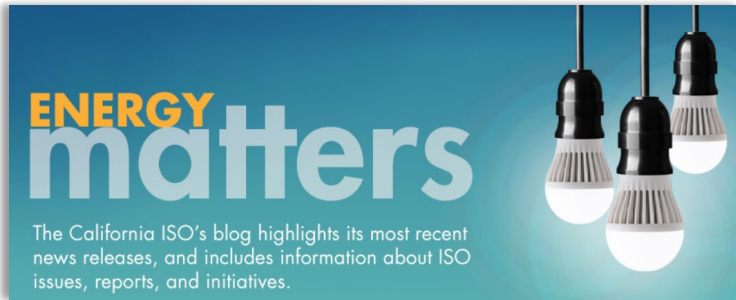
## Quantities

	Initial Proposal			Revised Proposal			Diff (Revised - initial)		
HE	Energy	RegUp	RegDN	Energy	RegUp	RegDN	Energy	RegUp	RegDN
1	-2	287	633	-32	339	354	-30	52	-279
2	-234	215	435	-233	230	229	1	15	-206
3	-665	299	229	-587	300	142	78	1	-87
4	-1082	300	64	-1231	356	47	-149	56	-17
5	-1001	300	128	-1147	413	125	-146	113	-3
6	15	299	224	-11	412	155	-26	113	-69
7	589	267	581	511	345	369	-78	78	-212
8	-511	260	736	-534	363	579	-23	103	-157
9	-1835	245	880	-2282	315	566	-447	70	-314
10	-2027	383	668	-2403	378	499	-376	-5	-169
11	-1946	247	705	-1974	263	418	-28	16	-287
12	-1245	241	488	-1264	336	362	-19	95	-126
13	-684	454	286	-686	541	129	-2	87	-157
14	-446	394	165	-446	419	121	0	25	-44
15	-484	671	95	-489	572	72	-5	-99	-23
16	194	812	72	195	805	52	1	-7	-20
17	586	1,383	0	351	1425	0	-235	42	0
18	2042	873	12	2077	961	0	35	88	-12
19	2323	1,218	0	2318	1238	0	-5	20	0
20	2511	1,329	64	2469	1303	53	-42	-26	-11
21	3027	692	69	2993	667	11	-34	-25	-58
22	1268	958	16	1313	962	21	45	4	5
23	203	120	27	152	93	33	-51	-27	6
24	32	215	191	-12	165	85	-44	-50	-106

# Questions?

# Next Steps

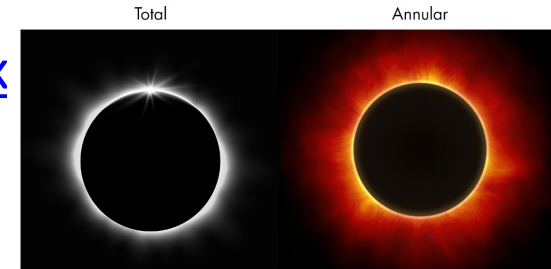
- Stakeholder Initiatives landing page:  
<https://stakeholdercenter.caiso.com/StakeholderInitiatives/Energy-storage-enhancements>
- Stakeholder call will be scheduled soon, please see ISO Calendar and Daily Briefing for more information.



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