A Financial Algorithm for Computing the Levelized Cost (US$/MWh) of the Bulk Storage of Solar (Wind) Energy (LCOS): An Algorithm for Bankers and Investors

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Abstract— this paper discusses the financial and technical principles underlying the levelized cost (LC) method of computing the cost (US$/MWh) of the bulk storage of solar (wind) electricity (LCOS). The paper presents a LC financial algorithm. The algorithm equations are presented. A glossary is presented. For rapid computation, an Excel LC Financial Algorithm Workbook is presented. The financial algorithm uses nine recognized energy storage plant (**ESP**) specifications (specs) to compute the LC of the stored solar (wind) electricity. Published (assembled) spec values for the proposed Highview Power/Encore Liquid Air Energy Storage Plant (LAES) Plant (Vermont), for the upcoming Tesla Moss Landing Li-ion Battery ESP (California) and the actual Cabin Creek Pumped Hydro ESP (Colorado) are used as case studies to demonstrate the algorithm. These spec values are subject to continuous revision. Revenue (R) is discussed only when reconciling the LCOS with GAAP accounting (the author believes that this a new addition to the LCOS literature). The goal of this paper is to present a standard computational financial algorithm for bankers and investors to use. The emphasis in this paper is presenting the author's LCOS algorithm, in developing the methodology for assembling the nine require specs and for reconciling the LCOS with GAAP financial statements. Bankers (investors, financial analyst's) can do a LC computation based on the paper's LCOS algorithm and on the algorithm's nine required ESP specs. The paper's LCOS algorithm gives the reader who has the nine ESP spec values, a quick "back of the envelope" verification of a developer's (manufacturer's; promoter's) value for their EPS' LCOS. A complication arises in using this paper's LC algorithm. The complication is that "published ESP spec values" are limited and that developers (manufacture's, promoter's) spec values must be confirmed by banker's using this paper's Excel LC Algorithm Workbook to compute the ESP LCOS. The paper has three case studies which discuss how to assemble the nine specs for an ESP when the specs publicly available. The goals of this paper are the development of the LCOS algorithm, the presentation of the spec assembly methodology and the reconciliation of the LCOS and the GAAP financial statements. The author leaves it to commercial (governmental, trade, academic) data collection entities to collection the LCOS algorithm's nine required specs for entry on this papers' Excel LC Financial Algorithm Workbook.

Download the Poster, the Pre-Convention Draft of the paper and the paper's Excel LCOS Algorithm Workbook with 4 Worksheets (final version {unless you find some errors}). GO TO: https://tinyurl.com/Solar-NE-20

A Financial Algorithm for Computing the Levelized Cost of Storing Solar (PV) Electricity (LCOS). An Algorithm for Bankers and Investors

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Spec values are continuously being revised by ESP developer's (promoters) and by energy storage data providers. Don't rely on the values below for your multi-million (billion) dollar (euro) bulk energy storage plant!

			Vermont	California	Colorado	
		Worksheet 1 Poster Table 1 with the Paper's current REVISED Three Case Study Spec Values	Highview/ Encore **LAES** Plant	Tesla **Moss Landing** ESP	**Cabin Creek** Pumped Storage Plant	
Line #						
	A. ESP CapEx					
1	Enter	ESP-Power Output-MW	50	182.5	324	
2	Enter	ESP Daily Energy Storage Capacity-MWh/day	400	730	1,296	
A	Computed	ESP Yearly Energy Storage Capacity-MWh/yr	146,000	266,450	473,040	
3	Enter	ESP Plant CapEx-US$/kWh	$135	$125	$250	
√-1	Computed	ESP Plant CapEx-US$/MWh	$135,000	$125,000	$250,000	
B	Computed	Total ESP Plant CapEx-US$/EPS	$54,000,000	$91,250,000	$324,000,000	
						COLOR
	B. Cost of the Stored Solar (Wind) Electricity					CODE
4	Enter	ESS Plant Round Trip Efficiency-η-%	70%	88%	86%	Specification
5	Enter	Cost of the Solar (Wind) Electricity to be Stored-COE-US$/MWh	$40.00	$40.00	$40.00	Computed Value
C	Computed	Cost of the Stored Solar(Wind) Electricity-COSE-US$/MWh	$57.14	$45.45	$46.51	√-Check Value
D	Computed	Extra Cost (COSE-COE) of the Stored Solar (Wind) Electricity-US$/MWh	$17.14	$5.45	$6.51	Transferred Value
E	Computed	% Increase in the Cost of the Stored Solar (Wind) Electricity	43%	14%	16%	
	C. ESP OpEx and Cost of Capital					
6	Enter	Annual Fixed O&M Cost-% Total ESP CapEx-Line B	1.00%	0.50%	0.50%	
F	Computed	Annual Fixed O&M Cost-US$/yr	$540,000	$456,250	$1,620,000	
7	Enter	Variable O&M Cost-US$/MWh	$1.00	$1.00	$1.00	
8	Enter	Physical Life of the ESP-Years	25	25	50	
9	Enter	Interest/ROE Rate-WACC-%	8%	8%	5%	
G	Computed	Capital Amortization Factor-CAF	0.0937	0.0937	0.0548	
H	Computed	Annual Capital Amortization-ACA-US$/yr	$5,058,654	$8,548,189	$17,747,662	
	D. Computation of the Levelized Cost of the Stored Solar (Wind) Electricity-LCOS-US$/MWh					
I	Computed	Annual Capital Amortization-ACA-US$/MWh	$34.65	$32.08	$37.52	
J	Computed	Fixed O&M Cost-US$/MWh	$3.70	$1.71	$3.42	
K	Transferred	Variable O&M Cost-from Line 7 above-US$/MWh	$1.00	$1.00	$1.00	
L	Transferred	Cost of the Stored Solar (Wind) Electricity-COSE- from Line C above-US$/MWh	$57.14	$45.45	$46.51	
M	Computed	Levelized Cost of the Stored Solar (Wind) Electricity-LCOS-US$/MWh	$96.49	$80.25	$88.45	
N	Computed	Levelized Extra Cost of the Stored Solar (Wind) Electricity-LECOS-US$/MWh	$56.49	$40.25	$48.45	
O	Computed	% Increase in the Levelized Cost of the Stored Solar (Wind) Electricity	141.2%	100.6%	121.1%	
√-2	Computed	LCOS/COE	2.4	2.0	2.2	
	F. Check Value-Total Annual O&M					
F	Transferred	Annual Fixed O&M Cost-from Line F above-US$/yr	$540,000	$456,250	$1,620,000	
P	Computed	Annual Variable O&M Cost-US$/yr	$146,000	$266,450	$473,040	
√-3	Computed	Check Value--Total O&M US$/yr	$686,000	$722,700	$2,093,040	2/14/2020