

Introduction

The use of lithium-ion batteries (LiB) for storage of electricity in behind-the-meter solar projects generates the ability to store electricity for use during peak demand charge periods. For properties that consume a significant volume of electricity, the use of stored energy during peak demand charge periods often results in significant savings. However, due to the high price of LiBs, they are not always an economically viable option. Recent studies have forecasted that the cost of LiBs for commercial use will continue its trend of decline into the future, making LiBs an economically viable option for many behind-the-meter solar projects that previously could not bear the expense.

Ottawa Renewable Energy Co-operative (OREC) enters into lease agreements for the use of rooftops for the installation of renewable energy systems in order to sell back generated electricity to the grid through Ontario's Net Metering program (2018). OREC is currently assessing the economic viability of using LiBs in their current and future behind-the-meter solar projects. This research then focuses on forecasting the economic viability of the use of LiBs for storage of electricity in behind-the-meter solar projects orchestrated by OREC within Ottawa.

Methodology

Data analysis

Lithium-ion battery (LiB) pack cost projections from multiple sources were analyzed and converted into cost projections relevant to the use of a LiB pack within the behind-the-meter solar project. The average of these cost projections was then computed and transformed by taking the logarithm of the cost projections in order to extrapolate the data to achieve relevant cost forecasts for LiB packs.

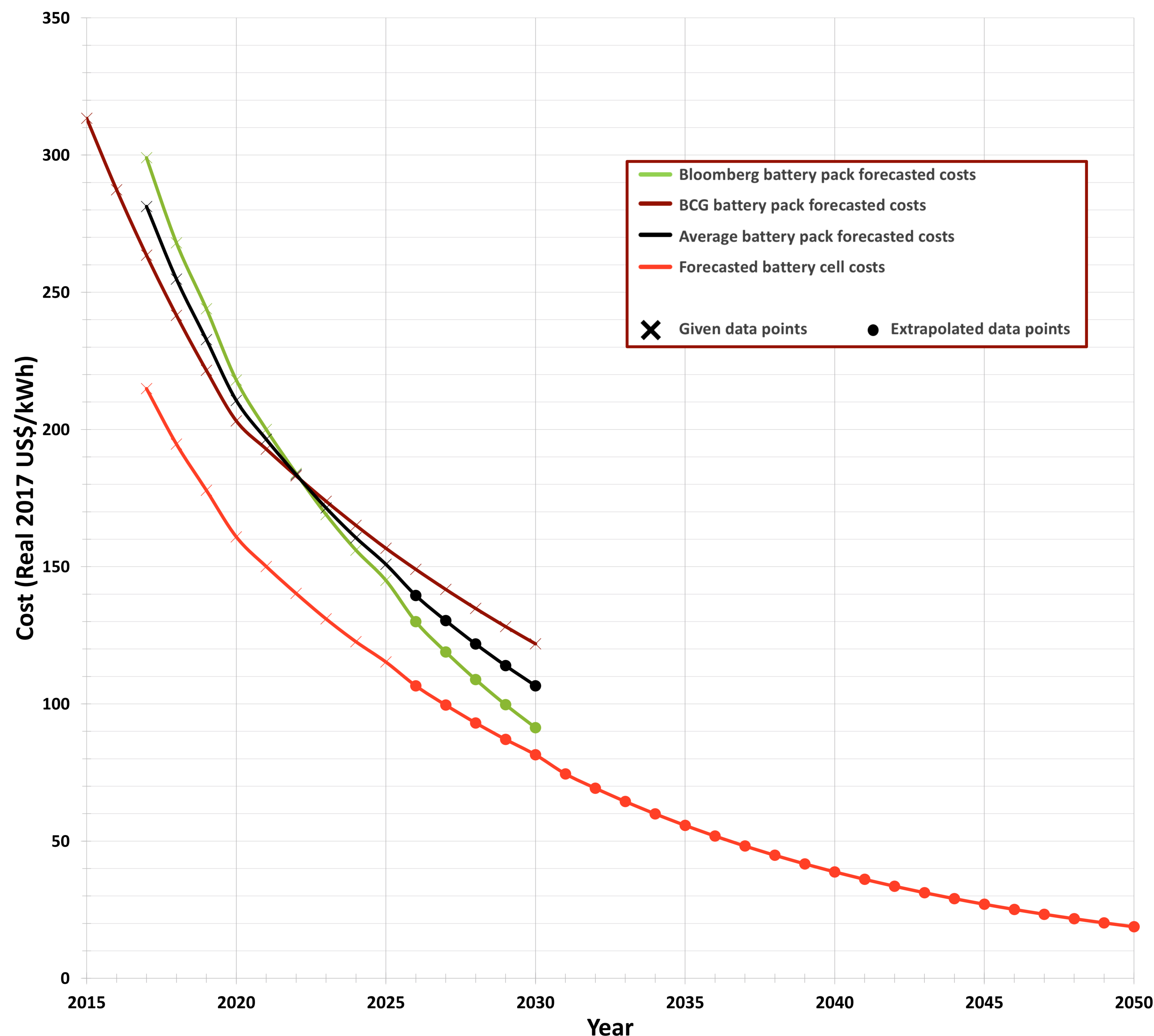
User interface creation

Using the extrapolated LiB pack cost projections, a user interface was produced which allows user input of relevant independent variables to determine an estimate of the internal rate of return (IRR) of establishing a behind-the-meter solar project with electricity storage using a LiB.

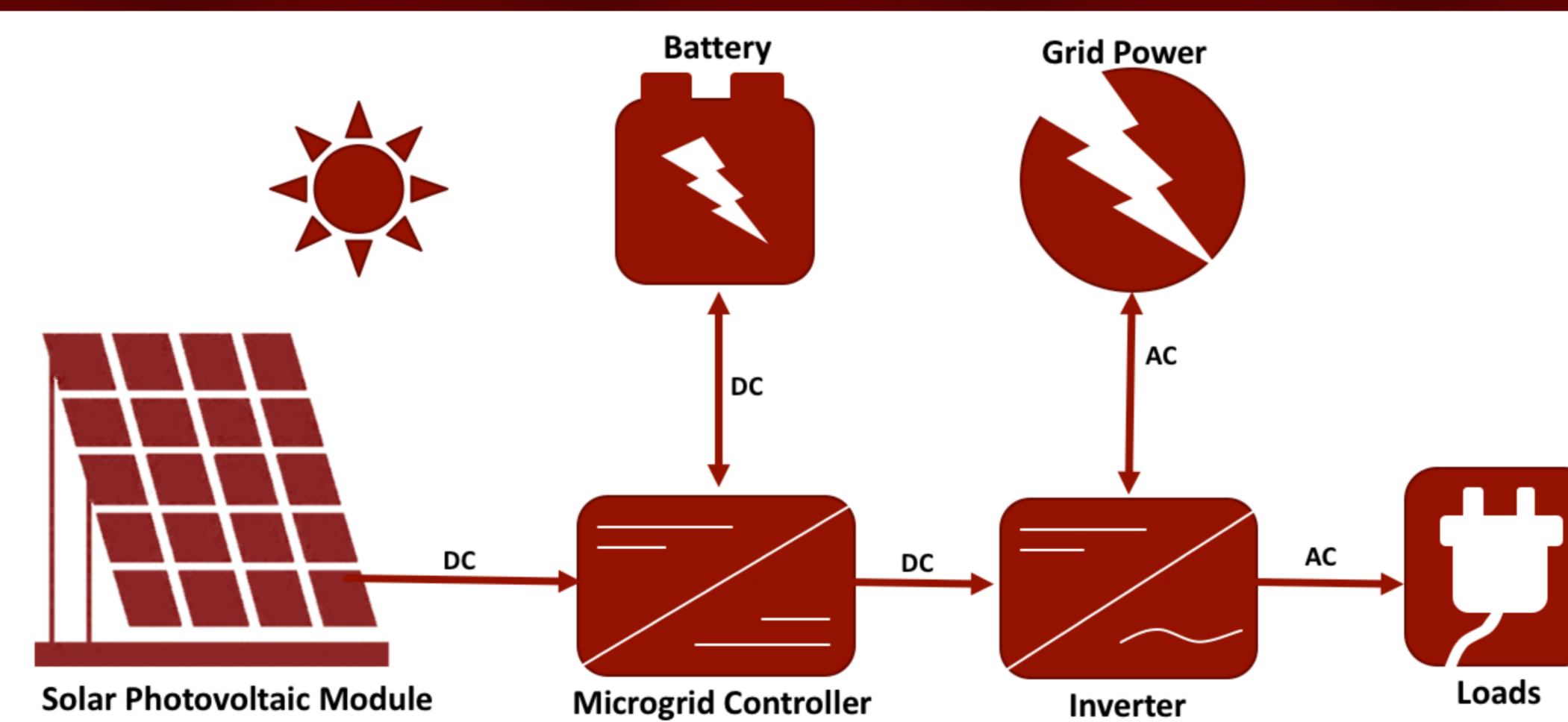
Economic analysis

The independent variable inputs for the user interface were then collected from the other analysts working on separate components of OREC's economic analysis, and entered into the relevant cells. This then returned the various forecasted revenues, expenses, profits, and IRR over the life of the behind-the-meter solar project. This was then repeated for multiple scenarios in order to develop a comprehensive understanding of how differing the equipment and structure of the solar project can impact the IRR of the project over its lifetime.

Forecasted costs of battery packs and cells



Behind-the-meter solar project with storage



Sample of internal rate of return calculation

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Time (t)	0	1	2	3	4	5	6	7	8	9	10
Projections											
Battery Pack Cost Projections (Real 2017 US\$/kWh)	254.8	232.77	210.56	196.43	183.55	171.42	160.52	150.85	139.48	130.31	121.81
Battery Cell Cost Projections (Real 2017 US\$/kWh)	194.67	177.83	160.87	150.07	140.23	130.96	122.64	115.25	106.56	99.56	93.56
Savings (Real 2017 CA\$)	302694.65	321738.23	340583.80	359232.88	377686.95	395947.50	414016.00	431893.92	427536.10	425398.42	423271.43
Savings (Real 2017 US\$)	233093.06	247757.76	262269.99	276630.90	290841.64	304903.36	318817.19	332584.26	329228.48	327582.33	325944.42
Electricity Price											
Forecasted Global Adjustment Value (Real 2017 CA\$/mWh)	105.48	114.51	123.54	132.57	141.60	150.62	159.65	168.68	167.68	167.68	167.68
Hourly Ontario Electricity Price (Real 2017 CA\$/mWh)	16.90	16.90	16.90	16.90	16.90	16.90	16.90	16.90	16.90	16.90	16.90
Other Charges (Real 2017 CA\$/mWh)	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90
Total Price (Real 2017 CA\$/mWh)	132.28	141.31	150.34	159.37	168.39	177.42	186.45	195.48	194.48	194.48	194.48
Total Price (Real 2017 CA\$/kWh)	13.23	14.13	15.03	15.94	16.84	17.74	18.65	19.55	19.45	19.45	19.45
Total Price (Real 2017 US\$/kWh)	10.19	10.88	11.58	12.27	12.97	13.66	14.36	15.05	14.98	14.98	14.98
Capital Costs											
Solar Capital Costs (Real 2017 US\$)	1035450										
Battery Cost (Real 2017 US\$)	127400										
Total Capital Costs (Real 2017 US\$)	1162850										
Other Costs											
Battery Cell Replacement (Real 2017 US\$)	0	0	0	0	0	0	0	0	0	0	46780
Inverter Replacement (Real 2017 US\$)	0	0	0	0	0	0	0	0	0	0	0
Operations & Maintenance (Real 2017 US\$)	11115	11115	11115	11115	11115	11115	11115	11115	11115	11115	11115
Recycling Cost (Real 2017 US\$)											
Year End Other Expenses (Real 2017 US\$)	11115	11115	11115	11115	11115	11115	11115	11115	11115	11115	57895
Year End											
Income from Operations (Real 2017 US\$)	-940871.94	236642.76	251154.99	265515.90	279726.64	293788.36	307702.19	321469.26	318113.48	316467.33	268049.42
IRR											28.9190274751%

IRR results

Six different scenarios were modelled with varying inputs. The inputs varied included the azimuth (orientation) of the solar panels, and the energy consumption. The scenarios, as well as their internal rates of return (IRR) are displayed below:

Average electricity consumption, 0 azimuth, modeled data, photovoltaic solar power generation system. [IRR: 28.919027%](#)
(Above is the base/normal scenario)

Average electricity consumption, 0 azimuth, empirical data, photovoltaic solar power generation system. [IRR: 24.706396%](#)

90th percentile electricity consumption, 0 azimuth, modeled data, photovoltaic solar power generation system. [IRR: 30.116910%](#)

Average electricity consumption, 29 (East) azimuth, modeled data, photovoltaic solar power generation system. [IRR: 28.857593%](#)

Average electricity consumption, -61 (West) azimuth, modeled data, photovoltaic solar power generation system. [IRR: 28.368769%](#)

Then, the base/normal scenario modelled without a battery:

Average electricity consumption, 0 azimuth, modeled data, photovoltaic solar power generation system, no battery. [IRR: 10.424383%](#)

Conclusion

It was observed that the internal rate of return (IRR) over the life of solar projects which employed lithium-ion batteries (LiB) to store electricity for use during peak demand charge periods is significantly higher than those that do not employ the use of LiBs.

Data also suggest that the cost of LiBs will decrease significantly and consistently during the foreseeable future.

This higher IRR in combination with the decreasing cost of LiBs will significantly improve and support the future economic viability of the use of LiBs in solar projects as while the costs associated with LiBs decrease over time, the increase in returns permitted by the utilization of a LiB for electricity storage will endure, resulting in an inflating IRR over time, other factors held constant.

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