Journal of Power Sources 320 (2016) 310–313

Contents lists available at ScienceDirect

Journal of Power Sources

journal homepage: www.elsevier.com/locate/jpowsour

Short communication

The cost of lithium is unlikely to upend the price of Li-ion storage systems

Rebecca E. Ciez [a], J.F. Whitacre [a, b, *]

[a] Department of Engineering & Public Policy, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, United States
[b] Department of Materials Science and Engineering, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, United States

HIGHLIGHTS

- Recent instability in lithium market worrying to battery manufacturers, investors.
- Lithium is not a significant contributor to lithium ion cell mass or cost.
- Reduction in global li price (approx. $7.50/kg) to $0 decreases cell cost by <3%.
- Lithium price of $25/kg increases battery costs by <10%.
- Price changes will have minimal impact on consumers, could affect battery producers.

ARTICLE INFO

Article history:
Received 8 March 2016
Received in revised form
4 April 2016
Accepted 15 April 2016
Available online 29 April 2016

Keywords:
Lithium ion
Battery cost

ABSTRACT

As lithium ion batteries become more common in electric vehicles and other storage applications, concerns about the cost of their namesake material, and its impact on the cost of these batteries, will continue. However, examining the constituent materials of these devices shows that lithium is a relatively small contributor to both the battery mass and manufacturing cost. The use of more expensive lithium precursor materials results in less than 1% increases in the cost of lithium ion cells considered. Similarly, larger fluctuations in the global lithium price (from $0 to $25/kg from a baseline of $7.50 per kg of Li_2CO_3) do not change the cost of lithium ion cells by more than 10%. While this small cost increase will not have a substantial impact on consumers, it could affect the manufacturers of these lithium ion cells, who already operate with small profit margins.

1. Introduction

Lithium ion battery powered electric vehicles are a reality, and with this comes much public and academic speculation concerning the importance of lithium availability and market price. Despite substantial cost reductions in recent years (59–70% per kWh between 2007 and 2014) [1], lithium ion batteries are still significantly more expensive than the Department of Energy target of $125/kWh by 2022 [2]. Precursor materials are a dominant contributor to battery mass and cost, and it is suggested in some corners that lithium prices will prove to be a crucial factor in the cost of battery storage. Some investors believe that inexpensive lithium is one key to reducing device and system costs, while others believe that increased demand will draw geopolitical and economic concerns about access to supply on par with current concerns about oil [3,4]. In both cases, it is assumed that extreme fluctuations in the lithium market could have a dramatic effect on the manufacturing cost of lithium ion batteries, and the corporate value proposition of these devices [5]. Furthermore, both lithium supply shortages and extreme price variations are frequently used as justifications for research on alternate cation electrochemical energy storage technologies such as sodium, magnesium, and potassium based systems. Here we show that even substantial increases in lithium costs will have relatively small (<10%) increases in total manufacturing costs per kWh at the cell level. We also comment on the impact this change in manufacturing cost could impact automotive lithium ion battery manufacturers.

* Corresponding author. Department of Engineering & Public Policy, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, United States.
E-mail address: whitacre@andrew.cmu.edu (J.F. Whitacre).

http://dx.doi.org/10.1016/j.jpowsour.2016.04.073
0378-7753/

2. Methods

We select two prismatic cell designs and two lithium ion battery chemistries, both based on Argonne National Lab's BatPaC model (specifically version 3, released in May 2015) [6]. They represent two different types of cells typically found on the market. Batteries with lithium manganese oxide spinel ($LiMn_2O_4$) and lithium nickel cobalt aluminum oxide ($LiNiCoAlO_2$) cathodes are currently used in several prominent PHEV and BEV models, so we use these cathode chemistries. In all cases the anode material is graphitic carbon. “High specific power” cells are used for applications where higher power per unit energy is needed, such as hybrid (HEV) and plug-in hybrid battery packs (PHEV), whereas “high specific energy” cells are used for all-electric battery electric vehicles (BEV). The high specific power cells are capable of faster charging and discharging, and have thinner electrodes and a higher mass fraction of current collector and separator material per cell. The high specific energy cells have thicker electrodes and lower mass fraction of separators and current collectors. Some of the key cell parameters from the BatPaC model for both cell formats and chemistries are listed in Table 1. From these cell models, we are able to construct a bill of materials and break down the costs of the cells, which is shown in Fig. 1.

From this bill of materials, we calculate the stoichiometrically balanced combinations of precursor materials used to make both the cell cathode and electrolyte (1.2 M $LiPF_6$), the only cell elements containing lithium. The lithium compounds, cathode precursor materials, and electrolyte precursor materials considered are listed in Table 2. We use lithium carbonate (Li_2CO_3) as the baseline estimate and compare it to combinations using lithium hydroxide (LiOH), which is approximately 15% more expensive per mole of lithium content [7,8].

We also perform a sensitivity analysis to determine the influence of large fluctuations in the lithium carbonate price. Here we specify a lower cost bound of $0 per kg, and an upper bound of $25/kg from a baseline of $7.50/kg (which is a reasonable approximation of the recent lithium price) [9–11].This upper bound is consistent with the highest estimate of the cost of extracting lithium from seawater, the world's largest lithium source, which could be utilized if justified by global demand [12].

3. Results & discussion

Our analysis shows that the use of lithium hydroxide, the slightly more expensive lithium compound, is unlikely to have a significant impact on the cost of batteries. For example, Table 3 shows the cost increase associated with making cathode materials with LiOH [13], instead of the standard lithium carbonate material. Using the significantly costlier LiOH results in a less than 1% increase in the overall cost of the cells in $/kWh.

The global lithium price is subject to market demand, but despite the projected increase in demand for lithium, long-term lithium production is expected to meet this demand [14]. The analysis of the market fluctuations in the lithium carbonate price also shows relatively small impacts on the cost of lithium ion cells. Fig. 2 shows that even if Li_2CO_3 were to be completely free, the reduction in cost per kWh is relatively small, 3% or less for all four batteries considered. As such, even if the global lithium market slows substantially, which is possible given the recent global downturn in commodities in general [15], the impact on cell and pack level cost is small. Similarly, lithium price increases of more than 300% – from $7.50/kg to $25/kg – would not lead to commensurate increases in battery costs; the maximum increase in the cost per kWh for the four batteries considered is less than 10%. To have even a 15% increase in cell costs, lithium prices would have to be much higher—between $36 and $87/kg—depending on the specific cell chemistry and format. These prices are unsustainably high, and would trigger other lithium producers to enter the market, increasing supply and reducing prices to the ocean removal cost.

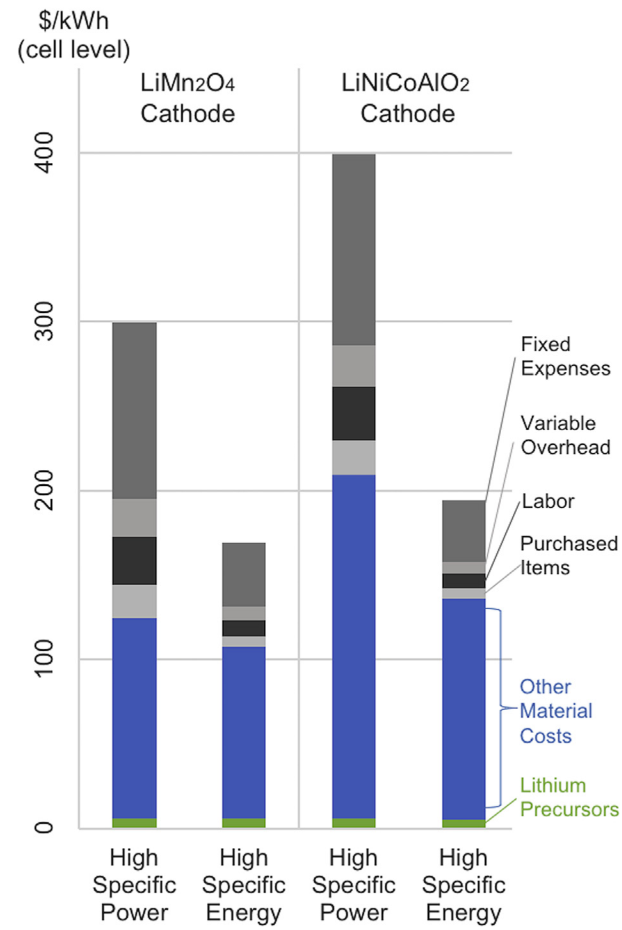

Fig. 1. Per kWh cell-level costs for lithium manganese oxide spinel ($LiMn_2O_4$) and lithium nickel cobalt aluminum oxide ($LiNiCoAlO_2$) batteries for high specific power and high specific energy cells. High specific power cells are typically used in PHEVs, while high specific energy cells are used in BEVs with larger battery packs.

Table 1
Key cell parameters from BatPaC model.

Cathode chemistry	Cell format	Number of bicell layers	Cell capacity (Ah)	Electrode material (kg/kWh)	
				Positive	Negative
$LiMn_2O_4$	High specific power	47	11.4	1.97	1.16
	High specific energy	17	46.1	1.76	1.15
$LiNiCoAlO_2$	High specific power	25	10.6	2.94	1.04
	High specific energy	19	42.5	2.94	1.02