<table>
<thead>
<tr>
<th><strong>Docketed</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Docket Number:</strong></td>
<td>19-IEPR-04</td>
</tr>
<tr>
<td><strong>Project Title:</strong></td>
<td>Transportation</td>
</tr>
<tr>
<td><strong>TN #:</strong></td>
<td>228033</td>
</tr>
<tr>
<td><strong>Document Title:</strong></td>
<td>Battery Storage Costs and Implications for the Electrification of Transportation</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>Presentation by Logan Goldie-Scot of Bloomberg NEF</td>
</tr>
<tr>
<td><strong>Filer:</strong></td>
<td>Raquel Kravitz</td>
</tr>
<tr>
<td><strong>Organization:</strong></td>
<td>Bloomberg NEF</td>
</tr>
<tr>
<td><strong>Submitter Role:</strong></td>
<td>Public</td>
</tr>
<tr>
<td><strong>Submission Date:</strong></td>
<td>5/1/2019 1:51:58 PM</td>
</tr>
<tr>
<td><strong>Docketed Date:</strong></td>
<td>5/1/2019</td>
</tr>
</tbody>
</table>
Battery Storage Costs and Implications for the Electrification of Transportation

California Energy Commission

Logan Goldie-Scot

May 2, 2019

@LoganGoldieScot
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery technology outlook</td>
<td>2</td>
</tr>
<tr>
<td>Battery components &amp; pack price sensitivity</td>
<td>9</td>
</tr>
<tr>
<td>Implications for electric vehicle uptake</td>
<td>13</td>
</tr>
</tbody>
</table>
Battery technology outlook
Average lithium-ion battery pack prices have fallen 85% since 2010
Cells make up roughly 70% of the total cost

Source: BloombergNEF Note: numbers may not add exactly due to rounding. The data in this chart has been adjusted to show real 2018 dollars.
BloombergNEF expects battery pack prices to continue to fall

Lithium-ion battery pack price (real 2018 $/kWh)

Source: BloombergNEF Note: Prices are an average of BEV and PHEV batteries and include both cell and pack costs. Cell costs alone will be lower. Historical prices are nominal, future ones are in real 2016 U.S. dollars.
Battery technology outlook

Ongoing cathode advancements will help achieve these costs reductions

Source: BloombergNEF
Battery technology outlook

New anode designs will also help

Savings from changing cathode

Savings from changing anode chemistry

Source: BloombergNEF
Battery technology outlook

Battery energy density is also improving rapidly

Cell energy density (Wh/kg)

Source: BloombergNEF, public announcements
Battery components & pack price sensitivity
Price rise and subsequent collapse of cobalt highlights market volatility

China Shanghai cobalt spot

China cobalt sulfate 20.5% DEL

Source: Antaike Information Development Co, Asian Metals Inc, BloombergNEF
Lithium prices have also fallen in recent months.
Commodity swings are unlikely to derail lower costs

### NMC (811) battery pack price sensitivity

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Current Price</th>
<th>$/metric ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium</td>
<td>102,410</td>
<td>0 to 180,000</td>
</tr>
<tr>
<td>Cobalt</td>
<td>49,963</td>
<td>0 to 95,000</td>
</tr>
<tr>
<td>Nickel</td>
<td>16,014</td>
<td>0 to 6,000</td>
</tr>
<tr>
<td>Manganese</td>
<td>3,174</td>
<td>0 to 6,000</td>
</tr>
</tbody>
</table>

**Source:** BloombergNEF  
**Note:** Prices true as of December 3, 2018. Size of bubbles denote % change in pack price. Central bubble is an arbitrary size.
Implications for electric vehicle uptake
Falling battery prices ensure that EVs will be cheaper than ICE in the mid-2020s

Source: BloombergNEF, EPA, ICCT, FEV, ONRL, IDL

Updated 2019 analysis available to BloombergNEF clients
Implications for electric vehicle uptake

Smaller vehicles are harder to electrify, cheaply

Projection of ICE and BEV pre-tax retail prices in the U.S. for small vehicle segment

2016 $ (thousand) and %

Source: BloombergNEF, EPA, ICCT, FEV, ONRL, IDL
Lower prices, better performing technologies underpin increasing battery demand

Implications for electric vehicle uptake

Updated 2019 analysis available to BloombergNEF clients from mid-May 2019, including Commercial vehicles outlook

Source: BloombergNEF
Copyright and disclaimer

The Bloomberg NEF ("BNEF"), service/information is derived from selected public sources. Bloomberg Finance L.P. and its affiliates, in providing the service/information, believe that the information it uses comes from reliable sources, but do not guarantee the accuracy or completeness of this information, which is subject to change without notice, and nothing in this document shall be construed as such a guarantee. The statements in this service/document reflect the current judgment of the authors of the relevant articles or features, and do not necessarily reflect the opinion of Bloomberg Finance L.P., Bloomberg L.P. or any of their affiliates ("Bloomberg"). Bloomberg disclaims any liability arising from use of this document, its contents and/or this service. Nothing herein shall constitute or be construed as an offering of financial instruments or as investment advice or recommendations by Bloomberg of an investment or other strategy (e.g., whether or not to "buy", "sell", or "hold" an investment). The information available through this service is not based on consideration of a subscriber's individual circumstances and should not be considered as information sufficient upon which to base an investment decision. You should determine on your own whether you agree with the content. This service should not be construed as tax or accounting advice or as a service designed to facilitate any subscriber's compliance with its tax, accounting or other legal obligations. Employees involved in this service may hold positions in the companies mentioned in the services/information.

The data included in these materials are for illustrative purposes only. The BLOOMBERG TERMINAL service and Bloomberg data products (the “Services”) are owned and distributed by Bloomberg Finance L.P. (“BFLP”) except (i) in Argentina, Australia and certain jurisdictions in the Pacific islands, Bermuda, China, India, Japan, Korea and New Zealand, where Bloomberg L.P. and its subsidiaries (“BLP”) distribute these products, and (ii) in Singapore and the jurisdictions serviced by Bloomberg’s Singapore office, where a subsidiary of BFLP distributes these products. BLP provides BFLP and its subsidiaries with global marketing and operational support and service. Certain features, functions, products and services are available only to sophisticated investors and only where permitted. BFLP, BLP and their affiliates do not guarantee the accuracy of prices or other information in the Services. Nothing in the Services shall constitute or be construed as an offering of financial instruments by BFLP, BLP or their affiliates, or as investment advice or recommendations by BFLP, BLP or their affiliates of an investment strategy or whether or not to "buy", "sell" or "hold" an investment. Information available via the Services should not be considered as information sufficient upon which to base an investment decision. The following are trademarks and service marks of BFLP, a Delaware limited partnership, or its subsidiaries: BLOOMBERG, BLOOMBERG ANYWHERE, BLOOMBERG MARKETS, BLOOMBERG NEWS, BLOOMBERG PROFESSIONAL, BLOOMBERG TERMINAL and BLOOMBERG.COM. Absence of any trademark or service mark from this list does not waive Bloomberg’s intellectual property rights in that name, mark or logo. All rights reserved. © 2019 Bloomberg.
Bloomberg NEF is a research firm that helps energy professionals generate opportunities. With a team of experts spread across six continents, BNEF provides independent analysis and insight, enabling decision-makers to navigate change in an evolving energy economy.

BNEF research and analysis is accessible via web and mobile platforms, as well as on the Bloomberg Terminal.

**Coverage.**

Renewable Energy
Power & Utilities
Gas
Carbon Markets & Climate Negotiations
Energy Smart Technologies
Storage
Electric Vehicles
Mobility and Autonomous Driving
Frontier Power
Emerging Technologies

Client enquiries:
Bloomberg Terminal: press <Help> key twice
Email: support.bnef@bloomberg.net

Learn more:
about.bnef.com | @BloombergNEF