DOCKETED	
Docket Number:	19-ERDD-01
Project Title:	Research Idea Exchange
TN #:	234257
Document Title:	University of California - Irvine and Davis Comments - Developing a harmonized life cycle database for energy storage technologies to support California's energy decarbonization goals
Description:	N/A
Filer:	System
Organization:	University of California - Irvine and Davis
Submitter Role:	Other Interested Person
Submission Date:	8/7/2020 11:45:50 AM
Docketed Date:	8/7/2020

Comment Received From: University of California - Irvine and Davis
Submitted On: 8/7/2020
Docket Number: 19-ERDD-01

Developing a harmonized life cycle database for energy storage technologies to support Californiaâ€™s energy decarbonization goals

Additional submitted attachment is included below.

Brian Tarroja, PhD., P.E
Advanced Power and Energy Program
Department of Civil & Environmental Engineering
University of California, Irvine
Irvine, CA, 92697-3550

Phone: (949) 824-7302 x11348
E-mail: bjt@apep.uci.edu

--

California Energy Commission
1516 Ninth Street
Sacramento, CA, 95814

August 7, 2020

Re: Developing a harmonized life cycle database for energy storage technologies to support California's energy decarbonization goals

Through a series of policies led by Senate Bill 100, California has declared its intention to develop a decarbonized electricity system. While there are differing visions of California's future decarbonized electricity system, many studies of pathways to develop such a system have commonly highlighted the need for the large-scale expansion of grid-connected energy storage systems to facilitate their development and reliable operation. For California, compliance with SB100 may require between 192 to 980 GWh of energy storage depending on the resource mix used to meet this goal[1]. For systems representative of the U.S. Northeast and Texas regions show that up to 1160 GWh of energy storage can be required to facilitate a fully decarbonized electricity system[2]. For reference, cumulative battery energy storage capacity deployed in the U.S. was just under 1.95 GWh as of 2018[3]. Therefore, the energy storage requirements of the future electricity system represent at least two orders of magnitude increase in energy storage capacity for stationary applications.

While grid-connected energy storage is critical for complying with California's clean energy goals, there exist gaps regarding our understanding of how to best develop and deploy these systems relating to 1) GHG emissions outside of California, 2) non-carbon environmental externalities, and 3) capturing the variety and continually evolving capabilities of energy storage technologies in system-wide planning efforts. We believe that many of these gaps can be filled through the development of a harmonized life

[1] Tarroja B, Peer RAM, Sanders KT, Grubert E. *How do non-carbon priorities affect zero-carbon electricity systems? A case study of freshwater consumption and cost for Senate Bill 100 compliance in California*. Applied Energy, 2020, 265: 114824

[2] Sepulveda NA, Jenkins JD, de Sisternes FJ, Lester RK. *The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation*. Joule, 2018; 2:2403–20.

[3] Smart Electric Power Alliance. *2019 Utility Energy Storage Market Snapshot*. 2019.

cycle database for current and emerging energy storage technologies that is continually updated to incorporate the latest state-of-the-art improvements on existing technology as well as the release of new technologies. The rationale for developing such a database is based on the following points:

- **Energy storage technologies have GHG emissions outside of California that must be better clarified to inform the selection of technologies designed to meet clean energy goals.** Policies such as Senate Bill 100 and complimentary policies in California were implemented to reduce greenhouse gas emissions. Since the impacts of greenhouse gas emissions are global, the rationale for selecting energy storage technologies to support California's decarbonized energy system must account for, at least indirectly, the GHG emissions contributed from the materials and production of such technologies that may occur outside of California. Improving our understanding of how much GHG emissions are contributed from the supply chain of an energy storage technology and more importantly what their main drivers are is critical for minimizing the extent to which the in-state GHG reductions from using energy storage are offset by out-of-state GHG emissions.

- **Energy storage technologies have non-carbon environmental externalities that need to be quantified and minimized.** The transition towards a decarbonized electricity system must not inadvertently exacerbate non-carbon environmental impacts. Accounting for the life cycle impact of energy storage technologies on non-carbon environmental metrics (i.e. air and water quality, safety) is critical for ensuring that the pathways towards meeting California's clean energy goals do not add to the State's existing environmental or equity issues. Proper accounting of this nature requires a harmonized and adaptable life cycle database for energy storage technologies. We have recently contributed research on this topic regarding flow batteries, and extensive knowledge gaps remain[4].

- **Energy storage technologies are continually progressing in capability, supply chain configuration, and cost reductions.** Life cycle inventory data on energy storage does not often reflect the state-of-the-art of a given technology due to the length of time and the need for permissions to collect protected data. This can lead to the characterization of energy storage technologies and their life cycle impacts in system-level assessments based on old or outdated data. For example, the use of cobalt in lithium-ion batteries is a mainstay of life cycle inventories for many of these batteries, but identification of this issue has spurred efforts to advance the technology to reduce or eliminate reliance on cobalt. When using an old life cycle inventory for planning far-future scenarios, these types of updates may not be adequately reflected.

- **Life cycle data on many energy storage technologies are absent.** To date, much of the available data on the life cycle impacts and material use of energy storage has focused on lithium-ion batteries due to their role in facilitating electric vehicles and electronics. Energy storage, however,

[4] He H., Tian S, Tarroja B, Ogunseitan OA, Samuelsen S, Schoenung JM. *Flow battery production: Materials selection and environmental impact*. Journal of Cleaner Production, 2020, 269: 121740, https://doi.org/10.1016/j.jclepro.2020.121740.

consists of many different technologies that not only vary in their capabilities, but also their supply chains, materials used, recyclability, and life cycle environmental impacts. Technologies other than lithium-ion batteries may also be needed to facilitate the transition to a decarbonized electricity system. Life cycle inventory data on many of these technologies, however, can be sparse or non-existent in the literature. For example, life cycle inventory data on flow batteries in the literature was limited to Vanadium Redox flow batteries, and data on other flow battery types such as Zinc-Bromide and Iron were non-existent before the CEC-funded project in 2017[5] to characterize these technologies. To have a more informed understanding of how to select energy storage technologies for decarbonization efforts while minimizing other externalities, an accessible database for the life cycle inventories of a wider range of energy storage technologies must be developed.

- **The existing life cycle inventory data on energy storage technologies can be difficult to compare on a consistent basis.** Existing life cycle inventory data on batteries – even for a common technology such as a given lithium-ion battery chemistry – are often difficult to compare to each other or against inventories for different energy storage technologies. This difficulty arises because life cycle analyses often use different system boundaries encompassing different numbers and types of processes in the supply chain and end-of-life phases of the energy storage technologies. For planning California's future, decarbonized electricity system, these differences can cause inconsistencies in the characterization of energy storage technologies that can either benefit some technologies over others or fail to capture important contributors to environmental impacts. Therefore, it is not sufficient that life cycle inventory data on different energy storage technologies be compiled, expertise in life cycle analysis must be applied to convert the data from different studies into a consistent framework.

To ensure that the pathways taken by the State to meet California's clean energy goals, we believe that it is in the State's best interest to fund and support the development and maintenance of a harmonized life cycle database for energy storage technologies. Such a database can serve as a powerful and consistent reference for characterizing the life cycle environmental impacts or benefits in system-wide planning of California's decarbonized electricity system. We envision that the development of such a database would be accomplished via the following processes:

- Collecting and compiling life cycle inventory data on a wide range of energy storage technologies, drawing upon a combination of working relationships with energy storage manufacturers and industry associations alongside the academic and government literature.
- Developing a consistent framework of assumptions and process boundaries for the data included in the database and life cycle analyses that leverage these data, based on input from relevant

[5] *A Comparative, Comprehensive Life Cycle Assessment of the Environmental and Human Health Impacts of Emerging Energy Storage Technology Deployment*, California Energy Commission. Grant No: EPC-16-039. PI: Brian Tarroja, Co-PIs: Julie Schoenung, Oladele Ogunseitan, and Scott Samuelsen.

stakeholders such as energy storage manufacturers, environmental justice groups, academic researchers, and government agencies.

- Performing life cycle analyses with boundaries consistent with the agreed-upon framework to update the database to reflect improvements in existing energy storage technologies or the characteristics of new and emerging technologies.
- Resolving the interaction of energy storage with the electric grid across the multiplicity of potential applications for use in decarbonized electricity system planning.

The University of California has extensive expertise in each of these four processes. Collectively, we represent expertise from energy storage characterization efforts across multiple technologies, relationships with entities involved in the energy storage industry at different levels from fundamental development to system integration, as well as expertise in life cycle analysis and characterization of the interactions of energy storage with the electricity grid system, specifically in the context of decarbonizing California's electricity system. We look forward to engaging in the process to develop this database to identify and support robust pathways to meet California's clean energy goals.

Sincerely,

Brian Tarroja, PhD., P.E
Manager, Advanced Power and Energy Program
Assistant Professional Researcher, Department of Civil and Environmental Engineering
University of California, Irvine

Julie Schoenung, PhD.
Professor and Chair, Department of Materials Science and Engineering
University of California, Irvine

Oladele Ogunseitan, PhD.
Professor, Department of Population Health and Disease Prevention
University of California, Irvine

Alissa Kendall, PhD.
Chair, Energy Graduate Group
Professor, Department of Civil and Environmental Engineering
University of California, Davis

Scott Samuelsen, PhD., P.E.
Director, Advanced Power and Energy Program
Professor, Department of Mechanical and Aerospace Engineering
University of California, Irvine