Battery Storage: North Carolina's Footprint in the Global Value Chain

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Summary

Battery storage is one of the fastest growing sectors of renewable energy and an important step toward a cleaner energy future. The technology has and will continue to become more important as the demand for wind and solar grows. Battery storage allows for the use of the energy produced by renewable sources around the clock.

North Carolina is primed for growth in this industry, both in installed capacity and in the development, manufacturing, and operation of new battery systems. This report focuses on the current and potential value chain for utility-scale lithium-ion battery systems in North Carolina.

Report key findings:

- 268 company locations, representing 22,865 employees and $9.49 billion in sales, currently work in the battery storage value chain in North Carolina. These are companies whose work includes, at least in part, developing, manufacturing, and operating lithium-ion battery storage systems.

- 1,218 company locations, representing 160,687 employees and $45.22 billion in sales, have the potential to work in the battery storage value chain. They are located in all corners of the state, including rural, urban and suburban communities.

The report comes at an important time. Costs for lithium-ion battery storage are dropping dramatically, while demand is growing—more than 98 percent of installed energy storage capacity from 2009 to 2018 has been lithium-ion based systems. North Carolina is well-positioned to capitalize on the growth of this industry, but the state currently lags behind its peers, falling outside of the top ten in installed utility-scale battery storage.

North Carolina's lag in battery storage is notable because of the state's well established leadership in solar production and generally friendly renewable policies.

To quote from the report, "North Carolina has the opportunity to lead in adopting battery energy storage systems in a way that better reflects its dominant position in renewable energy production and the extraordinarily capable base of manufacturing and service companies in the battery storage market space located in the state."

Photo: Indigo Bunting, Buzz Miller/Audubon Photography Awards

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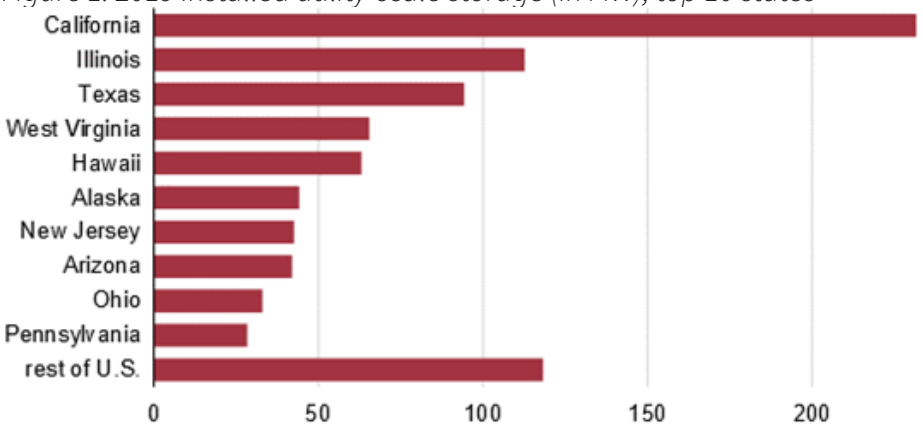
Lithium-ion Battery Energy Storage Systems: North Carolina's Company Footprint in the Global Value Chain

Lukas Brun and Gary Gereffi [1]

Introduction

Utility scale Lithium-ion Battery Energy Storage Systems (LiBESS) are energy storage technologies used by electric power generation system operators to collect energy and discharge it when electricity is needed later. Although a variety of battery energy storage technologies exist, LiBESS technologies dominate the utility market in the United States due to their excellent performance characteristics and rapidly declining costs. Over 98% of installed energy storage capacity from 2009-2018 has been lithium-ion based systems (NREL/USAID 2019). Lithium-ion battery costs have decreased by 70% from 2010-2016 and are projected to decline even further (Curry 2017). Similarly, utility scale LiBESS have become cheaper and expected to reduce by another 55% by 2025 (McKinsey 2018). This price decline, coupled with the need for additional power system flexibility resulting from increased solar and wind power generation, has led policymakers, regulators, and utilities to develop policies conducive to the deployment of LiBESS (NREL/USAID 2019). Particularly relevant policies are FERC Order 841 directing power system operators to allow utility-scale battery systems to engage in their wholesale energy, capacity, and ancillary services market, as well as other supportive state-level policies(Hutchins 2019). When combined with technology cost and performance improvements, these policies have enabled the quadrupling of installed utility-scale battery storage capacity from 214 MW in 2014 to 900 MW in March 2019 and is expected to increase to about 2,500 MW by 2023 (Hutchins 2019). The top 10 states in 2019 operating utility scale battery storage systems are presented in Figure 1.

Figure 1: 2019 Installed utility-scale storage (in MW), top 10 states



Source: Hutchins (2019)

North Carolina absence on this list is particularly notable due to the state's well-known leadership in solar energy production (#1 in the South; #4 in the U.S.) and generally friendly renewable energy production policies (Brun, Hamrick, and Daly 2015). North Carolina has the opportunity to lead in adopting battery energy storage systems (BESS) in a way that better reflects its dominant position in renewable energy production and the extraordinarily

capable base of manufacturing and service companies in the LiBESS market space located in the state.

Research Questions

The research questions addressed in this study are:

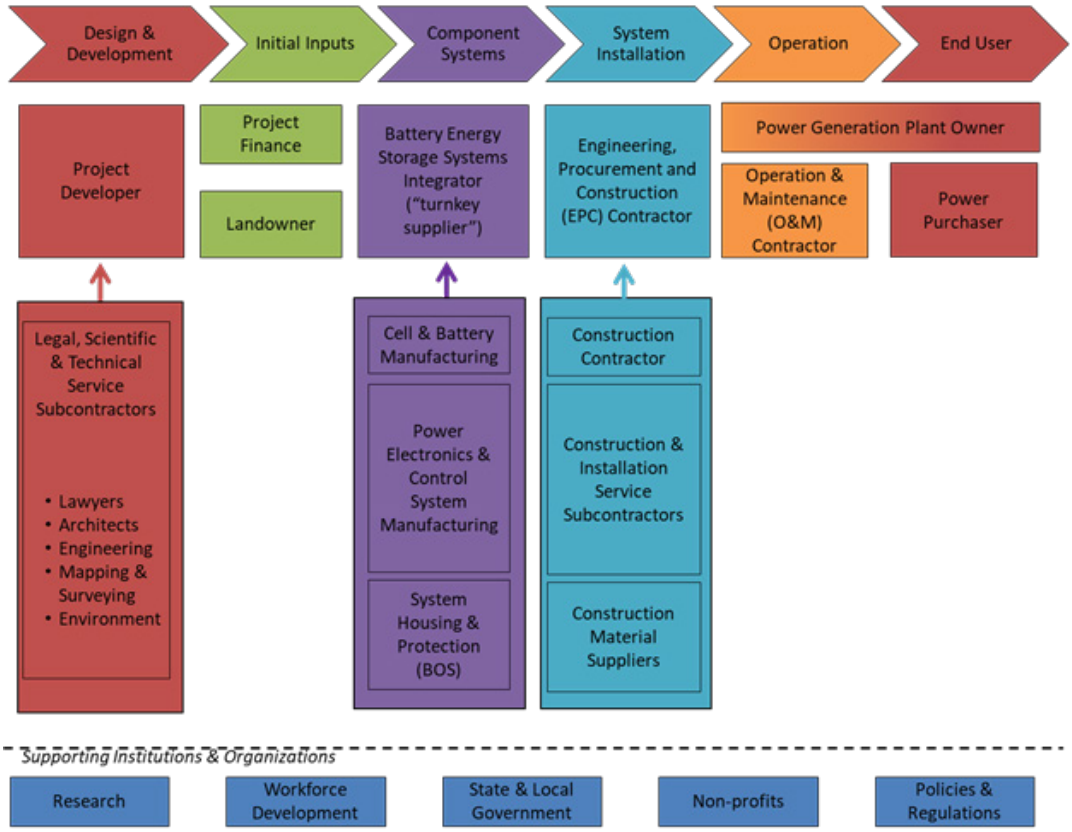
1. What companies currently participate in the North Carolina utility scale LiBESS value chain?
2. What companies have the potential to participate in the North Carolina utility scale LiBESS value chain?

For purposes of the analysis, utility scale storage systems are defined as units with one megawatt (MW) or greater power capacity, consistent with the definition used by the EIA (Hutchins 2019).

Methodology and Data Sources

The methodological basis for our work is the Global Value Chain (GVC) framework (Gereffi 2018; Gereffi, Humphrey, and Sturgeon 2005; Gereffi and Korzeniewicz 1994) adopted by international and domestic development agencies for over 25 years (Taglioni and Winkler 2016; Mayer and Gereffi 2019). The framework disaggregates final goods and services into their component parts and activities, tracing inputs from raw materials to final consumption, identifying companies producing them, and the organizations and institutions (i.e., regulatory requirements and industry standards) supporting the production system. At its heart, the GVC framework is an actor-oriented framework in which organizations in the private, public, and nonprofit sectors collaborate through various forms of supply chain governance and regulatory institutions to produce products and services consumed by end-users. Examples of previous GVC reports related to the energy sector have analyzed North Carolina's utility scale photovoltaic solar power industry (Brun, Hamrick, and Daly 2015), the Smart Grid (Lowe, Fan, and Gereffi 2011), Wind Power (Ayee, Lowe, and Gereffi 2009), Lithium Ion Batteries (Lowe et al. 2010), and concentrating solar power (Gereffi, Dubay, and Lowe 2008). Overall, over 50 GVC studies and reports conducted by the Duke Global Value Chain Center have been related to energy and infrastructure (DukeGVCC 2020).
For this project, we focused on companies in North Carolina participating in the utility scale LiBESS value chain segments, which we defined as comprising site design and development, initial inputs, component production, system installation, operation & maintenance services, and end users for LiBESS. To identify which companies currently participate in the North Carolina utility scale LiBESS value chain (research question 1), we first created a LiBESS value chain (Figure 2) describing the input-output structure and major components of the system.

Figure 2: Lithium-ion Battery Energy Storage System Value Chain



Source: Authors

We relied heavily on two previous GVC reports on utility scale solar (Brun, Hamrick, and Daly 2015) and the construction industry (Daly, Brun, and Guinn 2015) to create the value chain because the LiBESS value chain comprises part of a renewable energy production system plus the construction and affiliated services necessary to build it at a site. A list describing the LiBESS value chain actors is provided in Table 1.

Table 1: Value Chain Actors in Utility Scale Lithium-ion Battery Energy Storage Systems (LiBESS)

Segment	Subsegment	Description
Design & Development	Project developer	The owner of the project when it is initiated. The project developer is usually responsible for initial design and permits.
	Legal, scientific, and technical subcontractors	Professional service providers used for the development of BESS. These include legal, architectural design, engineering, surveying/mapping, and environmental impact services.
Initial Inputs	Landowner	The owner of the land on which the BESS is located.
	Project finance	The financial partner for the project (e.g., banks, credit unions, venture capital, specialty finance providers)

Segment	Subsegment	Description
BESS System Components	BESS Systems Integrator (“turnkey supplier”)	Providers of fully integrated BESS systems sold under a brand name. Turnkey suppliers are vertically integrated into all or most of the component systems described below.
	Component suppliers	
	Battery	Lithium ion mining and processing: the mining of lithium and processing it to be suitable for industrial use. Battery cell manufacturing: manufacturing battery cells and combining them to create rechargeable batteries. Module manufacturing: A battery pack consists of individual battery cells connected in a series and/or in parallel and encased in a mechanical structure. Rack manufacturing: consists of manufacturing a series of battery modules and protecting them in appropriate housing.
	Power electronics & control system	Inverter manufacturing: consists of manufacturing technologies and electronics that take direct current (DC) electricity as their input and produce alternating current (AC) electricity as their output. Inverters are essential because renewable power is generated in DC and must be converted to AC to be used for the grid. Battery control electronics & software (BMS): the electronic hardware and software needed to control the charging and discharging of batteries at optimal levels. System control electronics & software (SCADA): manufacturing consists of making electronic hardware and software capable of managing the BESS systems and subsystems and communicating with appropriate monitoring technologies.
	Balance of system (BOS)	HVAC manufacturing: an essential system to maintain optimal operating temperatures for lithium ion batteries. Fire suppression systems: water and non-water based safety systems to suppress fires that can occur due to the heat generated by BESS during operation, especially during charge and discharge of batteries. Housing: metal containers (which look like shipping containers/TEUs) to house the batteries and associated technology.

Segment	Subsegment	Description
System Installation	EPC contractor	The company primarily responsible for engineering, procurement and construction of the Li BESS. Developers may act as the EPC for their own projects ("developers self-performing").
	Construction (sub)contractor	The company responsible for the BESS site construction. The construction firm may be a subcontractor of either the project developer or the EPC contractor.
	Construction & Installation Subcontractors	The range of subcontractors required to build the BESS at a site. Specifically, these include site preparation contractors, concrete foundation & structure contractors, electrical contractors, HVAC contractors, and power line construction contractors.
	Construction material & equipment suppliers	The construction material, construction equipment manufacturers, and construction material and equipment wholesale suppliers used by construction and installation contractors to install the BESS at a site. Specifically, these include construction material manufacturers (i.e., concrete, rebar, wire, gaskets), construction equipment manufacturers (graders, bulldozers, tools) construction material and equipment wholesalers, and construction equipment rental & repair.
Operation	Plant Owner	The owner of the equity in the operating power plant. The owner is the beneficial recipient of the income generated by the power plant. The owner may be an investor owned utility, municipal owned utility, utility cooperative, plant developer, or other private investor.
	O&M contractor	The organization primarily responsible for technical operation and maintenance (O&M) of the power plant after it is commissioned.
End User	Power purchaser	The utility, municipality, or private commercial business purchasing the power output from the plant.
Supporting Institutions and Organizations	Supporting organizations	The organizations conducting research, facilitating information exchange, and advocacy efforts on behalf of interested parties.
	Policies	The federal and state policies supporting the development of BESS.

*BMS: battery management system; SCADA: supervisory control and data acquisition; BOS: balance of system; O&M: operation and maintenance. Note: a version with corresponding NAICS codes is provided as a separate attachment.

Source: Authors

In the second step of the analysis, we identified global firms manufacturing LiBESS systems and components. We arranged the companies along the subsegments of the LiBESS system components portion of the value chain and identified their position in the value chain. We based our assessment on their production and industry profiles provided on their websites and cross-checked our analysis with published industry sources (Fuhs 2019). We then searched whether the global firms we identified had branches or distribution partners in North Carolina. We visited their websites and took note of any North Carolina locations, conducted an online search using a mapped-enabled search engine to capture their address, and, finally, used subscription-based company database (Reference USA) to cross-check addresses and capture employment and sales information for their North Carolina locations. We created a database of these companies and related descriptive information about their operations in North Carolina.

In the third step of the analysis we supplemented the manufacturers database with North Carolina companies active in other portions of the value chain, specifically, in the design & development, initial inputs, construction, or operation & maintenance segments of the value chain. Data from four organizations, E4Carolinas, the North Carolina Economic Development Partnership (NCEDP), North Carolina Sustainable Energy Association's energy storage company database, and North Carolina Manufacturers Extension Partnership's Manufactured in North Carolina company database were enormously helpful at this stage. We identified companies active in these segments of the value chain, ensuring that they had some mention of LiBESS on their websites. We quickly realized that many of the North Carolina companies developing LiBESS are also active in the utility scale photovoltaic solar power value chain. As a result, we supplemented our online search by calling solar developers, EPCs, and design and development subcontractors to ask 1) whether they offered LiBESS on their sites, 2) whether they were in the utility-scale market, and if so, 3) their business model, specifically whether they were only developers and sold projects to third parties once constructed, or whether they provided operation and maintenance services to their development sites. We entered this information into the database, using a zero or one to designate what portion of the value chain they participated and joined it with the LiBESS integrators and component production firms gathered in the previous step.

In the fourth step of the analysis, we supplemented the database by identifying companies and organizations in the remaining portions of the value chain. These included power plant owners and power purchasers, including investor owned utilities, municipal utilities, and cooperatives and independent power producers. Although all power plant owners and purchasers could reasonably be included as stakeholders in the LiBESS value chain, we only kept companies in these segments of the value chain in the database that either had existing BESS sites or planned to do so as recorded in the U.S. Department of Energy Global Energy Storage Database (GESDB)[2]. Finally, we searched for private and public research organizations in North Carolina relevant to conducting BESS research and development (R&D), related nonprofits, and utility regulators to round out the analysis of the supporting institutions and organizations in the value chain. The analysis resulted in a total of 139 companies with a total of 268 unique North Carolina locations.

We then turned to answer the second research question regarding which existing North Carolina companies had the potential to enter the LiBESS value chain. Our approach relied on the industry classification codes structure to determine what companies conduct similar activities to the companies in the LiBESS value chain. As a first step, we collected the primary industry classification codes for the companies in our LiBESS company database and overlay them on Table 1. For segments of the LiBESS value chain not represented by existing North Carolina firms, we used the construction industry value chain defined in Daly, Brun, and Guinn (2015) and the U.S. Census Bureau's 2017 NAICS Search Engine[3] to identify appropriate codes related to each value chain activity. We then used a subscription-based company search engine to identify other companies in North Carolina with the same primary industry code and having at least ten employees. The search strategy was unsatisfactory as it resulted in almost 9,000 companies and yielded many small companies across a wide range of economic activities that did not correspond well to LiBESS-related activities[4]. A second search strategy identifying companies with fifty or more employees across all recorded NAICS codes (not just primary) in which the firm is active provided much more satisfactory results. In total, this strategy identified 1,218 company locations in North Carolina with the potential to enter the LiBESS value chain. In a final step, we found the North Carolina legislative districts (House and Senate) for each address using the North Carolina General Assembly's "Find Your Legislator" website[5] and added them to the database.

Findings

We find that companies currently active in the North Carolina LiBESS value chain are located in 81 NC House and 45 NC Senate Districts. These companies with 268 locations across the state have a total of 22,865 employees and generate $9.5 Billion in sales. Companies potentially active in the North Carolina LiBESS value chain are located in 118 NC House and all 50 NC Senate Districts. These companies with 1,218 locations have a total of 160,687 employees and generate $45.2 Billion in sales according to Reference USA. In total, the 1,486 company locations currently and potentially active in the North Carolina LiBESS value chain represent 183,552 employees and $54.7 Billion in annual sales. Please see Table 2.

Table 2: Summary Findings

	# districts >=1 Company (H)	**# districts >=1 Company (S)**	**Total Company Locations**	**Total Employees**	**Total Sales ($)**
Existing	81	45	268	22,865	9,494,633,000
Potential	118	50	1,218	160,687	45,215,836,860
		Total	1,486	183,552	54,710,469,860

Source: Authors, calculated from NC LiBESS company database. Employees and Sales are from ReferenceUSA.

The summary employee and sales information provided in Table 2 represents total company figures. Since companies have many products, the summary figures may not be accurate representations of the portion of sales and employment generated by LiBESS. However, even if only 10% of existing employment and sales was generated from LiBESS, this still represents 2,286 jobs and almost $950 million sales in North Carolina.

Limitations

This study is limited by the availability of location and business activity data on companies we identified in the LiBESS value chain. We relied on third party subscription databases to identify the addresses of firms and to report the sales and number of employees for each company. Reliance on subscription-based company databases introduces potential error in results due to possible inaccurate, missing, or outdated information despite the statement by the third-party provider that the information reported in company databases is verified annually. For firms in the LiBESS company database (research question 1), we overcame this limitation by first checking the addresses provided by ReferenceUSA with the company's website, and second, with an internet search engine to identify current locations. For the project deliverable identifying companies with the potential to participate in the value chain (research question 2), this source of potential error is greater as we relied solely on the location information provided by ReferenceUSA due to the number of companies captured. Please note: when companies have multiple locations, we report all locations regardless of whether the particular site produces products or services related to LiBESS systems. Thus, the databases reflect companies active or potentially active in the BESS value chain and who have branch locations in the places recorded in the company directory. Or stated another way, for companies with multiple locations, it would be inaccurate to conclude that LiBESS-related activity occurs at each specific site recorded in the directory; the company is active in the market space but not necessarily the specific location. Please also note that only a portion of reported sales and employment information for most companies will be related to the LiBESS value chain. Thus, summing employment and sales for the companies does not represent the direct economic impact of LiBESS activity in North Carolina.

A second limitation of the information collected for this project is due to our reliance on the NAICS structure to create a database of companies that could participate in the value chain but currently do not. The NAICS code structure is an imperfect, but widely used, mechanism to understand the business activity of a company. Its use captures relevant companies but also companies that may not be specifically related to the activity of interest[6]. For example, NAICS 423720 "Plumbing and Heating Equipment and Supplies (Hydronics) Merchant Wholesalers" includes both plumbing supply companies (as the name suggests) and well-known solar DSPs such as Strata and Cypress Renewables due to it also including "solar heating panels and equipment merchant wholesalers" under the same code. We mitigated the problem by providing all NAICS codes and the company business activity description, if provided by the subscription service. Despite these two limitations to the research, we believe the information provided in this project provides a good understanding of the North Carolina companies and activities in the LiBESS value chain.

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Footnotes

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2. https://www.sandia.gov/ess-ssl/global-energy-storage-database/
3. https://www.census.gov/eos/www/naics/index.html
4. For example, this search resulted in a number of nursing homes and residential support services.
5. https://www.ncleg.gov/FindYourLegislators
6. Industry classification systems are nested hierarchies in which the lowest digit is the broadest level and the highest digit is the narrowest level of specificity.