Customer Owned Battery Systems (COBS) can be used to ensure safe operation of distributed energy resources (DER). Developments in battery technology are beginning to make batteries affordable. With laws in Hawaii and California (and more soon to follow) requiring 100% renewable energy in the next few decades widespread use of distributed COBS is inevitable because their flexible operation allows for increases of DER penetration on a circuit. Identifying and operating COBS, however, will be nontrivial mainly because of their distributed nature and limited knowledge and control utilities will have over the devices. For one reason, many states do not have policies for customers to report installations PV or battery systems, so utilities do not know where these devices are. Second, since batteries are not yet commonly adopted, there is not enough data to study the impacts there is currently no simple. Finally, there is no simple, efficient, and accurate way for utilities to assess the positive impact that an installed battery (or a network of installed batteries) has on a distribution circuit. Unless utilities are prepared for the widespread use of COBS, utilities will be forced to limit the DER on a circuit, even though it may be capable of handling much more.

The question, therefore is “What can be done to prepare utilities to leverage benefits of COBS?” The answer lies in harnessing modern techniques and tools to create a framework for COBS identification and control. New (heterogeneous) sources of data are being collected by smart meters and a range of sensor technologies. New software has been developed that can efficiently complete power flow analysis and leverage the new data available to utilities. Also, algorithms developed at ASU can identify other customer owned PV that could be expanded to identify COBS. ASU has also developed sophisticated algorithms to maximize battery lifetime and customer savings. This proposal will leverage both the technology and theory of the new tools to accurately identify and assess the impact COBS have on the distribution system. Specifically, by collaborating with the experts at ASU I will connect data, rigorous mathematical analysis, and engineering applications to adapt existing algorithms with provable performance.

**Intellectual Merit:** This work significantly expands on the current state of the art PV identification by implementing the extraction and operation of COBS. Not only will it identify the locations of the COBS, but operational and physical parameters can be extracted such as battery size, discharge rate, normal operational function (back-up power or peak shaving), normal charging time, charging rate, and even the current state-of-charge (SOC). First, I will use battery control algorithms on a database of utility smart meter data to generate a wide variety of data representing different sizes and operations of COBS. This is necessary because of the lack of COBS being used today. Second, I will use tools from probabilistic graphical models to develop a computationally efficient data-driven framework for COBS identification and parameter extraction. This probabilistic approach will lead to the development of a supervised machine learning algorithm that can use heterogenous data types (historical smart meter data, expected PV generation at a customer’s location, and others) to identify COBS. Smart meter data from customers with and without COBS is expected to differentiate enough that a machine learning algorithm will be capable determining the differences between the two types of customers, as seen in figure 1. Once a COBS is identified from the dataset, the historical smart meter data from that customer will be periodic enough to extract the parameters after a couple of days with high degree of accuracy.

I will then develop a software add-on in OpenDSS, and open source distribution system simulator, that can use the extracted parameters to assess the impact COBS have on a distribution circuit. Lastly, using the results from the OpenDSS add-on, an algorithm will be developed to adjust minimal operational parameters of the COBS to optimize distribution circuit performance. Together, these tools will ensure safe grid operation, assess the operation of devices on the distribution system, and provide direction for optimal system management.

**Broader Impact:** Successful application of the proposed project will give distribution system operators and planning engineers all the information necessary to fully leverage the advantages of COBS in a distribution system. It uses the already available utility data and does not require control of a new communication network, resulting in an inexpensive yet sophisticated solution. It pulls the wealth of knowledge and experience available at ASU to create something that be necessary for future utility operation. The software will be able to alert system operators in real-time if a COBS has been installed, so operators can recommend optimal settings for grid and battery performance to the customer. Realistic data from existing NDA (Salt River Public Utility in Phoenix and Duquesne Light Company in Pittsburgh) will be used for validation.