



1. Introduction

S&C Electric Company (S&C) is pleased to provide information for the supply of and commissioning of integrated PureWave® Storage Management System (SMS) for the Living Pilot. As a globally recognised technical innovator in the power transmission and distribution industry with over 100 years of power systems experience, S&C has significant in-house engineering capabilities, a diverse suite of applicable products and the regional and global capabilities required to assist with the development and commercialization of next generation energy storage systems.

Not only does S&C manufacture equipment and solutions to meet the needs of many different applications in the energy sector, our Power Systems Solutions group provides full EPC/Turnkey solutions by utilizing our extensive in-house engineering, project management, and construction services. Included in our engineering group is a highly specialized systems studies team that has the capability to perform all of the studies required to integrate a complex Energy Storage System. We are currently involved in many highly technical Energy Storage deployments ranging from simple peak shaving applications to the combination of automated dynamic islanding and advanced distribution automation technologies used to managed a micro-grid which includes the integration of multiple renewable energy generation sources as well as diesel generation and the ability to seamlessly transfer to and from the utility grid. These solutions are commercially available now for the Living Pilot.

2. S&C Electric Company Experience and Benefits

S&C's Power Quality Products group represents the most experienced team providing MW size inverter based products and services available worldwide. Beginning in the early 1990s, S&C identified power electronics as a growing need for the worldwide electrical industry. The first power electronic based multi-MW High Voltage UPS was installed in 1996. Then the first inverter based DSTATCOM was installed in 1997 by employees of what is now the S&C's Power Quality Products. In 2006, the first S&C SMS Energy Storage System went into service. From those first systems, S&C has continued to grow and improve its power electronic offerings to address a wide variety of industry real and reactive power requirements.

- For the utilities industry – S&C has provided inverter based products and services that serve the utility industry starting in 1996. Since then S&C has grown our products for utility substations to include both PureWave® DSTATCOM Distributed Static Compensators and PureWave® Storage Management Systems equipment and services.
- For the renewables industry – S&C has provided numerous power electronic products and services that serve the renewable energy sector starting in 2001. S&C has grown our services in both substation and collector system design, construction and equipment installation, including design and installation of Dynamic VAR compensation and Energy Storage Systems.
- Power Electronics Project Experience – S&C has medium voltage PureWave® UPS Systems, PureWave® DSTATCOMs, PureWave® Storage Management Systems and PureWave® Community Energy Storage serving a variety of critical utility and end user process applications.

2.1 Key advantages

- S&C is a proven, profitable supplier to the Electrical Utility Sector who has demonstrated our long term and conservative engineering approach for more than 100 years. Utility sector business accounts for over 80% of S&C's annual turnover.
- Extensive experience in the Energy Storage field. S&C are globally recognized pioneers and technological innovators of large scale battery integrated power electronics with over 85MW of systems in service worldwide.



- Over 40MW / 165MWh of EPC energy storage projects in service featuring:
 - **Complex Multiple Renewables integration and micro-grid control, wind, solar, fuel cells, (and diesels) on the one grid-tied dynamically islanding micro-grid.**
 - **Peak Shaving**
 - **Smoothing/Load Following**
 - **Dynamic Islanding (including dynamic load management & load shedding)**
 - **Reactive Voltage Support**
 - **Frequency Regulation**
 - **Arbitrage**

- The first (and to S&C's knowledge the only) Energy Storage supplier in the world to have developed and successfully demonstrated (through actual field outages testing), multiple energy storage projects including proven, functional automated Dynamic Islanding schemes with intelligent load shedding.
- As a true R&D-focused organization and innovator of technologies associated with the power transmission and distribution industry, S&C has a 100+ year history of assisting Electrical Utilities and research institutions with the development and integration of new technologies.
- S&C's in-house system studies group is capable of performing all of the detailed studies required for the successful interconnection of an Energy Storage System, regardless of the size of the grid/micro-grid.
- Close relationships with many battery suppliers. S&C has successfully integrated with a larger variety of battery chemistries and suppliers than any other Energy Storage solution provider and is therefore very well qualified to provide unbiased advice on the selection of the most appropriate battery technology for the project at hand. Below are some of the battery chemistries S&C has integrated with:
 - **Sodium Sulphur (NaS)**
 - **Lithium-Ion (3 different suppliers)**
 - **Sodium Nickel Chloride**
 - **Sodium Metal Halide**
 - **Lead Acid (traditional)**
 - **Advanced Lead Acid (Ultra-battery)**

3. PureWave SMS Capabilities

Our systems are capable of providing the following functionality:

- **Peak shaving** - The SMS will charge and discharge its batteries in accordance with either a pre-programmed load profile or in response to control signals
- **Load Following/Smoothing** - The SMS will respond to control signals received requesting it to import or export real power (within the limitations of the battery). Typical measured response times are well below 50ms.
- **Reactive Power/ Voltage control** - S&C were the inventors of the utility connected inverter based dynamic VAR compensator with our PureWave® DSTATCOM. The SMS shares the same inverter design and control system as the DSTATCOM, as such it is highly capable of providing dynamic VAR compensation up to 1MVAR in order to control system voltage and power factor. Being a true 4-quadrant inverter with sophisticated, multi layered controls, the system can produce both real and reactive power simultaneously, with a variety of control algorithms available that prioritize the various system functions.
- **Frequency Regulation** - Upon receiving a signal from a utility frequency controller, the SMS will inject or absorb real power in order to affect system frequency. Typical response time to a set-point change is less than 50ms however this parameter is also configurable.

- **LVRT** - The SMS has the ability to operate under low voltage conditions and to “ride through” faults occurring elsewhere on the system. Since the SMS Battery System has its own source of real power, the LVRT capabilities are far greater than systems that use VAR’s alone, however the exact extent of the LVRT capabilities of the SMS cannot be determined until detailed system studies are completed.
- **Dynamic Islanding** - S&C have extensive experience with Dynamic Islanding. Our first Energy Storage system with dynamic islanding functionality was installed in 2006 and since then we have installed an additional 6 systems ranging from 1MW to 4MW in size. If the RMS voltage on any of these phases falls below 10% of nominal, or upon receiving an external signal to do so, the SMS master control will automatically open an upstream isolation device and the SMS will supply the load from the batteries. The transition time to supply good power to the load will depend on the breaker opening time, the voltage sag characteristics and load characteristics. The SMS typically supplies the load within one to two cycles after the breaker opens.

3.1 1MW SMS Basic Description



The 1MW PureWave SMS is housed in a single 20 foot ISO container as seen in the above photo. The inverter module has its own local controls which are located in a sealed cabinet on the front of the inverter module and the system master controls are housed in a segregated, sealed, air-conditioned room. AC and DC power cables all enter through the same side of the container and all control cabling enters through a separate gland-plate located in the control room. Exhaust hoods are made from light-weight, corrosion resistant aluminium and all external fixings are stainless steel. Below are 3D illustrations of the 1MW PureWave SMS system in a 20 foot ISO shipping container.

