APPLICATION NOTE

Renewable Energy Telecom Tower Power:

Greenfield and retrofit applications of the eIQ Energy Inc.'s Technology

eIQ Energy Inc. designs and develops power electronics, software, interface and customer applications for electric power production. While the applications tend to have renewable energy as prime power sources, the components are designed to operate autonomously and can be used with various sources including generators, AC and DC microgrids, and utility grids. Incorporating scalability such that customers need only address their present power needs and simply add sources and loads at their discretion or as funds permit, the eIQ approach also offers repeatability for installers and procurement and construction firms. Install once and repeat; no steep engineering learning curve. It is this scalability and repeatability that makes the eIQ solution a natural for addressing many installations for the same application although these applications may have differing power source constraints. This paper describes the application of the eIQ components to powering cellular telecommunications tower, whether they are greenfield or retrofits.

Diversity of Cellular Telecom Tower Power – loads and sources

Uptime is a critical aspect of cellular telephone systems. Loss of use equals loss of income, so systems are designed with built in redundancy, especially the power systems. In urban areas, power is typically provided through the local utility grid, with fuel based generators as back up sources. In more rural areas, or where access to the utility grid is problematic, generators may be the primary source. Renewable energy sources, such as solar power, are rapidly being incorporated with either generators or batteries. In addition to source diversity, load diversity is also evident. In cooler climates, the power may be solely for the transceivers and peripheral electrical gear, while in warmer zones, air conditioning of the radio stations is necessary , significantly upping the power requirements. For companies involved in the design, maintenance and operations of telecom towers, common components provide a lowering of these costs and reduced replacement inventory costs.

Base Transceiver Stations (BTS)

Virtually all stations have similar base transceiver stations, which require 48Vdc power sources. These are typically 1.5 – 2kW per BTS and several may coexist within the same installation. This power is mission critical. Switched Mode power supplies convert the AC to DC, but may also introduce harmonic distortion depending on their topology and quality (cost).

Lighting

Typically a few hundred watts per station, especially if the BTS is enclosed in a radio shed. Newer. LED lights replace older, less efficient incandescent or CCFL lights. LED lights can be run off either AC or DC.

Ventilation

Ventilation, without air conditioning, is usually temperature or time controlled, and electric motors open or close louvres as needed. Power draw is confined to periodic use, but the loss of such power could affect the performance of the system.

Air Conditioning

Air conditioners can be either AC or DC, with most installations using older AC drive units. While these units can be rated at 2kW, they actually need power sources sized at 5-10X that rating because of motor start up characteristics and a condition known as locked rotor amps, where the refrigerant essentially locks the motor and the motor then draws 5-10X the current to try to rotate the locked rotor. This alone adds considerable cost to power the station. DC driven air conditioner motors do not have the same condition and are advisable for either greenfield or AC air conditioner replacement. Air conditioning redundancy is not uncommon and can effectively double the number of air conditioners (but does not double the power since the air conditioner s do not run simultaneously).

Besides the locked rotor amp syndrome, AC motor start up can also introduce noise into the electric power system, noise which has to be filtered or shielded via line conditioners.

Utility Grid Power

To address all of the needs above, grid power is primarily used wherever possible. This grid power can be either single or three-phase, although for three-phase, each of the phases is used to power a block, rather than all three phases used for a single component. Load profiles of air-conditioned stations is typically in the 25-50kW range. The AC is then junctioned with an AC backup source, such as a fuel based generator via an automatic transfer switch which sense the loss of the utility grid and rapidly switches over to the back up generator. Any lag time between loss of grid and generator start up can adversely affect the stations transmissions.

Noisy or poor quality grid power will also need line conditioners to remove spikes and noise.

Generator Power

Generators can be used for either back-up, in the event of loss of grid, or as primary power sources when the grid is unavailable. Considering the negative aspect of generators- fuel costs, pollution, audible noise and maintenance costs, there is a movement replacing generators with renewable, battery equipped power sources. Generators can also be a source of sine wave distortion, hence the need for additional line conditioning.

In colder climates, engine block heaters will be needed, especially when the generator is used as a backup, effectively increasing power consumption from other sources.

Battery Backup

Batteries are commonly used to augment generators as back up systems. The batteries provide instantaneous back-up and the generators can then be efficiently run to recharge or top off the batteries. Lead acid (VRLA) are predominantly used, but with the continued drop in LiIon battery prices they are steadily being replaced by LiIon, which require less space (higher energy density), have longer cycle life and have virtually no maintenance compared to lead acid.

Solar Power

Solar power is increasingly under consideration for contributing power to the system. The challenge with solar power is that it is not dispatchable – it is only available when the panels are illuminated and then the power is proportional to the irradiance incident on the panels. While it can be used to augment other power sources, to be truly effective, it needs pairing with energy storage devices to provide an uninterruptible source of power. Solar power also needs Maximum Power Point Tracking electronics to ensure maximum energy is harvest from the PV array.

Solar power also increases the footprint of the installation, although in urban settings roof space can be leased for mounting the PV-modules, while in rural areas space may not be a factor.

Wind

Like solar, wind is not a dispatchable power source and needs storage to be effective. Wind can be an effective renewable energy source in areas where solar is not an option or where there is a predictable, continuous wind, or it can also augment any or all of the other sources.

Retrofit or Greenfield

In retrofit applications the critical components are already in place and it is the power sources and distribution that must be retrofitted to bring the installation to a desired operating level. Generators as primary, or secondary, sources are to be replaced with renewable energy coupled with energy storage devices. Utility grid is to be replaced with renewable energy plus energy storage due to economics or as a result of destructive or catastrophic events such as hurricanes, fires or conflict. In any case, it is desirable to perform the changes with as little disruption to the existing structures as possible, with minimal re-engineering design and with confidence that the modifications will operate and perform as planned.

In greenfield applications, the designer has the ability to optimize the design and choose components that best fit the installation. DC based air conditioning, DC bus distribution and minimal conversions between DC and AC provide opportunities for major efficiency gains resulting in dramatically lower power and energy costs. Additionally, greenfield applications can have a set of components, or building blocks, that are common to each installation and thereby reduce engineering, installation, maintenance and operations costs for the life of the site.

eIQ Energy Component Overview

Before delving into the various aspects of either retrofit or greenfield applications, a brief overview of the eIQ building blocks provides a reference for appreciating the advantages of such an approach and how easy it is to scale or replicate solutions.

High Voltage DC (HVDC) Backbone

The HVDC backbone forms the foundation upon which the other components operate because each component can be normalized onto a common structure regardless of that component's native operation. Disparate sources such as PV-modules, batteries, fuel cells, generators, AC grid, wind and small hydro turbines, as well as other similar microgrids can contribute their individual maximum power and energy. Common protocols allow for tailoring power and energy according to preferred business or operational rules that can be either autonomous or established by the operator. Loads can be supplied according to their individual needs through DC DC converters or DC AC inverters.

It is on this backbone that eIQ builds its suite of power and energy products.

Solar Power

Solar power is harvested from the PV and converted onto a high voltage DC (HVDC) bus for transmission to the other power components. The converter, the vBoost, makes each solar PV-module an independent power generator that has its own Maximum Power Point Tracking (MPPT). PV-modules can have different power levels, orientation and environmental conditions without affecting any other PV modules within the same system, and the system can be easily expanded by simply adding PV-modules as needed. The converter can be either free standing (applicable to virtually any PV-module make) or integrated directly onto the PV-module for efficient and familiar installation.

The vBoost is capable of up to 380W power conversion and can be used on multiple PV technologies such as crystalline silicon, CdTe and CIS/CIGS. It has an optional power line communication system that provides two-way communication between the PV modules and a central data-concentrator. This can be used for power monitoring, remote shutdown, anti-theft alarms, power conditioning (power curtailment) and maintenance trigger points.

Because each PV-module operates as an independent power generator and behaves as a current source, two to three times more power (up to 12kW) can be transmitted over the same ampacity wire as traditional series string arrays. This power generation independence offers additional benefits to space constrained installations where PV-modules may be installed in non-traditional array configurations.

Transmitting the power at a higher voltage also benefits locating the PV outside the immediate perimeter, such as on adjacent structure rooftops or ground mounts because the line losses are negligible compared to low voltage, high current transmission where considerably larger conductors are required.

The converters can be easily combined with modules from Merlin Solar to provide a virtually hurricane proof solar power system.

Batteries and Fuel Cells

Batteries, through a bidirectional DC DC converter, can be deployed onto the HVDC bus and charged or discharged as conditions dictate. This converter integrates with the battery management system (BMS) to set charge and discharge operating conditions depending on the chemistry of the batteries used and different battery chemistries, such as LiIon and Lead Acid could be used within the same installation.

For high surge applications, such as air conditioner Locked Rotor Amps (LRA) where from 5X to 10X the power is typically budgeted, super-capacitors can be used to reduce the number of batteries, keeping costs down.

Fuel cells, can also be integrated into the system and feed power onto the same common HVDC bus. Typically, fuel cells cannot be stacked (like batteries) to increase their output voltage. The same DC DC architecture used for the 48V to HVDC can be used to convert the fuel cells to the same operating voltage.

eIQ DC DC converter is capable of handling up to either 4kW (at 48V battery voltage) or 8kW (at 96V battery voltage) and controls the charge and discharge rates set by the BMS and user settings. Using bus voltage levels to rapidly trigger charge or discharge operation, the battery/converter pack can respond immediately to load demands.

Multiple battery packs equipped with the DC DC converter can be paralleled for virtually any desired energy storage and power output level. Additional units can be added at a later stage when power demand increases and as funds permit.

AC DC Rectifier

Converting to DC from AC sources such as utility grids, generators, wind turbines and AC microgrids is accomplished by a 16 kW rectifier. This bridge-less rectifier can input either single or three phase and multiple rectifiers can be paralleled for increased power handling. Designed for 120/240Vac, the bridgeless architecture significantly reduces harmonic distortion that is typically found in rectifiers, removing the need for additional line conditioning equipment. The rectifier operates autonomously as load demands increase or decrease and as the availability of other sources vary. It can also be controlled should the operator want to provide business rule operation.

The rectifier can also be equipped with an optional generator autostart circuit for generator backup and operational power.

DC AC Inverter

The eIQ inverter is a single phase 240/120Vac, 50/60 Hz (pure sine wave), 16kW, off-grid inverter that can be paralleled for increased power delivery to AC circuits and loads. This inverter is designed using state of the art silicon carbide FETs for small form factor and high conversion efficiency. It also features a hybrid active filter front end to greatly reduce the amount of electrolytic capacitors normally required for double frequency power ripple. The inverter is capable of high surge power delivery for locked rotor amp situations with AC motor based air conditioners.

The inverter is grid forming and can be used (under proper conditions) as a grid synchronizer for grid tied inverters present on the same HVDC bus. Unlike other off-grid inverters, the eIQ is designed for high voltage DC input and is optimized for 380Vdc operation.

The HVDC bus is also compatible with other grid tied and hybrid inverters for added flexibility.

DC DC converters

For equipment operating at 48Vdc, DC DC converters are available for down conversion from 380Vdc. Other DC voltages can also be supplied. DC operated air conditioners are significantly more efficient and do not require oversizing as in AC based air conditioners. For instance, a typical 2kW AC based air condition-

WEB: http://www.eIQenergy.com
ph: (800) 660-1320 email: info@eIQenergy.com

er's efficiency ranges from 46-51% (lower if an inverter is needed to convert from DC to AC), while a similar output DC based air conditioner will be 70-72% efficiency, thereby reducing the amount of power and energy requirement.

Data Monitoring and Control

Each eIQ component is equipped with a micro-grid link (uGridLink) that communicates with other uGridLinks within the system for data monitoring, data gathering and control. While the components can operate autonomously, the operator may want to have certain business rules apply, such as time of day grid use, battery capacity level maintenance, generator noise reduction and so forth. In addition, the uGridLinks communicate via Bluetooth to a smartphone based app for remote monitoring and operational settings. Other data transfers are also on each board - WiFi, Serial data, Modbus/Canbus and Ethernet.

Scenario Examples

eIQ system is highly flexible and easily configured to adapt to a wide variety of scenarios. Install only the needed components and add others on an as-needed basis, thereby keeping capex costs to a minimum.

Retrofit Existing Installations

- Solar, battery storage and off-grid inverters can be installed into existing grid tied or generator supplied installations. Such a system will mimic the grid and all internal equipment, converters and BTS units will operate as if tied to their original power sources.
- For generator supplied installations (no grid), adding battery storage alone will significantly increase the generators efficiency since it will be used to keep the batteries charged. Generators become highly inefficient when supplying loads lighter than their optimum, which means higher fuel and maintenance costs.
- Solar alone can be added to help offset expensive power or augment generator based power. While this power is not stored, it can help defray operational costs.
- Adding solar to an existing site can be challenging if the space is constrained. Transmitting the solar power over the HVDC bus reduces the current and decreases line losses while keeping the wire size small. Additionally, with the vBoost, the solar panels can be placed virtually anywhere, in any orientation providing maximum flexibility.
- The system is compatible with lead acid batteries which do not need immediate replacement when retrofitting a system. As these batteries age, replacing them with either lead acid or LiIon chemistries is now possible.

Greenfield Installations

- New installations offer the opportunity to optimize system performance at reduced capex and opex costs. System sizing is optimized and greatly reduced from AC equipped systems - typically from 25kW or 50kW down to less than 10kW or 20kW. System sizing is now predominantly the BTS and any air conditioning at nameplate (not surge).
- DC based power system for LED lighting, DC air conditioning, DC loads and battery storage is cost and energy efficient.
- Easy conversion to AC for any loads that must be AC powered. If no AC power is needed then inverter capex costs are eliminated.
- AC sources are easily coupled into the DC bus for added flexibility and redundancy. Such sources can be added any time with system disruption or reconfiguration.
- Disparate sources can be easily blended into a single power system. The blending operation can be either autonomous or directed by the system operator based on costs and other requirements.

Key Feature Summary

- ☑ Ease of Design
- ☑ Ease of Installation
- ☑ Repeatability
- ☑ Reliability
- ☑ Flexibility
- ☑ Scalability
- ☑ Lower Capex
- ☑ Lower Opex

web: http://www.eIQenergy.com
ph: (800) 660-1320 email: info@eIQenergy.com