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Conext™ XW+/XW/SW/MPPT SCC - Load Shedding and Load Shifting to Address Time-of-Use (ToU) Metering and Peak Demand Tariffs

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Application Note

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RISK OF FIRE, ELECTRIC SHOCK, EXPLOSION, AND ARC FLASH

This Application Note is in addition to, and incorporates by reference, the relevant product manuals for each product in the Conext series. Before reviewing this Application Note you must read the relevant product manuals. Unless specified, information on safety, specifications, installation, and operation is as shown in the primary documentation received with the product. Ensure you are familiar with that information before proceeding.

Failure to follow these instructions will result in death or serious injury.

Objective

The purpose of this Application Note is to explain how to configure the Conext XW+/XW/SW system to perform Load Shedding and Load Shifting, in order to reduce or avoid consuming energy from the grid (also referred to as AC mains or utility) during Time-of-Use (ToU) and Peak Demand periods. When configured for Load Shedding and Load Shifting, the asset owner (power consumer) consumes energy at a lower electricity rate or relies less on the grid with the support of the battery.

The Conext products below can utilize Load Shedding and Load Shifting:

Product	Models
Conext XW+	7048E, 8548E, 5548, 6848
Conext SW	2524, 4024, 4048
XW	4024, 4548, 6048
Conext MPPT SCC	MPPT 80 600, MPPT 60 150
Conext ComBox	n/a
Conext Battery Monitor	n/a

Definitions and Abbreviations

ToU	Time-of-Use
DoD	Depth-of-Discharge

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SOC/SoC	State-of-Charge
SCC	solar charger controller
PV	photovoltaic or solar
power consumer	asset owner

Use Case Scenario

A residential asset owner (power consumer) who has Time-of-Use (ToU) Metering will consume grid energy charged at different rates according to time-based usage rather than accumulated energy at fixed rate.

For ToU Metering, the electricity rates (in Australia) are normally charged with the following price schedule, where N is the cent value:

Off Peak Rate	$0.N/kWh
Shoulder Rate	approximately ($0.N x 2)/kWh
Peak Rate	approximately ($0.N x 4)/kWh

Both peak and shoulder rates occur during periods when solar energy can be generated. However, solar energy is intermittent, and the residential power consumer who does not have matching load and solar generation profiles would not be able can to fully utilize the solar energy yield. In this case scenario, the power consumer needs a grid-tied solar photovoltaic (PV) array with battery storage to conduct Load Shedding and Load Shifting by converting solar energy to a non-intermittent form of energy supply.

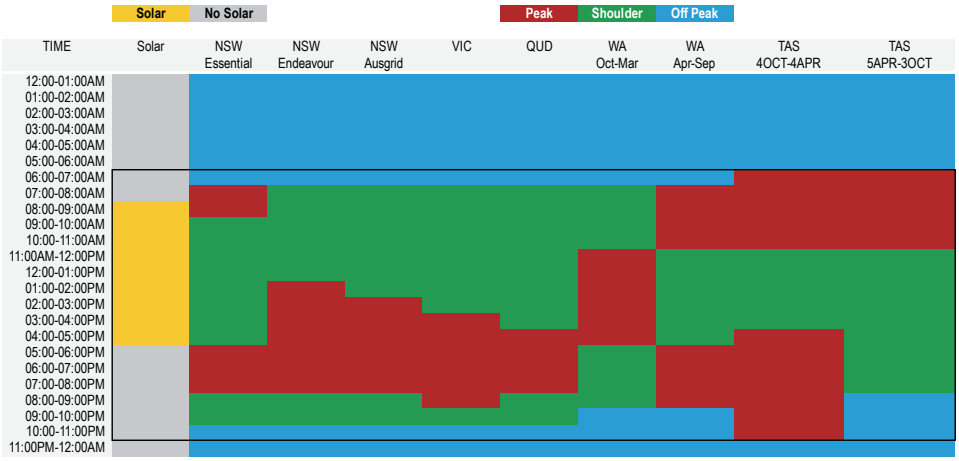

Figure 1 Time-of-Use (ToU) Period in Australia[a]

a.ToU is not available in all jurisdictions. Check with the local power utility if ToU is available.

A commercial power consumer who is subject to a Peak Demand tariff from the utility company is required to pay extra charges based on the previous month's Peak kVA reading in averaged 15-minute interval which is in addition to their per kWh usage. In many cases, the Peak kVA reading only happens several times within a month. Therefore, a battery storage solution is utilized to address peak demand power draw from the grid. This solution subsidizes grid current using energy stored in the battery and ensures current draw from the grid is not exceeded.

Cases for Application

- The battery is sufficient to cope with energy consumption during ToU period before sunrise (6:00AM-8:00AM) and after sunset (5:00PM-11:00PM). The PV system will need to generate energy sufficient for load consumption during ToU period (6:00PM-11:00PM).
- The battery is sufficient to cope with energy consumption outside solar generation period from evening to morning (5:00PM-8:00AM). The PV system will need to generate energy sufficient for load consumption throughout the day (12:00AM-12:00AM).
- The battery is sufficient to cope with energy consumed between peak load and base load throughout the day. The PV system will need to generate energy sufficient for the battery's storage capacity.

When Load Shedding and Load Shifting are Not Applicable

- If battery storage is meant to be 100% charged all the time such as when the intended application is to act like a UPS power backup system.
- If the system is totally standalone or off-grid.
- If the system is connected to an erratic and unreliable utility grid network which often causes batteries not to be fully charged.
- If the system relies on an AC-coupled PV inverter that generates and feeds solar energy directly to loads.

Feature

Load Shave

This feature allows the power consumer to define the "Maximum Current" draw allowed from the grid within a specific time frame in a day. The designated Time Period would be continuous, meaning there is a single "Start Time" and a single "Stop Time" repeated daily.

Enhanced Grid Support or Enhanced AC Support

Enhanced grid support is a feature which ensures that the battery is maintained at absorption stage until sunset by getting charged through a DC-coupled solar charge controller. The MPPT solar charge controller (MPPT SCC) ensures that the battery has sufficient state-of-charge (SOC) and is ready to supply energy for the night until sunrise or until the battery runs out.

This feature is referred to as Enhanced Grid Support in Conext XW+/XW. In Conext SW, it is called Enhanced AC Support.

To be able to utilize this feature and prioritize charging the battery throughout the day while doing Load Shave, the XW+/XW/SW system requires DC-coupling the solar array with either of the MPPT solar charge controllers below:

- high voltage solar charge controller - Conext MPPT 80 600
- low voltage solar charge controller - Conext MPPT 60 150

Charge Block

This feature allows the power consumer to define the Time Period when the battery is not allowed to be charged from the grid. The designated Time Period would be continuous, meaning there is a single “Start Time” and a single “Stop Time” repeated daily.

Procedure

These are the major steps in configuring the systems for Load Shedding and Load Shifting:

1. Define the battery parameters within Inverter Settings, Charger Settings, Battery Settings/Custom Battery Settings. **These settings remain constant**.
2. Define Load Shave parameters, Grid Support parameters and Grid Sell parameters within Grid Support Settings. **These settings can be tuned according to seasons**.
3. Define Charge Block Setting and Maximum Charge Rate within Charger Settings. **These settings will be based on ToU or Peak Demand requirements**.
4. Observe Battery SOC, Battery Voltage, PV and AC Daily Summary Trending, Batter Bank Daily Summary Trending and re-adjust Recharge Voltage and Low Battery Cut Off (LBCO) Voltage. **These settings will be tuned according to battery capacity and performance observation**.

Define Battery Parameters within Inverter Settings, Charger Settings, and Battery Settings/Custom Battery Setting

1. Set the voltage parameters of the battery according to recommended settings by the battery manufacturer.

   Check the battery manual’s recommended settings and compare them to the default settings for Flooded/Gel/AGM batteries for the XW+/XW/SW. If the recommended settings in the battery manual do not match the default settings, use Custom Battery Settings instead.
2. Inverter Settings
   - **Low Battery Cut Off (LBCO)**: set according to the battery manual’s recommended minimum battery voltage.
   - **High Battery Cut Off (HBCO)**: set according to the battery manual’s recommended maximum battery voltage.

3. Charger Settings/Custom Battery Settings
   - **Battery Bank Capacity**: according to installed Battery Bank Ah @ C20 rate
   - **Maximum Charge Rate**: calculated in percentage as Maximum Charge Current Allowed by Battery Manufacturer ÷ Inverter Maximum Charge Current
   - **Maximum Charge Rate for Commercial (with Peak Demand tariff)**: calculated in percentage as (Maximum Charge Current Allowed by Battery Manufacturer ÷ Inverter Maximum Charge Current) < Average Base Load Current
   - **Recharge Voltage**: Battery Voltage @ Desired Depth-of-Discharge (DoD)
   - **Charge Cycle**: XW/SW 2-stage, MPPT SCC 3-stage
   - **Equalize Support**: Enable for Flooded Battery. Disable for AGM/Gel Battery
   - **Equalize Voltage**: only define voltage setting for Flooded Battery
   - **Bulk Voltage, Absorption Voltage**: refer to battery manual
   - **Float Voltage**: refer to battery manual
   - **Battery Temperature Coefficient**: refer to battery manual
   - **Absorption Time**: refer to battery manual
   - **Low Battery Cut Out Hysteresis**: 2.0V

Define Load Shave Parameters, Grid Support Parameters and Grid Sell Parameters within Grid Support Settings

1. Define Grid Support parameters:
   - **Grid Support** mode **(XW+/XW)** or **AC Support** mode **(SW)**: Enable
   - **Grid Support Voltage (XW+/XW)**: 64.0V (for 48Vdc Battery Bank)
   - **AC Support Voltage (SW)**: 32.0V (for 24Vdc Battery Bank)
2. Select the Start Time and Finish Time for Load Shave to occur.
   - **Load Shave Start**: Beginning of Time of Use period. For example, 06:00AM or 07:00AM
   - **Load Shave Finish**: End of Time of Use period. For example, 10:00PM or 11:00PM
   - If this is to address Peak Demand Tariff then **Load Shave Start** should be 12:00AM and **Load Shave Finish** should be 12:00AM
   - If the power consumer wants to rely less on the grid then **Load Shave Start** should be 12:00AM and **Load Shave Finish** should be 12:00AM
3. For SW system, **PLS Dly 2h** allows SW to conduct Load Shave only after a two-hour delay to allow the battery to be charged by the MPPT SCC in Float Stage. Choose to enable or disable this feature.

4. Define the Load Shave's Maximum Current draw allowed from the grid.
   - **Residential Load Shave Amps**: 0 Amps
   - **Commercial (with Peak Demand tariff) Load Shave Amps**: Average Base Load Current to maintain current draw from the grid not exceeding Base Load
   - **Commercial (without Peak Demand tariff) Load Shave Amps**: 0 Amps

Define Charge Block Setting and Maximum Charge Rate within Charger Settings

1. Select the Charge Block Start Time and Finish Time to avoid the battery getting charged from the grid.
   - **Charge Block Start**: Beginning of Time of Use period. For example, 6:00AM or 7:00AM
   - **Charge Block Stop**: End of Time of Use period. For example, 10:00PM or 11:00PM
2. If the battery is sufficiently sized to cope with energy consumption outside solar generation period from evening to morning (5:00PM-8:00AM) and the PV system could generate energy sufficient for load consumption throughout the day (12:00AM-12:00AM) then XW+/XW's can be selected not to charge the battery using the grid by changing the control setting:
   - **Charger Enable/Disable**: Disable
3. For Commercial Power Consumer with Peak Demand Tariff, the load is usually large and peak demand most likely happens at daytime during business operating hours. Hence, it is recommended to define a sensible Load Shave Amps according to Base Load, and at the same time allow the battery to be charged using the grid at off-peak period between midnight and early morning. This way, the battery would have high SOC and ready for the beginning of business operating hours before sunrise. If the power consumer does not allow charging from the grid, the battery will be depleted in the morning and not able to address the high demand in the morning when appliances and equipment are being started. In this case, XW+/XW should allow:
   - **Charge Enable/Disable**: Enable.
   - **Charge Block Start**: Beginning of Business Operating Hour. For example, 6:00AM or 7:00PM
   - **Charge Block Stop**: End of Peak Time. For example, 10:00PM or 11:00PM
   - **Commercial (with Peak Demand tariff) Load Shave Amps**: Average Base Load Current to maintain current draw from the grid not exceeding Base Load

Observe Battery SOC, Battery Voltage, PV and AC Daily Summary Trending, Battery Bank Daily Summary Trending, and Re-tune, Recharge Voltage and Low Battery Cut Off (LBCO) Voltage

1. "PV & AC Daily Summary" trending in Conext ComBox page provides a good visibility whether the power consumer has successfully defined the correct time for Load Shave and Charge Block and how many hours the battery can usually last after sunset. These two parameters could be readjusted according to system need.
2. In some cases, the battery manufacturer's operation manual does not provide an accurate battery voltage value to reflect the correct DoD because this information is presented in graph form or due to cable loss which occur at the system. Hence, it is important for the power consumer to install a Conext Battery Monitor for this purpose and to find out (at the desired DoD or SOC) what is the Battery Voltage in decimal value. This could be observed from "Battery Bank Daily Summary" trending.
3. The power consumer will use the Conext Battery Monitor to investigate what is the Battery Voltage at 60-65% of SOC and in general, this value shall be set as the Recharge Voltage. When selecting the desired DoD, remember that Load Shedding and Load Shifting application may have more than one charge/discharge cycle per day. In general, for a system which does not have tuning support, XW+/XW/SW's:
   - **Recharge Voltage**: Battery Voltage @ 60-65% SOC
   - **Recharge Voltage**: if <47Vdc (for 48Vdc Battery System) or <23.5V (for 24Vdc Battery System) will raise "W48 DC Under Voltage" warning. Ideally, the Recharge Voltage shall not be lower than these values.
4. For XW system, the battery is regulated according to Low Battery Cut Off (LBCO). Therefore, it is important to understand that the Battery Voltage at 60-65% SOC shall be equivalent to LBCO +2V.
   Ensure that this defined Low Battery Cut Off (LBCO) value does not void battery warranty.
   - **Low Battery Cut Off (LBCO) for XW**: Recharge Voltage – 2V < Battery Voltage @ 50% SOC
   - **Low Battery Cut Off (LBCO) for XW**: Recharge Voltage – 1.5V (with 0.5V margin)
5. For XW+ System, the battery is regulated according to Recharge Voltage. Therefore, the Battery Voltage at 60-65% SOC shall be equivalent to Recharge Voltage +0.5V.
   - **Recharge Voltage**: Battery Voltage at 60-65% SOC – 0.5V
6. For SW System, the battery will conduct Load Shave until battery voltage reaches Low Battery Cut Out (LBCO). However, SW System will initiate Charge Cycle when Battery Voltage has reached Recharge Voltage.
7. DC-coupled PV system utilizing MPPT SCC should use Enhanced Grid Support feature to prioritize battery charging and health. If Enhanced Grid Support is not used, Grid Support Voltage should be set according to Battery Voltage @ 100% SOC.
   - **Grid Support Voltage (without using Enhanced Grid Support)**: Battery Voltage at 100% SOC

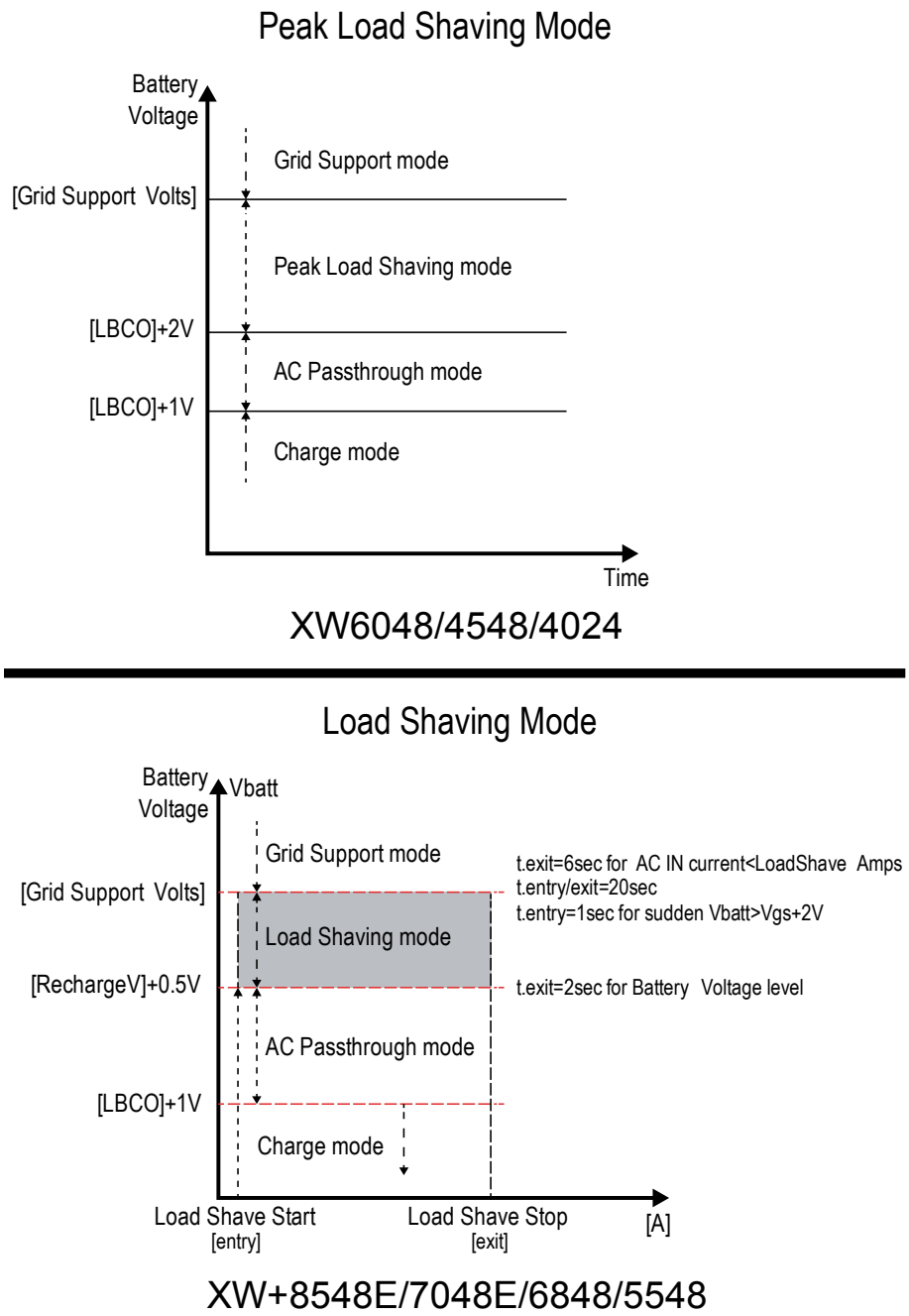

Figure 2 Conext XW+/XW Peak Load Shaving

Troubleshooting and Observation

Using a Residential Load Shedding example, with Load Shave set to 0 A for all time and charging from the grid is disabled on the XW+/XW, and with Grid Sell also disabled, the following three scenarios could arise:

Scenario 1: Ideal scenario with strong irradiance and system sized correctly according to Load Profile, for application to avoid drawing from grid during Time-of-Use (08:00-23:00 [8AM-11PM]) period.

Below “PV & AC Daily Summary” shows that the system is conducting Load Shedding from 08:00-23:00 [8AM-11PM] (ToU Period). The DC-coupled PV system using Enhanced Grid Support has generated enough solar energy to charge battery and to support daytime load. The battery has been fully charged before sunset and ready for the evening to conduct Load Shedding till battery reaches DoD.

Figure 3 PV & AC and Battery Bank for Scenario 1

Scenario 2: Fluctuating irradiance scenario and cloudy day. Solar has been converted to non-intermittent source of energy.

Below “PV & AC Daily Summary” shows that the system only manages to conduct Load Shedding from 09:00-15:00 [9AM-3PM] (ToU Period). The DC-coupled PV system using Enhanced Grid Support has not generated enough solar energy to charge battery. The solar energy could only be used to support six hours of daytime Load but nevertheless solar energy has been converted to non-intermittent source of energy to support Load with the battery.

Figure 4 PV & AC and Battery Bank for Scenario 2

Scenario 3: Weak irradiance scenario.

Below “PV & AC Daily Summary” shows that the irradiance is very weak and system could hardly conduct Load Shedding. Generated solar energy is fully consumed by daytime load. This scenario could happen during bad weather. The load demand consumption has completely overtaken solar energy generation.

Figure 5 PV & AC and Battery Bank for Scenario 3

Using a Commercial Load Shedding and Load Shifting application example, with Load Shave configured to 5 A from 08:00-23:00 [8AM-11PM] and Charge Block is set from 06:45-23:15 [6:45AM-11:15PM], the following two scenarios could be observed:

Scenario 1: Excess solar energy with battery SOC remains high.

During daytime, the excess DC-coupled solar energy generated by MPPT SCC with Enhanced Grid Support is fed directly to the load because the battery is fully charged. At evening, because the system has been set to do Load Shave 5 A and until 23:00 [11PM], hence, there is a flat red line after sunset. Battery is allowed to be charged using grid energy after 23:15 [11:15PM] for Load Shifting purpose and ready to conduct Load Shedding the next morning.

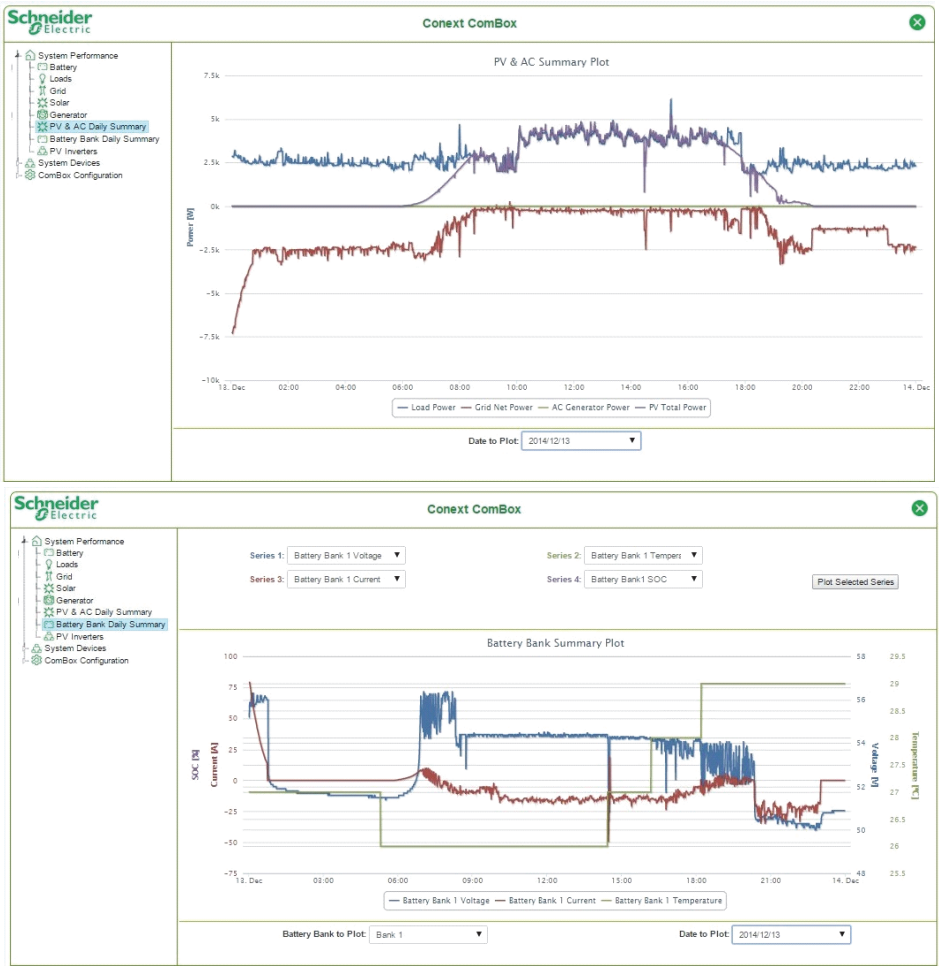

Figure 6 PV & AC and Battery Bank for Scenario 1

Scenario 2: Large daytime demand with no excess solar energy.

The generated solar energy is only enough for daytime load demand to limit current draw from the grid to < 5 A and battery charging. The Load Shave has been set to 5 A and hence, there is a flat red line from sunrise to sunset. This is different from the previous scenario because daytime load has consumed a high amount of energy and battery is not in fully charged state throughout the day until 16:00 where the red line is touching 0 kW. After 18:00 [6:00PM], the battery continues to do Load Shave to 5 A until 23:00 [11:00PM] and getting charged after 23:15 [11:15PM].

Figure 7 PV & AC and Battery Bank for Scenario 2

Exceptions

In order to ensure Load Shedding and Load Shifting application works according to expectation, a system designer will need to size the PV Array and the battery capacity by taking into account seasonal changes and load profile information. The expectation of Load Shedding and Load Shifting should not be constant, meaning that the system designer should not assume daily irradiance is strong and the load profile remains constant, but rather the scenario is subject to climate changes and usage factors.

When approaching Load Shedding and Load Shifting application, a system designer should find out the energy consumption from sunrise until sunset, energy consumption from sunset until sunrise, and solar performance (kWh/kWdc/day) in that specific location and comparing that with battery capacity. Battery Capacity (Ah) and PV Array (kWdc) should be sized with contingency.

Load Shedding and Load Shifting applications would require energy from the battery because energy demands happen at any time. Hence, it is recommended to have a DC-coupled PV system instead of AC-coupled PV system.