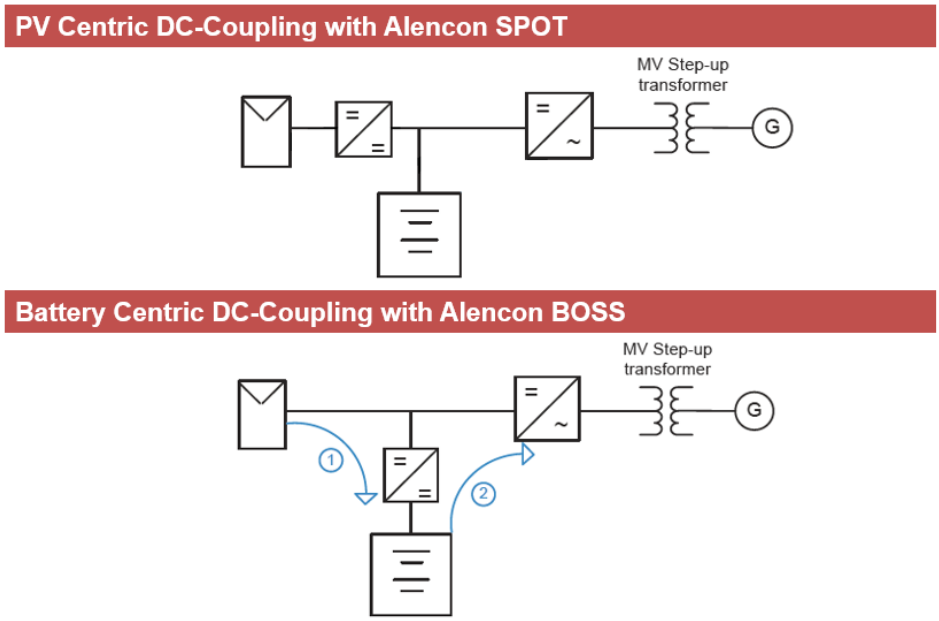

PV CENTRIC VS BATTERY CENTRIC DC-COUPLED SOLAR + STORAGE TOPOLOGIES

Which Approach Is Right for Your Next Solar Plus Storage Project?

Abstract

This white paper explains two methods for DC coupling solar and storage and unpacks the relative merits of each approach to help inform your system design choices.

Alencon Systems
info@alenconsystems.com

Contents

Introduction 2

PV Centric vs. Battery Centric DC Coupling Defined 3

When Does the Battery Centric Approach Make Sense? 4

When Does the PV Centric Approach Make Sense? 5

Summary 6

Figure 1 – Overview of DC-Coupled solar plus storage topologies. 2
Figure 2 – Schematic diagrams of a PV-centric approach to DC coupled Solar + Storage. 3
Figure 3 – Schematic diagrams of a battery-centric approach to DC coupled Solar + Storage. 4

Table 1 A summary of the relative merits to the PV and battery centric approaches to DC coupling of Solar + Storage. 6

PV Centric vs. Battery Centric DC Coupling: Which One is Right for Your Next Solar + Storage Project?

As DC-coupling grows in popularity, you will want to be sure to choose the right method for you next DC coupled Solar + Storage project. This article explains some factors to consider.

Author's Note: This white paper includes a number of embedded links to dive deeper into some of the technical points it raises. We've done this because we don't want to overwhelm with too much information but also want to make sure you have access to more information at your fingertips should you wish.

Introduction

The combination of solar plus storage continues to grow in popularity and deployed megawatts with each passing day. There are of course two ways to combine solar and storage, DC coupling and AC coupling. This white paper is will focus on the DC coupled approach to combining solar and storage, where the solar array and battery share the same inverter. Specifically, it will discuss two different approaches to DC coupling solar and storage, what we will refer to as the "PV Centric" and "Battery Centric" approach and the relative advantages of each approach.

As a manufacturer of DC:DC converters that support both of methods of DC coupling, here at Alencon we focus on counseling our customers on what the most sensible DC coupled approach for their application is.

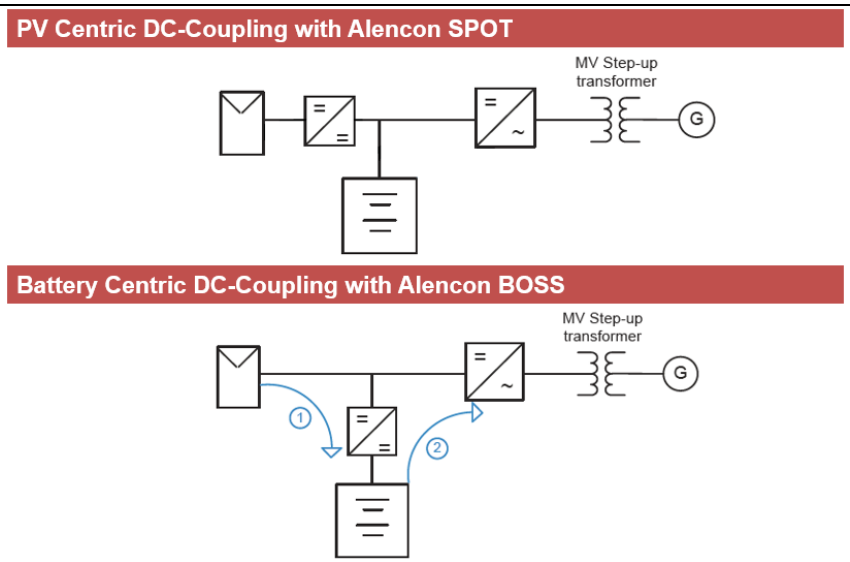

Figure 1 – Overview of DC-Coupled solar plus storage topologies.

The line drawings above provide a basic overview of two different DC coupled topologies. While these are shown in reference to Alencon's products, these diagrams are quite generic in nature. The drawing on top shows a PV centric approach to DC coupling while the drawing below shows the Battery centric approach.

PV Centric vs. Battery Centric DC Coupling Defined

Here at Alencon Systems, we build two products to support these two methods of DC coupling. The SPOT offers a PV centric approach, one where a unidirectional DC:DC converter is installed between the PV panels and a DC bus connecting a battery energy storage system (BESS) and an inverter. In this arrangement, the power flows from the PV panels in one direction through the DC:DC converter to directly charge a BESS. In this topology, the SPOT's job's is to harvest solar energy, a process known as maximum power point tracking (MPPT). The device then changes the distribution of the harvested current and voltage to a different level of current and voltage on the device's output which is needed to charge or discharge the battery, a process referred to as voltage mapping.

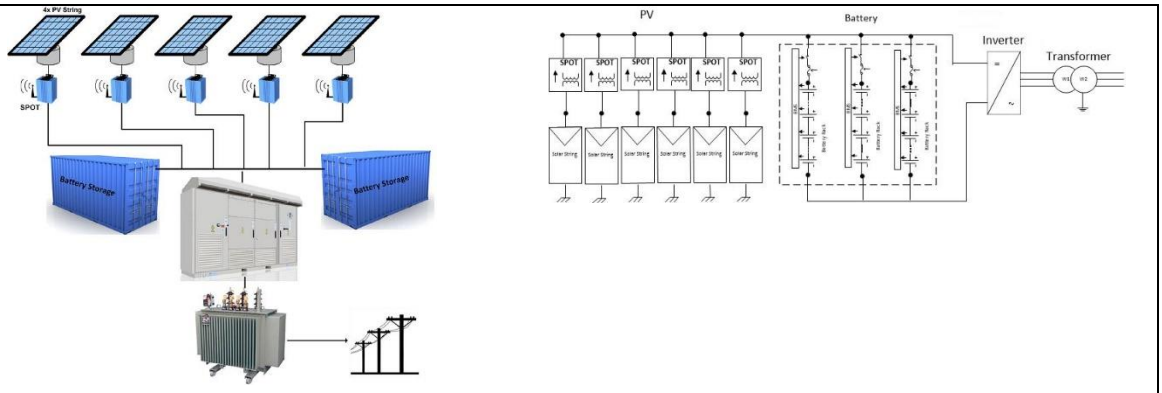

Figure 2 – Schematic diagrams of a PV-centric approach to DC coupled Solar + Storage.

The drawings shown above provide more detailed schematics of a PV centric approach to DC coupling. On the left is an illustration of the PV panels wired through DC:DC optimizers installed in a PV array and connected to a DC bus where the DC bus is connected a battery and a grid tied inverter. The schematic on the right shows how such a system would be wired.

The BOSS offers a battery centric approach to DC coupling, one where the DC:DC converter is installed between the battery racks and a DC bus connected to an inverter while the inverter is connected directly to the PV system. In this case, power flows through the BOSS in a bi-directional manner to charge and discharge the battery while the inverter performs the MPPT function to harvest power from the PV array. In this battery centric approach, the BOSS maps the voltage from the battery to that of the PV array.

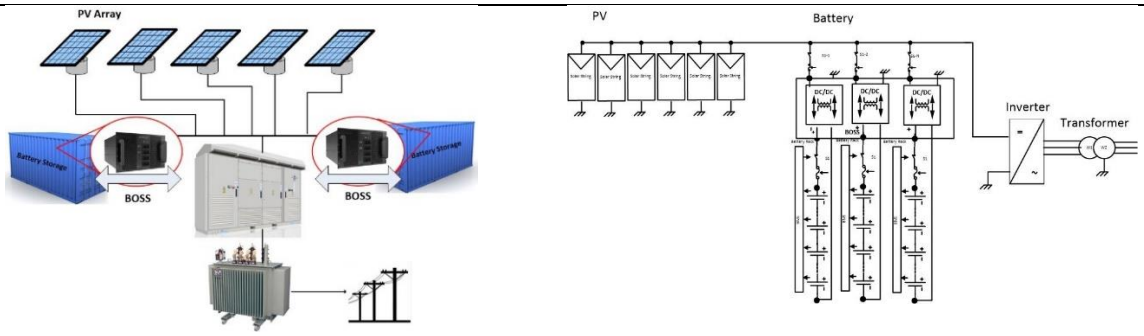

Figure 3 – Schematic diagrams of a battery-centric approach to DC coupled Solar + Storage.

The drawings shown above provide more detailed schematics of a battery centric approach to DC coupling. On the left is an illustration of a BESS wired bi-directional DC:DC optimizers connected to a DC bus where the DC bus is connected a grid tied inverter that is performing maximum power point tracking in the PV array. The schematic on the right shows how such a system would be wired.

When Does the Battery Centric Approach Make Sense?

The choice of which approach to DC coupling, PV centric or battery centric is right for your next solar plus storage project can be a nuanced.

When deploying DC coupled Solar and Storage, the power rating of the PV array is typically much higher than the power rating of the battery. A general rule of thumb is that the PV is three times the power of the battery, i.e. a 1.5 MW PV array would be paired with 500KW of battery storage power. Of course, battery capacity is not typically quoted in terms of power, but rather in energy, i.e. in kilowatt or megawatt hours (KWh or MWh). That energy is calculated as the duration of discharge of the battery times the power rating of the battery. So, in the example above, if the battery has a 4-hour discharge (which equates to a "c-rate" of C/4), the battery system would be rated at 2 MWh (i.e. 4 hours x 500 KW). However, when sizing power electronics like DC:DC converters, you will size the number of devices needed to the power rating of storage. As such, it follows that if you size you your power electronics to the smaller of the two power ratings in the system, i.e. the battery rather than the PV, the battery centric approach will be the more cost effective.

The battery centric approach, particularly when paired with a galvanically isolated, rack level DC:DC converter like the BOSS has other benefits as well. Specifically, such an approach can improve battery utilization by managing charge at the rack level, make battery storage augmentation easier over the life of the project and improve the safety of the system. The battery centric approach is optimal for pairing with uni-directional PV inverters that can handle MPPT but not bi-directional charge and discharge from the grid. A smaller DC:DC like the BOSS can be particularly helpful in pairing solar plus storage with

string inverters, whereas the larger, monolithic DC:DC units are typically designed to be paired exclusively with larger central inverters. Having smaller DC:DC conversion blocks is highly advantageous for commercial and industrial (C&I) and distributed generation (DG) projects that are typically deployed using string inverters.

When Does the PV Centric Approach Make Sense?

With all the benefits listed above, you might be wondering, why would anyone ever use the PV centric approach to DC coupling? Well, you might be surprised at how often it is used, as under certain circumstances, the PV centric approach offers some very compelling benefits not attainable with the battery centric approach. One such benefit is derived when you wish to use a bi-directional battery storage inverter (also often referred to as a PCS – power conversion system) that simply is not capable of performing MPPT. In such a case, the DC:DC would be placed in the PV array to perform maximum power point tracking and deliver the required voltage to the DC bus. In this sense, you can think of the PV installed DC:DC converter as "bolting on" the PV to an AC-coupled battery. This approach can have merit for a variety of reasons, including offering the ability to open the DC coupled solar plus storage system to more revenue streams, such as grid services, through the use of a bi-directional inverter.

The PV centric approach is also helpful when the PV array is highly distributed, as can be the case in a number of campus-type installations. In such cases, having MPPTs distributed across the PV array can help significantly increase PV yield. Additionally, the installation of DC:DC converters will assure no special considerations need to be made for avoiding the reverse bias of current into the PV array when charging or discharging the battery at night.

The PV centric approach to DC coupling can also help in maximizing DC overbuilds. Today, a major driver of installing storage on the DC side of the inverter is the desire to capture what would otherwise be clipped energy. Adding to this need is the fact that AC interconnects are getting harder to come by while PV panel prices continue to fall, making it more economical to significantly "overbuild" the PV array relative to the AC interconnect as defined by the name plate rating of the inverter. Any PV inverter will have a published maximum DC:AC ratio, typically between 1.2 – 1.5 PV input to AC power output. Based on the use case for the solar plus storage system, there may be a desire to have larger DC:AC ratio. This can often be the case in microgrids where the PV is the only source of power generation, so you need to significantly oversize the array to assure you have enough energy to service the load. During periods of significant solar energy overproduction, excess generation will be used to charge the battery. The PV centric approach facilitates larger DC ratios than a typical PV inverter would allow by allowing more granular control and curtailment of PV production during edge case scenarios when the battery is full and the PV is overproducing.

Summary

The table below summarizes the factors to consider when weighing the decision between deploying battery centric approach vs. the PV centric approach to DC coupled Solar + Storage:

Benefits to the Battery Centric DC Coupled Approach	**Benefits to Choose the PV Centric DC Coupled Approach**
Can be more cost effective because fewer DC:DC converters will need to be deployed (i.e. batteries are generally 1/3 the size of PV)	Can be ideal for use with bi-directional power conversion systems (PCS), i.e. battery inverters – can allow a DC coupled system to access more revenue streams like grid services etc.
With rack level DC:DC, augmentation can be much easier	Can facilitate DC overbuilds in excess of a PV inverter's standard DC:AC ratio – allows for more energy to be generated and stored
With galvanically isolated, rack level DC:DC, their can be many safety benefits including lower fault currents and early detection of electrical faults	Can be ideal for pairing with distributed PV arrays as distributed MPPTs will allow for greater energy yield
Generally, the preferred method when using PV (i.e. uni-directional) inverters	Will automatically assure no reverse bias from battery charge/discharge into PV array at night
Smaller DC:DC units can be ideal for use with both string and central inverters	Can provide more granular control and monitoring of PV array

Table 1 A summary of the relative merits to the PV and battery centric approaches to DC coupling of Solar + Storage.

The points raised above are meant as design guidelines. It is entirely possible your specific situation could differ. Here at Alencon we certainly welcome any feedback or questions you may have on the content of this white paper. You are welcome to contact us via email at info@alenconsystems.com or toll free at 888-410-7915.