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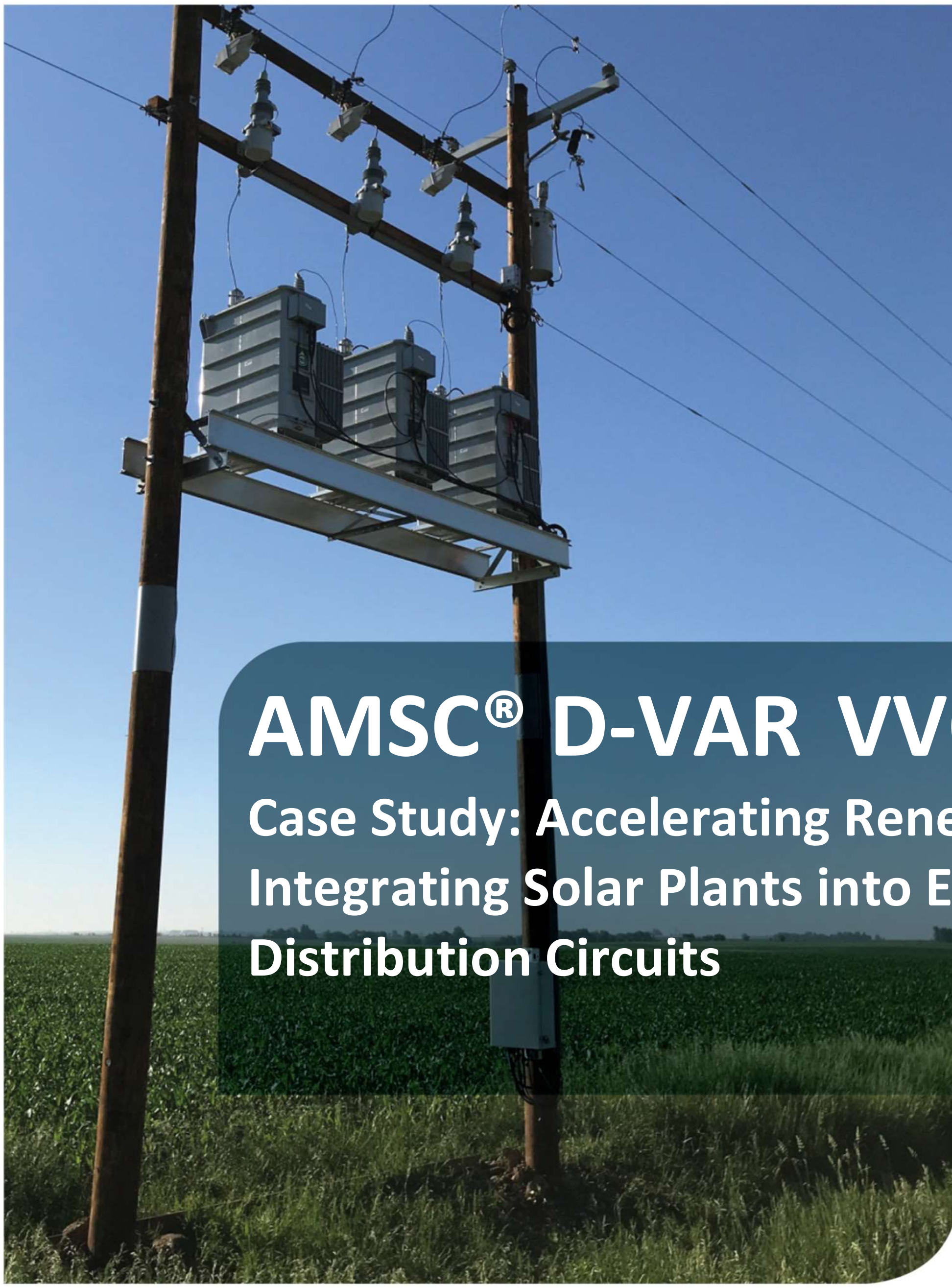

AMSC® D-VAR VVO®

Case Study: Accelerating Renewables by Integrating Solar Plants into Existing Distribution Circuits

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1. Introduction

The D-VAR VVO® Distribution STATCOM is a high-performance distribution-class voltage regulation solution. Utilities and project developers employing the D-VAR VVO can eliminate common voltage constraints that occur on utilty circuits and deliver an attractive stack of benefits to their end-customers. As a result of these benefits, the D-VAR VVO solution can offer justifiable capital deployment opportunities.

A summary of the value stack for utility applications of the D-VAR VVO Distribution STATCOM is provided in Figure 1.

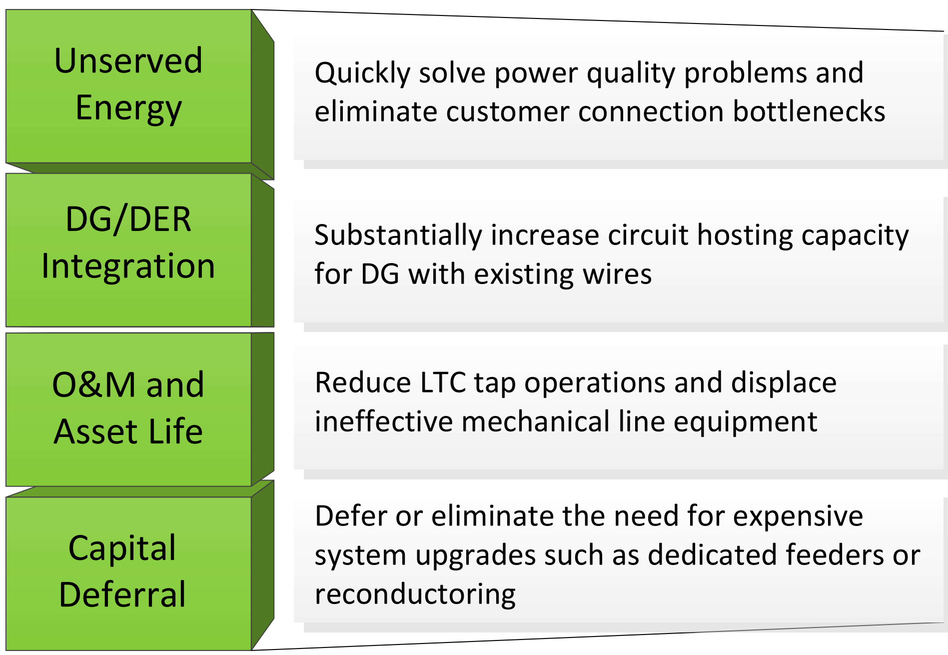

Figure 1. Value stack for D-VAR VVO applications.

While most D-VAR VVO applications provide multiple or all of the benefits within the value stack, this case study will highlight the *DG/DER Integration* and *Capital Deferral* value of a specific installation.

2. The Problem

As part of a utility community choice renewable program, a developer was seeking to connect a 3 MW solar plant to the utility's system. The investor-owned utility's standard solution for plants of this size was to offer construction of a *dedicated* feeder; dedicated to the solar farm, with no other customers served. Typically, the solar developer pays for the dedicated feeder and the utility maintains it.

The utility's primary rationale for a dedicated feeder was to avoid power quality issues that are likely to occur with larger distribution solar plants (e.g., plants that are 2MW+).

An integration study was performed to evaluate the power quality issues associated with connecting the plant into the *existing* feeder. Figure 2 clearly shows the expected voltage violations and why the plant was not allowed to be connected without a mitigation solution. Specifically, excessive voltage rise, or over voltage, can occur during maximum solar production; large voltage deviations can occur during partly cloudy days, eg, when solar output becomes intermittent.

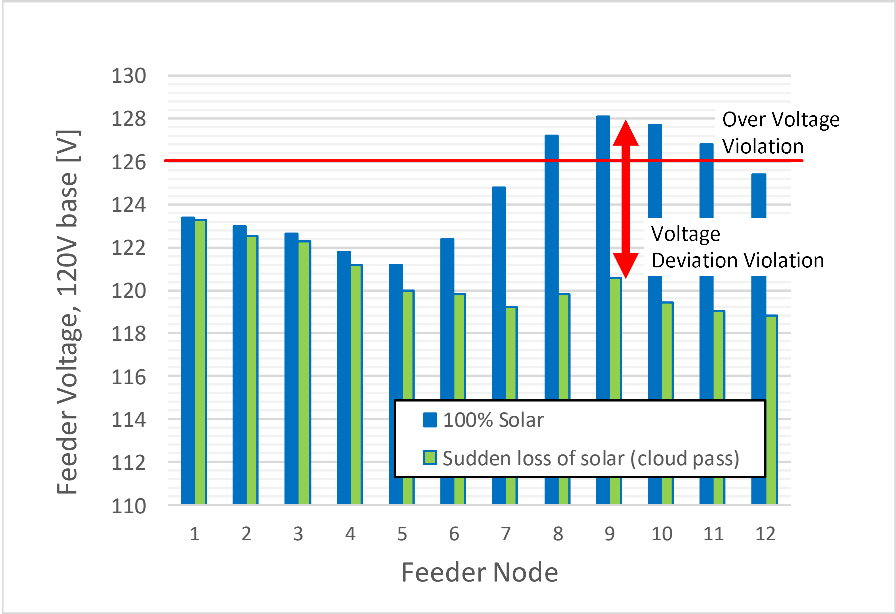

Figure 2. Estimated feeder voltage profiles for the 3MW solar plant connected to the existing utility feeder based on an interconnection study.

The developer and the utility consistently experienced that the traditional dedicated feeder solution resulted in substantial issues:

- Dedicated feeders are a ***significant portion of plant costs***, vary widely, and in many cases, make a site uneconomical (up to $800k/MW of installed solar*).
- ***Utilities are constrained*** with their ability to build dedicated feeders due to multiple issues including: siting the feeder, land acquisition, and/or environmental issues.
- ***The long timing*** of a dedicated feeder construction (24mos typical) makes projects infeasible.

3. The D-VAR VVO Solution

The utility worked with the developer to consider alternative options to address the voltage and power quality issues of connecting the solar plant. After thorough investigation, the D-VAR VVO Distribution Class STATCOM emerged as the most attractive solution.

As part of the evaluation, a consultant and the utility considered the control capabilities of the solar inverters as a potential solution. The following table summarizes why a solution relying only on the solar inverters was deemed to be inadequate.

Issue	Shortfalls in the Solar Inverter Approach
Equipment Ownership Risk	Solar inverters are not utility-grade, utility-owned voltage regulation equipment, and therefore could not achieve the operational certainty the utility required;
System Integration Risk	The utility Volt/VAR Control system could not communicate with or be coordinated with the customer-owned inverters;
Inverter Capacity	The solar inverters alone had insufficient capability to fully resolve the power quality problems;
Location Limitations	The location of the solar inverters are fixed to the solar plant, resulting in limited effectiveness in mitigating issues on the feeder;
Lack of Standardization	The utility could not ensure proper inverter settings, especially over time; The utility had previously experienced wide inconsistency in practice, including variability in solar inverter sizing, settings, and quality of implementation.

Table 1. Issues considered when evaluating solar inverters for controlling utility voltage and power quality.

The utility procured and installed the D-VAR VVO on the *existing* main line feeder, near the branch circuit to the solar plant (a short branch line was readily constructed). A simplified diagram of the circuit with the VVO solution is shown in Figure 3. A picture of a typical feeder installation of the D-VAR VVO equipment is shown on the title page of this case study.

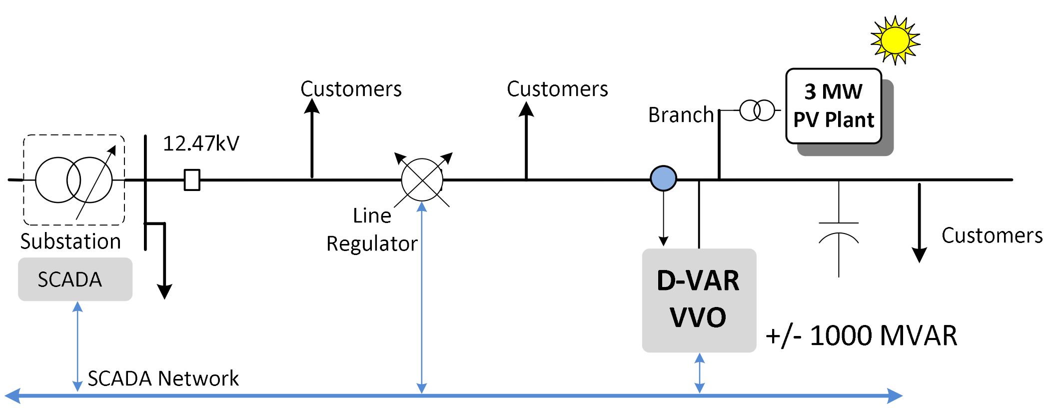

Figure 3. Simplified circuit diagram of the solar plant connecting into the existing feeder with D-VAR VVO.

Figure 4 shows a histogram of the voltages recorded on the utility feeder near the D-VAR VVO Distribution STATCOM installation (corresponds to Node #9 on the graph in Figure 2). This field data shows the high performance voltage regulation capability of the D-VAR VVO solution. The high voltage and voltage deviation issues are clearly resolved.

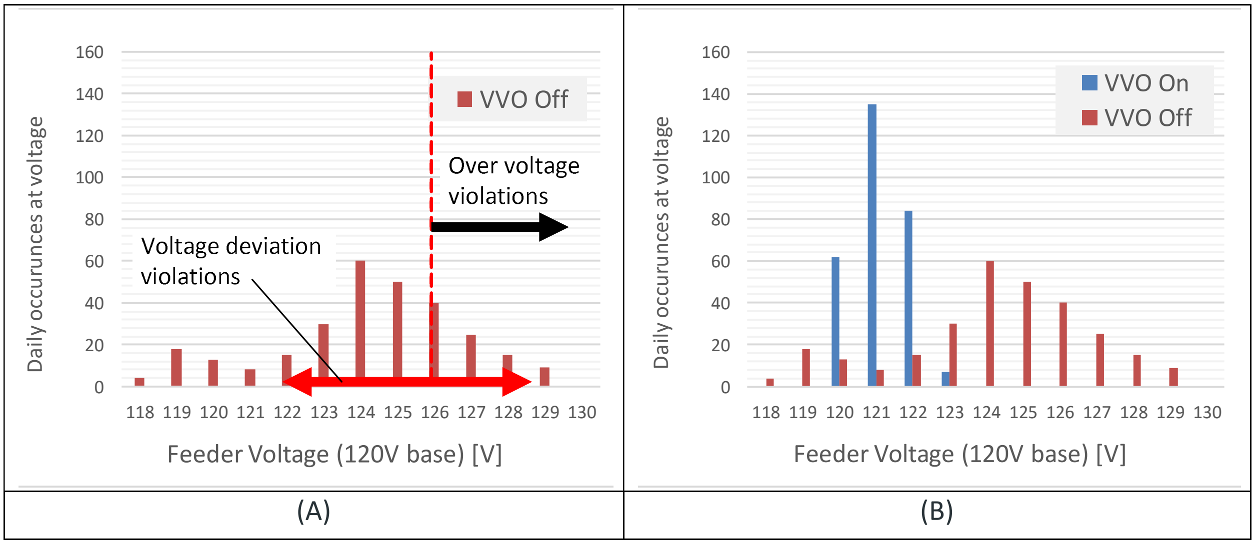

Figure 4. Histogram of the utility voltage near the D-VAR VVO installation with the 3MW plant generating.

Graph (A). Voltages during 12 hour period of a day, with D-VAR VVO turned Off (Red).
Graph (B). Voltages during 12 hour period of a day, with D-VAR VVO turned On (Blue) and turned Off (Red).

The D-VAR VVO Distribution STATCOM responds continuously and rapidly to correct voltage problems by injecting or absorbing VARS. This performance is possible because the D-VAR VVO is a power electronics device that adjusts output *thousands of times per second*.

In this application, the D-VAR VVO operates audtonomously in the Volt/Var control mode. The solution is providing excellent power quality as *the primary voltage regulator* on the downline portion of the feeder. The existing upstream line regulator remained in place and the settings unchanged. The utility Volt/VAR control system can provide updated voltage set points to the D-VAR VVO via SCADA, when necessary. This integration certainty was achieved because the D-VAR VVO is utility-grade equipment that is owned and operated by the utility.

The utility was able to justify cost recovery of the D-VAR VVO by enabling integration of community renewable energy into an *existing feeder that serves multiple utility customers*.

4. Summary

The D-VAR VVO solution in this case study achieved the following economic benefits:

- Accelerated interconnection of a new solar plant by at least 6 months when compared with a dedicated feeder solution
- Avoided the cost of building a dedicated feeder, with a solution that is approximately 20% of the cost.
- Allowed the utility to justify asset ownership, due to cost-effectiveness, and connection into existing feeders with hundreds of utility customers served
- Removed a significant portion of the grid connection cost from the developer (i.e., not having to pay for a dedicated feeder)
- Avoided operational risk & costs for both the developer and the utility because D-VAR VVO is utility-grade equipment that is owned an operated by the utility

Power quality issues similar to those highlighted in this case study are a common issue when integrating renewable plants into utility distribution systems. The D-VAR VVO Distribution STATCOM solution can help utilities and project developers accelerate renewable projects in a variety of scenarios:

- Utilities offering renewable community choice programs
- Regions or states with strong support for community solar
- Regions or states with growing renewable energy targets
- Provinces or states that require Non-Wires Alternatives
- States with PURPA generation initiatives
- Cooperative utilities seeking to own distributed generation to reduce energy risks

D-VAR VVO®

Helping utilities enhance service quality at the:

- **Right time** – Systems typically in stock or 20 wk standard lead time
- **Right size** - 1MVAR and 2MVAR sizes are tailored to distribution needs
- **Right location** – Distribution-class apparatus can be installed anywhere that it needs to be
- **Right certainty** – The performance certainty of utility-grade and utility-owned equipment

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- **Right value** – Multiple customer benefits enable attractive capital deployment

5. D-VAR VVO Case Studies

Website: https://www.amsc.com/gridtec/distributed-generation-solutions/#dvarvvo

D-VAR VVO Case Studies:

- Recovering unserved energy by solving power quality problems
- Accelerating renewable energy by connecting solar plants into existing feeders
- Serving modern energy customers: Increasing DG and Solar Hosting Capacity

6. Works Cited

*Sena, S. S., & Broderick, R. (2014). Analysis of 100 SGIP Interconnection Studies. Albuquerque, NM: Sandia National Labs

In a comprehensive study of interconnect costs for 100 distribution-connected solar plants, (Sena & Broderick, 2014) found that the cost of resolving voltage deviation violations ranged from $350k/MW - $850k/MW (per MW of installed solar).