Utility-Scale Solar Installations from Standardized Clusters

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ABSTRACT

A rapidly growing number of utilities, municipalities, and commercial entities are building utility-scale solar installations, to meet peak load requirements, to reduce and hedge current and future energy costs, to address renewable portfolio standards and/or to earn energy tax credits.

Despite the large potential market, virtually all utility-scale solar installations are still custom-designed and engineered for each new location. The unpredictability of construction, output and rate of return make it extremely difficult to understand how and when these investments will pay off.

In a system developed by SOLON Corporation, utility-scale solar installations are constructed from identical, one-megawatt clusters, each of which consists of solar modules, trackers, conversion equipment and monitoring systems. The cluster design, which is optimized for efficient energy output, enables faster construction using lean manufacturing techniques common to factory production.

The use of pre-configured clusters provides predictable peak energy output, greatly reduces uncertainty in design and construction and considerably lowers investment risk. In this paper we discuss the drivers for the cluster-based construction methodology and the benefits of the design.

Keywords: solar, utility-scale, solar farm, solar park, Velocity MW

1 APPROACHES TO UTILITY-SCALE SOLAR DESIGN

1.1 Traditional Custom Engineering

Today, virtually all large-scale solar installations are custom engineered, using solar modules from one supplier, mounting systems from a second supplier, and a collection of off-the-shelf components for the remainder of the system. This traditional, custom-engineering approach is problematic in a number of important ways:

1.1.1 Longer Time to Energize

Since the combination of components used in an installation is unique or varied across to that specific installation, all aspects of engineering, permitting, construction, test and commissioning require considerable time and effort.

1.1.2 Unpredictable Peak Power Output

Though performance model data will be used for any new installation, the actual output from the unique design and combination of components will not be known until a substantial portion of an installation has been constructed. This is compounded with the size of an installation. Variability in the performance model and in the degradation characteristics of the components make it difficult to accurately predict energy output over the life of the installation.

1.1.3 Unpredictable Construction

Custom designed systems are often affected by unforeseen losses that must be addressed in the field in order to meet peak output guarantees. The additional remediation efforts increase installation costs, extend construction timelines and delay commissioning.

1.1.4 Decreased Reliability

The lack of testing of the system as a whole until the project is complete leads to unexpected component degradation, debilitating interactions between components and other effects that may not become apparent for several months to years. Long term reliability is difficult to predict, and thus the long term return on investment is difficult to gauge.

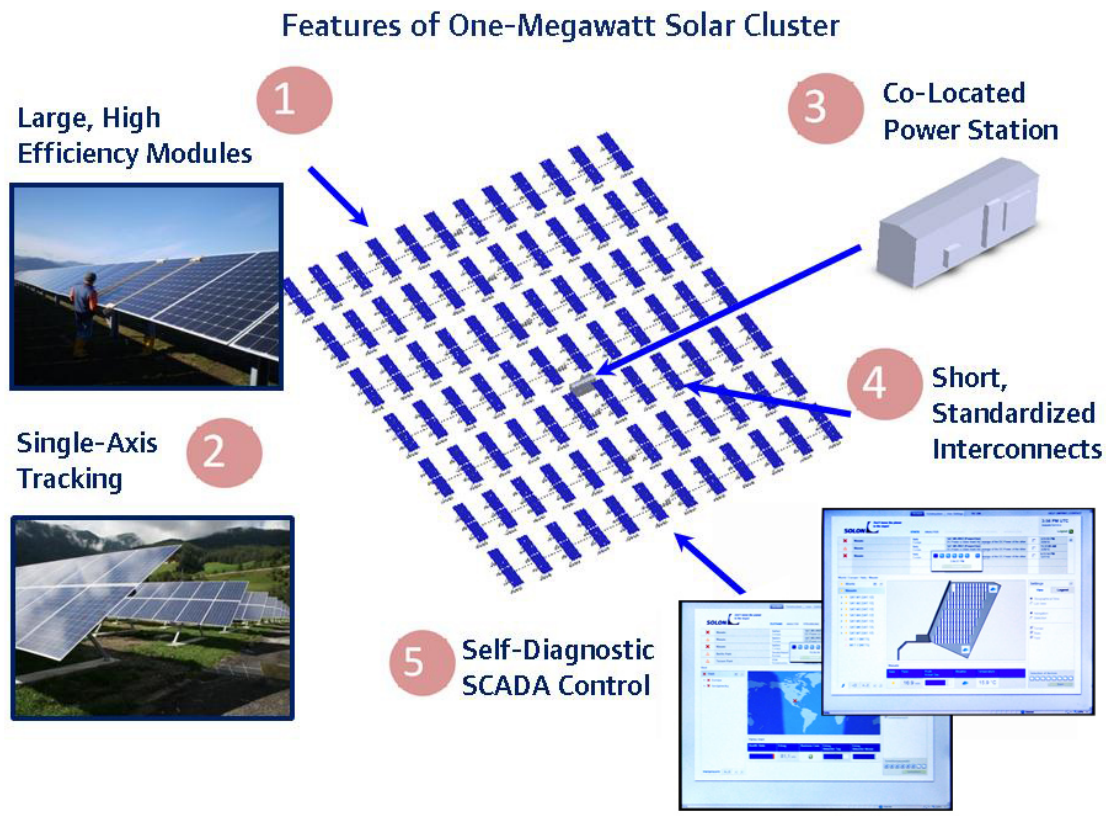
1.2. Standardized Construction from Clusters

SOLON Corporation, based in Tucson, AZ, has developed a more efficient alternative to custom engineering for large-scale solar. In this system, known as Velocity MW, utility-scale solar installations are constructed from standardized, one-megawatt clusters. The components of a cluster (Figure 1) are optimized for peak energy output, ease of installation and long-term reliability and predictability.

Since cluster design is, to a large degree, identical between sites, performance data, site preparation requirements and construction details are well-known prior to installation, which accelerates all aspects of design, permitting and construction. This data also enables much more accurate prediction of power output and investment return. Performance can be tested and verified when the

first cluster is installed, enabling near-immediate site compatibility feedback.

station, which houses inverters and a step-up transformer. The station arrives on site pre-assembled, allowing faster



Lastly, with the standardized cluster approach a 1MW site can begin producing power in 2-4 months compared to more than 9 months with a traditional approach (after all permitting approvals are received). Thus, a cluster-based system can begin generating revenue faster than a conventional system.

The Velocity MW cluster is designed around SOLON's large, high efficiency modules which increase annual output by 3-5%. The modules' large size reduces the total number of modules, connections, and overall BOS components, which improves efficiency and reduces installation time.

East-west tracking improves peak output by upwards of 30% over stationary (fixed tilt) installations The SOLON designed hydraulic trackers used in Velocity MW clusters are driven by a control algorithm that minimizes back-shadowing, adding 0.5-1 hour of output per day. Adding fixed, north-south tilt based can provide additional efficiency gains, depending on regional location. Collocated with each cluster is a pre-configured power

field assembly. Since all clusters share the same components, economies of scale make it cost-effective to use optimized balance-of-system (BOS) components rather than pieced together offerings. Interconnections to and from the power station are set to standardized lengths, enabling pre-assembly off-site and quick final assembly site.

The last major component of the Velocity MW cluster is its SOLON developed SCADA (Supervisory Control and Data Acquisition) system, which provides remote monitoring and self-diagnostics. Whereas typical solar systems come with only a DAS (Data Acquisition System) system, which only monitors output, the Velocity MW SCADA system sends automated alerts at the first drop in output. The SOLON SCADA system not only provides real time messaging of events, but also provides 15minute average values of all devices in the solar cluster, and offers remote control of the entire solar system – including tracking systems, inverters, transformers, and breakers. Early feedback allows operators to adjust or repair components prior to failure, which helps keep clusters on-line and at peak efficiency for longer periods of the year.

Important too is that the SOLON SCADA system has future functionality built in. As more PV is connected to the grid, the utilities' ability to control active and reactive power and output through storage will become paramount. Using SCADA and advanced inverters for this grid voltage control will come at a minimal cost, resulting in overall added value for the end user and lower Levelized Cost of Electricity (LCOE).

2 ADVANTAGES OF STANDARDIZED CONSTRUCTION

2.1 Lower Levelized Cost of Electricity

The primary advantage of standardizing utility-scale solar installations is that more power can be generated with lower initial and ongoing costs. Cost reductions are achieved through:

2.1.1 Lower Initial Costs ($/W)

By basing a new installation on standard clusters, the majority of design and engineering work can be copied or modified from previous installations rather than designed from scratch. Permitting and planning are easier to complete since the output characteristics of the clusters are proven and documented, and paperwork is already in place.

2.1.2 Lower Construction Costs

The use of standardized components enables efficient production techniques such as pre-assembly and off-site kitting to be applied during construction. Such techniques reduce labor requirements, construction time and on-site inventory.

2.1.3 Faster Time to Energy

The time required for system design, permitting, installation and qualification are all greatly reduced by the use of standard, well-characterized clusters. A Velocity MW installation can begin generating electricity in 2-4 months, versus 9-12 months for a typical design-to-fit system. Because clusters can be brought on-line individually or in groups, an installation can begin generating cash flow quickly.

2.1.4 Improved Supply Chain

Using the same components throughout an installation (and across many installations) drives down costs throughout the supply chain. Components can be purchased in exact quantities, reducing often-exorbitant restocking fees.

2.1.5 Higher Energy Output (kWh)

Optimized components are designed for compatibility and tested together to maximize efficiency. Line losses are minimized by careful cluster design.

2.1.6 Lower Operation and Maintenance Costs

Long-life components with well understood life cycles require fewer repairs, smaller parts inventories and significantly less downtime for maintenance.

Table 1 summarizes the major benefits of the cluster approach to utility-scale solar installations.

Benefit	Improvement
Upfront Cost ($/W)	> 5% Reduction
Output (kWh)	> 30% Improvement
Internal Rate of Return (IRR%)	> 3% Improvement
LCOE ($/kWh)	> 27% Reduction

Table 1. Improvements realized with Velocity MW cluster with single-axis tracking

2.2. Predictable, Reliable Energy Output

The design of Velocity MW clusters can be repeated or slightly modified for a wide range of sites and climates. From these installations an ever-growing body of performance data is becoming available for refining performance models and quantifying real-world performance. Figure 2 shows some of the sources of variability that affect power output estimates and the degree to which variability can be reduced through the use of standardized clusters and components.

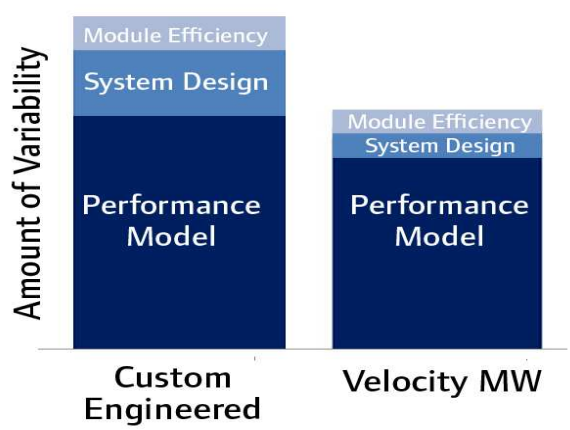


Figure 2. Reducing sources of variability leads to predictable peak output performance.

The result is a significant reduction in variability risk for peak energy output, which makes a project more bankable, with more predictable returns. Greater confidence in guaranteed project output will help project managers to obtain much more lucrative financing terms.

Figure 3 shows a comparison of SOLON's 5 step output guarantees versus traditional industry standard guarantees. Increased confidence in power output enables multi-year output guarantees, versus guarantees at 10 and 25 years only.

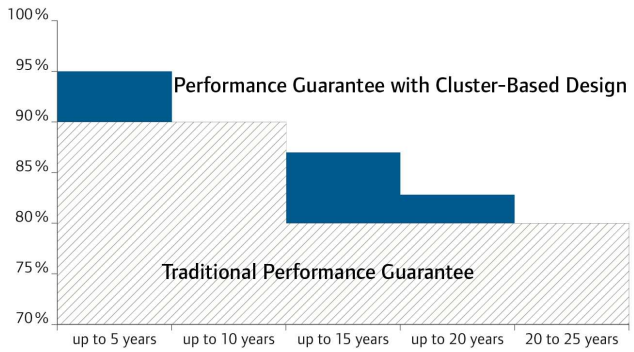


Figure 3: Increased predictability of cluster approach enables more refined power output guarantees.

2.3. Reduced Risk

Cluster-based design brings the risk of large-scale solar design far forward in the development process. Accurate energy output data help customers to fully understand their investment before breaking ground and help limit the exposure of the investment over time. Starting a new installation project with a well-documented cluster design and a body of field data drastically reduces the risks involved in meeting construction schedules, hitting performance targets and passing through site testing and sign-off prior to commissioning.

Moreover, in a cluster-based installation a "base cluster" can be constructed, tested and commissioned at the site to verify performance characteristics before additional construction is begun. Since all subsequent clusters in the array will perform identically, the actual performance of the entire installation can be verified many months earlier than in a conventional array.

The reduction in risk increases with the size of the installation as well (Figure 4). The longer schedules and greater number of components associated with larger installations add greater variability and risk with traditional construction methods. In contrast, with a standardized approach, once the base cluster has been commissioned the remainder of the installation becomes a factory for the mass production of megawatt clusters, with little additional risk.

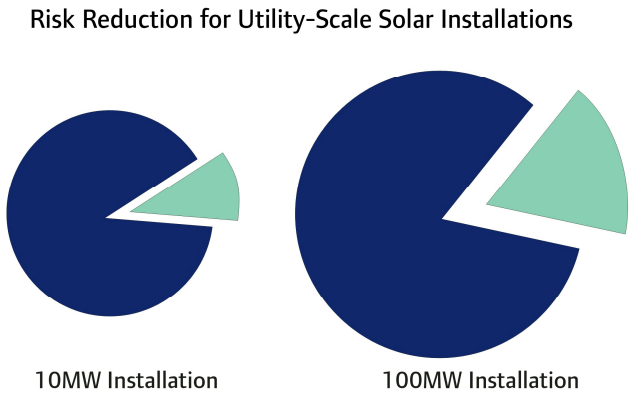


Figure 4. The standardized cluster approach decreases risk by a greater degree as the size of the installation increases.

3 CONCLUSION

Standardization of large-scale solar power plant design is critical to meeting the fast-growing demands of utilities and municipalities. The Velocity MW methodology developed by SOLON provides a means for increased, predictable energy output and decreased investment risk that will drive further adoption of large-scale solar installations.

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