NREL
Transforming ENERGY

PRECISE™

PREconfiguring and Controlling Inverter SEt-points

A Solution for Easy Solar Integration

Photo by Dennis Schroeder, NREL 45142

Solar power is arriving fast—sometimes faster than it can be managed. Each new solar system involves a new configuration, with a new set of questions around how to best optimize it: How should the system's inverter behave to maximize stability? Or to reduce solar curtailment? And what are the trade-offs? These questions are as real for a small community or campus as they are for a significant urban utility, and they can overwhelm the effort to integrate more solar safely and efficiently.

PREconfiguring and Controlling Inverter SEt-points™ (PRECISE™) is a software solution for configuring inverters quickly and effectively based on customer location and network design, saving utilities the effort of solving an immense optimization problem while supporting customer and industry momentum toward more solar. PRECISE keeps that momentum high by simplifying the greatest bottleneck for solar: the technical configuration that accompanies any new solar installation. To this end, PRECISE has received an R&D 100 award and has helped bring a significant amount of solar power onto real utility systems. PRECISE is the industry's one-stop option for rapid and reliable solar inverter configuration, and it is currently available for license.

PRECISE configures set points for solar inverters, such as Enphase's commercial inverters, which were used for evaluations within NREL's Energy Systems Integration Facility. *Photo by Dennis Schroeder, NREL 54155*

Software for a Changing System

Although the physical costs of solar panels have continued to fall, the soft costs of permitting, inspection, and interconnection have remained steady. These costs reflect the technical challenges of safely integrating solar systems, specifically the power inverter and the complex landscape that determines an inverter's operation.

Any solar inverter installment is characterized by:

- Standards issued by the electrical industry
- Regulations established by governments and commissions
- Technology-specific configuration
- A variety of operational parameters that set power output.

Moreover, each solar inverter exists within a wider electric grid, where the impacts of other devices are also considered. In short, there are many details that enter the decision-making process for new solar installments, and all have an impact on the central priority, which is to install solar inverters with optimal settings. Such complexity of installation means that blanket configurations are insufficient—every inverter should be independently programmed to maximize cost savings and minimize energy loss. Although customizing inverter settings is regularly a time-consuming process, PRECISE makes it convenient.

Customize to Optimize

Modern inverters enable greater control over settings and operation. This feature allows inverters to be programmed independently and optimized for any grid system. As opposed to a blanket or default configuration, PRECISE arrives at optimal settings and set points for an inverter. For example, when installing a new solar system, a utility's priorities are balanced between reducing customer losses from solar curtailment and reducing utility losses that occur from overvoltage or outage events.

The PRECISE Impact

With the vast range of possible configurations utilities need a dedicated software like PRECISE to compute optimal settings. Using PRECISE, the full potential of advanced inverters becomes available, and utilities can support their solar customers efficiently without investing in costly infrastructure upgrades or overcurtailing solar energy.

Curtailment and Power Quality: The Trade-Off

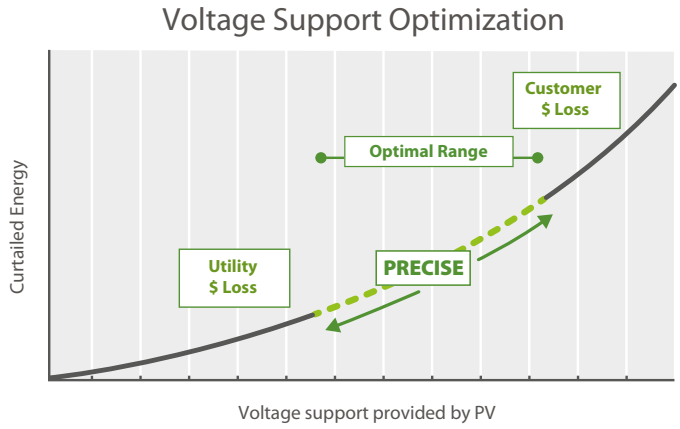
Priority number one for utilities is to guarantee reliable power to their customers. This priority takes on a new light in high-solar systems: As NREL discovered through its support for Hawaiian utilities, high-solar systems require some curtailment

to reserve energy for stabilizing electricity. But customers who recently installed solar—as well as utilities—want to avoid curtailing too much energy. There is a trade-off between curtailment and reliability. So, what is the right amount to curtail?

That question is exceedingly difficult to answer, leaving most utilities to err on the side of stability. But PRECISE is designed to find the right middle ground. It co-optimizes the two opposing criteria of grid operation and impacts on customer photovoltaic (PV) generation. PRECISE's proprietary optimization routine can assess the dual considerations of power quality and curtailment, and it suggests the optimal configuration for inverters.

Keeping Infrastructure Simple

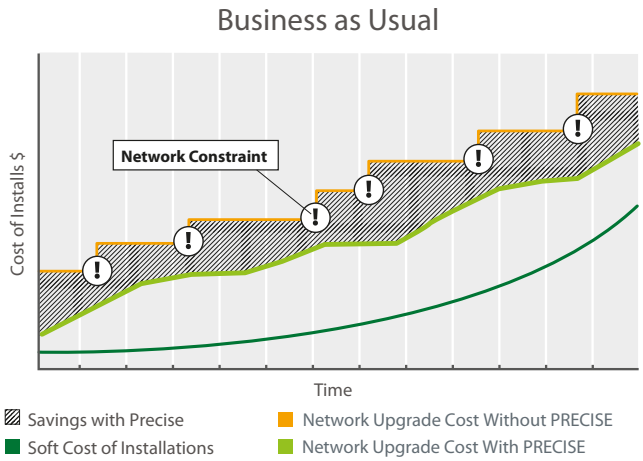
With the significant growth in solar, which could approach 17% of all U.S. generation by 2030, utilities have their eyes on how to adapt. There is no single route forward, and the customizability of modern inverters further expands the space of opportunities. If inverters are operated with blanket,



With PRECISE, inverters are optimized to support the grid and customers by balancing the competing interests of grid stability, and minimizing energy curtailment.

baseline functionality, however, these opportunities are not being realized. Using blanket configurations, utilities will necessarily fall back on physical upgrades to their distribution networks to accommodate the new inverter-interfaced technologies.

PRECISE helps prepare for incoming solar by keeping infrastructure simple. PRECISE takes full advantage of solar system customization available in advanced inverters and grants new control over the operational flexibility of inverters. Rather than confront solar growth with network buildouts, PRECISE brings subtle operational improvements to light—performing system-wide optimizations according to utility priorities in a matter of seconds.



Utilities can use PRECISE to reduce network upgrades by managing the operational flexibility of inverters.

No More Waiting: PRECISE for Solar Integration in Sacramento

In 2016, the Sacramento Municipal Utility District (SMUD) was facing high-pace customer PV growth. SMUD was pushing back wait times for new PV systems to review applications, bottlenecked by the need to correctly program each PV inverter's setting. Between the range of inverter models, their geographic distribution, and the local voltage characteristics, each PV system presented a unique problem, with important consequences for grid reliability and customer savings. SMUD needed a way to create unique inverter settings for millions of devices—a way to implement mass customization. That solution turned out to be PRECISE, which automated a process that otherwise required lengthy integration studies. In simulations of SMUD's distribution networks, PRECISE cut application times in half, from 10–15 days to 5.

Photo by Josh Bauer, NREL 54940

High-Level Operation

PRECISE's engine was built to ingest and analyze the large data sets required for grid analysis and to perform rigorous optimizations with those data sets. Utilities employ PRECISE once a customer applies for a new PV interconnection.

The PRECISE procedure is as follows:

1. Model the distribution feeder of a specific system.
2. Model the home-level distribution (secondary networks) using OpenStreetMap and geographic information system data.
3. Access load data and configure power limits.
4. Run analysis of inverter settings.
5. Optimize inverter settings.

Modular Design

The optimal set points are then programmed into the inverter. PRECISE also introduces several custom tools along the way. These tools can be deployed as independent modules, depending on a utility's needs. These include:

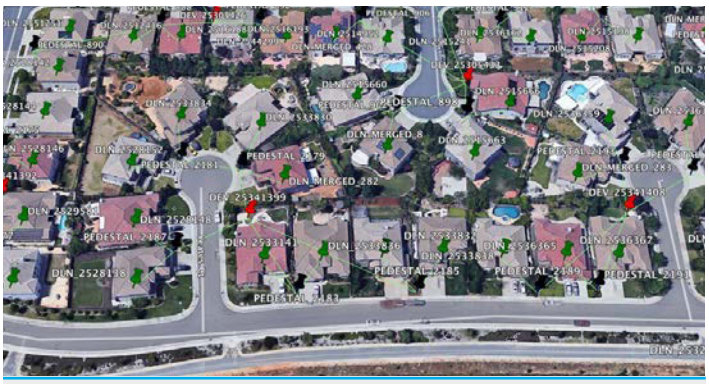
- Data ingestion: PRECISE intakes any utility-relevant data format and all popular existing data management tools, with the central data point being the customer's application for a new PV interconnection. Within PRECISE, data products are organized into a navigable graph-like schema. This graph structure is in JSON format and is easily extractable for use.
- Distribution modeling: Using only higher voltage distribution models, PRECISE automatically builds out a view of the down-to-the-home power system in OpenDSS. These models have been validated against true geographic depictions of customer neighborhoods.
- Optimization: PRECISE solves challenging optimal power flow problems according to the priorities set by the user. The optimization routines used by PRECISE are uniquely able to evaluate the economic and operational impacts of many inverter configurations, as well as the anticipated power from solar forecasts, and export an optimal setting.

Commercially Available

Distributed generation is now a fact for many utilities, and the problems that PRECISE solves are equally real. The first U.S. grids in California and Hawaii to make the transition to a PV-dense distribution network did so with NREL's help, which harbors some of the world's leading expertise for incorporating solar PV. This expertise has been incorporated in PRECISE throughout its development and up to its current status as an R&D 100 award-winning, licensable product.

If you are interested in licensing PRECISE for your own application, consider the following links:

- License PRECISE
- Learn more about licensing at NREL
- Learn more about other partnering opportunities at NREL.



Utilities have models of primary (higher-voltage) distribution networks, but new activity at the grid edge is increasing the importance of understanding distribution at the secondary (lower-voltage) level. PRECISE automatically models distribution systems down to the homes, a resource that most utilities currently don't have access to.

What Industry Says about PRECISE:

"Laboratory tests of the PRECISE platform have validated its capabilities to generate results, which match closely with the real-world hardware results. Such an innovation will open opportunities to provide optimal inverter settings daily—or even more frequently—to our microinverter systems, thereby maximizing solar PV generation without compromising grid safety or reliability."

– Enphase Energy

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