# Case Studies and Model Guidance for Establishing Solar Cybersecurity Working Groups

## A Cybersecurity Advisory Team for State Solar (CATSS) Tool

NASEO
National Association of State Energy Officials

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**Disclaimer:**
The CATSS Toolkit is designed to provide states with basic education on cybersecurity issues for solar and enable their efforts to support cybersecurity enhancements efforts for solar. Cybersecurity challenges for solar should not be viewed as unique. All electricity generation technologies are, to varying degrees of potential severity and vulnerability, susceptible to cyberattacks and disruption. As interconnected electricity generation technologies, solar systems—and DERs generally—have a unique advantage to ensure that cybersecurity is incorporated by-design and prior to deployment, rather than applied ex post facto. The recommendations provided within the CATSS Toolkit/this tool were developed to meet the expressed needs of State Energy Offices and Public Utility Commissions during the project, and their respective purviews, priorities, and directives to support cyber-secure solar deployment in their states. While many industry and federal partners were included in the CATSS Advisory Group, it must be noted that neither the states' nor other stakeholders' perspectives collected are exhaustive. The Toolkit represents a snapshot of a quickly evolving and complex area, and should not be treated as a definitive guide, but rather a basis for continued discussion and adaptation of public-private partnerships for solar cybersecurity.

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## Introduction

As states prepare for increased integration of distributed energy resources (DERs), establishing state-level working groups can be a first step for many states to discuss cybersecurity considerations of DERs. Several states have already established similar working groups, such as state-level homeland security or smart inverter working groups to advance solar cybersecurity protocols.

### State-Level Homeland Security Working Groups

A state-level homeland security working group can bring together relevant stakeholders to share ideas around mitigating cyber threats to solar and other DERs and to develop strategies that can be integrated into existing and future projects. A working group can utilize data to model potential threats and determine what additional data is still needed in the energy sector cybersecurity space. This can include data on threats that have impacted DERs in the state previously and general DER operational data (I.e., current status and power system measurements). Some of the tools that stakeholders in the working group may have access to include geospatial information, artificial intelligence (AI) models, and energy sector data sets. One example of a resource the working group can utilize are the cybersecurity assessment tools available from the U.S. Department of Homeland Security. These include the Cyber Resiliency Review, Cyber Evaluation Program, Cybersecurity Evaluation Tool, Cybersecurity Vulnerability Assessments through the Control Systems Security Program, Industrial Control Systems Technology Assessments, and Information Technology Risk Assessment.[1] States can utilize these tools to assess the cybersecurity landscape and share the resources with private sector partners and utilities to reinforce their own systems.

**Participants in the working group may include:**

- representatives from the private sector,
- state fusion center,
- state homeland security division,
- military,
- State Energy Office,
- Public Utility Commission,
- and other state agencies with cybersecurity responsibilities.

The expertise of this kind of working group can lead to the development of cybersecurity task forces focused around DERs, recommendations for policy makers and regulators, and the creation of a response strategy for when there are cyber threats to solar photovoltaic systems. Many states already have existing homeland security divisions to combat general cyber threats, but a working group can devote more time and resources to the specific issue of cybersecurity for solar through engagement with other relevant stakeholders who might not be involved in everyday homeland security efforts such as energy project developers or small rural electric cooperatives.

## State-Level Smart-Inverter Working Groups

A state-level smart-inverter working group will look at research, development, and deployment of smart inverters needed for integration of DERs. Inverters serve to convert direct current into alternating current used by homes and businesses to utilize the energy generated by solar systems. Smart inverters can provide more advanced functions including voltage regulation, frequency response, and grid stability.[2] The important role they play in supporting solar energy systems makes a potential cyberattack on an inverter extremely detrimental. If a hacker gains control of the inverter this can give them control of the power output of the solar system and also allow them to gain access to a connected battery inverter and overload it.[3] A study underway at the University of Georgia is looking at ways to detect interruptions to the system in real-time using a voltage sensor and a current sensor. It will collect data on the electrical waveforms and the sensor would see if there was any unusual activity. The frequency of the collecting (10,000 samples every second) is one method of identifying cyberattacks to solar systems quickly.[4]

Smart-inverter working groups can develop resources to share with regulators and policy-makers, make recommendations to the State Public Utility Commission, the Governor, and state legislature, and could determine the best opportunities for deployment of smart inverters in the state while providing technical assistance to interested parties.[5] Participants in the working group can include representatives from the national laboratories, State Energy Office, Public Utility Commission, developer community, utilities, and universities. Additional details on forming a state-level working group are outlined below.

## CASE STUDY:
## California Smart Inverter Working Group

Currently, there are few case studies or model guidance available to provide tools for establishing a state-level homeland security and a smart inverter working group, but California is one state leading the way in this space. In 2013, California established a Smart Inverter Working Group (SIWG) based on prior work done by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC). The working group was divided into three phases: autonomous functions, communication protocols, and advanced functions.

*Table One: Phases of California Smart Inverter Working Group*[6]

| PHASE ONE: Autonomous Functions | PHASE TWO: Communications Protocols | PHASE THREE: Advanced Functions |
|---|---|---|
| **This phase was completed by September 2017. It examined:**<br><br>Proposed changes by the CPUC for interconnecting smart inverters<br><br>Developing a safety certification process for inverters with autonomous functions<br><br>The time period for ensuring market fairness and collecting data on these inverters<br><br>CPUC consideration of mandating autonomous smart inverter functions for all DER systems connected to the larger distribution system in California. | **This phase was completed by March 2022. It examined:**<br><br>Developing an implementation plan for communications capabilities for smart inverters. | **This phase is in process and is examining key DER functions to be included in Rule 21 including:**<br><br>• Monitoring key DER data<br>• DER cease to energy and return to service command<br>• Limit maximum active power mode<br>• Set active power mode<br>• Frequency-watt mode<br>• Volt-watt mode<br>• Dynamic- reactive current support mode<br>• Scheduling power values and modes |

A lot of the work being done by the SIWG is based on CPUC Rule 21, which is a tariff focused on interconnection, operating, and metering requirements. Rule 21 was first adopted in 1982 by the CEC and has gone through multiple updates and iterations since that time. According to a report issued by the SIWG in 2014, Recommendations for Updating the Technical Requirements for Inverters in Distributed Energy Resources, a lot of the interconnection standards in Rule 21 are based on IEEE 1547, a DER interconnection standard that originally prevented DERs from islanding and required systems interconnected to the distribution grid to shut off if there are any power outages or major events impacting the larger system.[7] A more recent update to the standard, IEEE 1547a, now permits certain DER actions not previously allowed. Most importantly it allows for voltage regulation by a DER and modifies the language on voltage and frequency settings.[8] As a result of changes to the IEEE standards, California wanted to ensure that their distribution system could utilize these updated rules and properly prepare the state for the technical developments needed to integrate more distributed generation.[9] This led the CEC and CPUC to form the Smart Inverter Working Group. The working group will look at what opportunities are available in the state for smart inverters and seek to make policy recommendations through the multi-phased approach outlined above. Each IOU in the state is responsible for Rule 21 within their own service territories and has their own versions of the rule to meet the requirement. The three phases of the SIWG included deadlines for when each IOU needed to update their requirements for Rule 21.

CPUC rulemaking requires investor-owned utilities (IOUs) to work with the SIWG so that the IOUs can discuss technical details of proposals brought before the working group and provide insight into any products being developed and released, such as a Utility Cybersecurity Requirement Guide currently in review phase. These requirements must be followed by every IOU.[10] Based on recommendations by the working group, in December 2014, D.14-12-035 was issued to revise Rule 21 to require smart inverters be used by Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas and Electric Company.

## Challenges

According to the California SIWG, one challenge has been to fully understand all smart inverter functions and to get regulators to properly value the benefits of smart inverters.[11] Some of the smart inverter functions that the SIWG is looking at include dynamic volt-watt function, which allows inverters to provide a voltage stabilizing function, and ramp-rate control which limits fluctuations in the power output of solar systems when there are changing conditions (I.e., a rainstorm or clouds).[12]

In addition, due to the advanced capabilities of smart inverters, cybersecurity threats are high. The control system can be compromised, and the operation functions changed. With smart inverters often being located in the home of a customer, it can be simple, compared to well protected substation equipment, for a hacker to access the system and take control through the home area network or physical connection.[13] A study presented at the International Conference on Power Electronics, Control, and Automation demonstrated that this can lead to potentially dangerous voltage values.[14] These kinds of hacks to a smart inverter system could be very detrimental as they can impact the amount of power being dispersed and provide access to the battery system, but protective measures such as message encryption can mitigate some of these challenges.

The California SIWG put together several recommendations around cybersecurity including developing an interconnection handbook with cybersecurity guidelines, analyzing the critical risks to inverter-based systems, and determining responsibility for cybersecurity mitigation efforts (whether responsibility falls to the IOU or DER developer). More specifically, the SIWG looked at opportunities for securing stored data from unauthorized access which includes intermediary systems between the utility and DER system[15], ensuring all DER systems can share key data at the point of interconnection, providing cybersecurity at the transport and application layers and for user and device authentication, and utilizing basic configurations to get between different cyber configurations (such as cipher suites or network management).[16] These communications requirements will make it easier for the owner of the solar system to identify threats to the system and keep smart inverters working seamlessly.

## CASE STUDY:
## Hawai'i Interconnection Standards Working Group

In developing a state level smart inverter working group, it is important to know what interconnection rules may exist. In addition to California, Hawaii is a leading state in this space. Hawaii Rule 14H has helped expand the use of smart inverters in the state. Rule 14H was approved by the Hawaii Public Utility Commission in 2002 after a request by Hawaiian Electric Company (HECO), Hawaii Electric Light Company, and Maui Electric Company to establish interconnection standards for DERs. The three utilities based this joint request on national and other state commission guidelines.[17] Since 2002, there has been significant action taken to update the capabilities of older inverters. It was difficult to maintain system stability with these older inverters, so Hawaiian Electric worked to widen the voltage and frequency trip settings through collaboration with the manufacturer.[18]

HECO has also conducted studies with the National Renewable Energy Lab (NREL) that determined smart inverters generally benefit operations of the grid. In states like Hawaii with high solar deployment and potential, smart inverters can have a significant role in supporting solar systems, particularly when looking at the potential for new projects that have yet to be connected to the system. Already, the standards Hawaii has in place regarding smart inverters have helped increase hosting capacity and better protect customers particularly due to the volt-var inverter setting that allows more people to connect.[19]

While the Hawaii Public Utility Commission and Hawaii State Energy Office have not established an official working group, Hawaiian Electric did organize a Smart Inverter Technical Working Group which served to evaluate different potential technologies and look at seven grid support functions including volt-watt control and ramp rate control. The working group determined that these functions could help with over frequency issues and enable additional deployment of solar systems in Hawaii without harming the reliability of the grid or customer production when smart inverters are used appropriately.[20]

### Developing a State Working Group

The smart inverter standards in Hawaii and California can serve as examples for other states and, as of 2021, several other states were looking to engage in a similar process of evaluating smart inverter standards. These states include Arizona, Idaho, Illinois, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, New Mexico, New York, North Carolina, Texas, and Washington, DC.[21]

The examples above showcase some of the existing working groups and structures states have established around smart inverters and interconnection. Other state working groups centered around different topic areas that may have had successful outcomes might also serve as good examples. The processes taken to get to these outcomes could be replicated in a similar way. States should also consider that each state will have different requirements, policy structures, and regulatory systems that will impact the development and ecosystem of a working group. Some standards such as IEEE 1547-2018 could be leveraged when developing the working group strategy as the design can be modified depending on the state and local regulations in place (see the CATSS Standards Quick Guide for more information). IEEE 1547-2018 has several options depending on the goals of the system that states and utilities can consider prior to deployment.[22] It is also important to engage non-investor-owned utilities in the process, such as municipally owned utilities or electric cooperatives.

**The following is a consolidated list of the potential approaches that can be taken to form a state-level working group:**

- A request from one or more utilities to establish updated state interconnection standards can lead to legislative or regulatory action that might include developing a working group.
- State Energy Offices and Public Utility Commissions can reach out to utilities with existing working groups to enquire about collaboration or support opportunities. They can also work together to form a working group and bring in other relevant stakeholders.
- State Energy Offices can use existing funding to establish a working group (such as State Energy Program funds).
- Legislation could identify which stakeholders need to be involved in the working group or there can be a request for proposals put out for interested organizations.
- State Energy Offices and Public Utility Commissions interested in forming a working group should determine what the ultimate goals for the working group will be and how members will work to achieve them.
- For a working group created without legislative action, State Energy Offices and Public Utility Commissions will need to determine the appropriate participants in the working group based the working group's goal. This should include DER developers, cybersecurity experts, and investor- as well as consumer-owned utilities.
- The following are steps that need to be taken once the working group has been established:
    - Once the working group has been created, members need to develop a coordinated strategy and program plan with a detailed timeline. For example, a phased approach can allow working group members to address concerns one at a time over the course of several years. The initial phase should simply examine proposed changes that are needed for upgrading interconnection standards in the state and what role they see smart inverters having in future projects.
    - A regular meeting schedule should be established, along with an individual or organization to lead the meetings. Working group members will also need to determine whether meetings will be limited in scope or shared publicly.
    - The working group should demonstrate results and share resources such as white papers, technical reviews, or data collections as they are assembled or produced.

## Conclusion

State Energy Offices and Public Utility Commissions have opportunities to be leaders in establishing homeland security and smart inverter working groups. As states seek to develop policies, establish programs, and formulate regulations, working groups can provide technical knowledge, engage a variety of stakeholders, and make recommendations to enhance the function of solar PV systems, support integration with the grid, and mitigate cyber threats.

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