U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# Interconnection Standards for Combined Heat and Power (CHP)

## *State Standards that Impact Interconnection to the Electric Distribution Grid*

## Issue Brief

April 2020

Page intentionally left blank

# Foreword

This publication was written collaboratively by the U.S. Department of Energy Advanced Manufacturing Office (AMO) staff, AMO support contractors, and Combined Heat and Power Technical Assistance Partnerships (CHP TAPs) staff. Every effort has been made to confirm the accuracy of the provided information at the time of publication.

# Interconnection Standards for CHP

The United States has more than 81 gigawatts (GW) of combined heat and power (CHP) capacity installed at nearly 4,600 sites.[1] Over 99% of this capacity is interconnected with the grid,[2] generating approximately 12% of all electricity consumed in the United States.[3] CHP systems are interconnected to the grid because most CHP systems are sized to meet only a portion of a site's electric demand, and grid power is needed to supplement on-site CHP electricity generation. Some CHP installations do generate more electricity than required on site, and in these select cases, interconnection allows for the sale of excess power. For all CHP installations, grid interconnection provides backup power in the event of a planned or unplanned CHP system outage.

This Issue Brief examines state interconnection policies that apply to CHP throughout the United States. It discusses barriers to CHP interconnection and describes elements of effective interconnection standards. A comparison of interconnection standards for all 50 states and the District of Columbia is provided, with a focus on interconnection aspects that can help promote the adoption of CHP. The information in this document is intended to help inform state regulators, policy makers, utility personnel, electricity customers, and other stakeholders about the current status of CHP interconnection requirements, and how the interconnection process could be improved to accelerate the adoption of CHP.

## Policy Intent and Jurisdiction

Interconnection standards that apply to CHP and other types of distributed generation (DG) systems are intended to balance the objectives of electricity customers and suppliers. For electricity customers, interconnection standards ideally provide a transparent and efficient means to interconnect DG resources to the electric grid. For electricity suppliers, interconnection standards must maintain the safety, reliability, and power quality of the electric grid.

Jurisdiction for interconnection depends on whether a generator is connected at the transmission level or the distribution level,[4] as well as on whether electricity is sold into the wholesale market.[5] At the transmission level and for all wholesale transactions, the Federal Energy Regulatory Commission (FERC) has jurisdiction. FERC developed two interconnection procedures based on capacity: 1) Small Generator Interconnection Procedures (SGIP) up to 20 megawatts (MW) and 2) Large Generator Interconnection Procedures (LGIP) above 20 MW. FERC policies are adopted and administered by regional transmission organizations (RTOs) and independent system operators (ISOs) and modified, with FERC approval, to meet regional needs. At the distribution level, state utility commissions regulate interconnection. There are many variations between state interconnection standards, although states frequently base technical and safety requirements on two nationally recognized standards: Institute of Electrical and Electronics Engineers (IEEE) Standard 1547 and Underwriters Laboratories (UL) Standard 1741. Most CHP systems are interconnected at the distribution level, do not export electricity, and are subject to state interconnection standards.

---

[1] U.S. Department of Energy (DOE). CHP Installation Database. Data as of December 31, 2018. https://energy.gov/chp-installs.

[2] U.S. Environmental Protection Agency. Combined Heat and Power Partnership. Webinar on Utility CHP Standby Rates, 2018. Slide #7 presented by B. Hedman. https://www.epa.gov/sites/production/files/2018-06/documents/utility_chp_standby_rates.pdf.

[3] Based on Energy Information Administration data for total U.S. electricity generation in 2018. https://www.eia.gov/tools/faqs/faq.php?id=427&t=3. ICF calculated annual CHP electricity generation based on installed capacity from the DOE CHP Installation Database and estimated annual operating times for CHP systems.

[4] National Association of Regulatory Utility Commissioners and the United States Agency for International Development. n.d. An Introduction to Interconnection Policy in the United States.

[5] From PJM: "The purchase and sale of electricity to resellers (entities that purchase goods or services with the intention to resell them to someone else) is done in the wholesale market, while the purchase and sale of electricity to consumers is done in the retail market." https://learn.pjm.com/electricity-basics/market-for-electricity.aspx.

## Interconnection Rule Development Trends

Development of interconnection standards at the state level is often driven by stakeholders interested in renewable (i.e., solar and wind) power generation and, to a lesser extent, energy storage. Adoption of renewable and storage technologies has expanded significantly in recent years, and stakeholders representing these groups have, in general, had a large presence in working groups that help draft interconnection rules—significantly larger than that of CHP stakeholders. In addition to technology stakeholders, utility input has a strong influence on how rules are developed. Electric utilities are required to ensure grid reliability and safety, and in an effort to meet these needs, utilities may be inclined to push for over-designed protection hardware and controls, driving up costs for CHP and other DG installations.

CHP stakeholders need to be engaged in rulemaking proceedings to ensure that the benefits of CHP are not inadvertently overlooked or underestimated as standards are developed and evolve. For example, some interconnection rules currently exclude generation technologies powered by fossil fuels, even if a fuel such as natural gas is used in a high-efficiency CHP system.

## Barriers to Combined Heat and Power Interconnection and Effective Policies

DG development, including CHP, can be encumbered in states that do not have interconnection standards—but also in states that do have standards. State interconnection standards vary considerably and can lack language or provisions that encourage interconnection. Specific barriers include:[6]

- Interconnection rules that do not clearly establish timelines and fees
- Interconnection rules that differ between utilities within a state
- Protection requirements that are not commensurate with generator capacity and potential grid impacts
- Requirements for high-cost utility studies that are not commensurate with generator capacity

Interconnection standards that address these barriers and are effective for CHP development often have the following features or provisions:

- Address systems up to 10 MW or higher
- Apply to both fossil and renewable fuels
- Include capacity tiers
- Define dispute resolution process
- Include net metering
- Use standard technical requirements
- Use standard application forms and contracts
- Allow connection to network grids in addition to radial grids

[6] State & Local Energy Efficiency Action Network (SEE Action). Chapter 3. Interconnection standards for CHP with No Electricity Export. 2013. https://www4.eere.energy.gov/seeaction/system/files/documents/publications/chapters/see_action_chp_policies_guide_chap_3.pdf

### 10 MW Capacity or Higher

Interconnection standards in several states apply only to system capacities of a few hundred kilowatts (kW) or lower (some standards have an upper limit as low as 25 kW). These capacity limits are reasonable for many solar photovoltaic (PV) systems installed at residential and commercial locations, but these limits exclude a large segment of CHP installations, which often have capacities of several megawatts. The most effective interconnection standards apply to CHP systems with a capacity of 10 MW or higher. Along with a relatively high capacity threshold, effective standards also describe application procedures related to both capacity and grid impacts. Smaller-capacity systems can have a more streamlined approach (i.e., fewer documents and reduced processing time) compared to larger-capacity systems. Regarding grid impacts, most CHP systems do not export power and therefore have little or no impact on how much DG can be hosted on the electric feeder where the CHP system is located. A CHP installation that does not export power can benefit from a more streamlined application process compared to a similar-capacity PV installation that does export power.

**Communication Requirements for Direct Transfer Trip (DTT) Can Create Barriers for CHP**

DTT communicates a trip signal from the utility to a CHP plant and disconnects the generator from the grid. IEEE 1547 allows DTT communication using leased telephone lines, dedicated fiberoptic cable, or radio signals. Experience from Maryland shows that two utilities in the state typically require fiberoptic cable, which can be very expensive, for DTT communications. Under current interconnection rules in Maryland, CHP systems with a capacity of 2 MW and below could be required to install fiberoptic cable for DTT, potentially leading to cost-prohibitive outcomes for small CHP systems. DTT can also introduce a barrier to CHP based on jurisdiction. For example, if a utility can control CHP grid interconnection for periods other than grid outages, customers and investors may have reservations about pursing CHP development.

### Both Fossil and Renewable Fuels

Interconnection standards in many states are driven by a goal of increasing the adoption of renewable generation. Most CHP systems are fueled with natural gas and operate at high efficiency, resulting in a clean DG resource. In addition to operating on natural gas and other fossil fuels, CHP systems can be designed to use renewable fuels such as biomass, landfill gas, and digester gas. The most effective interconnection policies address both fossil and renewable fuels.

### Capacity Tiers

Effective interconnection standards use tiers based on generator size. Without capacity tiers, an interconnection standard uses a "one size fits all" approach based on the most complex installation, which will typically be the largest-capacity generator covered by the standard. A "one size fits all" approach may inhibit smaller CHP projects by imposing high fees and requiring extensive technical studies that are not commensurate with the impact of a smaller CHP system on the electric grid. Without capacity tiers, smaller CHP systems may be required to install expensive protection hardware and communication infrastructure that is appropriate for larger CHP installations but not needed for smaller installations (see sidebar on Direct Transfer Trip).[7] Effective interconnection standards are often developed with three or four tiers, or levels, with increasing timelines, study requirements, and hardware requirements with increasing capacity. Tiered standards often specify a fast-track option for small-capacity installations, thereby accelerating the interconnection schedule and minimizing costs. Tiers often also specify interconnection technology type, with inverter-based systems eligible for the fast-track tiers.

### Dispute Resolution

Disputes can arise when a customer desires to connect a CHP system to a utility's distribution system. For example, a utility may request a detailed technical study or perhaps an expensive protection relay or communication system that a customer may view as unnecessary. When disputes arise, effective interconnection policies can clearly describe a dispute resolution process, including time limits for affected parties to respond at each major step of the dispute resolution process.

[7] DOE CHP Technical Assistance Partnerships (TAP), Mid-Atlantic TAP. Policy Profile – Maryland Interconnection Standards. 2019. https://chptap.lbl.gov/profile/123/MarylandInterconnectionStandardspolicy-profile.pdf

### Net Metering

Interconnection standards are sometimes linked to net metering standards to encourage behind-the-meter CHP development. Net metering is often associated with renewable technologies such as solar PV but can also benefit CHP systems. While behind-the-meter CHP systems are typically not designed to export power to the electric distribution grid, there can be occasions when excess power is generated. In these instances, the economics of a CHP installation can be improved if systems are compensated for excess generation through net metering or another compensation mechanism.

### Standard Technical Requirements

The technical and safety requirements described in a state interconnection standard are typically based on one or more of the following nationally recognized standards: California Rule 21, IEEE 1547, UL 1741, and FERC SGIP. California Rule 21[8] is one of the first comprehensive state-level interconnection policies and was released in 2000. The three investor-owned utilities in California—Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric—are responsible for administering Rule 21. IEEE 1547 was initially released in 2003, and this standard, along with UL 1741, is commonly used by states as a basis for developing technical and safety requirements. The FERC SGIP was released in 2005 for interconnection with FERC's jurisdiction (typically transmission level). In recent years, some states have trended toward basing interconnection standards at the distribution level on FERC's SGIP.[9]

### Standard Application Forms and Contracts

Standard interconnection documents used for all utilities within a state make it easier for project developers to understand and comply with requirements. Standardized documents also benefit regulators by making it easier to assess interconnection applications and, if necessary, resolve disputes.

### Radial and Network Grids

Interconnection standards generally allow connection to radial electric distribution grids, but many distribution grids, particularly in cities with significant CHP potential, are configured as networks. Interconnecting a generator to a network grid may require additional engineering and protection to ensure that the generator does not inadvertently energize the grid during an outage. Studies have shown, however, that interconnection to network grids can be safely achieved.[10]

## Dissimilarities Between Different States' Interconnection Standards

According to the Database of State Incentives for Renewables & Efficiency (DSIRE), 45 states plus the District of Columbia have interconnection policies. While most states have interconnection standards, these standards may not encourage CHP, depending how they are written. The American Council for an Energy-Efficient Economy analyzed details of state interconnection standards and evaluated the applicability to CHP based on the following criteria:[11]

- Is the standard adopted by utilities serving the majority of the state's customers?
- Does the standard include all forms of CHP, regardless of fuel?
- Does the standard have multiple tiers and a fast-track option for smaller systems?
- Does the standard apply to systems of 10 MW or greater?

---

[8] California Rule 21. Accessed October 2019. https://www.cpuc.ca.gov/Rule21/

[9] National Renewable Energy Laboratory. State, Local, and Tribal Governments. Interconnection Standards. Accessed October 2019. https://www.nrel.gov/state-local-tribal/basics-interconnection-standards.html

[10] Regulatory Assistance Project. Interconnection of Distributed Generation to Utility Systems. 2011.

[11] American Council for an Energy-Efficient Economy. The 2019 State Energy Efficiency Scorecard. Report U1908. 2019.

Based on these criteria, 28 of the 45 states with interconnection standards, plus the District of Columbia, have interconnection policies that are effective for CHP (see Figure 1).

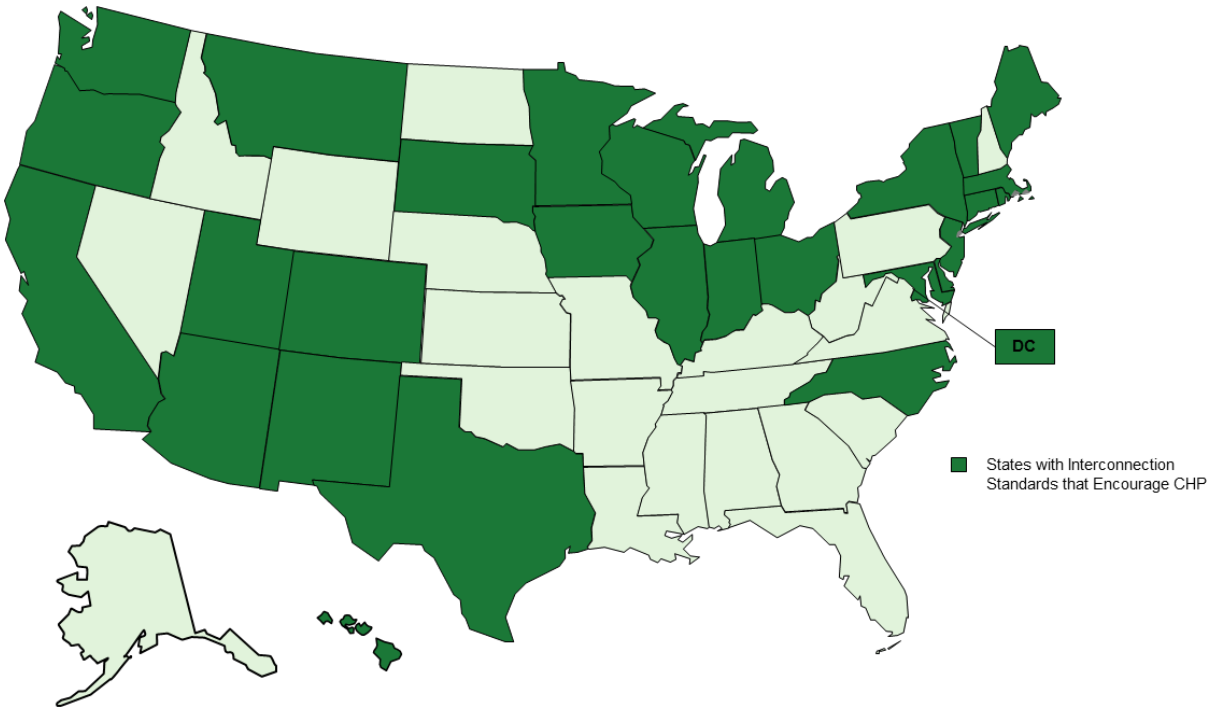


Figure 1. 28 states and the District of Columbia have interconnection policies effective for CHP[12]

Table 1 compares selected features of interconnection standards between all 50 states and the District of Columbia (51 table entries). Interconnection features covered in the table include maximum capacity, eligible fuels, tiers, dispute resolution, and net metering. Table results are summarized as follows:

- There are 46 standards (45 states plus DC), all of which include renewable fuels. Of the 46:
  - 33, or 72%, include fossil fuel.
  - 36, or 78%, have tiers.
  - 18, or 39%, describe a dispute resolution process.
  - 13, or 28%, reference net metering.
- A total of 29 states, or 63%, have a capacity of 10 MW or higher.

**Table 1. Comparison of CHP Interconnection Standards Between States**

| State | Existing Policy | Maximum Capacity | Eligible Fuel | | Provisions Addressed in Standard | | |
|---|---|---|---|---|---|---|---|
| | | | Fossil | Renewable | Tiers or levels | Dispute resolution | Net metering |
| **Alabama** | No | | | | | | |
| **Alaska** | Yes | 25 kW | | ● | | | |
| **Arizona** [a] | Yes | 10 MW | ● | ● | ● | | |
| **Arkansas** | Yes | 300 kW | | ● | | | ● |
| **California** | Yes | No limit | ● | ● | ● | ● | ● |
| **Colorado** | Yes | 10 MW | ● | ● | ● | ● | |

[12] Ibid.

| State | Existing Policy | Maximum Capacity | Eligible Fuel | | Provisions Addressed in Standard | | |
|---|---|---|---|---|---|---|---|
| | | | Fossil | Renewable | Tiers or levels | Dispute resolution | Net metering |
| **Connecticut** | Yes | 20 MW | ● | ● | ● | | |
| **Delaware** | Yes | 10 MW [b] | ● | ● | ● | | |
| **Dist. of Columbia** | Yes | 10 MW | ● | ● | ● | ● | |
| **Florida** | Yes | 2 MW | | ● [c] | ● | | |
| **Georgia** | Yes [d] | 100 kW | | ● | | | |
| **Hawaii** | Yes | No limit | ● | ● | ● | | ● |
| **Idaho** | No | | | | | | |
| **Illinois** [e] | Yes | 10 MW and larger | ● | ● | ● | ● | |
| **Indiana** | Yes | No limit | ● | ● | ● | ● | |
| **Iowa** | Yes | 10 MW | ● | ● | ● | ● | |
| **Kansas** | Yes | 150 or 200 kW [f] | | ● | | | ● |
| **Kentucky** | Yes | 30 kW | | ● | ● | | |
| **Louisiana** | Yes | 300 kW | | ● [g] | | | ● |
| **Maine** | Yes | No limit | ● | ● | ● | | |
| **Maryland** | Yes | 10 MW | ● | ● | ● | ● | |
| **Massachusetts** | Yes | No limit | ● | ● | ● | | |
| **Michigan** | Yes | No limit | ● | ● | ● | ● | |
| **Minnesota** | Yes | 10 MW | ● | ● | | | |
| **Mississippi** | Yes | 2 MW | | ● | ● | | ● |
| **Missouri** | Yes | 100 kW | | ● | | | ● |
| **Montana** | Yes | 10 MW | ● | ● | ● | | |
| **Nebraska** | Yes | 25 kW | | ● | | | |
| **Nevada** | Yes | 20 MW | | ● | ● | | |
| **New Hampshire** | Yes | 1 MW | ● | ● | ● | | ● |
| **New Jersey** | Yes | No limit | | ● | ● | | |
| **New Mexico** | Yes | 10 MW | ● | ● | ● | ● | |
| **New York** | Yes | 5 MW [h] | ● | ● | ● | ● | |
| **North Carolina** | Yes | No limit | ● | ● | ● | | |
| **North Dakota** | No | | | | | | |
| **Ohio** | Yes | 20 MW | ● | ● | ● | ● | |
| **Oklahoma** | No | | | | | | |
| **Oregon** | Yes | No limit | ● | ● | ● | | ● |
| **Pennsylvania** | Yes | 5 MW | ● | ● | ● | ● | |
| **Rhode Island** | Yes | No limit | ● | ● | ● | | |
| **South Carolina** | Yes | 100 kW | ● | ● | | | |
| **South Dakota** | Yes | 10 MW | ● | ● | ● | ● | |
| **Tennessee** | No | | | | | | |
| **Texas** | Yes | 10 MW | ● | ● | ● | ● | |
| **Utah** | Yes | 20 MW | ● | ● | ● | ● | ● |
| **Vermont** | Yes | No limit | ● | ● | ● | ● | ● |
| **Virginia** | Yes | 20 MW | ● | ● | ● | ● | ● |
| **Washington** | Yes | 20 MW | ● | ● | ● | ● | |
| **West Virginia** | Yes | 2 MW | ● | ● | ● | | |
| **Wisconsin** | Yes | 15 MW | ● | ● | ● | | |
| **Wyoming** | Yes | 25 kW | | ● | | | ● |

**Notes**

a) Draft regulations remain to be finalized.

b) Limit is 10 MW for renewable systems and 1 MW for fossil systems.

c) Waste heat to power is included as a renewable fuel, which could allow some fossil CHP to be eligible.

d) Standard applies only to fuel cells and renewable fueled generators.

e) Some aspects of interconnection rules have been adopted, while other aspects have not yet been adopted and are implemented under "emergency rules."

f) Size limit in statute is not clear.

g) Eligible systems include, but are not limited to, fuel cells and microturbines that use a renewable fuel such as biomass.

h) While the New York State interconnection standard applies to systems up to 5 MW, utilities that serve most of the state have procedures for systems up to 20 MW.

## Guidelines for Interconnection Customers

The process of getting a CHP system interconnected can be confusing and time-consuming. Figure 2 shows the steps involved from the perspective of a customer that installed a 600 kW CHP system in the Midwest. While interconnection is only one of several required steps, it can be a critical step that can have a major impact on how quickly a project can be developed.

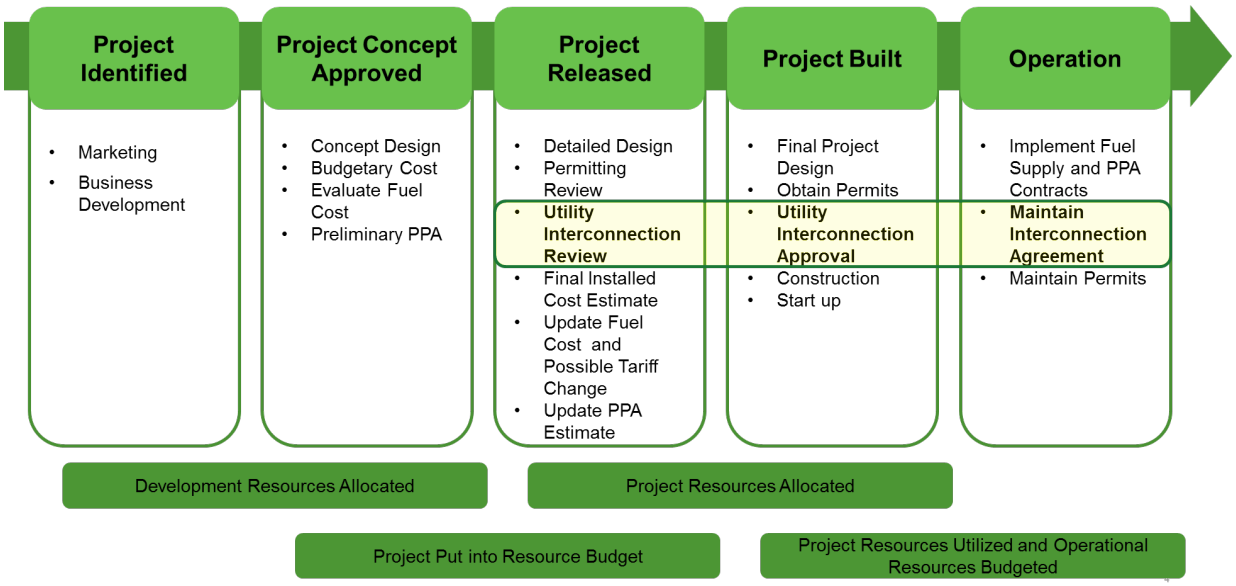


Figure 2. A customer's perspective of interconnection based on installing a 600 kW CHP system

**Source:** Adapted by ICF from MacAllister Machinery Company. Midwest Cogeneration Association Conference. C. Cummings. "Developing CHP Projects in the Midwest." 2019. www.macallisterpowersystems.com.

The checklist shown in Table 2 can help customers navigate the interconnection process. The list identifies important information that needs to be assembled and clearly communicated to utility representatives to help the interconnection process proceed in a timely manner.

**Table 2. CHP Interconnection Checklist**

1. Identify the utility or agency providing power and gas.
2. What is the generating facility address?
3. What are the utility account numbers?
4. What are the utility meter numbers?
5. What type of application is this?
    a. Will this be wholesale or behind-the-meter generation?
    b. What is the size of your generation behind the meter?
    c. Will this be a net energy metering connection?
    d. What is your energy source?
    e. Is the system synchronous, induction, or inverter-based?
    f. Is this renewable fuel?
    g. What mode of operation will you be using?
        i. Parallel mode – running in sync with the utility
        ii. Backup mode – isolated from the utility
        iii. Will your system be islandable?
    h. What is the project in-service date?
6. Will an interconnection study be required? (Many variables are involved in an interconnection study, and the cost of the study can vary significantly depending on site-specific CHP requirements and utility requirements.)

## Summary

A total of 45 states and the District of Columbia have interconnection standards, and 29 of these standards (28 states plus the District) may be considered effective for CHP. Even in these states with effective CHP standards, there is room for improvement. For all states, effective CHP policies have some or all of the following characteristics:

- **Address systems up to at least 10 MW.** Many state standards have relatively small capacity limits (kilowatt scale), and these standards miss a large segment of the potential for CHP.
- **Apply policies to both fossil and renewable fuels.** CHP systems are often fueled with natural gas and operate at high efficiency, offering a clean power resource. State interconnection standards that exclude fossil fuels miss the opportunity to add clean CHP to the resource mix.
- **Include capacity tiers.** Capacity tiers allow costs and study times to be commensurate with generator capacity and avoid situations that could result in cost-prohibitive outcomes for small CHP generators.
- **Define the dispute resolution process.** Differences between customers and utilities occur, and effective interconnection standards spell out the steps for resolving disputes and the timeline for resolving the disagreement.
- **Include net metering.** Net metering or other compensation mechanisms for excess electricity improve the economics for CHP as well as other generators that are interconnected to the grid.

- **Use standardized technical requirements.** Nationally recognized standards, such as IEEE 1547 and UL 1741, help both utilities and customers follow a consistent and transparent path.
- **Use standardized application forms and contracts.** Standardized forms used by all utilities within a state ease the burden on regulators and project developers.
- **Allow connection to radial and network grids.** CHP potential exists on both radial and network distribution grids, and effective interconnection standards address both types of distribution grids.

Development of state interconnection standards is often driven by stakeholders that are interested in solar, wind, and battery energy storage. Adoption of these technologies has expanded significantly in recent years, and stakeholders representing these groups actively engage in interconnection rulemaking. They have a strong presence in working groups that help draft interconnection rules—typically significantly larger than that of CHP stakeholders. In addition to technology stakeholders, utilities have a strong influence on how rules are developed, and utility viewpoints shape interconnection rules that affect CHP and other distributed energy resources. In some cases, interconnection rules also exclude fossil fuels or have relatively low capacity thresholds, which impede some CHP systems. These trends highlight the need for CHP stakeholders to increase engagement in interconnection rulemaking proceedings to ensure that the benefits of CHP are not inadvertently overlooked or underestimated as standards are developed and evolve.

Page intentionally left blank

U.S. DEPARTMENT OF
ENERGY

*Office of*
ENERGY EFFICIENCY &
RENEWABLE ENERGY

**For more information, visit:**
energy.gov/eere/amo
energy.gov/chp

DOE/EE-2069 ▪ April 2020