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Demand Response in Residential Energy Code

Technical Brief

December 2024

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U.S. DEPARTMENT OF ENERGY

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Pacific Northwest National Laboratory
Richland, Washington 99354

Preamble

The U.S. Department of Energy (DOE) and Pacific Northwest National Laboratory (PNNL) developed a series of technical briefs supporting national, state, and local initiatives to update and advance building energy codes. These technical briefs represent specific technologies, measures, or practices that can be incorporated as module-based “plug-ins” via the national model energy codes, such as the International Energy Conservation Code (IECC) or ASHRAE Standard 90.1 or can be adopted directly by state and local governments pursuing advanced energy savings. The collection of briefs is part of a larger effort to provide technical assistance supporting states and local governments working to update their energy codes.

This technical brief provides requirements for demand-responsive thermostats, water heaters, and energy storage systems that could be incorporated into model residential energy codes. It provides background on these technologies, impacts on the cost of construction, and model code language that can be plugged into the IECC or adapted into other energy codes.

Additional assistance may be available from DOE and PNNL to support states and local governments who are interested in adding demand response and other “stretch” provisions to their building codes. Assistance includes technical guidance, customized analysis of expected impacts (e.g., based on state-specific building stock, energy reduction goals, or utility prices), and further tailored code language to overlay state building codes or other standards. DOE provides this assistance in response to the Energy Conservation and Production Act, which directs the Secretary of Energy to provide technical assistance “to support implementation of state residential and commercial building energy efficiency codes” (42 USC 6833). PNNL supports this mission by evaluating concepts for future code updates, conducting technical reviews and analysis of potential code changes, and assisting states and local jurisdictions who strive to adopt, comply with, and enforce energy codes. This helps assure successful implementation of building energy codes, as well as a range of advanced technologies and construction practices, and encourages building standards that are proven to be practical, affordable, and efficient.

DOE Building Energy Codes Program
The U.S. Department of Energy provides technical assistance to states, municipalities and the design and construction industry supporting building energy codes. Modern building codes offer the latest technologies and cost-effective solutions, contributing to lower energy bills for homes and businesses and ensuring safe, efficient and affordable buildings. Learn more at energycodes.gov.

Executive Summary

As buildings account for over 75% of U.S. electricity use, effectively managing their loads can greatly facilitate the transition towards a clean, reliable grid. Grid-interactive efficient buildings (GEBs) combine efficiency and demand flexibility with smart technologies and communication to provide occupant comfort and productivity while serving the grid as a distributed energy resource (DER). In turn, GEBs can play a key role in ensuring access to an affordable, reliable, sustainable, and modern U.S. electric power system. Their national adoption could provide $100-200 billion in U.S. electric power system cost savings over the next two decades. The associated reduction in CO_2 emissions is estimated at 6% per year by 2030 (DOE 2021).

Building codes represent standard design practice in the construction industry and continually evolve to include advanced technologies and innovative practices. Historically, national model energy codes establish minimum efficiency requirements for new construction (ICC 2020).[1] Expanding codes to support GEB capabilities is a pivotal step towards realizing demand flexibility in support of a clean grid by addressing capabilities to improve interoperability between smart building systems, the grid, and renewable energy resources. Realizing GEBs requires buildings with automated demand response (DR) capabilities that enable standardized communication with or control of, subject to explicit consumer consent, energy smart appliances or home energy management systems. This is achieved through direct or indirect (i.e., via an aggregator) communication between appliances and the electric grid.

Energy codes can also support DR communication standardization and advance the deployment of building-integrated DERs such as energy storage, generation, and electric vehicles (EVs). Incorporating automated DR capabilities in energy codes provides many benefits to the consumers.. Specifically, it aligns building electric load demand with intermittent renewable energy source availability, decreases peak load on the electric grid, allows buildings to respond to utility price signals, supports electrical network reliability and market growth of products and processes aligned with clean economic growth.

The incorporation of DR into the model residential energy codes was considered for both the 2021 and 2024 International Energy Conservation Code (IECC) code development cycles. The approved DR measures in the 2021 cycle were removed in response to appeals (ICC 2020). Updated language was presented for consideration again for the 2024 IECC, where it was negotiated and again approved, and again removed in response to appeals (ICC 2024). This resulted in many sections, including sections on demand responsive controls, being moved to the credits options or an appendix as a voluntary application. This technical brief updates the proposed DR components such that they can be considered by states and local governments for direct incorporation into their codes, as well as for future IECC energy code development. The proposal refinements are intended to support consistency in approach and provide a degree of certainty for building owners, designers, contractors, manufacturers, and building and fire safety professionals. The scope of this technical brief includes three strategies for DR in residential buildings: 1) smart thermostats with demand-responsive control, 2) electric water heating incorporating demand-responsive controls and communication and 3) grid Integrated solar and energy storage systems.

[1] The term “model energy code” refers to the current published version of the International Energy Conservation Code-Residential and ASHRAE Standard 90.1, the documents referenced by the Energy Conservation and Production Act, as modified by the Energy Policy Act of 1992, as the minimum requirements for states adopting energy codes.

Contents

1.0 Demand Response in Residential Energy Codes

A rapid transition of the U.S. power system is underway that is reshaping the operation and performance of the electric grid. Persistent growth in renewable energy resources—driven by declining costs, improved performance, and decarbonization policies[2]—is starting to noticeably impact the electricity system (GridWise 2015). As buildings account for over 75% of U.S. electricity use, effectively managing their loads can greatly facilitate this transition towards a clean, reliable grid. Grid-interactive efficient buildings (GEBs) combine efficiency and demand flexibility with smart technologies and communication to provide occupant comfort and productivity while serving the grid as a distributed energy resource (DER). In turn, GEBs can play a key role in ensuring access to an affordable, reliable, sustainable, and modern U.S. electric power system. Their national adoption could provide $100-200 billion in U.S. electric power system cost savings over the next two decades. The associated reduction in CO_2 emissions is estimated at 6% per year by 2030. DOE's national GEB vision is to triple energy efficiency (EE) and demand flexibility[3] (DF) of the buildings sector by 2030 relative to 2020 levels (DOE 2021).

Building codes represent standard design practice in the construction industry and continually evolve to include advanced technologies and innovative practices. Historically, national model energy codes establish minimum efficiency requirements for new construction.[4] Expanding codes to support GEB capabilities is a pivotal step towards realizing DF in support of a clean grid by addressing capabilities to improve interoperability between smart building systems, the grid, and renewable energy resources. Realizing GEBs requires buildings with automated demand response (DR) capabilities that enable standardized communication with or control of, subject to explicit consumer consent, energy smart electric appliances or home energy management systems. This is achieved through direct or indirect (e.g., via an aggregator) communication between the appliances and the electric grid. Energy codes can also support DR communication standardization and advance the deployment of building-integrated DERs such as energy storage, generation, and electric vehicles (EVs).

Incorporating GEB considerations in energy codes can benefit all consumers by providing the following impacts:

1. Align the demand from building electric loads with the availability of intermittent renewable energy sources, such as wind and solar
2. Decrease the peak load on the electrical transmission and distribution networks to alleviate the need to use undesirable peak generation resources
3. Allow buildings to respond to utility price signals and provide grid services that control network characteristics, such as line frequency, system inertia and network voltage, and help prevent network and generation outages
4. Allow electricity suppliers to offset their short-term market imbalance by controlling

[2] Thirty-seven states representing 80% of U.S. population have enacted renewable portfolio standards or goals.

[3] Capability provided by DERs to reduce, shed, shift, modulate or generate electricity; energy flexibility and load flexibility are often used interchangeably with demand flexibility.

[4] The term "model energy code" refers to the current published version of the International Energy Conservation Code-Residential and ASHRAE Standard 90.1, the documents referenced by the Energy Conservation and Production Act, as modified by the Energy Policy Act of 1992, as the minimum requirements for states adopting energy codes.

flexible load on the network

5. Provide a market signal to companies and investors to develop products and processes that align buildings with the transition towards clean economic growth.

The incorporation of DR into the model residential energy codes was considered for both the 2021 and 2024 International Energy Conservation Code (IECC) code development cycles. The approved DR measures in the 2021 cycle were removed in response to appeals (ICC 2020). Updated language was presented for consideration again for the 2024 IECC, where it was negotiated and again approved, and again removed in response to appeals (ICC 2024). This resulted in many sections, including sections on demand responsive controls, being moved to the credits options or an appendix as a voluntary application.

DOE developed this technical brief to update the DR concept such that it can be considered by states and local governments for direct incorporation into their codes, as well as for future IECC energy code development. The DR requirements specified in this technical brief build upon the language considered for the 2024 IECC, as well as that contained in the New Buildings Institute's Building Decarbonization Code (Cheslak et al. 2021). In addition to sample code language, this technical brief adds further information and analysis developed by Pacific Northwest National Laboratory (PNNL). These requirement refinements are intended to support consistency in approach and provide a degree of certainty for building owners, designers, contractors, manufacturers, and building and fire safety professionals.

The scope of this technical brief includes three strategies for DR in residential buildings:

- Smart thermostats with demand-responsive control.
- Electric water heating incorporating demand-responsive controls and communication.
- Demand response inverters on renewable energy and energy storage systems.

1.1 Grid Integrated Thermostats

Thermostats have evolved over the many years since their first introduction for scheduling and control of heating, ventilation, and air conditioning (HVAC) equipment. The first programmable thermostat was released to the market in 1906 with additional features and functionality added over the ensuing decades (DOE 2016). The first digital programmable thermostats were introduced in the mid-1980s. In the 1990s and into the 2000s, thermostats continued to evolve with additional sophistication such as individual day scheduling, equipment control choices, and ancillary services such as humidification, dehumidification, and ventilation. Programmable thermostats were projected to reduce HVAC energy use by 30% (Pang et al. 2020). However, expected levels of energy savings from programmable thermostats were not achieved because of consumer frustration or apathy on the intricacies of programming the thermostat (DOE 2016). Savings projections were based on correct and optimal use of programming functionality.

In response to the usability issues of programmable thermostats, connected (smart) thermostats with improved interfaces and learning algorithms were brought into the market. Smart thermostats capitalized on advancement of data and communication technologies as well as simplifying the scheduling process (DOE 2016). Today's smart thermostat market is evolving quickly through rapid growth and innovation. The interaction of smart thermostats with a smart home can enhance security, comfort, and convenience. The next generation of smart thermostats will communicate with the grid for demand-responsive control.

Smart thermostats with DR control for heating and cooling systems are designed to communicate with the utility grid and adjust heating and cooling setpoints to preprogramed levels during times of high demand or high energy prices. Thermostats with DR control allow grid operators to reduce residential heating and cooling demand on the grid and keep expensive and high-pollution-generating systems offline. Homeowners maintain the ability to overside setpoint adjustments made by DR controls, but this may affect their energy savings or other benefits from participating in DR programs.

California's Title 24 Residential Code, Joint Appendix 5 stipulates that heating, cooling, and ventilation systems have thermostatic control with the ability to:

1. Automatically adjust temperature setpoints by +/- 4° Fahrenheit from a central point
2. Return the system to its original setpoint after the event
3. Provide an adjustable rate of change
4. Provide three modes of operation: automatic demand shed control, manual control, and disabled.

Residential smart thermostat requirements described in the sample code language combine controls of a Title 24 compliant thermostat with the negotiated language from the 2024 IECC development process.

1.2 Grid Integrated Water Heaters

Water heating accounts for 19% of the annual energy consumption in the U.S. residential building stock (EIA 2018). Electric storage water heaters provide an excellent opportunity for load shedding/shifting due to the energy storage capacity of the hot water. Heat pump water heaters (HPWHs) have the potential to reduce the annual energy consumption of residential water heating by 60-70% when compared to electric resistance water heating (DOE, n.d.). HPWHs water temperature setpoints can be increased or turned down or off to take advantage of lower utility pricing and lower hourly carbon emission rates during periods of low demand.

A study conducted by PNNL developed typical load shapes of HPWHs in the Pacific Northwest (Hunt et al. 2021). The HPWH load shapes can help utilities and DR aggregators establish baseline behavior and improve load forecasting algorithms. Water heaters require a minimum storage capacity of 20 gallons to provide sufficient energy storage for adequate load flexibility. Most existing and new homes in the U.S. have a water heater that is between 40 and 60 gallons, representing 2-3x the capacity for use in demand response. Four potential strategies for water heating demand-responsive control with various levels of sophistication and regulation are described below. The grid-connected strategy allows full demand flexibility in response to a real-time price or demand signal from the grid operator.

1. Manual Control – manual adjustment of appliance loads
2. On/Off Control – controlled on a fixed price time-of-use schedule
3. Load Up/Shed – load up water heater over setpoint temperature during demand trough and load shed, or pause heating of water, on peak demand
4. Grid Connected – water heater control based on future forecasting of demand from utility.

Water heaters with demand-responsive control must be supplied with a communication link that meets the Consumer Technology Association Standard 2045 (CTA-2045) for communication with the electric grid or DR signal providers (ANSI/CTA 2018). The CTA-2045 communication protocol stipulates controls to allow an HPWH to overload the tank temperature and increase storage capacity. The communication interface is analogous in concept to a USB socket on computers and other electronic equipment, but this socket is specifically designed for appliances (BPA, n.d.). CTA-2045 is the industry standard for demand-responsive control in water heaters but allows other communication protocols approved by a building official or other authority having jurisdiction. Versions of this standard are included in codes or other requirements in the states of California, Oregon, and Washington.

1.3 Grid Integrated Solar Systems with Energy Storage

Increased competition and reduced costs have led to a significant increase in the amount of solar generation, both at grid scale and distributed via integration with homes. Solar systems naturally produce direct current (DC) power. As a result, they are typically equipped with inverters to enable the power of alternating current (AC) equipment. Solar systems with inverters can be isolated, such that they can only power behind-the-meter equipment, or they can be integrated with the electric grid. However, it typically requires an interconnection agreement with the distribution grid operator.

It's important to remember that to provide grid services, inverters need to have a source of power they can control. Typically, this power comes from direct generation (a solar panel that is currently producing electricity) or storage from a connected battery system. These interactions are categorized into three main categories: automatic generation controlled by operator signals, grid-forming during black starts through sine wave injections, and reactive power that increases total power available to the grid.[5]

To provide flexibility for the ever-increasing amount of distributed renewable energy generation, an increase in energy storage systems (ESS), has come online.[6] ESS naturally produce DC power. As a result, they are typically equipped with inverters to enable the power of AC equipment. ESS with inverters can be isolated, such that they can only power behind-the-meter equipment, or they can be integrated with the electric grid through an interconnection agreement with the distribution grid operator.

When grid integrated or "smart" capabilities are added to inverters, grid operators can interact with distributed solar systems and other IBRs when the grid is not behaving as desired. Functionality of these inverters include (Knobloch et al. 2019):

- Load sharing and energy shifting
- Uninterrupted power supply
- Frequency containment and restoration
- Fault ride through capability
- Power ramp rate control
- Black start capability and resynchronization

While large, utility scale battery systems are most commonly called upon to serve these functions, an increase in distributed EES systems in residential buildings will provide an opportunity for additional grid support.

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[5] Reactive power itself is not consumed by devices; rather, it enhances accessibility of power to users.
[6] Most residential buildings use batteries as the primary ESS, but commercial buildings may use pumped-storage hydroelectric or solar thermal energy storage.

1.4 Benefits of Demand Response

DR provides substantial benefits to the consumer, utilities, and society (Xing et al. 2018). Consumers can reduce energy consumption during peak demand, take advantage of time-of-use or real-time pricing, and lower electric utility bills. Utilities can reduce capital costs, reduce fuel consumption and operating costs, and increase productivity and profit margins while operating power plants at optimized speeds. One additional benefit is enhanced grid resilience and stability. A more complete list of benefits is shown below.

Consumer Benefits

- Take advantage of time-of-use or real-time pricing
- Fewer rolling blackouts
- Reduced energy consumption during peak demand
- Reduced wholesale energy prices and prices paid by consumers
- Lower utility bills

Utility Benefits

- Reduced capital cost
- Reduced carbon emissions
- Reduced fuel consumption and operating costs
- Increased productivity and profit margins
- Operate power plants at optimized speeds
- Grid resilience and stability
- Enhanced voltage stability
- Balanced fluctuations in renewable energy generation

2.0 Economic Analysis

The costs associated with installing residential DR control strategies highlighted in this technical brief are discussed below. The installed costs for smart thermostats and electric water heaters with DR control are modest and depend on the design of the home.

The cost of a standard programmable thermostat required in the 2021 IECC ranges from $20 to $100 based on costs at local home improvement stores. A smart thermostat can range from $120 to $400 based on brand, model, and level of sophistication. The cost to install a programmable or smart thermostat ranges from $113 to $264, with the national average cost of $182.[7] Thus, the incremental cost of upgrading from a standard programmable thermostat to a smart thermostat with DR controls is anywhere between $100 and $200.

Electric resistance water heaters supplied with CTA-2045 communication have been manufactured but are not widely available. Heat pump water heaters (HPWHs) have taken over the energy efficiency segment of the water heater market, and brands at local home improvement stores include the CTA-2045 communication ports. The average cost for a 50-gallon electric resistance heater is $400, while the average cost for a 50-gallon HPWH is $1,300 at local home improvement stores (Salcido et al. 2021). The incremental cost of $900 plus additional condensate removal equipment of $75 results in a total cost differential of $975. For buildings already including HPWHs in the original design, the incremental increase in cost is $0. If the building specified an electric resistance water heater, the most straightforward way to implement the CTA-2045 communication for DR control is to switch to an HPWH with an incremental cost of $975. This cost does not consider utility rebates and other programs that are prevalent in many states, and therefore represents the worst case scenario for incremental cost.

While DR control functionality will reduce costs to utilities as well as electric costs to consumers, it is difficult to estimate or calculate the actual cost savings because of market variability. DR will present cost-saving opportunities for buildings as more homeowners take advantage of time-of-use or real-time pricing controls as they become more widely available. Adding DR controls in model energy codes can help homeowners have the capability of participating in DR programs with alternative utility pricing structures whether they exist now or in the future. Southern California Edison (SCE) offers demand response programs such as the SmartShift Rewards program that provides consumers with connected heat pump water heaters $50 for enrolling in the program and an additional $5 per month of participation. SCE also offers the Smart Energy Program, which rewards consumers with connected thermostats $75 for enrolling in the program and up to $40 in annual credits to their bills.[8] When DR requirements are part of the model energy code, it will not require homeowners or buildings to participate in any DR programs but will guarantee that residential buildings are capable of participating in DR programs.

[7] https://www.homeadvisor.com/cost/heating-and-cooling/install-a-thermostat/
[8] https://www.sce.com/residential/demand-response

3.0 Sample Code Language

This section contains model code language for any state or local government to overlay the current adopted version of the IECC and can be adapted to other existing residential energy codes. Numbering and specifics presented here are based on an adoption of the 2021 or 2024 IECC.

3.1 Definitions

For adoptions of the 2021 or an older version of the IECC the following definition shall be added to Section R202 of the of the IECC Residential provisions.

DEMAND RESPONSE SIGNAL. A signal that indicates a price or a request to modify electricity consumption for a limited time period.

DEMAND-RESPONSIVE CONTROL. A control capable of receiving and automatically responding to a *demand response signal*.

3.2 Demand-Responsive Thermostats

The following DR requirements shall be placed in Section R403 of the 2021 or 2024 IECC residential provisions. Where a jurisdiction is adopting the 2024 IECC, Section R408.2.8 shall be deleted and Table R408.2 amended to remove row R408.2.8.

R403.1.1.1 Demand response. The *thermostat* shall be provided with *demand- responsive control* capable of communicating with the Virtual End Node (VEN) using a wired or wireless bi-directional communication pathway that provides the occupant the ability to voluntarily participate in utility demand response programs. The thermostat shall provide three modes of operation automatic demand shed control, manual control, and disabled, and be capable of executing the following actions in response to a demand response signal:

1. Automatically increasing the zone operating cooling set point by the following values: 1°F (0.5°C), 2°F (1°C), 3°F (1.5°C) and 4°F (2°C).
2. Automatically decreasing the zone operating heating set point by the following values: 1°F (0.5°C), 2°F (1°C), 3°F (1.5°C) and 4°F (2°C).
3. Automatically return the system to its original setpoint after the event

Thermostats controlling single-stage HVAC systems shall comply with **Section R403.1.1.1.1.** Thermostats controlling variable capacity systems shall comply with **Section R403.1.1.1.2.** Thermostats controlling multistage HVAC systems shall comply with either **Section R403.1.1.1.1** or **R403.1.1.1.2**. Where a *demand response signal* is not available, the thermostat shall be capable of performing all other functions.

R403.1.1.1.1 Single-stage HVAC system controls. Thermostats controlling single-stage HVAC systems shall be provided with a *demand responsive control* that complies with one of the following:

1. Certified OpenADR 2.0a VEN, as specified under Clause 11, Conformance.

2. Certified OpenADR 2.0b VEN, as specified under Clause 11, Conformance.
3. Certified by the manufacturer as being capable of responding to a demand response signal from a certified OpenADR 2.0b VEN by automatically implementing the control functions requested by the VEN for the equipment it controls.
4. IEC 62746-10-1.
5. The communication protocol required by a controlling entity, such as a utility or service provider, to participate in an automated demand response program.
6. The physical configuration and communication protocol of CTA 2045-A or CTA-2045-B.

R403.1.1.1.2 Variable-capacity and two-stage HVAC system controls. Thermostats controlling variable-capacity and two-stage HVAC systems shall be provided with a *demand responsive control* that complies with the communication and performance requirements of AHRI 1380.

The following reference standards shall be placed in Chapter 6 of the 2021 or an older version of the IECC residential provisions.

AHRI

Air-Conditioning, Heating, and Refrigeration Institute
2311 Wilson Blvd, Suite 400
Arlington, VA 22201

1380—2019: Demand Response through Variable Capacity HVAC Systems in Residential and Small Commercial Applications
R403.1.1.1.2

CTA

Consumer Technology Association
Technology & Standards Department
1919 S Eads Street
Arlington, VA 22202

ANSI/CTA-2045-A—2018: Modular Communications Interface for Energy Management
R403.1.1.1.1
ANSI/CTA-2045-B—2018: Modular Communications Interface for Energy Management
R403.1.1.1.1

IEC

IEC Regional Centre for North America
446 Main Street, 16th Floor
Worchester, MA 01608

IEC 62746-10-1—2018: Systems interface between customer energy management system and the power management system – Part 10-1: Open automated demand response
R403.1.1.1.1

OpenADR

OpenADR Alliance
111 Deerwood Road, Suite 200
San Ramon, CA 94583

OpenADR 2.0a and 2.0b—2019: Profile Specification Distributed Energy Resources
R403.1.1.1.1

3.3 Demand-Responsive Water Heating

The following DR requirements shall be placed in Section R403 of the 2021 or 2024 IECC residential provisions. If included in an adoption of an older version of the IECC, the section numbering should be reviewed and changed to be sequential with the current adoption.

R403.5.4 Demand-responsive water heating. Electric storage water heaters with a rated water storage volume greater than 20 gallons (76 L) and a nameplate input rating equal to or less than 12 kW shall be provided with demand-responsive controls in accordance with Table R403.5.4.

Exceptions:

1. Water heaters that are capable of delivering water at a temperature of 180°F (82°C) or greater.
2. Water heaters that comply with Section IV, Part HLW or Section X of the ASME Boiler and Pressure Vessel Code.
3. Water heaters that use three-phase electric power.

TABLE R403.5.4 DEMAND RESPONSIVE CONTROLS FOR WATER HEATING

Equipment Type	**Controls**	
	Manufactured before 7/1/2025	**Manufactured on or after 7/1/2025**
Electric storage water heaters	AHRI 1430 (I-P) or ANSI/CTA-2045-B Level 1 and also capable of initiating water heating to meet the temperature set point in response to a demand response signal.	AHRI 1430 (I-P)

The following reference standards shall be placed in Chapter 6 of the 2021 or an older version of the IECC residential provisions.

AHRI

Air-Conditioning, Heating, and Refrigeration Institute
2311 Wilson Blvd, Suite 400
Arlington, VA 22201

1430—2022: Demand Flexible Electric Storage Water Heaters

R403.5.4

CTA

Consumer Technology Association
Technology & Standards Department
1919 S Eads Street
Arlington, VA 22202

ANSI/CTA-2045-A—2018: Modular Communications Interface for Energy Management
R403.5.4
ANSI/CTA-2045-B—2018: Modular Communications Interface for Energy Management
R403.5.4

3.4 Grid Integrated Solar and Energy Storage Systems

The following DR requirements shall be placed in Section R404 of the 2021 or 2024 IECC residential provisions. If included in an adoption of the 2021 IECC, the code section numbering will begin with R404.4. If included in an adoption of an older version of the IECC, the section numbering should be reviewed and changed to be sequential with the current adoption.

R404.5 Solar and energy storage inverters. Direct-current-to-alternating-current inverters serving *on-site renewable energy* systems or on-site electrical *energy storage systems (ESS)* shall be compliant with IEEE 1547 and UL 1741.

The following amendment shall be made in Section R408 of the 2024 IECC residential provisions.

R408.2.7 Renewable energy. Renewable energy resources shall be permanently installed and have the rated capacity to produce not less than 1.0 watt of on-site renewable energy per square foot of conditioned floor area. To qualify for this option, renewable energy certificate (REC) documentation shall meet the requirements of Section R404.4 and inverters serving renewable energy resources shall meet requirements of Section R404.5.

The following text shall be added to Section R405 of the 2021 IECC or 2024 IECC residential provisions, revising Table R405.2.[9,21]

TABLE R405.2 REQUIREMENTS FOR ENERGY RATING INDEX

SECTION	TITLE
Electrical Power and Lighting Systems	
R404.1	Lighting Equipment
R404.2	Interior Lighting Controls
R404.5	Solar and energy storage inverters

The following text shall be added to Section R406 of the 2021 IECC or 2024 IECC residential provisions, revising Table R406.2.[20,10]

TABLE R406.2 REQUIREMENTS FOR ENERGY RATING INDEX

SECTION	TITLE
Electrical Power and Lighting Systems	
R404.1	Lighting Equipment
R404.2	Interior Lighting Controls
R404.5	Solar and energy storage inverters

The following reference standards shall be placed in Chapter 6 of the 2021 or an older version of the IECC residential provisions.

IEEE

Institute of Electrical and Electronics Engineers, Inc. Alliance
3 Park Avenue, 17th Floor
New York, NY 10016-5997

1547: IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
R404.5

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[9] Portions of the table not revised are omitted from this brief and are not intended to be deleted by adoption of this language.
[10] Previous editions of the IECC use a different method of notating mandatory measures. For adoption of language with previous editions, review how that edition indicates mandatory measures and incorporate that notation to ensure all EV measures are mandatory for all compliance paths.

4.0 References

42 USC 6833. Chapter 42, U.S. Code, Section 6833. Available at http://www.gpo.gov/fdsys/pkg/USCODE- 2011-title42/pdf/USCODE-2011-title42-chap81-subchapII.pdf.

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CASE (California Statewide Codes and Standards Enhancement). 2022. *Nonresidential Grid Integration Final CASE Report.* Measure Number: 2022-NR-GRID-INT-F. Prepared by Energy Solutions for the California Statewide Codes and Standards Enhancement (CASE) Initiative under the auspices of the California Public Utilities Commission. https://title24stakeholders.com/wp-content/uploads/2023/01/T24-2022-CASE-Study-Results-Reports-NR-Grid_Final-1.pdf.

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