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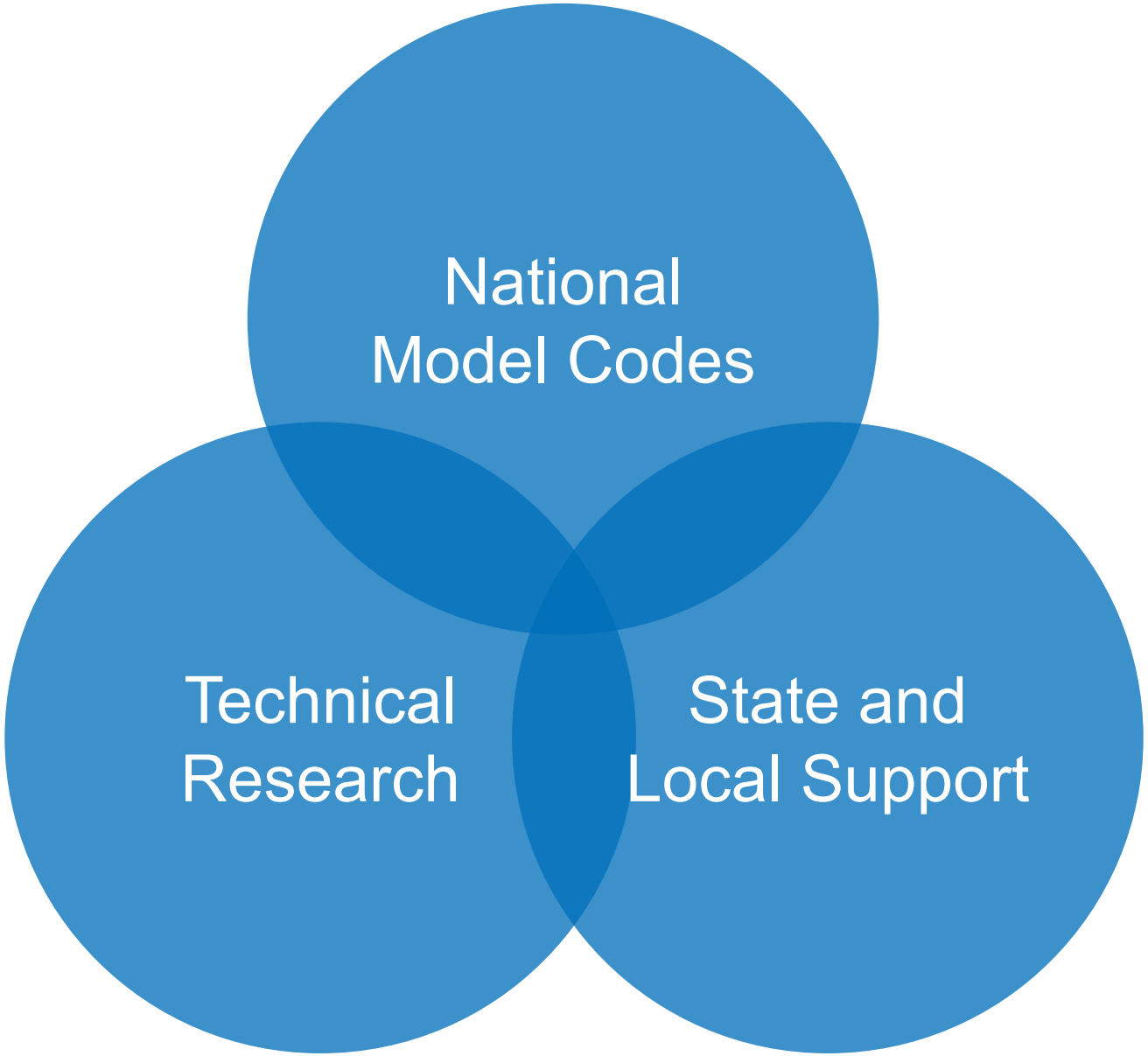
BECWG – Extreme Heat

2026-04-29



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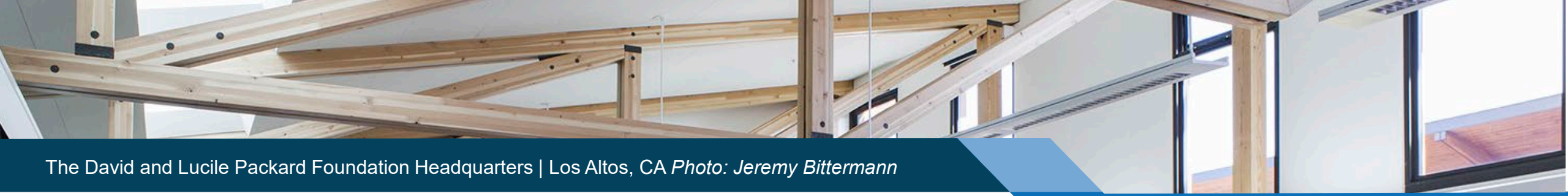

The David and Lucile Packard Foundation Headquarters | Los Altos, CA *Photo: Jeremy Bittermann*

Building Energy Resilience

- ***Building Energy Resilience:*** *The capacity for a building to withstand, respond to, and recover from acute and chronic stressors that impact the* ***maintenance of energy-critical functions*** *such as habitable thermal conditions, and the provision of lighting, fresh air, delivery of potable water, and powering of medical, refrigeration, and communication devices.*
- *Energy resilient buildings incorporate three core functions:*
  - ***passive survivability,***
  - ***grid-interactive efficient building*** *(GEB) technologies, and*
  - *the intentional design and use of* ***active systems****, including distributed energy systems (DERs), for buildings to* ***function independently of the grid****.*

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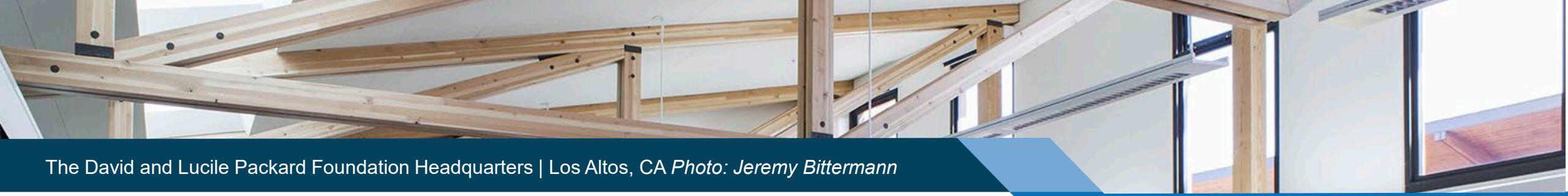
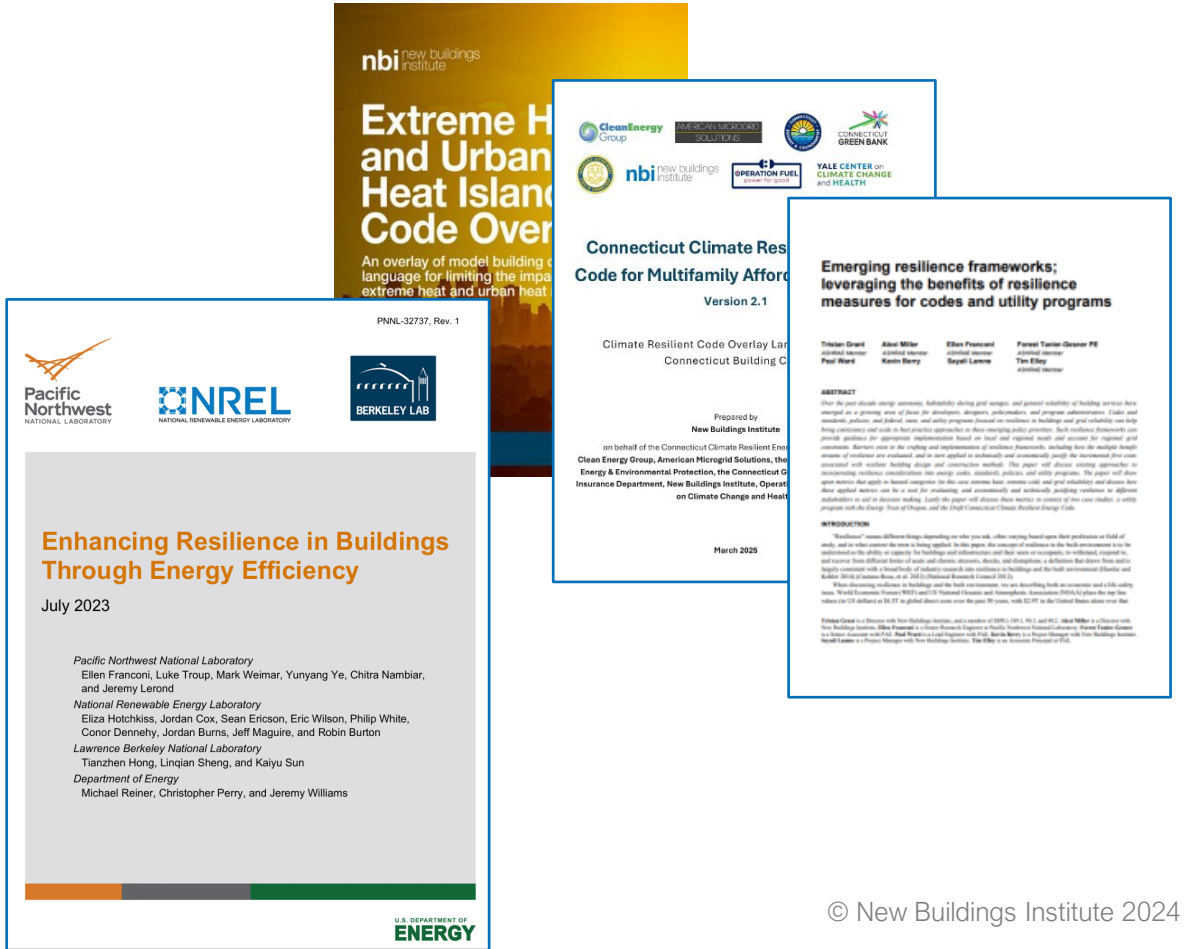


The David and Lucile Packard Foundation Headquarters | Los Altos, CA *Photo: Jeremy Bittermann*

Research and Frameworks: Energy Resilience Codes & Policies

- Connecticut Climate Resilient Energy Code (CT-CRE)
  - Residential & Multifamily
- ASHRAE 189.1 Resilience Appendix
- Critical load identification
- Evaluating performance under: historical TMY, historical "extreme" weather files, future files
  - Passive performance
  - Minimum energy power for critical loads



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CleanEnergyGroup

Climate Resilient Energy Codes for Multifamily Affordable Housing

This work is supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office Award Number DE-EE0010940.

CleanEnergy Group

AMERICAN MICROGRID SOLUTIONS

CONNECTICUT ENERGY & ENVIRONMENT

CONNECTICUT GREEN BANK

INSURANCE DEPARTMENT · STATE OF CONNECTICUT

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OPERATION FUEL power for good

YALE CENTER on CLIMATE CHANGE and HEALTH

What's a climate resilient energy code?

Designed to enhance a building's ability to continue providing heating, cooling, fresh air, access to water, plugs for essential devices (medical devices, phone charging, refrigeration) and comfortable conditions (temperature, humidity, etc.) in order to help occupants more safely shelter in place during severe weather events or power outages.

Improved Comfort

Increased Safety

Reduced Costs

Peace of Mind

CT-CRE Code Development

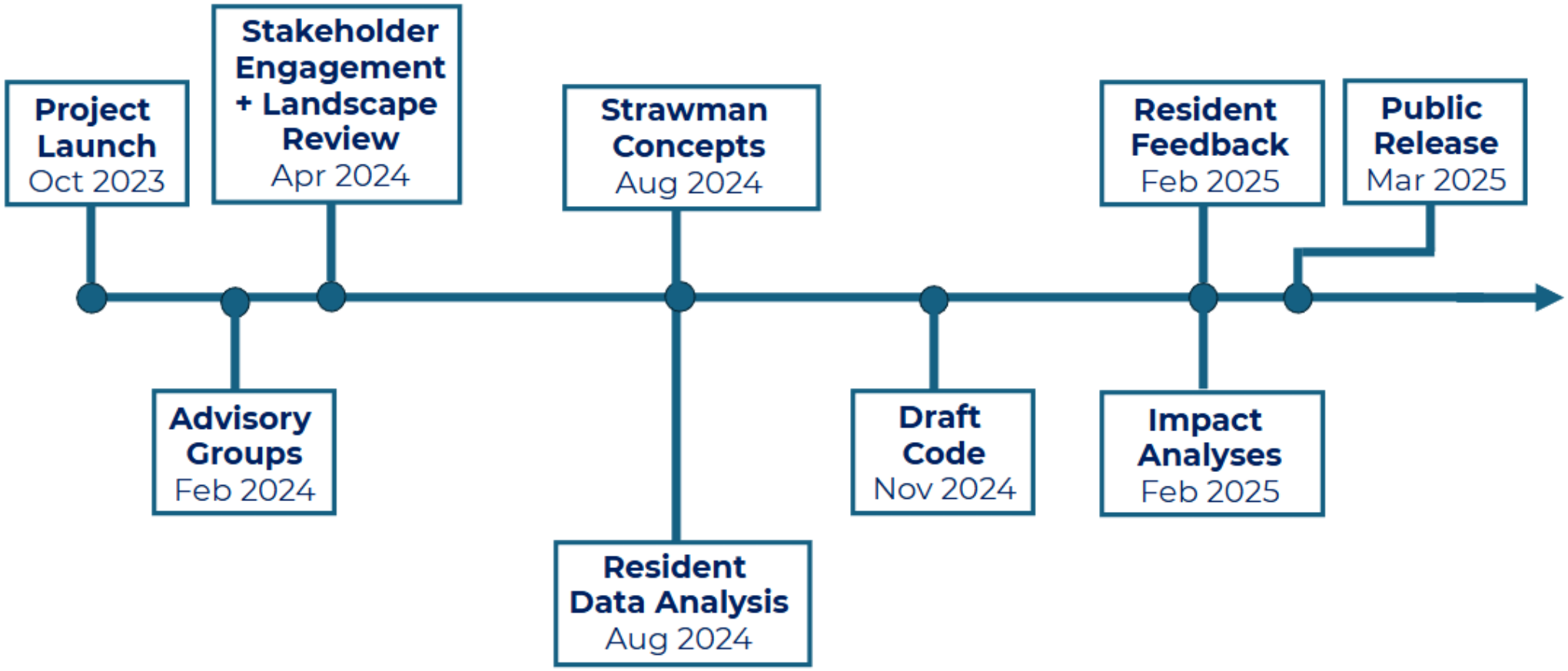
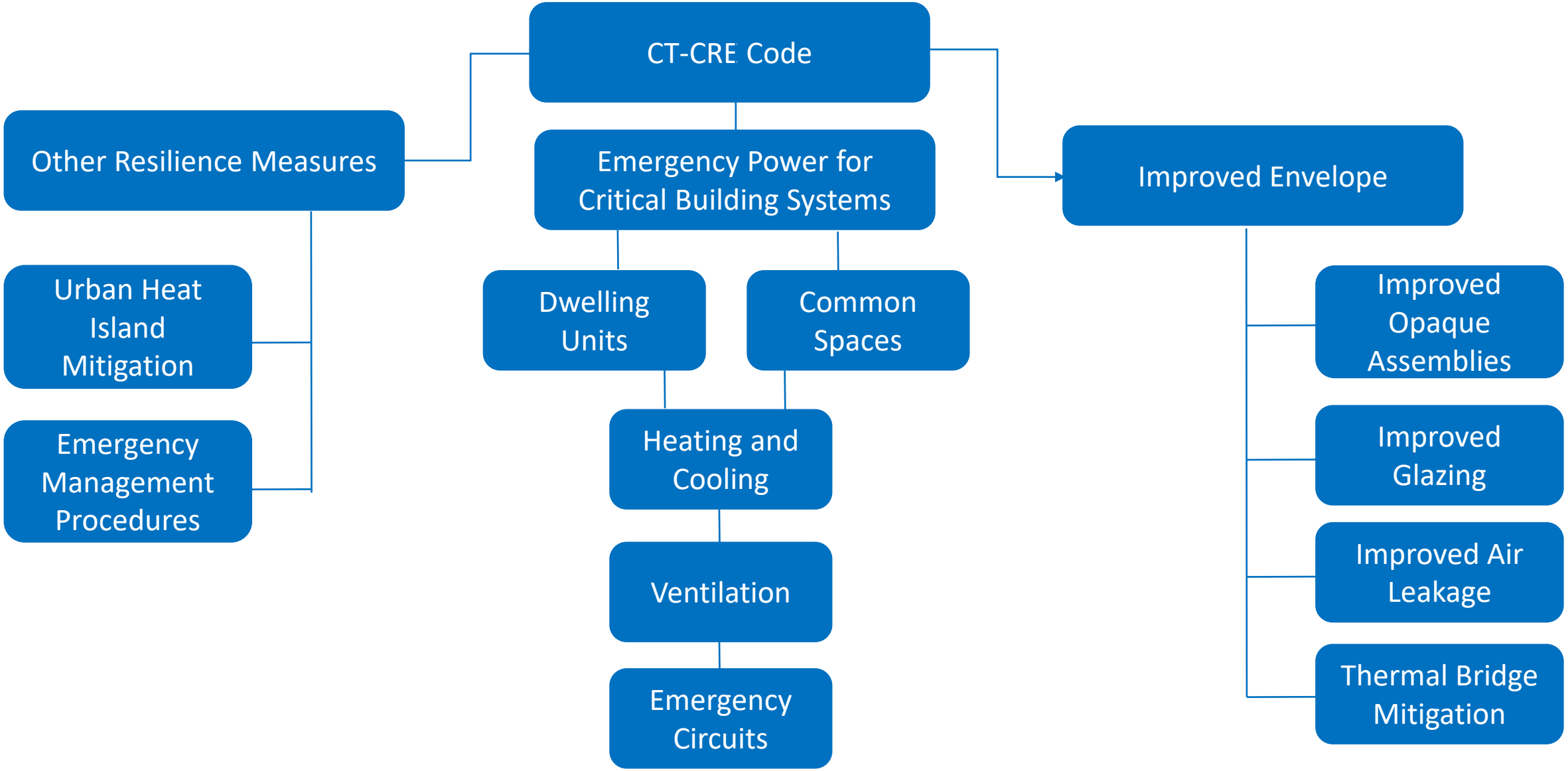


Figure Credit: Clean Energy Group

CT-CRE Code Framework



Climate Resilient Energy (CRE) Code
Thermal resilience metric analysis

Standard Effective Temperature (SET)

- SET is an effective indoor temperature metric that accounts for indoor dry-bulb temperature, relative humidity, mean surface radiant temperature, and air velocity, as well as the activity rate and clothing levels of occupants.

SET Degree Hours

- SET degree hours are the number of degrees above or below a specified indoor comfort threshold summed over a specified period.
- This study uses the comfort thresholds referenced in the LEED pilot credit (IPpc100, USGBC 2022).
  - Comfort threshold: SET degrees < 54°F for extreme cold and SET degrees > 86°F for extreme heat
  - To earn the pilot credit, the cumulative SET degree hours above or below the threshold shall not exceed 216 degrees over a 7-day period.
- This study provides SET degree hours
  - Occurring over 3 days and 7 days
  - Under no power conditions
  - During extreme heat and extreme cold
  - On average based on all apartment units in the building
  - For each apartment unit in the building

12°C

30°C

Source: IIJA Technical Assistance

Additional Analysis – Identifying Metrics

Table 1. Thermal Resilience and Grid Reliability Metrics

Metric	Primary Hazard Category	Description	Citation/Source
Heating SET Degree Hours	Thermal Resilience and Habitability	Degree hours below the base temperature threshold over a period	(Franconi 2023) (United States Green Building Council 2019)
Cooling SET Degree Hours	Thermal Resilience and Habitability	Degree hours above the base temperature threshold over a period	(Franconi 2023) (United States Green Building Council 2019)
Days of Safety (days to exceed 216°F/102°C SET dh)	Thermal Resilience and Habitability	Days before 216 SET degree hours are exceeded during a simulated no- or low-power operating condition	(Franconi 2023) (United States Green Building Council 2019)
Cooling energy consumption (kWh/SF)	Thermal Resilience and Habitability and Grid Reliability	An indicator of emergency power requirements to maintain habitable conditions, and magnitude of building peak load for heating and cooling	
Heating energy consumption (kWh/SF)	Thermal Resilience and Habitability and Grid Reliability	An indicator of emergency power requirements to maintain habitable conditions, and magnitude of building peak load for heating and cooling	
Grid Peak Contribution	Grid Reliability	Degree to which building demand contributes to load on the grid during system peak hours	(Miller and Carbonnier 2020)
Onsite Renewable Utilization	Grid Reliability	Building's consumption of renewable energy generated onsite (not exporting to the grid) over a year	(Miller and Carbonnier 2020)
Dispatchable Flexibility	Grid Reliability	Building's ability to automatically reduce demand (shed) for 15 minutes, controlled by utility/third party	(Miller and Carbonnier 2020)
Peak to Average Grid Ratio	Grid Reliability	Ratio of a buildings peak load to average load, an indication of how flat their use profile is	(Miller and Carbonnier 2020)

Results – Thermal Habitability

Table 2. DOE Prototype Thermal Resilience and Habitability Metric Results

Metric	DOE Midrise Prototype (ASHRAE 90.1-2019)	DOE Midrise Proposed (CT-CRE)
Heating SET Degree Hours (Base 54°F / 12°C)	592 / 311	155 / 68
Days of Safety Heating (Days to Exceed 216°F / 102°C SET dh)	3.9	7+
Typical Annual Heating Energy Consumption (kWh/SF)	2.79	1.18
Cooling SET Degree Hours (base 86F / 30°C)	155 / 68	271 / 133
Days of Safety Cooling (days to exceed 216°F / 102°C SET dh)	7	6.4
Typical Annual Cooling Energy Consumption (kWh)	0.76	0.87

Table 3. Design Case Thermal Resilience and Habitability Metric Results

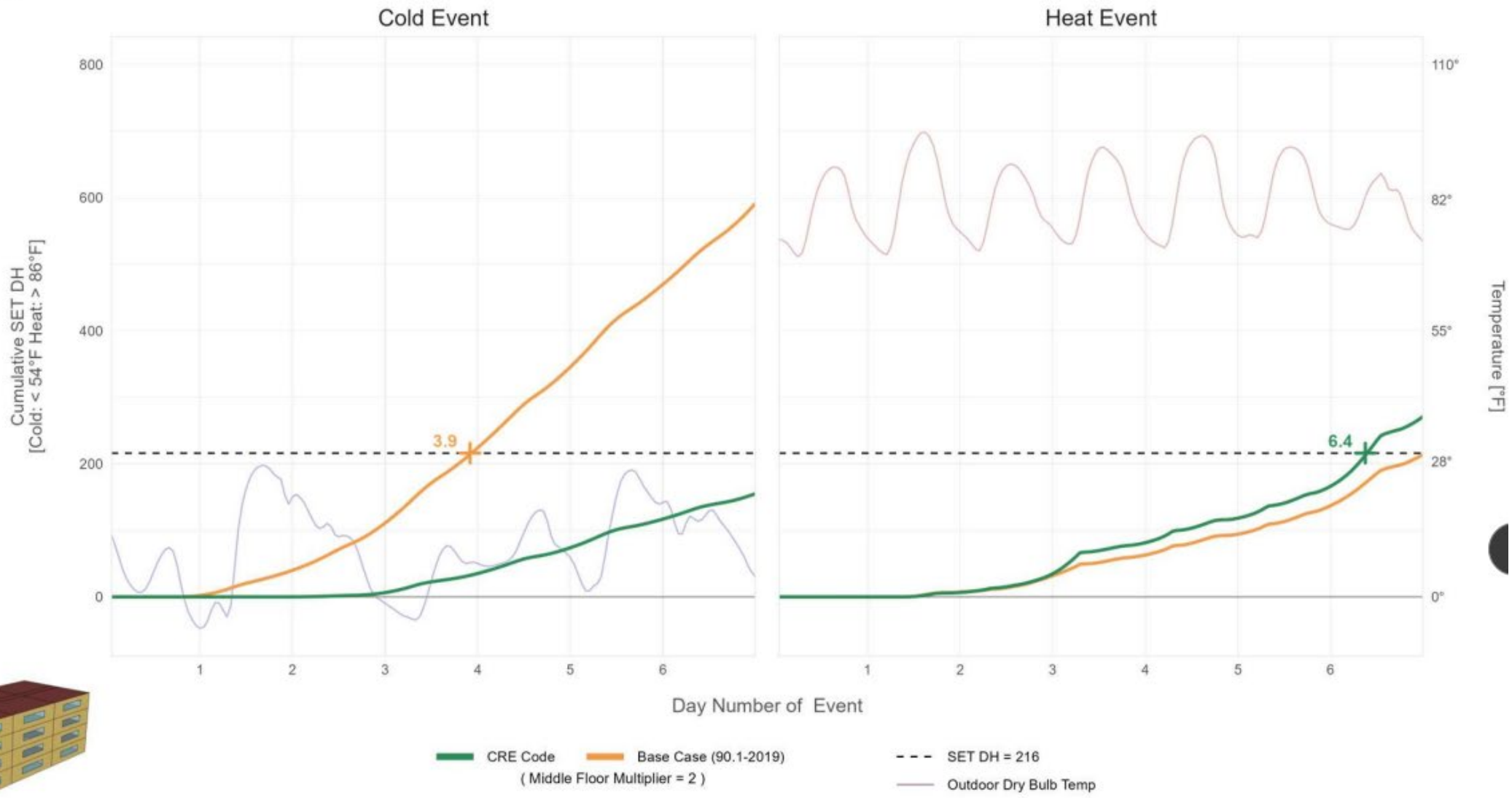
Metric	Design Case (ASHRAE 90.1-2019)	Design Case (CT-CRE)
Heating SET Degree hours (base 54°F / 12°C)	560 / 311	0 / 0
Days of Safety Heating (days to exceed 216°F / 102°C SET dh)	5.0	7+
Typical Annual Heating Energy Consumption (kWh/SF)	1.25	0.15
Cooling SET Degree Hours (base 86F / 30°C)	0 / 0	0 / 0
Days of Safety Cooling (days to exceed 216°F / 102°C SET dh)	7+	7+
Typical Annual Cooling Energy	0.92	0.75

ASSIFIÉ

Pacific Northwest
NATIONAL LABORATORY

Midrise Apartment
Average 'Occupied' Unit

Brainard



Results – Grid Reliability

Table. 4 DOE Prototype GridOptimal Grid Reliability Metric Results

Metric	DOE Midrise Prototype (ASHRAE 90.1-2019)	DOE Midrise Prototype (CT-CRE)
Grid Peak Contribution	32	41
Onsite Renewable Utilization	0	16
Dispatchable Flexibility	0	85
Peak to Average Grid Ratio	2.0	2.2

Table 5. Design Case GridOptimal Grid Reliability Metric Results

Metric	Design Case (ASHRAE 90.1-2019)	Design Case (CT-CRE)
Grid Peak Contribution	50	73
Onsite Renewable Utilization	0	24
Dispatchable Flexibility	0	99
Peak to Average Grid Ratio	2.7	2.9

		Resilient Power[1]
Solar		46 kW
Battery		60 kW / 246 kWh
Financial Returns		
Capital Cost		$503,800
ITC		$149,500
Capital Cost - Tax Benefit		$354,300
IRR		5.9%
NPV @6%, 20yrs		($900)
Simple Payback (years)		8.2
Utility savings	**First Year**	**20 Years**
Energy Savings	($4,440)	($122,028)
Demand Savings	$6,809	$191,267
Other Savings	$0	$0
Revenue & Cash Flow	**First Year**	**20 Years**
Total Utility Savings	$2,369	$69,239
RRES Buy-All Incentive	$21,886	$417,546
CT Energy Storage Solutions Incentive	$155,255	$205,728
Total O&M Expenses	($4,939)	($120,007)
Replacement capex	$0	($71,821)
Capital Cost after ITC	$0	($354,337)
Cash flow	**$174,571**	**$146,347**

Critical Load

Battery Size (kWh)

	10%	15%	20%	30%	40%
185	72	43	26	15	11
246	72	59	39	22	15
372	72	72	62	35	25
440	72	72	72	42	29
558	72	72	72	54	37

Typical Endurance (hrs)

185	26	18	13	7	5
246	34	26	19	11	7
372	54	40	29	19	13
440	66	49	36	24	16
558	72	63	50	29	23

Minimum Endurance (hrs)

Source: American Microgrid Solutions

Establishing Minimum Performance

Table RA4.1.1.1.1(1) Photovoltaic and Energy Storage Requirements for Buildings Meeting the Most Recent Version of 90.1

Climate Zone	Rated PV DC Wattage per Square Foot of Roof Area (W/SF)	Rated Energy Storage System Energy Capacity per Square foot of Conditioned Floor Area (Wh/SF)
CZ 1A	6.75	12.5
CZ 2A	6.75	12.0
CZ 2B	6.75	11.9
CZ 3A	6.75	12.0
CZ 3B	6.75	11.6
CZ 3C	6.75	10.0
CZ 4A	6.75	12.8
CZ 4C	6.75	11.3
CZ 5A	6.75	13.8
CZ 5B	6.75	12.4
CZ 5C	6.75	11.1
CZ 6A	6.75	15.6
CZ 6B	6.75	13.8
CZ 7	6.75	16.0
CZ 8	6.75	17.8

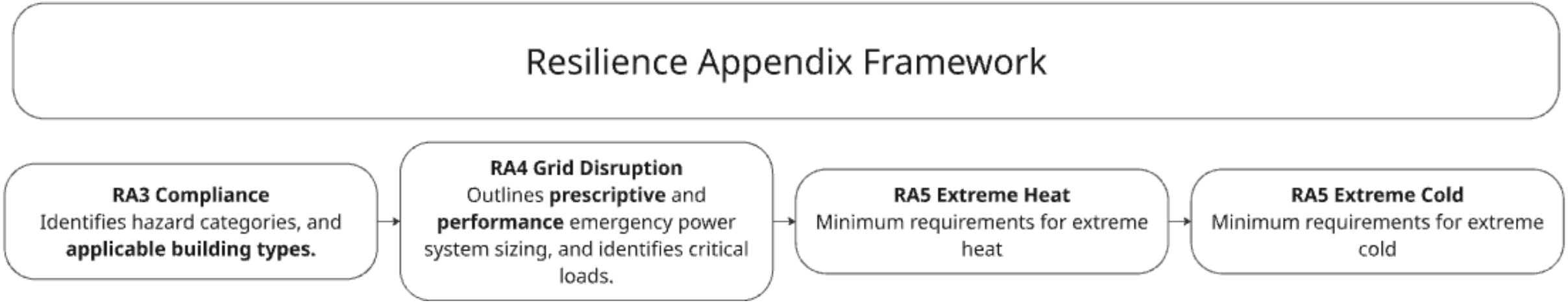
Table RA4.1.1.1.2 (1) Thermal Conditions

Thermal Design Condition	Thermal Condition Limits for Buildings With Standard Occupancy	Thermal Condition Limits for Buildings With Sensitive Population Occupancy	Threshold (SET Degree Hours)
Overheating	82°F(xC°)	78°F	216
Overcooling	55°F(xC°)	62°F	216

Table RA4.1.1.1.2 (2) Simulation Guidelines for *Emergency Power Mode* in Group-R Buildings

Modeling Approach	The building energy model shall be configured according to ASHRAE 90.1 Appendix G Table G3.1, proposed building performance column, unless otherwise specific in this appendix
Weather Data Sources	• Current and Historical Conditions: When using historical weather conditions, typical Meteorological Year (TMY or TMYx) files from the U.S. Department of Energy or Climate.OneBuilding.Org shall be used to represent current and historical weather conditions. • Future Conditions: Where the *authority having jurisdiction (AHJ)* approves or requires the use of future weather scenario data, climate projections shall be based on locally adopted scenarios or CMIP6 Shared Socioeconomic Pathways (SSP2-4.5 and SSP5-8.5) for 2050 and 2100 time slices, or equivalent regional datasets. • Each submission shall identify: the data source, station ID, geographic coordinates, scenario and time period, and file name (e.g., EPW).

Translating CT-CRE to ASHRAE189.1 (and other) Resilience Appendices



- Addresses performance sizing for emergency power systems (simulation guidelines)
- Methods for selecting and using future climate data
- Expand applicability to non-residential building types

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Resilient Southwest

Member Portal

About Team Resources Contact

- The Resilient Southwest Building Code Collaborative is working toward creating more resilient and efficient building codes to meet the unique needs and challenges of our region.

- Our goal is to provide the people of the Southwest more options for safe, comfortable, and efficient homes and buildings.

Resources

- Draft Connecticut Climate Resilient Energy Code - Clean Energy Group
- Standard 189.1 – Standard for the Design of High-Performance ASHRAE Green Buildings – Draft for proposed Appendix on Climate Resiliency - New Buildings Institute
- Resilience-Frameworks-FINAL-REVISED-2025-12-26.pdf
- Assessing the Benefits of Climate Resilient Codes - New Buildings Institute
- Extreme Heat and Urban Heat Island Code Overlay - New Buildings Institute
- Specialized Weather Data Files for Evaluating Thermal Safety and Grid Reliability Applications | Datahub
- Resilient Southwest – Creating more resilient and efficient building codes.