2018 ENERGY TRUST NET ZERO FELLOWSHIP

Passively Building for Resiliency:

Assessing Energy Efficiency and Resilient Design in Oregon Buildings for Today and Tomorrow

Partnership

RWDI

- Joel Good – Project Lead
- Richard Manning – Technical Director
- Jeff Lundgren – Climate Scientist
- Matthew Hyder – Energy Modeler

Oh Planning + Design

- Deb France – Architect

Portland Public Schools

- Steve Effros – Project Manager
- Aaron Presberg – Sr Project Manager, Energy & Sustainability

Big Picture

Oregon State Energy Assurance Plan
Oregon Department of Energy
Oregon Public Utility Commission
August 2012
2016 MITIGATION ACTION PLAN (THE MAP)
Agency Review Draft
The Oregon Resilience Plan
Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami
Report to the 77th Legislative Assembly
from Oregon Seismic Safety Policy Advisory Commission (OSSPAC)
2016 SEAOC CONVENTION PROCEEDINGS
Resilient Schools Through Leadership and Community Engagement
Kent Yu, PhD, SE; James Newell, PhD, SE; Darren Beyer, SE
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Beaverton, Oregon
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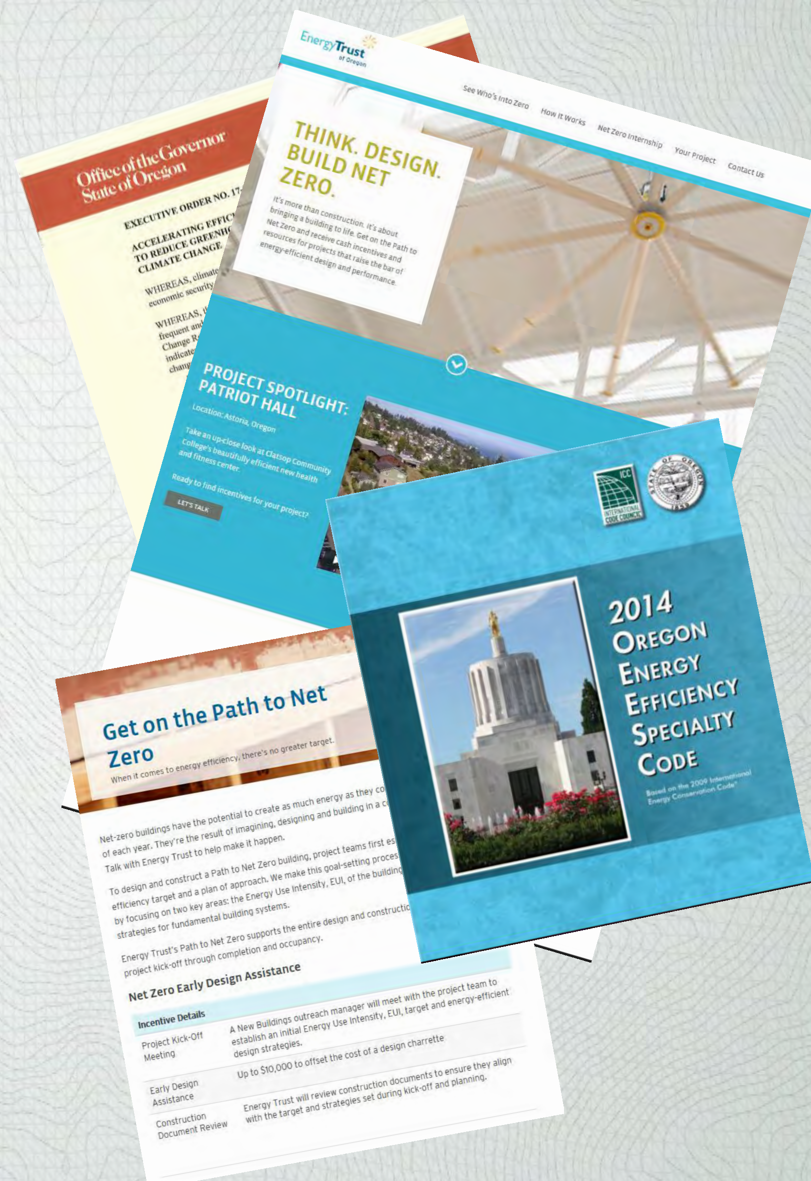
Chris D Poland Consulting Engineer
Canyon Lake, California
Jay Raskin, AIA
Jay Raskin Architect
Portland, Oregon
Richard L. Steinbrugge, PE
Beaverton School District
Beaverton, Oregon
Climate Change Impacts in the United States
U.S. National Climate Assessment
U.S. Global Change Research Program

Big Picture



Office of the Governor
State of Oregon
EXECUTIVE ORDER NO. 17-
Energy Trust of Oregon
See Who's Into Zero
How It Works
Net Zero Internship
Your Project
Contact Us
THINK. DESIGN. BUILD NET ZERO.
It's more than construction. It's about bringing a building to life. Get on the Path to Net Zero and receive cash incentives and resources for projects that raise the bar of energy-efficient design and performance.
PROJECT SPOTLIGHT: PATRIOT HALL
Location: Astoria, Oregon
Take an up-close look at Clatsop Community College's beautifully efficient new health and fitness center.
Ready to find incentives for your project?
LET'S TALK
Get on the Path to Net Zero
When it comes to energy efficiency, there's no greater target.
Net Zero Early Design Assistance
Incentive Details
Project Kick-Off Meeting
A New Buildings outreach manager will meet with the project team to establish an initial Energy Use Intensity, EUI, target and energy-efficient design strategies.
Early Design Assistance
Up to $10,000 to offset the cost of a design charrette
Construction Document Review
Energy Trust will review construction documents to ensure they align with the target and strategies set during kick-off and planning.
2014 Oregon Energy Efficiency Specialty Code

Big Picture

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Net Zero Early Design Assistance
2014 Oregon Energy Efficiency Specialty Code

Research Questions & Goals

Can we establish a **standardized methodology to assess the resiliency** of proposed developments in Oregon, and provide design teams with a method to evaluate resiliency implications?

Research Questions & Goals

standardized methodology to assess resiliency

Can we **clearly assess (quantify!) the value of passive design strategies for resiliency** beyond just energy savings (i.e., lower maintenance, longer lifespan, improved indoor environment)?

Research Questions & Goals

standardized methodology to assess resiliency

assess the value of passive design strategies for resiliency

To prepare our building designs for the future, we need an easy way to assess our local, future climate.

Create a **future climate weather data files for Portland and Bend for public use** with energy modeling software tools.

Research Questions & Goals

standardized methodology to assess resiliency

assess the value of passive design strategies for resiliency

future climate weather data files for Portland and Bend for public use

Leverage our findings to promote passive design practice in Oregon to **improve Community Resiliency and strive for Net Zero Energy**

Research Questions & Goals

standardized methodology to assess resiliency

assess the value of passive design strategies for resiliency

future climate weather data files for Portland and Bend for public use

improve Community Resiliency and strive for Net Zero Energy

Study Methodology

Resiliency

...**intentional design of buildings,** landscapes, communities, and regions in order to **respond to** natural and manmade **disasters and disturbances** - as well as long-term changes resulting from **climate change** - including sea level rise, increased frequency of heat waves, and regional drought

- Resilient Design Institute

... promoting the **design of buildings** that can **maintain temperatures**, **allow for light and remain inhabitable for longer periods**.

- Energy Trust of Oregon

... ensure that buildings will maintain **safe thermal conditions** in the event of an **extended power outage** or loss of heating fuel

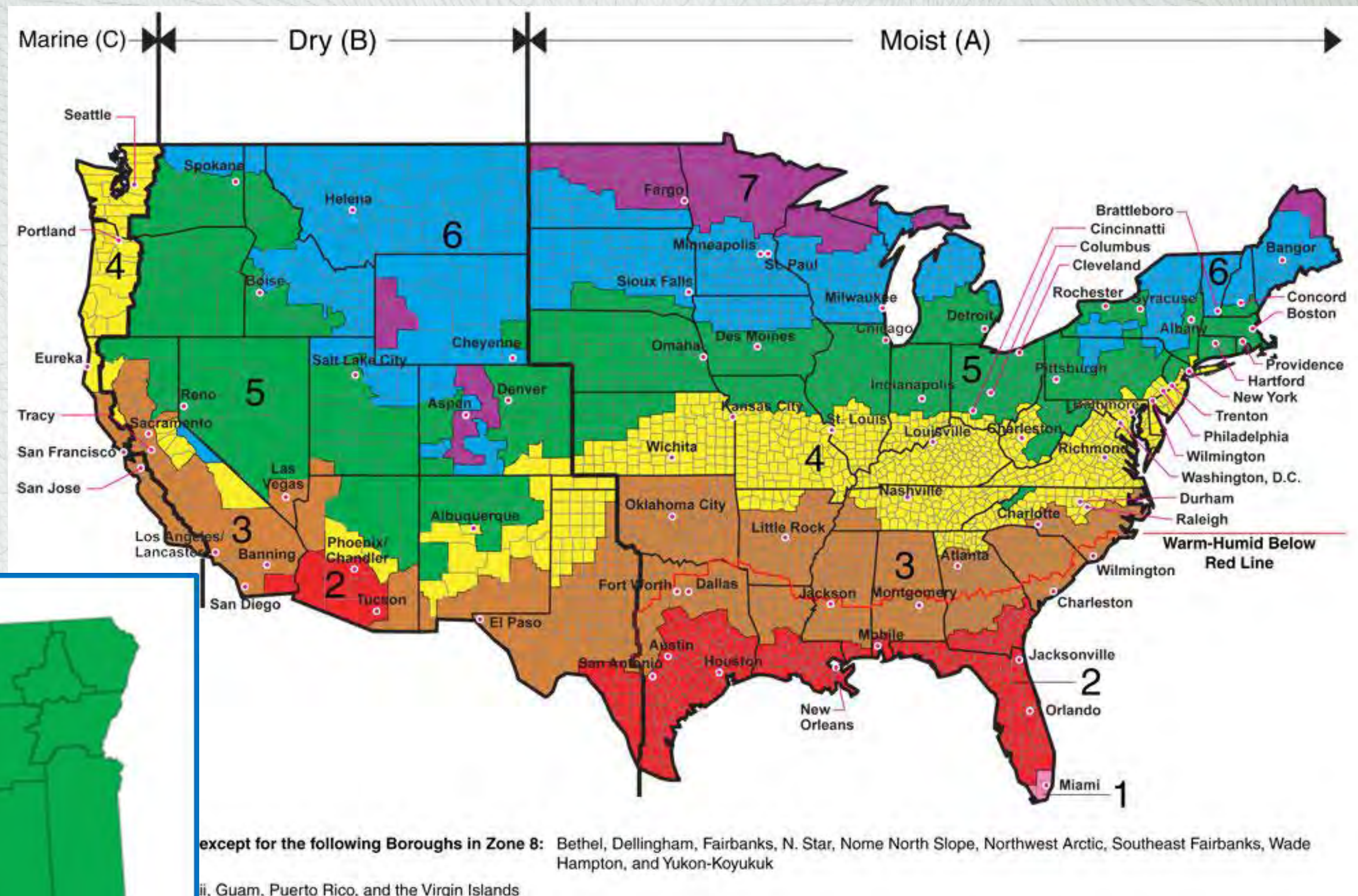
- Passive Survivability (thermal safety)

Study Design

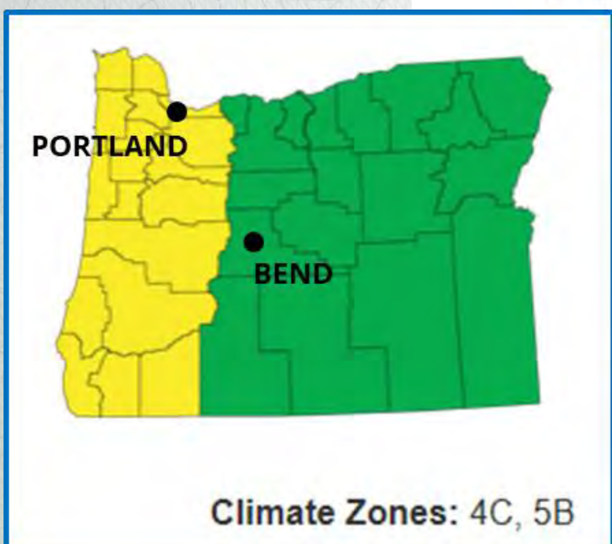
- Test resiliency for design strategies, location, & future climate

Passive Design Strategies	**vs**	**Active/Mech Design Strategies**
Marine Climate	**vs**	**Dry Climate**
Past	**vs**	**Future**

Climate



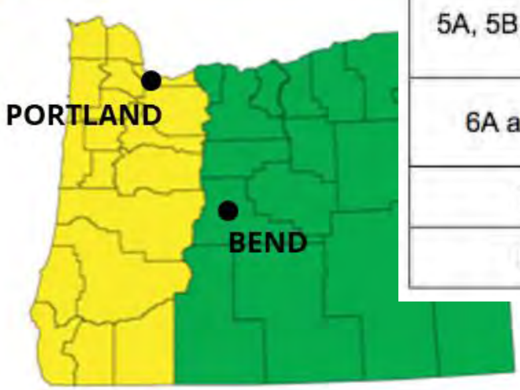
Marine (C)
Dry (B)
Moist (A)
Seattle
Portland
Eureka
Tracy
San Francisco
San Jose
Los Angeles/ Lancaster
San Diego
Spokane
Helena
Boise
Reno
Sacramento
Las Vegas
Banning
Salt Lake City
Cheyenne
Aspen
Denver
Albuquerque
Phoenix/ Chandler
Tucson
El Paso
Fargo
Minneapolis
St. Paul
Sioux Falls
Omaha
Des Moines
Milwaukee
Chicago
Detroit
Kansas City
Wichita
St. Louis
Indianapolis
Louisville
Charleston
Pittsburgh
Oklahoma City
Little Rock
Nashville
Charlotte
Richmond
Atlanta
Fort Worth
Dallas
Jackson
Montgomery
Mobile
Austin
San Antonio
Houston
New Orleans
Jacksonville
Orlando
Miami
Brattleboro
Cincinnatti
Columbus
Cleveland
Rochester
Syracuse
Albany
Bangor
Concord
Boston
Providence
Hartford
New York
Trenton
Philadelphia
Wilmington
Washington, D.C.
Durham
Raleigh
Warm-Humid Below Red Line
Wilmington
Charleston
1
2
3
4
5
6
7
except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk
ii, Guam, Puerto Rico, and the Virgin Islands



PORTLAND
BEND
Climate Zones: 4C, 5B

Climate

Zone Number	Zone Name	Thermal Criteria (I-P Units)	Thermal Criteria (SI Units)
1A and 1B	Very Hot –Humid (1A) Dry (1B)	9000 < CDD50°F	5000 < CDD10ºC
2A and 2B	Hot-Humid (2A) Dry (2B)	6300 < CDD50°F ≤ 9000	3500 < CDD10ºC ≤ 5000
3A and 3B	Warm – Humid (3A) Dry (3B)	4500 < CDD50°F ≤ 6300	2500 < CDD10ºC < 3500
3C	Warm – Marine (3C)	CDD50°F ≤ 4500 AND HDD65°F ≤ 3600	CDD10ºC ≤ 2500 AND HDD18ºC ≤ 2000
4A and 4B	Mixed-Humid (4A) Dry (4B)	CDD50°F ≤ 4500 AND 3600 < HDD65°F ≤ 5400	CDD10ºC ≤ 2500 AND HDD18ºC ≤ 3000
4C	Mixed – Marine (4C)	3600 < HDD65°F ≤ 5400	2000 < HDD18ºC ≤ 3000
5A, 5B, and 5C	Cool-Humid (5A) Dry (5B) Marine (5C)	5400 < HDD65°F ≤ 7200	3000 < HDD18ºC ≤ 4000
6A and 6B	Cold – Humid (6A) Dry (6B)	7200 < HDD65°F ≤ 9000	4000 < HDD18ºC ≤ 5000
7	Very Cold	9000 < HDD65°F ≤ 12600	5000 < HDD18ºC ≤ 7000
8	Subarctic	12600 < HDD65°F	7000 < HDD18ºC



Climate Zones: 4C, 5B

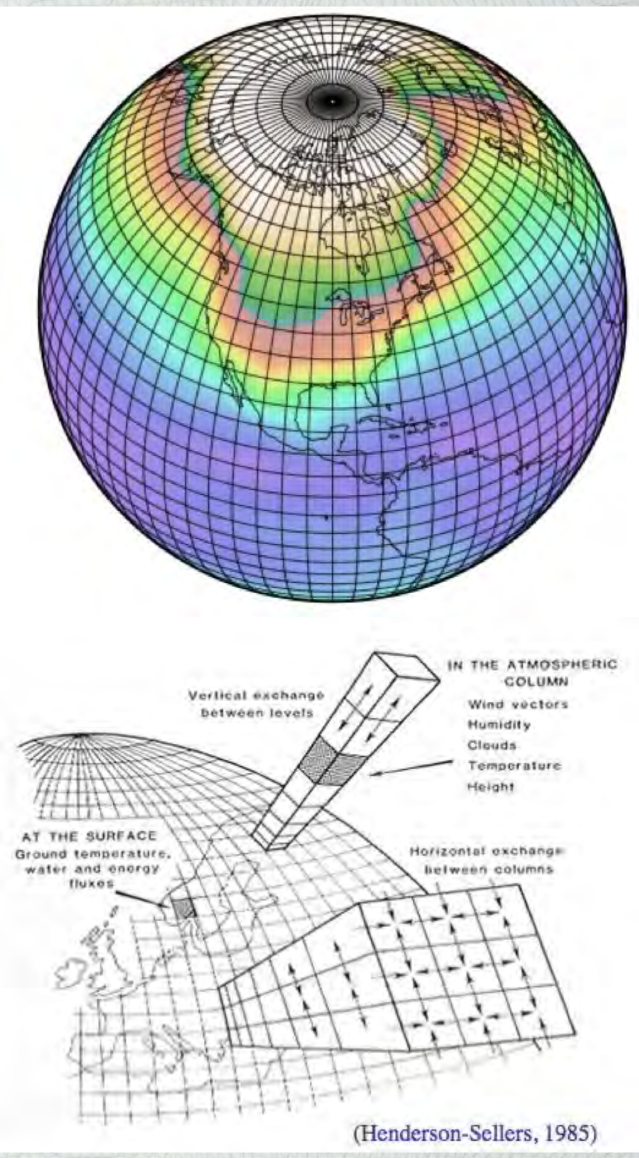
Future Climate Files

Future Climate Modeling

- Statistical Models
  - Adjust temperature, conform other properties

- Dynamic Models
  - Limited Area, or regional, model covers a sub-global area, but is driven at the boundaries by the global model

  - WRF – Weather Research and Forecast Model

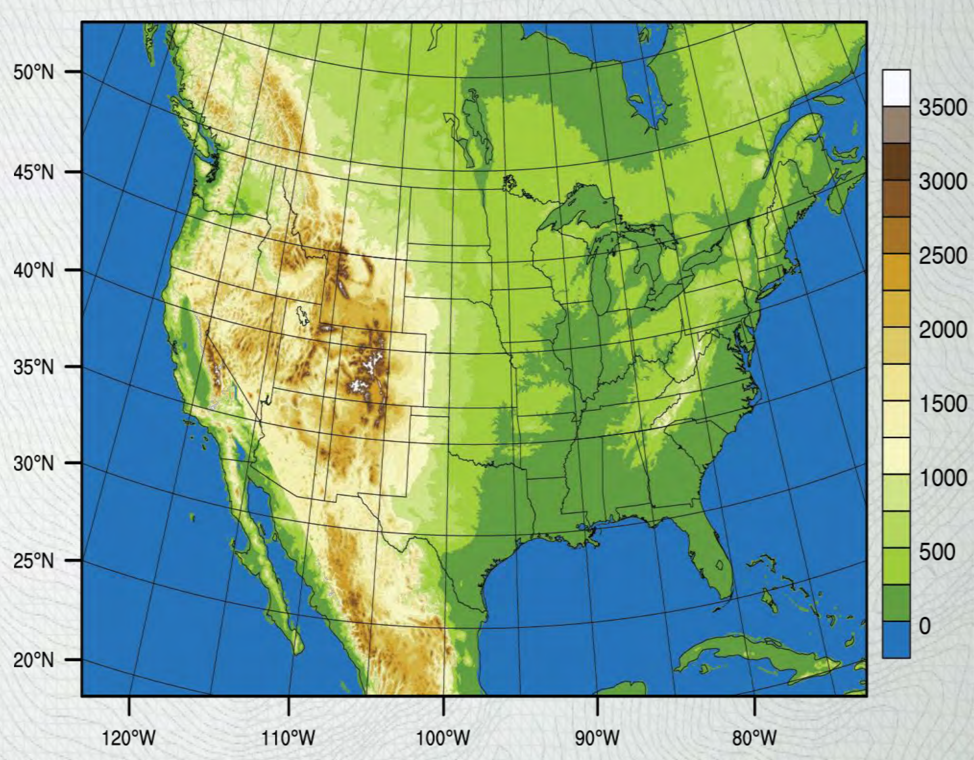


https://serc.carleton.edu/eet/envisioningclimatechange/part_2.html

Future Climate Files

NCAR - National Center For Atmospheric Research, Boulder CO

- High resolution simulation that permits convection and resolves at 4 km (2.5 mi) grid spacing over much of North America using WRF model (domain shown)
- Pseudo Global Warming approach: Future not run explicitly. Historical simulation perturbed at boundaries by the predicted global change.
- Perturbation from ensemble average of 19 CMIP5 for rcp8.5 forcing for period 2071-2100
- Base period is 2000-2013, 'future' is same period with perturbation applied



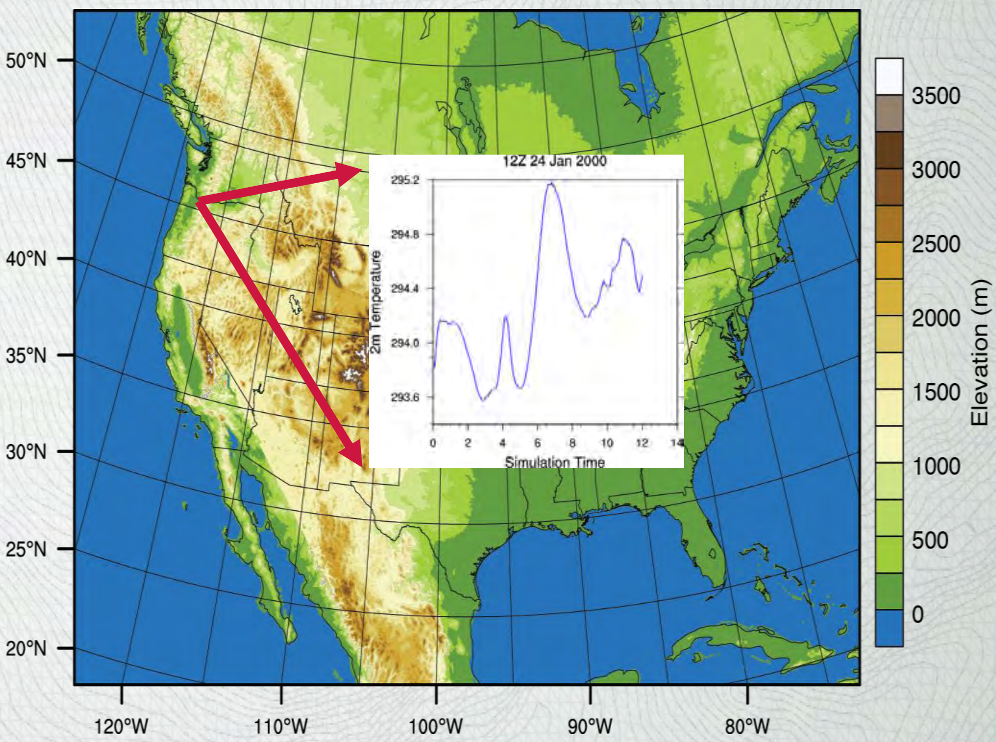
Rasmussen, R., and C. Liu. 2017. ***High Resolution WRF Simulations of the Current and Future Climate of North America***. Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory. https://doi.org/10.5065/D6V40SXP.

CMIP5 = Coupled Model Intercomparison Project Phase 5
RCP8.5 = "High Emissions" Scenario

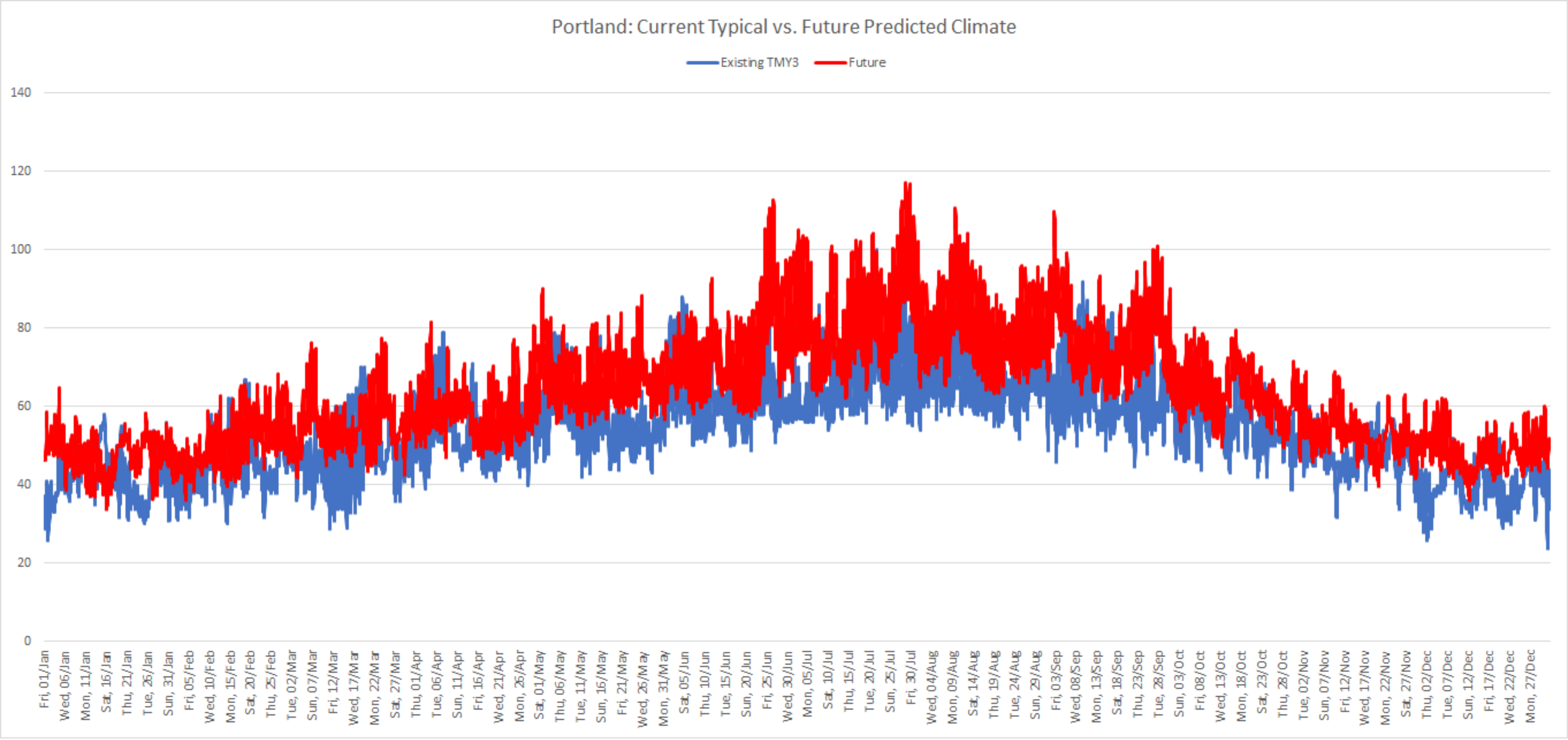
Future Climate Files

WRF → TMY → EPW

- Extract time series point meteorology from WRF model files
- Derived 'Modified' TMY3 analysis. TMY3 approach using the 13 available years (rather than 30)
- Convert future WRF derived TMY data to EPW format for energy modelling

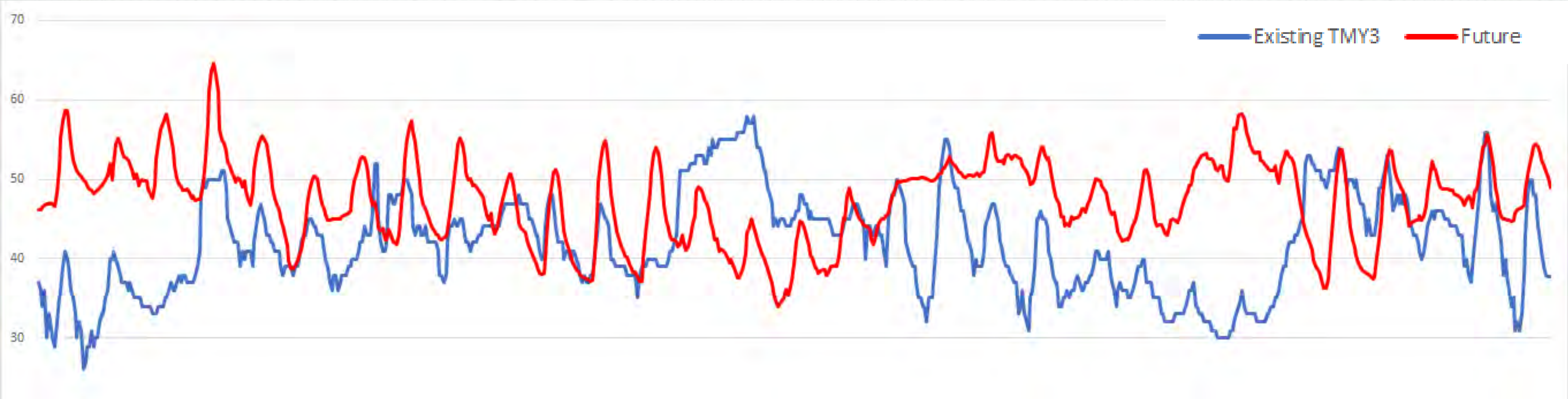


Future Climate Files

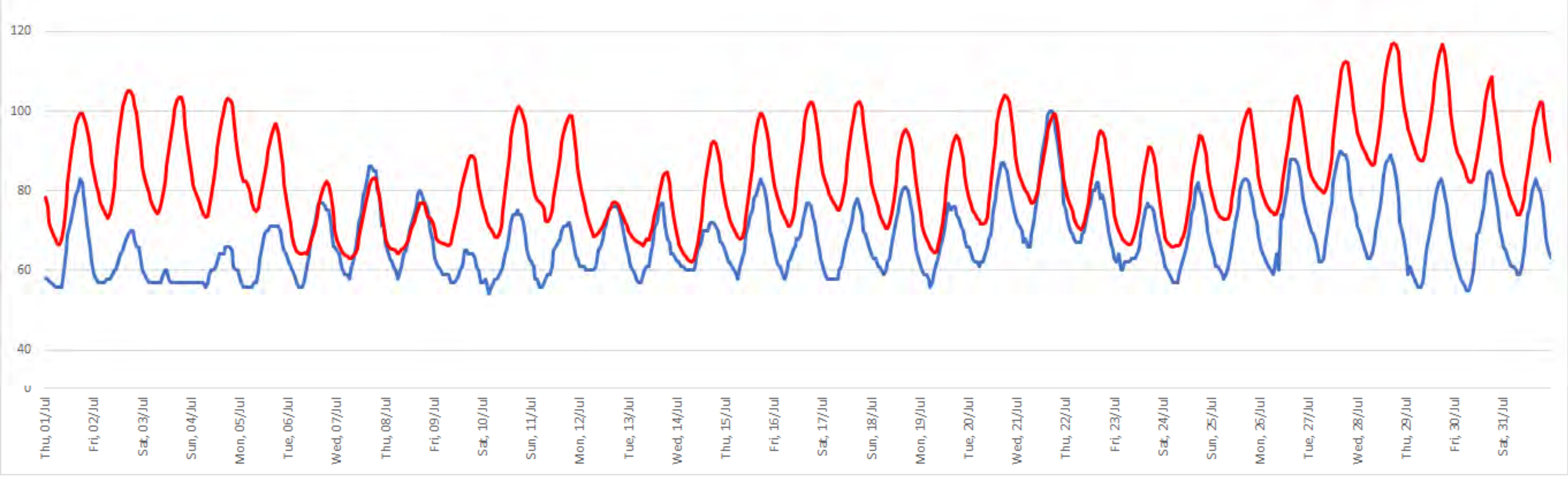


Future Climate Files

Portland - Dry Bulb Temperature - January



Portland - Dry Bulb Temperature - July



Representative Case Study

- A practical design case
- Programmatic constraints
- Community importance
- Repeatability

Representative Case Study

Kellogg Middle School, Portland – Rendering courtesy of Oh Planning & Design

Representative Case Study

Kellogg Middle School, Portland – Rendering courtesy of Oh Planning & Design

Building Energy Models

Start with a baseline:

Oregon energy code (OEESC, 2014 → ASHRAE 90.1-2010)
Standard mechanical systems

Two high performance paths:

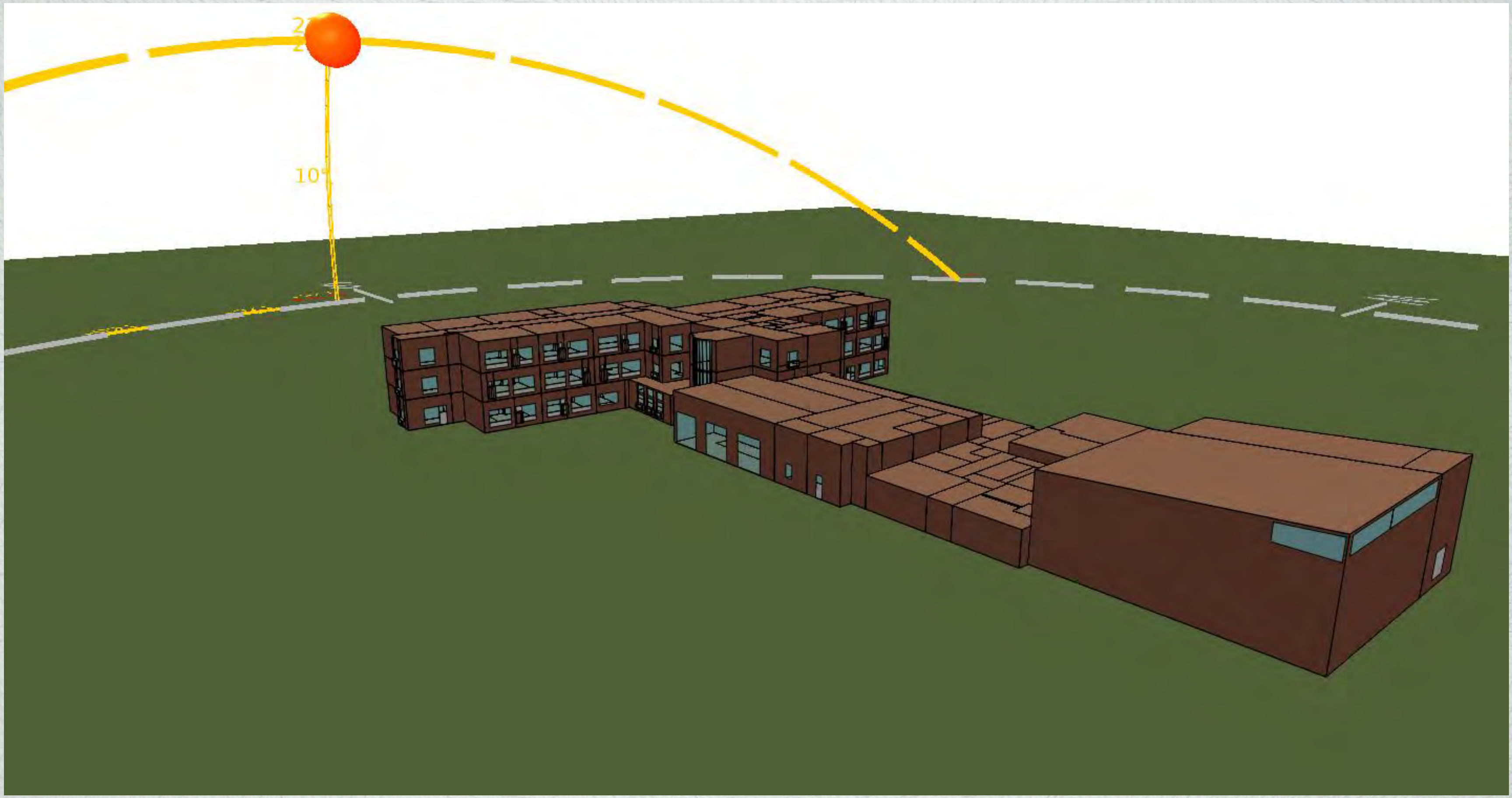
Passive Design Path

Active / Mechanical Design Path

High Energy Performance

(Match EUI)

Building Energy Models



Building Energy Models
Oregon Code Baseline

TABLE 502.1.1
BUILDING ENVELOPE REQUIREMENTS - OPAQUE ASSEMBLIES

CLIMATE ZONE	5 AND MARINE 4	
	All other	Group R
Roofs		
Insulation entirely above deck	R-20ci	R-20ci
Metal buildings (with R-3.5 thermal blocks[a, b])	R-13 + R-13	R-19
Attic and other	R-38	R-38
Walls, Above Grade		
Mass	R-11.4ci	R-13.3ci
Metal building[b]	R-13 + R-5.6ci	R-13 + R-5.6ci
Metal framed	R-13 + R-7.5ci	R-13 + R-7.5ci
Wood framed and other	R-13 + R-3.8ci or R-21	R-13 + R-3.8ci or R-21
Walls, Below Grade		
Below grade wall[d]	R-7.5ci	R-7.5ci
Floors		
Mass	R-10ci	R-12.5ci
Joist/Framing (steel/wood)	R-30	R-30
Slab-on-Grade Floors		
Unheated slabs	NR	R-10 for 24 in. below
Heated slabs	R-15 for 24 in. below	R-15 for 24 in. below
Opaque Doors		
Swinging	U-0.70	U-0.70
Roll-up or sliding	U-0.50	U-0.50

For SI: 1 inch = 25.4 mm.
ci = Continuous insulation. NR = No requirement.
a. Thermal spacer blocks are required.
b. Assembly descriptions can be found in Table 502.2(2).
c. When heated slabs are placed below grade, below-grade walls must meet the exterior insulation requirements for perimeter insulation according to the heated slab-on-grade construction.

TABLE 502.3
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

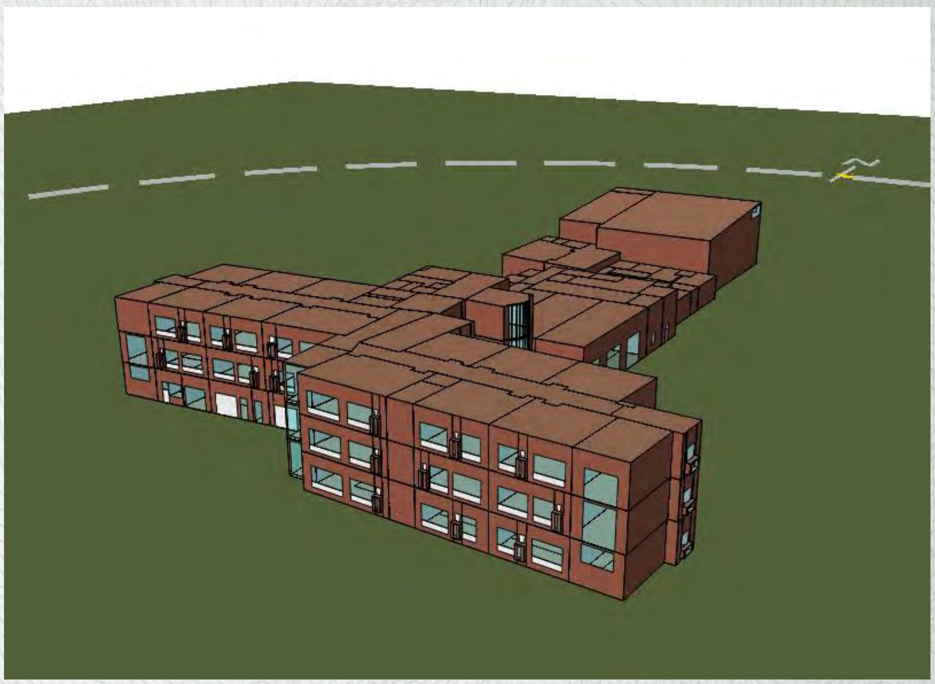
CLIMATE ZONE	5 AND MARINE 4
Vertical fenestration (30% maximum of above-grade wall)	
Fenestration type	*U*-factor
Framing materials other than metal with or without metal reinforcement or cladding	
Fixed, operable, and doors with greater than 50% glazing	0.35
Metal framing with or without thermal break	
Fixed: including curtain wall/storefront	0.45
Entrance door	0.80
All other[a]	0.40
SHGC-all frame types	0.40
Skylights (3% maximum of roof area)	
U-factor	0.60
SHGC	0.40

a. All others includes operable windows, and non-entrance doors with greater than 50 percent glazing.

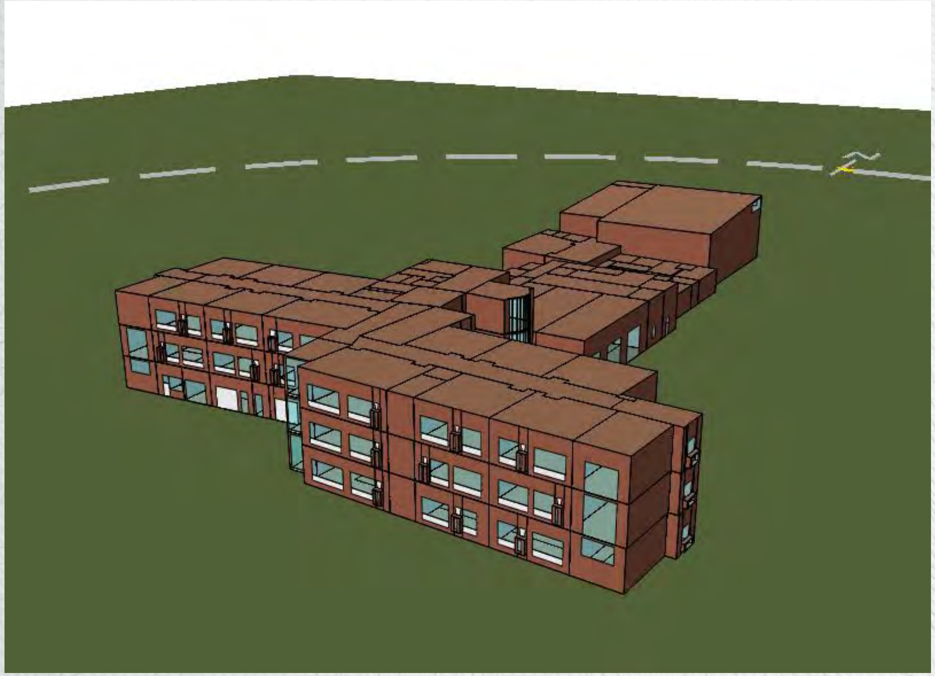
502.4.1.2.1 Materials. Materials with an air permeability no greater than 0.004 cfm per square foot (0.02 L/s · m²) under a pressure differential of 0.3 inches water gauge (w.g.) (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in Items 1 through 15 shall be deemed to comply with this section provided joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions:

Building Energy Models
Passive Design Strategies

- Passive House Envelope
- High performance glazing
  - Triple pane, low-e, w/ thermal breaks/spacers
- Tight envelope
- Additional solar shading
- Daylight, LED lighting w/ controls
- ERV
- Radiant heat w/ High efficiency condensing boiler



Building Energy Models
Mechanical / Active Design Strategies

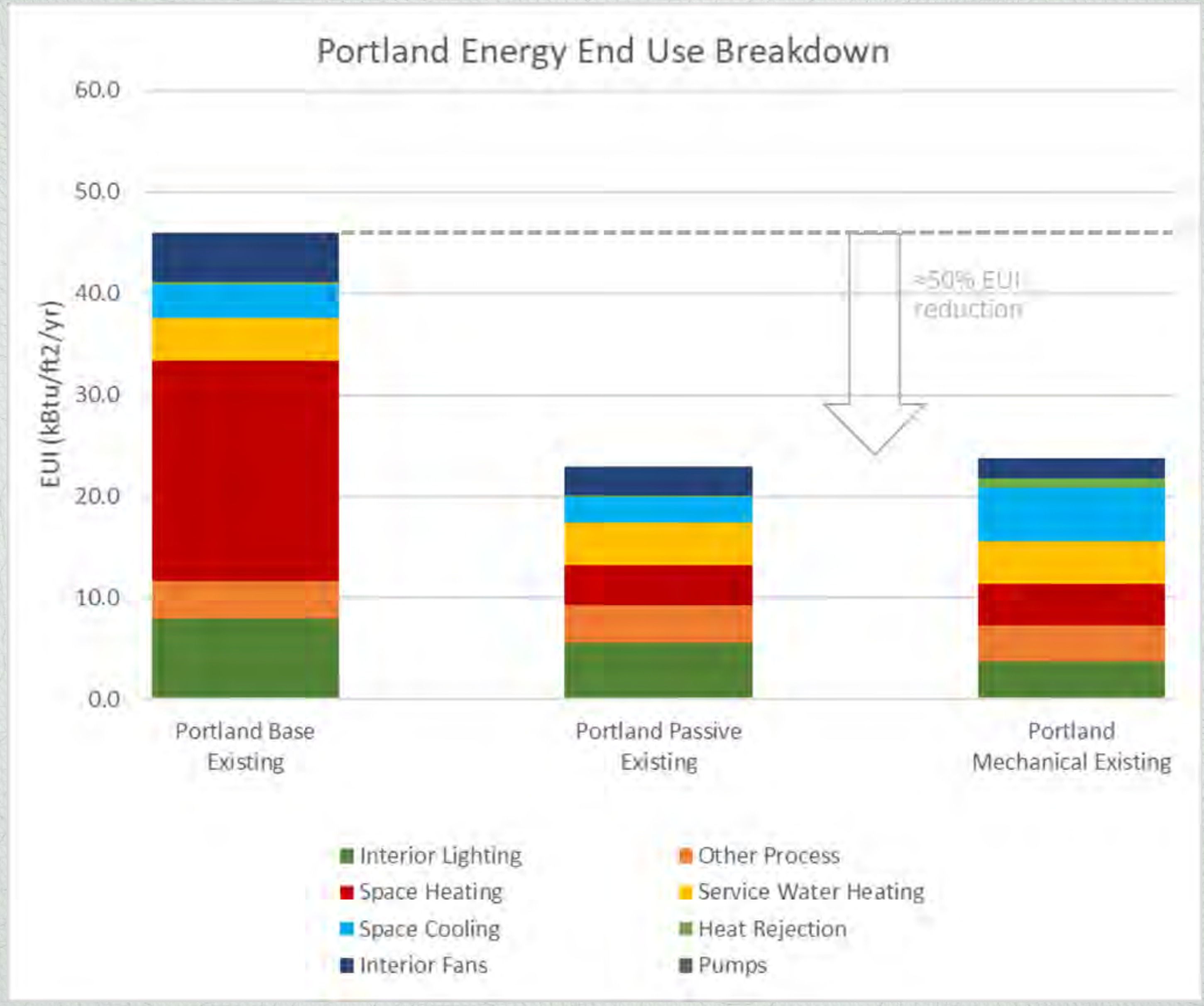


- Code compliant envelope, glazing, and air tightness
- No solar shading
- LED lighting w/ controls
- Variable refrigerant flow (VRF) heat/cool system
- High efficiency ERV
- High efficiency pumps & ECM motors

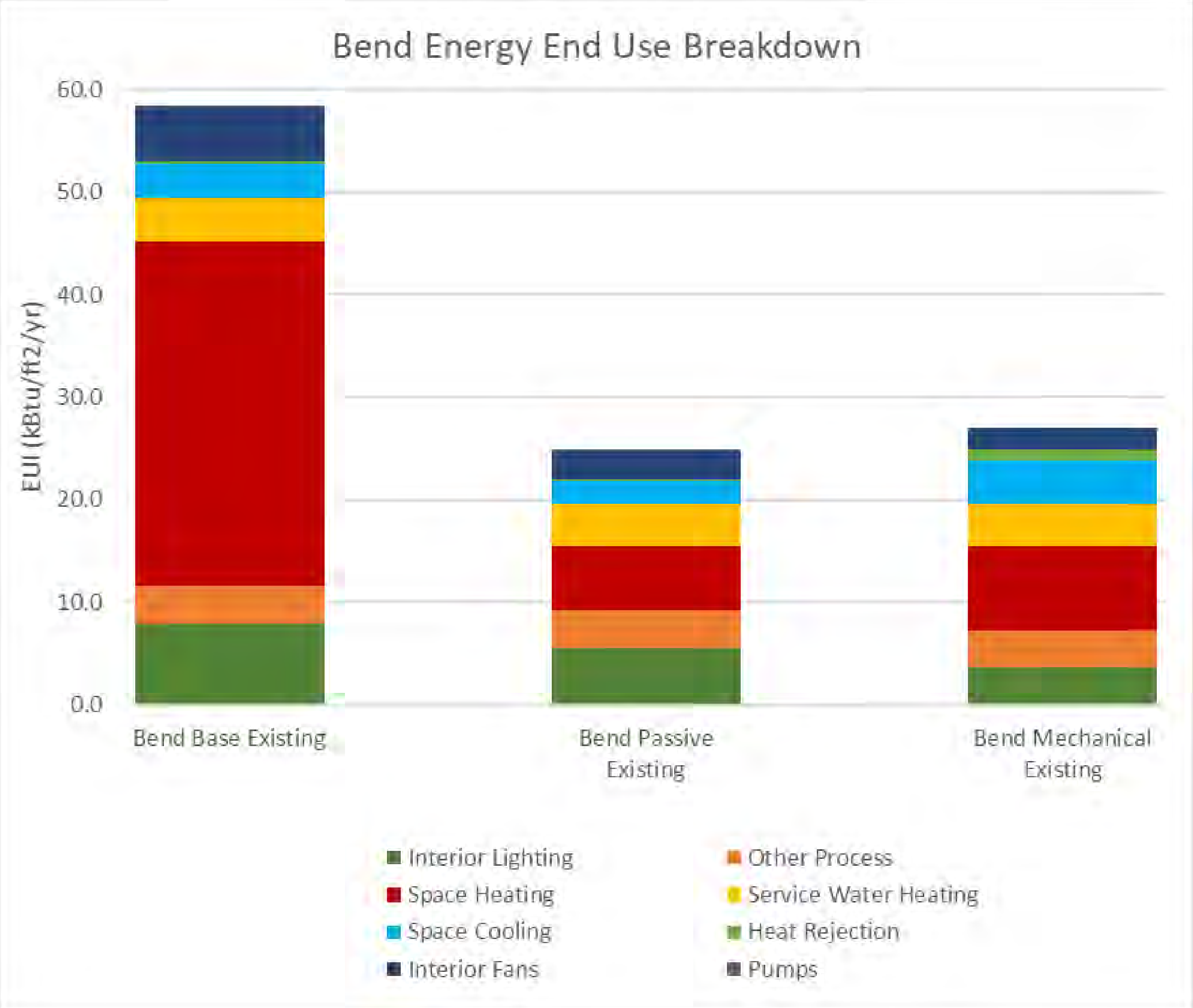
Energy Model - Inputs

		Baseline Case	Passive Case	Mechanical Case
Envelope				
Typical Exterior Wall		15.0 R-value	35.5 R-value	15.0 R-value
Typical Roof		20.0 R-value	60.0 R-value	20.0 R-value
Gross Window to Wall Ratio		16%	16%	16%
Glazing		U-0.45: All windows	South facing: U-0.14| All other: 0.12	U-0.45: All windows
Glazing (SHGC)		All windows: 0.4	South facing: 0.64 | All other: 0.37	All windows: 0.4
Shading Overhangs		None	1.5" for all windows and orientations	None
System Level				
Main HVAC	System Type	Packaged VAV w/reheat, Mixed Air	Packaged VAV with Reheat, 100% OA, Radiant panels	DOAS, 100% OA, gas furnace | Air source VRF zonal
	System Fans	Total for System: 78.1 kW	Total for System: 52.6 kW	Total for System: 33.5 kW
	Energy Recovery	None	Sensible: 70% | Latent: 65%	Sensible: 90% | Latent: 70%
	Heating	Natural draft hot water boiler	Condensing hot water boiler	System: Gas furnace | Zone: VRF Heat pump
	Cooling	DX Cooling | EER 9.8	DX Cooling | EER 9.8	System: None | Zone: VRF Heat pump
AHU (gym)	System Type	Packaged VAV w/reheat, Mixed Air	Packaged VAV with Reheat, Mixed Air	Packaged VAV with Reheat, Mixed Air
	System Fans	Total for System: 10.8 kW	Total for System: 7.9 kW	Total for System: 11.1 kW
	Energy Recovery	None	Sensible: 70% | Latent: 65%	None
	Heating	Natural draft hot water boiler	Condensing hot water boiler	Heat pump
	Cooling	DX Cooling | EER 9.8	DX Cooling | EER 11.5	None
Plant Level				
Space Heating Efficiency		80.0%	92.0%	Gas Furnace: 80% | VRF: 4.0 COP
DHW Boiler Efficiency		80.0%	80.0%	80.0%
Fixture Flow Rates		Lav: 0.5 gal/min | Shower: 2.5 gal/min	Lav: 0.5 gal/min | Shower: 2.5 gal/min	Lav: 0.5 gal/min | Shower: 2.5 gal/min
Space Level				
Equipment Load		0.5 W/ft2 (classrooms)	0.5 W/ft2 (classrooms)	0.5 W/ft2 (classrooms)
Lighting Power Density		1.23 W/ft2 (classrooms)	0.86 W/ft2 (classrooms)	0.86 W/ft2 (classrooms)
Lighting Occupancy Sensors		Most spaces	Most spaces	Most spaces
Lighting Daylight Sensors		None	None	All perimeter spaces - continuous dimming

Energy Model – Portland Benchmarking



Energy Model – Bend Benchmarking



Study Findings

Key Findings

Climate Zone Shift

End-use & Fuel Shift

Passive Design Improves Resiliency

Shift in Design Decisions

Key Findings

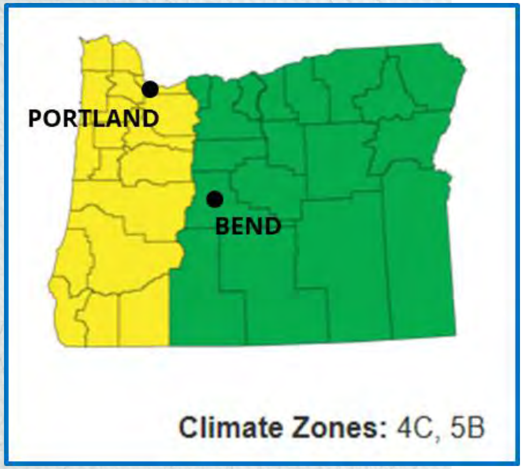
Climate Zone Shift

End-use & Fuel Shift

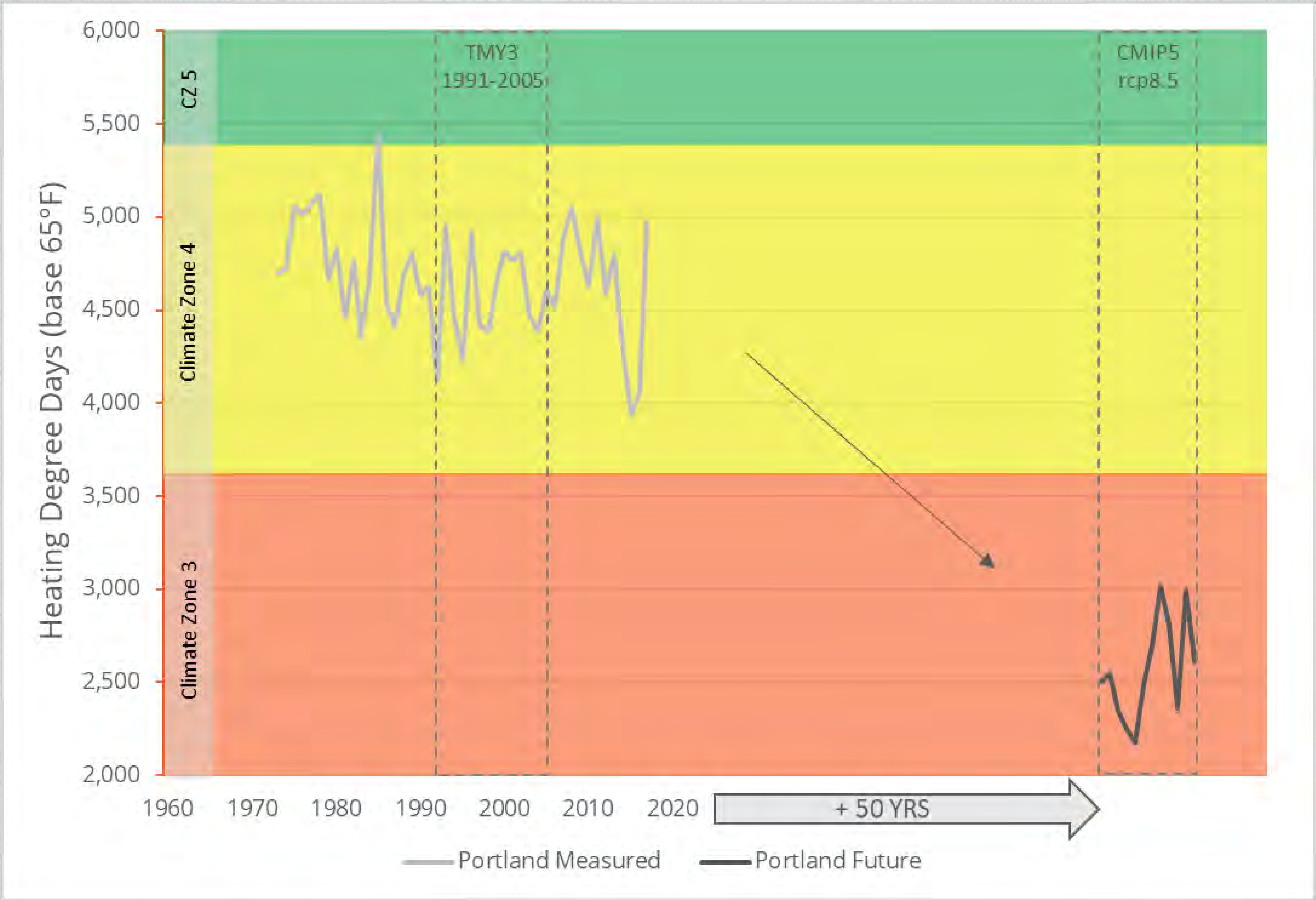
Passive Design Improves Resiliency

Shift in Design Decisions

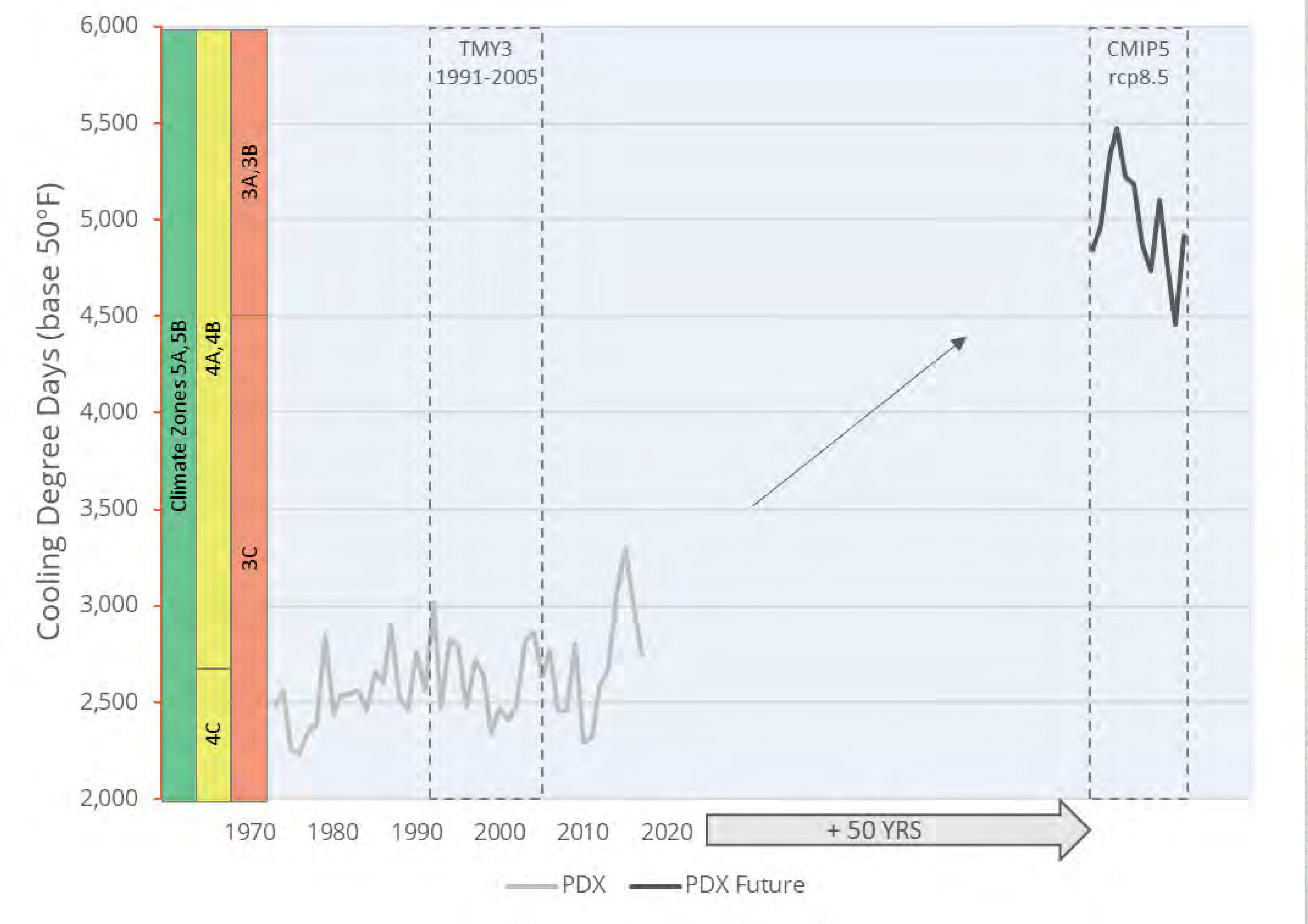
Climate Zone Shift



Climate Zone Shift - Portland



Climate Zone Shift - Portland



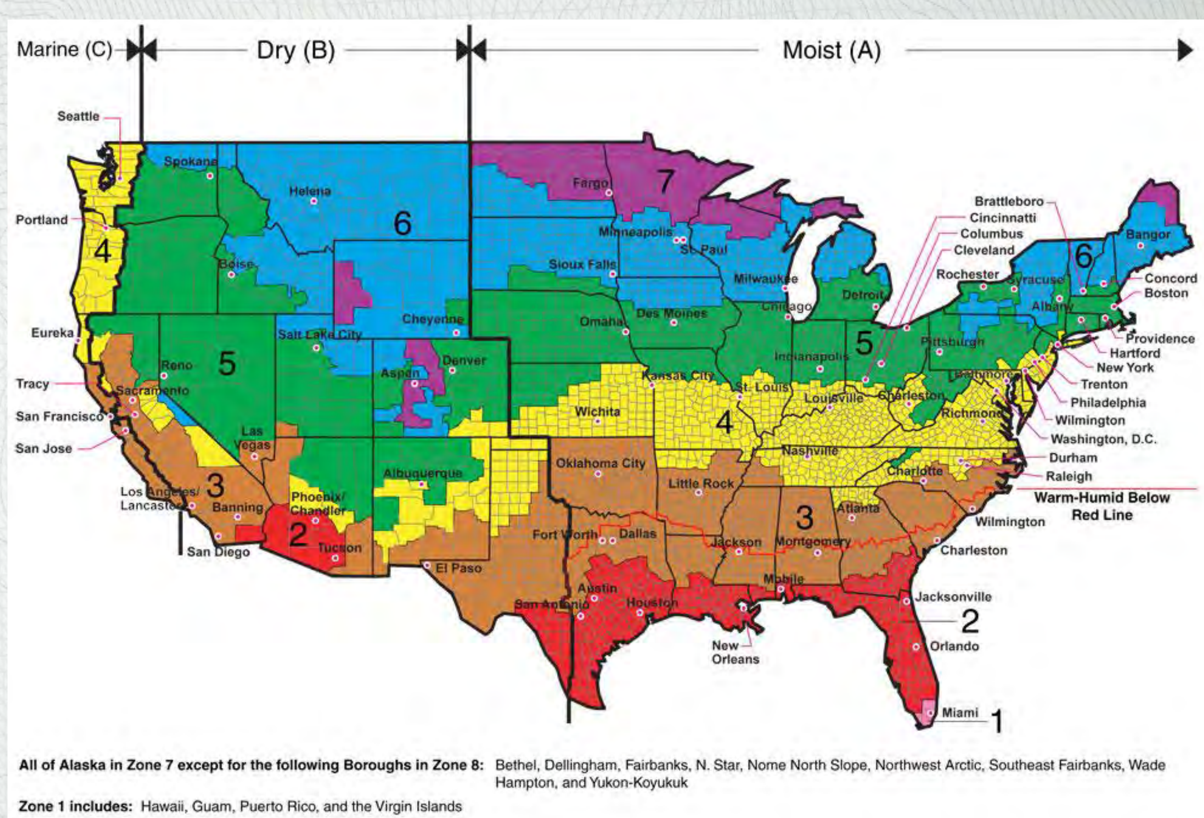
Climate Zone Shift - Portland

Portland

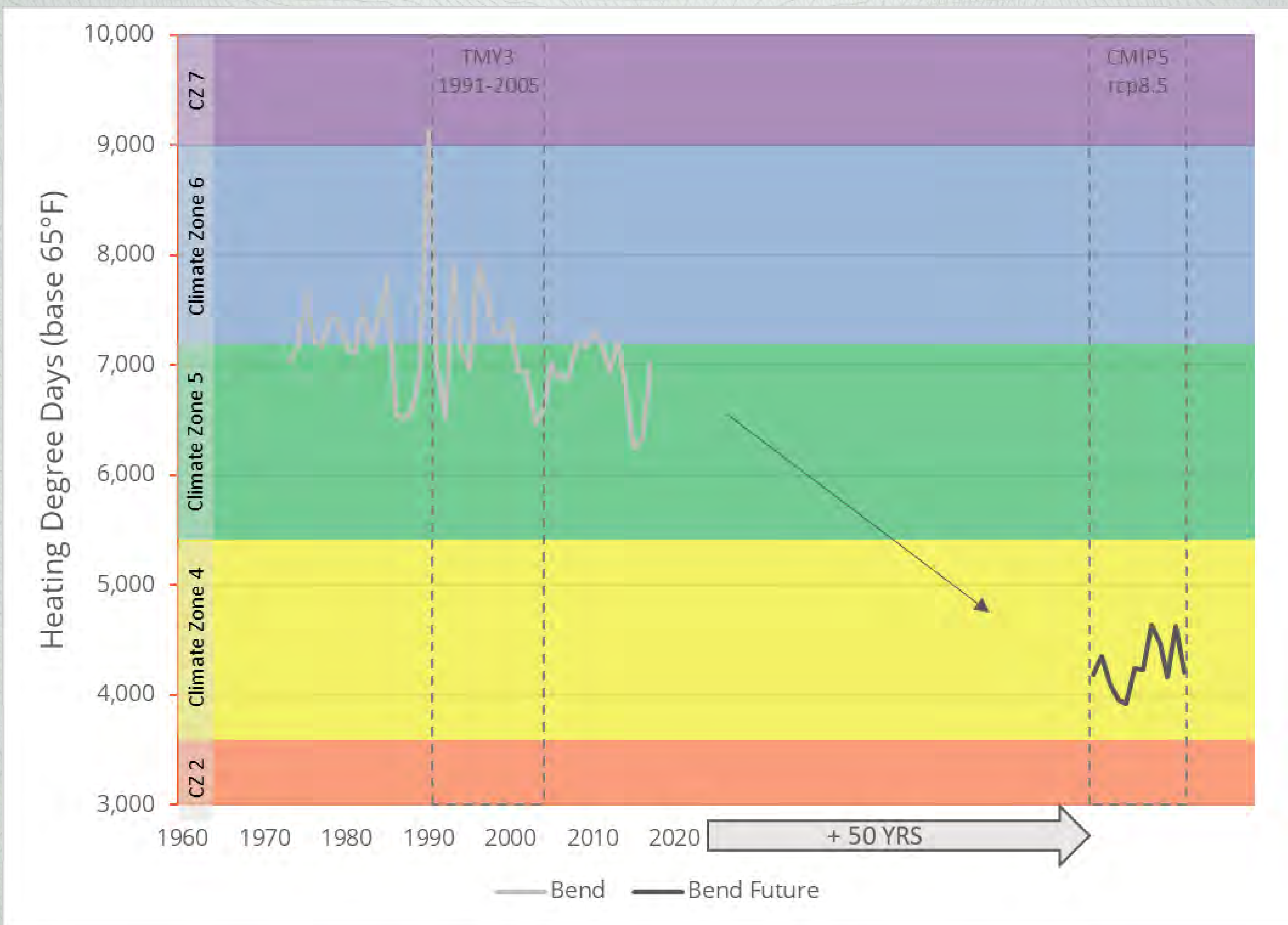
- Today = 4C (mixed marine)
- Future = 3A (warm humid)

3A cities

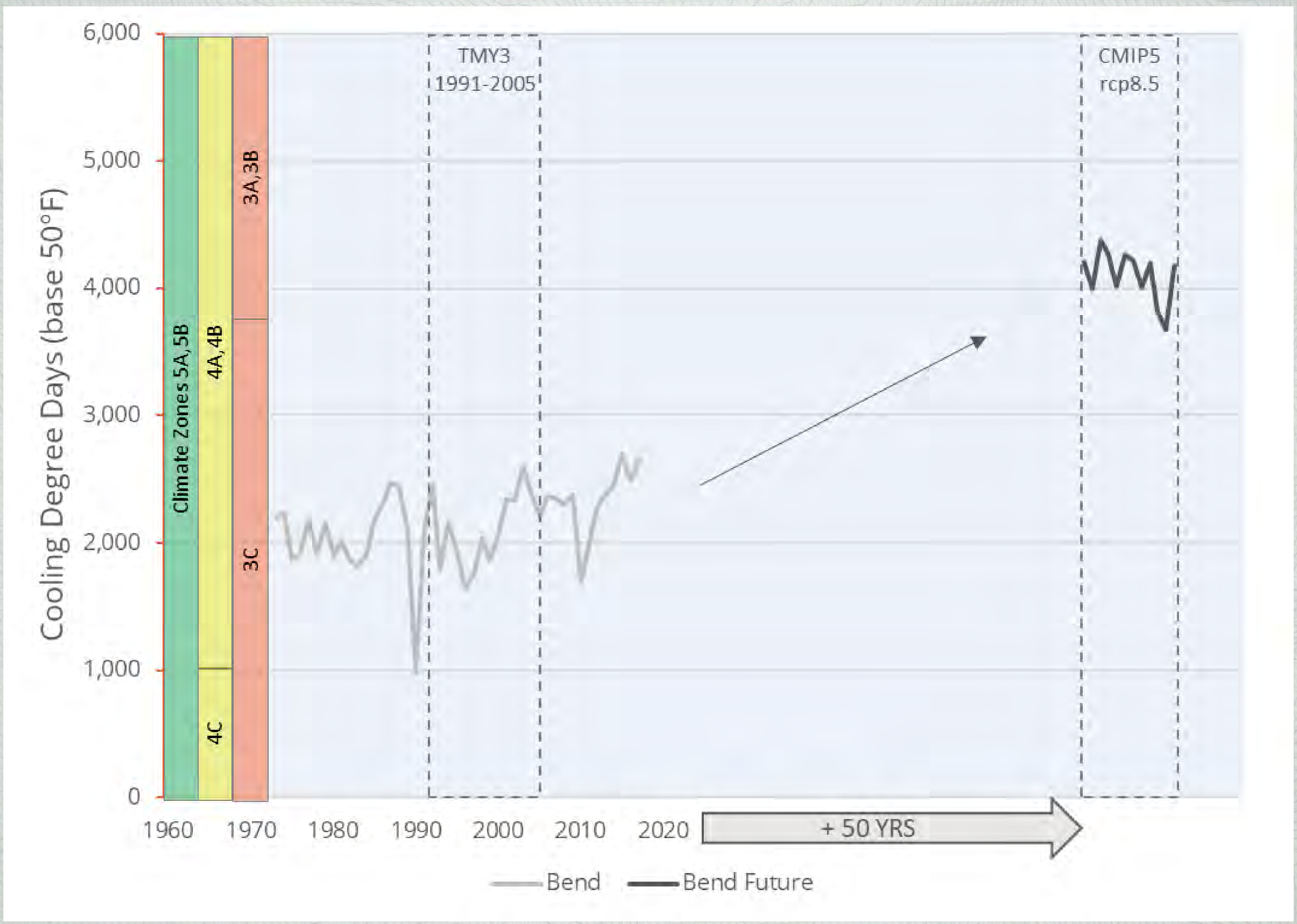
- Oklahoma City, OK
- Dallas, TX
- Little Rock, AR
- Jackson, MI
- Atlanta, GA



Climate Zone Shift – Bend



Climate Zone Shift - Bend



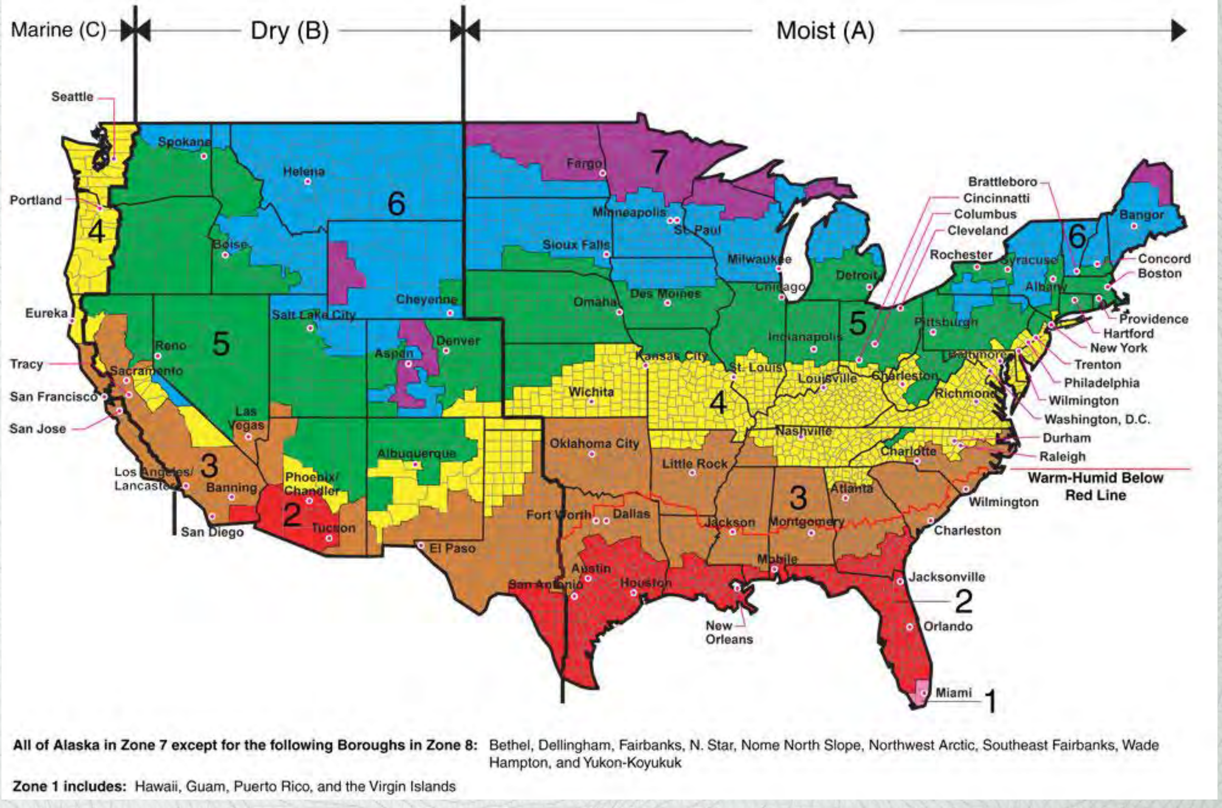
Climate Zone Shift - Bend

Bend

- Today = 5B
  (cool dry)
- Future = 4B
  (mixed dry)

4B cities

- Albuquerque, NM



Key Findings

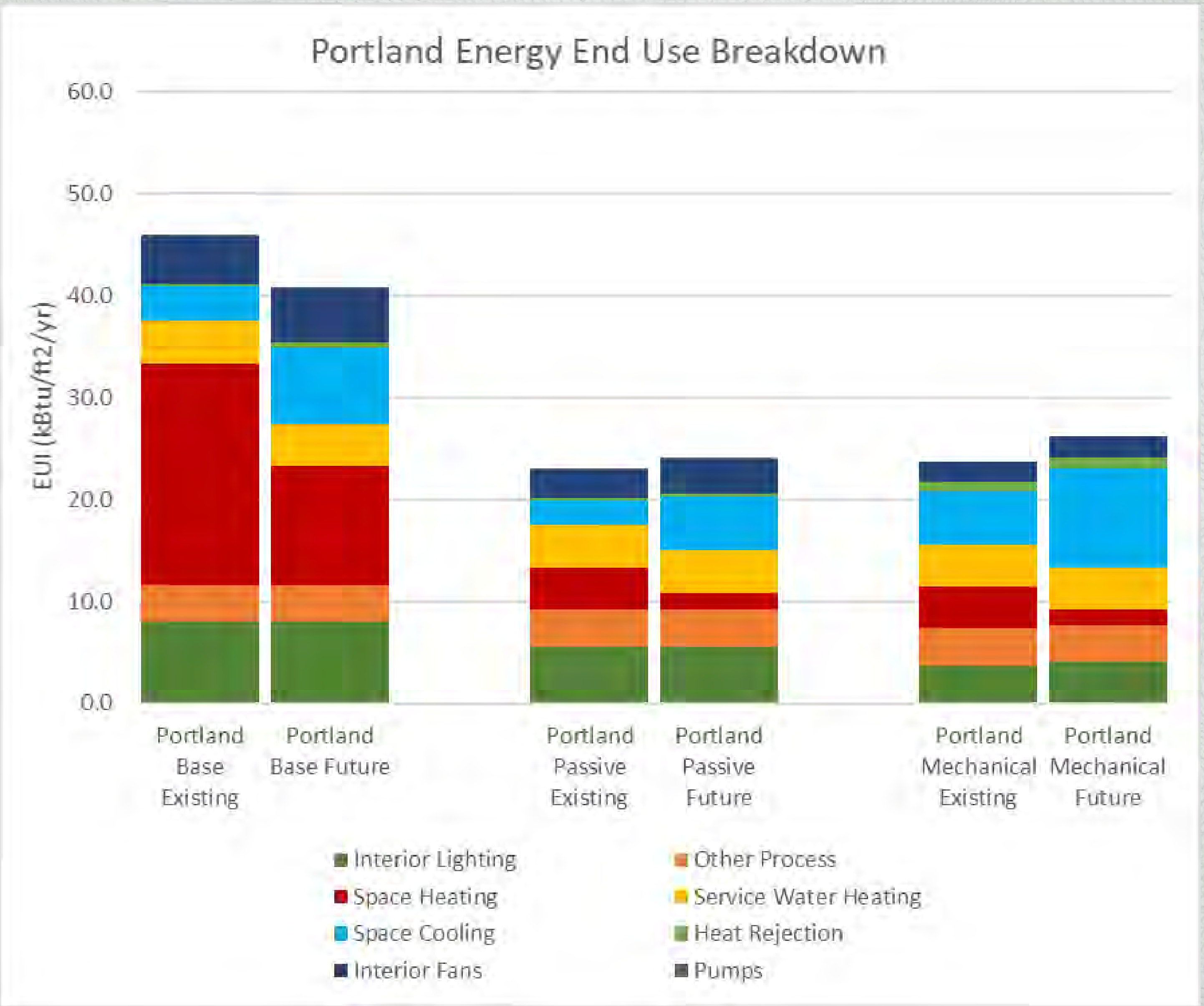
Climate Zone Shift

End-use & Fuel Shift

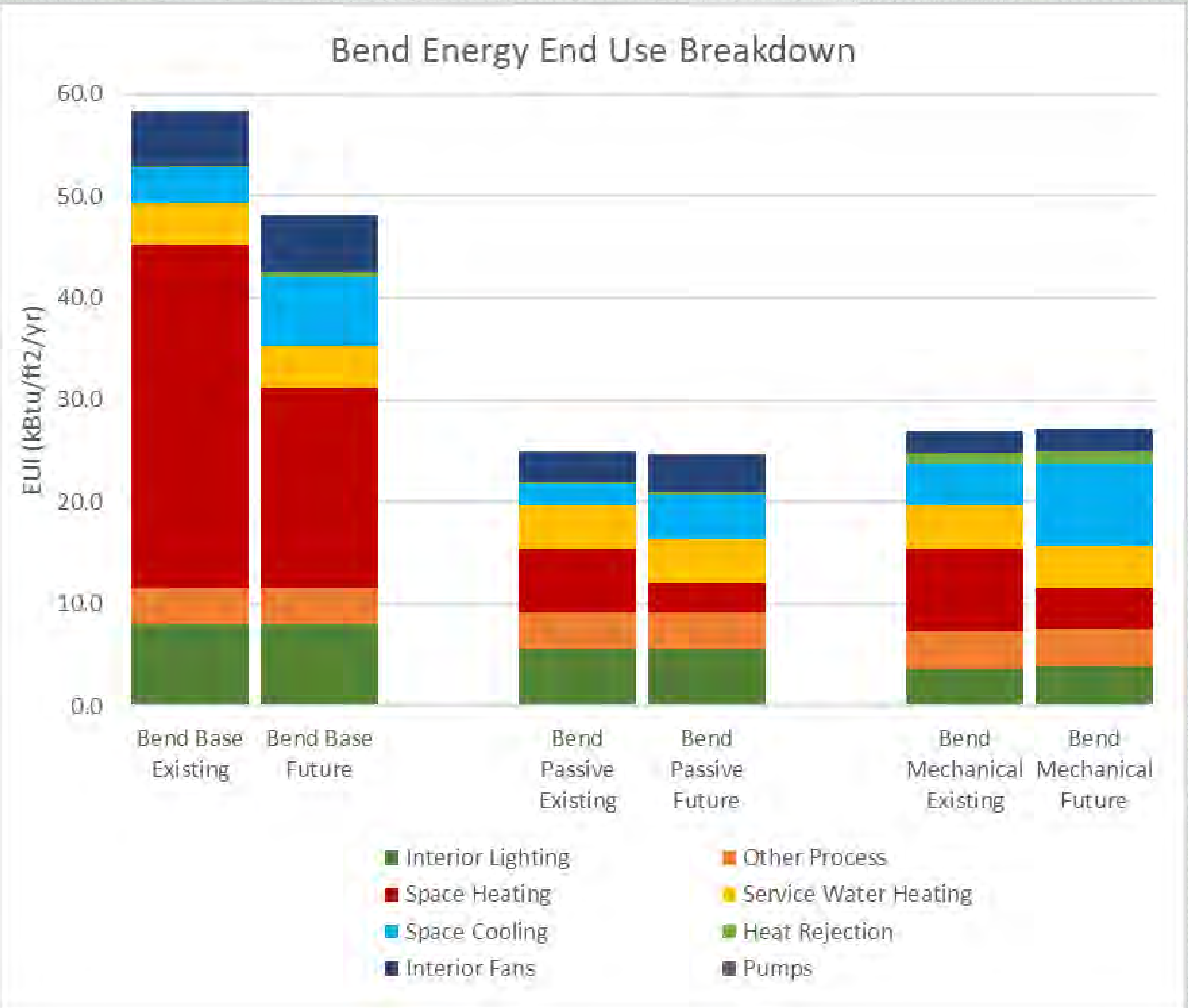
Passive Design Improves Resiliency

Shift in Design Decisions

End-use & Fuel Shift



End-use & Fuel Shift



Key Findings

Climate Zone Shift

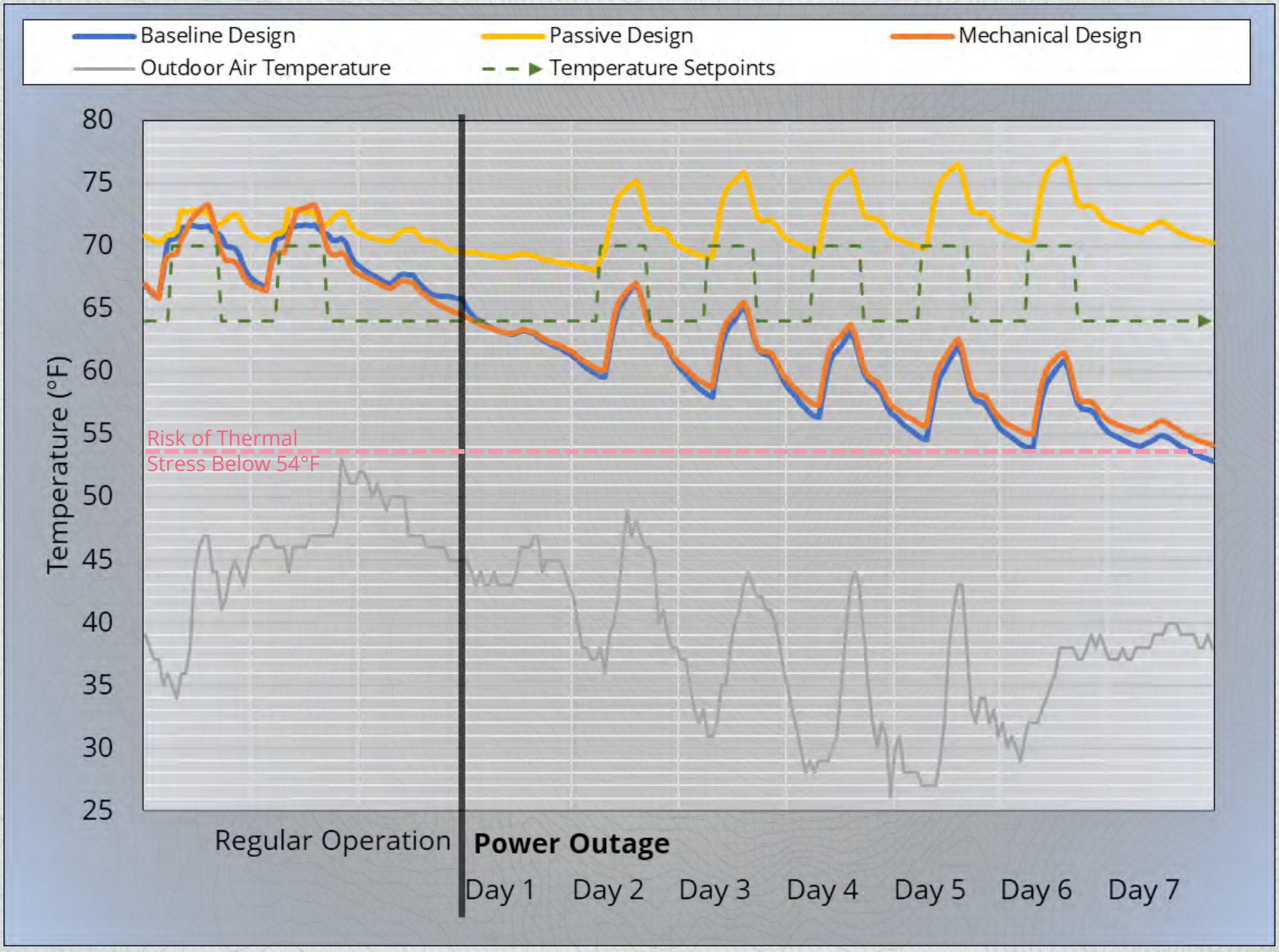
End-use & Fuel Shift

Passive Design Improves Resiliency

Shift in Design Decisions

Passive Design Improves Resiliency

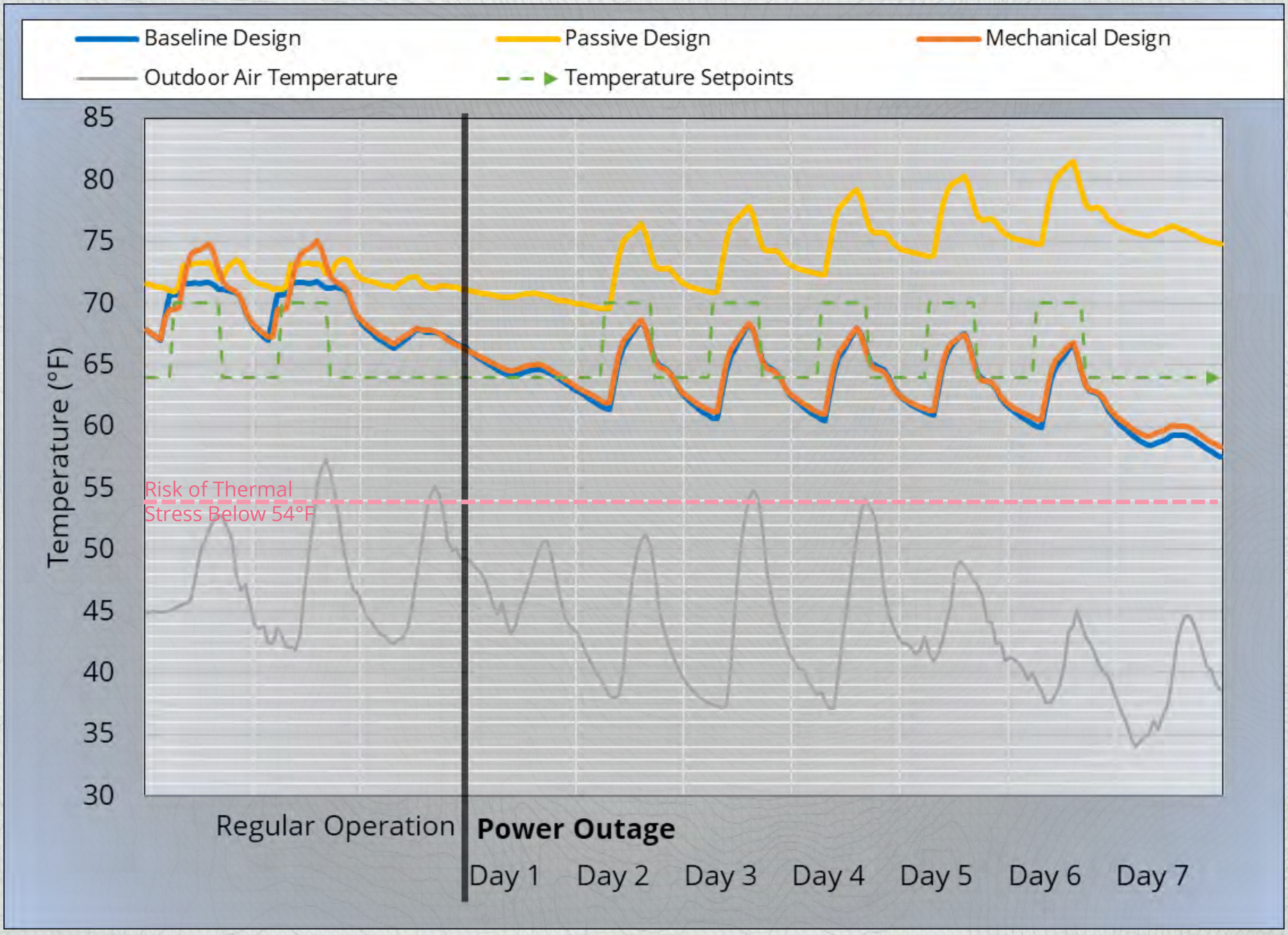
Portland – Existing - Winter



Classroom – North Facing – 2nd Storey - 36 occupants

Passive Design Improves Resiliency

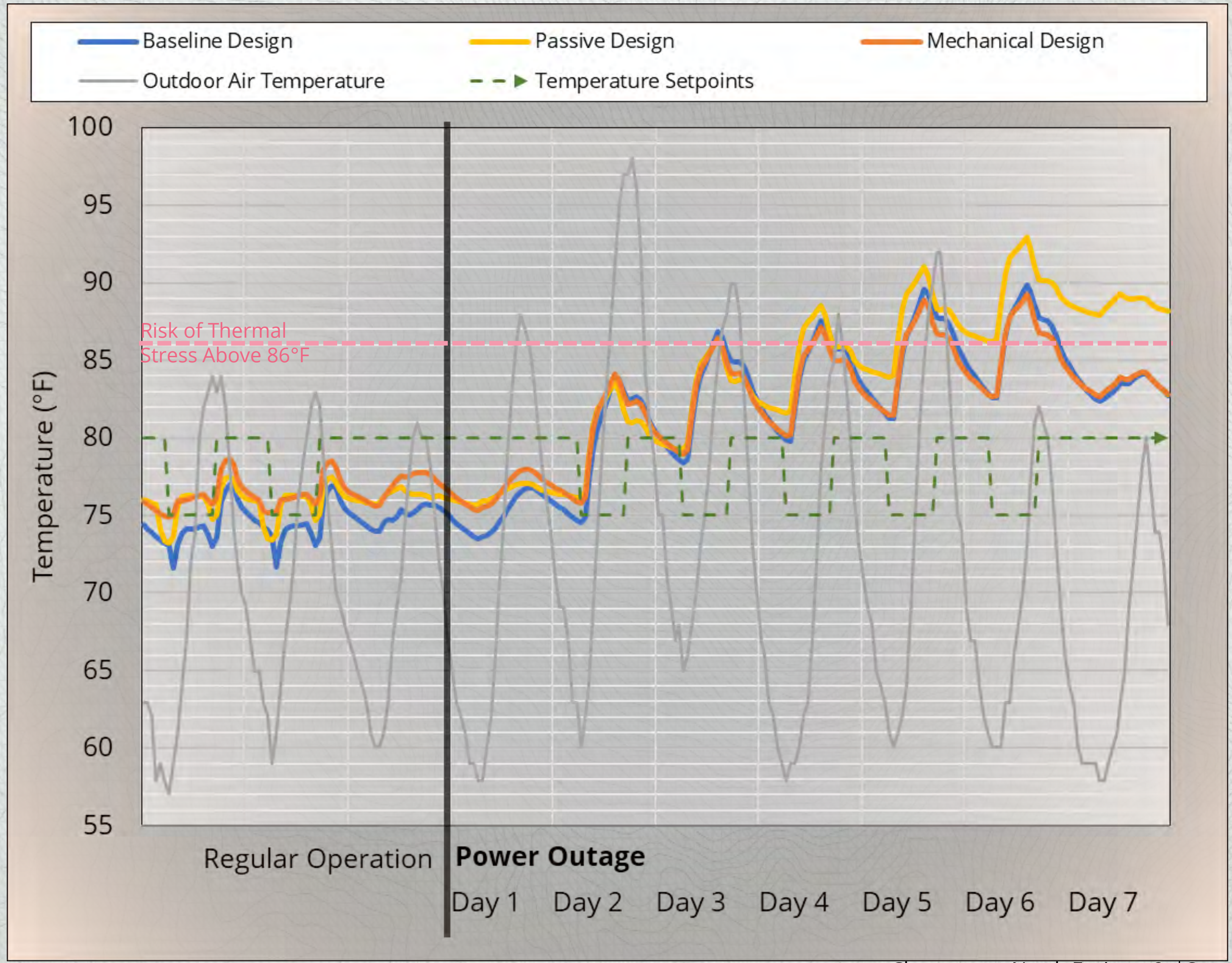
Portland – Future - Winter



Classroom – North Facing – 2nd Storey - 36 occupants

Passive Design Improves Resiliency

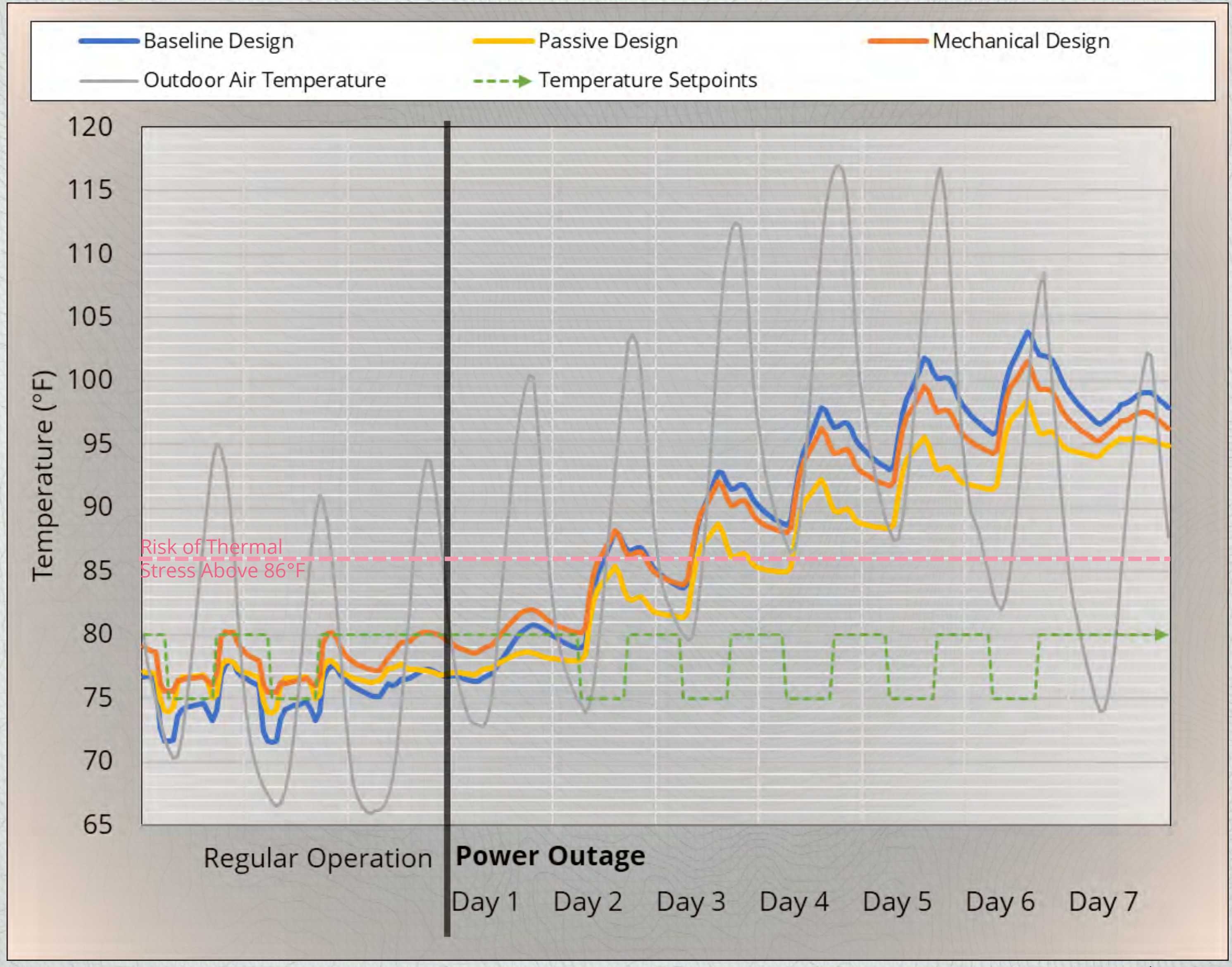
Portland – Existing - Summer



Classroom – North Facing – 2nd Storey - 36 occupants

Passive Design Improves Resiliency

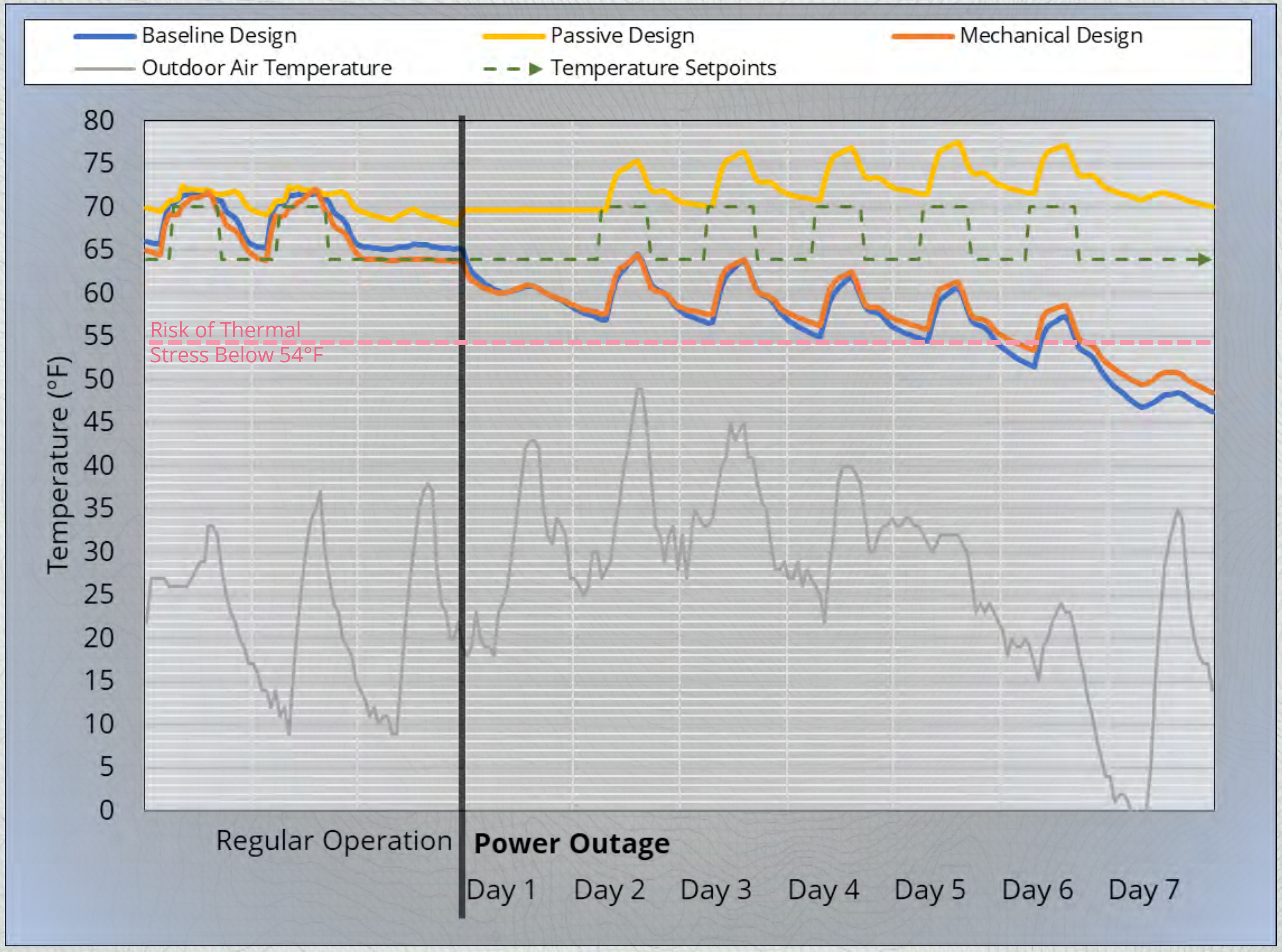
Portland – Future - Summer



Classroom – North Facing – 2nd Storey - 36 occupants

Passive Design Improves Resiliency

Bend – Existing - Winter



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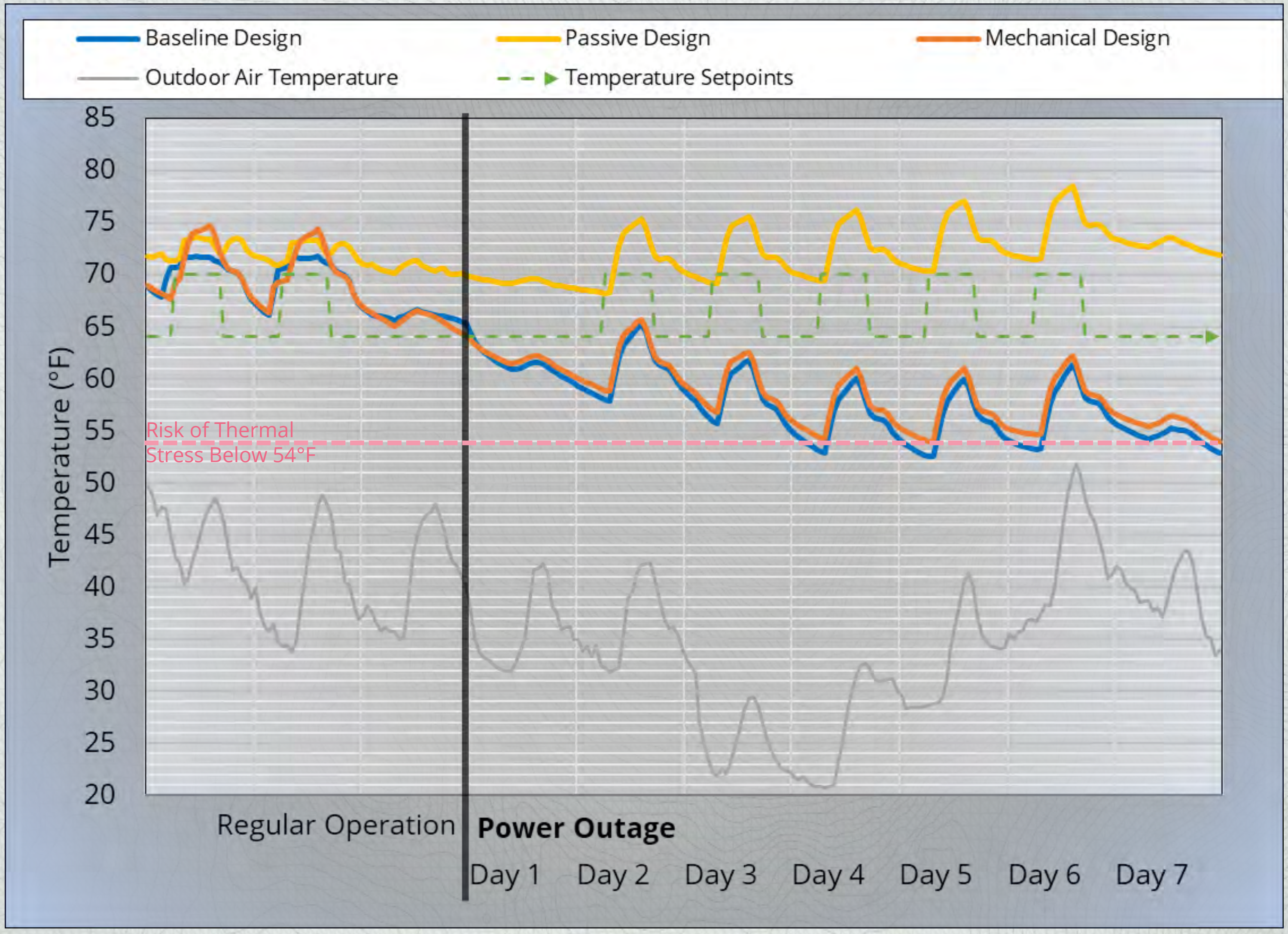

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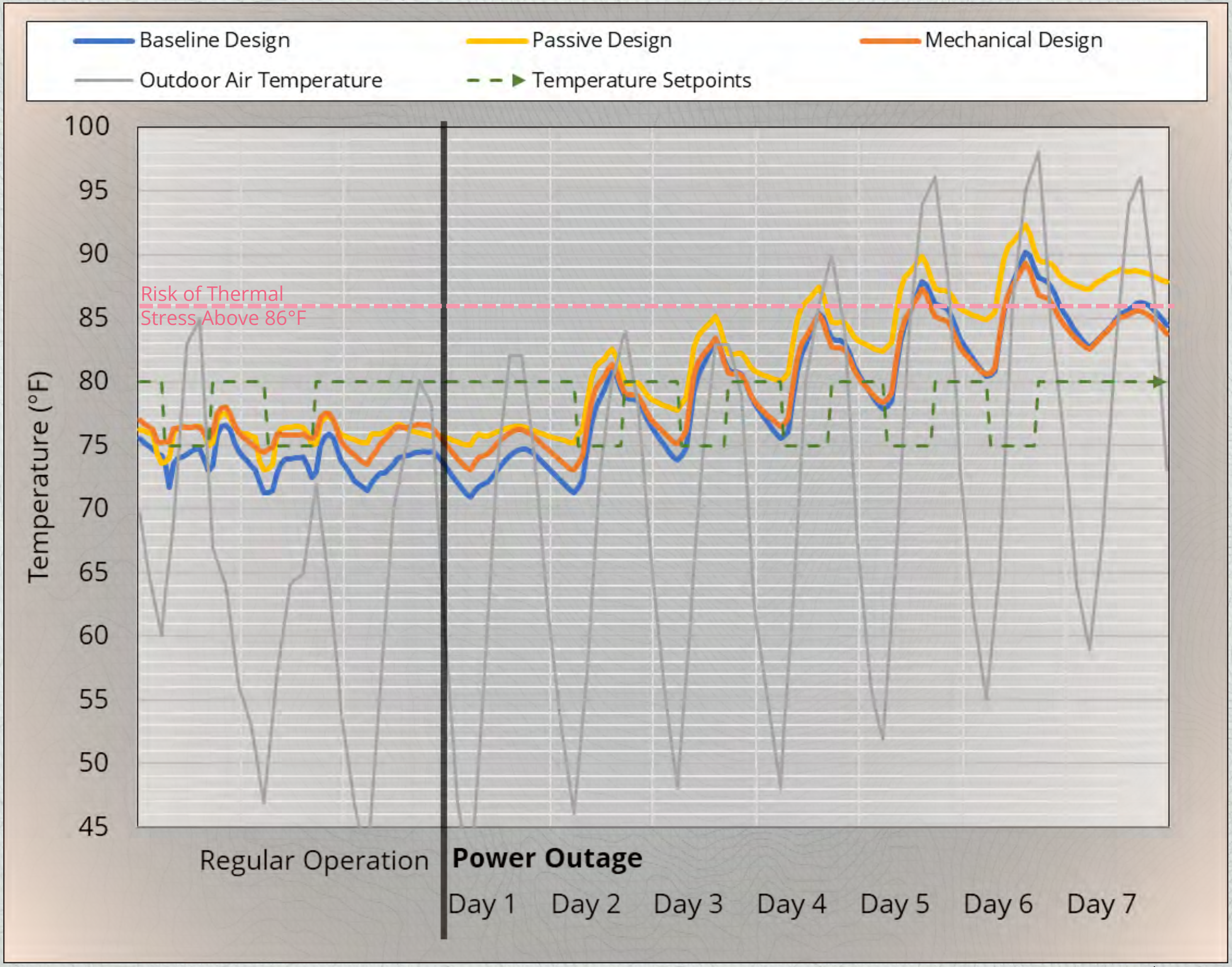

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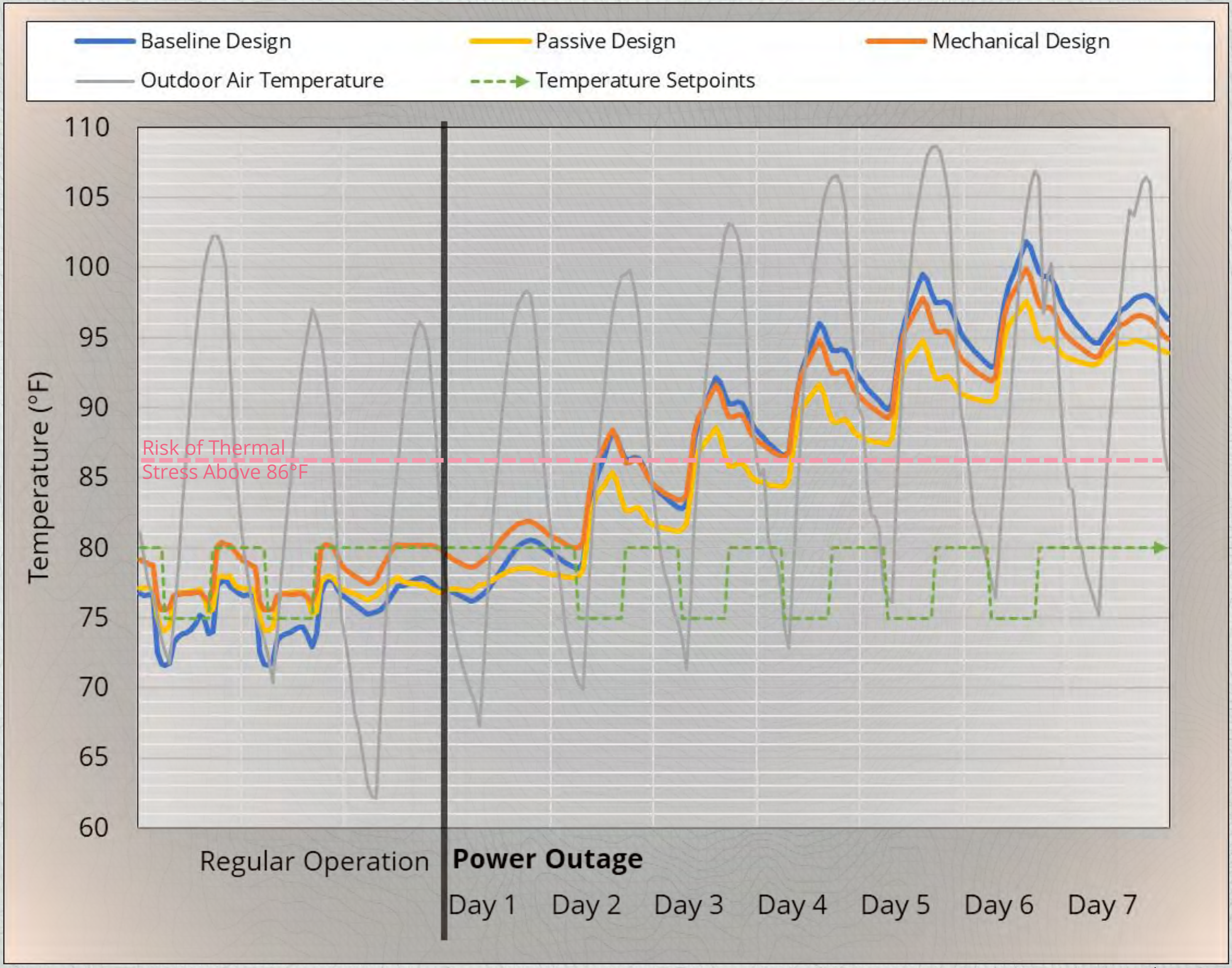

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Key Findings

Climate Zone Shift

End-use & Fuel Shift

Passive Design Improves Resiliency

Shift in Design Decisions

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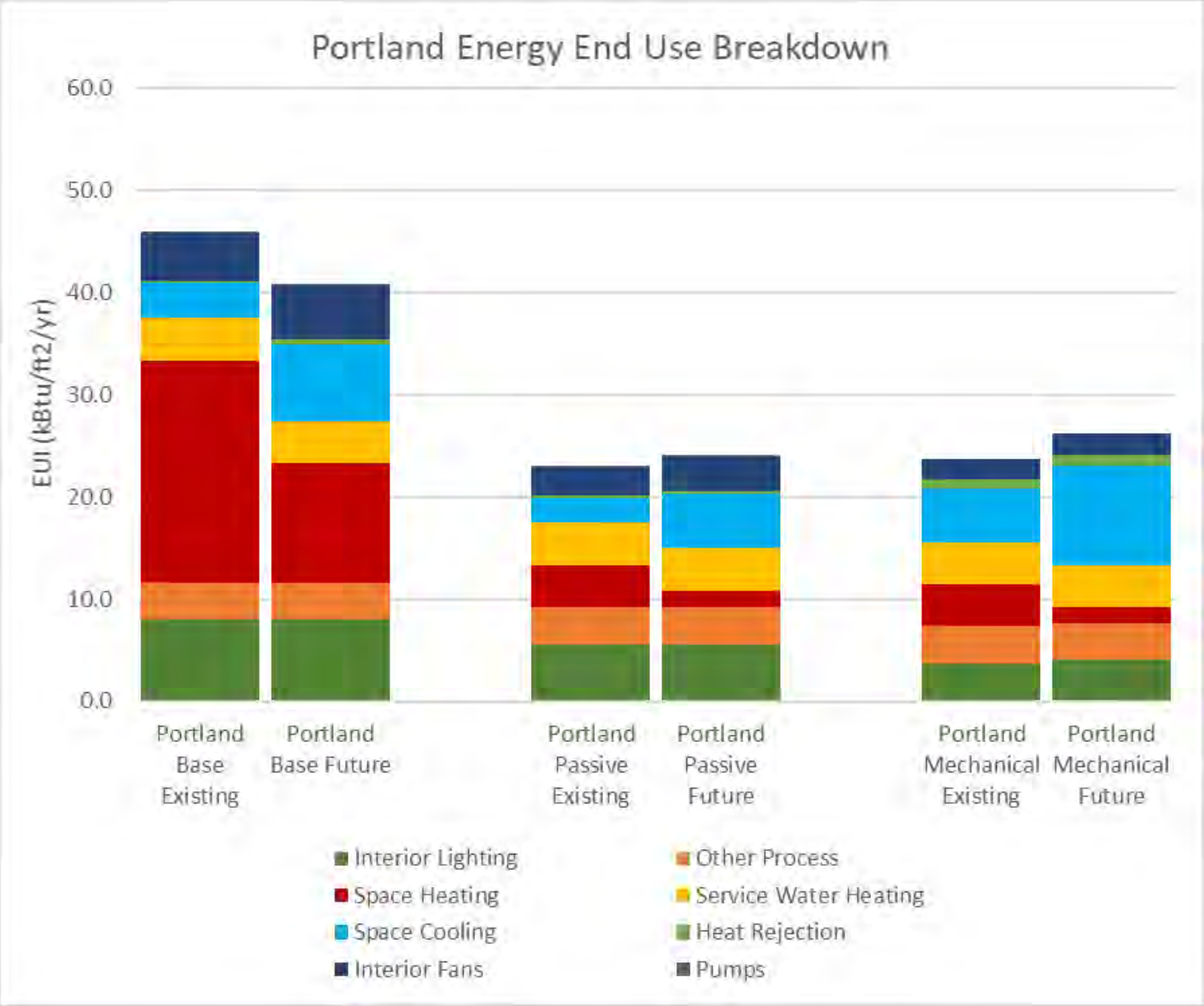
Heating to Cooling Dominated

Future climate tips Portland from heating to cooling dominated



Shift in Design Decisions
Heating to Cooling Dominated

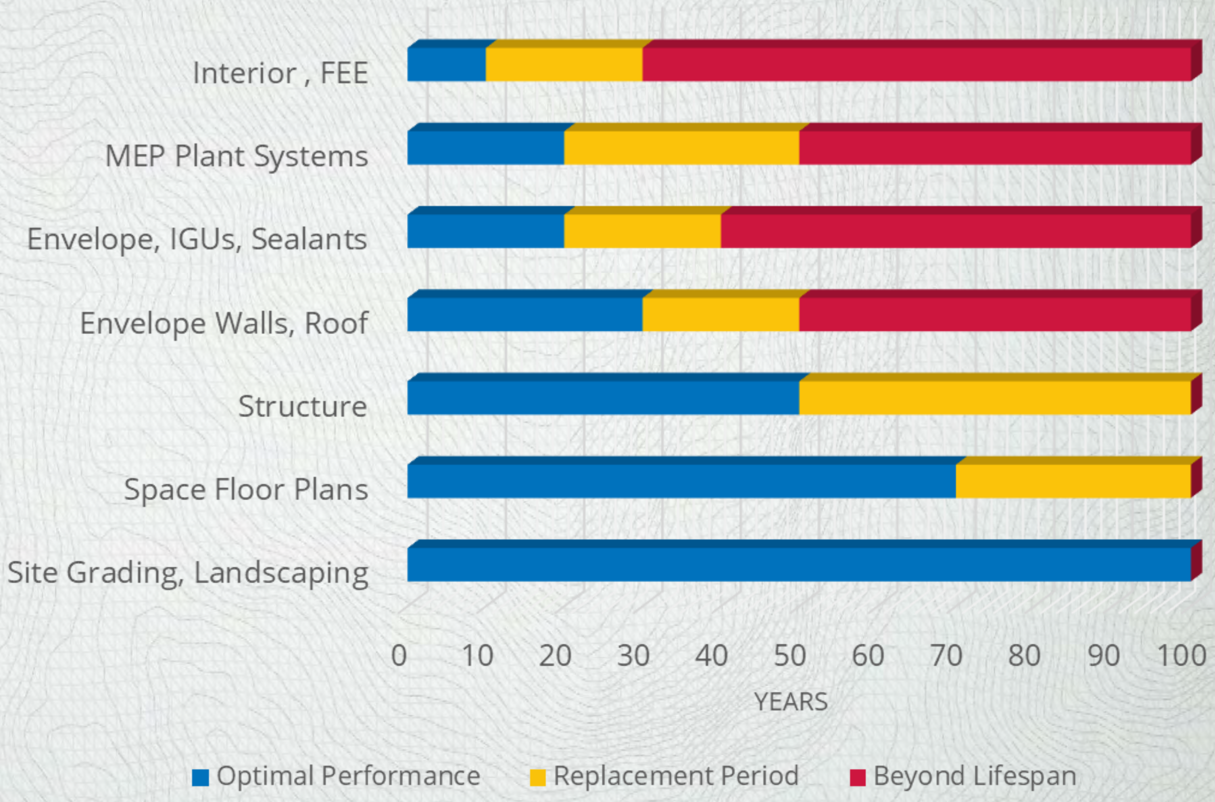
Future climate tips Portland from heating to cooling dominated

- Changing guidelines & rules of thumb
- Solar Heat Gain Coefficient
- Solar Shading & Thermal Mass
- Envelope Tightness
- Natural Ventilation

Shift in Design Decisions
Heating to Cooling Dominated

And when should we start….

now.



In Conclusion

Conclusions / Lessons Learned

- Passive survivability / thermal resiliency methodology

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- Future climate files available for Portland and Bend
- Climate zone shifts (HDD, CDD, moisture)
- Climate shift creates end-use and fuel type shift
- Design strategies need to accommodate
- Passive design measures:
  - more resilient in future climate
  - provide path to net zero

Future Research

- Perform life cycle cost/carbon analysis of passive vs mechanical design approaches
- Explore in more depths the impacts of future climate on system sizing & additional building design decisions
- Explore strategies to provide ventilation for resilient buildings

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Design community

Thank you!

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