2022 Residential Building Stock Assessment (RBSA) Findings

Mike Psaris

Senior Program Manager, NEEA

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Agenda

Study Overview

Findings

Resources

Q&A

Study Overview

2022 RBSA Vision Statement

“Support the region's energy efficiency, resource planning, and utility objectives through a regionally representative, statistically rigorous, and comprehensive assessment of residential buildings.”

Use Cases

- Baselines
- Conservation potential assessments (CPAs)
- Integrated resource plans (IRPs)
- Regional power planning
- Program evaluation
- Market characterization and progress
- Program opportunity assessment

2022 RBSA Workgroup

Purpose: The Residential Building Stock Assessment (RBSA) Work Group provided NEEA with decision support and coordination on key components of the study's design and implementation.

- Avista
- Bonneville Power Administration
- Cascade Natural Gas
- Clark PUD
- Energy Trust of Oregon
- Idaho Power
- Northwest Natural Gas
- Northwest Power and Conservation Council
- Puget Sound Energy
- Regional Technical Forum
- Seattle City Light
- Snohomish County PUD

Eligible Building Types

- **Single-family**: Detached and attached residences.
  - This includes manufactured homes, duplexes, triplexes, quadplexes, and vacation homes.
  - This does **not** include mobile homes
- **Multi-family**: Apartments and condominiums with five or more units
  - Low-rise: 1 – 3 stories
  - Mid-rise: 4 – 6 stories
  - High-rise: 7+ stories

Data Collected

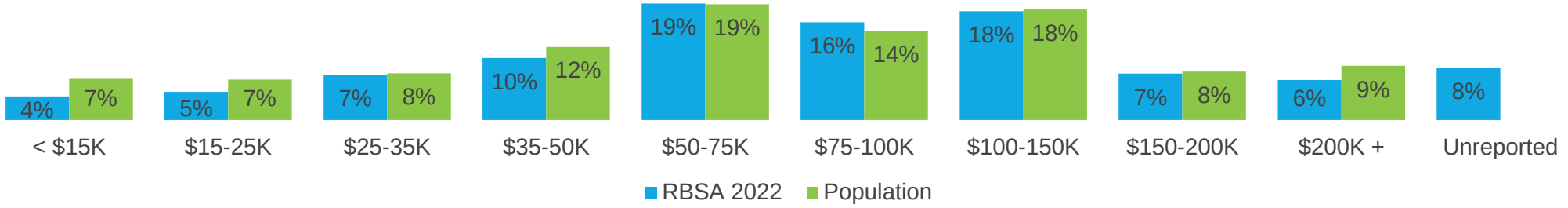
- **Single-family:** On-site visit by trained engineer
  - Audit of building characteristics
  - Interview questions
  - Release of energy usage data
- **Multi-family:** On-site, or virtual site, visit by trained engineer
  - Audit of unit and building characteristics
  - Interview questions
  - Release of energy usage data for tenant units

Recruitment

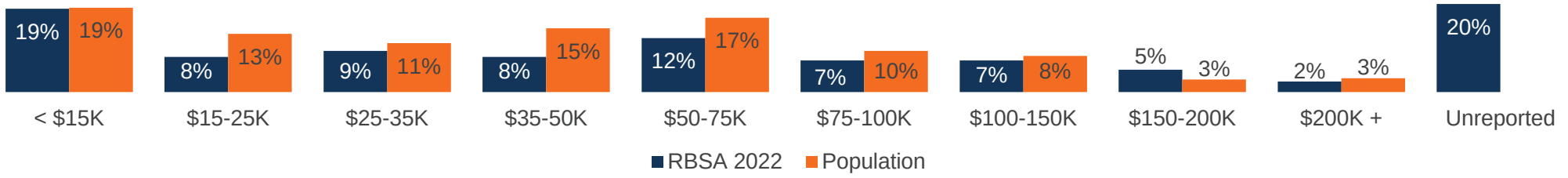
- **Single-family:** Recruitment letter or postcard mailed
  - Invites residents to take a web survey to assess eligibility
  - Schedule site visit
- **Multi-family:** Two approaches
  - Recruit property manager, then tenant unit
  - Recruit tenant unit

Income of Occupants of Homes

Household Income – People Living in Single-Family Homes



Household Income – People Living in Multi-Family Homes



Sample Design: Single Family

Controlled for the following:

1. Heating Zone (cold climate)
2. Income
3. State
4. Urban/Rural
5. Utility oversamples

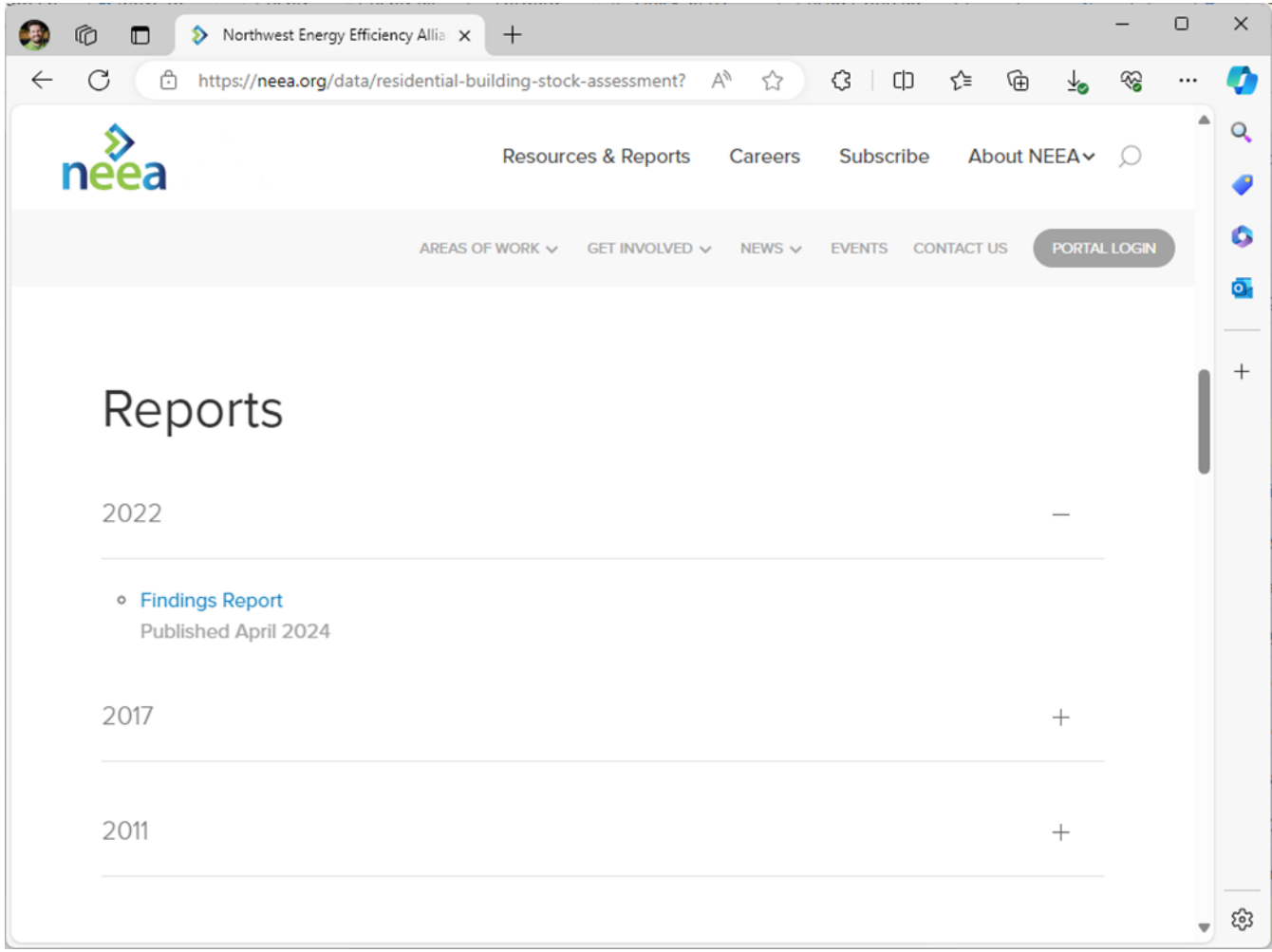
Sample Design: Multi-family

Controlled for the following:

- Height class:
  - Low-rise
  - Mid-rise
  - High-rise
- State
- Urban/Rural

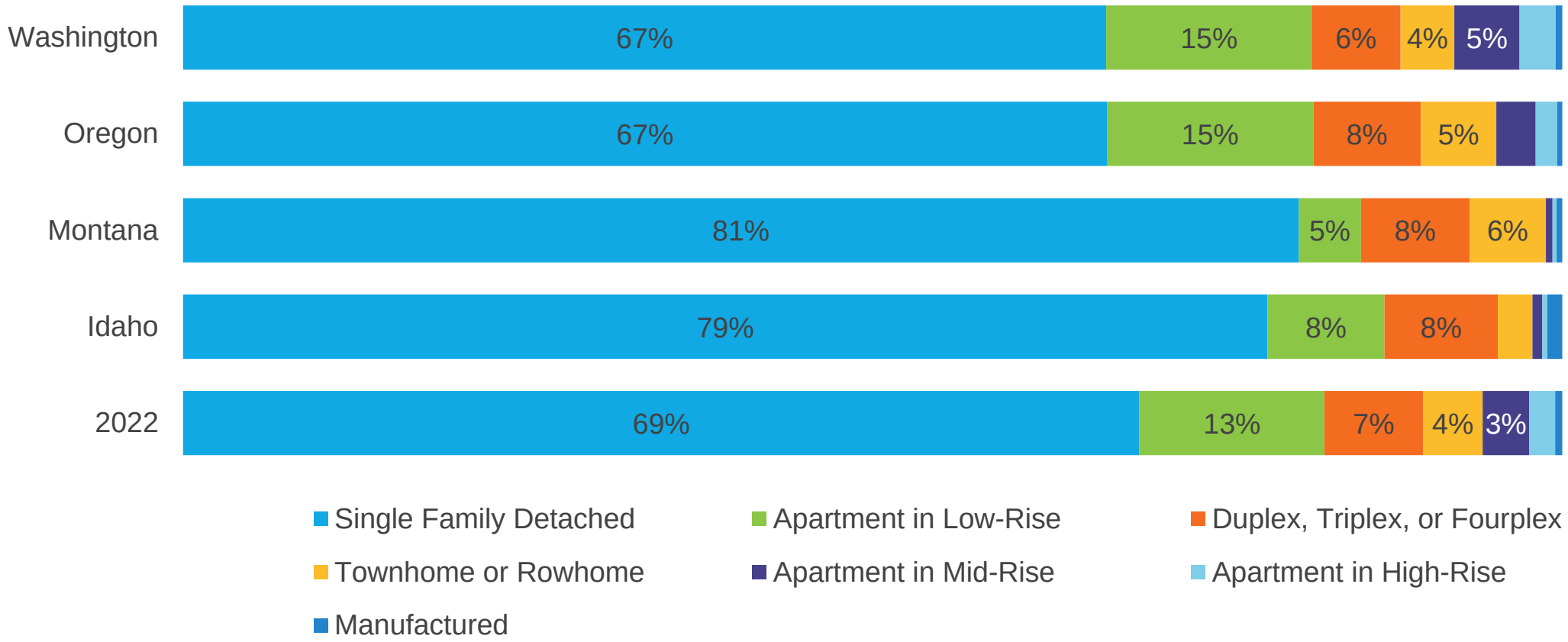
Study Deliverables

- Reports
  - Findings Report
- Data
  - One-line tables
  - Core tables
  - Data Dictionary
  - User Guide
- Documentation
  - Methods Report
- neea.org/rbsa

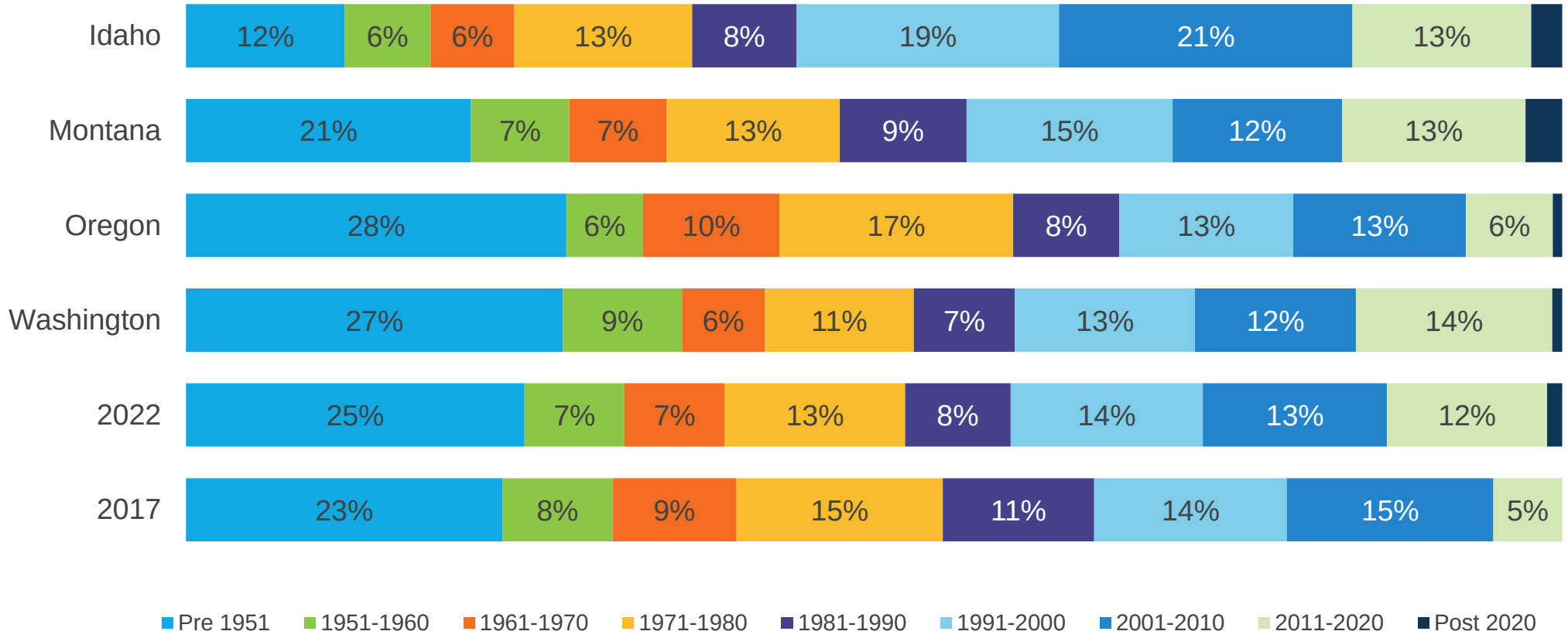


Findings

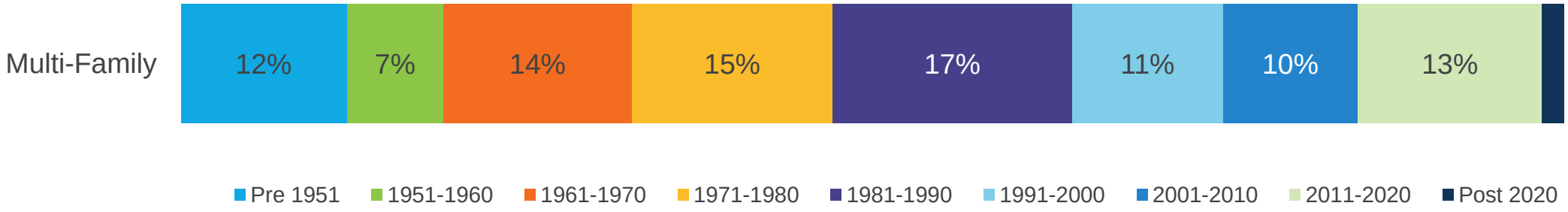
Housing Units by Type



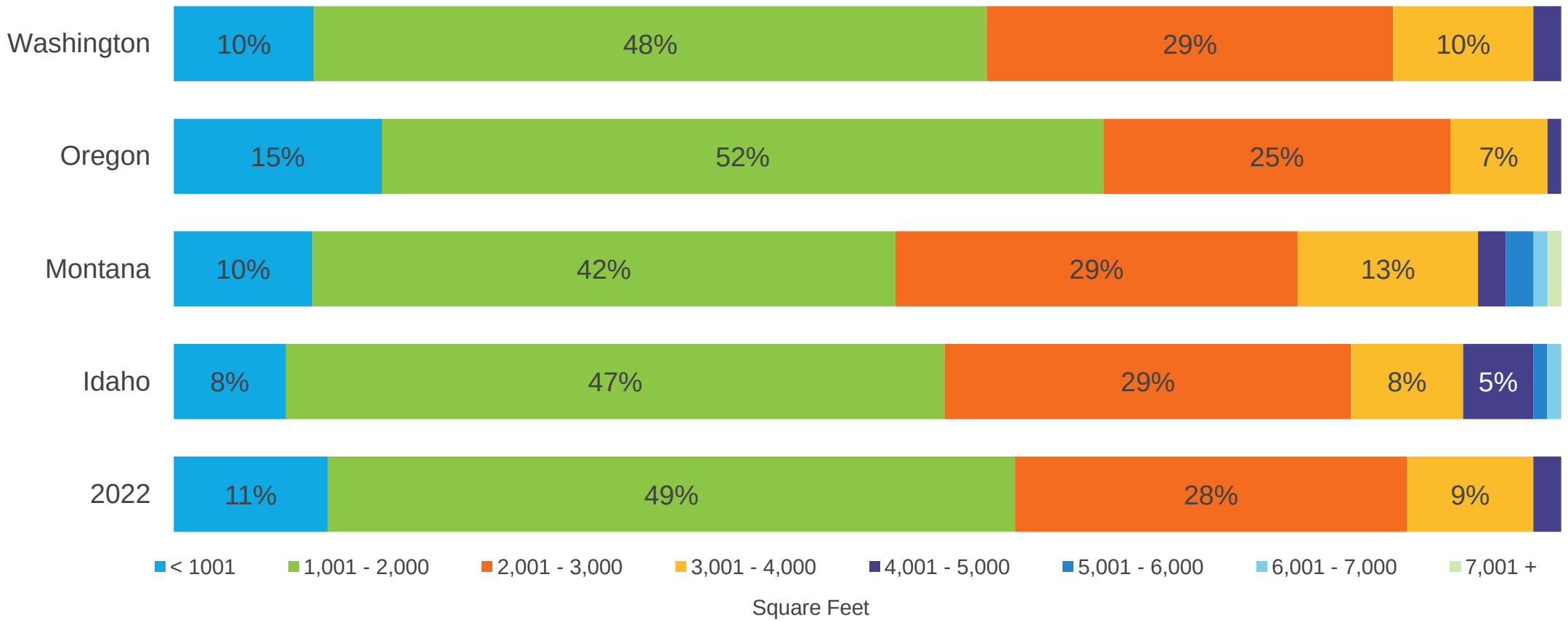
Housing Units by Vintage – Single Family



Housing Units by Vintage – Multi-family



Housing Units by Size – Single Family



EUIs by State – Single Family

- Electric EUI down slightly.
- Natural gas EUI holding steady.

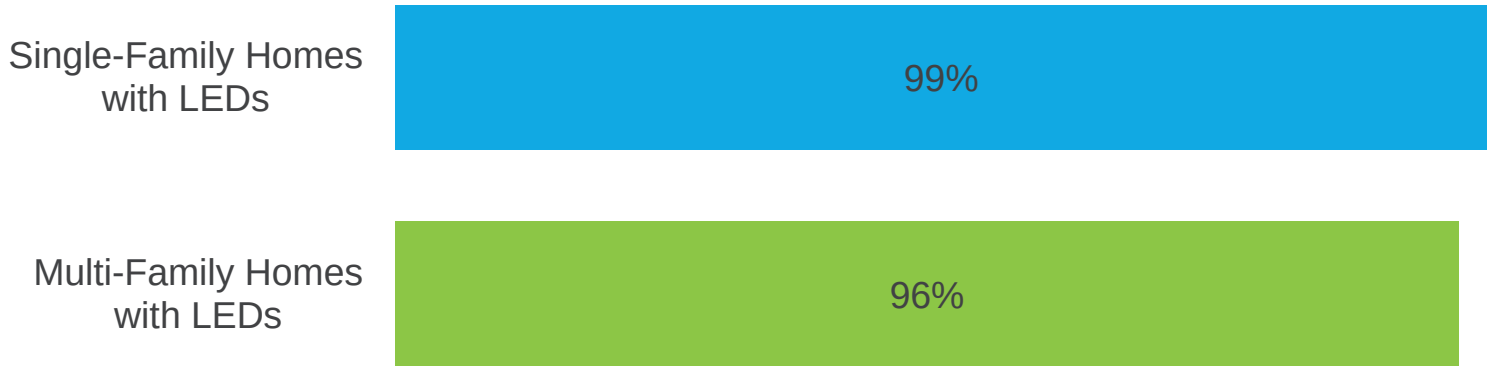
Electric (kWh/sq.ft.)	2022	2011
Idaho	6.7	7.6
Montana	5.5	5.4
Oregon	6.7	7.4
Washington	7.7	7.7
Overall	7.1	7.4

Gas (therms/sq.ft.)	2022	2011
Idaho	0.4	0.4
Montana	0.4	0.5
Oregon	0.4	0.4
Washington	0.4	0.4
Overall	0.4	0.4

Lighting

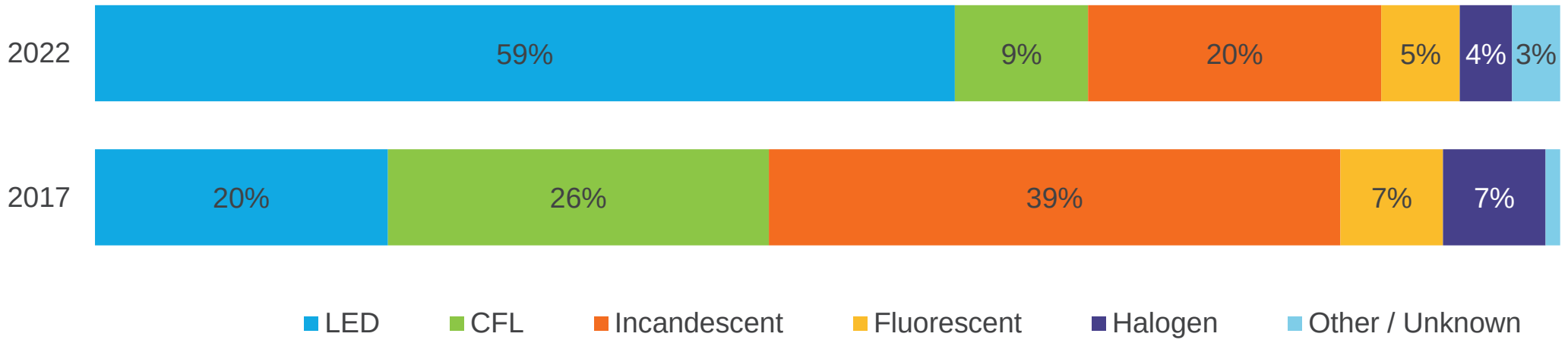
Residential Lighting

- LEDs are now the dominant lamp type in sockets across the Northwest
- Nearly all homes have LEDs



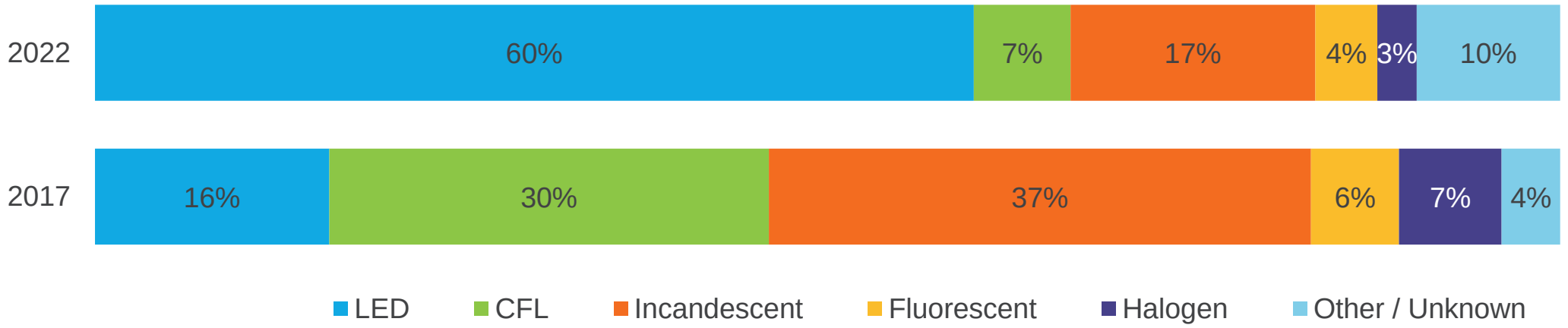
Residential Lighting – Single-Family Homes

- LED saturation up nearly ***200%*** since 2017
- Lighting power density down 43% since 2011



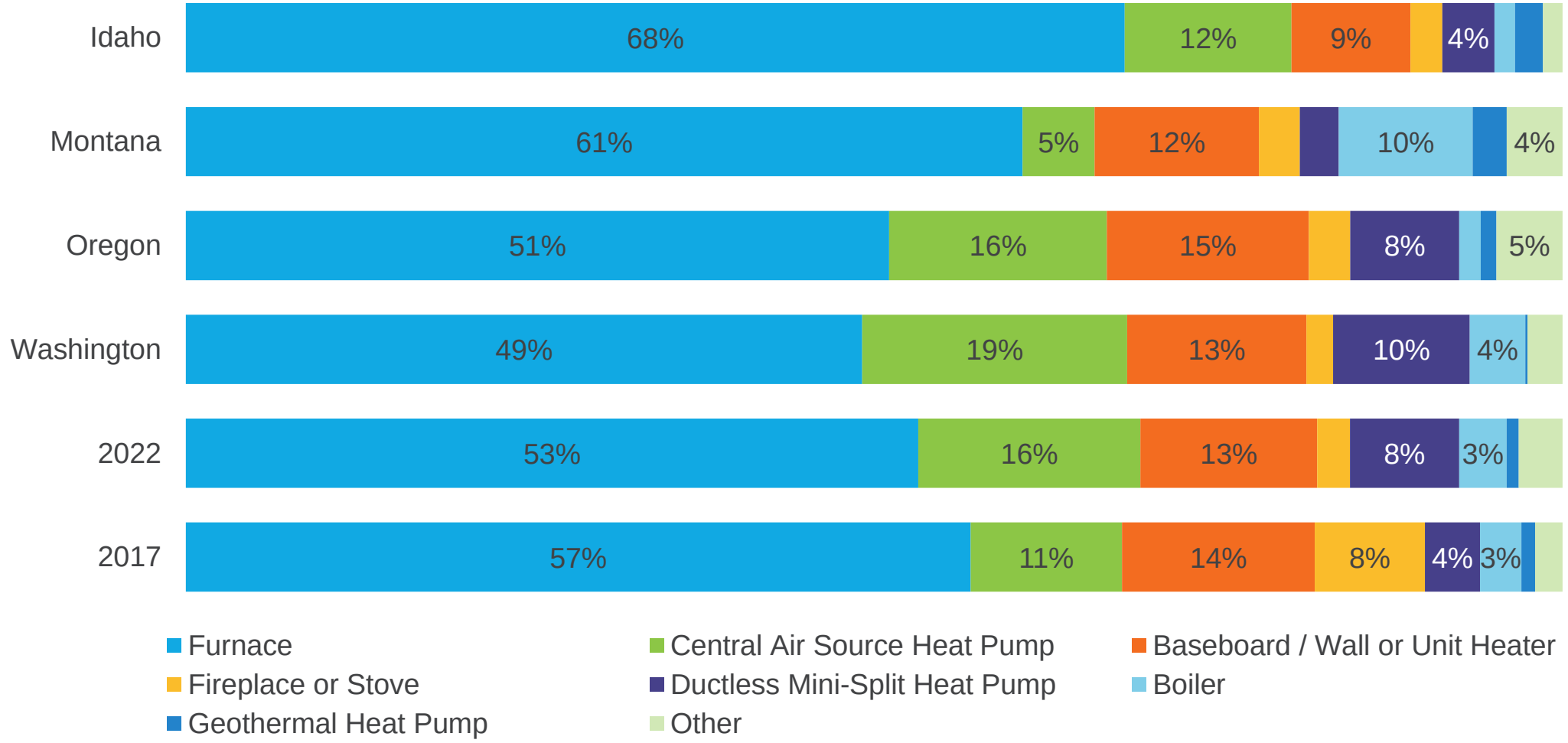
Residential Lighting – Multi-Family Homes

- LED saturation up ***275%***
- Incandescent lamp saturation down 54%
- CFL saturation down 77%

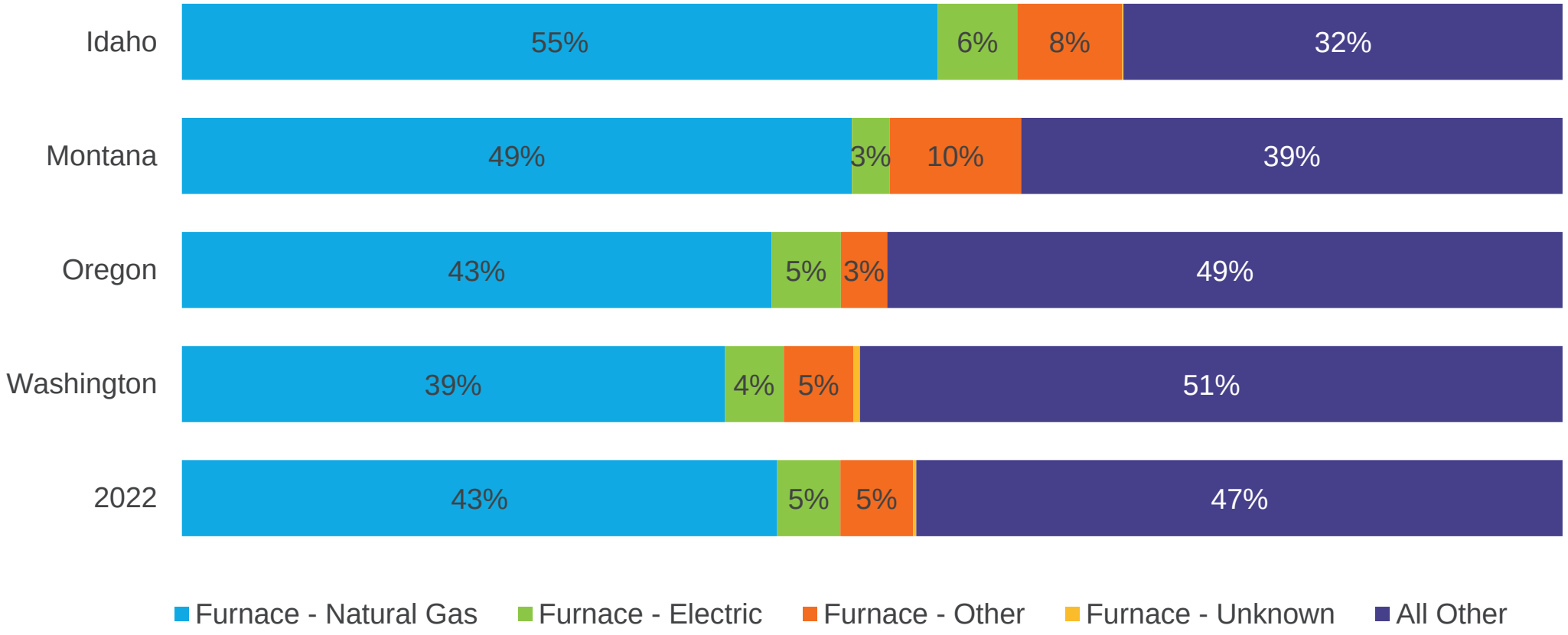


HVAC

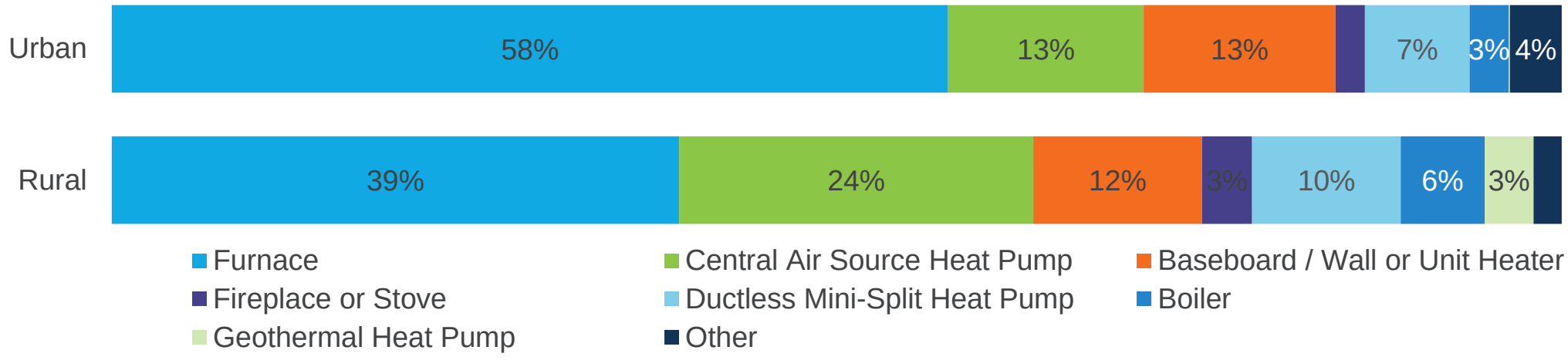
Single-Family Primary Heating

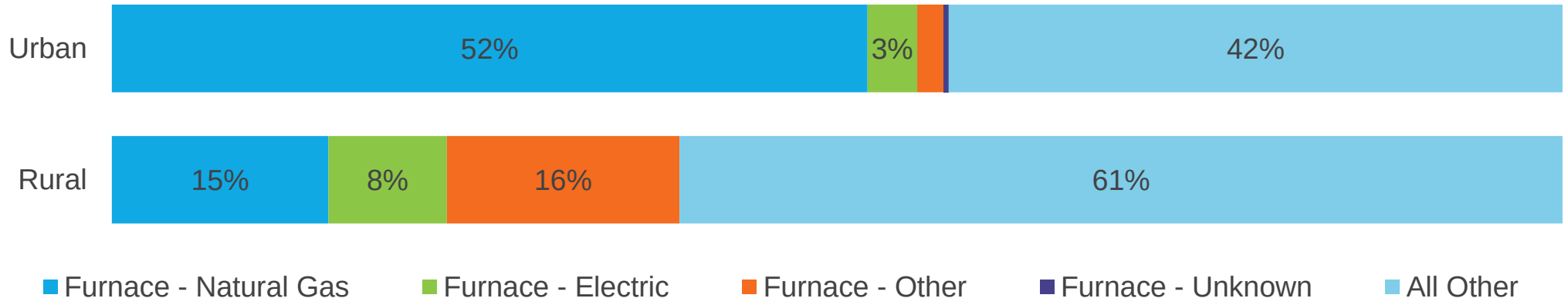


Single-Family Primary Heating - Furnace Fuels



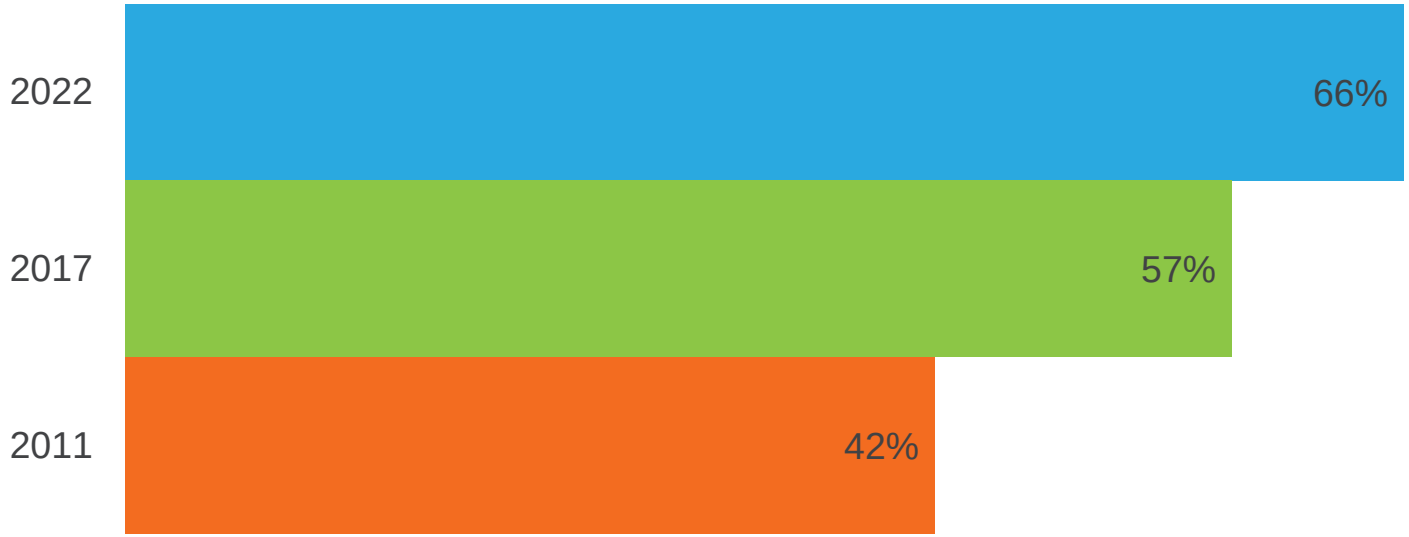
SF Primary Heating, Urban and Rural



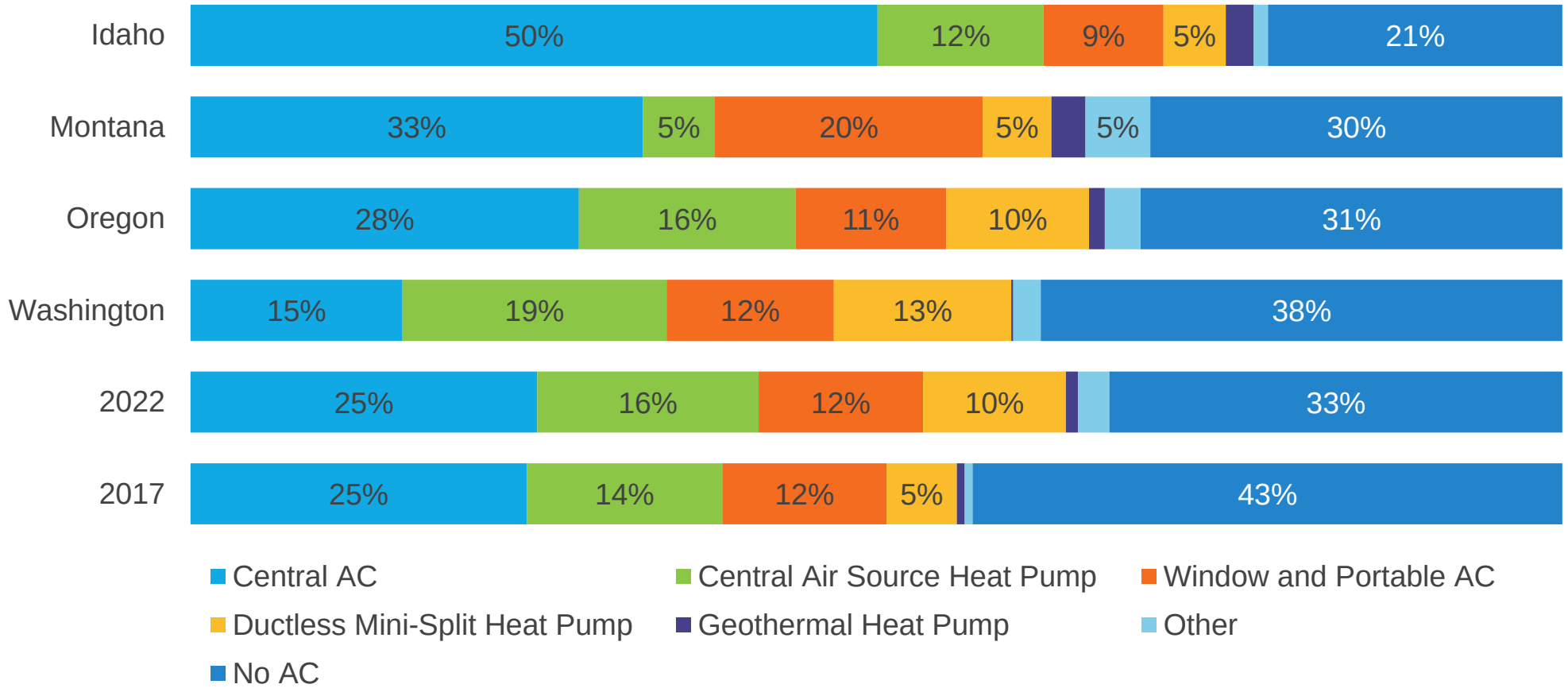


Single-Family Cooling is Increasing

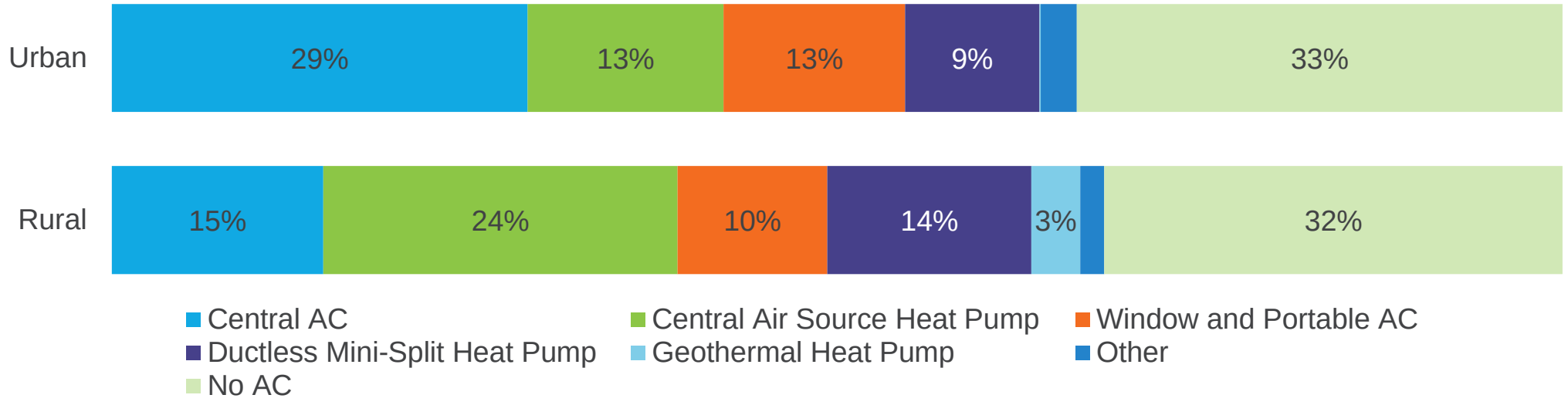
- Year over year increases in the percent of homes in the Northwest with cooling



Single-Family Primary Cooling



SF Primary Cooling, Urban and Rural



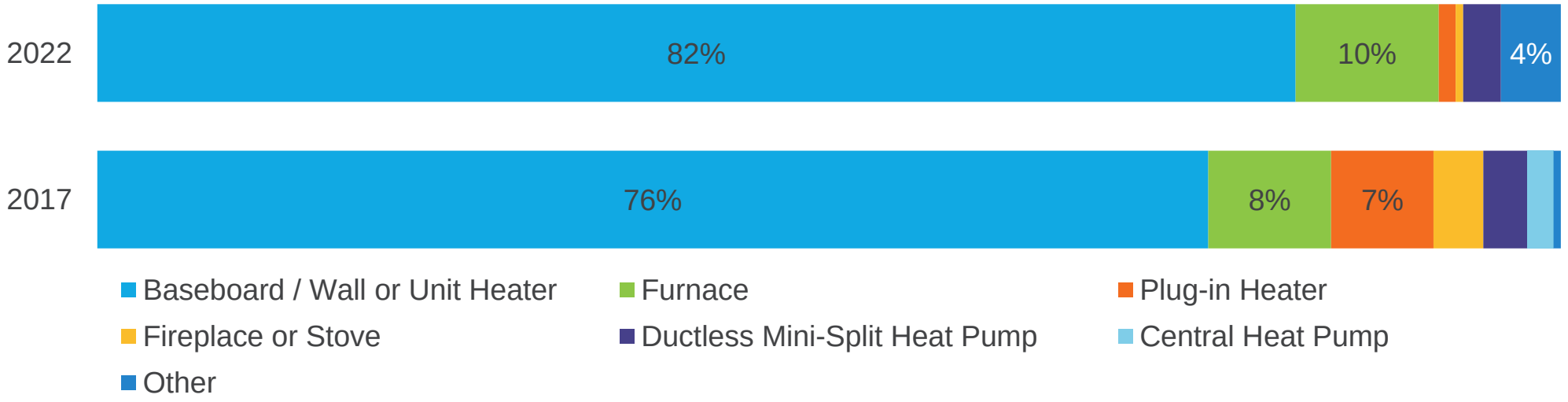
Single Family HVAC Efficiencies

- Efficiency metrics continue to improve

	2022	2017	2011
AFUE	86%	86%	84%
Central HP HSPF	8.9	8.3	8
DHP HSPF	10.8		
Central AC SEER	13.4	12.2	11.1
Central HP SEER	15.2	13.4	13

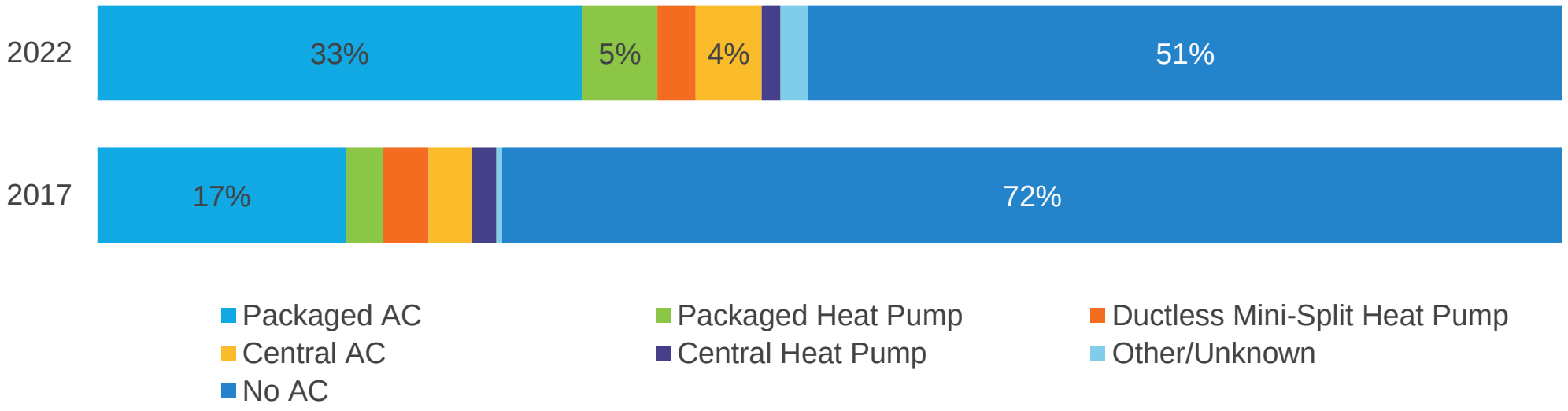
Multi-Family Primary Heating

- No big changes in multi-family unit heating equipment since 2017



Multi-Family Primary Cooling

- More packaged AC units in 2022 than 2017
- Fewer housing units with no cooling



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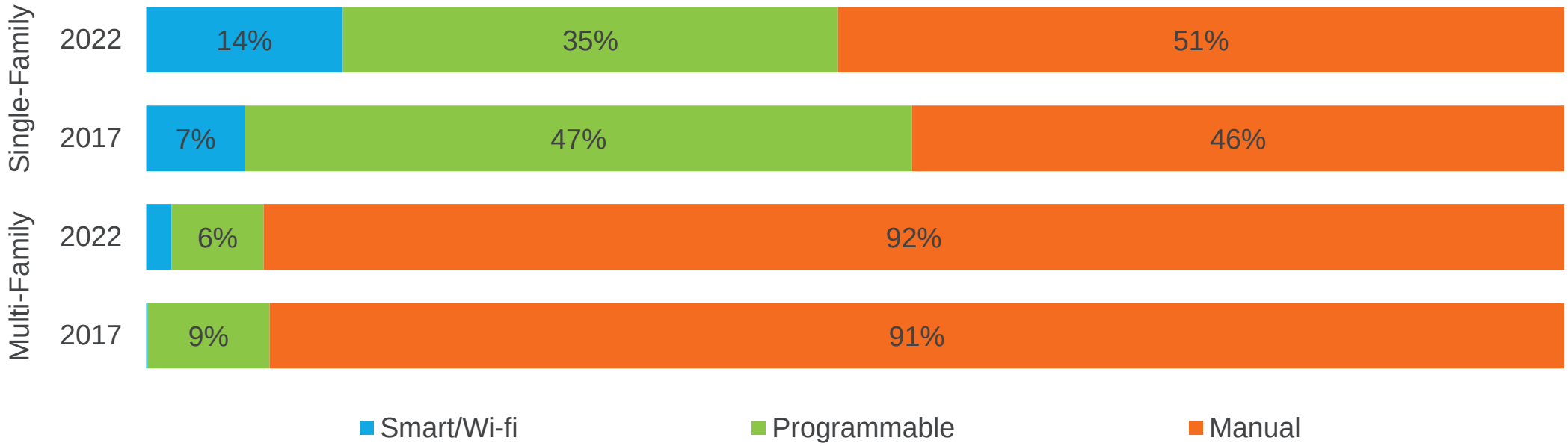
Thermostats

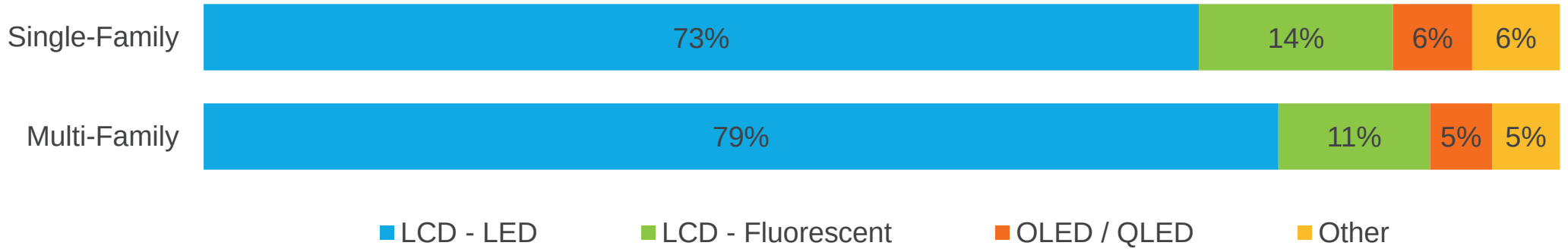
- Mix of thermostat types in single-family homes, with increases in smart / Wi-Fi thermostats since 2017
- Manual HVAC controls still dominant in multi-family



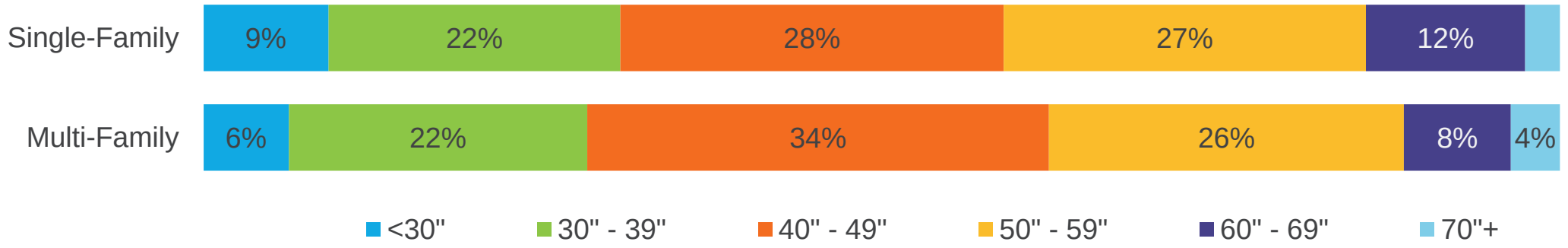
Appliances and Consumer Products

Televisions

- LCD TVs, especially LED versions, are dominant

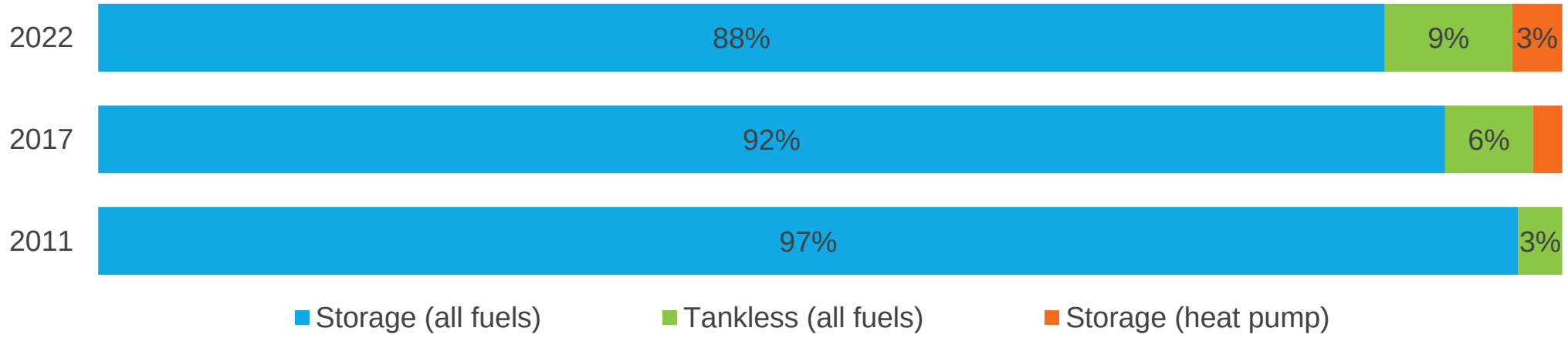


- Larger TVs (50+ inches) make up nearly 40% of TVs



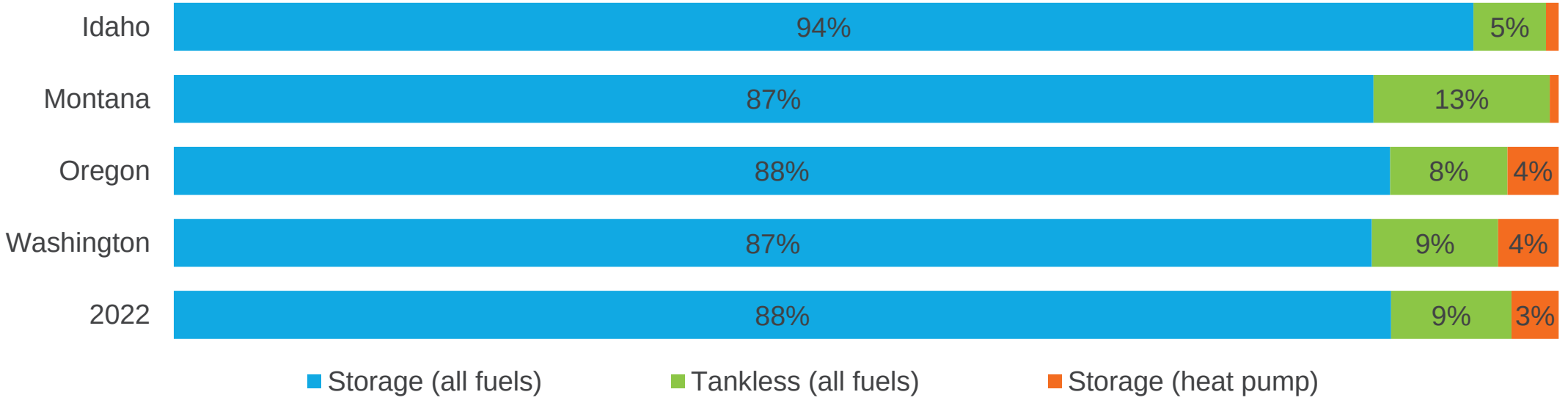
Water Heaters by Type, by Year

- Majority of water heaters are storage tanks (and not HPWHs).
- Tankless and HPWHs are slowly growing in prevalence in single-family homes.



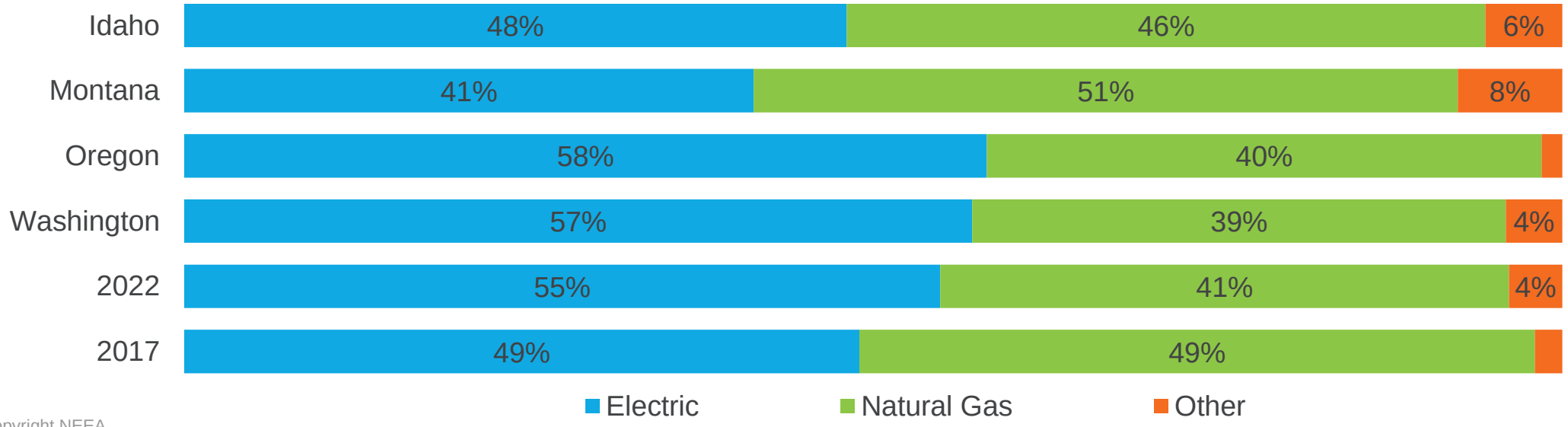
Water Heaters by Type, by State

- Idaho has a slightly higher prevalence of non-HP storage tanks.
- HPWHs are most prevalent in Oregon and Washington



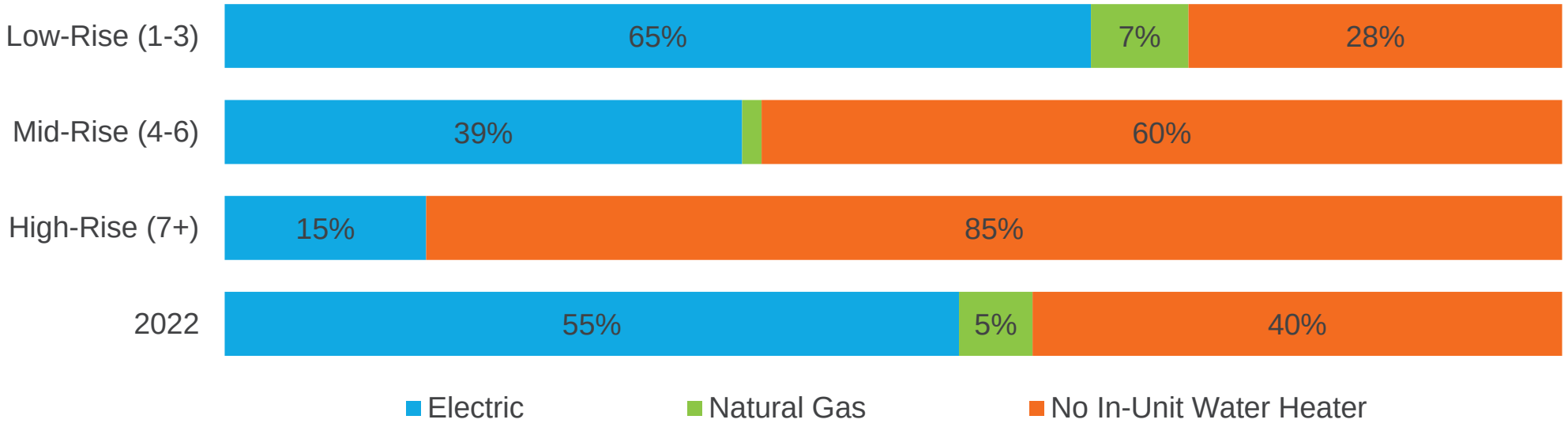
Water Heaters by Fuel, Single-Family

- 55% of water heaters in single-family homes are electric water heaters.
- Most of the rest are natural gas, with some variation by state (i.e., more natural gas in Montana).



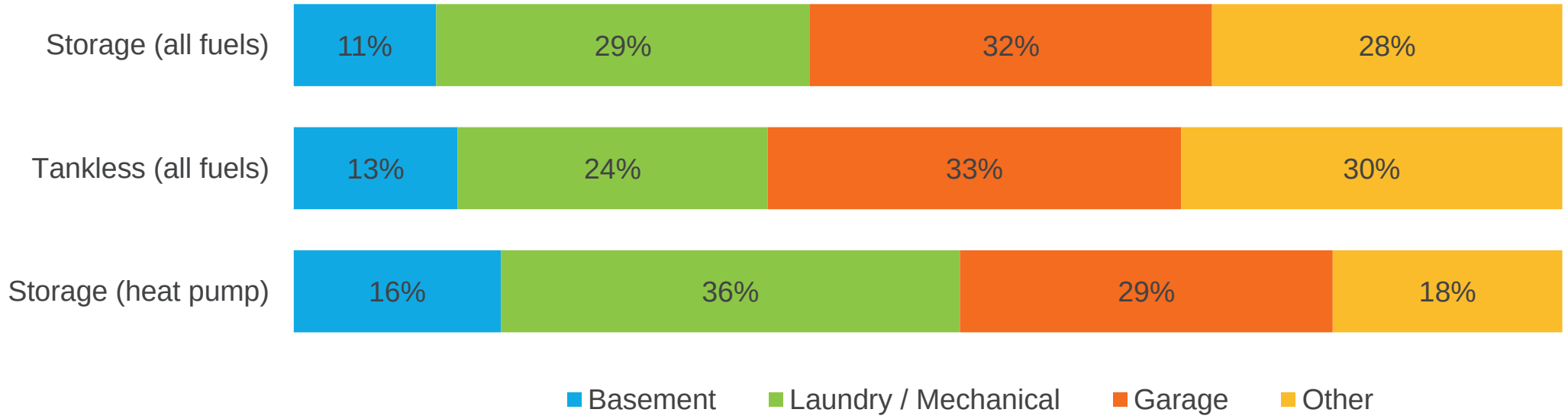
Water Heaters by Fuel, Multi-Family

- 55% of multi-family homes have electric water heaters.
- Considerable variation in the prevalence of in-unit water heaters by height class.



Water Heater Locations, Single-Family

- Most water heaters are either located in a dedicated laundry / mechanical room or in the garage.
- Water heaters are also often located in basements.



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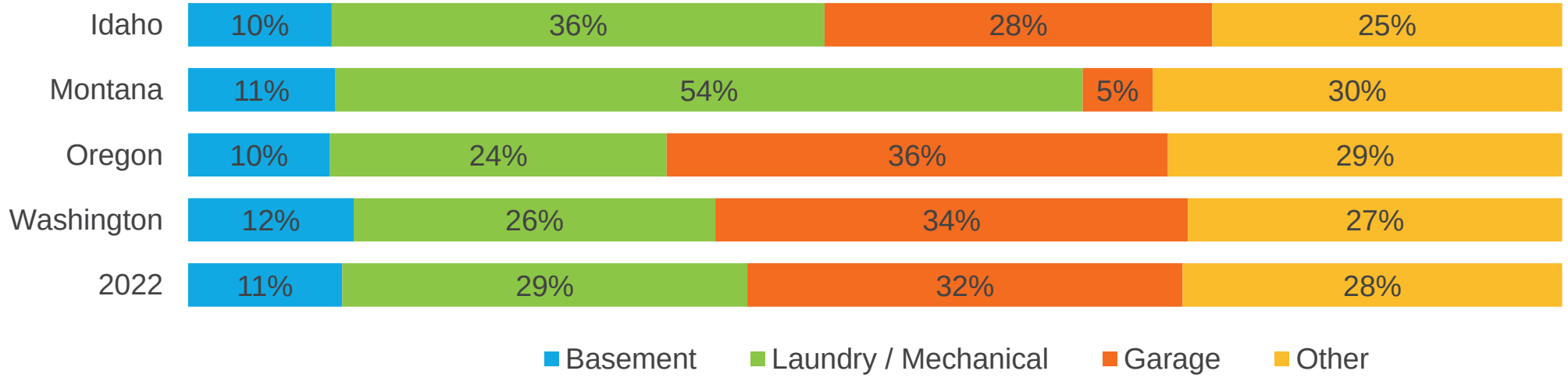
Storage Water Heater Locations, Single-Family

- Few storage water heaters in Montana are in garages (5%) compared to other states.
- Most water heaters in Montana are in dedicated laundry / mechanical rooms.



EVs and Solar

Distributed Gen and Electric Vehicles

- Prevalence of solar PV has increased since 2017.

	Idaho	Montana	Oregon	Washington	Overall
2022	8%	5%	10%	12%	10%
2017	2%	1%	3%	3%	3%

- Higher percent of homes have 1+ electric vehicle (including full EVs and PHEVs)..

	Idaho	Montana	Oregon	Washington	Overall
2022	2%	3%	8%	8%	7%
2017	0%	2%	2%	1%	1%

Resources

Findings Report – Appendix

- BPA/Non-BPA
- Heating Zone
- Home type
- Ownership
- State
- Urban/Rural

Findings Report – Appendix

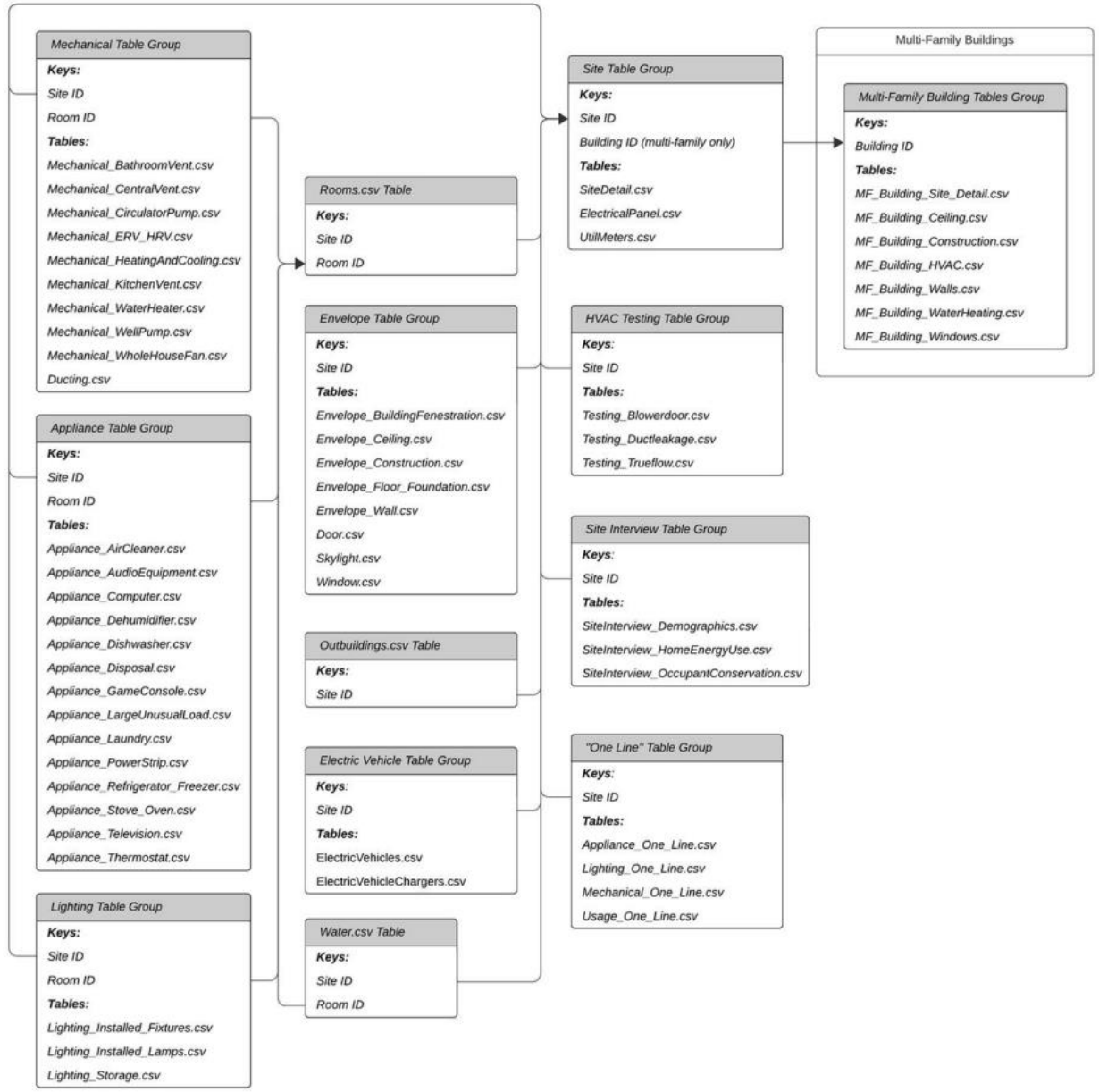
A2.3. Distribution of Installed Lamp Types by State

	ID	ID (n)	ID (CI)	MT	MT (n)	MT (CI)	OR	OR (n)	OR (CI)	WA	WA (n)	WA (CI)	Overall	Overall (n)	Overall (CI)
LEDs	58.5%	405	54.4%-62.2%	53.6%	252	48.8%-58.9%	61.3%	733	58.1%-64.0%	57.8%	835	55.0%-60.7%	58.5%	2225	56.7%-60.2%
CFLs	9.2%	299	7.8%-10.8%	8.3%	183	7.0%-9.7%	8.8%	482	7.7%-9.8%	9.1%	546	7.7%-10.5%	8.9%	1510	8.2%-9.7%
Incandescents	21.6%	345	18.9%-24.2%	22.9%	224	19.7%-26.6%	18.7%	591	16.3%-21.8%	19.7%	627	17.7%-21.8%	20.0%	1787	18.5%-21.5%
Halogens	2.0%	136	1.4%-2.8%	4.4%	121	3.4%-5.5%	2.7%	237	2.1%-3.3%	4.2%	323	3.3%-5.2%	3.5%	817	3.0%-4.1%
Linear Fluores-cents	6.2%	191	5.1%-7.4%	8.0%	144	6.4%-9.6%	5.7%	360	4.9%-6.8%	4.4%	335	3.6%-5.4%	5.3%	1030	4.8%-5.9%
Other Lamps	0.2%	30	0.1%-0.3%	0.0%	6	NA	0.3%	27	0.1%-0.6%	0.2%	30	0.1%-0.3%	0.2%	93	0.1%-0.3%
Unknown Lamps	2.3%	150	1.8%-2.9%	2.8%	117	2.2%-3.5%	2.6%	212	2.0%-3.1%	4.6%	379	3.9%-5.4%	3.6%	858	3.2%-4.1%

Site One-line Tables

	A	B	D	E	F	G	H	I	J
1	Table	Variable	Unit	Variable type	Variable Description / Question Text	2017 Table	2017 Variable	2011 Table	2011 Variable
142	Appliance_One_Line.csv	CK_SiteID		ID	Site ID				
143	Appliance_One_Line.csv	Building_Type		Single Choice selection	Building Type				
144	Appliance_One_Line.csv	Building_Category		Single Choice selection	Building Category				
145	Appliance_One_Line.csv	City		text	Site City				
146	Appliance_One_Line.csv	County		Single Choice selection	County				
147	Appliance_One_Line.csv	State		Single Choice selection	State				
148	Appliance_One_Line.csv	Zip		text	Zip Code				
149	Appliance_One_Line.csv	Region_SF_StrataVar		Single Choice selection	BPA Subregion				
150	Appliance_One_Line.csv	Attached_Detached_SF_StrataVar		Single Choice selection	Single-family weighting variable: attached or detached				
151	Appliance_One_Line.csv	BPA_SF_StrataVar		Single Choice selection	Single-family weighting variable: BPA electric utility				
152	Appliance_One_Line.csv	Sample_SF_StrataVar		Single Choice selection	Single-family weighting variable: Core or Oversample				
153	Appliance_One_Line.csv	NWN_SF_StrataVar		Single Choice selection	Single-family weighting variable: Northwest Natural Gas Service				
154	Appliance_One_Line.csv	Height_Class_MF_StrataVar		Single Choice selection	Multi-family weighting variable: building height class				
155	Appliance_One_Line.csv	Strata_Territory		Single Choice selection	Strata Name				
156	Appliance_One_Line.csv	Site_Case_Weight		decimal	Site weight				
157	Appliance_One_Line.csv	Strata_Population_Estimate		decimal	Estimate of the strata's population				
158	Appliance_One_Line.csv	Electric_Utility		Single Choice selection	Electric Utility				
159	Appliance_One_Line.csv	EIA_Electric_Utility_ID		ID	Electric Utility ID				
160	Appliance_One_Line.csv	Electric_Utility_BPA		Single Choice selection	BPA utility flag				
161	Appliance_One_Line.csv	Gas_Utility		Single Choice selection	Gas Utility				
162	Appliance_One_Line.csv	Conditioned_Area	Sq ft	decimal	Conditioned Area of home				
163	Appliance_One_Line.csv	Conditioned_Volume	Cu ft	decimal	Home volume				
164	Appliance_One_Line.csv	Qty_Rooms		integer	Number of rooms				
165	Appliance_One_Line.csv	Qty_Bedrooms		integer	Number of bedrooms				
166	Appliance_One_Line.csv	Qty_Bathrooms		decimal	Number of bathrooms				
167	Appliance_One_Line.csv	Cooling_Zone		integer	Cooling Zone (based on RTF cooling zone assignments)				
168	Appliance_One_Line.csv	Heating_Zone		integer	Heating Zone (based on RTF heating zone assignments)				
169	Appliance_One_Line.csv	Home_Vintage		integer	Home vintage				
170	Appliance_One_Line.csv	Ownership		Single Choice selection	Do You Rent or Own this home?				
171	Appliance_One_Line.csv	Qty_Occupants		integer	Number of occupants				
172	Appliance_One_Line.csv	TVs_Total		integer	Count of ____				

User Guide



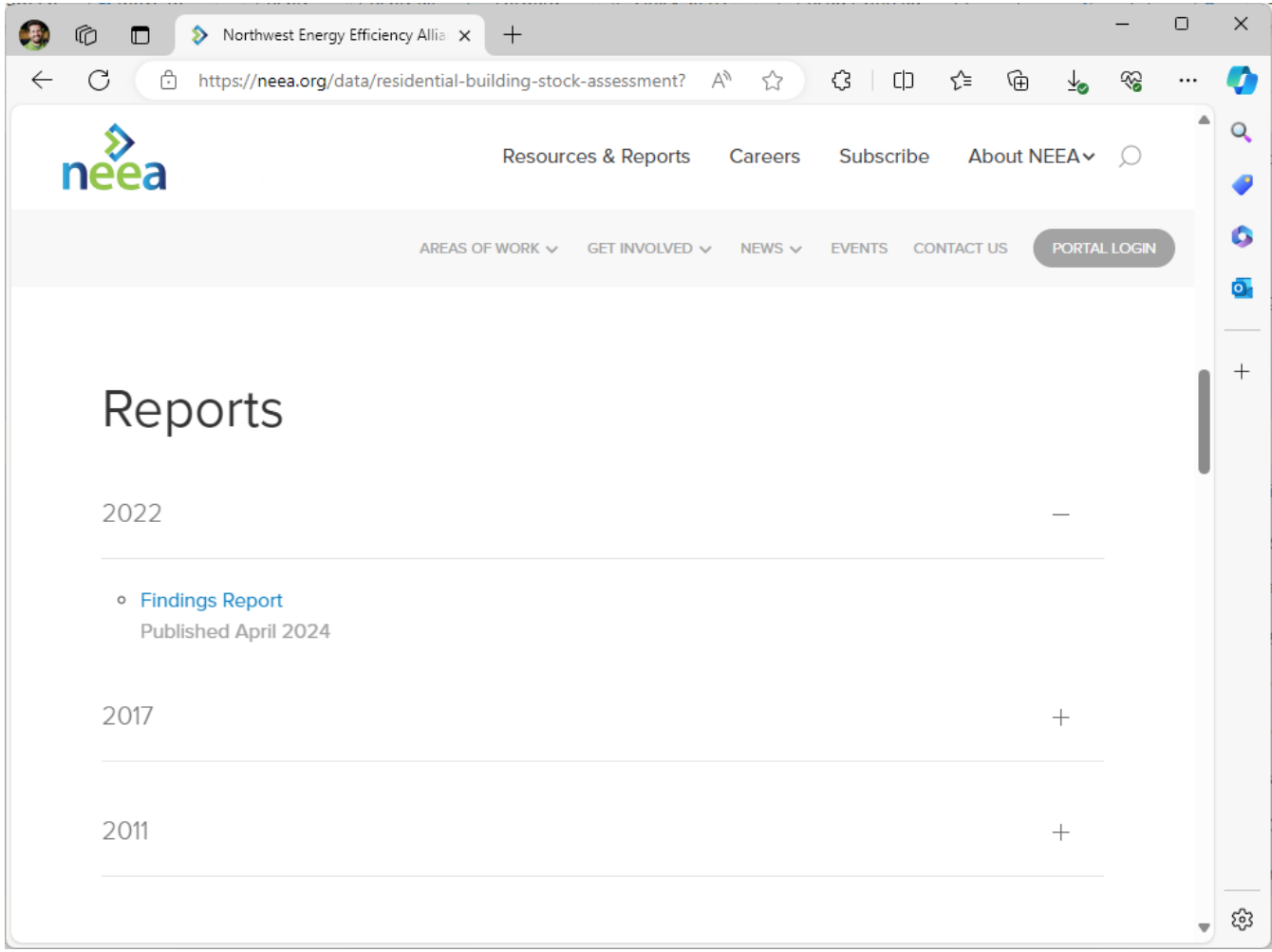
Code Snippets

```
# Python Code Demonstrating Weighted Analysis
# Example: Weighted Average of Known Television Sizes by State
import pandas as pd
import numpy as np

television_data_with_state_and_weight = pd.merge(
    Appliance_Television,
    SiteDetail[['SiteID', 'State', 'Site_Case_Weight']],
    on='SiteID',
    how='left'
)

# Filtering out rows where Size is 'Unknown', converting Size to numeric
television_data_grouped = television_data_with_state_and_weight[
    television_data_with_state_and_weight['Size'] != 'Unknown'
].copy()
television_data_grouped['Size'] = pd.to_numeric(television_data_grouped['Size'])
```

```
#### R Code For Bootstrapping ####
# Example: Confidence Interval for Average of Known Television Sizes by State

# Function to perform weighted bootstrap resampling and calculate 95% CI
bootstrap_ci_weighted <- function(variable, weights, n_iterations = 1000) {
  # Check if the number of observations is less than 10
  if (length(variable) < 10) {
    return(c(Lower_CI = NA, Upper_CI = NA))
  }

  means <- numeric(n_iterations)

  for (i in 1:n_iterations) {
    # Sample with replacement, considering weights
    sampled_indices <- sample(seq_along(variable), size = length(variable), replace = TRUE, prob =
weights)
    sample <- variable[sampled_indices]
    # Calculate mean
    means[i] <- mean(sample)
  }

  # Calculate 95% confidence interval
  ci <- quantile(means, probs = c(0.025, 0.975))
  return(ci)
}

# Example of applied function
television_data_with_state_and_weight %>%
```


Study Deliverables

- Reports
  - Findings Report (and summary tables)
- Data
  - Site One-lines
  - Core tables
  - Data Dictionary
  - User Guide
- Documentation
  - Methods Report
- neea.org/rbsa



Mike Psaris

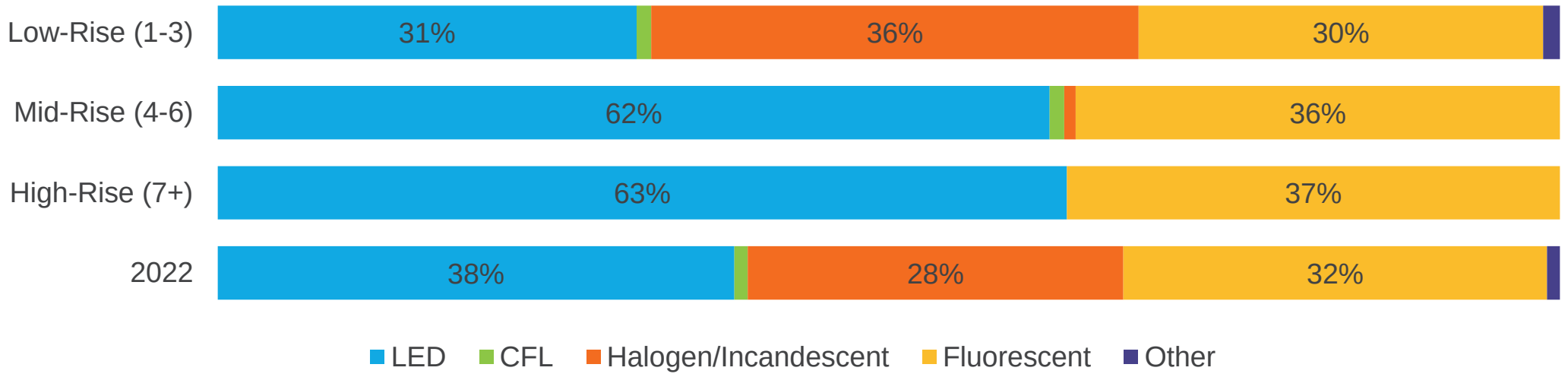
Senior Program Manager, NEEA

mpsaris@neea.org

Questions?

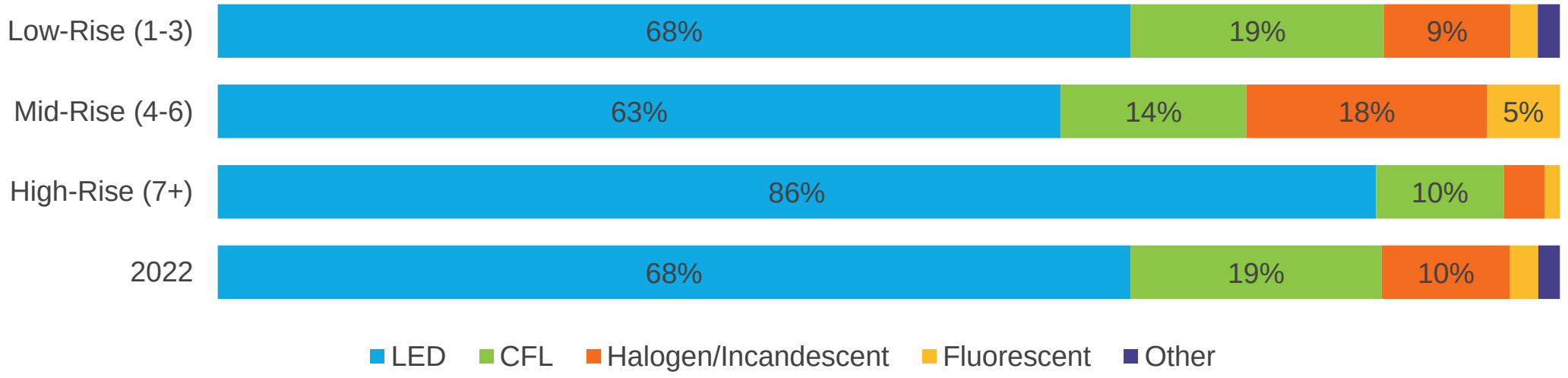
MF Buildings – Parking Area Lighting

- High-rise and mid-rise parking areas are predominantly illuminated by LEDs (63% and 62%, respectively).
- Parking areas at low-rises are roughly an equal mix of LEDs, halogen/incandescent lamps, and linear fluorescent lamps.



MF Buildings – Exterior Lighting

- Exterior area lighting is dominated by LED lamps across all building height classes.
- Exterior lighting at high-rises, in particular, consists of mostly LEDs (86%).

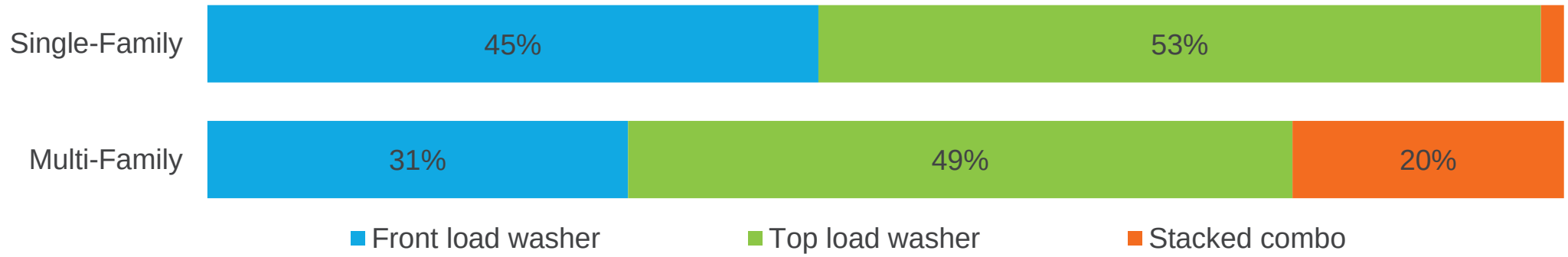


Residential HVAC

- Cooling is on the rise
- Heat pumps present in 30% of single-family homes
- Packaged AC (window and portable units) more prevalent in multi-family units
- Multi-family HVAC controls are largely manual

Laundry Equipment

- Stacked washers/dryers are more common in multi-family tenant units than in single-family homes.



- In single-family homes, 92 percent of dryers are electric, and the study found only electric dryers in tenant units.
- One percent of dryers are heat pump dryers.

