MADISON 2050 DECARBONIZATION STRATEGY

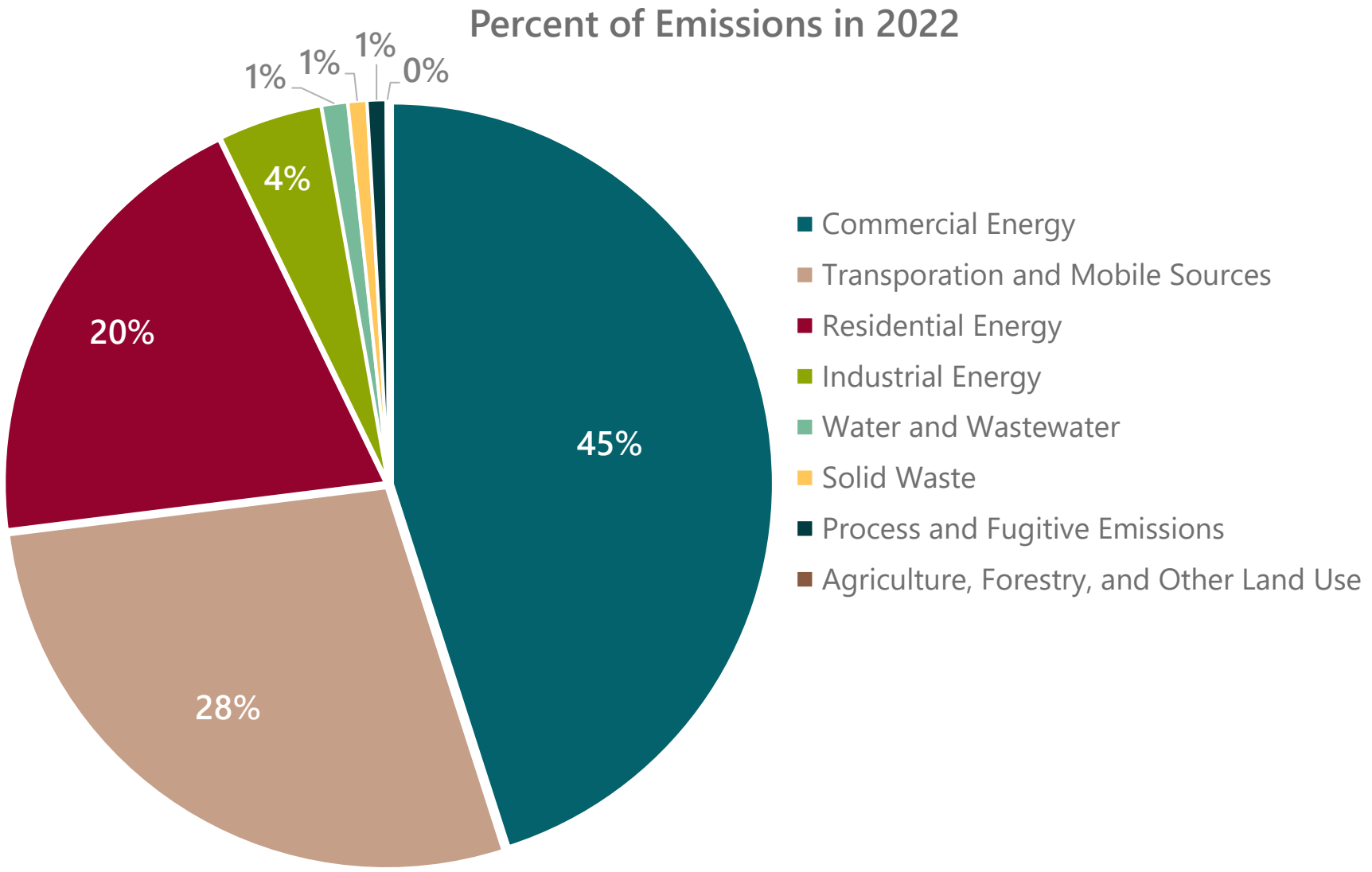
Alice Duncan-Graves
Bloomberg Harvard City Hall Fellow

THE BIG PICTURE

Commercial and residential energy use accounts for just under 65% of all Madison's emissions.

Emissions from commercial and residential buildings in Madison accounted for just under 65% of the City's total emissions in 2022. While Madison has set the goal to reach 100% renewable energy and net zero carbon emissions community-wide by 2050, the city must identify potential policies and programs to address building decarbonization.

This building stock analysis moves Madison closer to understanding its building stock and opportunities for decarbonization.



METHODOLOGY

ABBRIDGED METHODOLOGY

**Full methodology held in Appendix.*

1 Collect Data

Collect data from Assessor's Office, BI, Dane County, NREL and the U.S. Census.

2 Identify Typologies

Identify typologies based on building size and property use.

3 Identify Buildings

Filled in data gaps by collecting building information from web searches and footprint data.

4 Identify Trends

Using typologies and square footage, identified trends across the city.

5 Model Energy Use

Using NREL's ComStock and ResStock modeled energy use for Madison's buildings.

6 Electrification Ready Analysis

Using electrical panel size, modeled panel size needed for all single-family homes, duplexes and condos.

7 Overlayed Census Data

Identified trends across census block groups.

8 Identify Intervention Points

Identified key intervention points for policies and programs.

9 Policy Review

Policy, program and behavioral economics review and gap analysis.

10 Cost Modeling

Modeled installation, purchase and operating costs in the Madison context.

Note: Methodology and visuals inspired by the Building Electrification Institute's method and presentations for building stock analysis for multiple cities

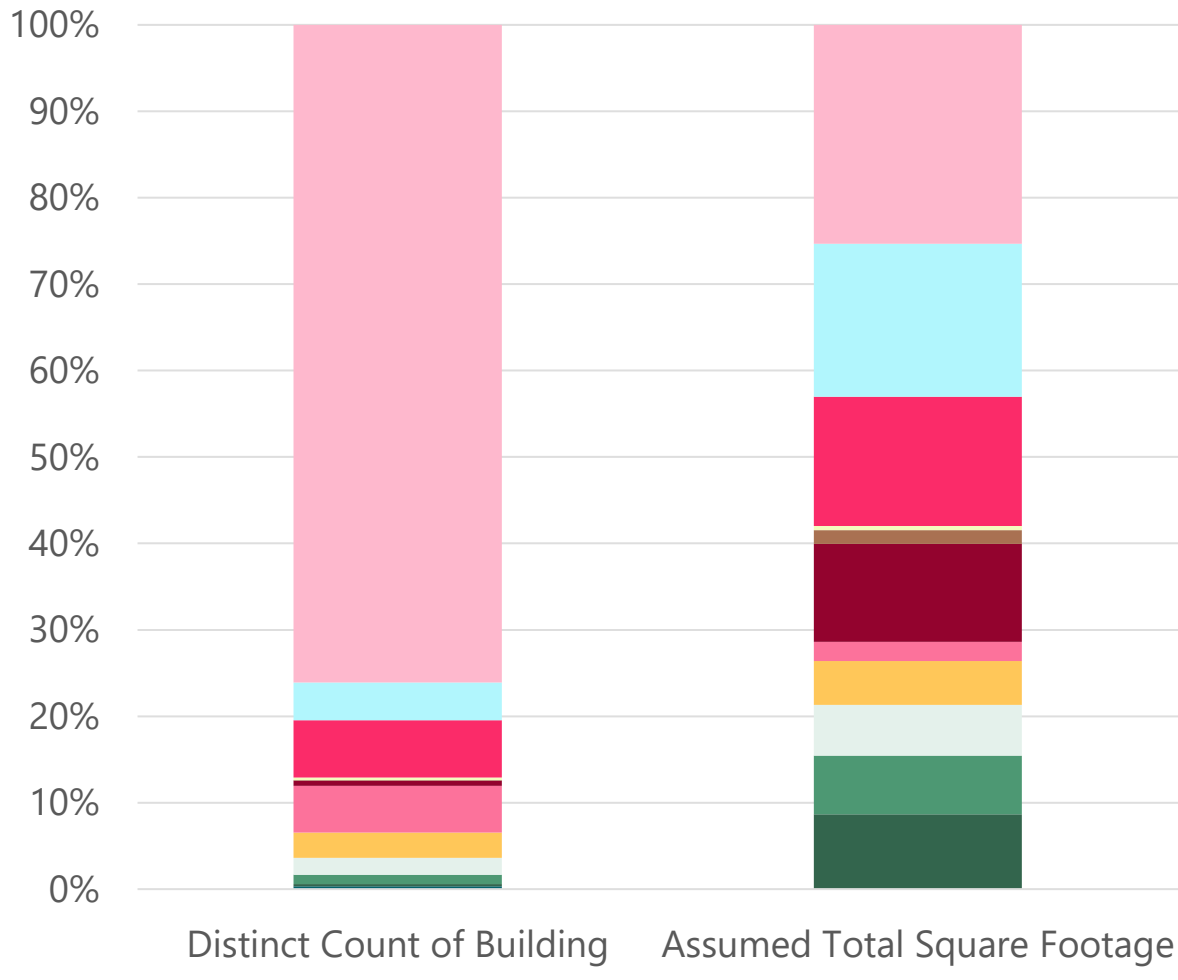
FINDINGS

SECTION 1. THE RESIDENTIAL LANDSCAPE: OPPORTUNITY AT SCALE

FINDING 1. Single-family homes are Madison's biggest residential decarbonization lever.

Single-family homes account for over 75% of buildings in Madison, but only 25% of square footage.

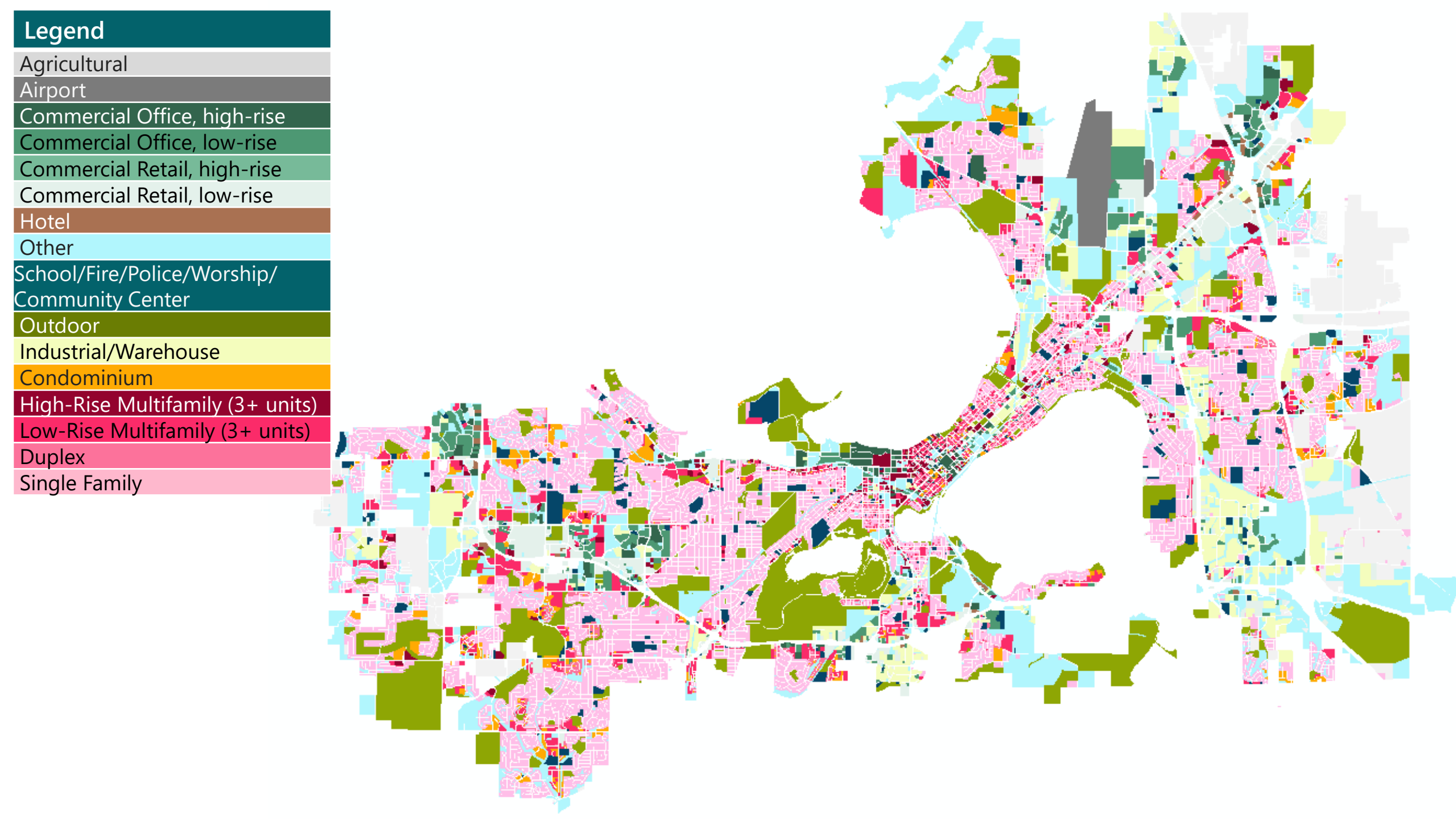
Typology	Total Buildings*	Total Parcels**	Assumed Total Square feet***
Agricultural	244	745	107,774
Commercial Office, high-rise	210	124	26,185,734
Commercial Office, low-rise	846	763	20,669,476
Commercial Retail, high-rise	1	1	45,270
Commercial Retail, low-rise	1,523	1,214	17,829,544
Other	3,429	4,487	53,885,868
Hotel	82	71	4,813,907
Industrial	225	154	1,518,273
Condominium	2,301	18,029	15,417,736
High-Rise Multifamily (3+ units)	456	394	34,452,399
Low-Rise Multifamily (3+ units)	5,170	3,181	45,472,565
Duplex	4,228	3,286	6,837,630
Single Family	59,565	49,457	77,011,391
TOTAL	**77,865**	**81,837**	**304,247,569**



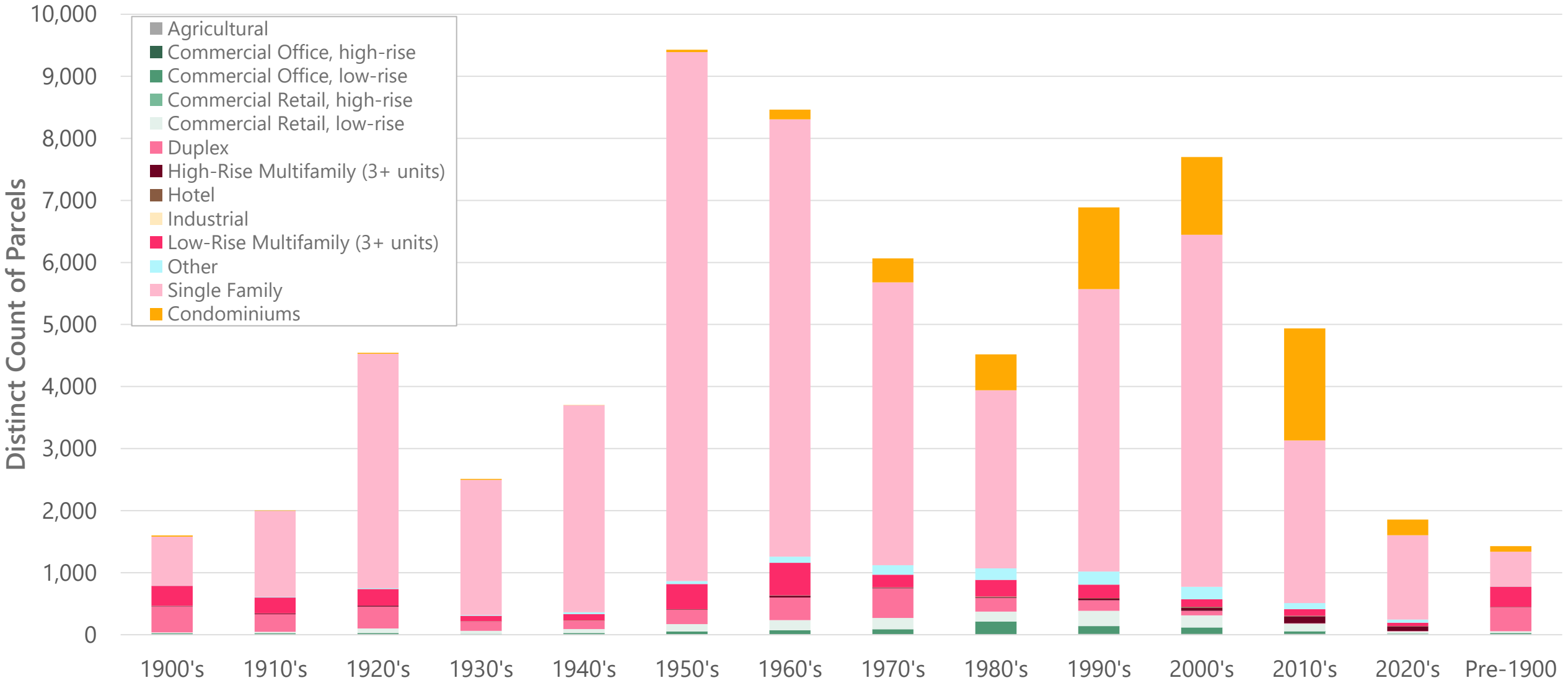
*Based on an overlay of building footprints from Dane County. Could include small, unheated/electrified structures.

**Distinct count of parcels. Note each condominium unit is given its own parcel number which inflates the number of parcel in relation to number of buildings.

***Includes total primary square footage from Assessor's data and building footprint from Dane County Parcels multiplied by the estimated number of stories from google street view for those with no data. 11,243 parcels have no square footage listed in Assessor's.


Legend
Agricultural
Airport
Commercial Office, high-rise
Commercial Office, low-rise
Commercial Retail, high-rise
Commercial Retail, low-rise
Hotel
Other
School/Fire/Police/Worship/
Community Center
Outdoor
Industrial/Warehouse
Condominium
High-Rise Multifamily (3+ units)
Low-Rise Multifamily (3+ units)
Duplex
Single Family

Property construction peaked in the 1950s and 60s, with single-family homes consistently the largest portion of properties constructed each decade.



Does not include those with no year built or condominium parcels (condominiums counted based on distinct address).

Models show Madison's single-family homes consume more natural gas than all other residential property types combined.

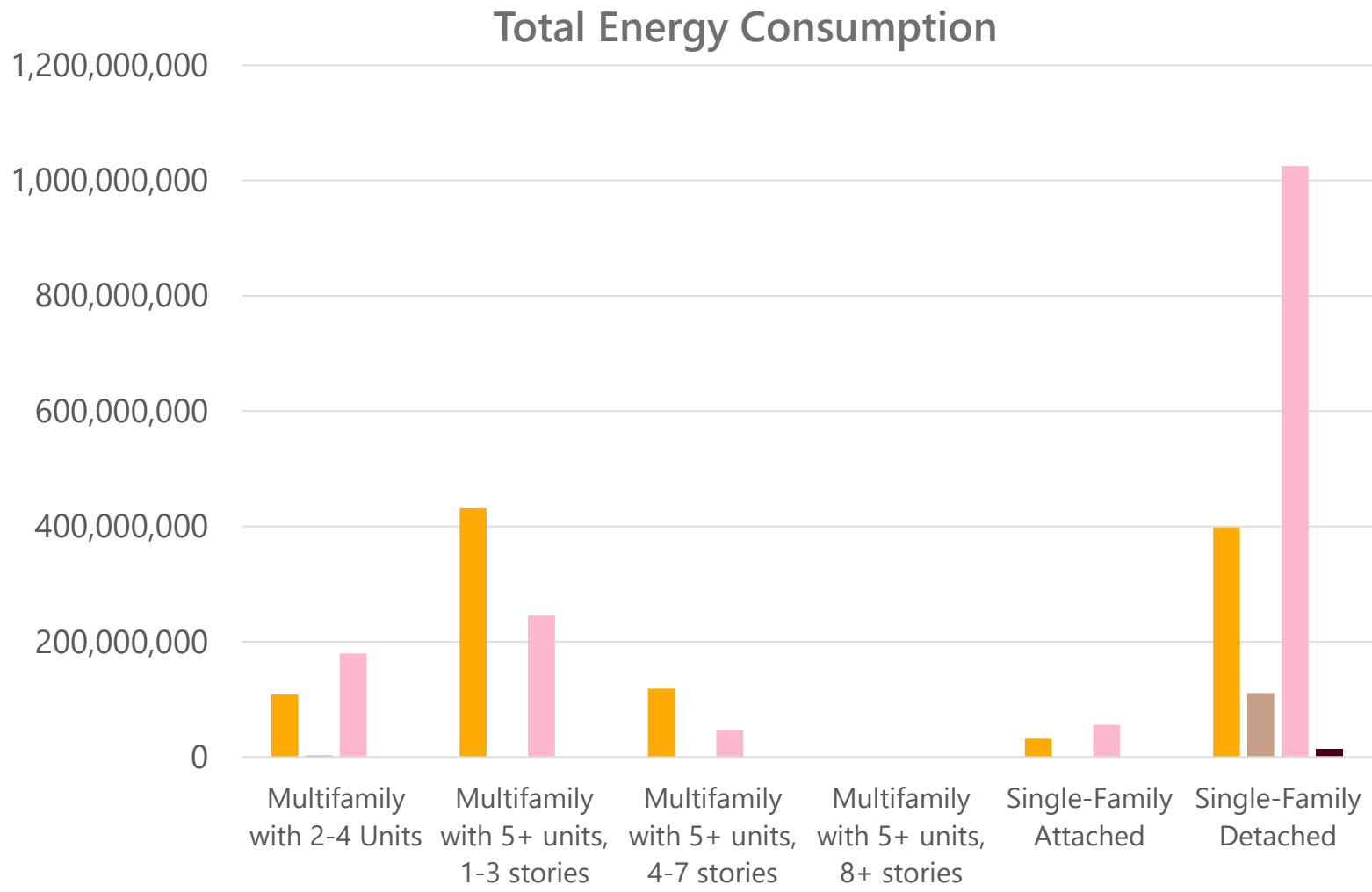
Modeled using ResStock, NREL's physics-based computer modeling for segment of residential building types. ResStock includes 921 building prototypes used to model energy usage in Madison.

There are 7 categories of buildings modeled:

- Attached single-unit
- Detached single-unit
- Mobile homes*
- 2-4 units multi-unit residential
- 5+ units multi-unit residential (1-3 stories)
- 5+ units multi-unit residential (4-8 stories)
- 5+ units multi-unit residential (8+ stories)*

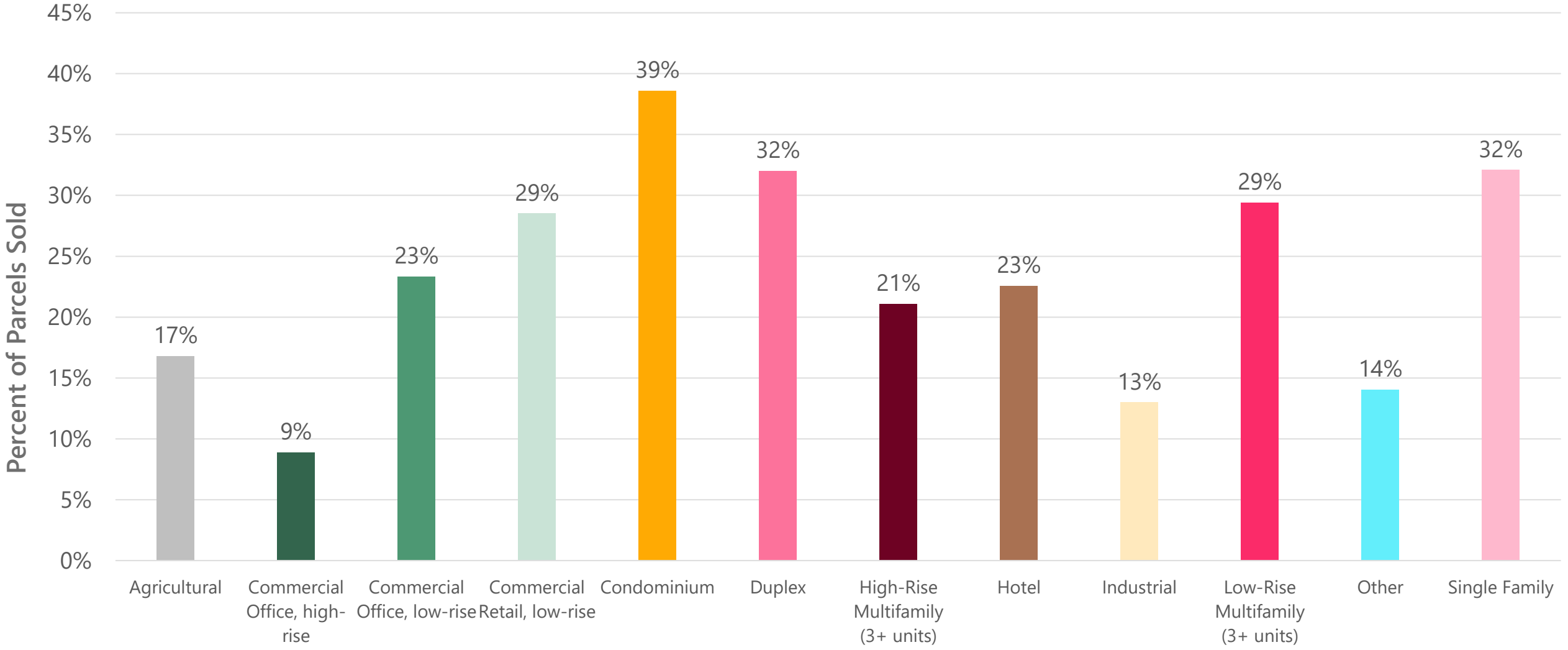
*Removed because Madison's data did not contain enough parcels to weight accurately. Weighted with Assessor's square footage, not with assumed square footage.

Note: based on GHG report, ResStock is overestimating electricity use, and underestimating natural gas.



NREL. 2024. ResStock General Reference Documentation. Golden, CO. National Renewable Energy Laboratory. https://nrel.github.io/ResStock.github.io/

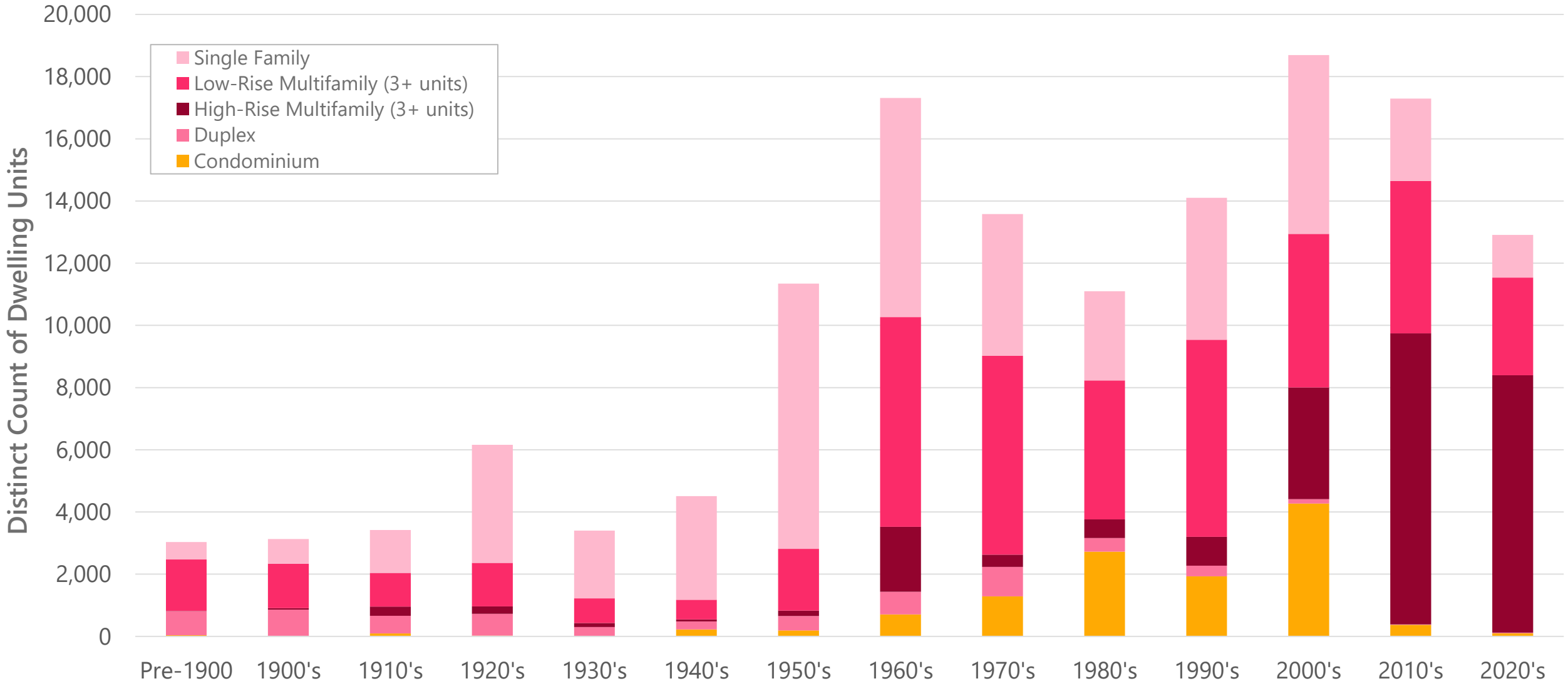
While condominiums have the highest turnover across the city, 32% of single-family homes and duplexes turned over from 2020 through 2024.



Note: this calculates the percentage assuming only one sale per parcel in 5 years, it does not account for a parcel being sold multiple times.

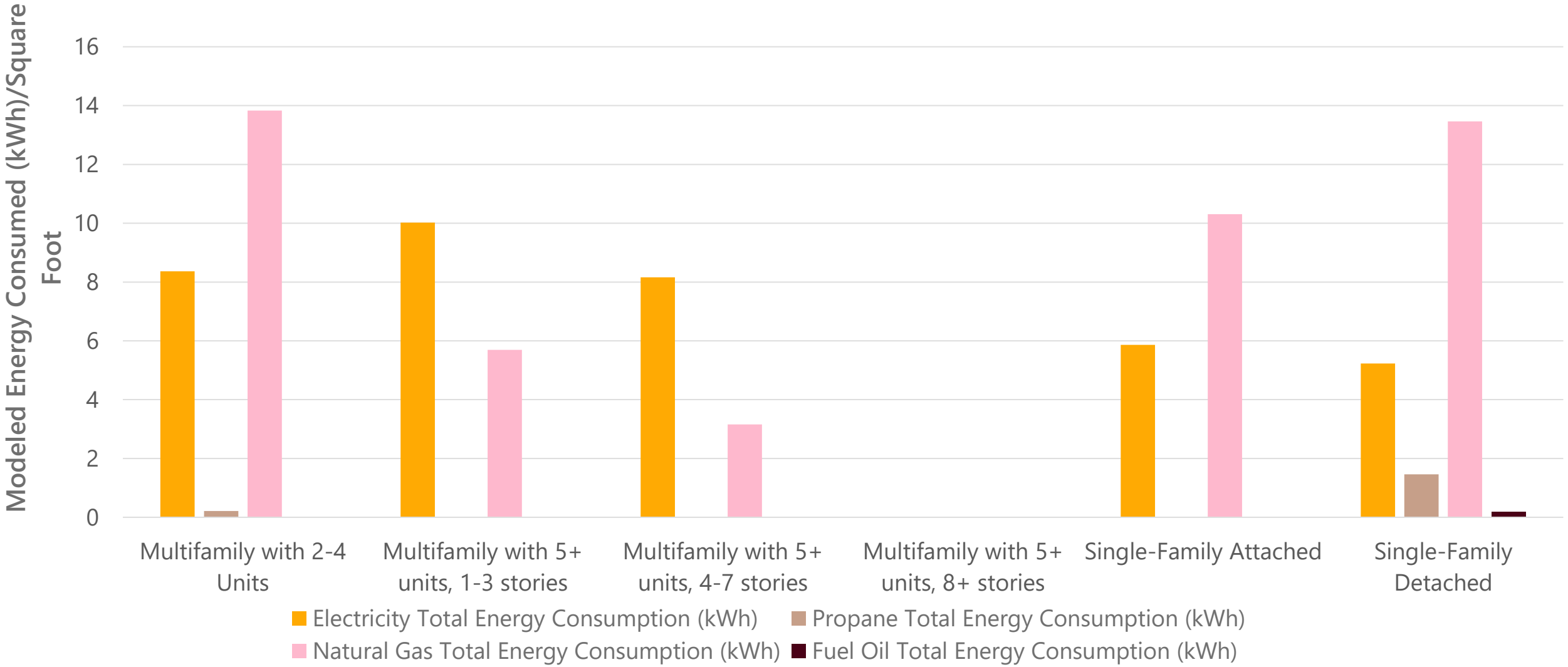
FINDING 2. Madison's move toward denser residential buildings advances energy efficiency.

Over time, Madison's residential construction has shifted to multifamily based on the number of dwelling units constructed.



Does not include those parcels with no year built noted.

Small residential properties (4 units or less) use the most energy per square foot across modeled energy use.



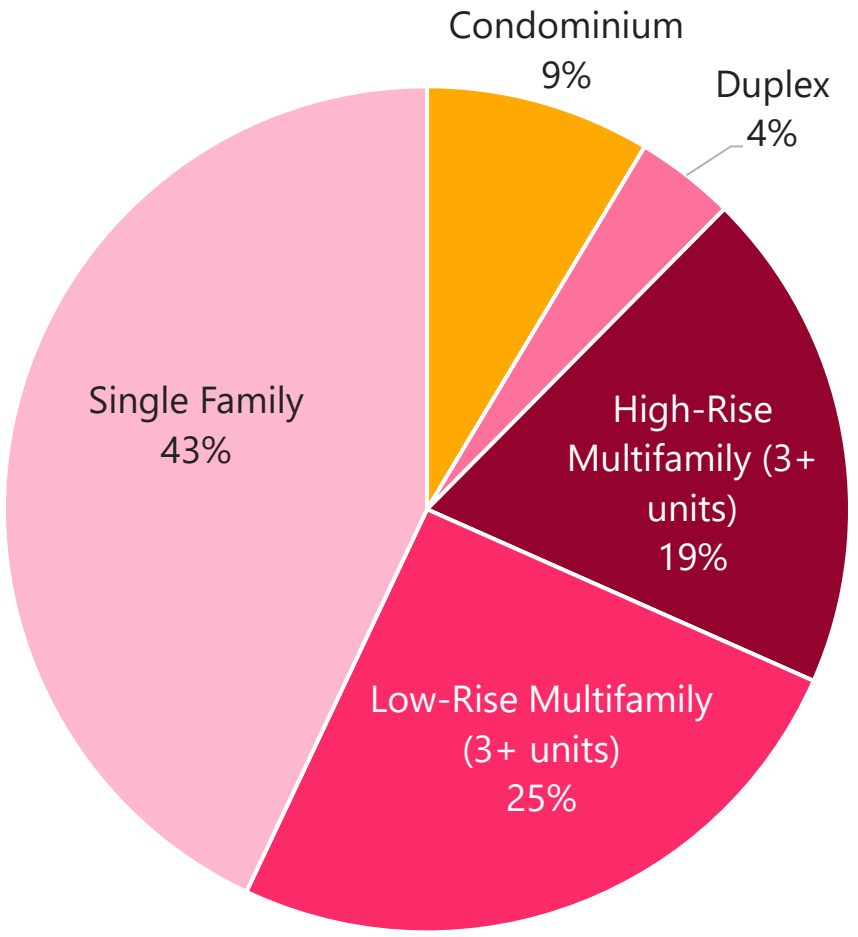
NREL. 2024. ResStock General Reference Documentation. Golden, CO. National Renewable Energy Laboratory. https://nrel.github.io/ResStock.github.io/

While low-rise/high-rise multifamily have over a third more dwelling units than single family, they account for approximately the same square footage.

Typology	Total Buildings*	Distinct Count of Units	Total Parcels**	Assumed Total Square feet***
Single Family	59,565	49,383	49,457	77,011,391
Duplex	4,228	6,539	3,286	6,837,630
Low-Rise Multifamily (3+ units)	5,170	42,156	3,181	45,472,565
High-Rise Multifamily (3+ units)	456	25,640	394	34,452,399
Condominium	2,301	11,995	18,029	15,417,736
TOTAL	**71,720**	**135,713**	**74,347**	**179,191,721**

**Based on an overlay of building footprints from Dane County. Could include small, unheated/electrified structures.*
***Distinct count of parcels. Note each condominium unit is given its own parcel number which inflates the number of parcels compared to the number of buildings.*
****Includes total primary square footage from Assessor's data and building footprint from Dane County Parcels multiplied by the estimated number of stories from google street view for those with no data. 11,243 parcels have no square footage listed in Assessor's.*

Percent of Square Footage by Typology



FINDING 3. Over a third of single-family homes may be electrification ready.

36% of single-family home, 13% of duplex and 11% of condominium parcels have panels assumed large enough to support electrification.

ASSUMPTIONS

Based on research performed by Slipstream and Pecan Street, a 200 AMP panel should be sufficient for most single-family homes to fully electrify. For purposes of this exercise, I will include duplexes and condominiums in the analysis, assuming the same panel size.

HIGH-LEVEL FINDINGS

	BELOW 100 AMPS	100 TO 199 AMPS	200 AND ABOVE AMPS
Single-Family Homes	1,994 (4%)	29,230 (59%)	17,992 (36%)
Duplex	417 (10.47%)	2,472 (75.23%)	344 (12.69%)
Condominium	218 (1.21%)	9,750 (54.08%)	1,964 (10.89%)

To further assess electrification readiness of single-family homes, we can drill down specifically into those with panels smaller than 200 AMPS.

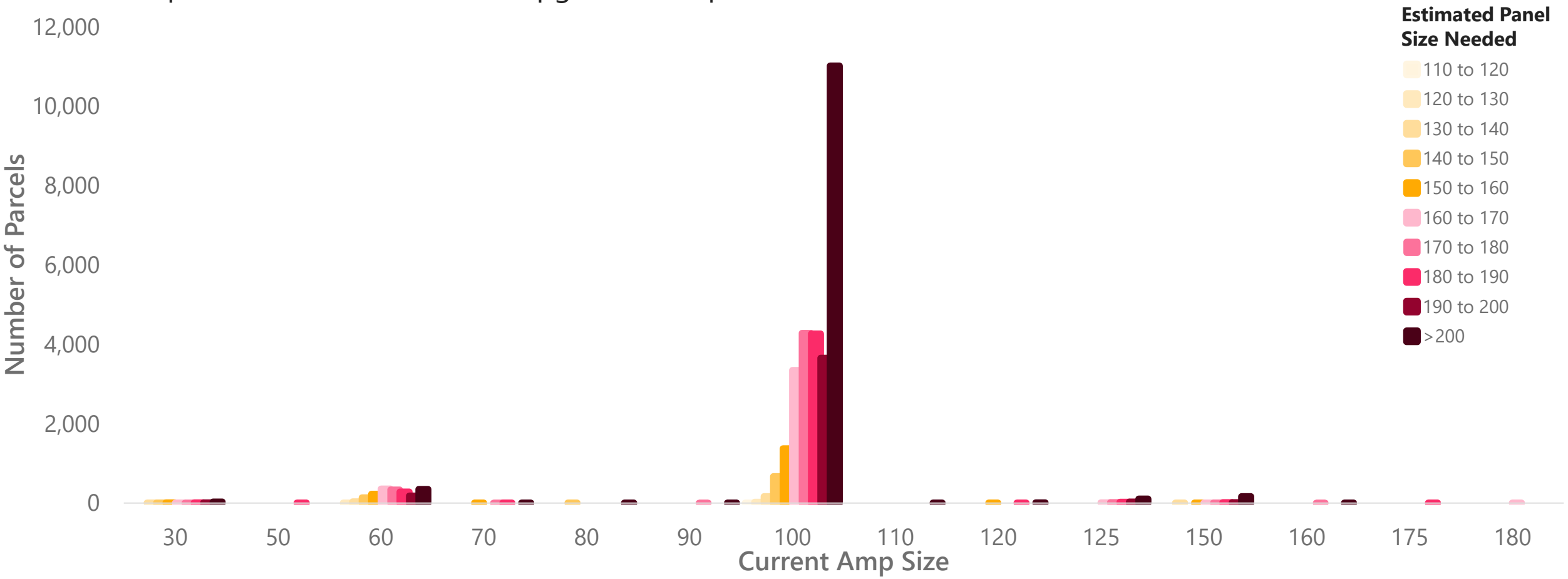
ASSUMPTIONS

Based on a buildings size and age we can further assess electrification readiness, particularly for single family homes to understand if there are any homes that may be able to electrify on less than 200A.

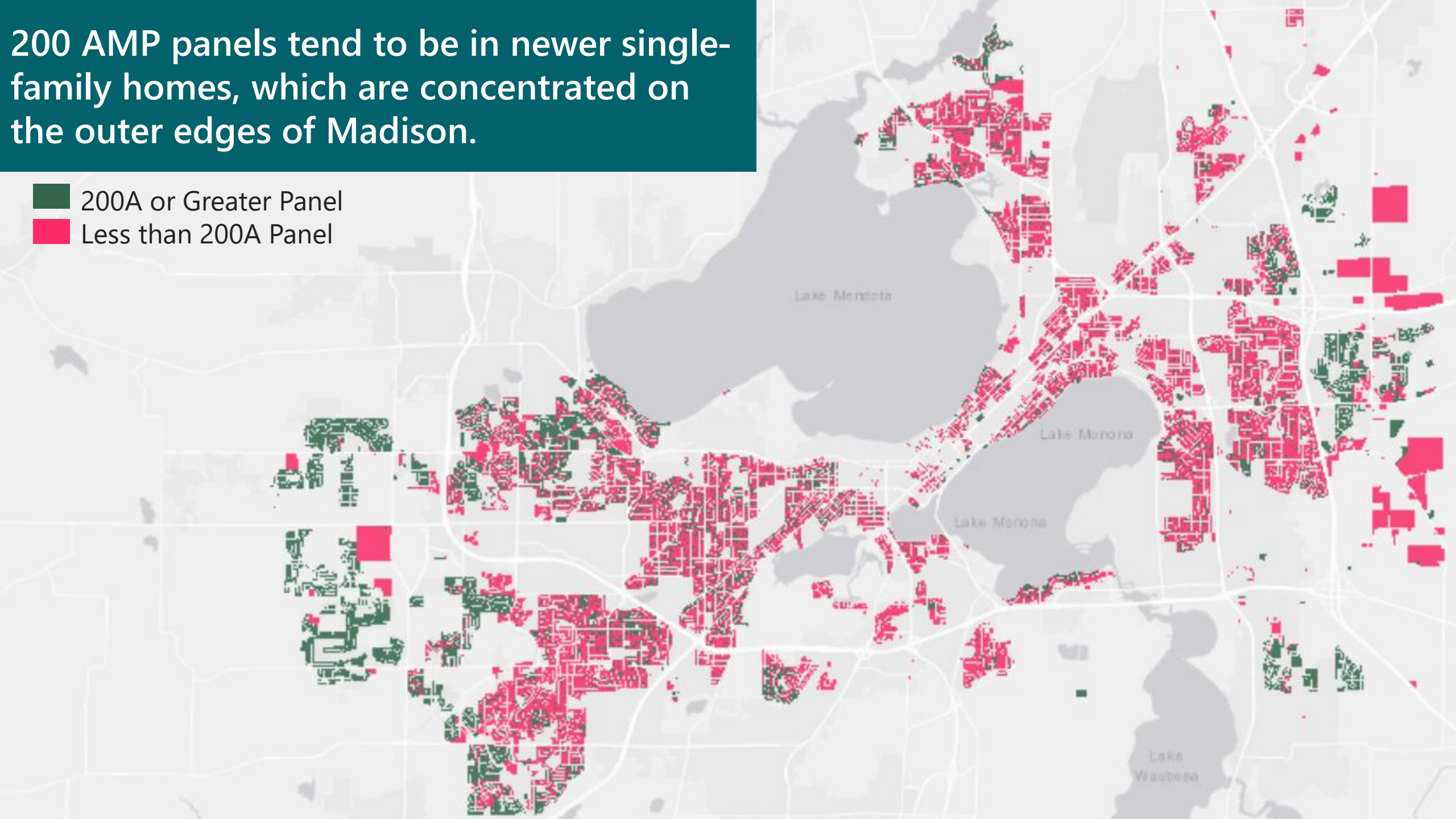
	BELOW 100 AMPS	100 TO 199 AMPS	200 AND ABOVE AMPS
Single-Family Homes	1,994 (4%)	29,230 (59%)	17,992 (36%)
Duplex	417 (10.47%)	2,472 (75.23%)	344 (12.69%)
Condominium	218 (1.21%)	9,750 (54.08%)	1,964 (10.89%)

For buildings with 100 AMP panels, most would require a 200 AMP panel to fully electrify.

With very strategic electrification and increased energy efficiency measures, some single-family homes may be able to electrify without a panel upgrade. The below visuals shows the current panel size for single family homes compared to the assumed size needed. Most parcels have an 100A panel and would need a 200A panel to electrify, only an estimated 2 parcels would not need to upgrade their panel.



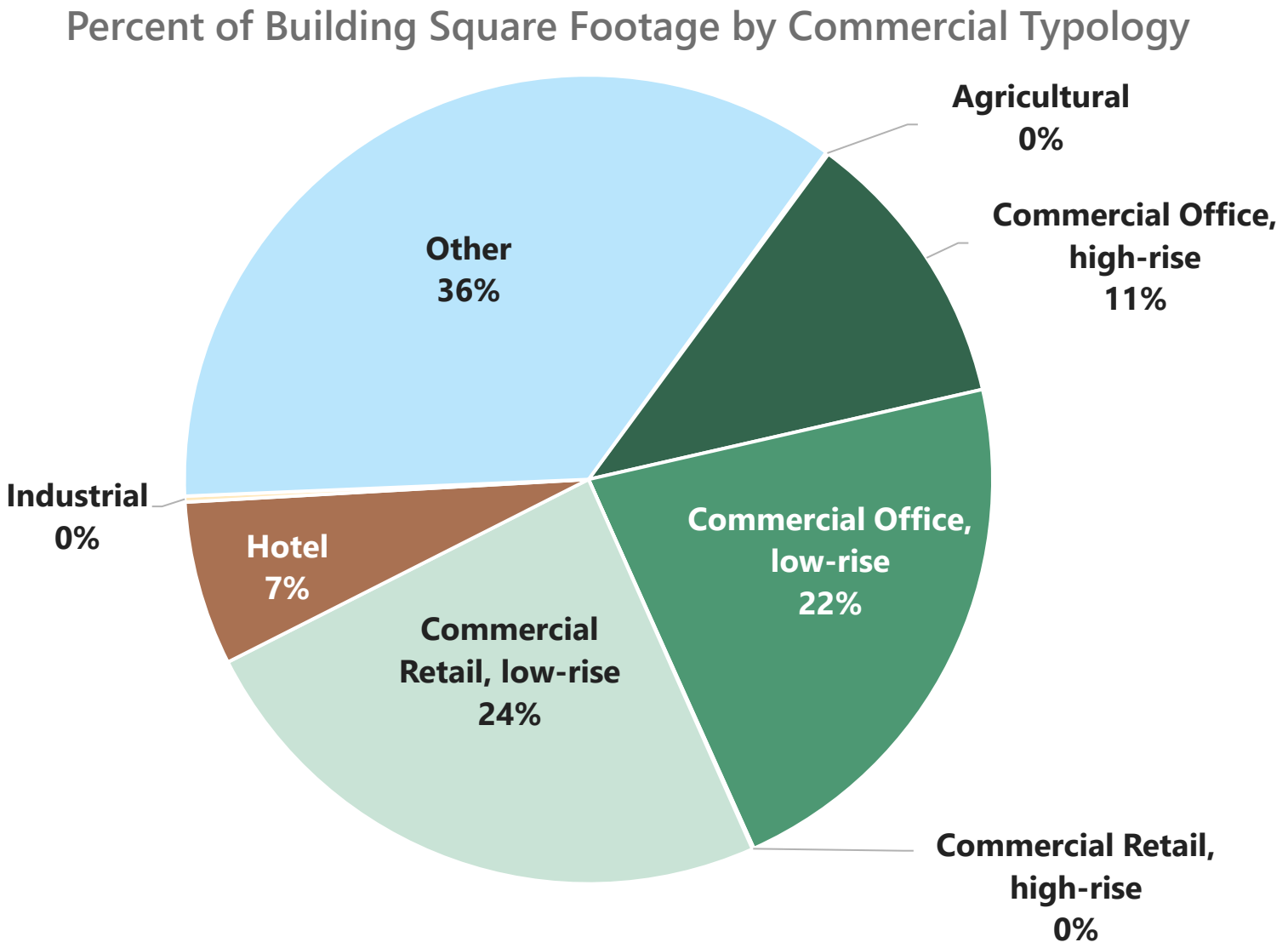
200 AMP panels tend to be in newer single-family homes, which are concentrated on the outer edges of Madison.



SECTION 2. THE COMMERCIAL SECTOR: A CONCENTRATED TARGET

FINDING 4. Office and retail buildings drive commercial energy use and should drive decarbonization strategy.

Office and retail buildings account for just over 57% of Madison's commercial square footage. Both property types must comply with BESP.



Modeled office and mercantile commercial buildings consume the most electricity and natural gas across all commercial building types in Madison.

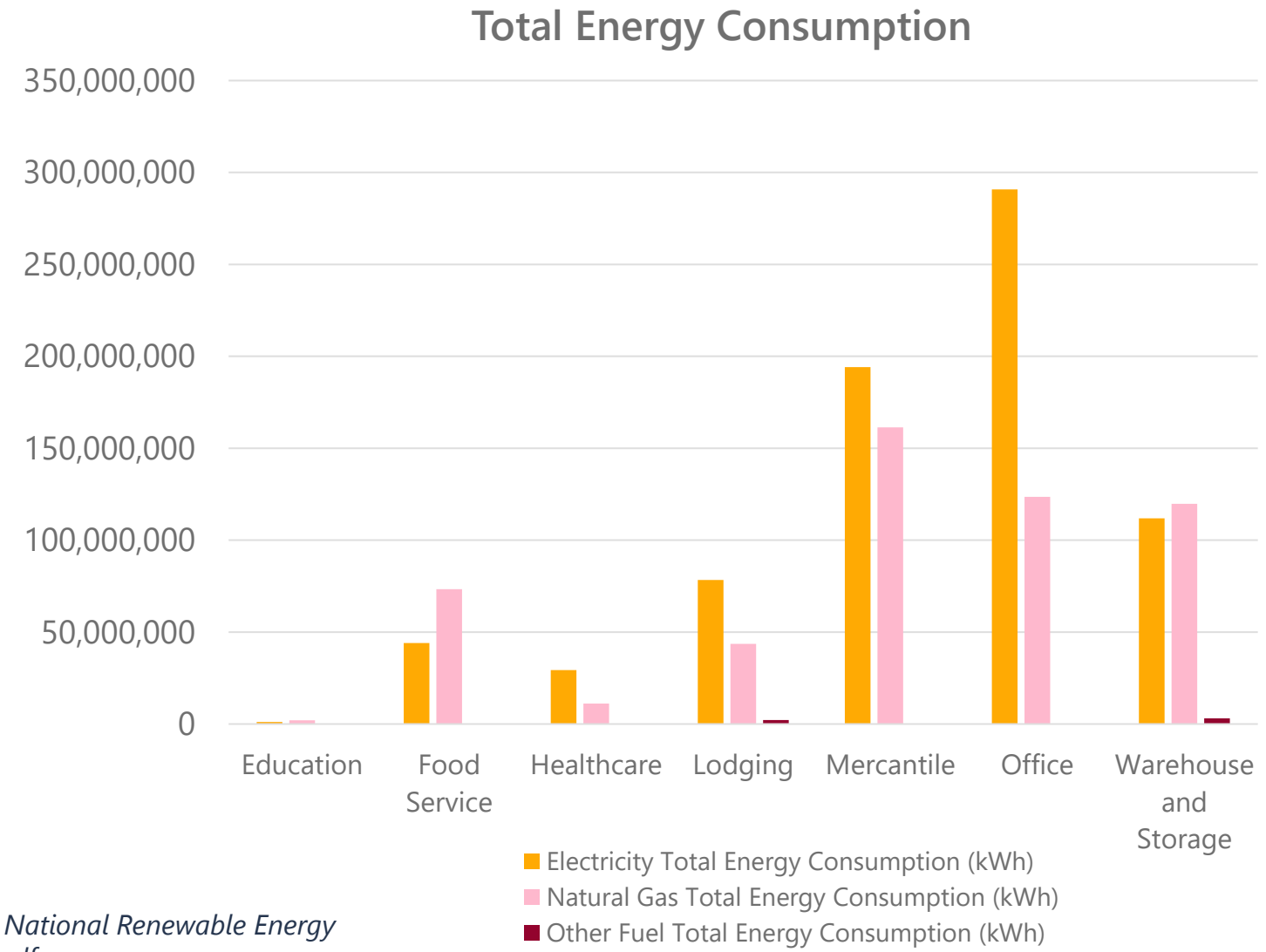
Modeled using ComStock, NREL's physics-based computer modeling for segment of commercial building types. Covers only 38% of distinct commercial parcels and 42% of commercial square footage based on above definitions of commercials. ComStock includes 700 building prototypes used to model energy usage in Madison. Weighted with Assessor's square footage, not with assumed square footage.

There are 7 categories of buildings modeled:

- Education
- Food Service
- Healthcare
- Lodging
- Mercantile
- Office
- Warehouse and Storage

And four building size buckets:

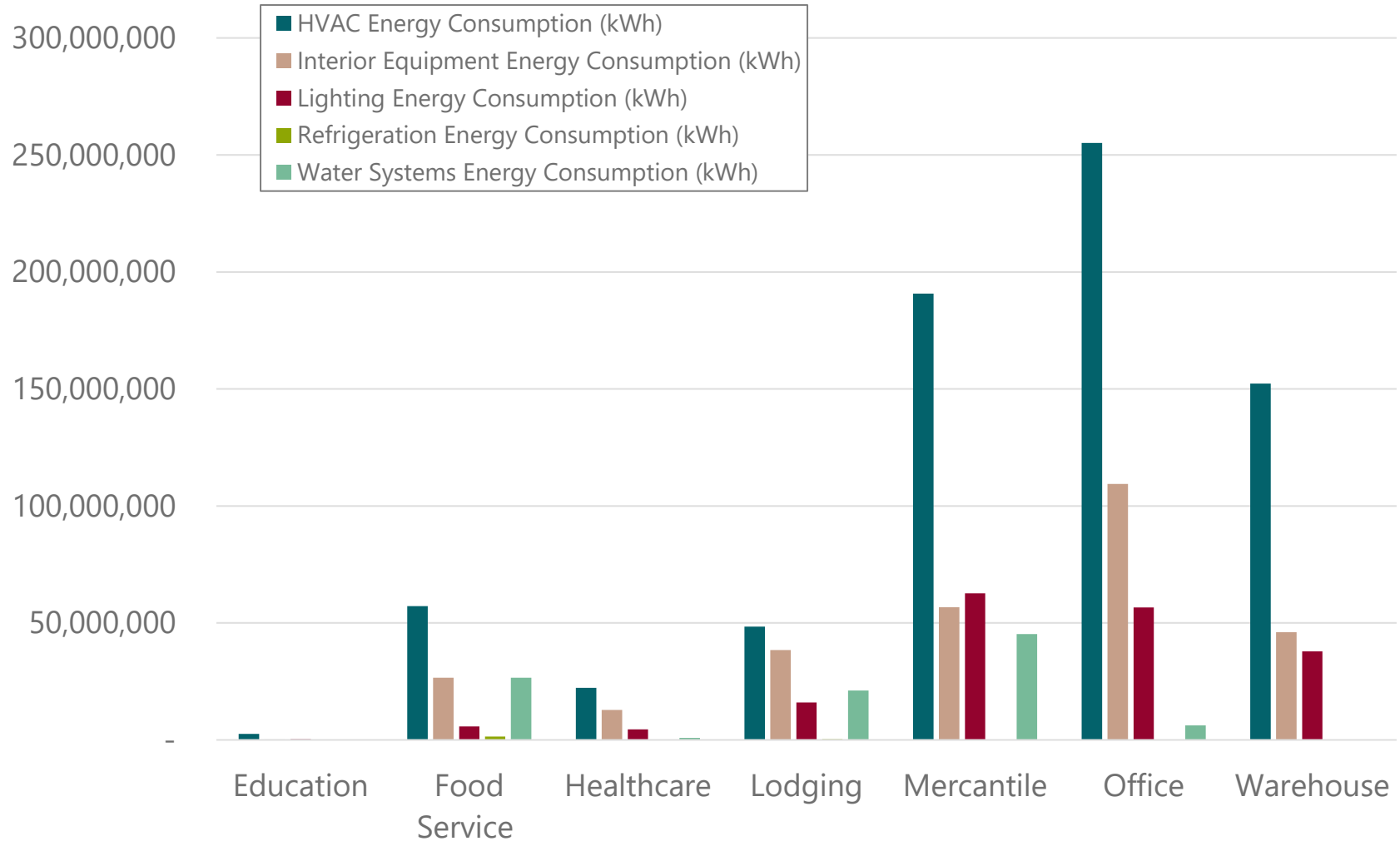
- <25k
- 25k to 50k
- 50k to 200k
- >200k



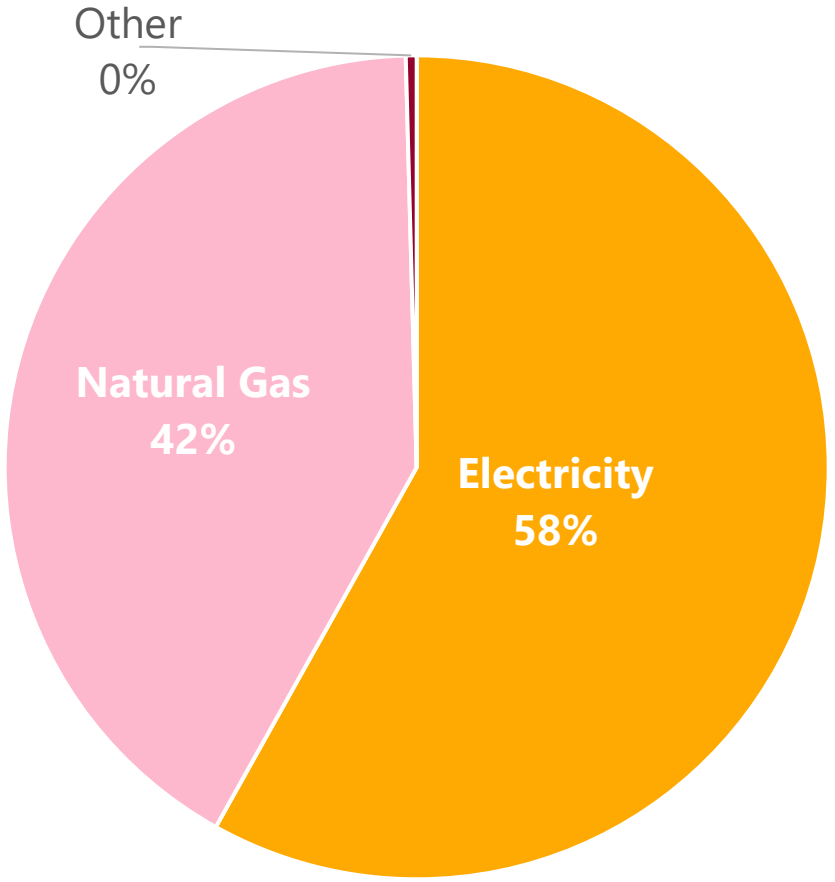
Parker, Andrew, et al. 2023. ComStock Reference Documentation. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-83819. https://www.nrel.gov/docs/fy23osti/83819.pdf

Modeled HVAC Energy consumption is consistently the highest energy consumption per commercial building class.

Total Energy Use by Building Type and System



Total Energy Use by Energy Type



SECTION 3. WHAT MADISON CAN AND CANNOT DO: THE POLICY LANDSCAPE

FINDING 6. Time of construction, sale, and equipment replacement provide potential levers for Madison to interact with building owners.

Key points of "natural" intervention with the built environment identified through policy review.

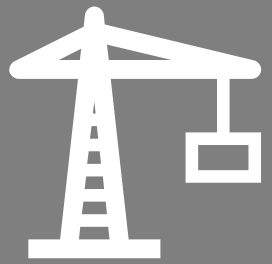
**Note: this does not include Date Certain policies.*

Permitting

Zoning

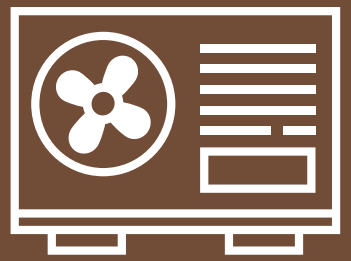
Time of Rent

Time of Sale



New Construction

Renovation



New Equipment

Created by Martin Whitaker from the Noun Project

Energy Use/Emissions

Examples of programs and policies across the U.S.

ZONING

Example Policies:

- Density bonuses tied to meeting LEED standards (Acton, MA)

Current Madison Programs: None.

PERMITTING

Example Policies:

- Streamlined permit for heat pumps (In process: San Francisco and Berkeley, CA)
- Increased permit fee for installation of gas equipment
- Electric retrofit bid required for application of permit to replace gas furnace/AC (Minturn, CO)
- Setback exemptions for heat pump condensing units (Berkeley, CA)

Current Madison Programs: Setback exemptions for heat pump condensing units.

NEW CONSTRUCTION

Example Policies:

- Electrification ready requirements/bonuses (Midwest Building Decarbonization Coalition)
- Permitting assistance for Net Zero construction (Washington DC)
- Fossil Fuel mitigation fee for new construction that is not all electric (In process: Chicago, IL)
- "No reconnection to gas" policy to remove obligation for natural gas hookups (In process: Berkeley, CA)

Current Madison Programs: None.

Examples of programs and policies across the U.S.

RENOVATION

Example Policies:

- Performance standard at time of renovation (Boston, MA)
- Minimum home energy score/or choose from suite of measures for renovations over certain size (Encinitas, CA and in process: Berkeley)
- Requirements for electrification for renovation over certain budget amount (Piedmont, CA)
- Require heat pumps in large commercial/multifamily if cost is on par with gas appliances (Denver, CO)

Current Madison Programs: None.

TIME OF REPLACEMENT

Example Policies:

- Electric retrofit bids with application for gas furnace/boiler replacement permits (Denver, CO)
- Phased in requirements for all newly installed equipment to be efficient and all electric (In process: San Francisco, CA)

Current Madison Programs: None.

ENERGY USE/EMISSIONS

Example Policies:

- Building Emissions Standards (Boston, MA, Seattle, WA and New York, NY)
- Buildings of certain size required to participate in clean energy program (San Francisco, CA)

Current Madison Programs: None.

Examples of programs and policies across the U.S.

TIME OF RENT

Example Policies:

- Energy audit required for buildings older than 10 years at time of rent (Austin, TX)
- Energy performance certificate needed before rent (UK)
- Rental efficiency standards (In process: Ann Arbor, MI)
- Weatherization requirements (phased in by EUI) for residential rental properties (Burlington, VT)

Current Madison Programs: None.

TIME OF SALE

Example Policies:

- Energy audit required for sale of property (San Francisco, CA and Austin, TX)
- Energy assessment presented to city and buyer (Berkeley, CA)
- DOE Home Energy Score Disclosure for Single-family and Townhomes (Ann Arbor, MI and Portland, OR)

Current Madison Programs: None.

Time of construction, sale, and equipment replacement provide potential levers for Madison to interact with owners and policy.

1. **Owner-occupied buildings present the greatest opportunity at time of sale, time of renovation and new equipment** because the owner has high control of decision-making and will be directly impacted by any changes. Buildings typologies with the highest owner-occupied rates include single-family homes, condominiums, duplexes and agricultural properties.

2. **Time of sale presents the highest opportunity for single-family homes and condominiums** which saw 32% and 39% parcel turnover between 2020 through the end of 2024.

3. **Time of rent and new construction present the highest opportunity for multifamily buildings, both low- and high-rise.** Over 90% of new parcel units were multifamily in 2024 and these properties have high renter-occupied rates.

4. **Time of renovation also presents a high opportunity for commercial offices,** which see the highest percentage of parcels pulling both HVAC and construction permits every year.

FINDING 7. Wisconsin's pre-emption laws significantly constrain Madison's ability to require decarbonization.

Madison is inherently constrained in its ability to set policy to require building decarbonization.

Madison is inherently constrained in its ability to set policy to require building decarbonization because of:

- **State preemption on building codes** (Sec. 101.02(7r)(a) and 320.06(1)(a)) which restricts Madison's ability to:
  - Have stretch codes
  - Require solar/electrification readiness
  - Impose a natural gas ban
  - Implement energy performance standards
- **Prohibition of rental licensing** as defined in Sec. 66.0104(2)(e)(4) which restricts Madison's ability to:
  - Have green rental licensing
- General **prohibition on requirements of landlords** as outlined in Sec. 66.0104 which restricts Madison's ability to:
  - Require landlords provide tenants information about energy use in properties
  - Require energy audits or energy performance certificates at time of rent
  - Set rental efficiency standards

Madison is inherently constrained in its ability to set policy to require building decarbonization.

- General **prohibition on time-of-sale, purchase or occupancy requirements** as outlined in Sec. 706.22 which restricts Madison's ability to:
  - Require energy audits or assessments at time of sale
  - Require certain upgrades at time of sale
  - Require energy use disclosure at time of sale
- Municipalities **can only impose taxes that are expressly authorized** by statute such as "wheel" taxes, and "room" taxes, and property taxes. Wisconsin municipalities are heavily reliant on property taxes which are strictly limited by the state in Sec. 66.0602 which restricts Madison's ability to:
  - Generate additional funds for sustainability work through dedicated taxes
- Only utilities are allowed to provide energy within their territory, **which limits the ability of 3rd party solar leasing, community solar** (unless owned and operated by the utility). Sec. 196.01(5)(a).

Further, Madison's local utility (MGE), which serves a vast majority of the properties in Madison, is investor-owned and not municipally controlled.