Chill out, Denver! How Efficient Building Electrification Cools the (Winter) Peak

Modeling 100% Building Electrification Scenarios in Denver

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Analysis Highlights

- We modeled **two pathways** for Denver to reach **100% building electrification,** using:
  - Colorado-specific load shapes by energy end use
  - Building-level data
- A fully electrified Denver could reach **peak winter loads** between **4.7 – 6.2 GW***
- Ground source heat pumps, a downtown geothermal network loop, and more efficient building envelopes **may reduce the future winter peak load by >1 GW**
- Energy efficiency plays a major role in **avoiding new substation investments**

Downtown Denver, as seen at night in the winter.

Image source: Tomasz Sajda/Eyeem. *Guide to Christmas in Denver*. Available at https://www.tripsavvy.com/christmas-events-in-denver-1061654

**not including other types of electrification, such as electric vehicles*

Synapse Energy Economics

- Founded in 1996 by Bruce Biewald and Jean Ann Ramey
- Leader for public interest and government clients in providing rigorous analysis of the electric power and natural gas sectors
- Staff of 40+ includes experts in energy, economic, and environmental topics
- Synapse has completed dozens of analyses for dozens of state, municipal, city, and not-for-profit clients focusing on impacts of building decarbonization and transportation electrification.

Background

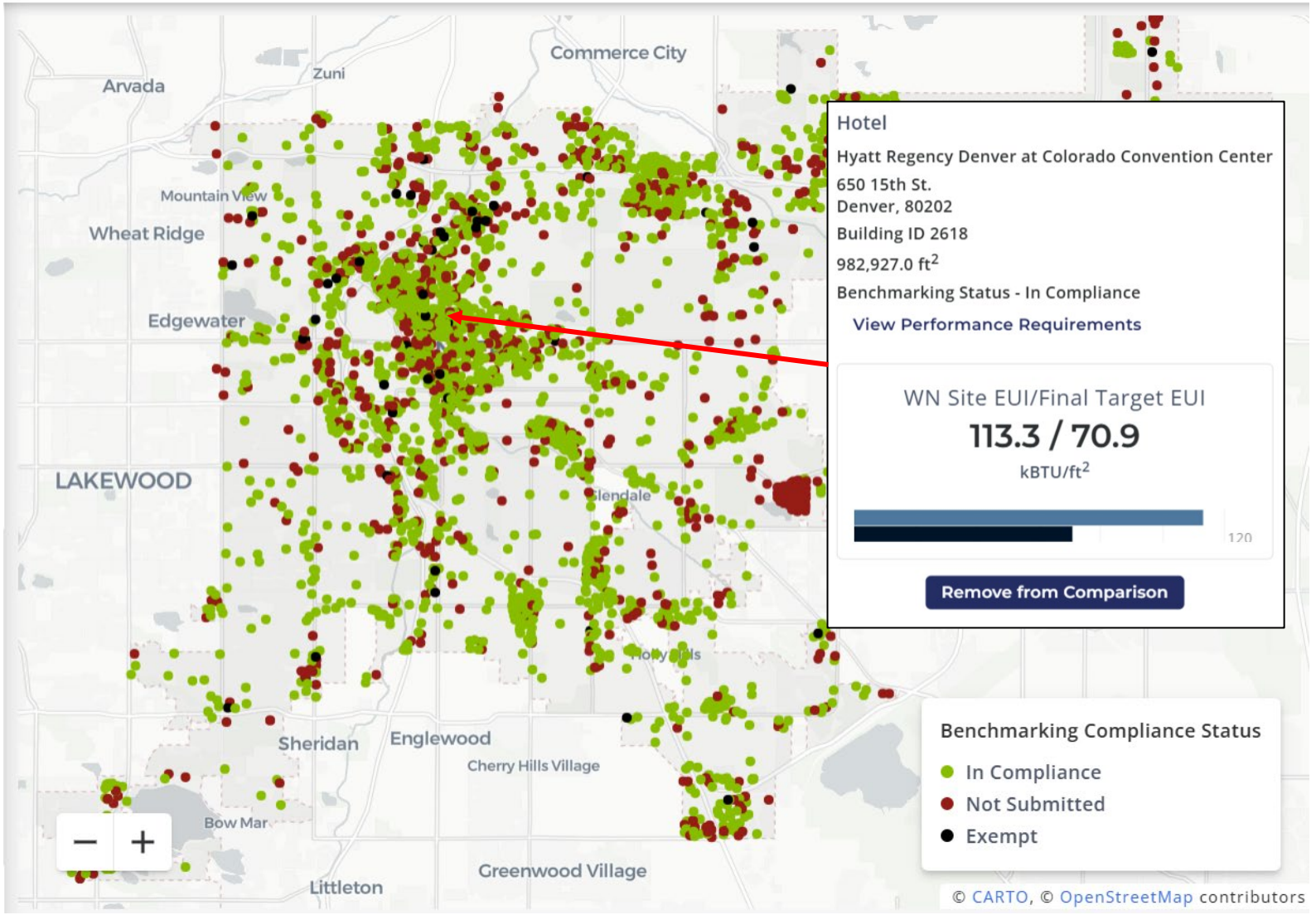
Denver has set a goal to reach zero greenhouse gas emissions by 2040.(1)

Building decarbonization:

- **Existing commercial & multi-family buildings** - Energize Denver (1)
- **New buildings** - 2023 updates to Energy Code(2)

Synapse was hired by the City and County of Denver's Climate Action, Sustainability, and Resiliency Office (CASR) to analyze building electrification pathways.

Status of buildings in compliance with Energize Denver



(1) Denver Climate Action Task Force. 2020. Denver Climate Action 2020 Recommendations Report
(2) Denver. 2024. Revised Municipal Code of the City and County of Denver, Colorado

Analysis Details

Key question:

If Denver fully electrifies buildings, what will be the range of peak winter impacts and how can added efficiencies reduce the peak?

Purpose: Estimate future peak demand impacts from building electrification (summer & winter)

Time horizon: 2040 (roughly)

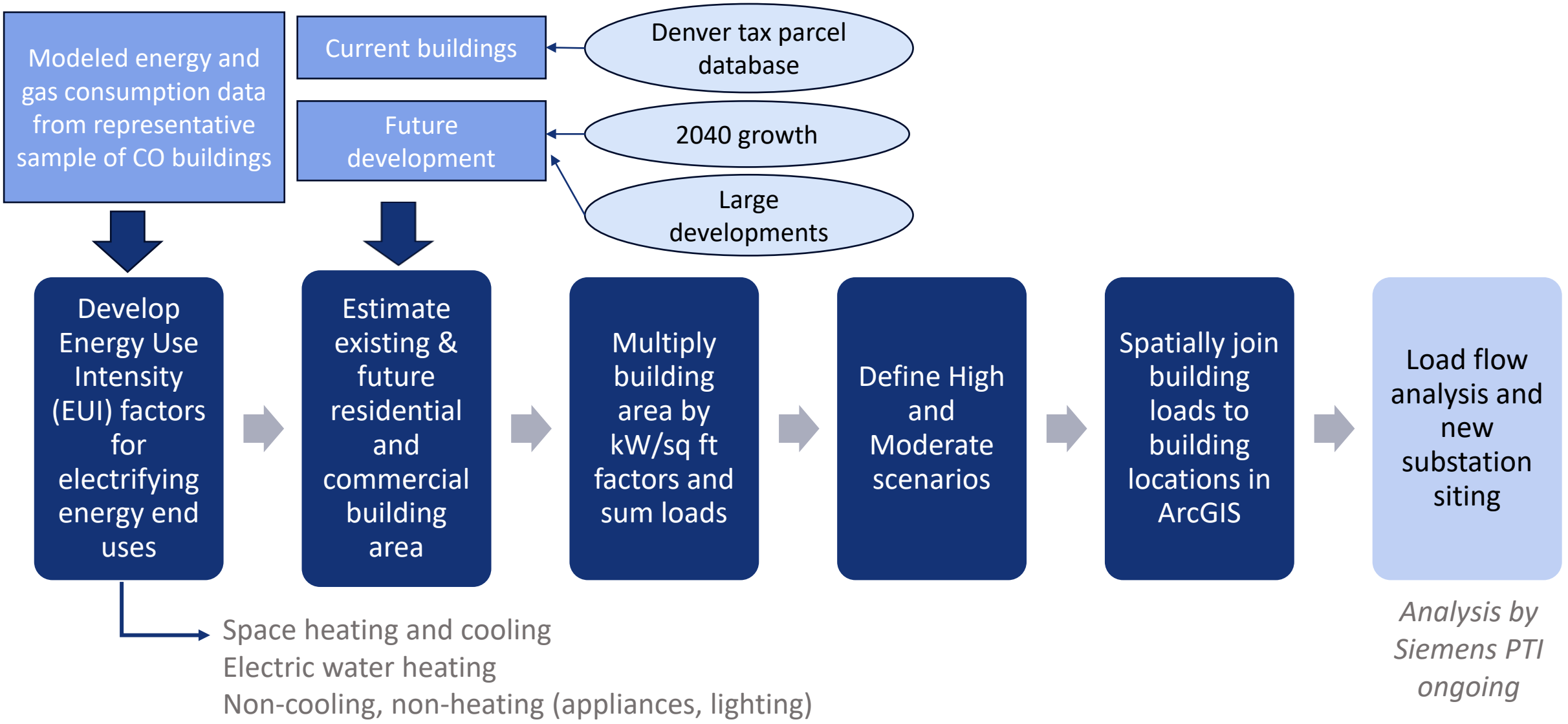
Building types: Existing and future commercial and residential buildings

End uses electrified: space heating and cooling, water heating, other loads (appliances, lighting, etc)

Scenarios: High case – air source heat pumps (ASHPs); Moderate case – higher envelope efficiencies & more ground source heat pumps (GSHPs)

Geographic resolution: City of Denver at the building-level, excluding Denver Intl. Airport

Analysis Process



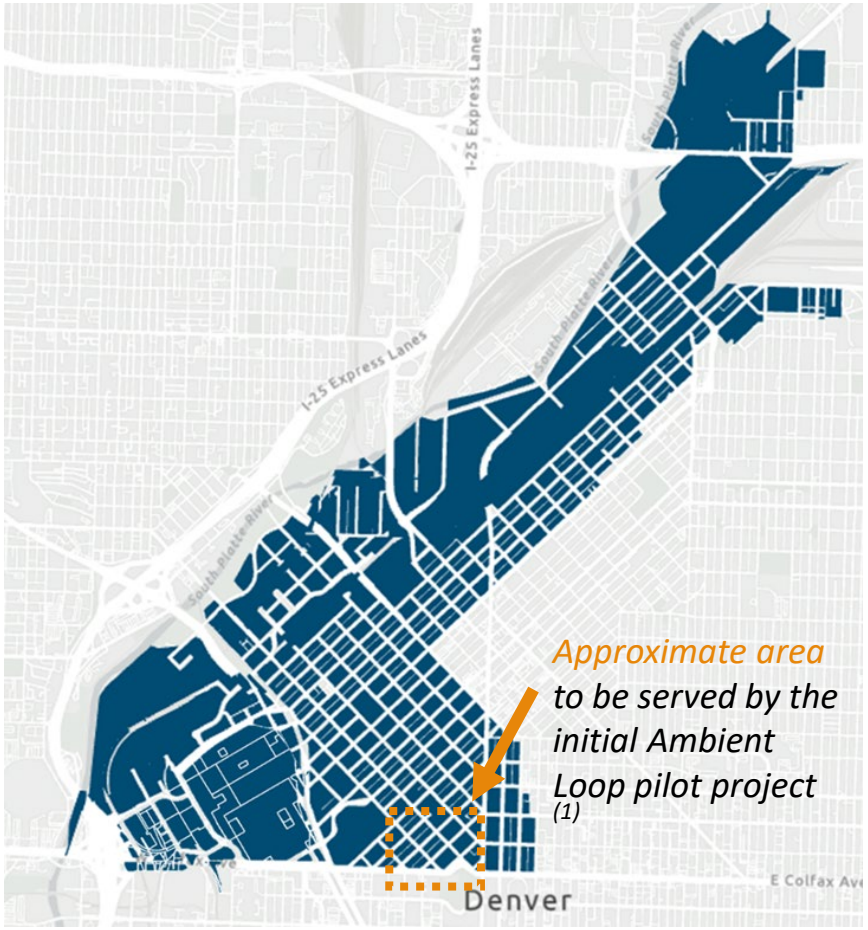
Analysis by Siemens PTI ongoing

Model Scenarios

	High Load scenario	Moderate Load scenario
Heating & cooling – **Downtown Denver**	ASHP only	Network geothermal loop
Heating & cooling – **All other areas**	ASHP only	10% GSHP, 90% ASHP
Other building efficiency measures	None	*Yes. See next slide*
Combustion backup	None	None
Electric resistance backup for ASHPs	Yes	Yes

EE Improvements in Moderate Load scenario

EE Improvement	Impact	Applicable buildings or area	Basis
General improvements (building envelope, lighting)	**Commercial**: 15-20% reduction in energy use **Residential**: 5-20% reduction in energy use	**Commercial**: pre-1970s buildings and buildings >5 ksf **Residential**: All buildings	Energize Denver & achievable efficiencies for residential buildings
GSHPs	1/3 of the energy used by ASHPs *(GSHP & network geothermal loop assumed to have a COP of 3)*	10% of all buildings outside Downtown Denver	COPs from literature & observed in recent projects
Network geothermal loop		Downtown Denver	Network pilot in progress



Downtown Denver (in blue) heats with a network geothermal loop in Moderate scenario (Synapse, 2025).

(1) Metro Water Recovery (April 2025). The Connector – Quarterly Updates. Available at https://www.metrowaterrecovery.com/wp-content/uploads/2025/06/Connector_Newsletter_April_-1_Issue-19_Remediated.pdf

Methods – Develop Energy Use Intensity Factors

Goal: produce **kW/sq ft energy factors** for summer and winter peak for different types of residential and commercial buildings using NREL's End-Use Load Profiles.(1)

Space heating (and cooling)

- Convert gas consumption to **heating service demand**
- Fit linear regression for service demand as a **function of temperature** or heating degree days (design temp -25 °F) and convert to electricity consumption

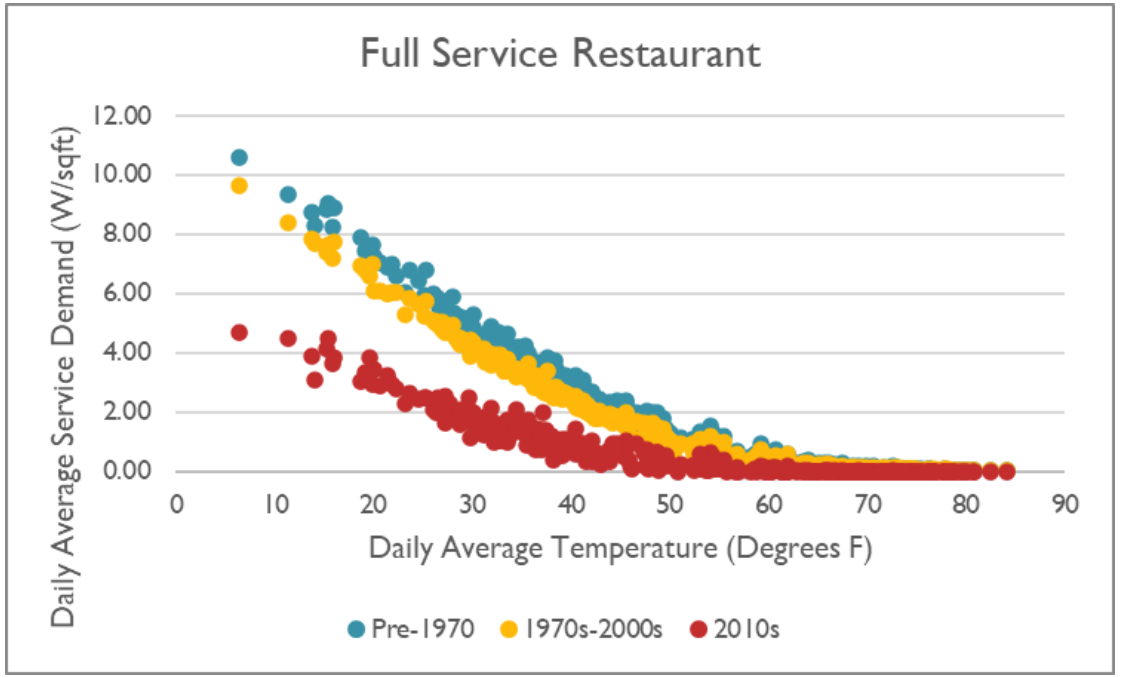
Electric water heating

- Convert gas consumption to electricity consumption using the efficiencies of the current water heating stock & heat pump water heater

Other loads - lighting/appliances

- Use energy data in NREL datasets, assume that future energy use remains at similar levels as today

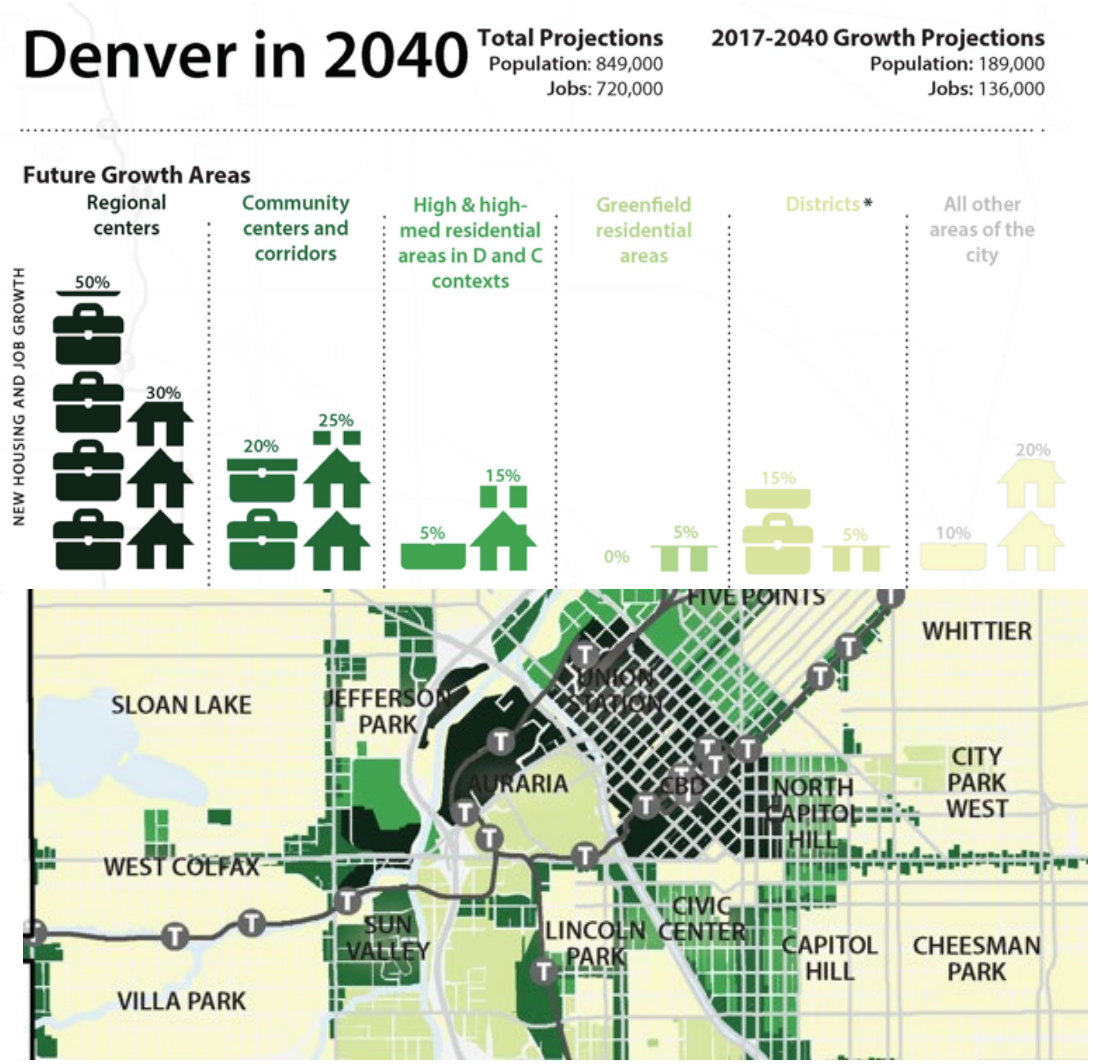
Space Heating Service Demand (W/sq ft) vs. Temperature (°F)



(1) National Renewable Energy Laboratory, 2025. *End-Use Load Profiles for the U.S. Building Stock.* Available at https://www.nrel.gov/buildings/end-use-load-profiles

Methods – Build a database of Denver current and future buildings

- Existing buildings (783 M ft^2):
  - 239,000 residential properties
  - 16,270 commercial properties
- Specific developments (14 M ft^2)
  - River Mile, Ball Arena, Fox Park
- Future buildings (170 M ft^2)
  - Allocate growth based on *Denver in 2040 Growth Strategy* map



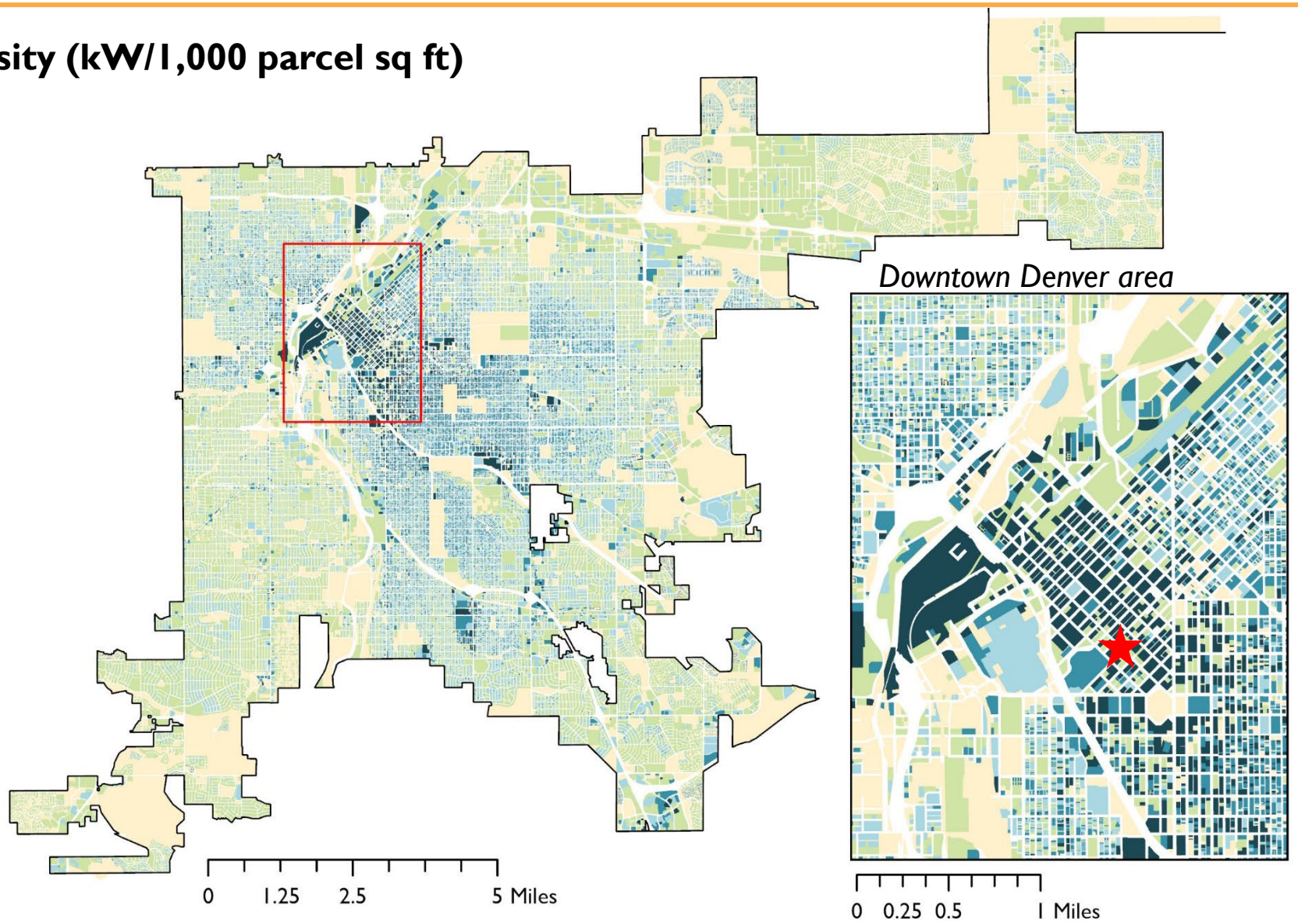
City of Denver Community Planning and Development. Blueprint Denver. 2019. Available at https://denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directory/Community-Planning-and-Development/Planning/Blueprint-Denver.

High Load (winter peak)

Winter peak energy intensity (kW/1,000 parcel sq ft)

- 0 – 1
- 2 – 3
- 4 – 5
- 6 – 10
- >10

Area	High Load (MW)
Downtown	640
Other areas	5,600
Total	6,240

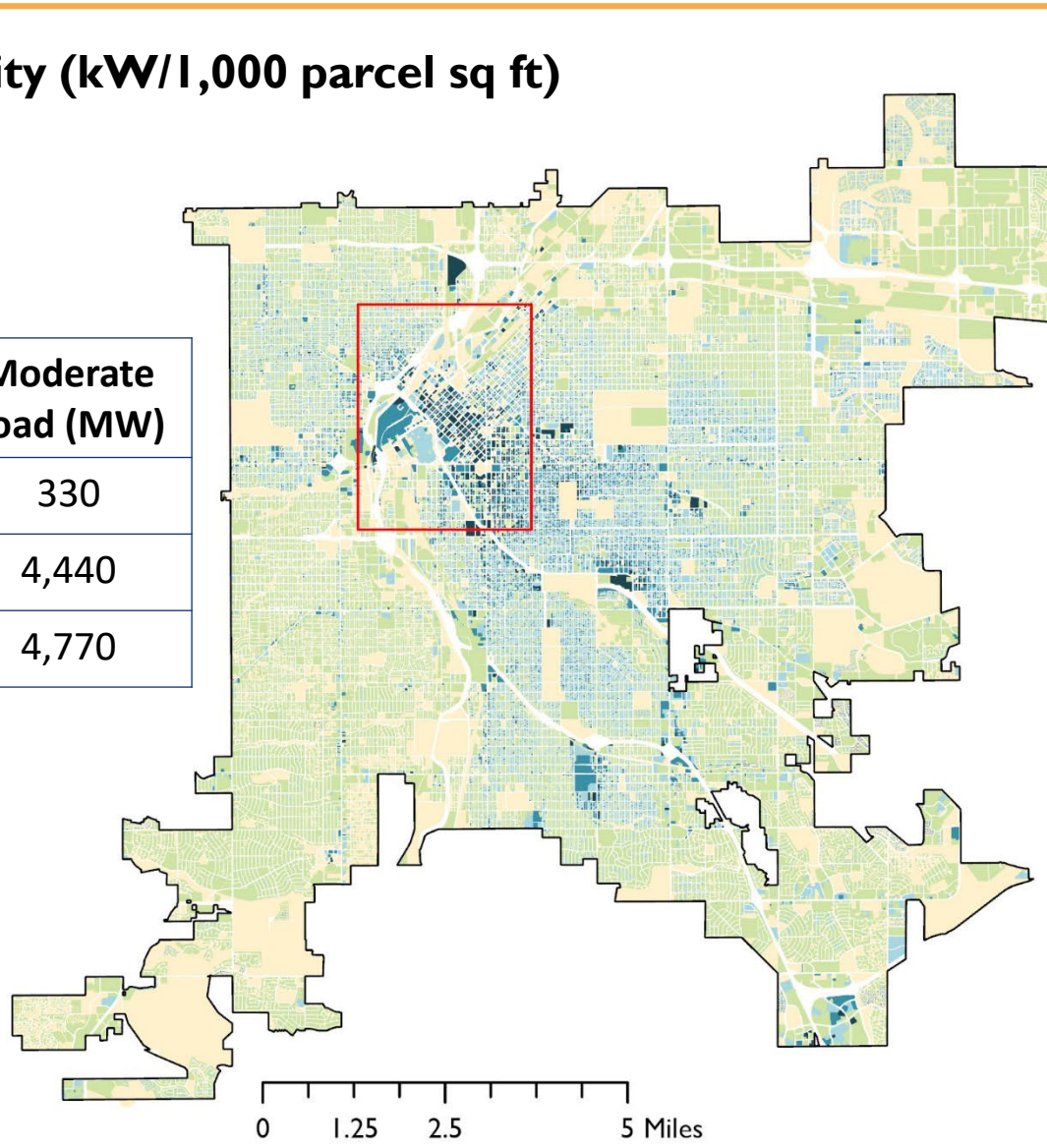


Moderate Load (winter peak)

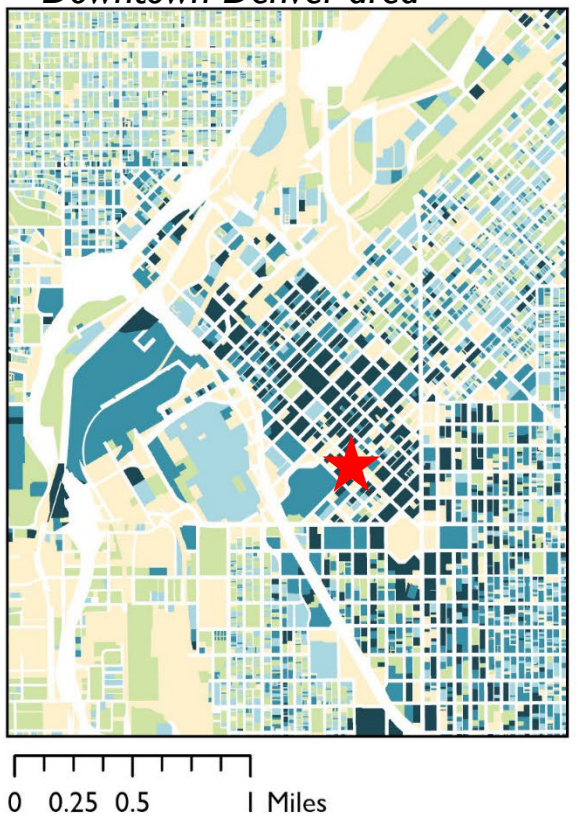
Winter peak energy intensity (kW/1,000 parcel sq ft)

- 0 – 1
- 2 – 3
- 4 – 5
- 6 – 10
- >10

Area	High Load (MW)	Moderate Load (MW)
Downtown	640	330
Non-downtown	5,600	4,440
Total	6,240	4,770

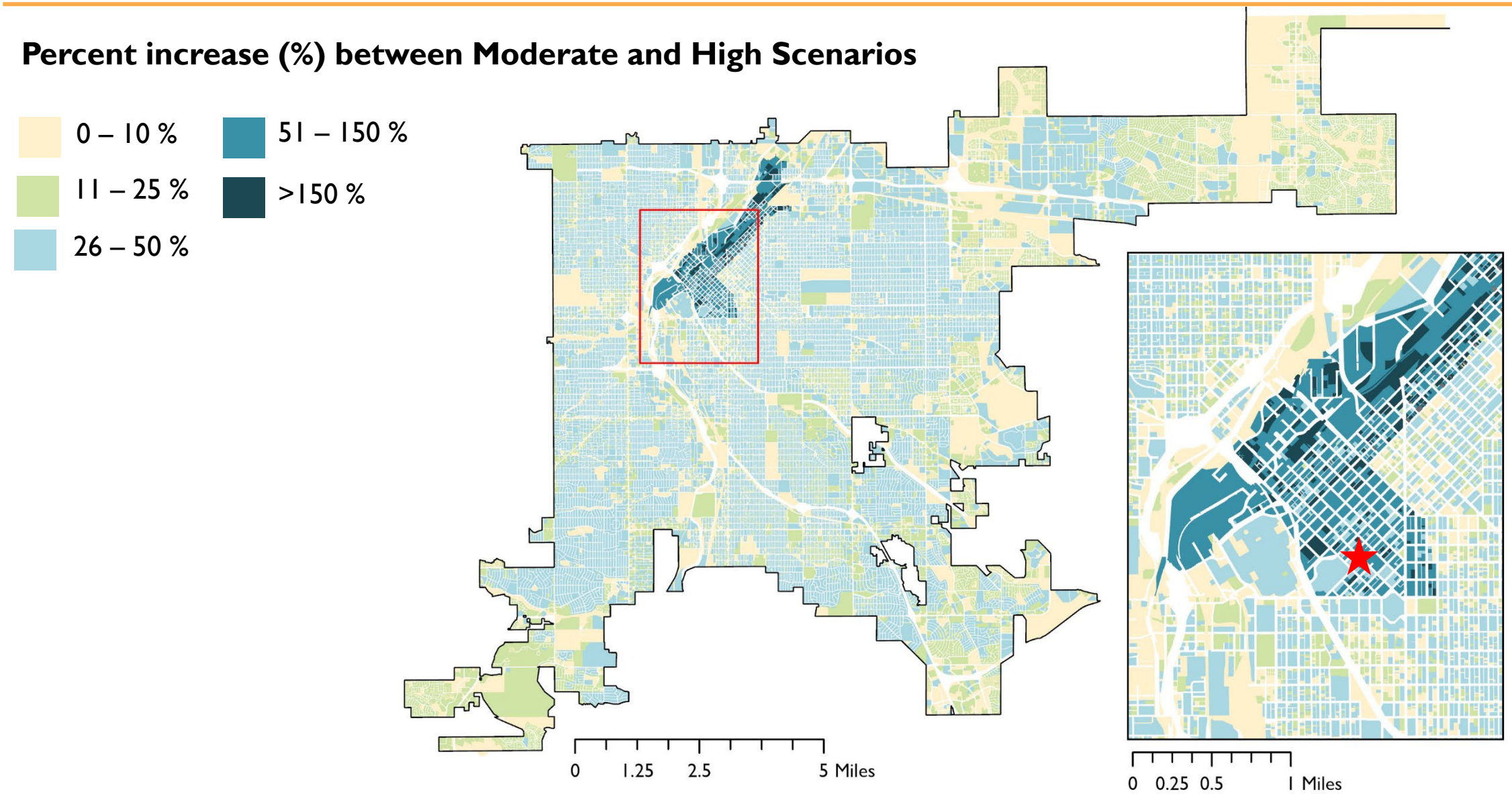


Downtown Denver area



Scenario Comparison

Percent increase (%) between Moderate and High Scenarios



Conclusions & Takeaways

Analysis conclusions

- Future Denver winter peak load: **4.7 - 6.2 GW**
- A mix of GSHPs + added building envelope efficiencies could reduce the peak by **>1 GW,** mitigating the need to build new substations.

Process takeaways

- Accurate building-level data is crucial (particularly building area).
- Data gaps exist in NREL's ComStock buildings (<2/3 commercial building types covered).
- Knowledge about the existing state of the grid is key for accurate modeling.
- Sources of uncertainty include electrification timeline, appliance/heat pump efficiencies, and expansion of the pilot geothermal loop to other parts of the Downtown.

Thank you!

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