ENERGY FINDINGS

The State of Electric Vehicle Adoption in Colorado for Multifamily versus Single-Family Dwellings: A Methodology for Quantifying Deviation from Parity

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Findings

Given that electric vehicle adoption is well underway, the spatial distribution of electric vehicle owners by housing type—single-family or multifamily— shows whether parity (equal adoption rates) is being achieved or to what extent adoption by housing type is over or undersaturated (i.e., over- or under-adoption). We use a proprietary dataset of vehicle registrations with modeled housing type to analyze saturation ratios in Colorado in 2022. We found significant single-family oversaturation and multifamily undersaturation in 14% and 23% of ZIP codes, respectively, suggesting Colorado can still mitigate disparities in electric vehicle adoption by housing type through accessible vehicles and charging.

1. Questions

Are residents of multifamily housing (MFH) as likely to own an electric vehicle (EV) as residents of single-family housing (SFH)? Surveys and data show that multifamily dwellers have significantly less access to EV charging infrastructure than those in single-family homes (Ge et al. 2021; Min and Lee 2020). This analysis examines adoption of battery-electric and plug-in hybrid electric vehicles (hereafter referred to as EVs) by multifamily residents using an underutilized proprietary dataset of vehicle owners' demographic characteristics, provided by Experian Information Solutions Inc. Using this dataset, we test our hypothesis that multifamily dwellers are less likely to own EVs compared to single-family residents.

2. Methods

Unlike studies that compare vehicle registration data with separate demographic sources, such as department of motor vehicles data and American Community Survey data (Liu, Roberts, and Sioshansi 2017; Araújo, Boucher, and Aphale 2019; Chen, Wang, and Kockelman 2015; Morton et al. 2018), we use derived counts from Experian's proprietary "vehicles in operation" registration demographic dataset (Experian Information Solutions Inc. 2022), available for purchase. Experian's model combines multiple sources, including transactional purchase and US Postal
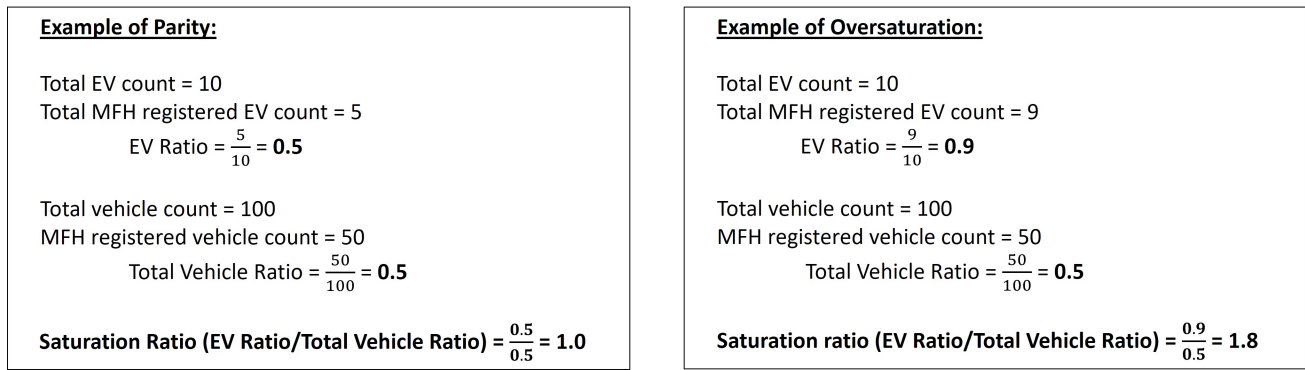
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Example of Parity:

Total EV count = 10
Total MFH registered EV count = 5
    EV Ratio = $\frac{5}{10}$ = **0.5**

Total vehicle count = 100
MFH registered vehicle count = 50
    Total Vehicle Ratio = $\frac{50}{100}$ = **0.5**

Saturation Ratio (EV Ratio/Total Vehicle Ratio) = $\frac{0.5}{0.5}$ = 1.0

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Example of Oversaturation:

Total EV count = 10
Total MFH registered EV count = 9
    EV Ratio = $\frac{9}{10}$ = **0.9**

Total vehicle count = 100
MFH registered vehicle count = 50
    Total Vehicle Ratio = $\frac{50}{100}$ = **0.5**

Saturation ratio (EV Ratio/Total Vehicle Ratio) = $\frac{0.9}{0.5}$ = 1.8

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Figure 1. Example use of the saturation ratio to determine parity (left) and oversaturation (right). (EV=Electric Vehicles; MFH=Multifamily Housing)

Service address data, to predict dwelling type for each vehicle registrant (cars and light trucks). In this study, we use 2022 ZIP code data from 620 residential ZIP codes in Colorado, aggregated by Experian.

The dataset includes three dwelling types: multifamily/condo, single-family, and other. In Colorado, multifamily residents accounted for 11.9% of vehicle registrations, and single-family residents 59.5%. The 'other' category (28.6%) includes marginal multifamily, PO box, and unknown. Since Experian considers this category questionable, we excluded it and used only multifamily and single-family.

Our analysis calculates saturation ratios that compare total vehicle registration with EV registration by housing type. It does not take into consideration the total mix of housing in each ZIP code, only the housing units associated with individual vehicle registrations. For each ZIP code, we calculated the fraction of all EVs that are registered to MFHs, and the fraction of all vehicles of any type that are registered to MFHs. We refer to the ratio of the former to the latter as the MFH EV saturation ratio, and it can be understood as measuring whether MFH residents are as likely as SFH residents to own EVs. We repeat these calculations for SFHs to calculate the SFH EV saturation ratio for each ZIP code. (see [Figure 1](#)). Therefore, each ZIP code is represented by two saturation ratios, one each for single-family and multifamily. A saturation ratio of 1 indicates parity (i.e., EV registrations within the dwelling type are proportional to the overall EV adoption rate and the vehicle registration rate among that dwelling type). Less than 1 means EVs are undersaturated and greater than 1 means EVs are oversaturated within the dwelling-type.

To determine statistical significance of these relationships, we used the hypergeometric distribution model of the SciPy–Stats package in Python. Using vehicle counts as an example, it uses total count of all vehicles and total EV count. Then when choosing randomly from a subgroup such as multifamily vehicles, the model calculates the probability of finding a given number of EVs within the multifamily subgroup if choosing randomly from the finite number of total vehicles. We used the cumulative distribution

Table 1. Count of Colorado ZIP codes by housing type (SF = single family; MFC = multifamily/condo) and count of electric vehicles registered in 2022, for 620 residential ZIP codes in the state. Numbers in parentheses are the percentage of all ZIP codes. *Counts for oversaturation and undersaturation are only those that are statistically significant (p-value < 0.05).

ZIP Count:	MFC ZIP codes	SF ZIP codes	Over saturated MFC* ZIP codes	Under saturated MFC* ZIP codes	Over saturated SF* ZIP codes	Under saturated SF * ZIP codes
No EVs registered	418 (67.4%)	255 (41.1%)	n/a	n/a	n/a	n/a
Between 1 and 5 EVs registered	65 (10.5%)	103 (16.6%)	2 (0.3%)	28 (4.5%)	0 (0.0%)	8 (1.3%)
Greater than 5 EVs registered	137 (22.1%)	262 (42.3%)	0 (0.0%)	114 (18.4%)	87 (14.0%)	26 (4.2%)

function to generate p-values for significance of undersaturation by dwelling type in each ZIP code because it measures probability of observing lower counts than expected; we used the survival function generated p-values for significance of oversaturation because it measure probability of observing higher counts than expected.

3. Findings

In 2022, EV adoption by multifamily residents was limited. Out of 620 ZIP codes, 418 had no EVs registered at multifamily residences (67.4% of ZIP codes), and another 65 had fewer than five EVs registered (10.5%) (Table 1). Small sample sizes meant that there was not much evidence of significant oversaturation of EVs in multifamily. The two ZIP codes that had p-values of less than 0.05 for oversaturation (ratio > 1.0) both had less than five EVs. Multifamily residences were more likely to be undersaturated, with 142 ZIP codes (22.9%) being statistically significant.

For single-family residences, 103 ZIP codes had fewer than five EVs registered (16.5%), and 255 ZIP codes had no EVs registered (41.1%). While there were only 34 ZIP codes where single-family EV adoption was significantly undersaturated (5.5%), 87 ZIP codes were significantly oversaturated (14%).

For multifamily, undersaturation ratios ranged from 0.09 to 0.92, with a median of 0.44 and for single-family, undersaturation ratios ranged from 0.22 to 0.95 with a median of 0.76 (Figure 2). Almost all locations with undersaturation of single-family had high EV counts in the "other" category that was not included here. Single-family oversaturation ratios ranged from 1.05 to 2.84 with a median of 1.20 and multifamily oversaturation ratios are influenced by small sample sizes (Figure 3).

The spatial distribution of both oversaturated single family and undersaturated multifamily follow a similar pattern, concentrated in Colorado's Front Range population centers (Denver, Boulder, Fort Collins,
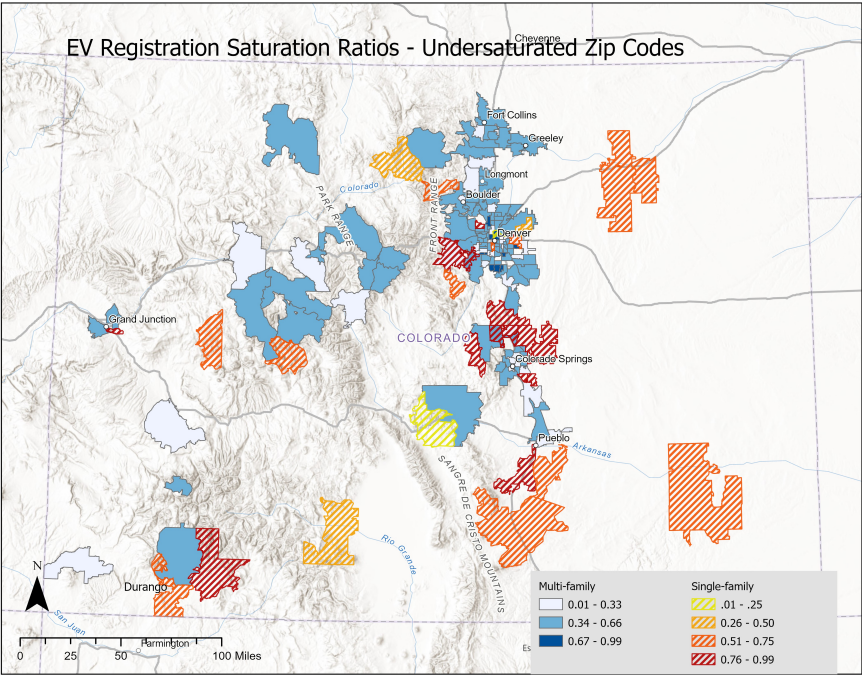
Figure 2. Colorado EV registration undersaturation ratios by ZIP code for both single-family housing (yellow to red spectrum) and multifamily housing (blue colors). Only ZIP codes with statistically significant undersaturation ratios are shown.
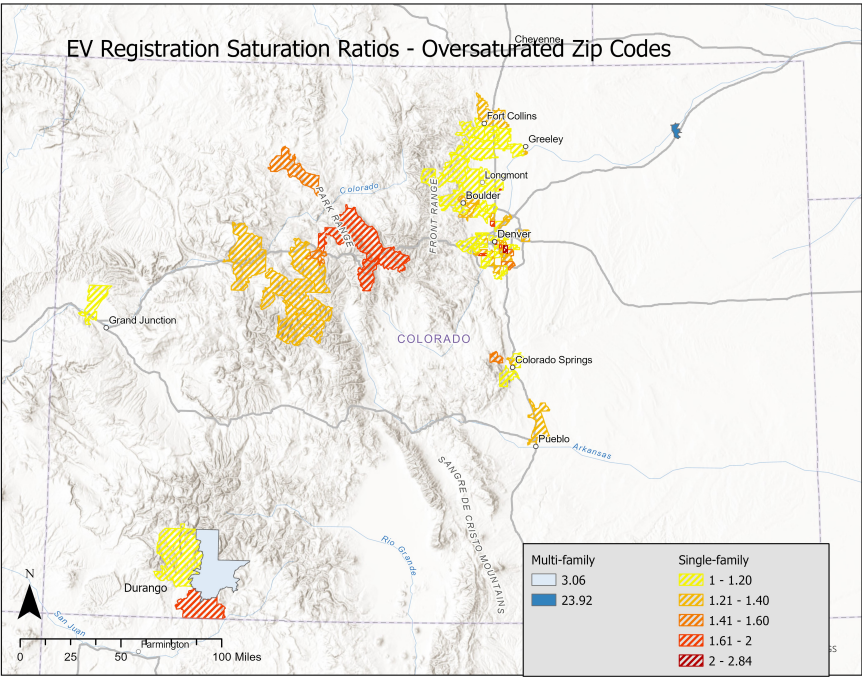

Figure 3. Colorado EV registration oversaturation ratios by ZIP code for both single-family housing (yellow to red spectrum) and multifamily housing (blue colors). Only ZIP codes with statistically significant oversaturation ratios are shown.

Colorado Springs, and Pueblo) where EV counts are highest. In addition, communities along I-70 from Denver to Grand Junction, and the Durango area are also hot spots for EV adoption by single-family residences.

Note that each ZIP code has four saturation ratios shown on the two maps: undersaturation for both MFH and single family, and oversaturation for both MFH and single family. Data inputs for this analysis and all generated saturation ratios are all provided as Supplemental Information.

As communities and states continue to invest in electric transportation infrastructure, the fate of vehicle owners in multifamily residences looms large. This analysis of vehicle registration data by housing type can inform strategically planned investments, including electric vehicle access and associated charging infrastructure, so that multifamily residents do not become undersaturated as EV owners. Future analysis will explore the potential causes of the areas of statistically significant over and undersaturation found in this study.

REFERENCES

Araújo, K., J. L. Boucher, and O. Aphale. 2019. "A Clean Energy Assessment of Early Adopters in Electric Vehicle and Solar Photovoltaic Technology: Geospatial, Political and Socio-Demographic Trends in New York." *Journal of Cleaner Production* 216:99–116. https://doi.org/10.1016/j.jclepro.2018.12.208.

Chen, T. D., Y. Wang, and K. M. Kockelman. 2015. "Where Are the Electric Vehicles? A Spatial Model for Vehicle-Choice Count Data." *Journal of Transport Geography* 43:181–88. https://doi.org/10.1016/j.jtrangeo.2015.02.005.

Experian Information Solutions Inc. 2022. "Vehicles in Operation – Demographics." Derived registration counts by the National Renewable Energy Laboratory. https://www.experian.com/automotive/vehicles-in-operation-vio-data.

Ge, Y., C. Simeone, A. Duvall, and E. Wood. 2021. "There's No Place like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure." NREL/TP-5400-81065. National Renewable Energy Laboratory. https://doi.org/10.2172/1825510.

Liu, X., M. C. Roberts, and R. Sioshansi. 2017. "Spatial Effects on Hybrid Electric Vehicle Adoption." *Transportation Research Part D: Transport and Environment* 52:85–97. https://doi.org/10.1016/j.trd.2017.02.014.

Min, Y., and H. W. Lee. 2020. "Social Equity of Clean Energy Policies in Electric-Vehicle Charging Infrastructure Systems." In *Construction Research Congress 2020*, 221–29. Reston, VA: American Society of Civil Engineers. https://doi.org/10.1061/9780784482858.025.

Morton, C., J. Anable, G. Yeboah, and C. Cottrill. 2018. "The Spatial Pattern of Demand in the Early Market for Electric Vehicles: Evidence from the United Kingdom." *Journal of Transport Geography* 72:119–30. https://doi.org/10.1016/j.jtrangeo.2018.08.020.

SUPPLEMENTARY MATERIALS

Supplemental Info, as a CSV

Download: https://findingspress.org/article/126421-the-state-of-electric-vehicle-adoption-in-colorado-for-multifamily-versus-single-family-dwellings-a-methodology-for-quantifying-deviation-from-parity/attachment/255332.csv