

Sustainable Transportation in
Charlottesville, Virginia

EV Charging Stations



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Business Problem

- Transportation emissions account for 29% of the greenhouse gas (GHG) emissions in the U.S.
- In Virginia, nearly half of all GHGs come from the transportation sector
- Switching from a gasoline powered vehicle to an electric vehicle could reduce GHG emissions by 73%
- Incentives for people to choose sustainable transportation methods are needed to help decrease fossil fuel use in the transportation sector

Stakeholders and Project Overview

- EV owners shop, dine, and visit areas that make it easy for them to charge their vehicle
- Explore the various EV charging stations in Charlottesville, Virginia to determine the top 10 venues that are within a radius of 400 meters (.25 miles) of each EV charging station
- Determine the ten most common venue categories near each station
- Group the EV charging stations into clusters using k-means clustering and visualizes EV charging station locations in Charlottesville and their clusters



Data Analysis Questions

- Which EV charging station should I use if I want to get pizza while my car charges?
- Which EV charging station should I use if I want to do some shopping while my car charges?

Data

- Charlottesville Open Data - Green Infrastructure (Transportation) dataset
 - Locations of EV charging stations in Charlottesville, VA expressed in latitude and longitude
- Foursquare API dataset
 - Types of venues near each charging stations.

Methodology

- **1. Import and prepare the data:** The Charlottesville Green Infrastructure dataset contains sustainable transportation infrastructure including public transit, bike and pedestrian infrastructure, ride sharing and alternate fueling locations. Download and convert the Charlottesville Green Infrastructure CSV file into a Pandas dataframe. Next, slice the data frame to extract EV Charging Station entries.
- **2. Visualize the EV Charging Stations:** To visualize the EV charging stations, create a map of Charlottesville and add markers to display the locations of the EV Charging Stations.
- **3. Display nearby venues:** Create Foursquare credentials and display the top 10 venues that are within a radius of 400 meters (.25 miles) of each EV Charging Station.
- **4. Analyze the venues:** Create a dataframe with each venues name, latitude, longitude, and category. Calculate the number of unique venue categories. Calculate the mean of the frequency of occurrence of each category.
- **5. Display the most common venues:** Display each EV Charging Station along with the 10 most common venues.
- **6. Cluster and visualize EV Charging Station clusters:** Run k-means to cluster the neighborhood into 4 clusters. K-means was chosen to group EV charging station areas with similar characteristics together. K-means minimizes intra-cluster distances and maximizes inter-cluster distances. Visualize the resulting clusters and add markers to the map. Examine each cluster to display the 1st-10th most common venues.

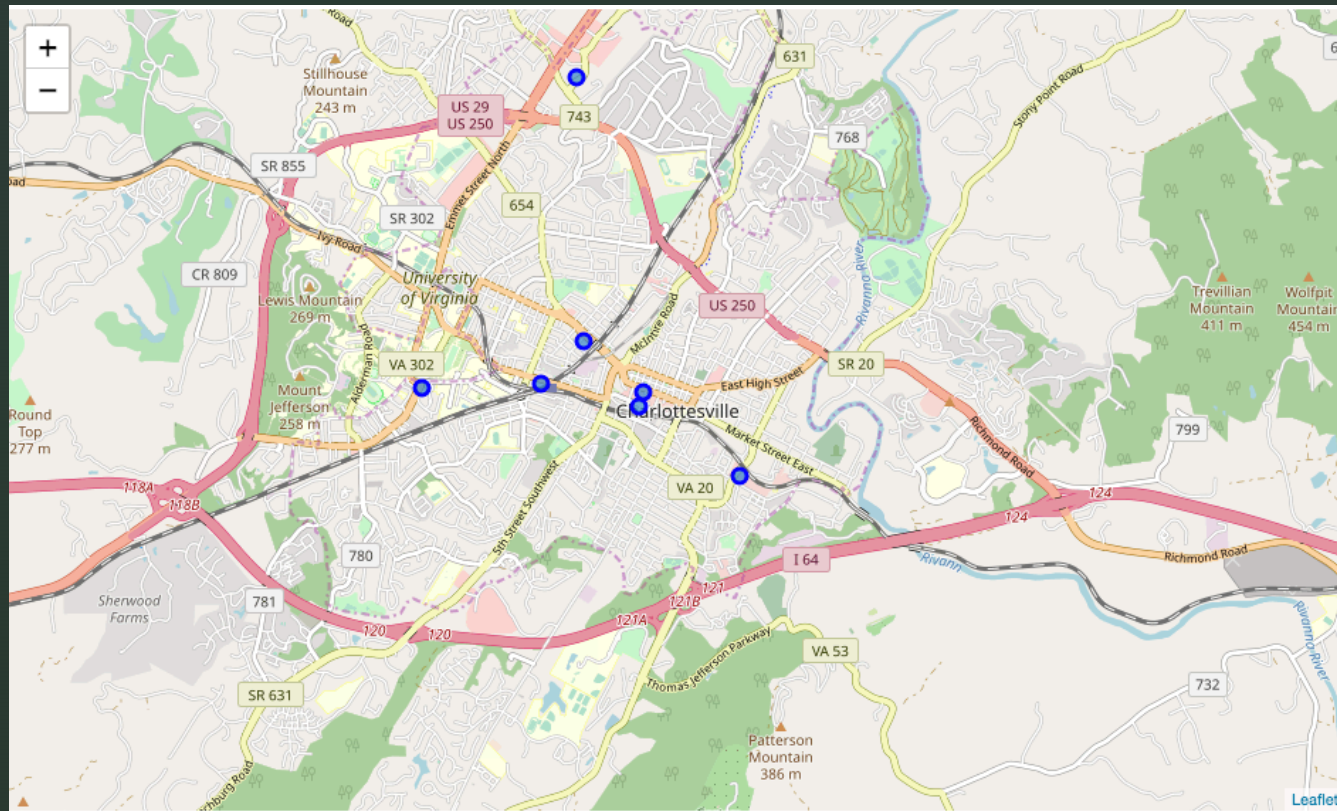
Analysis – Charlottesville Green Infrastructure dataset

	X	Y	OBJECTID	Webmap	Entry	Type_	Description	Address
0	-78.486762	38.032283	1	Bike Support	Carver Recreation Center	Bike Fix-it Station	A fix-it station is a temporary or permanent f...	233 4th St NW
1	-78.477374	38.029038	2	Bike Support	Downtown Transit Center	Bike Fix-it Station	A fix-it station is a temporary or permanent f...	615 Water St E
2	-78.454631	38.024054	3	Bike Support	Riverview Park	Bike Fix-it Station	A fix-it station is a temporary or permanent f...	end of Chesapeake Street
3	-78.493249	38.031931	4	EV Support	The Flats at West Village	EV Charging Station	Tesla Charger	852 W Main St
4	-78.480905	38.031099	5	EV Support	First and Market Parking Garage	EV Charging Station	Level 2, DC Fast	104 1st St N
5	-78.481435	38.029704	6	EV Support	Water Street Parking	EV Charging Station	DC Fast	Water Street
6	-78.507632	38.031464	7	EV Support	Oakhurst Inn	EV Charging Station	Level 2	100 Oakhurst Circle
7	-78.469102	38.023136	8	EV Support	Martin Horn	EV Charging Station	Level 2	210 Carlton Rd
8	-78.488893	38.061129	9	EV Support	Homewood Suites	EV Charging Station	DC Fast	2036 India Rod
9	-78.487974	38.035969	10	EV Support	Timbercreek Market	EV Charging Station	Level 2	722 Preston Ave
10	-78.477308	38.029074	11	Alt Transportation Resources	CAT Bus Transfer Station	Other	NaN	615 East Water Street
11	-78.470931	38.014089	12	Alt Transportation Resources	Jaunt	Other	JAUNT, Inc. is a regional transportation syste...	104 Keystone P
12	-78.491947	38.031397	13	Alt Transportation Resources	Charlottesville Train Station	Other	The Charlottesville AmTrack Station is served ...	810 W Main St
13	-78.485868	38.030134	14	Alt Transportation Resources	Greyhound	Other	NaN	310 West Main St
14	-78.471155	38.028278	15	Alt Transportation Resources	Starlight Express LLC	Other	NaN	1117 E Market St #H

Analysis – EV Charging Station dataset

	X	Y	OBJECTID	Webmap	Entry	Type_	Description	Address
0	-78.493249	38.031931	4	EV Support	The Flats at West Village	EV Charging Station	Tesla Charger	852 W Main St
1	-78.480905	38.031099	5	EV Support	First and Market Parking Garage	EV Charging Station	Level 2, DC Fast	104 1st St N
2	-78.481435	38.029704	6	EV Support	Water Street Parking	EV Charging Station	DC Fast	Water Street
3	-78.507632	38.031464	7	EV Support	Oakhurst Inn	EV Charging Station	Level 2	100 Oakhurst Circle
4	-78.469102	38.023136	8	EV Support	Martin Horn	EV Charging Station	Level 2	210 Carlton Rd
5	-78.488893	38.061129	9	EV Support	Homewood Suites	EV Charging Station	DC Fast	2036 India Rod
6	-78.487974	38.035969	10	EV Support	Timbercreek Market	EV Charging Station	Level 2	722 Preston Ave

Analysis – Visualize the EV Charging Stations



Analysis – Explore nearby venues

	name	categories	lat	lng
0	Continental Divide	Mexican Restaurant	38.031748	-78.491036
1	Sugar Shack Donuts & Coffee	Donut Shop	38.032918	-78.494927
2	Wild Wing Cafe	Wings Joint	38.031532	-78.491995
3	Peloton Station	Sports Bar	38.033243	-78.494078
4	Mel's Cafe	Southern / Soul Food Restaurant	38.031678	-78.490575
5	Hardywood Pilot Brewery & Taproom	Brewery	38.032496	-78.495093
6	Doma Korean Kitchen	Korean Restaurant	38.031693	-78.489938
7	The Draftsman, Autograph Collection	Hotel	38.032613	-78.496445
8	Potbelly's	Sandwich Place	38.032570	-78.494050
9	Snowing In Space Coffee	Coffee Shop	38.031559	-78.489936

Analysis – Combine EV Charging Station data with venue data

	Entry	Entry Latitude	Entry Longitude	Venue	Venue Latitude	Venue Longitude	Venue Category
0	The Flats at West Village	38.031931	-78.493249	Continental Divide	38.031748	-78.491036	Mexican Restaurant
1	The Flats at West Village	38.031931	-78.493249	Sugar Shack Donuts & Coffee	38.032918	-78.494927	Donut Shop
2	The Flats at West Village	38.031931	-78.493249	Wild Wing Cafe	38.031532	-78.491995	Wings Joint
3	The Flats at West Village	38.031931	-78.493249	Peloton Station	38.033243	-78.494078	Sports Bar
4	The Flats at West Village	38.031931	-78.493249	Mel's Cafe	38.031678	-78.490575	Southern / Soul Food Restaurant
...
58	Timbercreek Market	38.035969	-78.487974	Random Row Brewing Co.	38.035058	-78.486472	Brewery
59	Timbercreek Market	38.035969	-78.487974	Ace Biscuit & Barbecue	38.038035	-78.484864	BBQ Joint
60	Timbercreek Market	38.035969	-78.487974	Sticks Kebob Shop	38.038308	-78.489803	Middle Eastern Restaurant
61	Timbercreek Market	38.035969	-78.487974	Integral Yoga Natural Foods	38.038881	-78.489677	Health Food Store
62	Timbercreek Market	38.035969	-78.487974	Cafe 88	38.038918	-78.489844	Chinese Restaurant

Analysis – Calculate unique venue categories

Entry	Entry Latitude	Entry Longitude	Venue	Venue Latitude	Venue Longitude	Venue Category
First and Market Parking Garage	10	10	10	10	10	10
Homewood Suites	10	10	10	10	10	10
Martin Horn	9	9	9	9	9	9
Oakhurst Inn	4	4	4	4	4	4
The Flats at West Village	10	10	10	10	10	10
Timbercreek Market	10	10	10	10	10	10
Water Street Parking	10	10	10	10	10	10

Analysis – Display mean frequency of occurrence of each category

	Entry	American Restaurant	Art Gallery	BBQ Joint	Bagel Shop	Bakery	Bar	Beer Garden	Bookstore	Brewery	...	Pub	Sandwich Place	Shopping Mall	Soup Place	Southern / Soul Food Restaurant	Speakeasy	Sports Bar	Thai Restaurant	Wine Shop	Wings Joint	
0	First and Market Parking Garage	0.0	0.000000	0.0	0.00	0.0	0.000000	0.0	0.0	0.0	...	0.0	0.0	0.1	0.1		0.0	0.1	0.0	0.000000	0.1	0.0
1	Homewood Suites	0.1	0.000000	0.0	0.00	0.0	0.000000	0.0	0.0	0.0	...	0.1	0.0	0.0	0.0		0.0	0.0	0.000000	0.1	0.0	
2	Martin Horn	0.0	0.111111	0.0	0.00	0.0	0.111111	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0		0.0	0.0	0.111111	0.0	0.0	
3	Oakhurst Inn	0.0	0.000000	0.0	0.25	0.0	0.000000	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0		0.0	0.0	0.000000	0.0	0.0	
4	The Flats at West Village	0.0	0.000000	0.0	0.00	0.0	0.000000	0.0	0.0	0.1	...	0.0	0.1	0.0	0.0		0.1	0.0	0.1	0.000000	0.0	0.1
5	Timbercreek Market	0.0	0.000000	0.1	0.10	0.1	0.000000	0.1	0.0	0.1	...	0.0	0.0	0.0	0.0		0.0	0.0	0.000000	0.0	0.0	
6	Water Street Parking	0.0	0.000000	0.0	0.00	0.0	0.000000	0.0	0.1	0.0	...	0.0	0.0	0.1	0.1		0.0	0.1	0.0	0.000000	0.0	0.0

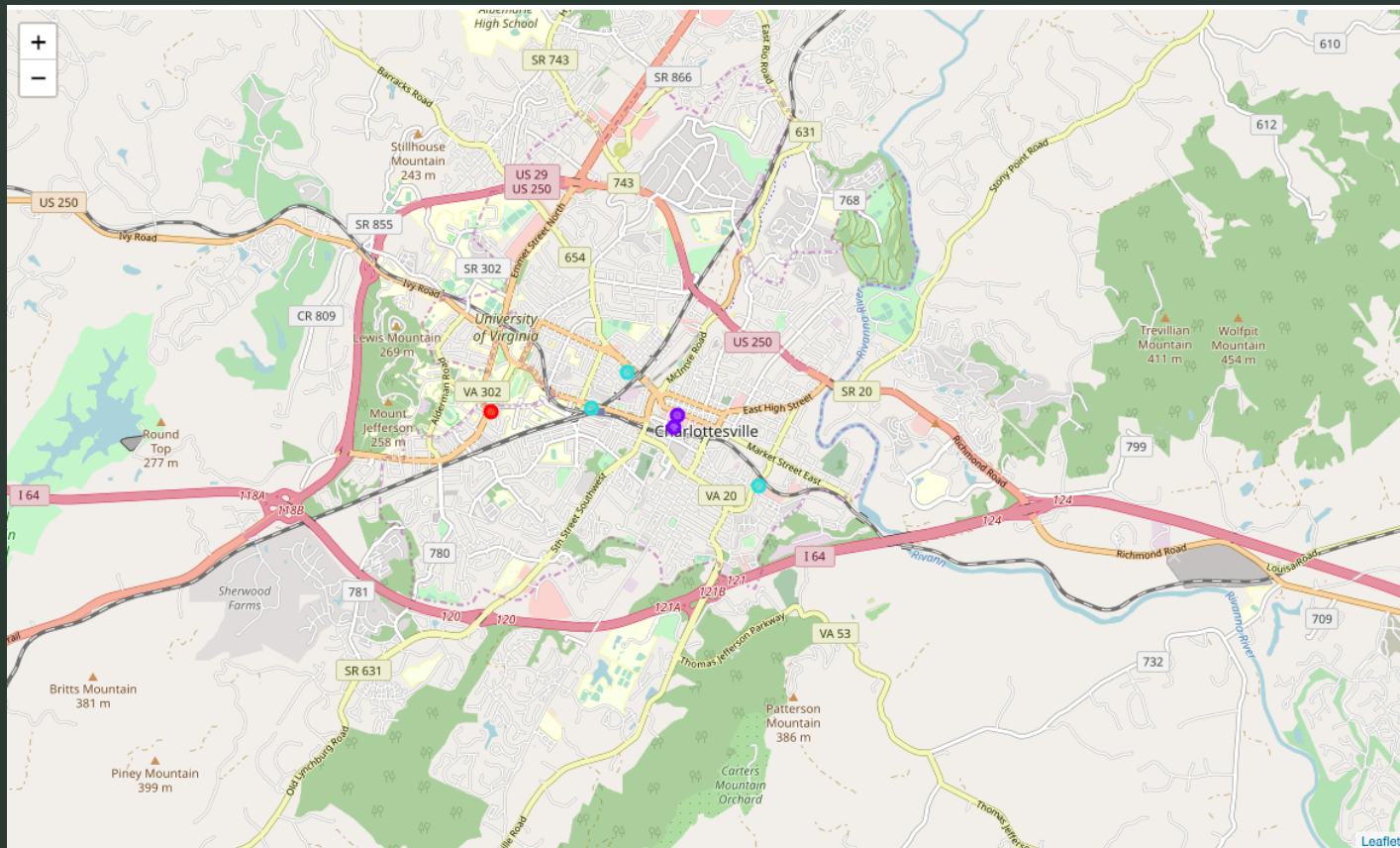
Analysis – Display the most common venues

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-----First and Market Parking Garage-----
      venue  freq
0      Music Venue  0.2
1      Dessert Shop  0.1
2      Wine Shop    0.1
3      Speakeasy    0.1
4      Soup Place   0.1
5      Shopping Mall 0.1
6      Burger Joint  0.1
7      Farmers Market 0.1
8      Pie Shop     0.1
9      American Restaurant 0.0
  
```

	Entry	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
0	First and Market Parking Garage	Music Venue	Shopping Mall	Dessert Shop	Wine Shop	Burger Joint	Pie Shop	Farmers Market	Soup Place	Speakeasy	Café
1	Homewood Suites	Grocery Store	Indian Restaurant	American Restaurant	Wine Shop	Hotel	Pub	Mediterranean Restaurant	Dumpling Restaurant	Café	Dessert Shop
2	Martin Horn	Farmers Market	Thai Restaurant	Art Gallery	Bar	Comfort Food Restaurant	Pizza Place	Laundry Service	Chinese Restaurant	Business Service	Café
3	Oakhurst Inn	Café	Hotel	Bagel Shop	Coffee Shop	Wings Joint	Farmers Market	Dumpling Restaurant	Donut Shop	Dessert Shop	Comfort Food Restaurant
4	The Flats at West Village	Wings Joint	Sandwich Place	Hotel	Coffee Shop	Korean Restaurant	Mexican Restaurant	Brewery	Donut Shop	Sports Bar	Southern / Soul Food Restaurant
5	Timbercreek Market	Health Food Store	BBQ Joint	Bagel Shop	Bakery	Beer Garden	Juice Bar	Brewery	Garden Center	Middle Eastern Restaurant	Chinese Restaurant
6	Water Street Parking	Music Venue	Bookstore	Burger Joint	Dessert Shop	Speakeasy	Soup Place	Shopping Mall	Coffee Shop	Farmers Market	Donut Shop

Analysis – Cluster and visualize



Analysis – Examine each cluster

1

	Entry	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
1	First and Market Parking Garage	Music Venue	Shopping Mall	Farmers Market	Wine Shop	Burger Joint	Pie Shop	Dessert Shop	Soup Place	Speakeasy	Bakery
2	Water Street Parking	Music Venue	Shopping Mall	Dessert Shop	Coffee Shop	Burger Joint	Bookstore	Farmers Market	Soup Place	Speakeasy	Bakery

2

	Entry	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
0	The Flats at West Village	Wings Joint	Sports Bar	Coffee Shop	Southern / Soul Food Restaurant	Hotel	Sandwich Place	Korean Restaurant	Donut Shop	Brewery	Mexican Restaurant
4	Martin Horn	Business Service	Thai Restaurant	Art Gallery	Comfort Food Restaurant	Bar	Chinese Restaurant	Pizza Place	Farmers Market	Wings Joint	Donut Shop
6	Timbercreek Market	Garden Center	Chinese Restaurant	Health Food Store	BBQ Joint	Bagel Shop	Bakery	Beer Garden	Brewery	Juice Bar	Middle Eastern Restaurant

3

	Entry	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
3	Oakhurst Inn	Amphitheater	Hotel	Bagel Shop	Coffee Shop	Café	Wings Joint	Business Service	Dumpling Restaurant	Donut Shop	Dessert Shop

4

	Entry	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
5	Homewood Suites	Grocery Store	Indian Restaurant	Pub	Dumpling Restaurant	Wine Shop	Hotel	Mediterranean Restaurant	American Restaurant	Sandwich Place	Bookstore

Results – Nearby venues for each EV Charging Station

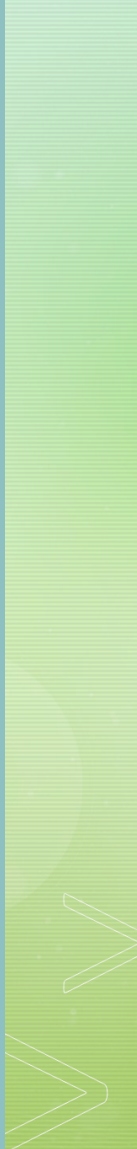
EV Charging Station: The Flats at West Village Continental Divide Sugar Shack Donuts & Coffee Wild Wing Cafe Peloton Station Mel's Cafe Hardywood Pilot Brewery & Taproom Doma Korean Kitchen The Draftsman, Autograph Collection Potbelly's Snowing In Space Coffee	EV Charging Station: First and Market Parking Garage The Jefferson Theater Charlottesville Historic Downtown Mall Jack Brown's Beer & Burger Joint Revolutionary Soup The Paramount The Alley Light Charlottesville City Market The Pie Chest Market Street Wineshop Downtown Splendor's Gelato	EV Charging Station: Water Street Parking The Jefferson Theater Charlottesville Historic Downtown Mall Jack Brown's Beer & Burger Joint Revolutionary Soup The Paramount The Alley Light Charlottesville City Market Splendor's Gelato Blue Whale Books Mudhouse
EV Charging Station: Homewood Suites Homewood Suites by Hilton Charlottesville Pub Whole Foods Trader Joe's Maharaja Mezeh Mediterranean Grill Marco & Luca Noodle Shop Burtons Grill Milan Indian Cuisine Wine Warehouse	EV Charging Station: Martin Horn Beer Run Red Lantern Belmont Pizza and Pub Pad Thai Firefly Cavalier Produce The Glass Palette Frontrunner Sign Studios	EV Charging Station: Timbercreek Market Cardinal Hall MarieBette The Juice Laundry Bodo's Bagels Fifth Season Gardening Co. Random Row Brewing Co. Ace Biscuit & Barbecue Sticks Kebob Shop Integral Yoga Natural Foods Cafe 88
	EV Charging Station: Oakhurst Inn Oakhurst Inn Starbucks Einstein Bros. Bagels West Range Cafe McIntire Amphitheatre	

Results – Most common venue categories for each EV Charging Station

First and Market Parking Garage Music Venue Wine Shop Speakeasy Farmers Market Soup Place Shopping Mall Burger Joint Dessert Shop Pie Shop American Restaurant	Homewood Suites Grocery Store Indian Restaurant Dumpling Restaurant Wine Shop Pub Mediterranean Restaurant Hotel American Restaurant Bookstore Sandwich Place	Martin Horn Comfort Food Restaurant Art Gallery Thai Restaurant Bar Farmers Market Business Service Pizza Place Chinese Restaurant American Restaurant Mediterranean Restaurant
Oakhurst Inn Café Bagel Shop Amphitheater Coffee Shop Hotel Sports Bar Pie Shop Juice Bar Wine Shop Korean Restaurant	The Flats at West Village Wings Joint Coffee Shop Korean Restaurant Sports Bar Southern / Soul Food Restaurant Mexican Restaurant Donut Shop Brewery Sandwich Place Hotel	Timbercreek Market Chinese Restaurant Beer Garden Health Food Store Middle Eastern Restaurant Garden Center Brewery Juice Bar Bakery BBQ Joint Bagel Shop
	Water Street Parking Music Venue Speakeasy Farmers Market Soup Place Bookstore Shopping Mall Burger Joint Dessert Shop Coffee Shop American Restaurant	



Discussion

- Shows the variety of different venues and venue categories located within 400 meters (.25 miles) of each EV Charging Station in Charlottesville, VA.
 - Enables EV owner stakeholders to decide which EV Charging Station to use based on their needs.
 - Current EV Charging Stations are located to take advantage of amenities in the areas of downtown, midtown, uptown, the "Corner", and Woolen Mills.
 - The k-means clustering to visualize clusters with similar venue categories could help city and business planners to determine new locations for EV charging stations that will address any gaps in EV charging station area amenities.
 - Those who are interested in starting a new business could view the most common venues for each EV charging station to determine what type of business would be a complementary category for each area and to determine competition.
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Conclusion

- The analysis and results in this project benefits EV owner stakeholders to choose the best EV charging station for their needs.
- Also benefits city planners and current and future business owners for planning services and amenities near current and proposed EV charging stations.
- Future work for this project could be to add location data for proposed new EV charging stations to view the nearby venues and the most common venues for the area. The proposed new EV charging stations can also be added to the k-means clustering to determining similarities and differences in the venue categories.
- This project helps an EV owner answer questions such as "Which EV charging station should I use if I want to get pizza while my car charges?" and "Which EV charging station should I use if I want to do some shopping while my car charges?".
- This project also helps current and new business owners answer questions such as "What competition is located near each EV charging station?" and "What gaps in services are opportunities at each EV charging station?".
- The project lends itself well to future research to answer the question "Where should new EV charging stations be installed to fill gaps in services and amenities located nearby?".