

ELECTRIC VEHICLE READINESS PLAN FOR OHIO

Drive Electric  Ohio

Appendix



Clean Fuels Ohio



U.S. Department of Energy

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This document was prepared for informational purposes only, to serve as a resource and to assist the State of Ohio and electric vehicle stakeholders as they seek appropriate ways to plan for and implement EV technology and policies supporting such infrastructure. This report was prepared at a time when widespread adoption of EVs was in early stages and when policies and practices addressing electric vehicles and supporting technology have been evolving. The findings and recommendations included herein reflect this "snapshot" in time, although every effort has been made to anticipate and accommodate evolving technologies.

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Regional Economic Perspective



AECOM analyzed the current data reflecting the ongoing recovery from the 2008/2009 Recession. The study considered data reflecting national economic conditions as expressed by (1) the condition of financial institutions, (2) consumer borrowing, (3) home prices, (4) employment, and (5) retail spending, and then focused on metrics specific to Ohio.

AECOM analyzed economic metrics to determine how Ohio and the study areas have performed and recovered since the recession began in 2007. Regional gross domestic product, wages, employment and consumer spending provide context for the economic security and purchasing strength of consumers.

Key Findings about Ohio's economy include:

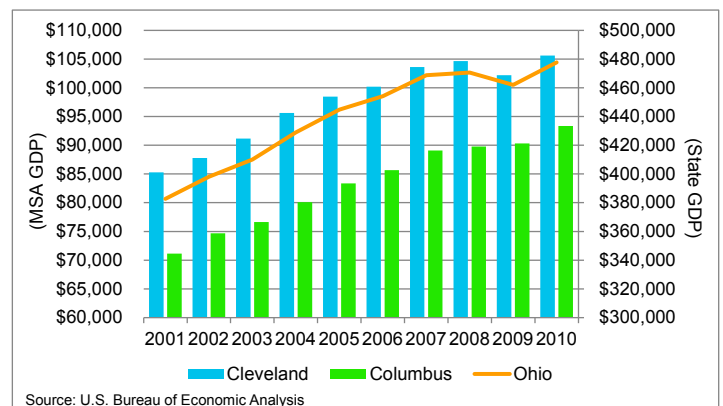
- The Columbus MSA's gross domestic product grew at a faster rate than that of Ohio.
- Unemployment peaked at 9.6 percent in Q1 2010 before falling below 8 percent by July 2011.
- Ohio lost significant employment during the recession, losing 387,500 jobs from 2006 to 2010 or 8 percent of total employment. Columbus fared better losing 38,000 jobs from 2007 to 2010 or 4 percent of total employment. Cleveland has been shedding jobs since 2001, losing 126,000 jobs through 2010, 11 percent of total employment.
- Nationwide, and in Ohio, consumers are saving more of their income than they did in 2000.

Gross Domestic Product

Gross domestic product (GDP) for Ohio and the MSAs grew over the last decade. Utilizing data provided by the Bureau of Economic Analysis, the analysis shows growth into the recession and then the impact of the recession on GDP.

- Ohio GDP grew at 3.4 percent going into the recession. Since 2007 Ohio GDP has grown at 0.6 percent
- Cleveland MSA grew at 3.3 percent going into the recession. Since the recession annual GDP growth has been 0.6 percent
- Columbus MSA grew at 3.8 percent going into the recession. Since the recession annual GDP growth has been 1.6 percent
- Ohio GDP shrank from 2008 to 2009 but in 2010 recovered to above pre-recession levels at \$477 billion
- Cleveland MSA GDP growth declined from 2008 into 2009 but recovered above pre-recession levels to \$105 billion in 2010
- Columbus MSA GDP growth slowed in the recession but it did not decline

Figure 1: Gross Domestic Product by MSA (\$ Millions)

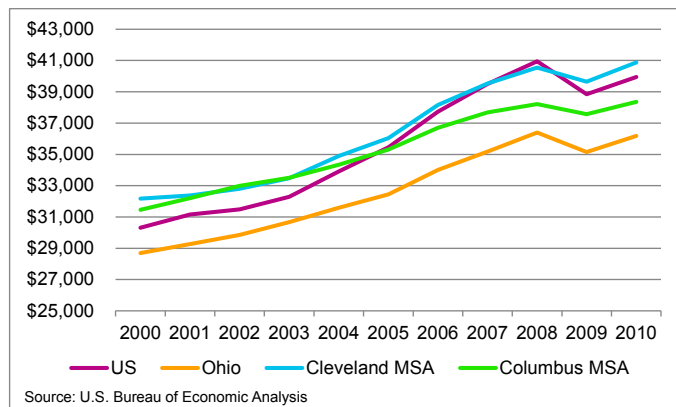


Per Capita Income

The Bureau of Economic Analysis (BEA) annually compares per capita income. The following chart shows per capita income growth into the recession and how it has declined and then recovered from the recession.

- Going into the recession, the per capita income nationally was growing at an annual rate of 3.7 percent, but since 2007 the rate has been 0.4 percent.
- Pre-recession income growth in Ohio was 3 percent, and post-recession growth is 0.9 percent.
- In Cleveland, pre-recession income growth from 2000–2007 was 3 percent. Since the recession growth has been 1.1 percent.
- Incomes in Columbus were growing at 2.6 percent pre-recession, while post-recession growth has been 0.6 percent.

Figure 2: Per Capita Income

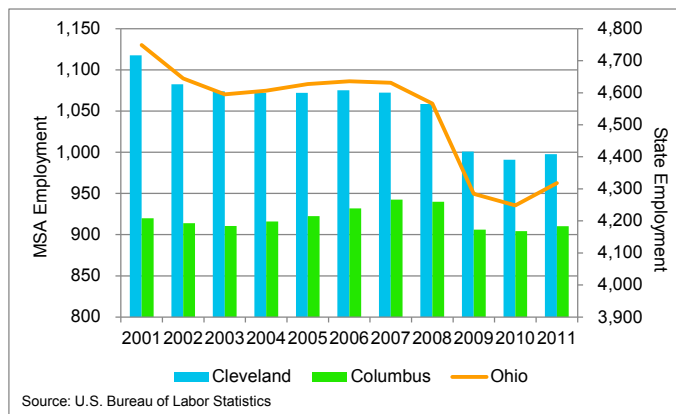


Employment

Employment is crucial to determining the economic vitality of a State or local economy. The following analysis from the Bureau of Labor Statistics (BLS) examines how employment has changed since 2001. The impact of the recession was significant for Ohio employment.

- Employment in Ohio and the study area MSAs declined from 2001 to 2010.
 - Ohio employment declined by 500,000
 - The Cleveland MSA saw the greatest decline in employment share, losing 126,000 jobs
 - Columbus MSA employment declined by 16,000
- While the past ten years resulted in decreased employment, from 2010 to 2011 both MSAs and Ohio experienced growth in employment.

Figure 3: Ohio & MSA Employment (thousands)

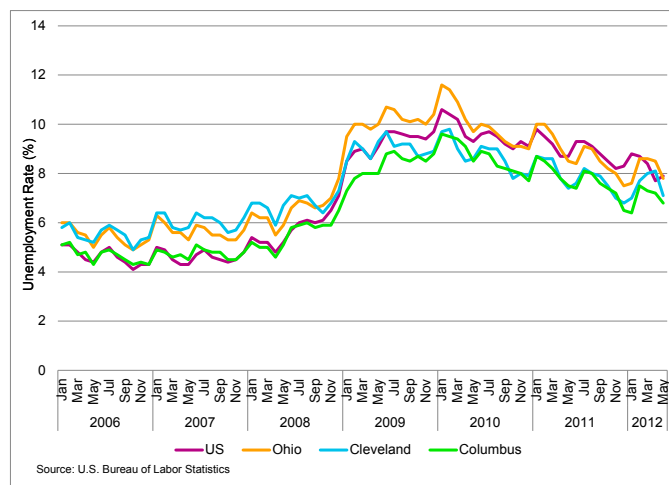


Unemployment

Unemployment following the onset of the recession in 2007 has been a significant problem across the nation. The Bureau of Labor Statistics provides monthly unemployment rates. The following chart shows historic unemployment rates and the recession's impact on metro region unemployment rates since 2006, prior to the majority of job losses occurring during the recession.

- Both the Cleveland and Columbus MSA unemployment has followed the statewide trends
- Unemployment peaked in January and February of 2010
 - 11.6 percent for Ohio in January 2010
 - 10.2 percent for Cleveland MSA in February 2010
 - 9.6 percent for Columbus MSA in January 2010
- Unemployment rates have continued to fall since their peak, with the Columbus and Cleveland MSAs performing better than the state and national averages.

Figure 4: Unemployment Rates

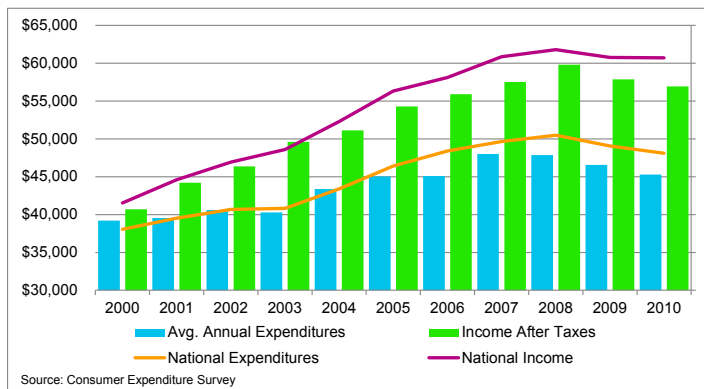


Consumer Spending

The Consumer Expenditure Survey by the Bureau of Labor Statistics provides context for Midwest and national consumer spending and the impact of the recession. The following chart compares the average annual expenditures versus the income after taxes. The key trends are:

- The Midwest annual expenditures increased through 2007 but have decreased following the recession's start
- Income after taxes in the Midwest peaked at \$59,793 in 2008 and has since declined to \$56,918 in 2010, a reduction of 4.8%
- The gap between how much consumers are spending and income after taxes has been widening both regionally and nationally, indicating greater rates of saving

Figure 5: Consumer Income and Annual Expenditures



The following calculation was used to determine total spending on gasoline in Ohio by individual owners and private fleet vehicles (passenger cars and light trucks).

Table 1: Total Gas Spending in Ohio, Private and Commercial Autos

	Total	Private and Commercial Automobiles*
Ohio vehicle registrations, 2011	11,788,000	6,427,000
Average miles per year, U.S. autos	11,300	11,300
Total miles	133,209,000,000	72,621,000,000
Average miles per gallon, U.S. autos	23	23
Total gallons	5,792,000,000	3,157,000,000
Average price per gallon of gas, Ohio 2012	\$3.61	\$3.61
Total spending on gasoline	\$20,908,000,000	\$11,398,000,000

* Includes commercial vehicles, excludes publicly owned vehicles

Sources: Ohio Bureau of Motor Vehicles, U.S. Department of Transportation, U.S. Department of Energy

Vehicle Sales

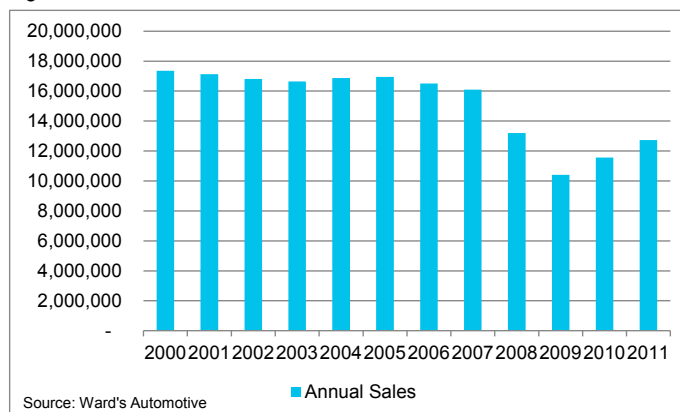


National Perspective

Data obtained through Ward's Automotive for national vehicle sales highlights the small share held by alternative fuel vehicles in the total U.S. vehicle market. In 2011, 12.7 million cars and trucks were sold. Of those, 271,000 (2.1 percent) were hybrids and 9,754 (0.1 percent) were EVs.

Annual vehicle sales have been declining in the U.S. since 2000 when 17.3 million vehicles were sold. Sales had declined annually by one percent from 2000 through 2007 but the recession saw an annual decline of 20 percent from 2007 through 2009. In 2009, sales volume hit bottom at 10.4 million vehicles sold. Sales in 2011 recovered to 12.7 million vehicles sold.

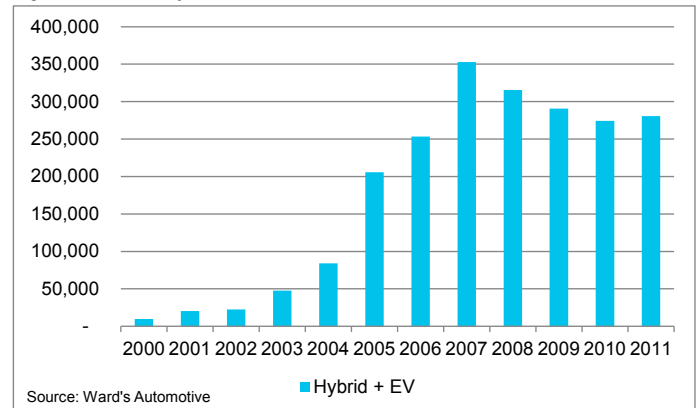
Figure 6: Annual U.S. Vehicle Sales



The adoption of hybrid vehicles has been touted as a leading indicator for EV demand forecasting. 2000 was the first year of sales in a measureable volume for hybrids with 9,350 vehicles sold. Until the recession the segment was growing rapidly by 68 percent annually from 2000 through 2007 to 352,862 vehicles. Sales volume has declined each year following 2007 to the 2011 sales volume of 270,859. As a share of total sales hybrids represented 3.7 percent in 2007, grew to 4.4 percent in 2009, and declined to 4.1 percent for 2010 and 2011.

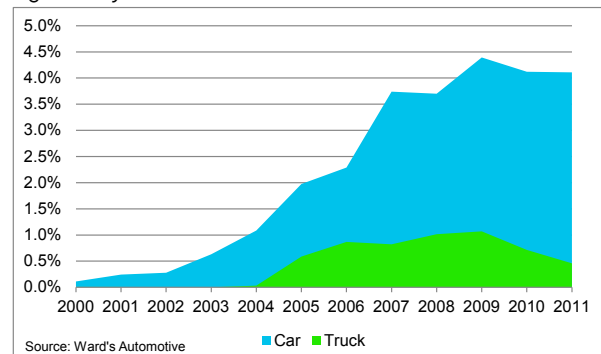
The 2011 sales volume of electric vehicles is not necessarily an indication of weakness in this segment as 2011 represents the first year that EVs made a push onto the scene with 9,754 units sold. These vehicles are targeted at a similar consumer segment as hybrid vehicles. The following chart looks at the combined sales volume of hybrids and EVs and indicates a small uptick in sales occurring in 2011.

Figure 7: Annual Hybrid & EV Sales Volume



The figure below shows hybrid penetration for the car and truck market as opposed to sales volume. This figure illustrates the minimal share which these markets have had since 2000 but also how, until the recession, they were growing rapidly.

Figure 8: Hybrid & EV Penetration



Vehicle Ownership in Ohio

Polk is an automotive data firm which aggregates vehicle ownership for the state of Ohio and provides a snapshot of specific dates for ownership totals. The data from Polk allowed AECOM to examine the localized penetration rates for various vehicle types, specifically hybrids, to be able to more accurately forecast local adoption of EVs.

Ownership data is calculated at the county level by fuel type and vehicle segment. This section utilizes the definitions developed by Polk when referring to fuel and vehicle types. The fuel types focused on are gas, gas/electric (hybrids), and electric. These fuel types were then analyzed by vehicle segment. For the Columbus and Cleveland MSAs and the I-71 corridor, the variations at the county level are illustrated below.

Statewide Trends

The statewide analysis provides the backdrop for the local trends in vehicle ownership. In 2000, there were 9.25 million vehicles owned and in 2011, 10 million, for a compound annual growth rate (CAGR) of 0.8 percent. Three of the 10 largest counties are part of the study area: Franklin County for the Columbus MSA, and Cuyahoga and Lorain counties for the Cleveland MSA.

Table 2: Ohio Counties with Largest Vehicle Ownership

	2000	2011	CAGR
CUYAHOGA	999,850	991,481	-0.1%
FRANKLIN	865,819	963,476	1.0%
HAMILTON	638,061	676,124	0.5%
MONTGOMERY	428,540	454,566	0.5%
SUMMIT	428,938	445,796	0.4%
LUCAS	356,018	355,118	0.0%
STARK	331,243	351,005	0.5%
BUTLER	255,403	307,306	1.7%
LORAIN	224,156	252,967	1.1%
MAHONING	216,310	220,933	0.2%

Source: Polk

The breakdown in vehicle ownership statewide, by fuel type, can be found in the following table. In 2000, gasoline accounted for 97 percent; as other fuel types gained hold that share has decreased to 92 percent in 2011. Alternative fuels grew but still account for less than 1 percent, though flex fuel vehicles grew to 4.3 percent. Gas/electric vehicles, (i.e. hybrids) while growing from 171 vehicles in 2000 to 49,003 in 2011, only account for 0.5 percent of total vehicles in Ohio. Electric vehicles are new to the market and only limited vehicle models are available in Ohio, specifically the Volt and Leaf.

Table 3: Vehicles by Fuel Type

	2000	2011	CAGR
Gas	8,948,833	9,291,013	0.3%
Diesel	95,449	159,306	4.8%
Alt Fuel	297	11,702	39.7%
Flex	68,503	434,234	18.3%
Gas/Electric	171	49,003	67.3%
Electric	8	266	37.5%
Unknown	137,891	131,584	-0.4%
Total	9,251,152	10,077,108	0.8%

Source: Polk

For gas/electric vehicles in 2011, 67 percent were Basic Economy (car), 14 percent Upper Midsize (car), 9 percent sport utility, and 5 percent mini sport utility.

Table 4: Gas/Electric Vehicles by Segment

	2000	2011	Share
BASIC ECONOMY (CAR)	0	32,971	67%
UPPER MIDSIZE (CAR)	0	7,079	14%
SPORT UTILITY	0	4,625	9%
MINI SPORT UTILITY	0	2,299	5%
BASIC SPORTY (CAR)	0	655	1%
FULLSIZE UTILITY	0	453	1%
LOWER MIDSIZE (CAR)	0	451	1%
MIDDLE LUXURY (CAR)	0	303	1%
PRESTIGE LUXURY (CAR)	0	76	0%
FULLSIZE PICKUP	0	67	0%
UNKNOWN (CAR/TRUCK)	171	24	0%
TOTAL	171	49,003	

Source: Polk

When the vehicle type segments are broken down for electric vehicles, 242 (91 percent) are listed as low speed vehicles (golf carts and similar vehicles capable of speeds up to 25 mph). The remaining 24 electric vehicles which are not low speed vehicles are predominately roadsters, which are open two-seat cars such as the Tesla Roadster. The lack of vehicles of this type does not indicate a lack of demand necessarily, but is due in part to the fact that Ohio has not been a primary market of focus for auto manufacturers (whose primary efforts have been focused on the East and West coasts), and current EV models have not yet been released in any meaningful way to consumers in Ohio. In the coming years more EV models will be available for purchase in Ohio.

Table 5: Electric Vehicles by Segment

	2000	2011	Share
LOW SPEED VEHICLE	0	242	91%
ROADSTER (CAR)	0	16	6%
BASIC ECONOMY (CAR)	0	3	1%
COMPACT PICKUP	5	3	1%
FULLSIZE VAN (CARGO)	0	1	0%
MINIVAN (PASSENGER)	3	1	0%
Total	8	266	

Source: Polk

Vehicle Ownership in the Columbus MSA

The Columbus MSA grew from 1.33 million cars owned in 2000 to 1.57 million cars owned in 2011, an annual growth rate of 1.5 percent. Gasoline remains the dominant fuel type with 92.9 percent in 2011. The gas/electric fuel type accounts for 0.7 percent with 10,416 total vehicles. Electric vehicles account for even less with 47 total vehicles.

Table 6: Columbus MSA Vehicles by Fuel Type

County	2000							Total
	Gas	Diesel	Alt Fuel	Flex	Electric	Gas/Electric	Unknown	
Delaware	89,949	1,071	2	868	0	2	1,476	93,368
Fairfield	105,450	1,586	2	841	1	2	1,842	109,724
Franklin	841,466	7,369	55	7,071	2	22	9,834	865,819
Licking	123,178	1,813	1	859	0	7	2,157	128,015
Madison	30,090	593	0	209	0	1	457	31,350
Morrow	28,480	589	1	146	0	2	543	29,761
Pickaway	39,998	694	1	233	0	0	755	41,681
Union	37,765	598	1	273	0	1	588	39,226
Total	1,296,376	14,313	63	10,500	3	37	17,652	1,338,944

County	2011							Total
	Gas	Diesel	Alt Fuel	Flex	Electric	Gas/Electric	Unknown	
Delaware	138,632	2,024	16	6,194	4	1,401	1,730	150,001
Fairfield	120,813	3,036	144	5,271	1	684	1,739	131,688
Franklin	903,605	7,887	899	36,427	34	6,762	7,862	963,476
Licking	143,837	3,541	167	6,508	3	736	2,216	157,008
Madison	32,168	1,083	51	1,786	1	145	520	35,754
Morrow	30,979	1,173	45	1,430	2	84	531	34,244
Pickaway	43,919	1,375	64	2,154	1	156	730	48,399
Union	45,604	1,315	31	1,873	1	448	609	49,881
Total	1,459,557	21,434	1,417	61,643	47	10,416	15,937	1,570,451

Source: Polk

In 2000, gas/electric vehicles were just entering the market in the Columbus MSA with only 37 vehicles. In 2011 gas/electric represents a growing segment with 10,416 vehicles, 68 percent of which are basic economy (car) and 14 percent which are upper midsize (car).

Table 7: Columbus MSA Gas/Electric Vehicles by Segment

	2000	2011
BASIC ECONOMY (CAR)	0	7,047
UPPER MIDSIZE (CAR)	0	1,483
SPORT UTILITY	0	946
MINI SPORT UTILITY	0	443
BASIC SPORTY (CAR)	0	199
FULLSIZE UTILITY	0	114
LOWER MIDSIZE (CAR)	0	90
MIDDLE LUXURY (CAR)	0	55
PRESTIGE LUXURY (CAR)	0	18
FULLSIZE PICKUP	0	17
UNKNOWN (CAR/TRUCK)	37	4

Source: Polk

Electric vehicles followed a similar trend to the state with the majority of the existing vehicles being low speed vehicles (golf carts), with three roadsters and one basic economy.

Table 8: Columbus MSA Electric Vehicles by Segment

	2000	2011
LOW SPEED VEHICLE	0	43
ROADSTER (CAR)	0	3
BASIC ECONOMY (CAR)	0	1
COMPACT PICKUP	3	0

Source: Polk

Vehicle Ownership in the Cleveland MSA

The Cleveland MSA grew from 1.62 million cars in 2000 to 1.69 million cars in 2011, an annual growth rate of 0.4 percent. The largest county in terms of vehicle ownership, Cuyahoga, actually decreased in total vehicle ownership from 999,850 vehicles in 2000, down to 991,481 in 2011. Even with this loss Cuyahoga represented 62 percent of total vehicles in 2000 and 59 percent in 2011. Gasoline vehicles represented 97 percent of vehicles in 2000 and 93 percent in 2011. The next largest fuel segment was flex fuel vehicles which grew from 0.9 percent of total vehicles in 2000 to 4.4 percent in 2011. Gas/electric vehicles represented 0.6 percent of total vehicles in 2011.

Table 9: Cleveland MSA Vehicles by Fuel Type

2000								
County	Gas	Diesel	Alt Fuel	Flex	Electric	Gas/Electric	Unknown	Total
Cuyahoga	977,269	4,035	49	8,187	0	21	10,289	999,850
Geauga	71,746	941	3	739	0	5	1,265	74,699
Lake	187,899	1,165	15	1,610	1	0	2,457	193,147
Lorain	215,971	1,876	0	2,586	0	5	3,718	224,156
Medina	124,004	1,461	2	1,542	0	5	2,045	129,059
Total	1,576,889	9,478	69	14,664	1	36	19,774	1,620,911

2011								
County	Gas	Diesel	Alt Fuel	Flex	Electric	Gas/Electric	Unknown	Total
Cuyahoga	928,679	5,080	1,271	40,435	16	6,225	9,775	991,481
Geauga	78,302	1,721	102	6,210	3	676	1,563	88,577
Lake	191,148	1,824	228	8,848	5	866	3,053	205,972
Lorain	231,870	2,980	319	12,234	5	1,229	4,330	252,967
Medina	142,319	2,560	197	7,689	4	855	2,745	156,369
Total	1,572,318	14,165	2,117	75,416	33	9,851	21,466	1,695,366

Source: Polk

Gas/electric vehicles, which represent 0.6 percent of total vehicles in 2011, are predominately basic economy with 68 percent of gas/electric vehicles falling into this category. The next largest vehicle type is Upper Midsize with 15 percent of total share, followed by Sport Utility with 10 percent.

Table 10: Cleveland MSA Gas/Electric Vehicles by Segment

	2000	2011
BASIC ECONOMY (CAR)	0	6,515
UPPER MIDSIZE (CAR)	0	1,465
SPORT UTILITY	0	977
MINI SPORT UTILITY	0	518
BASIC SPORTY (CAR)	0	106
FULLSIZE UTILITY	0	94
LOWER MIDSIZE (CAR)	0	80
MIDDLE LUXURY (CAR)	0	64
PRESTIGE LUXURY (CAR)	0	19
FULLSIZE PICKUP	0	7
UNKNOWN (CAR/TRUCK)	36	6

Source: Polk

As in Columbus, the majority of the Cleveland MSA's 33 electric vehicles are low speed vehicles with six being roadsters and one being basic economy in 2011.

Table 11: Cleveland MSA Electric Vehicles by Segment

	2000	2011
LOW SPEED VEHICLE	0	26
ROADSTER (CAR)	0	6
BASIC ECONOMY (CAR)	0	1
MINIVAN (PASSENGER)	1	0

Source: Polk

Vehicle Ownership in the I-71 Corridor

The I-71 corridor counties of Ashland, Richland, and Wayne grew at an annual rate of 0.8 percent from 246,051 cars in 2000 to 268,405 in 2011. Similar to the MSAs which it connects, gasoline remained the dominant fuel type but decreasing in total share from 97 percent to 91 percent. Flex fuels grew from one percent to five percent while gas/electric vehicles represented 0.3 percent.

Table 12: Corridor Vehicles by Fuel Type

County	2000							Total
	Gas	Diesel	Alt Fuel	Flex	Electric	Gas/Electric	Unknown	
Ashland	41,180	580	2	279	0	0	707	42,748
Richland	107,300	1,062	1	631	0	1	1,802	110,797
Wayne	89,019	1,430	3	659	0	2	1,393	92,506
TOTAL	237,499	3,072	6	1,569	0	3	3,902	246,051

County	2011							Total
	Gas	Diesel	Alt Fuel	Flex	Electric	Gas/Electric	Unknown	
Ashland	45,015	1,213	70	2,412	1	108	815	49,634
Richland	105,746	1,778	172	6,896	4	312	1,540	116,448
Wayne	93,182	2,756	124	4,488	0	344	1,429	102,323
TOTAL	243,943	5,747	366	13,796	5	764	3,784	268,405

Source: Polk

Gas/electric vehicles grew from three unknown vehicles types in 2000 to 764 vehicles in 2011, of which 531, or 70 percent, are basic economy cars. The next largest segment is upper midsize car which represents 11 percent of gas/electric vehicles.

Table 13: Corridor Gas/Electric Vehicles by Segment

	2000	2011
BASIC ECONOMY (CAR)	0	531
UPPER MIDSIZE (CAR)	0	81
SPORT UTILITY	0	71
MINI SPORT UTILITY	0	42
BASIC SPORTY (CAR)	0	14
LOWER MIDSIZE (CAR)	0	8
FULLSIZE UTILITY	0	7
MIDDLE LUXURY (CAR)	0	7
PRESTIGE LUXURY (CAR)	0	2
FULLSIZE PICKUP	0	1
UNKNOWN (CAR/TRUCK)	3	0

Source: Polk

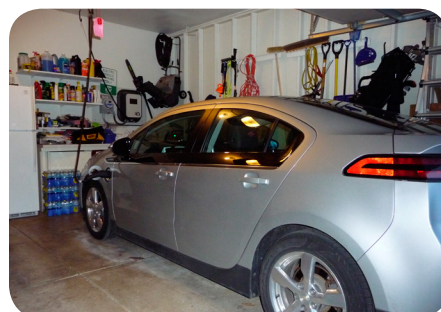
The corridor has five electric vehicles registered in 2011 with four being low speed vehicles and one being a roadster.

Table 14: Corridor Electric Vehicles by Segment

	2000	2011
LOW SPEED VEHICLE	0	4
ROADSTER (CAR)	0	1

Source: Polk

Population Demographics



This study examined Census data identifying changes and trends in a variety of categories between 2000 and 2010. Key findings, discussed in detail in this section, include:

- Between 2000 and 2010, Ohio's population grew slower than the nation
- Between 2000 and 2010 the Columbus MSA's population grew faster than Ohio's
- 70 percent of housing stock in Columbus is single unit, attached or detached
- 68.4 percent of housing stock in Cleveland is single unit, attached or detached
- Columbus MSA median household income is higher than that of Ohio
- Columbus has a significant share of population between 20-29, at 21.1 percent
- The vast majority of commuters in the study areas travel less than 25 miles each way to get to work
- Education, healthcare and government are the largest regional employers
- Spending on vehicles, new and used, is down compared to past years

Population Indicators

The U.S. Census released the 2010 population figures for the nation, State, MSA and City. The following table shows the annual rates of population growth between 2000 and 2010.

Table 15: Population Change

	2000	2010	CAGR
United States	281,421,906	308,745,538	0.9%
Ohio	11,353,140	11,536,504	0.2%
Cleveland MSA	2,148,143	2,077,240	-0.3%
Cleveland	478,403	396,815	-1.9%
Columbus MSA	1,612,694	1,836,536	1.3%
Columbus	711,470	787,033	1.0%

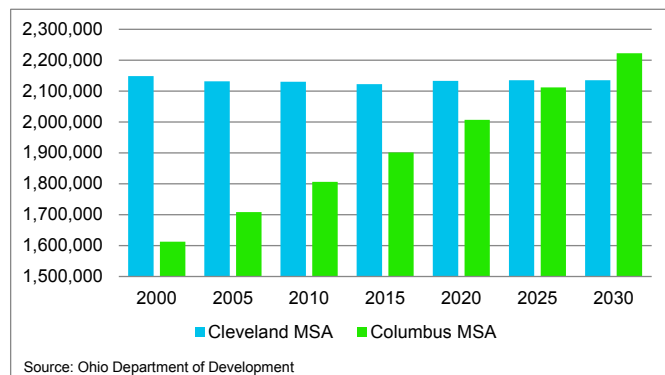
Source: U.S. Census

- Ohio's population grew at 0.2 percent annually from 2000 to 2010, slower than the national growth rate of 0.9 percent, adding 183,000 residents
- Cleveland had an annual population decline of 1.9 percent, approximately 17 percent of its total population over 10 years while the MSA lost 3 percent of its total population over the same period
- The Columbus MSA grew annually at 1.3 percent while the City grew at 1 percent

Population projections were created by the Ohio Department of Development in 2005 which produced estimates at five year intervals at a county level for the State of Ohio and were based on the 2000 Census figures for population. While the projections do not match the actual 2010 Census figures they still provide a trend for growth in the region. The following chart shows the projections for the Columbus and Cleveland MSAs from 2000 to 2030.

- The Cleveland MSA is projected to maintain the current levels of population
- The Columbus MSA is projected to grow by 100,000 every five years
- The Columbus MSA population will overtake the Cleveland MSA by 2025

Figure 9: Ohio Population Projections

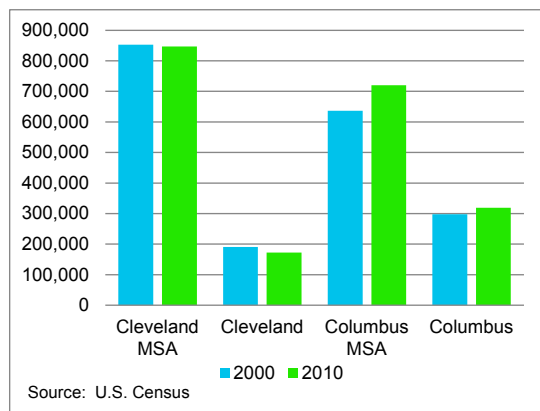


Households

Households for the MSAs and their largest cities are shown in the chart below.

- The City of Cleveland contains 20 percent of the MSA households
- The City of Columbus contains 43 percent of the MSA households
- Cleveland lost 1 percent of its households annually
- The Columbus MSA grew annually at 1.2 percent while the City grew at 0.7 percent
- Average HH size was 2.4 in the Cleveland MSA and City
- Average HH size was 2.5 in the Columbus MSA and 2.3 in the City of Columbus

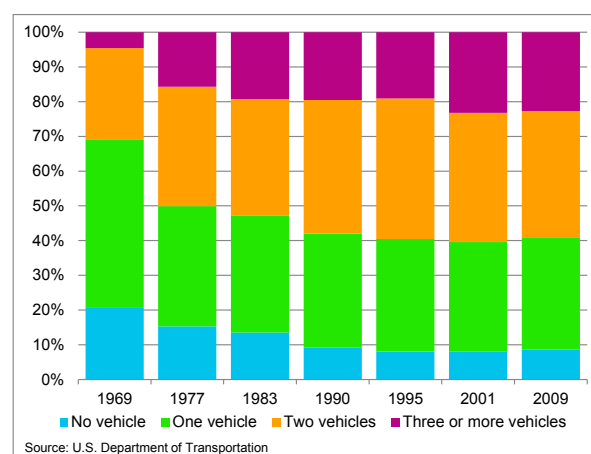
Figure 10: Households



Change in Vehicle Ownership by Household

Household vehicle ownership has changed over time, with more households having a greater number of cars. Figure 11 presents vehicle ownership by household using data gathered by the U.S. Department of Transportation (DOT) through its National Household Travel Survey. The share of households that own more than one vehicle increased through the 1990's and has since stabilized with approximately 60 percent stating that they own two or more vehicles.

Figure 11: Vehicles Owned by Household



Housing Units

The 2010 American Community Survey lists housing units in metro regions and characteristics of residents. These characteristics identify residents who may have access to at-home charging stations and homeowners who may be more inclined to invest in the cost of home charging stations. Single unit homes, both attached and detached, are more likely to have parking available, in a driveway or garage.

- In both MSAs, the majority of housing units are single-unit
 - 671,922 single-units in the Cleveland MSA (68 percent of all housing units)
 - 542,296 single-units in the Columbus MSA (70 percent of all housing units)
- 12 percent of housing units are vacant in the Cleveland MSA and 10 percent are vacant in the Columbus MSA

Table 16: Housing Profile

	Cleveland	MSA	Columbus	MSA
Total Housing Units	955,798		793,030	
Occupied Units	840,929	88.0%	707,956	89.3%
Vacant Units	114,869	12.0%	85,074	10.7%
Homeowner Vacant	2.3%		2.7%	
Renter Vacant	9.9%		9.8%	
1-unit, detached	623,046	65.2%	483,505	61.0%
1-unit, attached	48,876	5.1%	58,791	7.4%
Multi-unit	273,028	28.6%	233,173	29.4%
Non-traditional	10,848	1.1%	17,561	2.2%
Occupied housing units	840,929		707,956	
Owner-occupied	568,859	67.6%	446,235	63.0%
Renter-occupied	272,070	32.4%	261,721	37.0%

Source: U.S. Census, American Community Survey 2010

Household Income and Wages

A breakdown of income by geographic region shows where income groups are concentrated.

- In Columbus, 87 percent of households earn less than \$100,000 compared to 80 percent for the MSA
- 28 percent of the Columbus MSA's household incomes over \$100,000 live in the City
- In Cleveland, 94 percent of households earn less than \$100,000 compared to 83 percent for the MSA
- 7 percent of the Cleveland MSA's household incomes over \$100,000 live in the City

Figure 12: Household Income by Region

The following chart looks at the median household income.

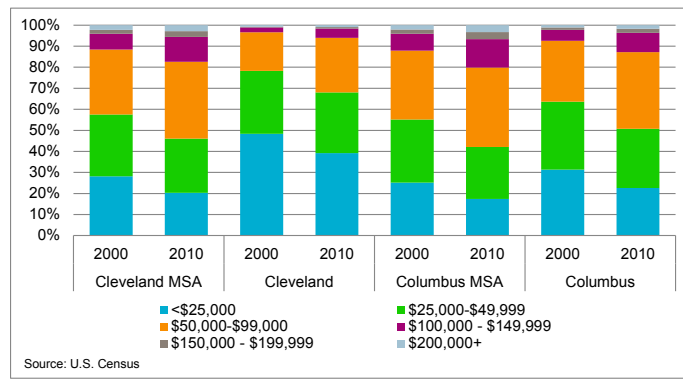
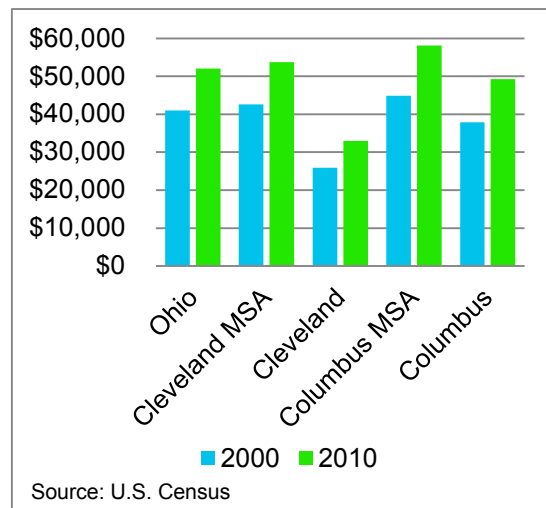


Figure 13: Median Household Income



- Ohio's median household income was \$40,998 in 2000 and grew at an annual rate of 2.4 percent to \$52,047 in 2010
- The Columbus MSA had a higher median household income than Ohio at \$58,099 in 2010, growing annually at 2.6 percent
- Household incomes in Columbus grew at 2.7 percent, to \$49,302 in 2010

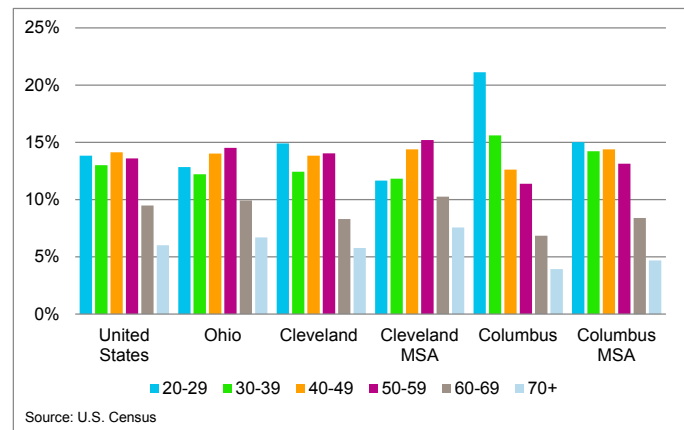
- Household incomes in the Cleveland MSA grew at 2.3 percent with a 2010 median household income of \$53,755
- Household incomes in Cleveland grew at 2.4 percent, to \$32,974 in 2010

Age

Variations in age categories can indicate unique characteristics and needs for the given population. The following comparison looks at the United States, Ohio and the two MSAs and their primary cities and compares their populations over 20 years of age in 10 year intervals.

- United States age segments for 20 to 59 ranges between 13 and 14 percent of total population
- The City of Columbus' 20-29 age group is 21 percent of the population
- The Cleveland MSA has greater shares of older population segments over the age of 40

Figure 14: Age Breakdown by Region



Median ages increased from 2000 to 2010.

- The Cleveland MSA was older at both the City and MSA level than the Columbus MSA
- The Cleveland MSA and City grew older at a faster annual rate than the Columbus MSA

Table 17: Median Age

	2000	2010	CAGR
Cleveland MSA	37.3	40.0	0.7%
Cleveland	33.0	36.3	1.0%
Columbus MSA	33.7	35.6	0.5%
Columbus	31.0	32.2	0.4%

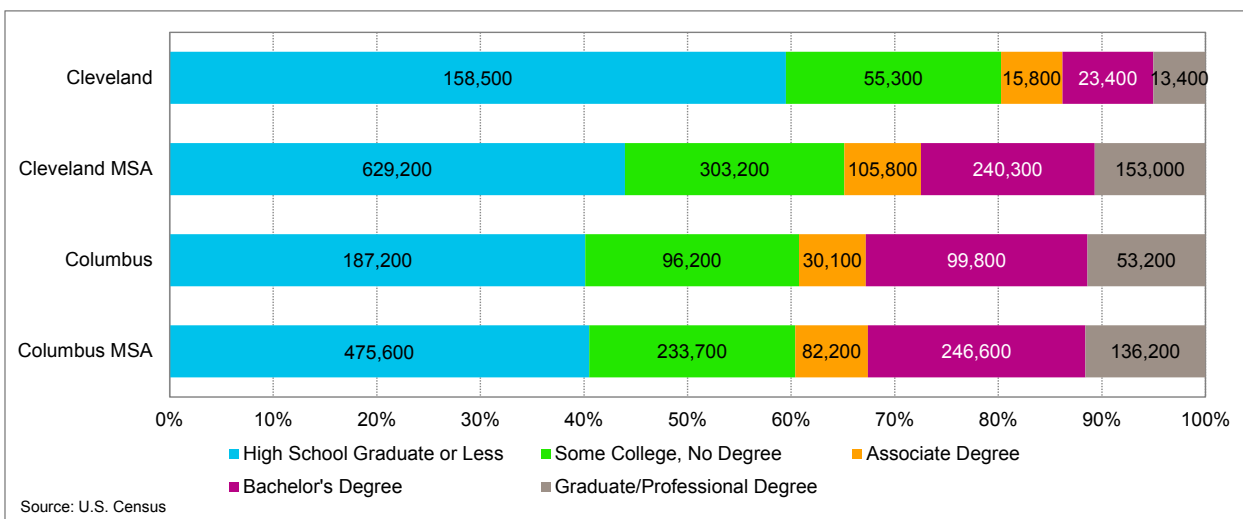
Source: U.S. Census

Educational Attainment

Educational attainment helps describe differences in population and highlights where EV users may be more likely to live. The following chart shows the share of the population over 25 by their educational attainment from a high school education or less through a graduate/ professional degree.

- Cleveland MSA residents with a college degree account for 28 percent of the population while in the City 14 percent of residents have a college degree
- The Cleveland MSA has 153,000 graduate degree holders but the City only has 9 percent of those residents
- Columbus MSA residents with a college degree account for 33 percent of the population; this percent is the same for the City
- The Columbus MSA has 136,000 residents with a graduate degree with 39 percent living in the City

Figure 15: Educational Attainment



Car Buying Habits

The Consumer Expenditure Survey (CES) from the Bureau of Labor Statistics provides a national comparison of household spending on vehicles. The following figures look at the spending variations between regions and educational attainment, discussed earlier in this report as an indicator of early adoption of EVs.

Regional Variations

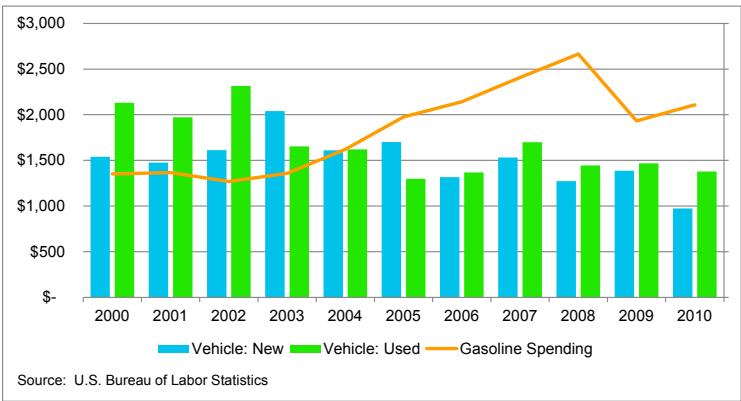
The Midwest region, as seen in the figure below, either matches the average household spending on new vehicles nationally or is slightly lower (please note that these figures account for all households, not only households which purchase a vehicle in a given year). Households in the West region spent significantly more than other regions from 2004 through 2007 but have since come back in line with national spending rates. Southern household spending has trended with national spending. In 2010, Midwest spending on new vehicles was the lowest of any region, an average of \$978 per household compared to a national average of \$1,219 per household.

Figure 16: Average Household Spending on New Vehicles



Available data indicates that households in the Midwest historically spend more on used vehicles. As gasoline spending began to climb, the overall vehicle spending in both categories has declined with 2010 spending levels on new vehicles being the lowest yet, below \$1,000 per household.

Figure 17 : Midwest Vehicle Purchases vs. Gasoline

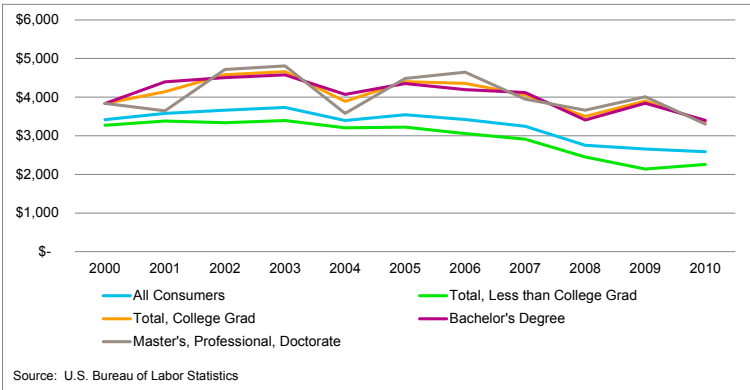


Educational Variations

Looking at the Consumer Expenditure Survey by education provides another facet for the spending potential.

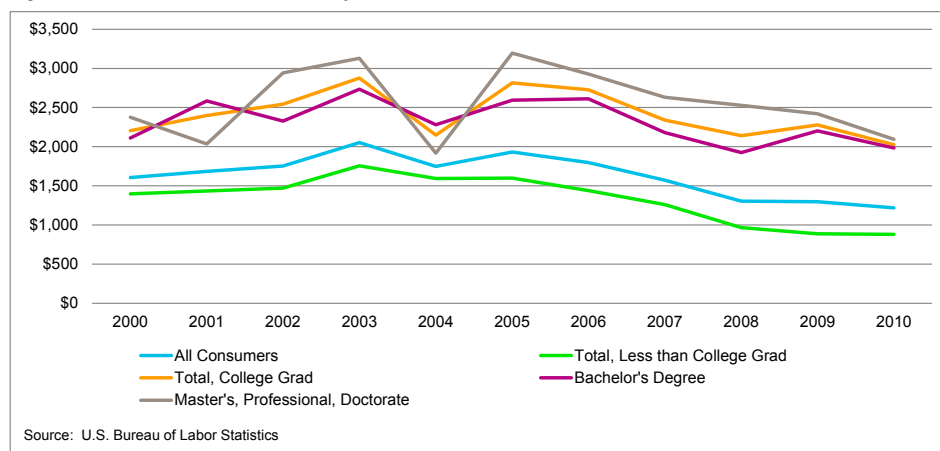
The following chart shows the total average annual household expenditures on vehicle purchases by educational attainment. The spending for those without a college degree is less than for those with a degree but total spending with a degree does not vary depending on the level of degree.

Figure 18: Vehicle Purchases, Net Outlay (by education)



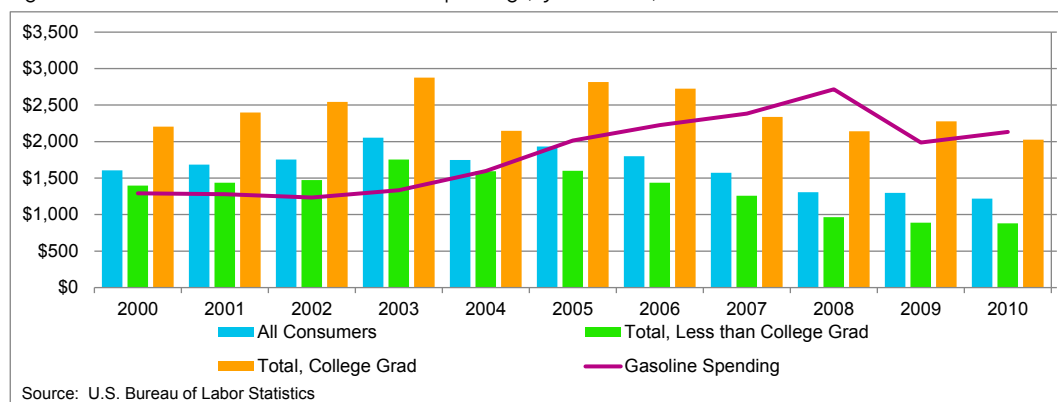
Buyers with less than a college education spend significantly less on new cars than those with a degree. Additionally, the trend shows that among buyers with advanced degrees, spending on new cars had been growing faster than other categories but already was decreasing from 2005 prior to the recession and remained lower in 2010 and below 2000 spending levels.

Figure 19: Vehicle Purchases, New (by education)



When household spending on new car purchases is compared against spending on gasoline there appears to be an inverse relation between the spending amounts on new cars and the amount spent on gas. For those with a college education the trend is less pronounced, but still appears to indicate that the cost of gasoline places a constraint on new car purchases.

Figure 20: New Vehicle Purchase vs. Gasoline Spending (by education)



Hybrid and EV Ownership Forecast

Methodology

AECOM developed the EV demand forecast model using data from partner organizations, expert opinion on industry development, and a number of baseline assumptions on market conditions impacting EV adoption in the Ohio vehicle market, specifically the Columbus and Cleveland MSAs and the I-71 corridor connecting them. The projected forecasts use a number of metrics and key assumptions, drawn from the existing demographic and economic conditions in the study MSAs, national trends in vehicle shares/sales, local vehicle ownership, and industry experts' forecasts. These conditions informed the share of electric vehicles forecast in each market.

Data sources used for this analysis include U.S. Census, Polk Automotive, EPRI, Ward's Automotive, and industry expert opinions.

- Forecasts of overall vehicle ownership relied on historic ownership rates, determined on a county by county basis from Polk, tied to population growth in order to determine future vehicle ownership.
- Specific share targets for new vehicle sales were tied to EPRI estimates and forecasts.
- Hybrid, EV, and EV shares are calculated at an MSA level. MSA shares are averages of county level new vehicle sales created by EPRI.

This section presents AECOM's findings for the potential total vehicle ownership by type and the annual vehicle sales by type. These represent forecasts based on existing conditions.

Annual Vehicle Sales

Using the new vehicle sales shares for hybrids, plug-in hybrid electric vehicles, and electric vehicles developed by EPRI at the county level, AECOM developed an MSA average that was then applied to vehicle sales forecasts to generate an annual new vehicle volume by type.

The table below shows the share of annual new vehicle sales. Hybrid shares of new vehicle sales are expected to increase at a significantly higher rate of adoption than will plug-in hybrid electric vehicles or electric vehicles. Hybrids are expected to grow in share to 60% of all new vehicle sales through 2030, while PHEV (including extended range) and EV shares will grow to approximately 15% of all new vehicle sales in 2030.

Table 18: Percent share of Annual New Vehicle Sales by Vehicle Type

	2015	2020	2025	2030
Hybrid Vehicles	37.6%	57.0%	63.8%	60.1%
Plug-In Hybrid Electric Vehicles (PHEV)				
Columbus MSA	0.9%	3.4%	7.2%	11.4%
Cleveland MSA	0.8%	3.4%	7.2%	11.4%
Corridor	0.6%	3.0%	6.8%	11.0%
Electric Vehicles (EV)				
Columbus MSA	0.3%	1.1%	2.5%	3.9%
Cleveland MSA	0.3%	1.1%	2.4%	3.9%
Corridor	0.2%	1.0%	2.3%	3.7%

Source: EPRI, AECOM

New vehicle sales for PHEVs and EVs in 2015 are forecast to be approximately 2,030 vehicles across the Columbus and Cleveland MSAs and the corridor. Hybrids during this same time period are forecast to be nearly 70,000 vehicles. By 2030 these figures are forecast to grow to 33,410 PHEVs and EVs, and 130,000 hybrid vehicles.

Table 19: Number of New Vehicle Sales

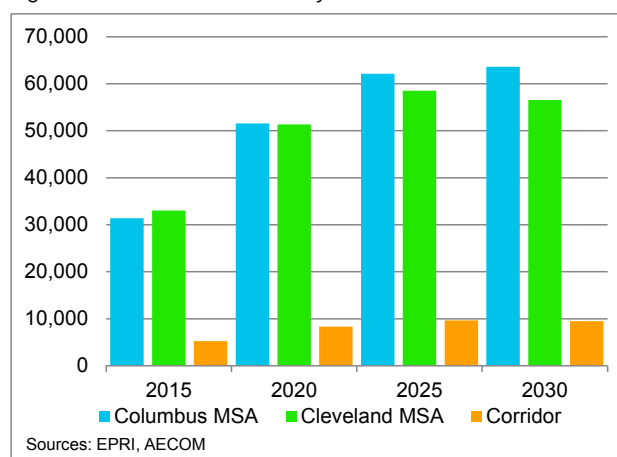
	2015	2020	2025	2030
Hybrid Vehicles				
Columbus MSA	31,470	51,700	62,750	64,410
Cleveland MSA	32,800	50,920	58,310	56,350
Corridor	5,270	8,320	9,680	9,500
Plug-In Hybrid Electric Vehicles (PHEV)				
Columbus MSA	770	3,250	7,360	12,600
Cleveland MSA	670	2,990	6,570	10,720
Corridor	80	440	1,030	1,740
Electric Vehicles (EV)				
Columbus MSA	260	1,080	2,450	4,200
Cleveland MSA	220	1,000	2,190	3,570
Corridor	30	150	340	580

Source: EPRI, AECOM

Hybrid Vehicles

Hybrid vehicle sales are forecast to grow significantly through 2030, with numerous vehicle makes and models in auto manufacturer lineups being offered with hybrid components. The figure below shows the annual sales volume in each study area. The Columbus and Cleveland MSAs are forecast to have similar shares of hybrid sales through 2025, at which point Columbus is projected to begin having a larger number of hybrids sold annually than Cleveland. The I-71 corridor is forecast to grow to nearly 10,000 hybrids sold annually by 2030.

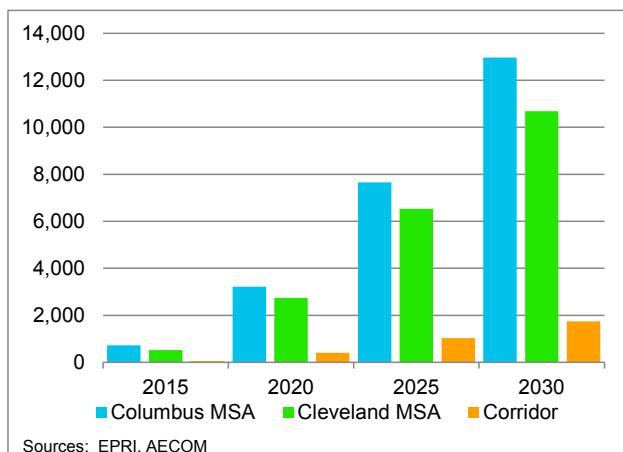
Figure 21: Annual Vehicle Sales, Hybrids



Plug-In Hybrid Electric Vehicles

PHEV annual sales volumes are forecast to grow rapidly in comparison to pure EVs, contributing 75% of all new EV sales annually. The figure below includes the forecast growth in annual PHEV sales, showing that in 2030, 12,600 PHEV vehicles are expected in Columbus, 10,720 in Cleveland, and 1,740 in the corridor.

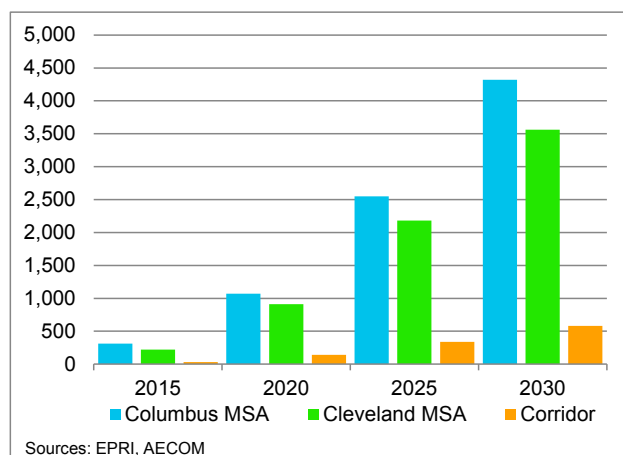
Figure 22: Annual Vehicle Sales, Plug-In Hybrid Electric Vehicles



Electric Vehicles

All-electric vehicles are forecast to contribute 500 annual vehicle sales for the study markets in 2015, growing to 8,350 vehicle sales in 2030. The individual MSAs will contribute most of those with 4,200 for Columbus and 3,570 for Cleveland through 2030, with the corridor accounting for 580 vehicles.

Figure 23: Annual Vehicle Sales, Electric Vehicles



Total Vehicle Ownership

While the annual vehicle sales (the number of vehicles sold in a given year) for PHEVs and pure EVs is a small share of the overall vehicle market, over time total EV ownership (the number of vehicles on the road at a given time) in these markets will grow to be a significant number of vehicles.

Table 20: Total Vehicle Ownership

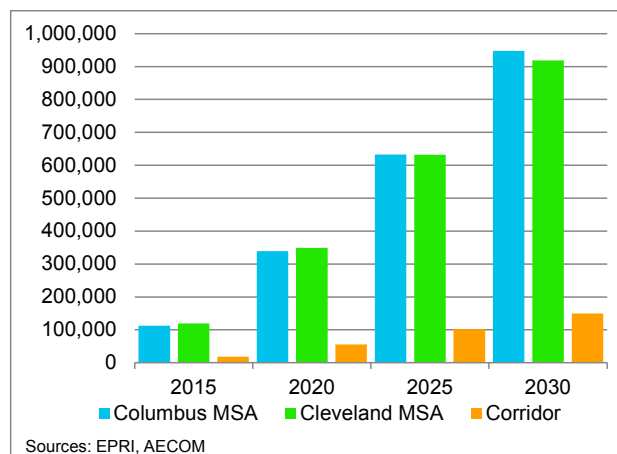
	2015	2020	2025	2030
Hybrid Vehicles				
Columbus MSA	112,990	339,870	635,750	954,250
Cleveland MSA	118,350	346,550	627,800	913,310
Corridor	18,110	55,160	101,570	149,420
Plug-In Hybrid Electric Vehicles				
Columbus MSA	1,950	12,620	40,570	92,850
Cleveland MSA	1,720	11,490	36,740	82,010
Corridor	210	1,580	5,470	12,740
Electric Vehicles				
Columbus MSA	650	4,210	13,520	30,950
Cleveland MSA	570	3,830	12,250	27,340
Corridor	70	530	1,820	4,250

Source: EPRI, AECOM

Hybrid Vehicles

Hybrid ownership will be the greatest of the three categories examined, growing to slightly fewer than 1,000,000 vehicles in each of the MSA markets, with Columbus forecast to have nearly 954,250 and Cleveland to have 913,310. The corridor as well is forecast have a modest number of vehicles with 149,420.

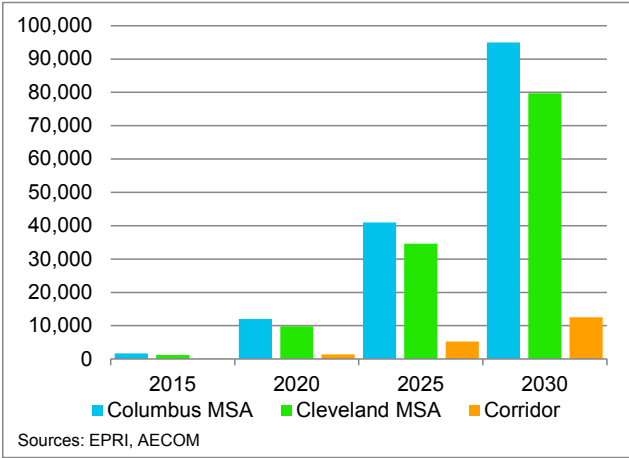
Figure 24: Total Vehicle Ownership, Hybrids



Plug-In Hybrid Electric Vehicles

PHEV ownership through 2020 is going to be relatively small in terms of total vehicles owned, with 12,620 vehicles in Columbus, and 11,490 in Cleveland, but is forecast to grow to 30,950 vehicles in Columbus in 2030, and 27,340 in Cleveland. Ownership of PHEVs in the corridor is forecast to be 12,740 vehicles by 2030.

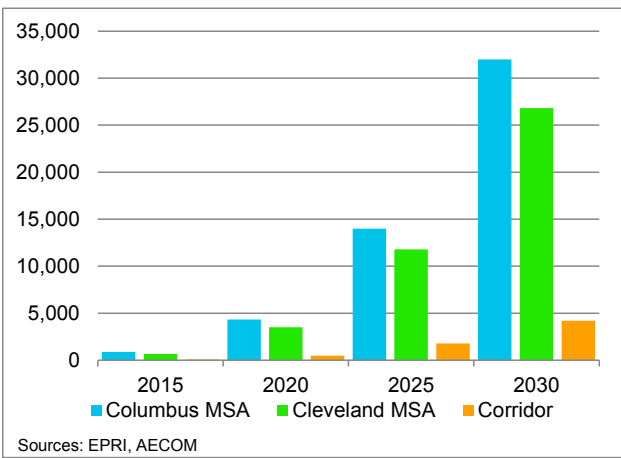
Figure 25: Total Vehicle Ownership, Plug-In Hybrid Electric Vehicles



Electric Vehicles

All-electric vehicles through 2020 will be a small number of total vehicles owned, less than 5,000 in each MSA. By 2030 growth in EV ownership is forecast to reach 31,000 in Columbus and 27,000 in Cleveland, with 4,250 EVs in the corridor.

Figure 26: Total Vehicle Ownership, Electric Vehicles



Location and Commute Patterns of Likely EV Owners



AECOM has developed a profile of Early Adopter and Early Majority characteristics in Ohio based on an analysis of demographic and economic data specific to the MSAs, and a review of profiles generated by car manufacturers and industry experts.

Early Adopters and Early Majority Characteristics, by Deloitte

Deloitte's study¹ examining EV adoption identified the following characteristics for their EV early adopters and early majority segments.

Early Adopter

- Young, very high income individuals, such as high-profile celebrities
- Previous adopters of hybrid vehicles
- Household incomes in excess of \$200,000
- Own one or more vehicles

Early Majority

- Households with an income between \$100,000 to \$150,000
- 44.9% of men vote, 44.5 % of women vote
- Men represent 67% of this segment
- 13.4% of men have an income of at least \$100,000
- Urban and Suburban residents with garage
- Drive less than 100 miles per week
- Age between 40 to 44

Early Adopters Characteristics, by Nissan²

Nissan has similarly identified an Early Adopter with the characteristics listed below for its Nissan Leaf. Note the age difference between the Nissan and Deloitte profiles.

- Young Baby Boomer approximately 45 years old
- Average income of \$125,000
- Owns their home with garage space for the Leaf's Charger

- College level education
- Drives less than 50 miles per day
- Plugs their EV into the charger at home every day
- Are likely to have previously owned a hybrid vehicle

Ohio Early Adopter/Early Majority Characteristics, by AECOM

AECOM has taken these industry identified characteristics, paired with economic and demographic data specific to Ohio, to determine the range of individuals who will fit the Early Adopter and Early Majority characteristic in this state. Early Majority consumers share many of the traits of Early Adopters, but with more modest household incomes. Another difference is that Early Majority commuters tend to drive shorter distances over the course of a week. The following represent general ranges:

Ohio Early Adopter

- Young Baby Boomer or young, very high income individuals
- Median household income in excess of \$150,000
- Previous hybrid owners
- Owns more than one vehicle
- College Educated
- Drives less than 50 miles per day
- Has a single-family home with garage or available parking

Ohio Early Majority

- Median household income of \$100,000–150,000
- Middle-aged households between 40–44 years
- More likely to be male
- Homeowner with garage in urban core or suburbs
- Drives shorter distances, closer to 10 miles one way for commute

¹ Unplugged: Electric vehicle realities versus consumer expectations; Deloitte, 07/27/2012

² Gordon-Bloomfield, N. Just 'Who is a Typical 2011 Nissan Leaf Buyer?' We Find Out. Green Car Reports, 09/10/2010

Early Adopter and Early Majority Characteristics in Study Area MSAs

Using the benchmark characteristics defined for Early Adopters, there appears to be a segment of the population in the study area MSAs that fit a number of the criteria. The following provides high level characteristics of these two adopter groups for the Columbus and Cleveland MSAs.

Columbus MSA

Considering only the household incomes in the Columbus MSA, less than 50,000 households meet the threshold of Early Adopter incomes, though nearly twice that number of households fall within the income range for the Early Majority. The total pool of potential EV owners falling into the Early Adopter and Early Majority categories is nearly 150,000 households, though only 40,000 live in the City of Columbus. The majority of Columbus' residents and workers live within the ranges of the EVs currently on the market, driving less than 50 miles daily, with almost 70% driving less than 20 miles.

Early Adopter Characteristics

- 7% of MSA households earn over \$150K, 25% live in Columbus proper
- 68% of housing units in the Columbus study area are single-family
- 82% of Columbus area workers commute less than 25 miles (each way)
- 67% of Columbus area workers commute less than 10 miles (each way)
- 33% are college graduates, 33% of those live in Columbus proper
- 12 % have graduate/professional degrees, 11% live in Columbus proper

Early Majority Characteristics

- 20% of MSA households earn over \$100K, 28% live in Columbus proper
- 14% of MSA households earn between \$100,000 and \$150,000, 30% live in Columbus proper
- 67% of Columbus area workers commute less than 10 miles (each way)

Cleveland MSA

In the Cleveland MSA, 46,000 households earn more than \$150,000 while 100,000 households earn between \$100,000 and \$150,000, making the total potential Early Adopter and Early Majority pool 146,000 households. Fewer than 7% of those households live in the City of Cleveland. Eight-three percent of workers commute less than 50 miles daily, and 54% commute less than 20 miles daily.

Early Adopter Characteristics

- 6% of the MSA earns over \$150K, 6% live in Cleveland proper
- 70% of housing units in the Cleveland study area are single-family
- 83% of Cleveland workers commute less than 25 miles (each way)
- 54% of Cleveland workers commute less than 10 miles (each way)
- 28% are college graduates, 14% live in Cleveland proper
- 11% have graduate/professional degrees, 5% live in Cleveland proper

Early Majority Characteristics

- 17% of MSA households earn over \$100K, 7% live in Cleveland proper
- 12% of MSA households earn between \$100,000 and \$150,000, 7.5% live in Cleveland proper
- 54% of Cleveland workers commute less than 10 miles (each way)

Early Adopter and Early Majority Cities

AECOM analyzed the cities in the Columbus and Cleveland MSAs outside each City proper to determine which had the largest number of households that met the income for the Early Adopter and Early Majority. For each MSA analyzed, the first table shows the top five communities by Early Adopter households while the second shows the top five communities by Early Majority households. While some communities appear on both lists, others have a higher share in one category than the other, indicating at which adoption phase greater attention should be focused on them. The tables also show the share of each city's population that is represented by the Early Adopters and Early Majority.

Columbus MSA

In the Columbus MSA cities, there are approximately 100,000 households with incomes over \$100,000, and 36,000 over \$150,000. This means that 69% of the region's potential Early Majority lives within incorporated areas and 78% of the Early Adopters do. Seventeen percent of the Early Majority lives in the top five communities (by income) listed below and 27% of the Early Adopters do, meaning that focus on those communities will be needed to serve a significant portion of the Early Adopters and Early Majority.

Table 21: Columbus MSA Cities with Early Adopter Households

	#	Over \$150,000
		Share
Dublin	4,200	27.2%
Upper Arlington	2,700	19.3%
Westerville	2,200	16.1%
Gahanna	2,000	15.3%
Powell	1,400	36.6%

Source: U.S. Census, AECOM

Table 22: Columbus MSA Cities with Early Majority Households

	#	Over \$100,000
		Share
Dublin	7,400	48.6%
Westerville	5,200	37.3%
Upper Arlington	5,100	36.6%
Gahanna	4,500	34.4%
Hilliard	3,400	33.1%

Source: U.S. Census, AECOM

Cleveland MSA

In the Cleveland MSA cities, there are approximately 120,000 households with incomes over \$100,000, and 44,000 over \$150,000. This means that 82% of the region's potential Early Majority lives within incorporated areas and 92% of the Early Adopters do. Sixteen percent of the Early Majority live in the top five communities (by income) listed below and 20% of the Early Adopters do, meaning that focus on those communities will be needed to serve a significant portion of these consumers.

Table 23: Cleveland MSA Cities with Early Adopter Households

	Over \$150,000	
	#	Share
Strongsville	2,442	14.0%
Westlake	2,365	16.8%
Shaker Heights	2,353	20.1%
Solon	1,960	23.4%
Cleveland Heights	1,513	7.6%

Source: U.S. Census, AECOM

Table 24: Cleveland MSA Cities with Early Majority Households

	Over \$100,000	
	#	Share
Strongsville	5,800	33.6%
Mentor	4,700	24.5%
Westlake	4,600	32.5%
Parma	4,200	12.3%
Shaker Heights	4,000	33.9%

Source: U.S. Census, AECOM

Top Employers and Commuting Patterns

Where the Early Adopters and Early Majority Live and Work

Large regional employers in the Columbus and Cleveland MSA represent concentrations of employees. These employers are found within the central business districts as well as the surrounding MSA. These employers represent the following sectors: healthcare, government, education, financial activities, and manufacturing. Cleveland's top 10 largest employers contribute 85,000 jobs, and Columbus' contribute 140,000 jobs.

Cleveland Largest Employer Characteristics

The following represent the characteristics of the 10 largest employers in the Cleveland MSA.

- 8.6% of Cleveland's total employment
- Healthcare represents 5.2% of total employment
- Manufacturing represents 1.1% of total employment

Table 25: Cleveland 10 Largest Employers, 2012

Rank	Company	Sector	Employees
1	Cleveland Clinic Health System	Hospitals	39,088
2	Giant Eagle	Food grocery	12,216
3	Summa Health System	Health care hospitals	10,000
4	The Progressive Group of Insurance Cos.	Insurance	8,900
5	Swagelok Co.	Valves and fittings	3,686
6	Sherwin-Williams Co.	Manufacturing and retail	2,996
7	Southwest General Health Center	Health care hospitals	2,600
8	Kaiser Permanente	Nonprofit	2,187
9	The Lubrizol Corp.	Industrial goods	2,087
10	Eaton Corp.	Industrial equipment	1,716
Total			85,476

Source: The Plain Dealer

Columbus Largest Employer Characteristics

The following represent the characteristics of the 10 largest employers in the Columbus MSA.

- 15.4% of Columbus' total employment
- Government represents 4.6% of total employment
- Education represents 4.2% of total employment
- Financial Services represents 3.1% of total employment
- Healthcare represents 2.7% of total employment

Table 26: Columbus 10 Largest Employers, 2012

Rank	Company	Sector	Employees
1	The Ohio State University	Education	29,685
2	State of Ohio	Government	22,030
3	JP Morgan Chase	Financial Activities	16,975
4	Ohio Health	Health Care	16,000
5	Nationwide Insurance	Financial Activities	11,235
6	United States Government	Government	10,800
7	City of Columbus	Government	8,653
8	Columbus Public Schools	Education	8,611
9	Mt. Carmel Health Systems	Health Care	8,448
10	Honda of America	Manufacturing	7,400
Total			139,837

Source: City of Columbus

AECOM analyzed the commuting patterns for Columbus and Cleveland to determine concentrations of employment and where employees live in relation to where they work. The following analysis uses the US Census' OnTheMap data for 2009 to examine key municipalities from which employees commute, the age and incomes of employees and the market sectors they are employed in to determine how these commuting characteristics will influence infrastructure needs.

Columbus Commuting Patterns

The table below looks at the top 10 cities where Columbus workers live and highlights the fact that 39 percent of people who work in Columbus live in Columbus. For those living outside the City limits and commuting in, the population is dispersed in terms of where people live.

- For Columbus residents, 54 percent work in Columbus
- For Columbus workers, 39 percent live in Columbus
- Dublin is the next largest City employing residents of Columbus
- Upper Arlington is the next most common area of residence for Columbus workers
- There are residents of Columbus that work in Cleveland or Cincinnati

Table 27: Where Columbus Workers Live and Residents Work, Top 10 Cities

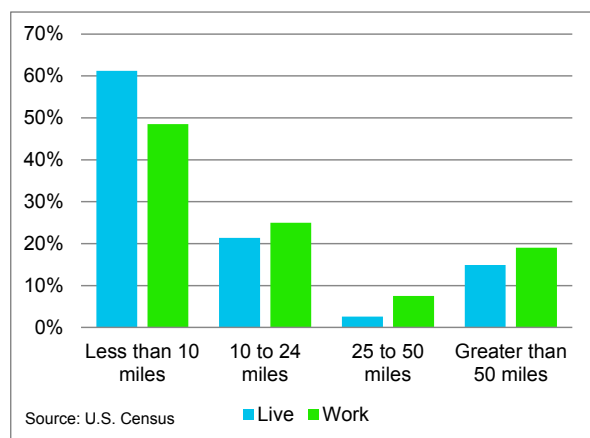
Where Residents Work			Where Workers Live		
Columbus	163,195	53.6%	Columbus	163,195	39.1%
Dublin	14,202	4.7%	Upper Arlington	8,612	2.1%
Westerville	8,680	2.9%	Gahanna	7,966	1.9%
Grove City	5,720	1.9%	Dublin	7,599	1.8%
Worthington	4,970	1.6%	Westerville	7,579	1.8%
Hilliard	4,768	1.6%	Reynoldsburg	6,948	1.7%
Gahanna	3,806	1.2%	Hilliard	6,582	1.6%
Whitehall	3,778	1.2%	Grove City	6,546	1.6%
Upper Arlington	3,274	1.1%	Whitehall	4,089	1.0%
Cleveland	2,958	1.0%	Lancaster	3,732	0.9%
Cincinnati	2,587	0.8%	Delaware	3,724	0.9%

Source: U.S. Census

The figure below outlines distances traveled each way to and from the City of Columbus for commuters.

- 82.6 percent of Columbus residents travel less than 25 miles to their place of employment
 - 61.2 percent travel less than 10 miles
- 73.5 percent of Columbus workers travel less than 25 miles from their place of residence
 - 48.5 percent travel less than 10 miles

Figure 27: Columbus Commute Distance



Commuting Patterns of Top Five Early Adopter Cities

In order to understand the commuting patterns of the Early and Majority adopters in the region that live outside the City of Columbus, AECOM analyzed the top five secondary cities in the region that have the highest number of potential Early Adopters by income. The table below shows the distances traveled by residents of the top five secondary cities identified with concentrations of potential Early Adopters, identifying how far these residents travel to get to work and if an EV would be viable for their commute.

In all five cities, between 80% and 87% of residents drive less than 25 miles to work. At 76%, Upper Arlington has the most residents who drive less than 10 miles to work. Gahanna is second with 61% of residents commuting fewer than 10 miles to work. The remaining communities of Dublin, Westerville, and Powell have approximately 43% - 45% travelling fewer than 10 miles.

Table 28: Top Five Cities, Columbus MSA

	Under 10 Miles		10-25 Miles		% of Total
Upper Arlington	11,221	76.0%	1,552	10.5%	86.5%
Gahanna	10,391	60.5%	3,616	21.1%	81.6%
Dublin	7,943	45.1%	7,054	40.1%	85.2%
Westerville	7,666	45.0%	6,097	35.8%	80.8%
Powell	1,694	43.5%	1,503	38.6%	82.1%

Source: U.S. Census

As indicated in the table below, the primary destination for commuters in these five cities is Columbus, and for every city, excluding Powell, the home city represents the second largest employment destination. For Powell, Dublin and Westerville are top destinations for commuters after Columbus, with Powell itself coming in fourth.

Table 29: Primary Commute Locations, Top Five Cities, Columbus MSA

	Columbus	Home City
Upper Arlington	58.4%	6.7%
Gahanna	49.9%	7.4%
Dublin	45.1%	16.9%
Westerville	45.7%	11.1%
Powell	44.5%	2.7%

Source: U.S. Census

Cleveland Commuting Patterns

The following section examines the commuting patterns of Cleveland residents and workers, highlighting the places where they commute to and from as well as the distances they travel to their place of employment.

- Compared to Columbus, Cleveland has a smaller share of its workers who live within the City limits, with more coming from the surrounding suburbs
- There are a number of workers who are commuting from Columbus to Cleveland
- Those that live in Cleveland are more likely to work in Cleveland than outside the City
- Parma was the most common place of residence for those working in the City but living outside, and is also the most common employment center for Cleveland residents to commute for work

Commuting Patterns of Top Five Early Adopter Cities

In order to understand the commuting patterns of the Early Adopters in the region who live outside the City of Columbus, AECOM analyzed the top five secondary cities in the region that have the highest number of potential Early Adopters by income. The table below shows the distances traveled by residents of the top five secondary cities identified with concentrations of potential Early Adopters to identify how far these residents travel to get to work and if an EV would be viable for their commute.

In all five cities, over 80% of residents commuted less than 25 miles to work, with three of the five at nearly 90% of workers. Cleveland Heights and Shaker Heights had 77% and 80%, respectively, commuting fewer than 10 miles to work, and commutes between 10–25 miles at 12% and 10% respectively. The remaining three cities of Westlake, Solon, and Strongsville have approximately 44–46% of commuters traveling less than 10 miles.

Table 30: Where Cleveland Workers Live and Residents Work, Top 10 Cities

Where Cleveland Workers Live			Where Cleveland Residents Work		
Cleveland	62,713	27.1%	Cleveland	62,713	46.20%
Parma	9,531	4.1%	Parma	3,557	2.60%
Lakewood	8,284	3.6%	Independence	2,262	1.70%
Cleveland Heights	6,989	3.0%	Beachwood	2,233	1.60%
Euclid	5,586	2.4%	Solon	2,071	1.50%
Strongsville	4,271	1.8%	Euclid	2,055	1.50%
Shaker Heights	4,163	1.8%	Westlake	2,050	1.50%
North Olmsted	3,873	1.7%	Brooklyn	2,026	1.50%
Westlake	3,559	1.5%	Middleburg Heights	1,802	1.30%
Garfield Heights	3,095	1.3%	Lakewood	1,788	1.30%
Columbus	2,958	1.3%	Cleveland Heights	1,746	1.30%

Source: U.S. Census

The following chart shows the distance which commuters who live or work in Cleveland travel each way.

- 88.4 percent of Cleveland residents travel less than 25 miles each way for work
 - 69.8 percent travel less than 10 miles each way
- 82.7 percent of Cleveland workers travel less than 25 miles each way for work
 - 53.4 percent travel less than 10 miles each way

Figure 28: Cleveland Commute Distance (one way)

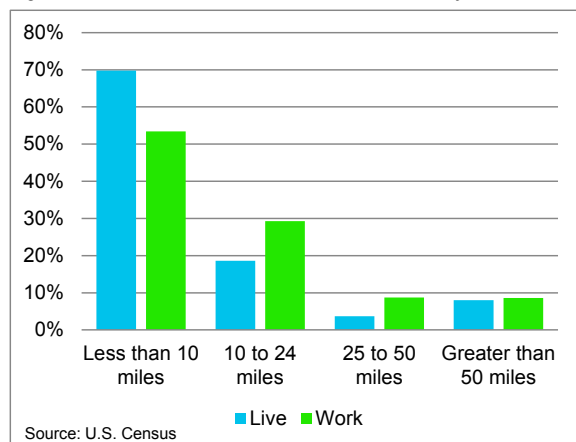


Table 31: Top Five Cities, Cleveland MSA

	Under 10 Miles		10–25 Miles		% of Total
Cleveland Heights	13,553	76.6%	2,083	11.8%	88.4%
Shaker Heights	8,786	80.0%	1,040	9.5%	89.5%
Westlake	5,979	43.6%	5,481	40.0%	83.6%
Solon	4,405	45.6%	4,332	44.8%	90.4%
Strongsville	1,694	43.5%	1,503	38.6%	82.1%

Source: U.S. Census

Cleveland represents a primary commute destination for all five cities with their home cities representing the second most common destination. In Cleveland Heights and Shaker Heights, 44% and 47% (respectively) of their commuters travel to Cleveland with 7% to their home city, the second most common destination. Westlake, Solon, and Strongsville have fewer commuters traveling to Cleveland but it still represents the most common destination, followed by the home cities.

Table 32: Primary Commute Locations, Top Five Cities, Cleveland MSA

	Cleveland	Home City
Cleveland Heights	43.70%	7.50%
Shaker Heights	46.70%	7.10%
Westlake	30.40%	14.20%
Solon	23.10%	15.00%
Strongsville	24.60%	12.50%

Source: U.S. Census

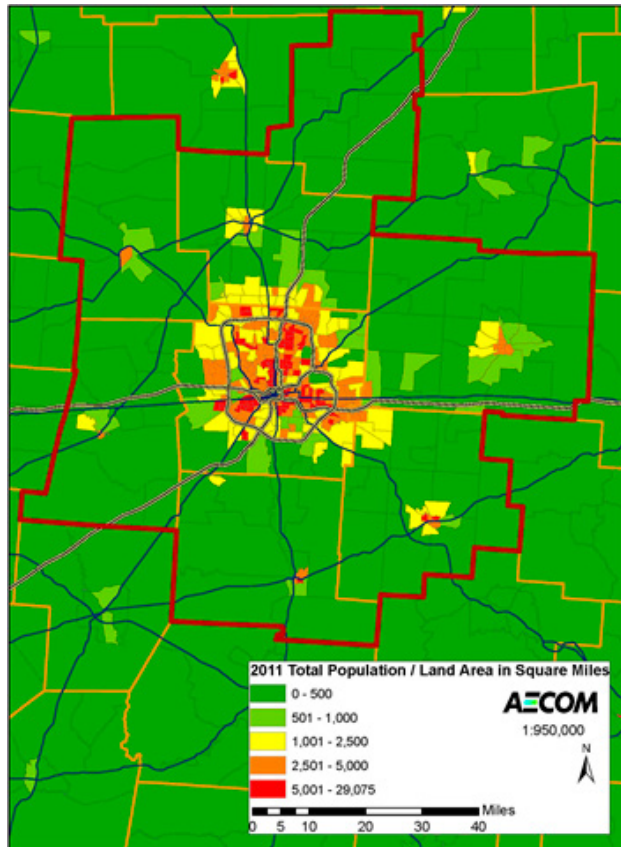
Population Density

Population density is important over the long term for EV infrastructure development because when the EV is financially viable or advantageous to the wider consumer market, communities with the greatest density will see the highest demand on utility infrastructure.

Columbus MSA

The majority of Columbus' population density occurs within Franklin County, with the remaining outlying counties in the MSA having density of less than 500 persons per square mile, except around the smaller cities in the region.

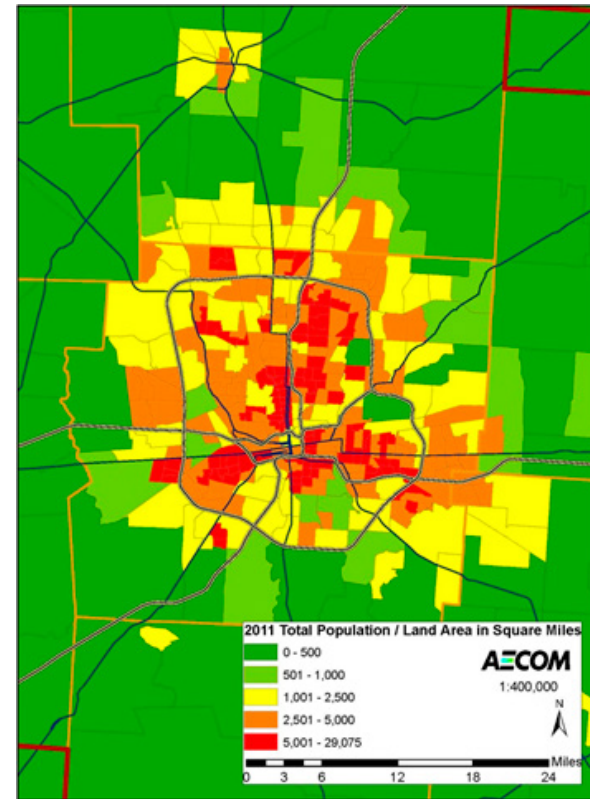
Figure 29: Columbus MSA Population Density by Census Tract



Source: ESRI

The following figure examines the dense core of the Columbus MSA to show further that the most dense census tracts in the region, containing more than 5,000 persons per square mile, occur within the I-270 ring roads.

Figure 30: Columbus Core Population Density by Census Tract

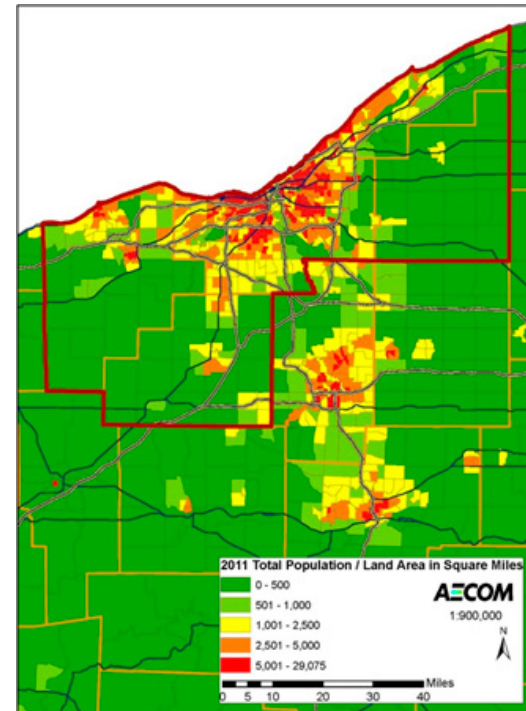


Source: ESRI

Cleveland MSA

The Cleveland MSA has a dispersed population with density focused in the downtown core in Cuyahoga County, along the lakefront communities, and down the I-71 corridor. Outside the MSA, along I-77 there are greater population densities in the Akron and Canton areas.

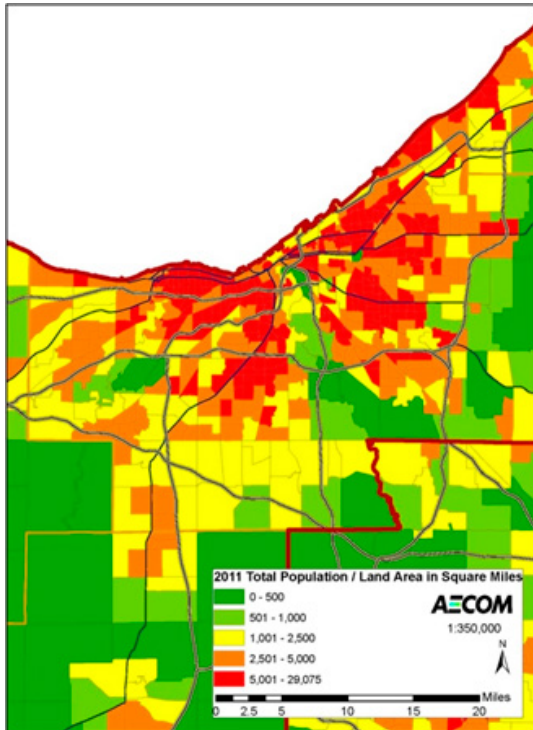
Figure 31: Cleveland MSA Population Density by Census Tract



Source: ESRI

The following figure examines the core of the Cleveland MSA to determine where population density is the greatest. In the eastern area the population density is greatest around the Cleveland Heights and Shaker Heights outside the core. South of Cleveland the Parma area has the greatest density.

Figure 32: Cleveland Core Population Density by Census Tract



Source: ESRI

Early Adopter Concentrations

While over the long term the goal is to spread EV infrastructure throughout each metro region, the initial focus for encouraging EV adoption will be to target the Early Adopters and Early Majority. In this segment the geographic distribution of those characteristics will be examined to highlight clusters of individuals that meet those criteria in order to develop targeted strategies such as marketing, ease of purchase, home charging infrastructure implementation and other issues relevant to EV ownership. In addition, the Early Adopter and Early Majority concentrations are important for the utility companies to identify, as these will be the areas where the electric grid is first impacted by EV home charging.

Household Incomes

Household incomes are a major determinant for Early Adopters as the ability to purchase the comparatively more expensive EVs will be a major hurdle to overcome. The following segment examines Census tracts that have high concentrations of upper income households, as these areas are likely to see higher early adoption demands. This does not mean these locations should be focused upon exclusively to the detriment of the rest of the regional EV infrastructure system.

The data is presented in two segments, the first being those households with a household income over \$200,000 annually, as these will be the households least impacted by the price premiums of existing EVs. The second set of maps examines households with income between \$150,000 and \$200,000, the next group of potential Early Adopter households based on the affordability criteria.

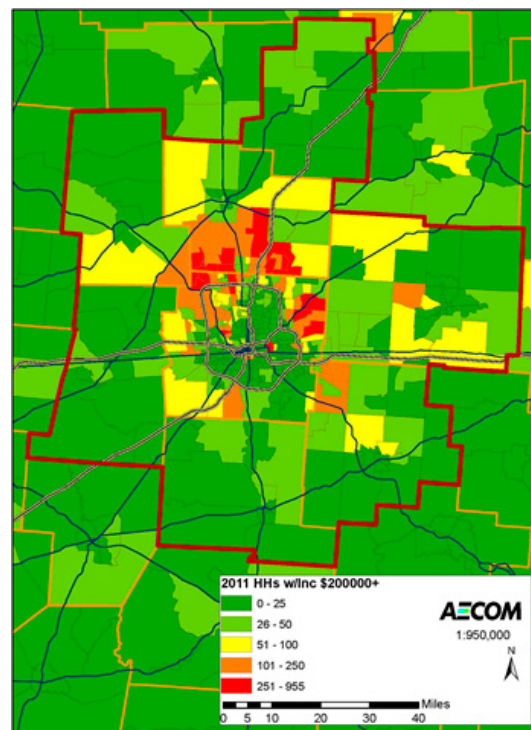
Columbus MSA

In the Columbus MSA, the earlier segment examining Early Adopters and their commuting patterns identified a number of cities that fell into the category of Early Adopter cities, specifically Upper Arlington, Gahanna, Dublin, Westerville, and Powell.

Household Incomes Over \$200,000

When the number of households with incomes over \$200,000 is compared by Census tract, the Census tracts in areas outside of Columbus' I-270 and north of I-70 have the highest number of total households, with some clusters of Census tracts located elsewhere. These clusters of high income households correlate with the communities of Upper Arlington, Dublin, Powel, Westerville, and Gahanna.

Figure 33: Columbus MSA HH's with Incomes over \$200,000, by Census Tract



Source: ESRI

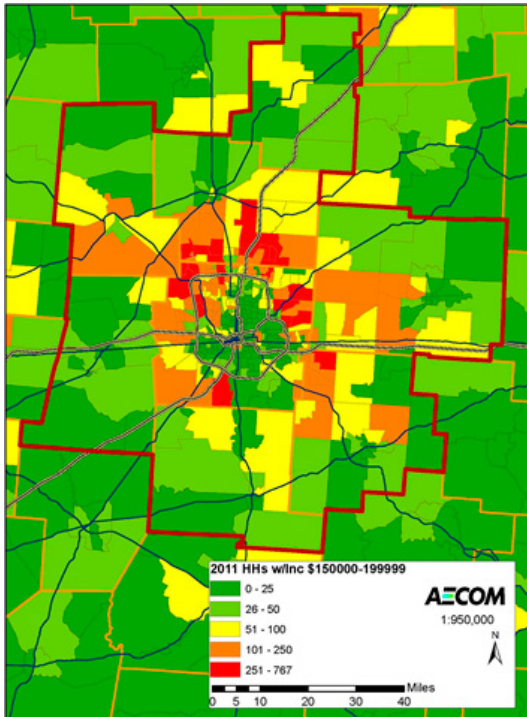
Household Incomes \$150,000-\$200,000

By income, the households earning between \$150,000 and \$200,000 are still considered to be in the Early Adopter range. For this group, vehicle premiums may be possible to overcome but may see slightly less demand initially than those in the highest income category.

In the Columbus MSA, those households follow the density of incomes

seen in the previous section with more households in the outlying areas of the MSA, representing the more exurb locations. In this income range, Pickerington, a community to the south and east of I-270 and I-70, joins the previously identified higher-income communities.

Figure 34: Columbus MSA HHs with Incomes \$150,000–\$200,000, by Census Tract



Source: ESRI

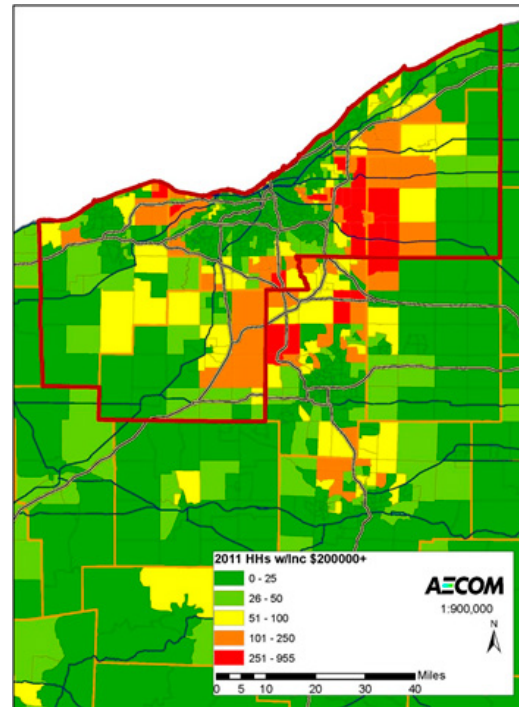
Cleveland MSA

In the Cleveland MSA, the earlier segment examining Early Adopters and their commuting patterns identified a number of cities that fell into the category of early adopter cities, specifically Strongsville, Westlake, Shaker Heights, Solon, and Cleveland Heights.

Household Incomes Over \$200,000

The Census tracts in the Cleveland MSA with household incomes over \$200,000 are most heavily concentrated east of the city. The Census tracts correspond to communities east of I-480 and I-90, such as Solon. In the south of the Cleveland MSA, there are a number of Census tracts between I-71 and I-77 south of I-80 with greater numbers of high income households. Along Lake Erie east of Cleveland there are a number of Census tracts meeting the income criteria, roughly corresponding with the communities of Westlake, Avon, and Avon Lake.

Figure 35: Cleveland MSA HHs with Incomes over \$200,000, by Census Tract

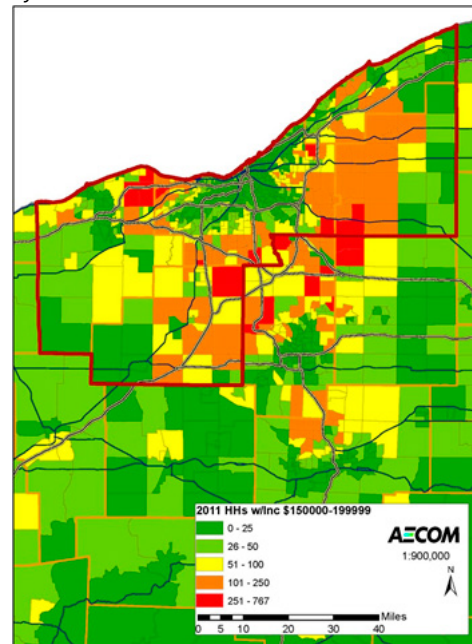


Source: ESRI

Household Incomes \$150,000–\$200,000

Trends in this income category closely followed that of the highest income households. The Census tracts east of I-480 have even more households with incomes within this range, extending further towards the MSA boundary. West of Cleveland, the Census tracts around Avon contain the greatest number of households, and south follow similar Census tracts as found with households over \$200,000.

Figure 36: Cleveland MSA HHs with Incomes \$150,000–\$200,000, by Census Tract



Source: ESRI

Workplace Charging Demand

Workplace charging represents the second leg of the EV charging station planning. As stated in the introduction to the broader discussion of charging locations, the focus of this section is to identify the concentrations of employees within the region, key employers, and office parks in order to target the needed infrastructure support as well as to highlight the viability of the EV for commuters traveling to those locations.

In this analysis, AECOM considered the city center of each MSA and used the data provided in the previous section on commuting patterns of employees in the region, resulting in the conclusion that the majority of employees worked within 10 and 25 miles of work. AECOM further looked at the regional employers based on the number of employees to identify those employers who had a significant employee base and whose involvement in workplace EV charging could serve the greatest number of individuals while also spreading awareness for the technology's viability to a broader audience. Finally, AECOM looked at the location of office parks throughout the region to highlight trends in clusters of office space where similar advantages can be leveraged.

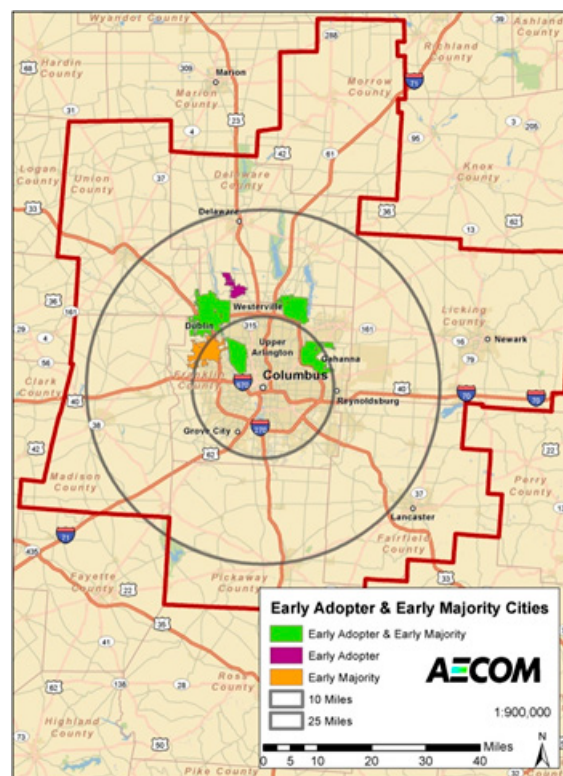
Commute to the City Center

To demonstrate that the viability of utilizing a EV to commute for work, AECOM has developed two maps that show the distance from the city center. The maps illustrate the amount of the MSA communities that are within 10 and 25 miles of the city center. As identified in the section of the report examining commuting patterns, the majority of workers in the region work within that distance, well within the range of EVs.

Columbus MSA

From downtown Columbus, a commuter could drive from as far out as Delaware and still be within 25 miles one way of downtown. The figure below shows a 10 and 25 mile ring from the city center in order to demonstrate the amount of the MSA that is within the viable commuting distance of EVs currently on the market. To further highlight the case, Early Adopter and Early Majority cities, identified previously based on their household incomes, are displayed to show that those communities are generally located along I-270 and generally within 10 miles of the city center.

Figure 37: Distance to the City Center, Columbus

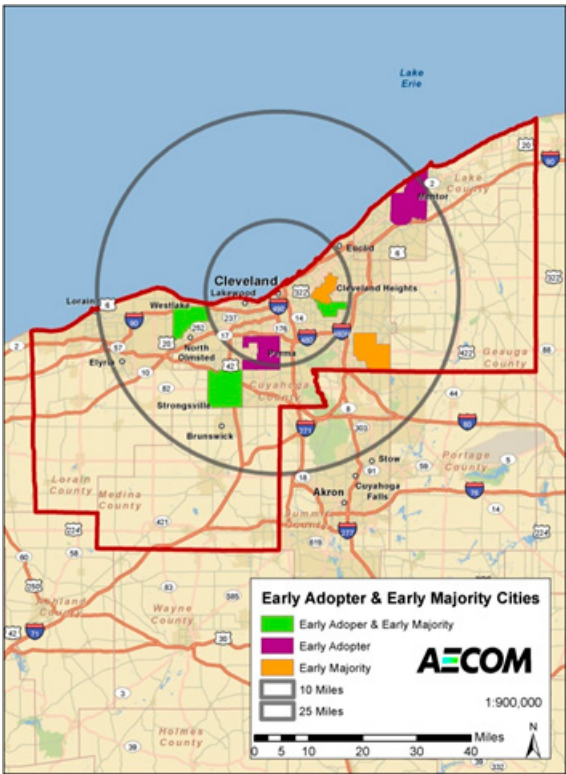


Source: ESRI

Cleveland MSA

From downtown Cleveland, a commuter could drive from as far east as Mentor and still be within 25 miles one way of downtown. The figure below shows a 10 and 25 mile ring from the city center in order to demonstrate the MSA communities that are within the single charge range of EVs currently on the market. To further highlight the case, Early Adopter and Early Majority cities, identified previously based on their household incomes, are displayed to show that those communities are spread throughout the region. Cleveland Heights, Shaker Heights, and Parma are all within 10 miles of the city center.

Figure 38: Distance to the City Center, Cleveland



Source: ESRI

Largest Employers

A region's largest employers focus a considerable amount of activity and commuting into given areas of an MSA. This section examines where the 10 largest employers are located in each MSA to gain greater understanding of the impact that EV adoption may have. In fields where educations and incomes of employees are higher, the likelihood that there will be Early Adopters and Early Majority individuals is increased as is the overall number of employees who may request workplace charging.

The maps in this section consider employment locations by number of employees to show where the largest employers are located. The largest are those with over 1,000 employees, followed by employers with 500-1,000 employees.

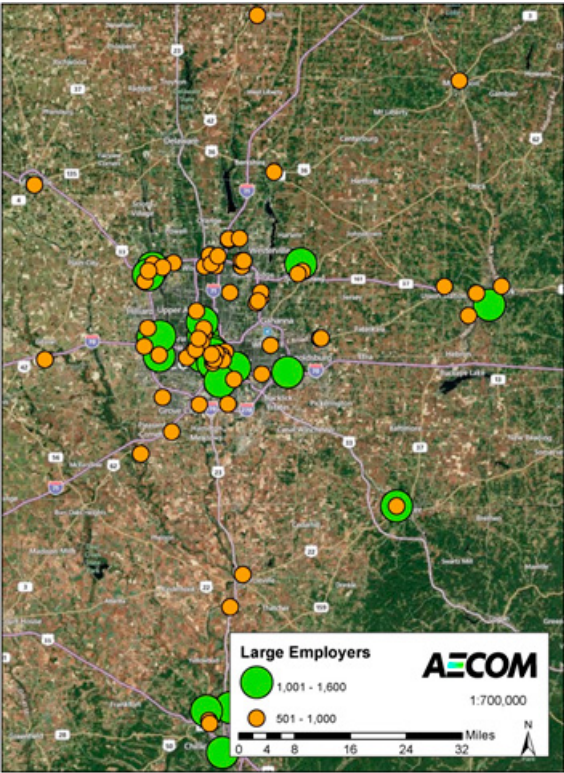
Columbus MSA

In Columbus, the largest employers are in the fields of education, government, healthcare, financial services, and manufacturing. The Columbus MSA is dominated by a number of large institutional entities that are concentrated in different sections of the MSA. The example of a concentrated employer would be the United States government which has a significant presence in downtown Columbus. In contrast, the Columbus Public School system is also a major employer, but its employees are dispersed throughout the metro area.

The following figure shows that the largest employers are concentrated in and around Columbus with a few exceptions in outlying areas. The employers with over 1,000 employees are generally located within a short distance of the downtown core, or along I-270. There is a cluster

of employers with between 500-1,000 employees around the intersection of I-71 and I-270. For a list of large employers in the Columbus MSA, please see Table 26.

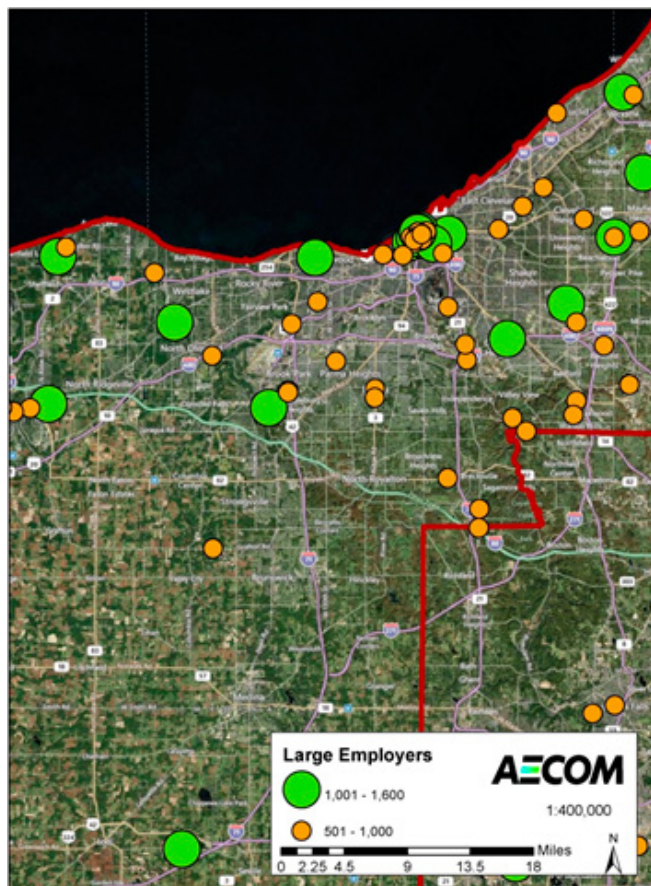
Figure 39: Largest Regional Employers, Columbus MSA
Cleveland MSA



The largest employment fields in the Cleveland MSA include healthcare, manufacturing, retail, insurance, and nonprofit firms. Certain employers, such as Giant Eagle, have multiple locations and a dispersed employee footprint, while other employers have a more limited number of locations thereby concentrating their employee footprint. A difference seen in the table below, compared to the Columbus MSA, is that government and educational employers do not have as large of a portion of total employees, while a variety of manufacturing is more dominant.

The following figure shows that the largest employers in the Cleveland MSA are distributed throughout the region. There is a cluster of the largest employers in the downtown, with the rest being in the outlying suburbs of the MSA in a roughly semi-circle pattern. The employers with 500-1,000 employees were similarly disbursed throughout the region. For a list of large employers in the Cleveland MSA, please see Table 25.

Figure 40: Largest Regional Employers, Cleveland MSA



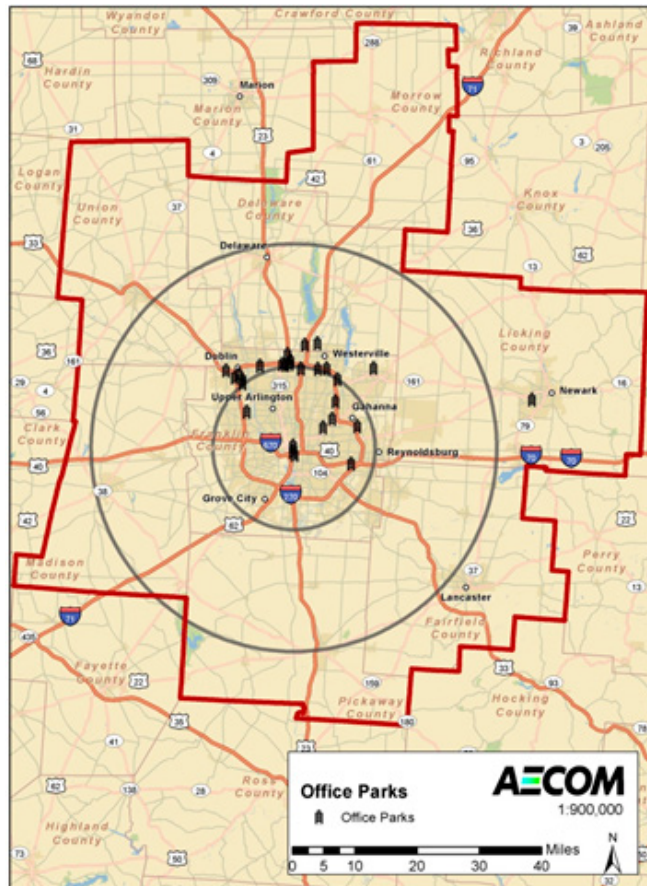
Source: InfoUSA

Office Parks

Office parks are larger than individual offices so their infrastructure capacity and concentrations of office workers who may meet the Early Adopter and Early Majority profiles are potentially greater. Another possible advantage of office parks for coordinated EV infrastructure adoption is that they are often managed by larger institutional/commercial property owners.

The following figure shows the office parks located within the Columbus MSA. The key finding is that outside the downtown core, the majority of office parks are located in the north along the I-270 corridor. These office parks are conveniently located in near proximity to the Early Adopter and Early Majority cities previously identified.

Figure 41: Columbus MSA Office Parks



Source: Columbus Business First

Public Charging Stations

Hospitals

Hospitals, like office parks, offer an ideal location for charging infrastructure. Like office parks, they employ a significant number of people at a single location, many of whom are highly educated and with greater than average incomes, meaning they could meet the profile of Early Adopters. Hospitals also have significant visitor traffic that could take advantage of charging infrastructure. As a tangential benefit, road signage already provides directions to hospitals so if EV owners are aware they are able to use these charging stations, hospital-based charging would serve as a reliable safety net for EV users.

Utilities may need to examine the grid infrastructure for hospital-based charging. Hospitals traditionally have a large demand for electricity themselves and the additional demand of highly used EV charging stations may strain the local transformers serving the facility.

Columbus MSA

In contrast to office parks in the Columbus MSA, which are located along the I-270 ring road, hospitals in the region are more dispersed to better serve the population. Hospitals throughout the region fall into three general groupings. Outside the core of the MSA, there is approximately one hospital per county, located in population centers along US and state highways. A second segment of hospitals are those located along the

EV charging infrastructure in the more densely concentrated central area of the MSA will serve the greatest number of people. the outlying hospitals should be considered prime opportunities as well, as these locations extend the EV range and provide an element of re-fueling "peace of mind" to EV owners.

Hospitals
H Hospitals

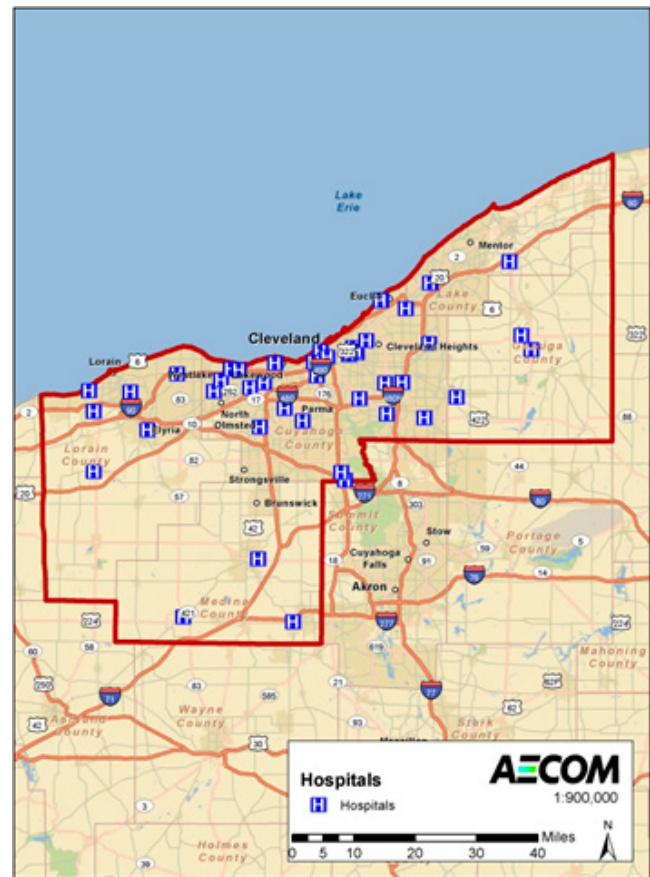
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N

Cleveland MSA

Figure 43: Hospitals, Cleveland MSA



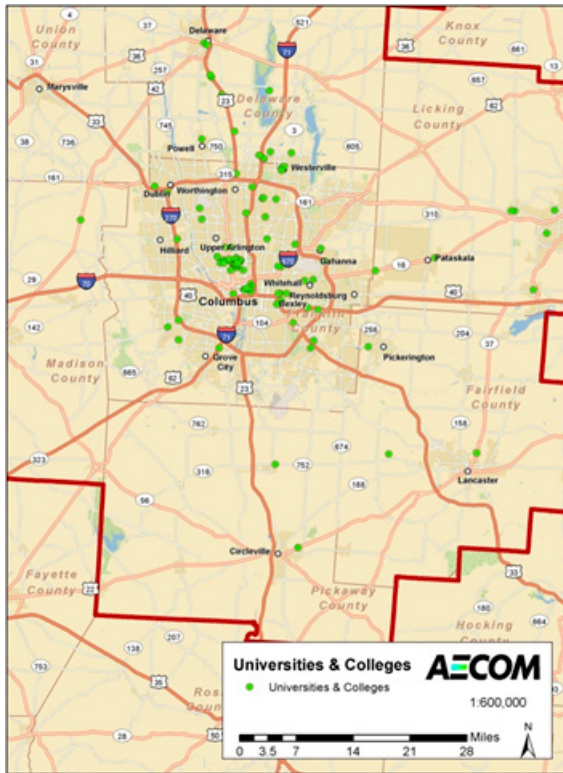
Colleges and Universities

- an educated workforce, which corresponds to Early Adopter and Early Majority characteristics
- a large number of employees in a concentrated area
- an employee and student base present on campus for hours at a time, enhancing the viability of Level 2 and, especially, Level 1 charging
- able to leverage grant funding available to public institutions
- often host to public events (sports, culture) that bring in people who are not affiliated with the University

Columbus MSA

31

Figure 44: Colleges and Universities, Columbus MSA



Source: InfoUSA

Cleveland MSA

The colleges and universities in the Cleveland MSA are mostly in the inner ring suburbs surrounding Cleveland, though the largest cluster is the area around Case Western Reserve University which is in the City proper. The second largest cluster is in the area of the Cuyahoga Community College Eastern Campus.

Figure 45: Colleges and Universities, Cleveland MSA



Source: InfoUSA

Government Buildings

Government buildings offer high visibility and demonstrate the commitment of a given agency to supporting EV adoption. By being early implementers of EV infrastructure, the municipal, state, and federal agencies that install the infrastructure will gain understanding of the challenges involved in implementation and can help to streamline the process for future users with regards to permitting, coordination with utilities, and managing the associated costs.

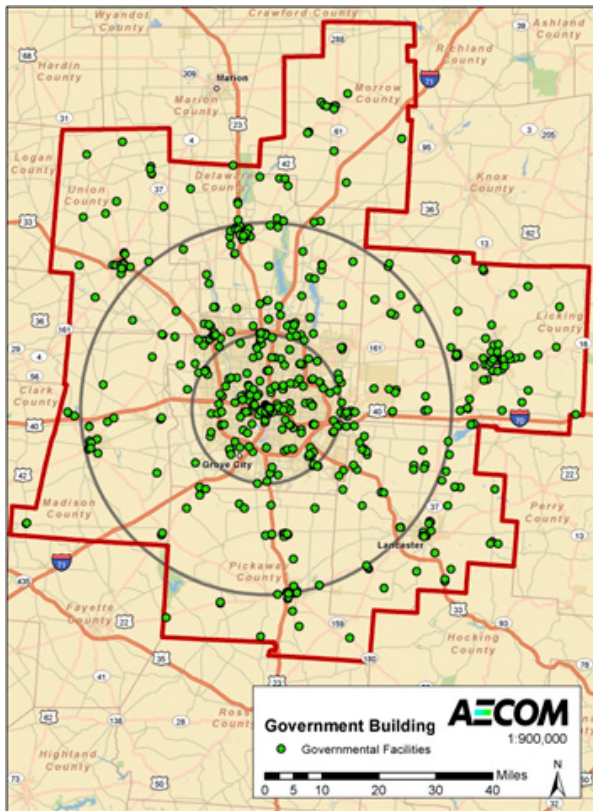
For EV charging infrastructure installed at government buildings, the importance of visibility is greater than at private locations. The visibility will help to increase public awareness of the EV charging network and, similar to hospitals, will create the connection in the EV driver's mind that they can seek out most government buildings when needing a charge.

For non-emergency government fleets, the use of EVs should allow the agency to decrease the volatility of operating costs that occurs due to fluctuations in fuel prices and take advantage of potential cost-savings created by a dedicated charging source for multiple vehicles.

Columbus MSA

The Columbus MSA has the unique characteristic of being the State Capital so in addition to the collection of county, township, and municipal government facilities there are also a number of State and Federal government facilities located throughout the region, with the majority being in downtown Columbus. Outside the MSA core, facilities are sparse and represent the local government buildings with clusters such as around Newark.

Figure 46: Government Buildings, Columbus MSA

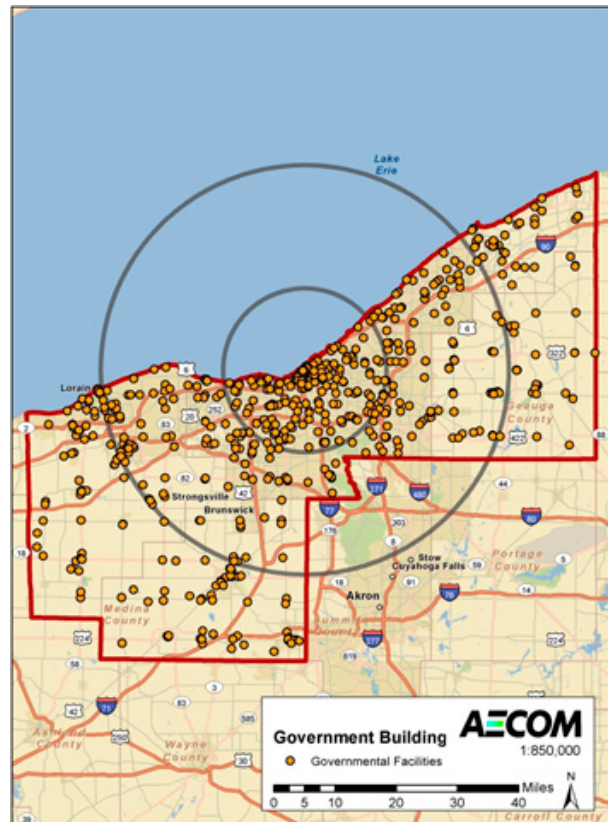


Source: InfoUSA

Cleveland MSA

The governmental buildings in the Cleveland MSA are spread throughout Cleveland and the nearby suburbs with the greatest density of government buildings in the outlying area in lakefront communities as well as in Elyria and Medina.

Figure 47: Government Buildings, Cleveland MSA



Source: InfoUSA

Destinations

Destinations are defined in this report as regional attractions (such as amusement parks and zoos), commercial locations (such as shopping malls), and rest areas. Destination charging is different from home and workplace charging in that the needs of the user are less consistent than in the other EV charging locations. Destinations may have shorter parking times, less predictable demand, and unique constraints due to ownership location or the commercial viability of charging station business models.

This section highlights general characteristics of a number of potential destination charging locations and examine the differences, advantages, and disadvantages each destination location type may possess.

Attractions

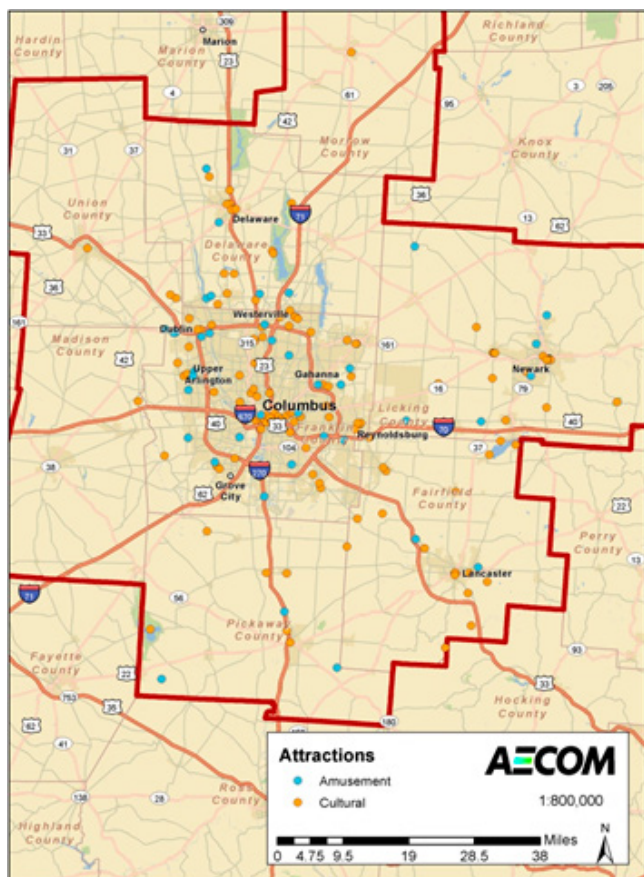
Regional attractions are locations that draw visitors from throughout the region and from even further in some cases. Venues may include sports stadiums, museums, parks, convention centers, theatres, aquariums, and zoos. These venues often include large designated parking facilities and visitors usually stay for at least two hours, and often more, on a single visit.

Some venues, such as theatres and stadiums, are event based and will have a demand for EV charging stations that is highly volatile based on the event schedule. Other venues such as museums, parks and zoos will have a more consistent demand profile for EV charging use based upon hours of operation, and will likely exhibit a demand schedule similar to

the incoming and outgoing flows of visitors over the course of the day. These two scenarios exhibit a different set of demands and challenges for venues that install EV charging infrastructure as the availability of charging stations to EV drivers varies in each case.

Demand for EV charging stations at destinations will likely be low through 2015. Over time as EV ownership and vehicle range increase, the demand for EV charging stations at destinations will also increase.

Figure 48: Amusement and Cultural Attractions, Columbus MSA



Source: InfoUSA

In the Cleveland MSA the cultural attractions are well distributed throughout the region while the amusement type attractions are concentrated in the southwest suburbs.

Figure 49: Amusement and Cultural Attractions, Cleveland MSA



Source: InfoUSA

Commercial Locations

Commercial locations such as shopping centers and individual retailers have similarities to regional attractions in that people will travel further to go to them, but the majority of retail establishments are local in nature, serving a relatively compact customer base within a few miles' distance from the consumer's residence. As such, the economic viability for installing EV charging stations can vary based on the type of retailer, length of visitor stay, and geographic location of the business.

Individual Retailers

A number of retailers have indicated an interest in implementing pilot programs to test out EV charging infrastructure at their locations including Walgreen's, Macy's, Kohl's and Best Buy. There are multiple reasons why a retailer may choose to include EV charging stations on their property, such as cultivating a green image, furthering commitments to environmental policies, to assist in the LEED certification of new construction, and to keep customers in their stores longer.

Shopping Centers

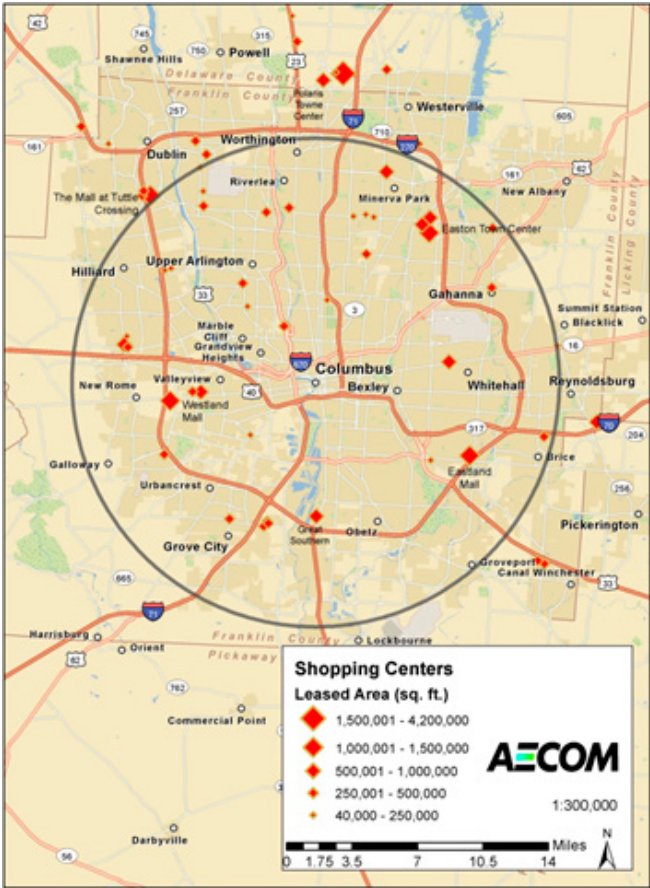
In addition to retailers who have shown an interest in EV charging infrastructure for their individual stores, large shopping centers, malls and strip malls offer an additional location for potential charging stations. With large volumes of daily traffic to and from these locations and with

shoppers staying for an extended period of time, these locations provide an opportunity for EV charging stations to be conveniently located in areas where users are encouraged to leave their vehicles for longer periods than at individual retail locations.

Columbus MSA

In the Columbus MSA, there are numerous shopping centers of various sizes, ranging from 40,000 square feet to 4,200,000 square feet, with the majority of locations spread throughout the region along the I-270 ring road. The largest mall to the southwest of downtown is the Westland Mall, and the Eastland Mall is the largest to the southeast. The Mall at Tuttle Crossing is a collection of centers in the northwest, and the Easton Town Center is the largest collection to the northeast. North of I-270 along I-71 is the Polaris Fashion Place. There are few very large shopping centers in the downtown area over 250,000 square feet, most tend to be in the outlying suburbs.

Figure 50: Columbus MSA Shopping Centers over 40,000 sq. ft.

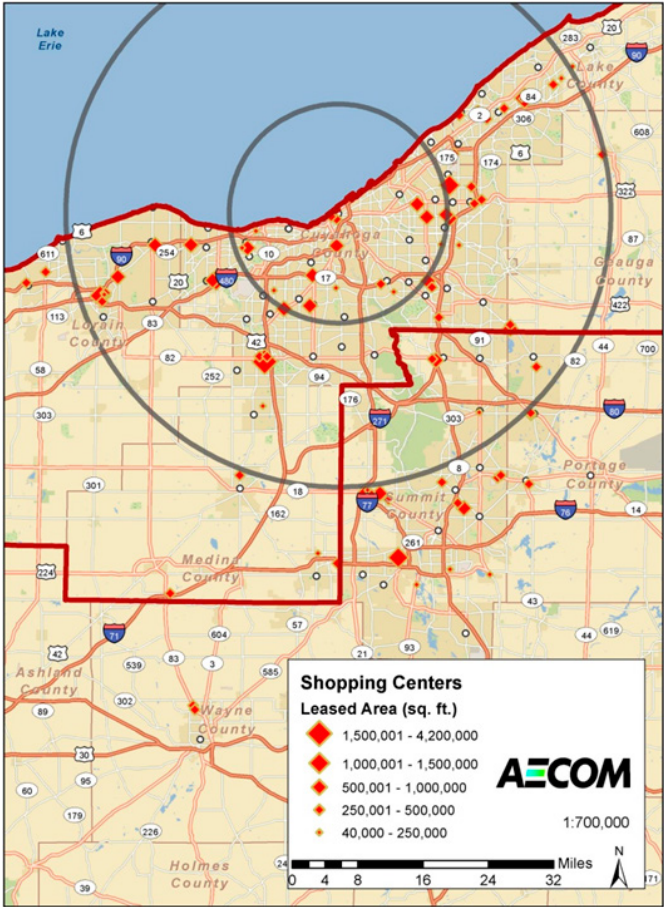


Source: InfoUSA

Cleveland MSA

The Cleveland MSA has a mix of large and very large shopping centers distributed throughout the MSA. One of the region's largest shopping center is the South Park Shopping Center in Strongsville.

Figure 51: Cleveland MSA Shopping Centers over 40,000 sq. ft.



Source: InfoUSA

Rest Areas

The figure below shows the locations of all rest areas in Ohio. For the I-71 corridor connecting the Columbus and Cleveland MSAs, there are rest areas just north of Columbus in Delaware (mile marker 129), and truck-only locations outside of Morrow (mile marker 149), Wayne (mile marker 196), and Medina (mile marker 224). At first glance there would also appear to be a rest area midway between the two MSAs in the town of Mansfield, but this station is actually located a few miles off the interstate, meaning the prime location for EV charging between the two MSAs is less accessible.

Figure 52: Ohio Rest Area Locations



Source: Ohio Department of Transportation (ODOT)

In the table below, the characteristics of the three pairs of rest areas are compared, as well as the truck only site in Morrow. The locations with car parking are modern facilities with between 28–32 spaces for cars and 12–28 for trucks. The amenities vary with the Wayne rest areas having the most.

Table 35: I-71 Rest Areas

County	Route	Dir.	Mile Marker	Amenities	Parking		Location Type
					Car	Truck	
Delaware	I-071	NB	128	Vending, Drinking Water	28	12	Modern
Delaware	I-071	SB	129	Vending, Drinking Water	29	11	Modern
Morrow	I-071	NB	149		0	18	Truck Only
Morrow	I-071	SB	149		0	18	Truck Only
Wayne	I-071	NB	197	Vending, Family Restroom, Drinking Water	32	28	Modern
Wayne	I-071	SB	197	Vending, Family Restroom, Drinking Water	32	26	Modern
Medina	I-071	SB	224	Drinking Water	32	20	Modern
Medina	I-071	NB	224	Drinking Water	32	12	Modern

Source: ODOT

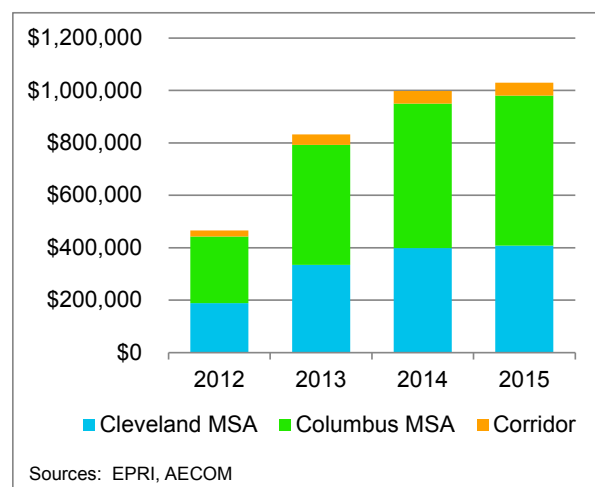
State Tax Revenue



Sales taxes are collected on vehicle purchases and are determined by the county in which the vehicle is purchased. The following section outlines potential sales tax revenues generated by the sale of new PEVs in the study areas using sales forecasts and averages of county sales tax rates for each area. The forecast goes through 2015 as these are years where the decrease in battery costs can be more accurately projected and therefore decreases in vehicle costs more reasonably estimated.

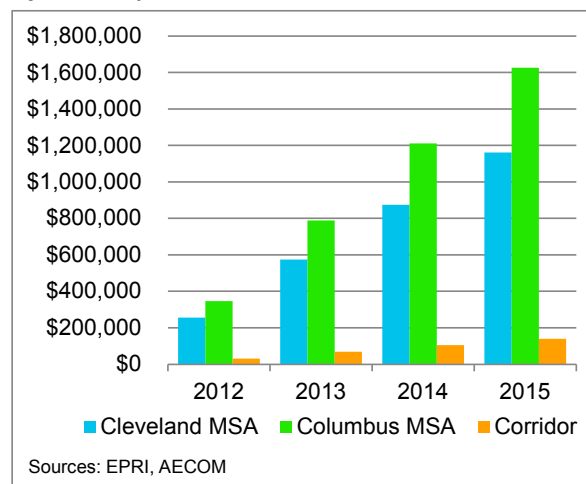
In the figure below, the sales tax revenue generated by new sales of all-electric vehicles in each of the MSAs and the 1-71 corridor are shown annually through 2015. Total revenues would increase from approximately \$465,000 in 2012 to \$1 million in 2015. The combined revenue over the time period is \$3.3 million.

Figure 53: Projected All-Electric Vehicles Sales Tax Revenue



The next figure shows that the sales tax revenue for PHEV will be greater than that of all-electric vehicles. This is due to a larger number of sales of these vehicles during those years. In 2012, combined revenues could be as high as \$632,000, reaching \$2.9 million by 2015, for a combined total over the time period of \$7.2 million.

Figure 54: Projected PHEV Sales Tax Revenue



Fuel Tax Revenue

As in the comparison for fuel savings, the 2012 Nissan Leaf and Chevrolet Cruze have been used in this comparison to illustrate the difference in revenue that a single electric vehicle would have on fuel tax revenues collected in the State of Ohio.

The following table illustrates a challenge facing fuel tax revenue. As fuel efficiency in cars improves, the amount of fuel tax revenue that all cars generate decreases; over time fuel tax revenue reductions are not caused by electric vehicles alone.

Table 36: Annual Fuel Tax Revenue per Car

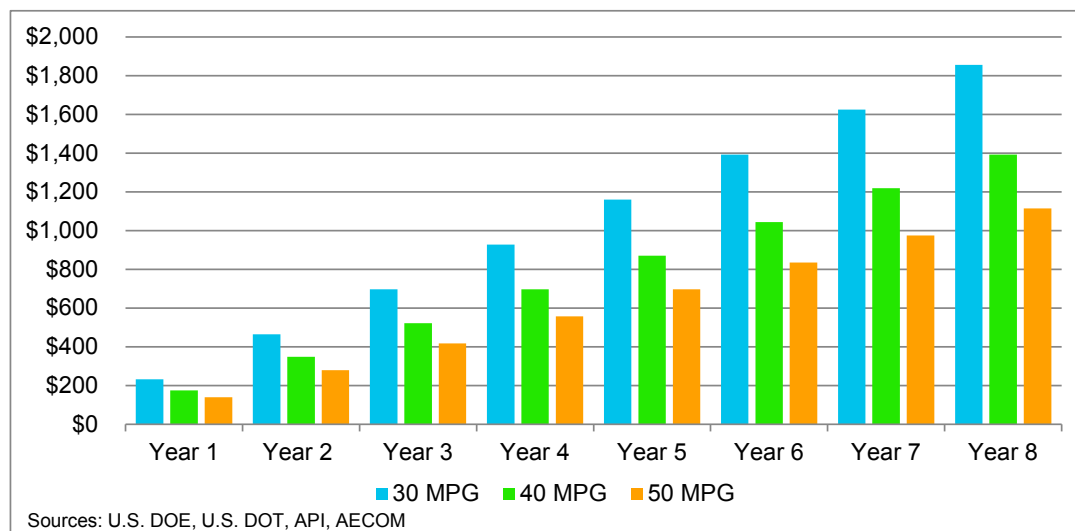
	30 MPG	40 MPG	50 MPG
Consumption (gallons per year)	500	375	300
Annual Fuel Tax			
Federal (\$0.18 per gallon)	\$92	\$69	\$55
State (\$0.28 per gallon)	\$140	\$105	\$84
Total	\$232	\$174	\$139

Total Fuel Tax for 8 Years			
Federal (\$0.18 per gallon)	\$736	\$552	\$442
State (\$0.28 per gallon)	\$1,120	\$840	\$672
Total	\$1,856	\$1,392	\$1,114

Sources: U.S. Department of Transportation, U.S. Department of Energy, American Petroleum Institute (API), AECOM

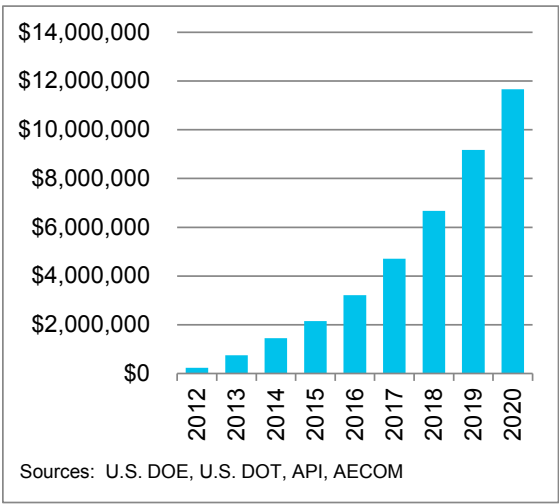
Over the eight year life of owning a 2012 EV, the driver will have been saved from purchasing 4,000 gallons of fuel, meaning that they would not have paid a cumulative \$1,856 in federal and state fuel taxes (assuming no increase in those gas tax rates). Figure 3 shows the decreasing tax loss that arises from increasing CAFE standards, as they are now legislated to average over 50 MPG by 2025, with lighter/smaller vehicles (similar to marketed EVs in size) in some cases already with MPG ratings in excess of 40 MPG.

Figure 55: Cumulative Fuel Tax Revenue Equivalent for MPG Ranges: 30, 40, 50 MPG



The magnitude of fuel tax losses then decreases as the comparable vehicles become more fuel efficient. In the next figure, the cumulative impact of lost fuel tax revenue is calculated for EVs in the study areas. Equivalent MPG ratings are considered to be 30 MPG through 2015, at which point they grow to 40 MPG, then in 2020 to 50 MPG. As there are some conventional vehicles already rating 40 MPG, this trend could be accelerated due to auto manufacturers' innovations in vehicle technologies.

Figure 56: Cumulative Fuel Tax Loss



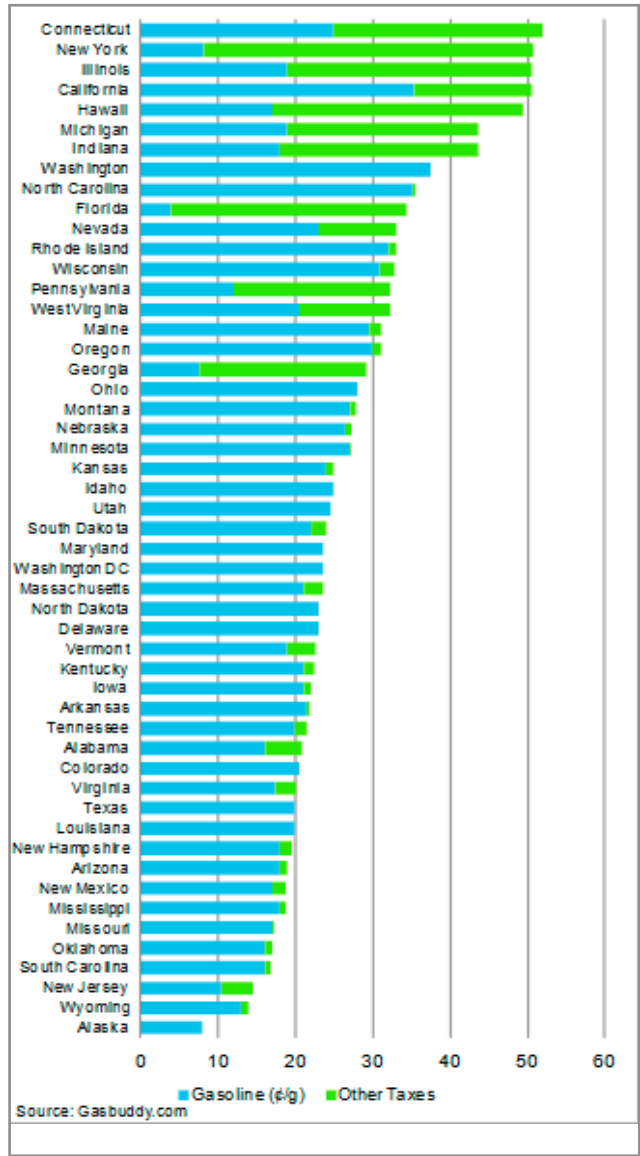
Fuel Tax Structure

EVs do not require gasoline, and plug-in hybrids require significantly less gasoline. Consequently the owner either pays no fuel tax, or a smaller fuel tax. This poses a challenge for road infrastructure funding as those taxes have traditionally been used to pay for the new construction and upkeep of roads, which an EV will still use. The following analysis looks at the existing fuel tax structure, as well as the potential alternatives to the existing fuel tax.

The fuel tax at the federal level is 18.4 cents per gallon of unleaded gas and 24.4 cents for diesel which is meant to pay for roadway maintenance, improvement and expansion. The federal fuel tax rate was last raised in 1993, and is not adjusted for inflation.

In addition to the federal fuel tax, States also individually tax gasoline sales. States either have a fixed flat rate per gallon or a “variable-rate” which ties the tax to inflation. The fixed rate is more common among the States. In Ohio, the fixed rate tax levied by the State is 28 cents per gallon. In addition to the fuel tax some states include gas in their sales tax, inspection fees, and underground storage tank (UST) fees.

Figure 57: State Fuel Taxes



A challenge facing the fuel tax is that as the fuel efficiency of vehicles improves through the increasing CAFE standards, the amount of gas used decreases while vehicle miles and infrastructure degradation remains the same, and may increase, exacerbating the gap between transportation revenue and transportation funding needs.



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