Greening the Energy Supply: Transportation

A Policy Recommendation and Research Guide for Columbus Green Transportation

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Executive Summary

The purpose of this research is to determine what policies and incentives the City of Columbus might pursue in order to help transition its local energy supply for transportation toward the use of renewable, less carbon-intensive, and less toxic alternatives. This report also assesses the viability of the STAR Communities rating system as a measure of the City of Columbus' sustainability as it relates to transportation. We chose to focus our research on the current and future ownership of fuel-efficient and alternatively fueled vehicles in the residential sector. The City of Columbus has become a leader in green transportation and it is, therefore, an excellent opportunity to use the City as an example to the public.

To begin our project we conducted extensive research in the realm of available alternative fuel technologies and the policies used to promote their adoption. This was done in conjunction with our project member Tyler Palmer, who is an intern at Clean Fuels Ohio, and through online research. Next, because the transportation portion of the STAR Communities technical guide focuses on increased ownership of alternative and more fuel efficient vehicles over time, we needed to determine if Columbus had seen an increase in ownership of these vehicle types. In order to investigate this, we acquired Ohio BMV data for Franklin County that shows the number of alternative fuel vehicles sold in the county from 1998-2012. We were unfortunately unable to acquire data regarding the sales and registration of fuel-efficient vehicles in Columbus. Instead, we chose to look at the average MPG of vehicles being sold. With this accomplished, we then analyzed the initiatives that other cities had undertaken in order to incentivize increased ownership, and researched scholarly articles for use in developing recommendations for the City.

Following our research, we are able to determine that Columbus should do quite well in the STAR Communities framework for its green transportation. We can say with confidence that Columbus has increased its percentage of alternatively fueled vehicles, and we think that the data—which suggests that traditionally fueled vehicles over the last five years have on average raised their fuel efficiency—will hold true here in Columbus. Thus, points should be earned in these categories. Additionally, we have noted a large variation in the incentives and policies that cities use to spur the adoption of alternative and fuel-efficient vehicles. Different cities have enacted and utilized initiatives that revolve around financial incentives provided to those looking to purchase AFV's and their required infrastructure. Funding for these incentives has come from either federal grants, such as the American Reinvestment and Recovery Act, or individual statewide grants and it is unlikely the Columbus will be able to acquire similar funding in the near future.

Our recommendations revolve largely around addressing barriers to adoption rather than financial incentives that directly subsidize technologies. Our recommendations include a focus on education and resource accessibility for current and potential alternative fuel vehicle owners through a collaborative development of online tools; greater engagement of Columbus residents through various promotional outlets; and finally, development of a concrete plan for future EV infrastructure implementation. We believe that these recommendations will lead to greater ease and rate of adoption of alternative and fuel-efficient vehicles and will help to ensure that the City of Columbus remains a leader in green transportation.

Introduction

The phrase "greening the energy supply" often evokes images of windmills and solar panels. These are the most current and widely available alternatives to the non-renewable sources from which most of our electric power is generated. The use of these non-renewable resources, like coal and natural gas for electric power production, poses a serious threat to the environment. They are large contributors to greenhouse gas emissions, which are a cause of global climate change (whitehouse.gov, 2013). According the United States Environmental Protection Agency (EPA), total greenhouse gas (GHG) emissions in 2011 in the United States amounted to an equivalent of 6,702 million metric tons of CO_2. Of this amount, 33% of the total was attributed to electricity generation (U.S. Environmental Protection Agency, 2013). It stands to reason than that this should be a key focus of policy makers, but there is another piece of the energy supply puzzle that cannot be overlooked: fuel for transportation. Transportation was responsible for 28% of total GHG emissions (U.S. Environmental Protection Agency, 2013), which is only five percent less than the amount produced by electricity generation. These two sectors of the energy supply are the two largest contributors to GHG emissions (U.S. Environmental Protection Agency, 2013).

However, there is a significant difference between electricity generation and transportation in terms of individual choice. The average individual does not have nearly as much potential to help curve the GHG emissions of electricity generation as they do for transportation. An individual could convert their homes to use solar energy, but most cannot afford the upfront cost of such a system (Russell, 2013). The solar energy company Sunrun estimates the cost of installation to be between $18,000 and $40,000 (Sunrun Inc., 2014). Although these figures are similar in price for what one might expect to pay for an automobile,

an automobile is a necessity for most Americans. Although the same argument can be made for electricity, there is more to it than just buying a solar power system as one does with an automobile. There are many barriers to adopting solar power in an individual's home. "A study by the National Renewable Energy Laboratory (NREL) found that only 22 to 27 percent of residential rooftops are suitable for solar photovoltaic (PV) systems" (Hois). Adding to the problem is the fact that many homeowners' associations restrict such installations, and if you live in an apartment complex you are a likely out of luck (Hois).

The length of time required for sufficient return on investment also presents an additional problem. Of those who can install a whole home solar power system, they can expect to take an average of 15 years to pay it off (Russell, 2013). In addition to these barriers associated with individual adoption of alternative energy sources, those who must keep their traditional electricity sources are not directly responsible for the GHG emissions being created, and are therefore unlikely to feel responsible for doing their part to make a change. These emissions are produced by large power plants and facilities. It should, consequently, be the companies that are producing and providing the power that must be held responsible. This is proving to be difficult, as it is commonly argued that air quality improvements come at the cost of economic development. However, this is not the case—through environmental mandates and efficiency measures, the number of unhealthy air quality days in Columbus has dropped by 82% while total GDP has increased by 40% between 1980 and 2013 (Figure 1) (See Appendix A) (U.S. Department of Commerce, Bureau of Economic Analysis, 2013; United States Environmental Protection Agency, 2013). President Obama's newly proposed Climate Action Plan describes regulation of GHG emissions from electric power sources, but there is still a long road ahead and many hurdles to overcome before that happens (Executive Office of the President, 2013).

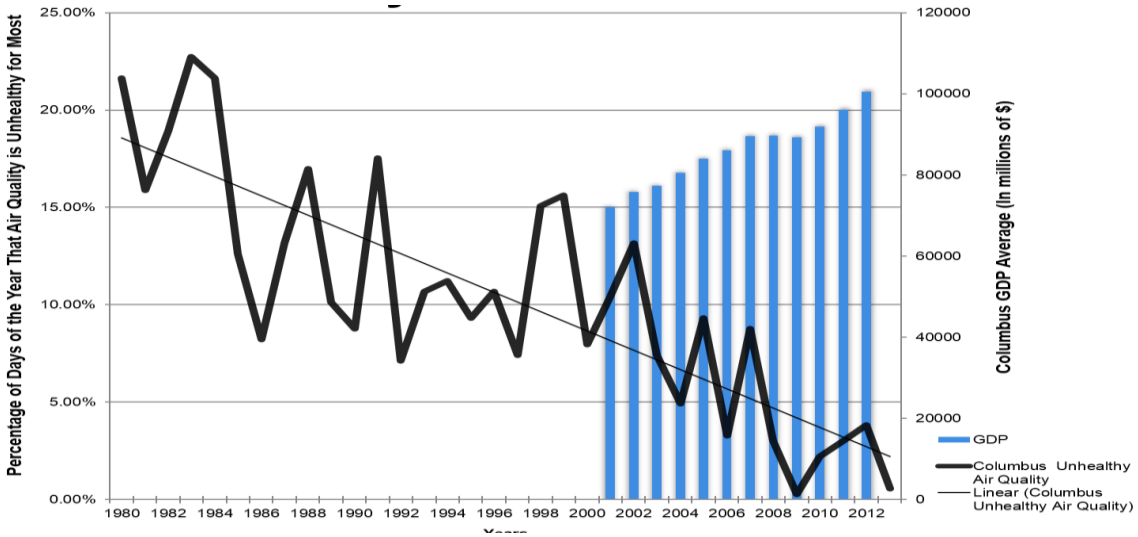

Figure 1: Number of Unhealthy Air Quality Days versus GDP (Columbus, OH)

Transportation, especially personal transportation, is something very tangible to an individual. Making an individual choice that can directly impact GHG and pollutant emissions is something very powerful (U.S. Environmental Protection Agency, 2013). It is for this reason, and the fact that the City of Columbus has already provided an excellent example for citizens to follow through their well-recognized efforts with their "Green Fleet," that we have chosen to focus our efforts and research on greening Columbus' personal transportation. The goal of our research, therefore, became to help transition the city's local energy supply for transportation toward the use of renewable, less carbon-intensive, and less toxic alternatives.

Research Findings

STAR Communities and Background

The Sustainability Tools for Assessing and Rating (STAR) Communities system was the basis for our research, specifically the Greening the Energy Supply section of the Climate and Energy "goal area" of the STAR system, called CE-3. The mission of STAR Communities is "to

address the needs of U.S. cities, towns and counties seeking a common framework for sustainability." The STAR Communities framework evaluates and quantifies "the livability and sustainability" of these area types. This is done via a self-reporting point system. In CE-3, there are a total of 15 points available. There are two ways that the city can earn these points by completing specified "Community Level Outcomes" or "Local Actions." For CE-3, 70% of the 15 points available can be achieved through the "Green Vehicles" (Transportation) and "Electrical Energy Supply" outcomes. It is from the transportation sector of these outcomes that we derived our research focus. It should also be noted that the "Green Vehicles" outcome also shows up in "Economy and Jobs" goal area the "Green Market Development" objective, and follows the exact same criteria except that it does not include the bonus section. This means that points for this outcome are actually awarded in several categories, and should, therefore, be of particular interest to the city should it decide to join STAR communities (STAR Communities, 2013).

The "Green Vehicles" outcome has two parts and a "bonus" section. To score points in part one, the City must "demonstrate increased ownership of alternative fuel vehicles by residents over time" and, to score points in part two, "demonstrate increased ownership of fuel-efficient vehicles by residents over time" (STAR Communities, 2013). These points are achieved by providing "the most recent annual or 5-year average percent change in alternative and fuel-efficient vehicles respectively" (STAR Communities, 2013). This data should be obtained via The Ohio Bureau of Motor Vehicles (BMV) and synthesized to show the five-year percentage changes for each "part" (STAR Communities, 2013). The bonus section requires that the city "demonstrate a decreased percentage of residents who own motor vehicles" (STAR Communities, 2013). Although STAR communities calls this a bonus section, it does mean that,

if the criteria is met, then more than the 15-point maximum for CE-3 can be achieved. In fact, if criteria are not met for this section, a small fraction of a point is lost (.26) (STAR Communities, 2013).

Columbus is a city that has witnessed a great deal of urban sprawl. As a result, its citizens rely greatly on personal transportation to get to their places of work and entertainment. Along with that fact that Columbus' population has continued to rise, we think it is unlikely, therefore, that Columbus could achieve the bonus points in this objective.

Our research reveals that the City of Columbus has performed quite well in terms of increased ownership of alternatively fueled and fuel-efficient vehicles over the last five years. We were able to acquire data provided by the Ohio BMV that indicates increased ownership of alternative fuel vehicles in Franklin County since 1998, when only one hybrid was sold (Bureau of Motor Vehicles, State of Ohio, 2014) (see Appendix B). Since then, sales of alternatively fueled vehicles have really taken off. The data that we acquired included data through 2013, but we were warned by the supplier that the data for 2013 might not be complete, so we chose to exclude it from our calculations.

The key to gaining points for Outcome 1, Part 1 (increased ownership of alternative fuel vehicles by residents over time) is to show that over a five-year time span that increased ownership has occurred (STAR Communities, 2013). As seen on Figure 2, alternative fuel vehicle ownership has been on the rise at a relatively consistent rate (Bureau of Motor Vehicles, State of Ohio, 2014). Figure 2 depicts the total number of alternatively fueled vehicles from 1998 to 2012 in Franklin County, as well as the change in sales from year to year (Bureau of Motor Vehicles, State of Ohio, 2014). Notice the leveling off of sales from 2007-2011 during the economic recession. Despite this, the five-year percentage increase from 2008-2012 was 162.8% (Bureau of Motor Vehicles, State of Ohio, 2014). If Columbus were to join the STAR communities, it is clear by this data that points would be achieved in Outcome 1, Part 1.

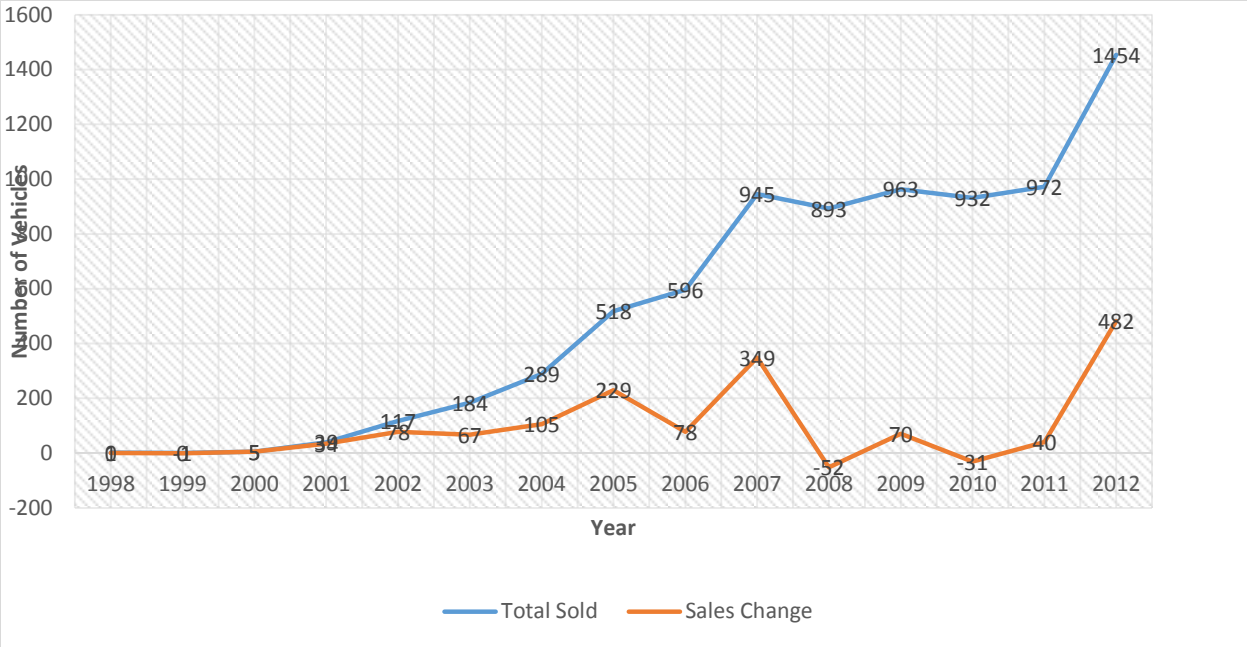

Figure 2: Alternative Fuel Vehicle Sales Trends

Unfortunately, we were not able to acquire data that directly indicated whether or not the City would achieve points for Outcome 1, Part 2 (increased ownership of fuel-efficient vehicles by residents over time). Despite this, we do believe that the City would achieve its points in this category. We believe this to be true for two reasons. First, automobile manufacturers are continually improving their vehicles' average miles-per-gallon (MPG) across all sectors of the market, and second, people are making better decisions regarding the MPG of vehicles that they are buying (TrueCar.com, 2012). We acquired data on the average MPG of vehicles sold in the

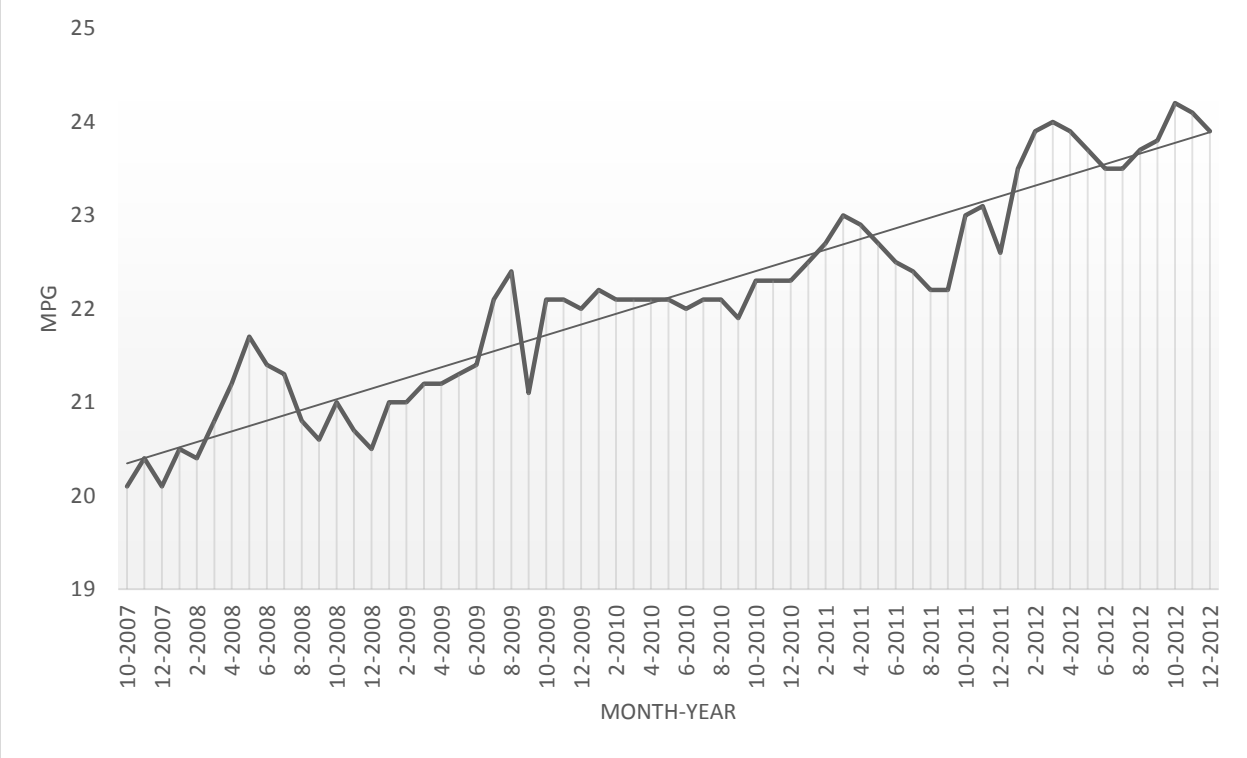

Figure 3: Average MPG Trends of Sales (Oct. 2007 - Dec. 2012)

United States from October 2007 to December 2012 (Richard, 2013) (See Appendix C). As can be seen in Figure 3, it is clear that during this time period average MPG rose significantly. The average MPG of vehicles sold rose by 18.9% (Richard, 2013). This indicates that people are

making better choices about the cars that they are buying, but this trend is not exclusive to just a few sectors of the market. Vehicles across all sectors of the market are becoming increasingly fuel efficient (TrueCar.com, 2012). From February 2011 to February 2012 sales of automobiles from twelve manufacturers were evaluated on the average MPG in the "small", "midsize", and "large truck" sectors of the market (TrueCar.com, 2012). Just within this one year period, small cars showed an increase of 1.9 MPG, midsize cars showed an increase of 1.4 MPG, and large trucks showed a .7 MPG increase (TrueCar.com, 2012) (See Appendix D). Though data for Columbus may be slightly different from the United States as a whole, it is clear that this is a trend that should hold true. Through inference then, we can say with a good deal of confidence that Columbus would achieve its points in Outcome 1, Part 2.

Again, unfortunately, we were not privy to BMV data that would indicate whether or not Columbus would get the "bonus" points. However, as stated above we don't think it is very likely that the City would due to the high dependency of most residents on motor vehicles.

From the data we acquired to determine how Columbus would fare in the "Green Vehicles" outcome, we can conclude with good certainty that Columbus would likely do well in both Parts 1 and 2. We are not so confident to say what the result would be for the "bonus" section, but it is very likely that the City of Columbus could determine this much more easily than we could. Perhaps the more significant takeaway from these data, however, is that the upward trend of alternatively fueled vehicles will likely continue over time. It is in this vein that we continued our research to discover what other cities are doing to help green their transportation energy supplies for both public and privately owned vehicles; what some of the benefits are for doing so; and then synthesized this data into recommendations that the city can

use to implement, promote, and incentivize the use of greener alternatives to those that use non-renewables for their fuel source.

Benchmarking and Assessing Columbus against Other Green Transportation Leaders

In conducting research in relation to alternative fuel vehicle infrastructure and incentive programs, it is important to understand the current progress that Columbus has made in order to promote this type of technology and market innovation. Columbus has established the Get Green Columbus initiative, which works to "identify and implement projects to reduce impact on the environment through the city's influence" (Get Green Columbus, 2014). Through this program, the city has managed to launch a pilot program, Car2Go, with over 250 Smart cars available to the public. Additionally, key initiatives include increased use of bicycling as an alternative mode of transportation, installation of electric vehicle charging and compressed natural gas (CNG) stations, and an increase in the number of City CNG fleet vehicles. Currently, Columbus has 55 CNG vehicles in use with 33 still on order, along with the nearly 300 alternative fuel vehicles in use throughout the city (Get Green Columbus, 2014).

Through its own green fleet efforts, Columbus has become a model for green transportation and has positioned itself as an example for its citizens and businesses. Via this model, the City would now like to see the community increase adoption of alternative fuel vehicle technology. While these technologies are still in their early stages, there are many examples of businesses and private citizens taking initiative to pursue these opportunities. Some prime examples can be seen in the use and incorporation of smart cars in city fleet vehicles, primarily in security and operations, as well as installing public electric charging stations with no fee to users (Going Green Easton, 2014). Additionally, The Ohio State University has

implemented the use of biodiesel in all of the Campus Area Bus Service (CABS) buses, earning them an Ohio Green Fleets Star (OSU Transportation and Traffic Management, 2014).

Although Ohio is lagging behind in incentive programs to help promote the adoption of alternative and more fuel-efficient vehicles, Ohio does have five incentive programs in place (The US Department of Energy & Alternative Fuels Data Center, 2014). These include the Ethanol Production Investment Tax Credit, the School Bus Retrofit Grant Program, Alternative Fuel and Fueling Infrastructure Incentives, the Heavy-Duty Emissions Reduction Grant Program, and the Weight Restriction Increase for Natural Gas Vehicles. These have helped business and residents increase ownership of alternative fuel vehicles, but these alone may not be enough to reach the desired goals. For example, some of our neighboring states have better and more comprehensive incentive programs. The Alternative Fuel Incentive Grant (AFIG) Program in Pennsylvania favors the expansion of business and offers $3,000 for the purchase of new alternative fuel vehicles, including electric vehicles (EVs), and plug-in hybrid electric vehicles (PHEVs). Natural gas vehicles (NGVs) and propane vehicles qualify for rebates of $1,000.

As businesses, academic centers, and public entities have increased their adoption, so too have private residents of the city, influencing the City of Columbus to install CNG stations and EV charging stations. The city is not, however, only looking to marginally increase these rates of adoption, but exponentially grow these rates to become a leader in this market and for this technology. In order to meet to the desired goals of the Mayor's Green Team, and Mayor Coleman himself, it is imperative to study what other leading cities have done in order to provide the incentives, programs, and infrastructure that are crucial to aiding its citizens in adopting these vehicles.

When looking at what other cities have done in order to increase adoption and provide the necessary infrastructure for these vehicles, we directed our research towards cities of comparable or larger economic scales in relation to Columbus. Therefore, cities within California such as San Francisco and San Jose, as well as Indianapolis, Indiana, cities in Central Florida, and Boston, Massachusetts, were all studied in order to understand what these cities were offering that Columbus is not, or where Columbus could be performing better.

California Cities: San Francisco and San Jose. Given San Francisco's size and their renowned environmentally conscious activities, it was difficult to narrow down which programs should be highlighted. However, some key programs that appeared to have a significant impact on the community, both economically and socially, are noted. Currently, the State of California has nearly 35 incentives, and over 50 laws dealing with alternative fuel and electric vehicles (The US Department of Energy & Alternative Fuels Data Center, 2014). Some of these programs, especially in the larger cities, deal with companies with a large number of fleet vehicles. For example, in San Francisco, under the San Francisco Municipal Transportation Agency (SFMTA), taxi companies are required to reduce their total emissions by 20%. In order to accomplish this, the city has implemented the Zero Emitting Neighborhood Taxi Fleet Program that will acquire electric vehicles for drivers willing to service the outer neighborhoods of the city. In addition, the city will provide the fueling and recharging stations for these vehicles in order to reduce the costs that these companies and drivers will bear. Not all the incentives provided by the city are monetary, however. For example, the city offers the statewide California High Occupancy Clean Air Stickers program, which allows low-emission and zero-emission vehicles to drive solo in the carpool lanes.

While San Jose has maintained and joined California's goal of reducing total transportation emissions by 50%by 2040, they are also advocating for the increased use in car sharing programs. Similar to that of Car2Go in Columbus, Zipcar in San Jose has a smaller registration fee of only $6 a month, and an hourly charge of $8-10 (Zipcar, Inc., 2014). With only 27 cars, this program is much smaller than Columbus' current car sharing program, but the significantly lower registration fee program will make this program more accessible and affordable to citizens. San Jose also offers incentives to those who own electric vehicles in the city by allowing them to park in City parking garages and at City parks for free. In addition to this, the City offers a streamlined residential permitting process, which expedites the permitting process to facilitate the installation of home charging stations.

Indianapolis: Project Plug-In. Indianapolis has established Project Plug-In, a "commercial scale pilot of plug-in electric vehicles (PEVs) and smart grid technology, working together to demonstrate an energy efficient transportation system solution." The program and its partners:

> aim(s) to develop, deploy, demonstrate, market and evaluate a range of PEVs powered by an integrated charging infrastructure located at homes, businesses, and parking facilities. The pilot will span the service territories of two regulated utilities and include the development of a model regulatory framework and network architecture needed to take smart grid and plug-in systems to scale (The City of Indianapolis, 2012).

In addition, the project has been structured to promote participation by commercially sold plug-in vehicles so that technical and consumer data on hundreds of vehicles is likely by the end of the project. (The City of Indianapolis, 2012)

For this project, the city received federal funding in order to help with its goals, and was awarded $6.4 million through the American Recovery and Reinvestment Act, which was distributed by the State of Indiana. In addition, partner contributions have continued to help in vehicle deployment, charging infrastructure and data collection and analysis. Additionally, the State of Indiana has roughly 20 incentive programs or tax credits ranging from Fuel Blend exemptions, to Natural Gas Tax Credits, to Research and Development Grants (The City of Indianapolis, 2012).

Central Florida and Florida. Central Florida and Florida as a whole is making significant strides in the alternative and electric vehicle markets. With over 970 public and 122 private electric charging stations, Florida is already seeing large increases in adoption rates due to the vast amount of established infrastructure (The US Department of Energy & Alternative Fuels Data Center, 2014). With the nearly 160 alternative refueling stations in place, the Biofuels Investment Tax Credit and the HOV Lane Exemption are two main factors driving adoption in this area. The Biofuels Investment Tax Credit is "an income tax credit is available for 75% of all capital, operation, maintenance, and research and development costs incurred in connection with an investment in the production, storage, and distribution of biodiesel, ethanol, or other renewable fuel in the state, up to $1 million annually per taxpayer and $10 million annually for all taxpayers combined," which helps with production costs and consumer burdens (The US Department of Energy & Alternative Fuels Data Center, 2014).

Boston, Massachusetts: The Massachusetts Electric Vehicle Initiative. In Boston and throughout Massachusetts, there is a key initiative devoted to advancing plug-in, fuel cell and battery electric vehicles. This project, called The Massachusetts Electric Vehicle Initiative, is a partnership between the Massachusetts Clean Cities Coalition, the Executive of Energy and

Environmental Affairs, MassDEP, the Massachusetts Clean Energy Center, the Massachusetts Department of Public Utilities and the Department of Transportation. This partnership of stakeholders targets programs and actions that promote the incorporation of electric vehicles into current and needed infrastructure (Massachusetts Clean Cities, 2014). This program is similar to that of the Indianapolis Project Plug-In, but with nearly 90 stakeholders, offers more flexibility and funding opportunities. Similar to Clean Fuels of Ohio, Boston also has a program in place, Greater Boston Breathes Better Program, which aims to increase alternative fuel and electric vehicle registration. Through this program, they have managed to gain more than $8 million in federal funding which has helped incentivize both public and private organizations to green their own fleet vehicles (Greater Boston Breathes Better, 2013). As a result, the entire state has nearly 570 electric vehicle-charging stations and roughly 60 alternative fuel stations (The US Department of Energy & Alternative Fuels Data Center, 2014).

Moving Forward: Recommendations

Based on the research that we have conducted, we have identified a set of recommendations for increasing the ownership of alternative fuel and fuel-efficient vehicles by residents over time. In general, our research indicates that it is cost prohibitive for Columbus to provide financial incentives for alternatively fueled vehicles (AFVs) on a city-wide level and therefore should leave incentives up to the state of Ohio. Instead, the city should focus their efforts on programs that are not as financially burdensome. This includes education through increased informational availability about AFVs, better promotion and awareness building, increased access to electric vehicle charging infrastructure, and development of a collaborative stakeholder network for charging and fueling infrastructure. We discuss each of these in turn.

Greater Informational Availability and Educational Outreach:

According to diffusion of innovations theory, one of the main factors influencing the adoption of new technologies is the relative availability of information regarding the technology. For this reason, we stress the need for Columbus to provide greater accessibility of information about AFVs to encourage adoption (Hubbard G., William, 2007). One of the ways that the City can improve its informational reach is through making improvements to its website. Currently, the city's website provides links to many areas that the viewer can use to gain more information about alternative fuel vehicles; however, many of the links are broken. It is our recommendation that the City move its green transportation section to a devoted subpage of the City website. From this new page, the City would be able to better highlight its own initiatives through the use of promotional videos, and graphics rather than simple bulleted text.

Additionally, Columbus should collaborate with Clean Fuels Ohio on this new page to develop a set of "toolkits" for electric vehicle (EV) and natural gas vehicle (NGV) owners. Ideally, these toolkits would provide new AFV owners with pertinent information such as:

- Information on how to use the different kinds of charging and fueling infrastructure before they try it in person
- A list of all the available EV charging networks, as well as how to obtain necessary membership cards
- Links to home charging resources and procedures for permitting as well as the regulating bodies involved in home charging
- Links to AFV fueling infrastructure mobile apps
- Safety information and the inspection cycle of NGV fuel cylinders

- Information on how to contact Clean Fuels Ohio in order to find further information about the benefits of alternative fuels and any other questions that they may have

Our goal is not to supersede Clean Fuels Ohio, but to supplement the service that they provide and to drive Columbus residents' interest in their direction.

Promotion and Presence:

Next, in order for Columbus to truly encourage the greater adoption of alternative fuel vehicles within the general public and have an impact, the city must place greater emphasis on its promotion, signage, and social media presence. While the city has already taken tremendous strides to place itself as a leader in fleet sustainability, its goal of increasing greater adoption of alternative fuels will not be realized if no one is aware of this goal or the commitments that Columbus has made to improve air quality and green its image. There are over twenty EV charging stations in Columbus, one CNG fill station, and another CNG station set to open in the middle of this year. However, you might not know this unless you were already actively seeking out this information or knew where to look within the city (The City of Columbus, Ohio 2014).

Currently, The City of Columbus' Twitter page is in a sad state with only 749 tweets and 906 followers,. In contrast, the City of Ann Arbor logged 3,425 tweets and 7,506 followers—clearly an unacceptable difference. In order to promote the opening of the new CNG station and encourage community engagement, we recommend that the city revamp its social media presence on Twitter and Facebook in order to build more interest in citywide sustainability initiatives—not just in relationship to transportation. Another way that Columbus might further engage community interest in alternative fuel vehicles is by advertising through conventional means such as local newspapers and websites, as well as rebranding alternatively fueled city fleet

vehicles to stand out better to the public. This is important since the easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Because of this, we recommend that Columbus consider the benefits of increasing its presence and sustainability message through these methods. Our research shows that the chance to be aware of an innovation such as a cleaner city fleet, and gain direct information about and observe its use, will lead to a positive impact on adoption (Petschnig, Martin 2014).

Electric Vehicle Collaborative Partnership

Our last and boldest recommendation is that the City of Columbus take inspiration from Indianapolis' 'Project Plug-IN' by fully embracing the future of electric vehicles through a collaborative partnership to accelerate the development and implementation of a plug-in electric vehicle ecosystem. We have decided to focus on electric vehicles for this suggestion because the STAR Community rating system indicates a focus on increasing alternative fuel vehicle and fuel-efficient vehicle ownership in residents. Research shows that the electric vehicle market has the greatest potential for growth within the residential consumer market. This is due to the high number of consumer-friendly options available and the high relative advantage of unique benefits as well as the perceived visual appeal and safety of electric vehicles compared to other AFVs (Petschnig, Martin 2014). We recommend that the City of Columbus work with businesses and utilities to develop a plan for an integrated charging network of electric behicles that would involve the use of smart grid technology and conventional and solar-powered charging stations in homes, businesses and parking facilities across the city. We do not think that Columbus is quite ready to implement such a plan anywhere in the near future, considering the large financial investment it would require, but we think that opening discussion into such a possibility sooner,

rather than later, will put Columbus in a position to determine the incremental steps that will need to be taken in order to realize such a future.

Limitations of Current Research

Due to the complex nature of some of the decision-making schemes that we had to consider in order to incentivize increased use of AFV's, and the private nature of some of the data, it was not feasible for us to undertake the proper studies and analyses by ourselves within the limitations of our project. For this reason, our analysis is constrained to extrapolating the results of others onto our own findings. Nonetheless, we are confident in our conclusions and findings. Future research might involve greater collaboration with others given that our collaboration was unfortunately limited. For example, we had initially proposed to survey residents, but unfortunately we were not able to carry out this research.

Conclusions

The purpose of this research was to determine what (if any) policy or incentives the City of Columbus might pursue to help transition its local energy supply for transportation toward the use of renewable, less carbon-intensive, and less toxic alternatives. In addition, we sought to assess the viability of the STAR rating system as a measure of the City of Columbus' sustainability as it relates to residential and business transportation. We chose to focus our research on the current and future ownership of fuel-efficient and alternatively fueled vehicles of Columbus residents because the City of Columbus has shown a high level of success and achievement in their own regards and can be used as an example to the public and businesses alike. Furthermore, the majority of focus of the "Greening the Energy Supply" section of the STAR rating system is on residential ownership.

We believe that Columbus should do quite well in the STAR Communities framework for its green transportation. We can say with confidence that Columbus has increased its percentage of alternatively fueled vehicles over the last five years, and we think that the data, which suggests that traditionally fueled vehicles over the last five years have raised their average fuel efficiency, will hold true here in Columbus. Thus, points should be earned in these categories. More research must be done beyond our capabilities to determine whether or not Columbus' total ownership of automobiles has fallen to achieve the "bonus" points, but as previously stated we believe it to be unlikely. Of course, regardless of the STAR Communities results, we can say with certainty that the market for fuel-efficient and alternative fuel vehicles will continue to rise and become more and more the norm for personal transportation. It is imperative then that Columbus capitalize on this opportunity in order to get a foothold on the infrastructure that will be needed to facilitate the future of personal transportation. Doing so will help to guarantee that Columbus remains a leader in green transportation and a model for its citizens.

In summary, we believe that our strategic recommendations represent the best course of action for the city in moving towards the future of greener transportation and that the city is taking the right path in pursuing better air quality by reducing petroleum usage, increasing efficiency, and pursuing alternative fuels. By recommending that Columbus first focus on education and providing resources for current and potential alternative fuel vehicle owners through a collaborative development of tools with Clean Fuels Ohio, we believe that the city can lay the groundwork for overcoming some of the main barriers to adoption of AFVs. Our recommendation of promotional outlets complements our recommendation regarding better educational outreach, and will help the city better engage with citizens in order to gain

momentum in interest for AFVs. And finally, our recommendation that the city develop a plan for future EV infrastructure represents a next iteration in the development of an AFV-friendly city that Columbus started with the creation of its CNG fill stations. There are different duty-cycles and uses for each alternative fuel technology, so it is important that the city diversify and meet the needs of both businesses and residents. We believe that, while businesses will be able to capitalize on the excellent CNG infrastructure that we currently have, residents are more likely to utilize electric-based technologies and will derive greater benefit from them. By following these recommendations, the City of Columbus will set itself up for success and contribute to their ongoing pursuit of sustainability.

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Appendices

Appendix A: Meta data for data file named “Columbus AQI and GDP.xlsx”

- This dataset shows the total number of unhealthy air quality days (determined as the combination of unhealthy for sensitive groups, unhealthy and very unhealthy days) in the Columbus metropolitan area from 1980 to 2013 versus total GDP (in current millions of dollars) in the Columbus metropolitan area from 2001 to 2012.
- Sources:
    - U.S. Department of Commerce, Bureau of Economic Analysis. (2013). GDP by metropolitan area (millions of current dollars). Retrieved 03/28, 2014, from http://www.bea.gov/itable/iTable.cfm?ReqID=70&step=1#reqid=70&step=10&isuri=1&7007=-1&7036=-1&7003=200&7035=-1&7006=18140&7001=2200&7002=2&7090=70&7004=naics&7005=-1&7093=levels
    - United States Environmental Protection Agency. (2013). Air quality index report. Retrieved 03/28, 2014, from http://www.epa.gov/airdata/ad_rep_aqi.html

Appendix B:

year	total sold	raw sales change	Percent sales change	total
1998	1	0	0	1
1999	0	-1	-100	1
2000	5	5		6
2001	39	34	680	45
2002	117	78	200	162
2003	184	67	57.26495726	346
2004	289	105	57.06521739	635
2005	518	229	79.23875433	1153
2006	596	78	15.05791506	1749
2007	945	349	58.55704698	2694
2008	893	-52	-5.502645503	3587
2009	963	70	7.838745801	4550
2010	932	-31	-3.219106957	5482
2011	972	40	4.291845494	6454
2012	1454	482	49.58847737	7908
five year	'08-'12	'03-'07	'98-'02	
raw change	561	761	116	
percent change	162.8219485	513.5869565	11700	

- This dataset shows the total number of alternative vehicles sold in Franklin County in each year from 1998 to 2012. From this data, the changes in sales from year to year, the percentage change from year to year, totals, as well as five interval changes (needed for STAR Communities).
- Data provided by Bureau of Motor Vehicles, State of Ohio
    - Contact:
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Appendix C

Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007										20.1	20.4	20.1
2008	20.5	20.4	20.8	21.2	21.7	21.4	21.3	20.8	20.6	21.0	20.7	20.5
2009	21.0	21.0	21.2	21.2	21.3	21.4	22.1	22.4	21.1	22.1	22.1	22.0
2010	22.2	22.1	22.1	22.1	22.1	22.0	22.1	22.1	21.9	22.3	22.3	22.3
2011	22.5	22.7	23.0	22.9	22.7	22.5	22.4	22.2	22.2	23.0	23.1	22.6
2012	23.5	23.9	24.0	23.9	23.7	23.5	23.5	23.7	23.8	24.2	24.1	23.9

- This dataset depicts the average MPG of vehicles sold in the United States in each month between October 2007 and December 2012. This data originally comes from the University of Michigan Transportation Research Institute (UMTRI).
- Source:
    - Richard, M. G. (2013). The average fuel economy of all vehicles sold in the U.S. in 2012 was 23.8 MPG. Retrieved March 12, 2014, from http://www.treehugger.com/cars/average-fuel-economy-all-vehicles-sold-2012-was-238-mpg.html

Appendix D

	Average Small Car MPG			Average Midsize Car MPG			Average Large Truck MPG		
Manufacturer	Feb-12	Feb-11	YoY	Feb-12	Feb-11	YoY	Feb-12	Feb-11	YoY
Chrysler	25.0	24.3	0.7	24.0	24.0	0.0	15.8	15.6	0.2
Ford	32.2	28.6	3.6	26.7	25.5	1.2	17.4	15.8	1.6
GM	30.3	28.2	2.0	25.8	25.4	0.4	17.0	17.1	0.0
Honda	32.3	29.9	2.4	26.1	25.7	0.5	17.2	16.9	0.3
Hyundai	31.3	28.7	2.6	27.8	26.7	1.1	N/A	N/A	N/A
Mazda	29.0	26.0	3.0	24.9	23.7	1.2	N/A	N/A	N/A
Mitsubishi	24.8	25.8	-1.0	24.3	24.3	0.0	N/A	N/A	N/A
Nissan	30.8	28.8	2.0	25.2	23.7	1.5	14.3	14.2	0.1
Subaru	28.2	22.2	5.9	24.2	24.0	0.2	N/A	N/A	N/A
Suzuki	N/A	N/A	N/A	25.0	25.0	0.1	N/A	N/A	N/A
Toyota	35.3	34.4	0.9	28.5	24.4	4.1	15.4	15.6	-0.2
Volkswagen	30.5	29.1	1.5	29.2	24.6	4.6	N/A	N/A	N/A
Industry	**31.7**	**29.8**	**1.9**	**26.4**	**24.9**	**1.4**	**16.8**	**16.0**	**0.7**

- This dataset depicts the average MPG of vehicles sold across three sectors of the market (small car, midsize car, and large truck) from February 2011 to February 2012. It is broken down into vehicles manufacturers and then averaged into the entire "industry".
- Source:
    - TrueCar.com. (2012). Average fuel economy for new cars sold in February 2012 rises to 23.2 MPG according to TrueCar.com's TrueMPG. Retrieved May 21, 2014, from http://blog.truecar.com/2012/03/12/average-fuel-economy-for-new-cars-sold-in-february-2012-rises-to-23-2-mpg-according-to-truecar-coms-truempg/