

AIR QUALITY & ENERGY

N3. MODERNIZE ELECTRIC GRID FOR GREATER RESILIENCE AND MORE EFFICIENT ENERGY DISTRIBUTION

N4. IMPLEMENT PROGRAM FOR INDIVIDUALS AND BUSINESSES TO REDUCE ENERGY USAGE DURING PEAK DEMAND

N5. IMPLEMENT IDLING REDUCTION EDUCATIONAL CAMPAIGN

A3. IMPLEMENT EDUCATIONAL CAMPAIGN ON ENERGY AUDITS AND RENEWABLE ENERGY TO REDUCE EMISSIONS FOR RESIDENTIAL AND BUSINESS USERS

A4. INCREASE INVESTMENT IN AND/OR PURCHASE OF RENEWABLE ENERGY

A5. INCREASE NUMBER OF AIR QUALITY MONITORING STATIONS TO PROVIDE BASELINE DATA AND PUBLIC EDUCATIONAL OPPORTUNITIES

A6. USE DATA AND BEST PRACTICES TO ADAPT TRANSPORTATION MODES AND INFORM ECONOMICS OF TRANSPORTATION. (E.G., REDUCE SINGLE OCCUPANCY, LOWER POLLUTING FUELS, LOWER EMISSIONS VEHICLES, INCENTIVES OR REQUIREMENTS TO PROVIDE EV CHARGING STATIONS, EXPAND TRANSPORTATION OPTIONS AND TIMES TO REDUCE OVERALL TRANSPORTATION POLLUTION)

Pollution and its associated air quality impacts are not new problems for the urban landscape. Humans have long burned biomass for energy, transportation, and heat. Under certain weather conditions (clear and calm conditions), air quality may be extremely deteriorated. Airborne particles, also known as particulate matter, are small liquid droplets or solids that can enter the lungs and cause major health issues. Episodes of intense airborne pollutants are more frequent during the wintertime when the atmosphere is more likely to be stable. During summer, increased sunlight duration combined with emissions from power plants and vehicles lead to the development of ground-level ozone (smog). Ozone can cause irritation of the nose and throat, chest tightness, coughing, and shortness of breath.

People most at risk from these pollutants are those with heart or lung disease, such as asthma, children and older adults, and those that are often active outdoors. In Columbus, MORPC monitors both of these pollutants, issuing daily air quality forecasts and providing alerts when levels are considered unhealthy for sensitive groups of people. The [End of Season Report from 2017](#) showed that pollutant levels considered unhealthy for sensitive groups were reached on 2 days.¹ On 80 days in 2017, ozone pollution levels were moderate or higher according to the Air Quality Index system, and on 25 days particulate matter pollution levels were moderate or higher. Nonetheless, air quality has continued to improve in Central Ohio in recent decades despite population growth in the region.

The main drivers in the decrease in ozone and particulate matter air pollution in Central Ohio (and across the eastern United States) are changes in emissions from vehicles and from power plants. On-road transportation is still the largest source of volatile organic compounds (VOCs) and nitrogen

¹ "Air Quality Monitoring End of Season Report for Central Ohio." *Mid-Ohio Regional Planning Commission*. Dec. 13, 2017. <http://www.morpc.org/news/morpc-report-shows-air-quality-improved-in-2017>. Accessed Jan. 2018.

oxides (NO_x), both important precursor emissions for ozone and particulate matter. However, national emission control programs have served to decrease emissions from this sector significantly. The decrease in emissions from power plants has been driven by a mix of both national emission control programs and the decrease in numbers of coal-fired power plants due to the falling price of natural gas and subsequent coal plant retirements.

Along with these two main drivers, local efforts to improve air quality have been increasing. Local governments and public transit providers have been converting their fleets to cleaner fuels and electric vehicles; more businesses and governments are taking on no idling policies and employing anti-idling technologies in their fleets; the Central Ohio Greenways trail system has continually expanded; and MORPC and partners are working to increase the number of commuters biking, busing and carpooling to work instead of driving alone through initiatives like the annual Commuter Challenge.² These efforts all add up incrementally to cleaner air for Central Ohio and are important for shifting the norms and behaviors that affect air quality, especially with a future of continued population growth and climate change impacts in the region.

However, temperatures in Columbus have been rising at rates greater than the national average and are expected to continue in the future.³ Evidence shows that nights are warming faster than days, creating additional demand for cooling. Ultimately, this leads to greater energy consumption, emissions from power plants, and more airborne pollutants available for the development of ground-level ozone. To make matters worse, increasing duration of consecutive hot days leads to air stagnation and the buildup of pollutants over time. Together, these processes can lead to major health concerns, especially for those prone to respiratory problems. Similarly, there is a growing body of research on the localized nature of air pollution that suggests that traditional estimates of citywide air pollution based on a few select measurements are inaccurate and that personal exposure can vary tremendously between locations, even those short distances apart.⁴ What actions could the city support that would help ensure that despite the increasing temperatures, air quality continues to improve in Columbus?

N3. MODERNIZE ELECTRIC GRID FOR GREATER RESILIENCE AND MORE EFFICIENT ENERGY DISTRIBUTION

N4. IMPLEMENT PROGRAM FOR INDIVIDUALS AND BUSINESSES TO REDUCE ENERGY USAGE DURING PEAK DEMAND

The Franklin County Energy Study, to be released in the near future, provides a detailed look at energy use within Franklin County over the past six years.⁵ Discovered during the data collection phase for this report, Franklin County is a net importer of energy in both fuels for transportation and heating

² "Welcome to Central Ohio Greenways." *Mid-Ohio Regional Planning Commission*. <http://centralohiogreenways.com/>. Accessed Jan. 2018.

³ Great Lakes Integrated Sciences and Assessment (GLISA) and the University of Michigan Climate Center. "Climate Change in Columbus Ohio: An assessment of Columbus' Key Climate Changes, Impacts, and Vulnerabilities of Concern." Mar. 2016. http://research.bpcrc.osu.edu/education/greenteam/FINAL_ColumbusFinalReport_3.0.pdf. Accessed Dec. 2017.

⁴ Aja Ellis. "Black Carbon in Three Parts: 50 nm particles, 500 m distances, & 5000 km transport." Presentation at the Byrd Polar and Climate Research Center - The Ohio State University in Columbus, OH on Jan. 5, 2018.

⁵ "Energy Study and Technical Assistance." *Mid-Ohio Regional Planning Commission*. <http://www.morpc.org/program-service/energy-studies-and-technical-assistance>. Accessed Jan. 2018.

and electricity for use in residential, commercial, and industrial settings. Overall, 69% of energy in Franklin County dissipates as heat rather than being used for its intended function. Examples include, but are not limited to, electric system losses as heat in the case of thermoelectric generation facilities, fuel burned for vehicles stopped in traffic, and energy expended with incandescent light bulbs to generate heat in addition to light. This number suggests that there are significant savings and environmental benefits to be derived from improving energy efficiency including the direct energy and associated unused energy.

Much of the generation and distribution system is outside of Franklin County and regulated by state and federal agencies, limiting the direct actions that the city can take to improve resilience and efficiency. But, there are a number of initiatives, offered by Franklin County, the City of Columbus, local electricity providers (AEP, Columbus Division of Power, Ohio Edison, South Central Power), and natural gas providers (Columbia Gas) to improve energy efficiency for customers. As far as electricity providers, AEP and Columbus Division of Power are the major players.

AEP has been implementing a number of grid modernization initiatives, each needing approval by PUCO. AEP has moved forward with advanced metering, appliance incentives, energy audits, and demand response. While the City of Columbus does not have any direct control over these initiatives involving AEP, the city can advocate for those that improve resilience, enhance efficient energy distribution, and reduce energy usage during peak demand.

Columbus Division of Power has existed since 1899. The division is a full-service, publicly owned electric utility that serves ~14,000 customers and the street light system (53,000+ lights) throughout the city. The division uses revenue from energy sales to support and maintain the street light system at no cost to the taxpayers.⁶ Like AEP, the Columbus Division of Power is proceeding with advanced metering infrastructure and offers demand response. Being a division of city government, Columbus has greater control over the actions of the Columbus Division of Power, keeping in mind that any actions taken should ensure that citizens still receive affordable and reliable electricity.

Peak demand can be reduced through careful design of new facilities and retrofitting of existing facilities. The Columbus-Franklin County Finance Authority's EnergyWorks program provides financing to businesses and non-profit organizations located in Franklin County for cost-effective energy efficiency programs in both new and existing facilities.⁷ This initiative can be combined with PACE, allowing property owners to finance their improvements through future property tax payments, thus enabling the use of upfront funds for improvements that can be paid back incrementally over time.⁸ The recent renovation of the PNC Plaza in downtown Columbus is an example of a project that took advantage of EnergyWorks and PACE. In addition to infrastructure improvements, incentives for behaviors that align with reduced consumption could be implemented for the individuals living and working within a building. Therefore, social scientists in addition to engineers should contribute to efforts to reduce peak demand.

⁶ "The Division of Power." *The City of Columbus, Public Utilities*.

<https://www.columbus.gov/utilities/about/The-Division-of-Power/>. Accessed Jan. 2018.

⁷ "Energy Works Franklin County." Franklin County Economic Development & Planning Department.

<https://development.franklincountyohio.gov/energy-works>. Accessed Jan. 2018.

⁸ "Property Assessed Clean Energy Programs." *U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy*. <https://energy.gov/eere/slsc/property-assessed-clean-energy-programs>. Accessed Jan. 2018.

CHAPTER INSET: The Columbus SmartCities is working to modernize the electric grid through utility scale renewables, improve efficiencies, and deploy smart meters.⁹ Likewise this program is working to increase use of electric vehicles and multi-modal mobility options. An example of a program of SmartCities was a significant rebate on purchases of a model of electric vehicles in Summer 2017.

N5. IMPLEMENT IDLING REDUCTION EDUCATIONAL CAMPAIGN

Idling reduction practices have been implemented by many school districts to protect youth and reduce inhalation of particulate matter from diesel exhaust. Still, while it is more common to see anti-idling signage in close proximity to building air intakes, there are a significant number of fleets and individual vehicles that continue to idle when not in motion. A focused educational campaign within Columbus could help alter these harmful practices. Unfortunately, many individuals are still idling their vehicles based on outdated practices that are not necessary with modern vehicles.¹⁰ For instance, driving off gently after running the vehicle for 30 seconds will warm up the engine and interior more quickly than idling. Starters and batteries are more durable than in the past and will not be damaged by being turned on and off when stopped at a drive through or to pick someone up.

This campaign should include vehicles with gasoline engines, whereas previous campaigns only targeted those with diesel engines. The message should clearly articulate the economic and environmental benefits of not idling vehicles and a description of why these practices are not needed with modern vehicles. High-impact target audiences could include fleet managers and delivery services. The city should create ways of conveying this information to the general public, utilizing freeway traffic information boards and social media outlets. With the shift towards electric fleets and personal vehicles, the need for this program will be reduced over time as internal combustion engines become a smaller part of the transportation sector. Projected changes in the vehicle market show growth for electric vehicles.¹¹

A3. IMPLEMENT EDUCATIONAL CAMPAIGN ON ENERGY AUDITS AND RENEWABLE ENERGY TO REDUCE EMISSIONS FOR RESIDENTIAL AND BUSINESS USERS

Energy efficiency programs have been provided by utilities under programs funded by ratepayers approved by the PUCO. In Columbus, both [AEP](#) and [Columbia Gas](#) provide energy efficiency programs, including online information, rebates, and energy audits.^{12,13} Energy audits are one of the most cost effective ways to reduce energy consumption. As part of these programs, an expert conducts an independent analysis, property owners are given a detailed report that includes payback periods for

⁹ "Smart Columbus Home." *The City of Columbus, Smart Columbus*. <https://www.columbus.gov/smartcolumbus/home>. Accessed Jan. 2018.

¹⁰ U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. "Idling Reduction for Personal Vehicles." May 2015. https://www.afdc.energy.gov/uploads/publication/idling_personal_vehicles.pdf. Accessed Jan. 2018.

¹¹ Jess Shankleman. "The Electric Car Revolution is Accelerating." *Bloomberg Businessweek*. Jul. 6, 2017. <https://bloomberg.com/news/articles/2017-07-06/the-electric-car-revolution-is-accelerating>. Accessed Jan. 2018.

¹² "Energy Saving Programs." *American Electric Power Ohio*. <https://www.aepohio.com/save/business/programs/>. Accessed Jan. 2018.

¹³ "Ways to save." *Columbia Gas of Ohio*. <https://www.columbiagasohio.com/ways-to-save/home-energy-assessment>. Accessed Jan. 2018.

energy efficiency actions, and contractors can be arranged to make remediations on a schedule determined by the property owner. To incentivize high impact actions, the utilities often subsidize actions with short repayment periods. There are additional programs, for both energy audits and energy efficiency remediations, targeted toward low income populations. While these programs have the potential to save customers money and have a significant environmental benefit, they suffer from sounding “too good to be true.” For many customers that are unfamiliar with state law, it appears puzzling that the utility would offer programs to save them money and reduce their consumption of energy. The Columbus Division of Power does not currently offer but is considering the implementation of a similar program.¹⁴

The City of Columbus should partner with the utilities to serve as a trusted ambassador in an educational campaign to reach new audiences. Past conversations with utility providers revealed interest in reaching a larger audience with these programs, presenting an opportunity for partnership with the City of Columbus. Likewise, any educational campaign, especially one targeted at businesses and non-profits, should highlight the previously mentioned Columbus-Franklin County Finance Authority’s EnergyWorks and PACE programs. Greater details on such an initiative are anticipated in the forthcoming Local Government Energy Partnership from MORPC. Audiences to be targeted should include those who offer the overall greatest energy savings for the investment of financial resources, or those that lack the financial resources to make remediation on their own and for which utilities are a disproportionately high cost.

Columbus customers who receive their electricity through AEP or the Columbus Division of Power have the opportunity to purchase a portion or all of their electricity from renewable sources. But, many customers are unaware of these opportunities, let alone how to participate. Therefore, even a minor educational campaign could yield a significant increase in participation. Educational campaigns need to inform AEP customers about the PUCO [Apples to Apples Comparison](#) (specifically the renewable energy options) and Columbus Division of Power customers about the [EcoSmart Choice Green Pricing Program](#).

^{15,16}

A4. INCREASE INVESTMENT IN AND/OR PURCHASE OF RENEWABLE ENERGY

Most of the electricity generated for Columbus is derived from the burning of coal in facilities far from the city, and the particulate matter and ozone that are emitted travel relatively short distances. Therefore, these two air pollutants are adversely impacting populations downwind of the generating facilities, rather than the people for whom they are created. Conversely, the carbon dioxide emitted by the facilities travels great distances, exacerbating global climate change and necessitating additional climate change adaptation planning everywhere. With increased offerings for electric vehicles and incentives to purchase such vehicles in Columbus, it is reasonable to anticipate growing demand for electricity from the transportation sector. Without transitioning toward greater use of renewables, the

¹⁴ Telephone correspondence with Kristian Fenner of the Columbus Division of Power on Jan. 16, 2018.

¹⁵ “Apples to Apples: Electric.” *Public Utilities Commission of Ohio, Energy Choice Ohio*. <http://www.energychoice.ohio.gov/ApplesToApplesCategory.aspx?Category=Electric>. Accessed Jan. 2018. REPEATED.

¹⁶ “EcoSmart Customer Choice.” *The City of Columbus, Public Utilities*. <https://www.columbus.gov/Templates/Detail.aspx?id=2147498138>. Accessed Jan. 2018. REPEATED.

use of electric vehicles will merely shift the problems of ground-level ozone and particulate matter emitted for transportation in Columbus from Central Ohio to Southeastern Ohio. Additionally, as transportation would still ultimately rely on combustion of fossil fuel for electricity generation, greenhouse gases that cause climate change will continue to be generated.

AEP's generation of electricity is largely driven by burning of coal in large thermoelectric facilities along the Ohio River. Overall AEP is diversifying its portfolio in Ohio beyond coal-burning power plants, and it generated approximately 16% of its energy from renewables in 2016. AEP Ohio, which serves AEP's Ohio customers reached an agreement with the Ohio Public Utilities Commission in 2016 to propose commitments to 400 MW of solar generation and 500 MW of wind generation produced in Ohio. The renewable energy projects must be ultimately be approved by the PUCO. The Columbus Division of Power purchases its electricity on the wholesale market, approximately 885,000 MWh of power each year.¹⁷ Since 1987, the City of Columbus has been generating electricity at the O'Shaughnessy Hydroelectric Plant, which consists of two water turbines located on the Scioto River. In 2017, Division of Power directly purchased about 12,000 MWh of power from COBE, a local bio-waste facility, and NYPA, an operator of several hydroelectric complexes and small clean power plants fueled by natural gas.^{18,19} The division has a goal of receiving 20 percent of its energy from renewable sources by the end of 2018, and 50 percent of its energy from renewable sources by 2023.²⁰

In addition to purchasing energy from renewable resources, the Columbus Division of Power has a plan to add new LED street lights and convert old HPS lights to LED fixtures throughout the city. The first phase of the conversion plan will be to replace 4,500 of the City's approximately 53,000 streetlights with LED fixtures, focusing on our arterial corridors to generate the highest possible power and costs savings. The project's anticipated construction start is spring 2018.²¹ This program will reduce energy consumption and air pollution, in addition to the amount of renewable energy the division will need to purchase, without reducing the quality of life in Columbus.

Individuals can also play a role by purchasing their electricity through a renewable energy supplier or installing their own home renewable energy systems. Since the deregulation of the electricity sector in Ohio, most customers have been able to select the supplier (but not their distributor) of electricity. This means that for residents of Columbus who have AEP or the Columbus Division of Power as their distributor, renewable energy can be procured by selecting a different supplier without needing to install infrastructure on their residences. AEP customers may find additional information by visiting the PUCO Apples to Apples Comparison.²² Columbus Division of Power customers may review the EcoSmart Choice Green Pricing Program for options that allow customers to offset up to 100% of their

¹⁷ E-mail correspondence with Kristian Fenner of the Columbus Division of Power on Jan. 11, 2018.

¹⁸ "Purchasing Renewables." *The City of Columbus, Public Utilities*.

<https://www.columbus.gov/Templates/Detail.aspx?id=2147498067>. Accessed Jan. 2018.

¹⁹ "Generation Overview." *New York Power Authority*.

<https://www.nypa.gov/power/generation/generation-overview>. Accessed Jan. 2018.

²⁰ "Powering a Greener Columbus." *The City of Columbus, Public Utilities*.

<https://www.columbus.gov/GreenPower/>. Accessed Jan. 2018.

²¹ "Citywide Street Lighting." *The City of Columbus, Public Utilities*.

<https://www.columbus.gov/utilities/customers/Citywide-Street-Lighting/>. Accessed Jan. 2018.

²² "Apples to Apples: Electric." *Public Utilities Commission of Ohio, Energy Choice Ohio*.

<http://www.energychoice.ohio.gov/ApplesToApplesCategory.aspx?Category=Electric>. Accessed Jan. 2018.

electric usage.²³ This green pricing program funds the purchase and retirement of renewable energy certificates through American Municipal Power. Providing information on these programs will be part of the educational campaign detailed in **A3**.

Customers served by AEP or the Columbus Division of Power as their distributor are also able to install renewable energy generation on their property, generally wind turbines and solar panels, while still being part of the electric grid. However, even with a state buydown of the interest rate for loans for renewables and federal incentives, installation of renewable energy is unavailable to many customers. For some, it is not the cost but rather their property arrangements (i.e. those living in apartments, condominiums, or have property with little direct sun exposure) that limit their availability. Commercial-scale renewable energy projects are more cost effective per unit energy generated than smaller residential systems, and they allow for scalability in accordance with the planned transition to renewables; however, they offer less control for customers and are expanding more slowly than some individuals desire.

Eventually, all electricity generation should be transitioned to low or zero emission sources, coupled with enhanced energy storage. Interim localized solutions include coupling renewables with natural gas turbines to provide electricity when ample sunlight is not available or during periods of calm winds. While reducing consumption of electricity use is the most cost-effective way to reduce emissions, energy that is still needed should be derived from renewable sources.

The average annual growth rate of photovoltaic (PV) solar capacity in Franklin County since 2010 is 65%, and 7 MW of solar PV were installed in Franklin County as of August 2017.²⁴ Additionally, there has been some generation of electricity via hydroelectric and biogas sources. However, Columbus has historically derived only a small portion of its energy portfolio from renewable sources.²⁵ Other communities in Ohio, such as Minster, Bowling Green, and Oberlin have also taken steps to increase the percentage of energy from renewable sources in their portfolio and offer case studies for comparison. Renewable energy need not be significantly more expensive and comes with health benefits, such as improved air quality. While there are obstacles to overcome with regard to reliability of renewables (distribution and storage), all communities will eventually need to transition to sources of energy that do not result in net emissions of greenhouse gases.

A5. INCREASE NUMBER OF AIR QUALITY MONITORING STATIONS TO PROVIDE BASELINE DATA AND PUBLIC EDUCATIONAL OPPORTUNITIES

There are currently three ground-level ozone sensors and two particulate matter sensors maintained by [Ohio EPA](#) collecting data from three sites in Columbus.²⁶ A fourth site is currently offline. These stations provide near real-time data for air quality alerts and long-term data sets for planning. Likewise, data collected from these stations determine Columbus' compliance with federal air quality standards. The stations provide a coarse look at air pollution within the city but do not capture the

²³ "EcoSmart Customer Choice." *The City of Columbus, Public Utilities*. <https://www.columbus.gov/Templates/Detail.aspx?id=2147498138>. Accessed Jan. 2018.

²⁴ "Energy Study and Technical Assistance." *Mid-Ohio Regional Planning Commission*. <http://www.morpc.org/program-service/energy-studies-and-technical-assistance>. Accessed Jan. 2018. REPEATED.

²⁵ "Sustainability." *American Municipal Power*. <https://www.amppartners.org/sustainability>. Accessed Jan. 2018.

²⁶ "Current Air Quality Map." *Ohio Environmental Protection Agency*. <http://wwwapp.epa.ohio.gov/gis/mapportal/>. Accessed Jan. 2018.

heterogeneity of air quality that occurs across Columbus neighborhoods based on their proximity to pollution sources. Therefore, to enhance observations specific to areas throughout the city and improve both planning and education, Columbus should increase the number of stations within the network. These extra monitors, added by the city, would not be part of the Ohio EPA monitoring network as there are specific criteria for inclusion in that network. Hence, these additional sensors would not be for compliance with federal National Ambient Air Quality Standards, but rather to collect additional data for the Columbus region.

Due to infrastructure costs, the technical skills required of staff, the need for validation of data, and possible logistical considerations of siting, station placement is critical. Data collected in early years will provide an air pollution baseline for comparison as the city continues to grow in population and development and transportation patterns change. Educational opportunities should include the health impacts of ozone and particulate matter to contextualize the importance of data collection. Likewise, finer resolution data collection is more likely to motivate individuals if they are to consider air quality impacts on the places where they live, work, and play. Such awareness could inform decision-making (e.g., where and when to exercise, desirability of a residence downwind of a heavily used interstate) and advocacy for public policies (e.g., such as better emissions controls, improved public transportation).

Air quality monitoring stations, while traditionally expensive, have been declining in cost over the past few years. In fact, some consumer-grade systems have been developed and integrated into networks that allow citizen scientists to collect data. One of the concerns of these systems is maintaining quality control of data. But, with sufficient education about their limitations, there might be a role that consumer-grade systems can play in both supplementing data collection and educating the public. Over time, a larger network of stations will provide a more refined temporal and spatial view of pollution, allowing Columbus to make decisions that improve public health and quality of life.

A6. USE DATA AND BEST PRACTICES TO ADAPT TRANSPORTATION MODES AND INFORM ECONOMICS OF TRANSPORTATION. (E.G., REDUCE SINGLE OCCUPANCY, LOWER POLLUTING FUELS, LOWER EMISSIONS VEHICLES, INCENTIVES OR REQUIREMENTS TO PROVIDE EV CHARGING STATIONS, EXPAND TRANSPORTATION OPTIONS AND TIMES TO REDUCE OVERALL TRANSPORTATION POLLUTION)

There is a growing and changing landscape of transportation options in large, urban centers such as Columbus and an expanding suite of data collection tools available to better understand people's needs and preferences. This data collection, in coordination with planning among the various players in transportation, can help weave Columbus' transportation options into a fluid tapestry that serves people in a more effective and efficient way with lower emissions. As with any system, small nudges, be they incentives or disincentives, could be introduced to promote behaviors that move the system to greater effectiveness and efficiency while continuing to lower emissions.

Change is easiest when financial decisions of individuals align with behaviors that are desired. For example, variable demand-based fares could be introduced to incentivize transportation, including, commutes outside of peak hours. With commuters, this structure is only likely to work if educational campaigns or other incentives engage employers who have the capacity to adjust work hours. Sometimes, these barriers to behavioral change are not readily obvious, but once overcome, can tip a system toward greater adoption. For instance, past research has shown that while many employees expressed interest in vanpools, many are unwilling to actually participate once such programs began.

With the addition of a limited number of rides home in a cab each year in cases of emergencies (a relatively small cost), a greater number of individuals were willing to join the vanshares²⁷. Finding the root of barriers to participation may require careful data collection and consultation with social scientists.

We also know that the last mile of transport (initially for delivery of goods but more recently applied to the stretch between a primary mode of transport and an individual's final destination) is often the missing link in a system and the focus of the Columbus SmartCities initiative.²⁸ Careful consideration should be given to ways that existing components of the transportation system can bridge the last mile, and where new components need to be created to fill voids. When various options are explored, all other things being equal, those that result in lower emissions should be given preference. These decisions should be underpinned by the data collected in Columbus, experts in the transportation sector, and research conducted globally. Efforts to incentivize purchase of a greater number of electric vehicles and provide charging stations, in addition to offering multi-modal transportation options, are all being lead by the Columbus SmartCities initiative.²⁹

²⁷ "Guaranteed Ride Home Programs: Implementing Commuter Benefits Under the Commuter Choice Leadership Initiative." *U.S. Environmental Protection Agency*. Sep. 2001. <https://tinyurl.com/ybr2h5x9>. Accessed Jan. 2018.

²⁸ "Mobility Matters Podcast." *TransLoc Studios*. Episode 001, Part 1: Aug. 2017. <http://go.transloc.com/mobility-matters-podcast>. Accessed Jan. 2018.

²⁹ "Smart Columbus Home." *Smart Columbus*. <https://www.columbus.gov/smartcolumbus/home>. Accessed Jan. 2018.