University Transportation Center Research Project

Final Report

EFFECTS OF PRIVATE TRANSPORTATION IMPROVEMENTS ON ECONOMIC DEVELOPMENT

By

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Abstract:

In this project, we explored opportunities and effects of public-private or private-private partnerships for mobility improvements (incl. alternative fueled shuttles and IT infrastructure) and assessed their effects on local and regional economic development (incl. low income workers/households).

Our major focus was on South-Atlanta and the region around the City of Hapeville where closure of the Ford Hapeville assembly plant has negatively impacted the local economy. We partnered with Ford Motor Company and Jacoby Development to study the extended benefits of Jacoby Development's "Aerotropolis Atlanta" development planned for the site of the former Ford assembly plant in the City of Hapeville, Georgia. ***We assessed the triple bottom line benefits of different mobility and transportation options for the site, surrounding neighborhoods, the adjacent Atlanta airport, and the regional transportation system, coupled with different energy generation and industrial co-location options***. Increased understanding of such benefits will also impact developments at other former manufacturing sites.

In recent years, transit oriented developments in previously developed urban areas have linked private investments and redevelopment activity that is residential and commercial/retail business based. The projected private investment for redevelopment explored here will help to retain and grow industrial business and job opportunities that can compensate for the loss of a major industrial employer. This, in turn, will help to reverse a trend of good jobs lost in urban areas that is gaining increasing national attention.

Towards the end of this project, we expanded our research to explore the potential of implementing a broader aerotropolis concept that would encompass other communities in the airport's sphere of influence, serving to promote a logistics-based, clean tech development strategy. This concept is seen as a promising solution to addressing the uneven development pattern of the metro area in which the southern crescent portion that encompasses the airport has not benefitted from the mobility and transportation improvements and associated economic development of the northern half.

Literature Search:

Studies have been done on intermodal transport, but invariably are focused on linking to public transport. The opportunities for private-private multimodal transport are not covered. Studies have been done on Intelligent Transportation Systems but mostly with respect to automotive and/or truck related congestion avoidance, whereas our work focuses on economic development potentials for novel "mobility on demand" and "vehicle to vehicle" and "vehicle to cloud" communications.

A review of the Research in Progress (http://rip.trb.org/search) and published research (http://ntl.bts.gov/tris) shows research on evaluating alternative powered vehicles from an environmental point of view, but the effects on local economic development are not included. Many of these studies also do not take a systems perspective with respect to providing urban mobility that integrates multiple transport modes. Neither has any of those projects involved the collaboration of both a major vehicle manufacturer AND a real estate developer as in our project. Our link to air transportation is also unique and the project is significant in that it includes air, rail, shuttle, and single occupancy vehicles (incl.

alternatively powered vehicles) as part of the study. Furthermore, the Aerotropolis Atlanta's proximity and linkage to both airport and transit, and the private-sector's initiative for environment sensitive technologies makes it a unique high-end development project, which is insufficiently covered by the literature of transit-oriented development. The published research database includes one study focused on creating metrics for measuring how brownfield redevelopment can reverse urban sprawl, (http://rip.trb.org/browse/dproject.asp?n=18414) and a research needs statement for case studies of how private sector real estate developers can act as partners and funding sources for transit. The completed research contributes to both of these research areas.

Research Objective:

Jacoby Development is redeveloping the site of the old Ford Hapeville assembly plant into a mixed use commercial site called "Aerotropolis Atlanta" that is adjacent to the Atlanta's Hartsfield Jackson Airport. Part of this development is integration of an airport parking lot covered with solar panels, shuttle services between the development, the airport, and potentially surrounding neighborhoods, and freight transport and access for light industrial facilities, and potential use of the adjacent rail line for goods and people movement.

This multi-disciplinary study focused on how the Aerotropolis development can achieve sustainability by interlinking state-of-the-art transportation and mobility systems, renewable energy sources, high tech companies and state-of-the-art information technologies, and creates socio-economic benefits for the surrounding areas. The study was led by Georgia Tech professors Bert Bras (Mechanical Engineering) and Nancey Green Leigh (City and Regional Planning). Leigh led the original concept study for the City of Hapeville for redeveloping the Ford site.

Results:

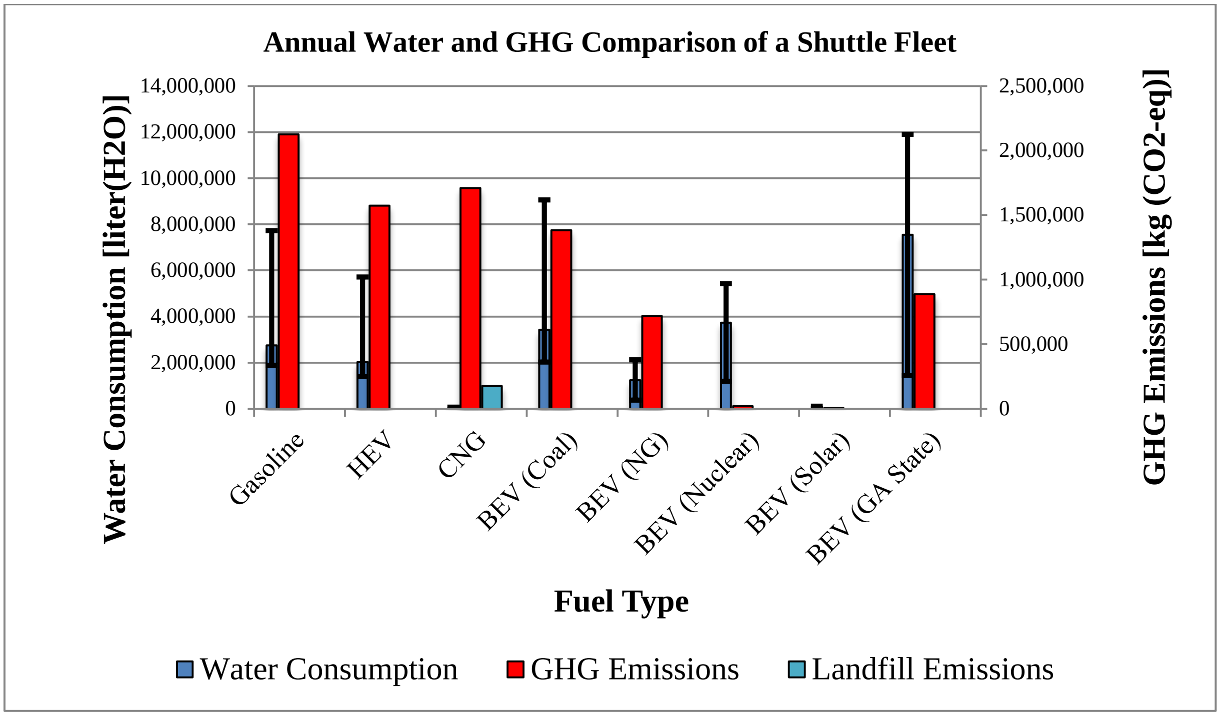
Specific aspects the study focused on were: Transportation, Mobility and Renewable Energy and Employment and Economic Development.

Transportation, Mobility and Renewable Energy: the primary objective of the study is to investigate the best choice of vehicles and fuels (including electric vehicles) for shuttling passengers to the new international terminal. Of broader and long-term concern is realizing the potential of airport- and transit-adjacent development to accommodate new growth without worsening traffic congestion and air quality.

We investigated a variety of alternative fuels types including: gasoline, hybrid, CNG, and battery EV. For each fuel type we computed the purchase price, life-cycle operating cost, greenhouse gas emissions and indirect water consumption. We found CNG to have the lowest purchase price (not including infrastructure for re-fueling), electric vehicles to have the lowest fuel consumption price, and CNG to have the overall cost over the life-cycle of the vehicle. Data were too limited to include the BEV in the life-cycle cost analysis.

The CO2 emissions and daily water consumption for gasoline, hybrid, CNG (landfill), battery EV (Coal), battery EV (NG), battery EV (nuclear), battery EV (hydro), and battery EV (solar) were also calculated the results are summarized in the chart below. The comparison between water consumption and GHG emissions is often an overlooked issue as fuels that emit less GHGs often consume more water. There is no fuel choice that is superior in all aspects and for all potential scenarios. Rather the specific scenario must be investigated and the underlying decision factors must be identified to be able to differentiate between the described tradeoffs. More details can be found in the full paper attached as Appendix A This work was performed by a graduate MS Thesis student advised by Dr. Bras and funded by the Ford Motor Company as a match to the project.

Figure A. Water Consumption and Greenhouse Gas Emission comparison for Atlanta Aerotropolis Shuttle Fleet



<u>Employment and Economic Development</u>:
This task of the research project had two foci. First, it considered the employment and economic development impacts of the Jacoby Aerotropolis redevelopment project of the former Ford Assembly site in Hapeville, Georgia. Second, it explored the larger concept of Aerotropolis as that of a specialized urban economy contained within a 20 mile radius of an airport that is being discussed worldwide, and its potential for economic development in the Atlanta metro region.

For the first focus, three research tasks were completed.

1. Employment and wage projections were created for a solar paneled park and ride lot on the former Ford site that would service the Hartsfield Jackson Airport's new international terminal. Three occupations were considered: shuttle driver, parking lot attendants, and automotive mechanics. It was estimated that the project would create 25 jobs total (not including administrative positions) with an annual payroll (salary and benefits) of approximately $1.26 million.
2. Because alternative fuel vehicles are anticipated to be used in the park and ride operation, research on the education and skill requirements, as well as wage levels of alternative fuels vehicle technicians was conducted. It was found that typical education and training required high

school degrees plus a 2 year post-secondary training program. There is a certification program for Alternative Fuel/CNG vehicle technicians; however, it is not a pre-requisite for employment. Alternative Fuels Vehicle Technician salaries begin at $25,000 per year and can go as high as $100,000 for master level mechanics.

3. Created a fiscal and economic impact analysis for the City of Hapeville from the project. This analysis used the LOCI impact model developed by Georgia Tech. Its results were limited by incomplete data availability and are limited only to the first year that the project would be in operation. The results indicate the net present value to the city of the project would be $359,000 for the first year. Income from the project would largely go to non-city residents, and there would be a little over $300,000 in retail expenditures generated by the project.

The Regional Aerotropolis Concept

For the second focus, the larger concept of Aerotropolis was explored with a literature review, an analysis of recent air cargo processing and distribution activity at Hartsfield Jackson International Airport, an analysis of existing and potential regional transportation linkages, and a determination of the local city and county governments, along with socioeconomic characteristics of the cities' populations, that would be encompassed within the Aerotropolis boundary. This analysis was extended by one of the research project's graduate student assistants who made this topic the focus of her required option paper for the master's degree in city and regional planning. This paper focused on how Hapeville's development could benefit from being an airport city within the Aerotropolis. It also explored the Aerotropolis concept's promise for regional economic development, and the opportunities and limitations for applying this concept to the metro Atlanta area. Figure B contains a map depicting the boundaries of an Atlanta airport based Aerotropolis and the local governments contained within it.

The Atlanta metro region has long been characterized by significant inequality between its northern and southern halves. Despite the fact that HJIA is located in the southern half of the region, most of the southern cities have significantly lower economic attainment and significantly higher rates of black populations. This is particularly the case for those located closest to the airport as can be seen in Figures B, C, and D.

To pursue the potential of the broader regional aerotropolis concept, subsequent research funded by an in-kind match explored the concept further, and included analysis of existing aerotroplis developments in the U.S. and internationally. Concerns over the impacts of urban development for sprawl and climate change have come to include aerotropolis development. The energy sustainability of the aerotroplis has been criticized because of its reliance on non-renewable resources and generation of high levels of traffic. Consequently, the development of alternative energy solutions is an important consideration for the creation of an Atlanta aerotropolis plan. These would be aimed at reducing the environmental impacts of logistics and transport based industry activity. They would also focus on reducing environmental impacts of the large numbers of employees commuting within the aerotropolis economy, as well as the residential and business energy use in the south metro cities.

The results of this phase of the research project were presented to an Atlanta Regional Commission-sponsored symposium on economic development strategies by Investigator Leigh in June 2012. This symposium was attended by 160 representatives from city and county government and the business community.

Figure B. Atlanta Aerotropolis: 20 mile radius and Local Governments

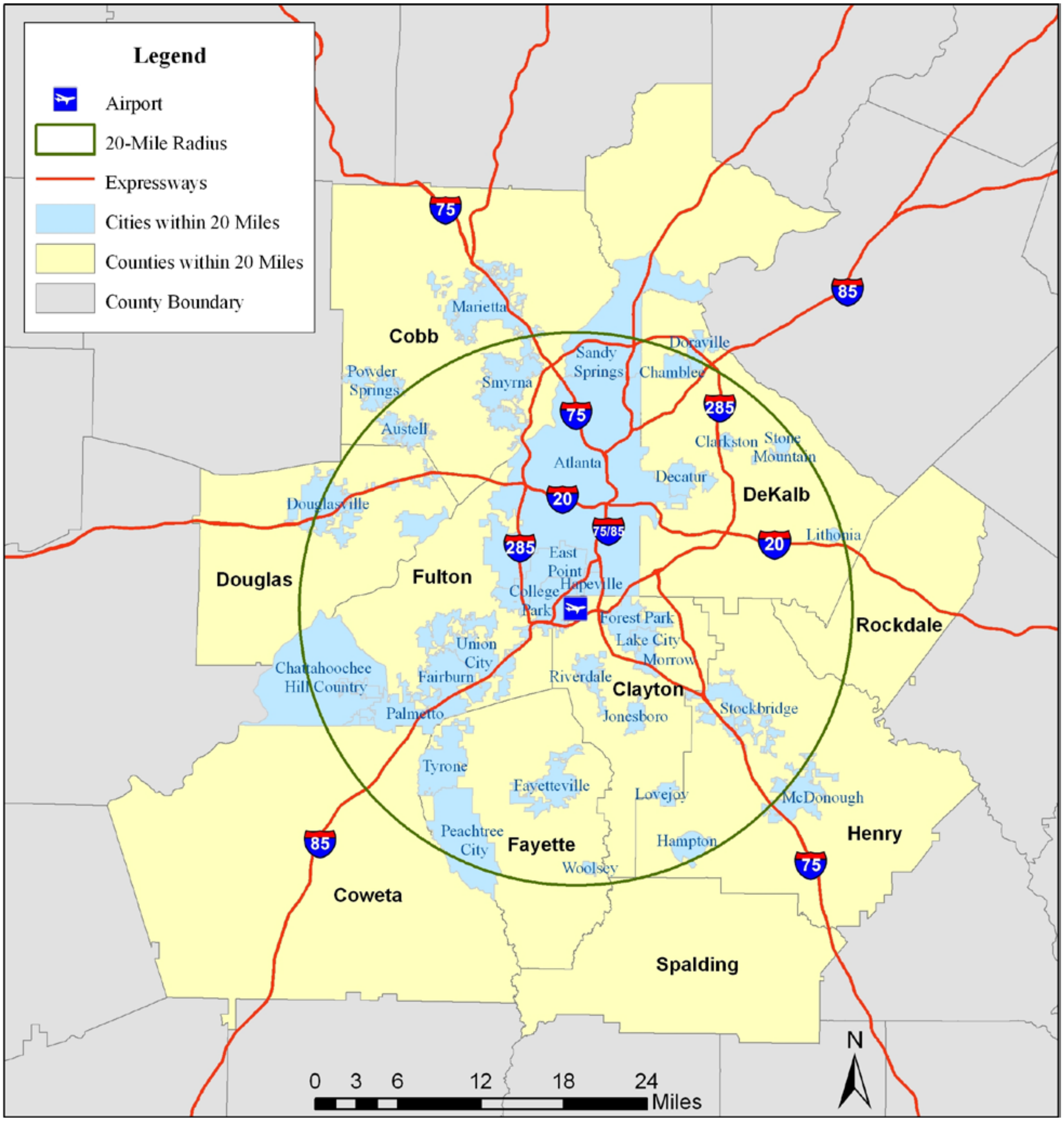


Figure C. Minority Population in Atlanta Cities within an Aerotropolis Radius, 2010

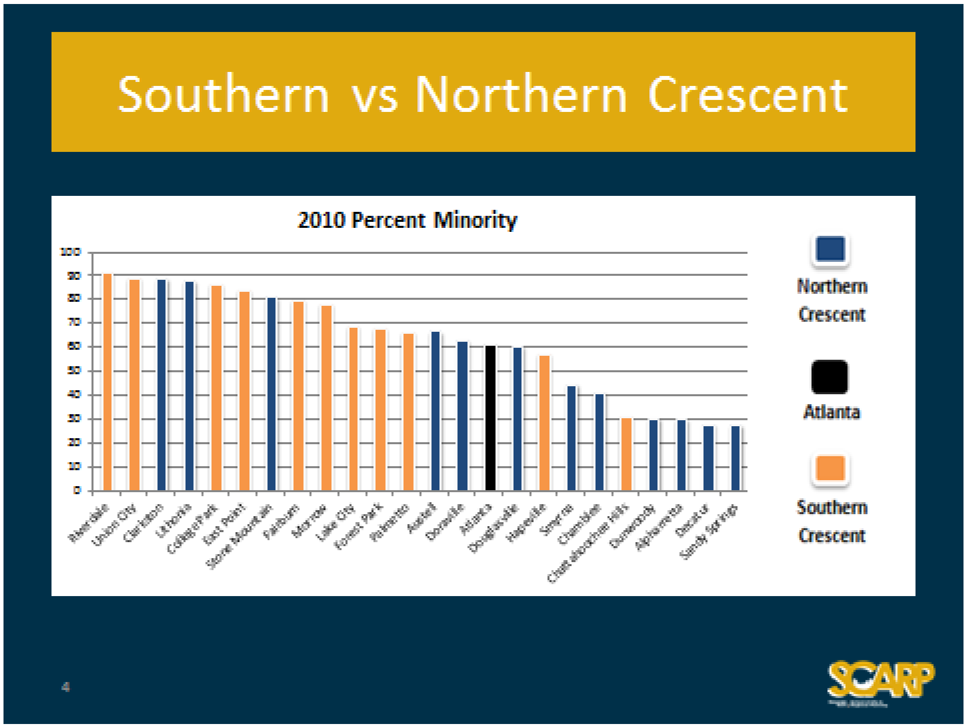


Figure D. Household Income in Atlanta Cities within an Aerotropolis Radius, 2010

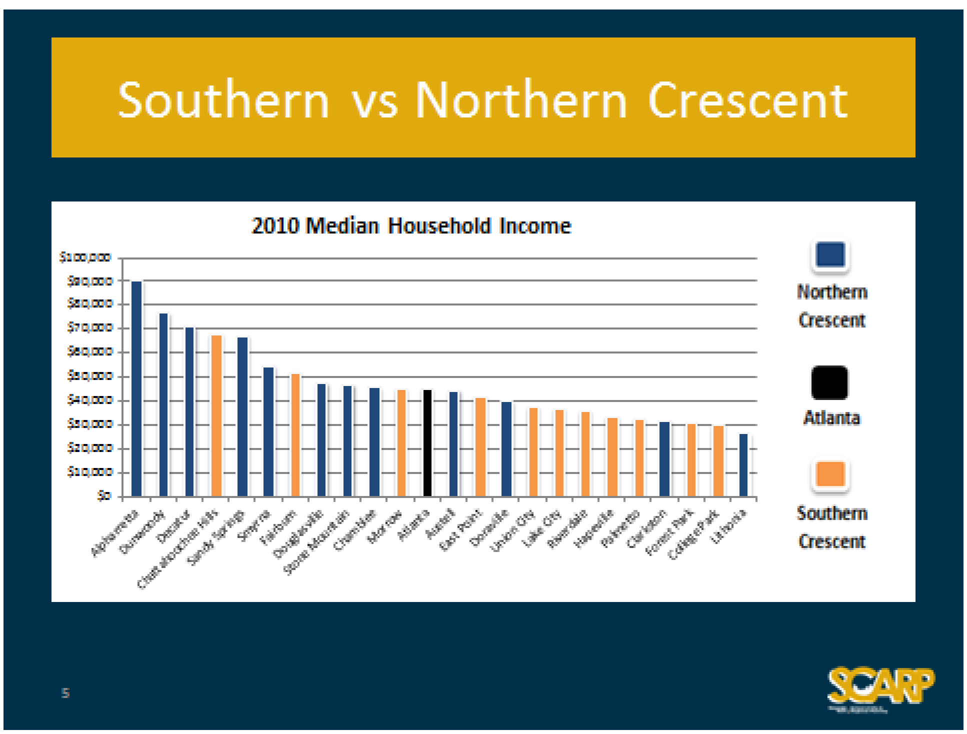
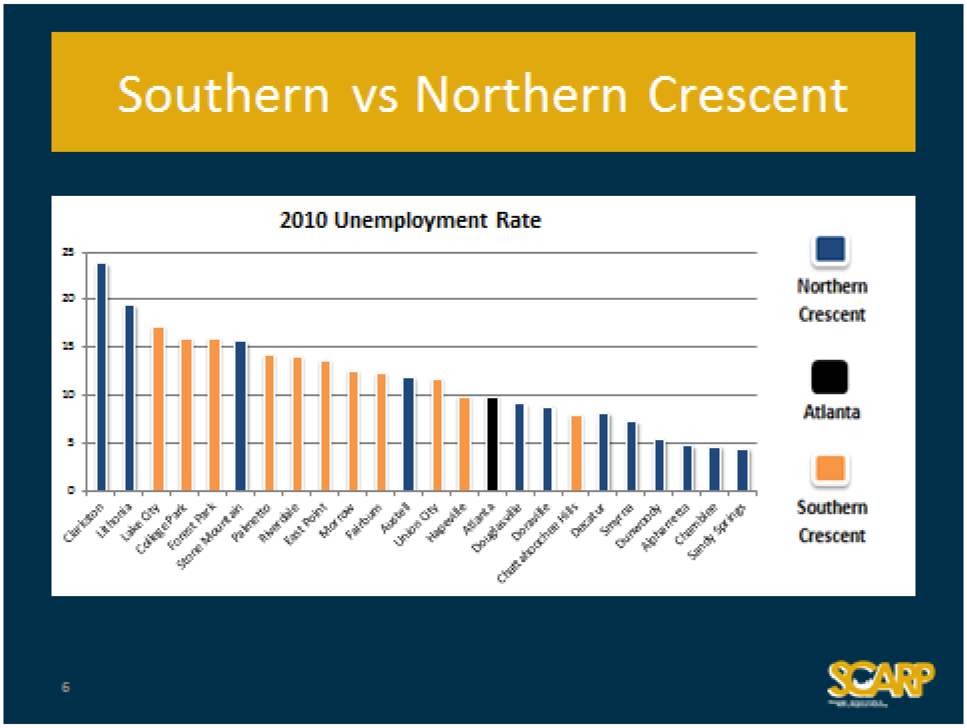


Figure E. Unemployment in Atlanta Cities within an Aerotropolis Radius, 2010



Research Significance:

From a broader impact point of view, Jacoby Development is planning a number of redevelopments of closed automotive assembly plants. While these are some of the most challenging brownfield sites in the nation, their good rail and highway access, a fundamental component of being able to move assembled new autos, provides a foundation for the transit oriented development that will be explored with the Hapeville site. The results of this study will directly inform the development of other sites, for example, Ford's Indian River Rd plant in Norfolk, VA, which is also being developed by Jacoby. The potential, therefore, exists that this study may forge a synergistic long term private-private partnership between a real estate developer (Jacoby) and vehicle manufacturer (Ford) that could benefit the economic development of several localities affected by the manufacturer's assembly plant closings. A comprehensive understanding of benefits, challenges, and issues around such developments and partnership shows cumulative economic development benefits at the local level, but also for the image of the companies involved. The study provides insight for local governments on whether and how much they should foster such private-private development and mobility partnerships.

The project is significant for Georgia (and other states) in that it quantifies the effects of integrated multi-modal transportation on local economic development. In addition, the case study of Hapeville and Aerotropolis provides insight into what extent such efforts benefit the larger transportation system. In Atlanta and other major metropolitan regions, the question of how to accommodate new growth without worsening traffic and air quality has been a persistent challenge. The potential of Aerotropolis Atlanta to sustain new growth and, at the same time, reduce individual travel and energy consumption is the beginning of a new model showing how private-private partnership could generate significant public benefit.

Appendix A:

Financial and Environmental Comparisons of an Alternative Fuel Powered Shuttle Fleet

ABSTRACT

Commercial shuttle fleets are a unique opportunity to expand a company's environmental goals based on sound financial decisions through the use of alternative fuel vehicles (AFVs). Shuttle services provide a logistical advantage for the use of AFVs due to their predetermined route structure that allows for central fueling stations for the alternative fuels. Additionally, a company may be more cognizant of the operating expenses (fuel costs, maintenance costs, etc.) than the typical household consumer and therefore be able to realize the full life-cycle cost advantages during the decision making process. Not all fleet situations are created equal and thus must be approached individually to insure that the chosen fleet composition is truly advantageous for the given scenario. The use of AFVs provides the added opportunity for the improvement of the consumer perception of the brand through marketing strategies that publicize the company's environmental efforts. In this paper, different drivetrain options are analyzed with respect to their financial cost as well as greenhouse gas emissions and water consumption – the latter not typically being considered in fleet environmental impact analyses. A case study focused on a local airport shuttle fleet is used to focus the analysis. As shown in the results, water consumption and greenhouse gas emission almost show an inverse relationship due to the potential large water consumption of electric power generation. Local variations in electricity gridmix and water consumption in fuel production can impact these results. Nevertheless, from a pure environmental perspective, solar powered battery electric vehicles are preferred. Landfill gas powered shuttles are the superior choice if more conventional drivetrains with significantly lower upfront costs are preferred.

INTRODUCTION

Currently, there is a growing demand for ways to reduce the national transportation network's dependence on petroleum. Global oil reserves are primarily located in the Middle East with 65% of the global oil reserves; a region that has a history of instability and is currently the center of a multitude of international conflicts and political unrest.[1] The industrialization of large developing countries such as India and China has created a new strain on the global oil supply in addition to the increasing oil demand from the developed US and EU. This demand has begun to outpace the rate of discovery as for every four barrels consumed only one new barrel is discovered.[1]

The global transportation network consumes ¾ of world oil imports and produces ¼ of greenhouse gas (GHG) emissions.[2] The environmental impact on global warming and pollution by the world's gasoline based auto industry has increased the support for the advancement of alternative fuel sources. These three major issues of national policy, oil supply depletion, and environmental impact show that an alternative fuel source would help alleviate some of the most critical national and global concerns.

The development of alternative fuels faces a variety of challenges in replacing the internal combustion engine (ICE) in the transportation network. Alternative fuels, in general, are immature technologies that have both high costs and low functionality. Struben et al. detailed these challenges through dynamic behavioral model that explores the transition from ICE to AFVs. This model takes into account not only the innovation adoption criteria such as word of mouth, social exposure, and the willingness of consumers to consider these alternative platforms but also the feedback influences of the various evolutions of technology. Struben stresses that, due to the fact that gasoline is priced below the level that reflects the environmental and other negative externalities. AFVs would have difficulty in overcoming the barriers necessary to achieve self-sustaining adoption. However, the main concern is the typical consumer choice that takes into account the role that transportation has as a source of personal identify and social status.[3]

Other works have focused on alternative fuel vehicles and their environmental mitigation potential in reducing greenhouse emissions. For example, Ogden et al. investigated the societal lifecycle costs of cars with alternative fuels that included not only the financials of the initial purchase cost and fuel cost but also the externality costs of oil supply security and damages of polluting emissions and greenhouse gases.[2] Some research has also focused on water consumption. For example, Scown described the water requirements for different fuel productions by constructing a life-cycle inventory and also detailing a potential methodology for including impact of the particular water consumption.[4]

Most of the prior work focuses on personal vehicles (automobiles). In this paper, however, we will focus on fleet vehicles, specifically shuttle fleets, as the source of AFV adoption. The use of alternative fuels for fleet operations is not a novel application per se and potential benefits and drawbacks have been examined before. For example, Johnson has provided an extensive business case analysis for CNG in Municipal fleets through analyzing project profitability depending on various fleet-operating parameters.[5] As a specific application, the NREL qualitatively described the use of alternative fuel vehicle fleets within airports both theoretically and by illustrating current uses at national airports.[6] A number of fuel types have been represented by Yacobucci, who provided an investigation into the current state of different potential alternative fuel sources, while discussing the potential advantages and disadvantages of each implementation.[7]

None of the preceding work, however, has combined an analysis of different fleet options from financial, greenhouse gas emissions and water consumption perspectives. In this paper, we will quantify the annual operating cost, greenhouse gas emissions, and water consumption of a number of different alternatively fueled fleet vehicles. This paper will illustrate that these various concerns should be integrated to provide a more robust decision making for a given scenario. Specifically, we will investigate the annual cost, greenhouse gas emissions and indirect water consumption from fuel production of gasoline, natural gas, hybrid and battery electric powered vehicles. Because of the regional dependency of electric grid mixes, we will use a shuttle fleet for the Atlanta airport as a focal case study. As will be shown, the combination of minimizing water consumption, greenhouse gas emissions and annual costs may cause some unexpected outcomes.

FLEET DRIVETRAIN TECHNOLOGIES

The majority of potential alternative fueled fleet technologies are not available directly from the Original Equipment Manufacturers. Instead fleet vehicles are converted to the correct specifications by an approved third-party company. These approved third-party conversion companies will often provide a comparable warranty service for the converted vehicle.

The simplest to implement would be a fleet with a hybrid drivetrain that runs on gasoline while a traction motor in parallel can power the vehicle at low speeds and recharges through regenerative braking. A hybrid provides greater efficiency due to the reduced demands on the gasoline engine and brakes. However, this improved fuel economy comes at a higher purchase cost to provide for the additional technological components. Additionally, the hybrid drivetrain still carries the stigma of relying on a gasoline engine instead of an alternative fuel source. The reduced environmental impact during the use phase of the vehicle is only associated with the reduced fuel consumption due to being more efficient than traditional drivetrains.

Compressed natural gas (CNG) vehicles run on natural gas that is compressed and stored within pressurized tanks, while meeting the same safety standards as gasoline vehicles. Natural gas can either be extracted from wells or captured from decaying organic material from landfills. Recently, 80 to 90% of the natural gas consumed in the United States was produced domestically. CNG is sold in gallons of gasoline equivalent (gge), the amount of CNG that contains the same energy content as a gallon of gasoline.

Electric vehicles (EVs) are a fuel type that is currently experiencing great technological growth. Electric vehicle technology has been limited in the past by the available battery capacity technology both in terms of manufacturing cost and available energy density.[8] Currently, major automakers are introducing a series of battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV): Ford (Focus and Transit Connect Electric), Nissan (Leaf), and GM (Volt). Along with significant government incentives, this introduction of vehicles by major auto manufacturers, as well as smaller ones such as Tesla, will spur the development of electric vehicle technology over the coming years. The battery technologies implemented in consumer cars will most likely transition into electric shuttles as the technology becomes more cost effective. Another limiting factor of electric vehicles is the recharge time of the vehicle once the battery has been depleted. The fastest available technology is referred to as a Level 3 charging system, which must be connected to a dedicated 480 Volt and 125 Ampere circuit. Level 3 stations would be able to charge a vehicle in around 30 minutes but costs range from $30,000 to $60,000 for purchase and installation.

METHODOLOGY

Vehicle Specifications

The four different shuttle options analyzed are gasoline, hybrid, compressed natural gas (CNG), and electric (BEV). These options are compared to reduce the project cost of ownership, greenhouse gas (GHG) emissions, and the water consumption in the fuel production and extraction. All of the vehicles in the comparison are based on Ford's E-450 chassis with a shuttle bus body to provide a consistent cost comparison. Partner companies convert Ford's E-450 vehicles to AFV drivetrains. Azure Dynamics is a conversion company that takes light to heavy-duty commercial vehicles and converts the vehicle to an electric or hybrid electric drive. Their E-450 hybrid shuttle has a number of fuel economy boosting features including electric-launch assist, engine-off at idle, and regenerative braking. BAF Technologies provides dedicated CNG Ford vehicles for a variety of applications including the certified E-450 cutaway shuttle. Although there is not currently an all-electric shuttle available, it was included in the environmental analysis to provide a comparison for the likely future developments.

The manufacturers' stated fuel economy and range for the various vehicle types are:

- Gasoline: 7.00 miles/gal (2.98 km/liter), 280 miles
- Hybrid: 9.45 miles/gal (4.02 km/liter), 378 miles
- CNG: 7.00 miles/gal (2.98 km/liter), 203 miles
- Electric: 1.18 miles/kWh (1.90 km/liter), 99 miles

The electric fuel economy was derived based on an average between a linear fit of fuel efficiency vs. vehicle weight and a comparison of gasoline fuel economy and electric vehicle efficiency proportions. These values were then used in calculating the fuel consumption cost and environmental impact.

Financial Implications

Purchase cost, operating cost, and salvage cost are the three main financial components to take into consideration during the decision process. These expenditures must be balanced to ensure that there is sufficient initial capital for the project, while also providing for the longevity of the program. Although AFVs typically have a higher purchase cost, the large number of miles traveled can present significant fuel cost savings over conventional gasoline. The operating cost can be split between the fuel consumption cost and maintenance cost and should include conversion for the time value of money so that the future cash flows are discounted to obtain the net present costs of the various alternatives. The net present cost allows a direct comparison to determine the lower life-cycle cost of ownership.

The fuel cost can also vary from year to year depending on the impacts of the market on fuel prices. The price of CNG is historically less than that of gasoline and tends to be more stable. Additionally, the national retail price of electricity has a general upward change varying by approximately 2% per year. Therefore, projections for the life-cycle of the project should include estimates for the trends of the respective fuel types. The consistency of the fuel price is important in defining the operating budget of the fleet as unexpected spikes in fuel cost could jeopardize the liquidity of the program. This variability can be managed by fleet operators by locking in contracts with fuel supplies for a longer time period and thus create a stable price.[9]

Another potential advantage of electric vehicles is the supplementary revenue streams that could be obtained through providing ancillary services to the electric grid while the vehicle is charging. Electric vehicles are potential assets within the frequency regulation market that can provide regulation by adjusting the rate at which the vehicle charges. EVs would be able to provide a distinct advantage to traditional generators, which are slower to react, produce more emissions, and are least efficient with variable output. There are two different power interactions possible between electric vehicles and the electric grid; grid-to-vehicle charging (G2V) and vehicle-to-grid capability (V2G). The current generation of electric vehicles provides only one-way G2V charging, where the electric grid provides energy to the vehicle through a charging station. Future generations of vehicles may be able to provide V2G services as the vehicle becomes a distributed energy and power resource capable of bi-directional charging. However, there is a significant increase in the cost structure for V2G vehicles as well as uncertainties of the impact of the increased cycling on the battery life-cycle.

Environmental Implications

As previously stated, current environmental analyses typically focus on one aspect of the environmental implications of fuel choice. Instead this paper proposes that both GHG emissions and water consumption should be examined due to the fact that electric vehicles are often seen as reducing greenhouse gas emissions, but electricity generators are also major consumers of water. Hence, it is important to identify the relationship between improvements in these categories.

Greenhouse Gas Emissions

The CO_2 equivalent emissions were calculated using the full life-cycle model called GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) developed by the DOE's Argonne National Laboratory. GREET allows the evaluations of various vehicle and fuel combinations on a full fuel-cycle basis. The emissions per unit energy of the various fuels are broken up into upstream and tailpipe emissions. Upstream emissions are defined as the emissions from the production and transportation of feedstock and production and distribution of product fuels. Tailpipe emissions are the direct emissions due to the combustion of the product fuels during vehicle operation. The global warming potentials of the greenhouse gases are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

For a pure BEV, the emissions of the fuel source have been transferred upstream to the source of the electricity, the respective type of power plant, which determines the true environmental impact of the vehicle. Table 2 presents the Georgia state electricity mix that defines the respective percentages of electricity provided by the different plant types, which will be used in an example scenario. In May 2011, the total electricity output for Georgia was 1,739 GWh consisting of the following sources:[10]

- Petroleum: 9 GWh (0.08%)
- NG Fired: 2,101 GWh (17.90%)
- Coal: 6,393 GWh (54.46%)
- Nuclear: 2,722 GWh (23.19%)
- Hydro: 268 GWh (2.28%)
- Renewable: 246 GWh (2.10%)

Table 1 presents the energy content and greenhouse gas emissions of the various fuel types. Electric power sources do not have any tailpipe emissions since there is no combustion during vehicle operation and the entirety of the emissions is related to the upstream content. Landfill CNG is captured from decaying organic material and is provided a negative upstream content since this methane and carbon dioxide is being prevented from escaping to the atmosphere.

Table 1. GREET CO_2-Equivalent Emissions by Fuel Type

Fuel Type	**Energy Content**	**Upstream**	**Tailpipe**	**Total**	**Unit**
Gasoline	116,090 Btu/gal	0.019	0.078	0.096	$g(CO_2\text{-Eq})/Btu$
Hybrid		0.019	0.078	0.096	
CNG	116,090 Btu/gge	0.017	0.061	0.078	
CNG (Landfill)		-0.053	0.061	0.008	
BEV (Coal)	3,412 Btu/kWh	0.362	0	0.362	
BEV (NG)		0.188	0	0.188	
BEV (Nuclear)		0.005	0	0.005	
BEV (Hydro)		0.001	0	0.001	
BEV (Solar)		0.001	0	0.001	
BEV (GA State Mix)		0.232	0	0.232	

Water Consumption

Water consumption is a much different issue from greenhouse gas emissions because it must be addressed at the local level. In regions that have a surplus of water, variations in the level of consumption may have little noticeable impact. However, in water scarce regions, the same consumption could put extreme strain on the available water resources.

In this paper, water consumption is defined as freshwater withdrawals which are evaporated or incorporated in products and waste, and thus lost for further use in the local community. This is in contrast to water use, which is defined as all water that goes into a system. Most of this typically leaves the system as waste water.

The water consumption that is analyzed is based only on the water that is consumed in the extraction, processing, transportation, and electricity generation of the desired fuels within a local transportation network. Table 2 presents the water consumption for the various fuel types in terms of liters of water per liter of fuel or kWh of electricity.

Table 2. Water Consumption by Fuel Type

Fuel Type	**Extraction**	**Process**	**Transport**	**Plant**	**Local Total**	**Unit**	**Ref**
Gasoline	2.10	1.09	0.65	0.00	3.84	liter (H_2O)/liter (fuel)	11
Hybrid	2.10	1.09	0.65	0.00	3.84	liter (H_2O)/liter (fuel)	11
CNG	0.00	0.05	0.03	0.01	0.09	liter (H_2O)/ liter (gasoline equivalent)	11-12
BEV (Coal)	0.01	0.03	0.42	2.60	3.06	liter (H_2O)/kWh	11
BEV (NG)	0.00	0.06	0.03	1.02	1.11	liter (H_2O)/kWh	13

BEV (Nuclear)	0.00	0.13	0.00	3.20	3.33	liter (H_2O)/kWh	11
BEV (Hydro)	0.00	0.00	0.00	179.50	179.50	liter (H_2O)/kWh	14
BEV (Solar)	0.00	0.00	0.00	0.02	0.02	liter (H_2O)/kWh	11
BEV (GA State Mix)	0.01	0.06	0.23	6.44	6.74	liter (H_2O)/kWh	10-11, 13-14

This data represents the local total water consumption in the extraction, processing, transportation, and any water consumed at the plant level or to compress the natural gas (listed in Plant column of Table 2). For the electricity sources the majority of the water consumption is at the plant level due to the water required in the cooling processes within the plant. CNG is also dependent on the source of power for the compressor as there is either electric or natural gas powered devices. To compress the natural gas to the 4,000 psi range requires 0.01-0.016 kWh/SCF for an electric compressor or natural gas compressors operate at approximately 91.7% efficiency with 8.3% of the gas used to power the compressor.[12] This discrepancy creates variability in the impact of CNG vehicles depending on the technology utilized at the fuel storage location. Additionally, natural gas has come under increasing scrutiny in the extraction phase if it is extracted using hydraulic fracturing (fracking) that would both increase water consumption and has significant water quality concerns.

It should be noted that considerable variability exists in the water consumption data for the various fuel types depending on location and technology used. More on this variability is given in the Supplementary Information section of this paper.

The impact of the water consumption is also variable as the same water consumption will have varying effects in different watershed regions. Therefore, water consumed farther upstream for fuel recovery is not included as this aspect is considered outside of the local impact region for the Georgia specific case study. If the water consumption during the extraction of crude oil is considered for gasoline, the water consumption total increases by 2.10 liter (H_2O)/liter of gasoline produced to a total 3.84 liter (H_2O)/liter of gasoline produced.

AIRPORT SHUTTLE SCENARIO

Airports are ideal areas to focus on for AFVs due to the associated air quality concerns and the tendency to be located in air quality nonattainment zones [6]. Additionally, the fleets travel routes that provide for integrated central refueling stations and the high mileage increases the potential fuel savings of AFVs. Another aspect that is hard to quantify is the potential public goodwill and airport image improvement that may be gained by passengers being transported to their respective flights through sustainable methods. These reasons have led airports to operate successful CNG fleets over the past decade with the number growing with the maturation of the technology.

Route Description

The specific scenario analyzed is the shuttle program of the planned Aerotropolis Atlanta development at the site of the former Ford Hapeville automotive assembly plant at Hartsfield Jackson International Airport in Atlanta, GA. The Aerotropolis Atlanta plans to feature a 30-acre parking area that will feature two separate shuttle services: one to the existing western terminal and another to the new international terminal. There will be 6 shuttles each servicing the western terminals (5 mile distance) and 6 more servicing the international terminal (1.4 mile distance).The Western Terminal travel time is 20 minutes (10 minutes each way) with two 5 minute stops for a total of 30 minutes. The International Terminal travel time is 8 minutes (4 minutes each way) with two 5 minute stops for a total of 18 minutes. It is assumed that the International Terminal is served 24/7 but at half capacity (3 shuttles) from 1:00-5:00 am. The Western Terminals will have no service from 1:00-5:00 am. This means that the two shuttle fleets serving the International and Western terminals drive 1,232 and 2,400 miles, respectively, for a total of 3,632 miles/day or 1,325,680 miles/year.

Results & Discussion

Financial

The main cost items in purchasing and operating a shuttle fleet are listed in Table 3. The purchase prices were broken down to include the price of the chassis, any necessary conversion, body price, state tax, and any governmental incentives. Using the route description and the fuel economy data provided, the annual fuel consumption is calculated based on 1,325,680 miles traveled each year by the fleet. The gasoline and CNG prices used are the average price from the Lower Atlantic region as defined by the PADD for October 2011 [15]. The electricity data is obtained from the Georgia state profile from EIA and is the commercial price from August 2011 [16].

Not included in the financial analysis is the infrastructure cost for the AFV fueling stations. If a CNG-equipped fueling is not available or conveniently located for the fleet, it may require a significant infrastructure investment in the magnitude of millions of dollars. In our case, a CNG refueling station was available for use nearby and no infrastructure investment was needed for CNG AFVs. Even a landfill with ongoing LFG recovery was available locally. CNG refueling could require an increased burden of maintenance and operation of the refueling station dependent on the monthly throughput of CNG in GGE. Johnson derived the polynomial estimation in Equation 1 of this increased cost based on industry data,

Total Annual Fuel Cost	**$634,433**	**$469,950**	**$304,906**	**$117,514**
Annual Maintenance	equivalent	equivalent	equivalent	equivalent
Fleet Life-Cycle (5 year) Fuel Cost	**$3,172,163**	**$2,349,750**	**$1,524,532**	**$587,568**
Fleet Total Life-Cycle (5 year) Cost	**$3,790,619**	**$3,554,106**	**$2,219,932**	**>>$1,800,000***

Environmental – Greenhouse Gas Emissions and Water Consumption

The environmental impact is calculated using the fuel economies and the respective data from Table 1 and 2 using equations 2 and 3.

have a significant effect on water consumption due to the evaporation from hydropower lakes. This water consumption for hydroelectric plants is mostly due to the large surface area of the reservoirs, which contribute to high evaporation rates. The hydroelectric aspect of the Georgia state mix, although it only contributes approximately 2% of the state electricity, represents 64% of the water consumption for the vehicle fleet. Figure 1 does not include the source of purely hydroelectric battery electric vehicle due to the water consumption values skewing the perspective of the chart.

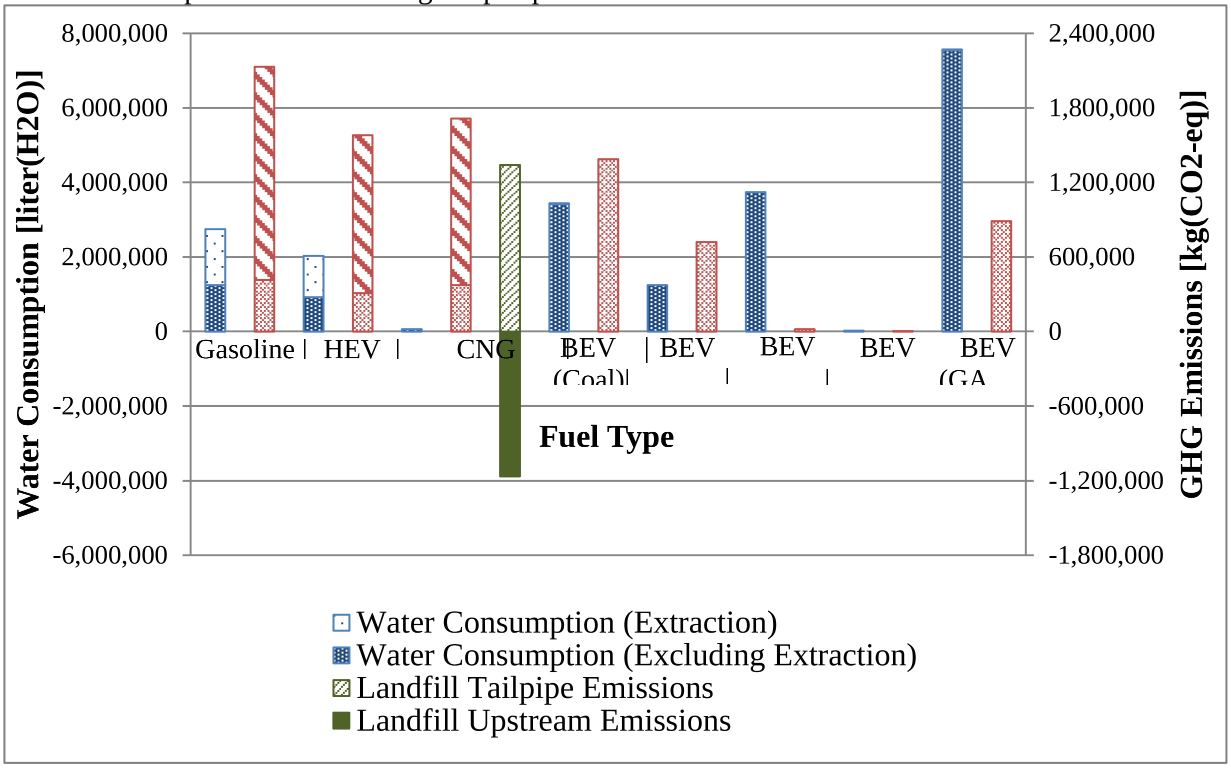


Figure 1. Fleet Annual GHG Emissions and Water Consumption Comparison by Fuel Type

Impact of Fuel Extraction on Water Consumption

The water consumption due to fuel extraction was also included in the fleet annual water consumption. But in localities like Georgia, the fuel may be refined, but is typically not extracted. Hence, the associated water consumption does not impact the local community as much as its processing. As seen in Figure 1, the impact of extraction is most evident in the water consumption for the gasoline powered vehicles. The electric vehicle is not as affected in this reduction primarily due to the plant water consumption being the driving factor for this fuel type.

Impact of Water Consumption Uncertainties

Significant variability exits in water consumption rates for the various fuel options (see Supporting Information). Figure 2 displays how the uncertainty within the water consumption data impacts the annual water consumption by fuel type.

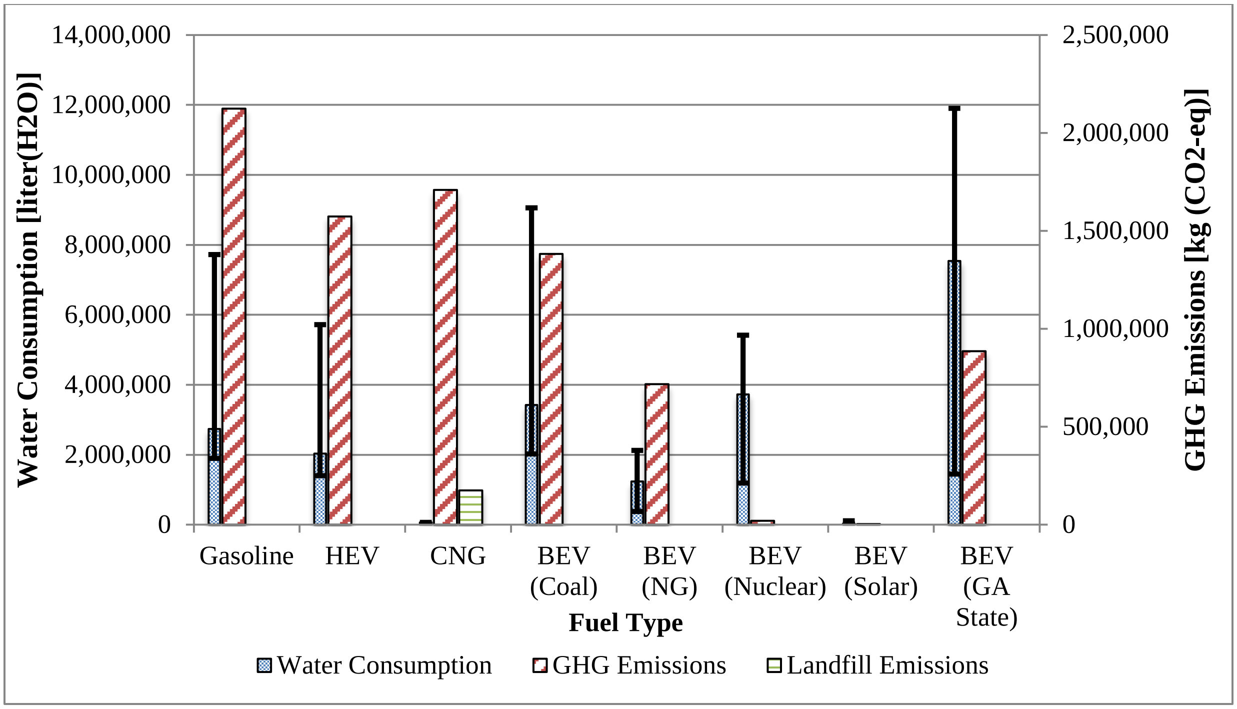


Figure 2. Fleet Annual GHG Emissions and Water Consumption Comparison by Fuel Type including Water Consumption Uncertainty

The wide variation in the results due to the uncertainty of the data exemplifies the difficulty in determining the water consumption footprint for the fleet depending on the scope of the analysis and accompanying assumptions. However, the same inverse relationship between water consumption and GHG emissions can be observed. Outside of electricity produced from solar and natural gas, there is significant water consumption for energy generation types that produce less GHG emissions.

Another significant challenge is consistently using the most locally relevant data in comparing various specific fleet scenarios. Figure 3 presents an example of this wide variation by comparing the theoretical water consumption for a BEV fleet in a number of different states that have varying electricity generation mixes and different water consumption for hydroelectricity.

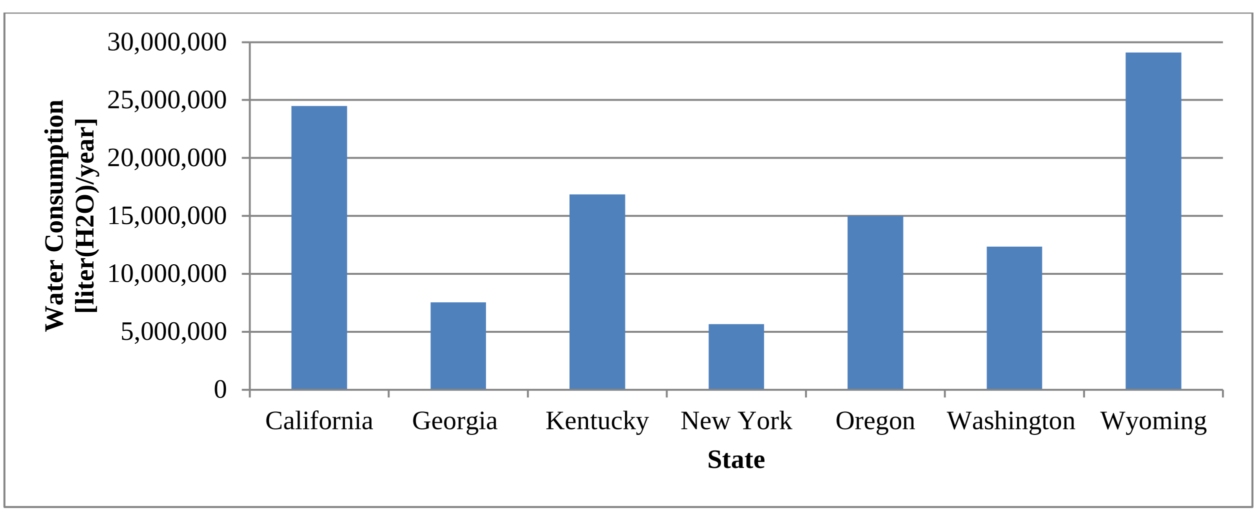


Figure 3. Comparison of Water Consumption for a 12 Vehicle BEV Fleet in Different States

This comparison shows that the wide variability in the outcomes of this analysis depending on the locality of the scenario. More on the variation in water consumption due to hydroelectric power generation can be found in the supplementary information.

Clearly, the decision process for fleet composition relies on being able to accept the tradeoffs associated with AFVs. This paper provided an assessment of aspects that are often overlooked and not fully understood in terms of the interrelated relationships between financial, GHG emissions, and water consumption. As shown, some fuel types may limit greenhouse gas emissions, but consume more water. Other fuel types require a higher purchase cost, but provide operating cost savings over the life of the vehicle. Some operators may prefer the simplicity of operation and the familiarity of conventional gasoline or hybrid drivetrains. However, through careful analysis an informed decision can be made that takes into account the specific scenario's variables to maximize the triple bottom like benefit of the shuttle fleet. As shown in this paper, there is no fuel choice that is superior in all aspects and for all potential scenarios per se, especially when uncertainties with respect to grid mix and hydroelectric power evaporation rates are taken into account. Specific scenarios must be investigated and the underlying decision factors must be identified to be able to differentiate between the described tradeoffs. Nevertheless, for the given case of the Atlanta airport shuttle fleet, solar powered BEV and landfill gas powered CNG shuttles provided the lowest environmental impacts. If the financial point of view is factored in too, then the CNG (ideally landfill gas) powered shuttle fleet becomes the preferred choice.

Additional and Future Considerations

There are a number of aspects that could be further incorporated into the study to provide further robustness, such as the daily refuel characteristics of the different fuels based on the range of the vehicles. The number of refuels would significantly influence the composition of the fleet since there is a time and therefore a cost associated with having to refuel these vehicles. Additionally, it would useful to introduce a demand response model that would scale the number of shuttles in service based on the number of passengers and workers that would be utilizing the shuttle at different times of day/week. For example, a BEV shuttle has a range of 99 miles and the airport fleet of 12 electric vehicles would require 36 recharges per day to cover the distance to the International and Western terminals, whereas a hybrid vehicle fleet with 378 mile range would require only 9 refuels per day. A CNG vehicle fleet with 203 mile range each would require 17 refuels. The number and speed of refuels impacts the ease in implementing a respective fleet, as for a BEV there are challenges around managing the required time to recharge depleted batteries.

Other revenue stream may potentially be taken into consideration for fleet operators, especially for electric vehicles. Electric vehicles have the unique ability to provide services back to its fuel source through ancillary services for the utility in helping to maintain grid reliability. These ancillary services, such as frequency regulation, could transform the vehicle from a single purpose tool into a dynamic multifunctional asset. However, this must be properly managed to maximize potential benefits to the operator.

Finally, a methodology to inferring the associated impact of the water consumption on a location specific basis would help to represent the true effect of the resource use. Water impact methodologies, approaches, indicators, and metrics are still evolving and thus incorporate a number of different aspects and provide a wide-range of results. The main difficulty is defining both the quantity of water used as well as the resulting impact of the locational aspects. As described previously, water is a location specific resource and the same consumption has varying impacts depending on the locations' available resources and demand constraints. Jeswani et al. have thoroughly outlined numerous methodologies for assessing this impact as well as the strengths and limitation that show that depending on the chosen method there can be large variations in the results.[17] This would help differentiate the importance of the environmental factors, GHG emissions and water consumption, to understand for a specific local what fuel type is appropriate. In water scarce regions the potential impact of water consumption would be must more drastic and a fuel source that limits the local water consumption would be much more suitable for a fleet in this region.

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Appendix B:

Public and Private Supply of Transportation around Airport Communities

The Jacoby Aerotropolis project, by the nature of its location, is a transportation-oriented development. It lies next to the busiest airport in the world as well as a Norfolk-Southern railroad corridor. The site also has access to two interstate highways. The Jacoby Aerotropolis site, city of Hapeville, and other communities in the area are heavily reliant on automobiles, creating significant barriers for potential employees and consumers who do not own and operate a motor vehicle.

The transit options available in Hapeville near the Jacoby Aerotropolis site include MARTA bus Routes 95 and 172, which connect passengers to MARTA rail stations at College Park, Oakland City, and West End; Speedy Wiz Transport, a private bus service, Route 501; and a number of hotel shuttles. In 2010, MARTA discontinued Routes 72 and 77 servicing Hapeville as part of a large-scale program to cut operating costs across the system. Route 95, which connects to West End station, services Hapeville with 15-minute headways, while Route 172, which connects to College Park and Oakland City stations, services Hapeville with 45-minute headways. Also in 2010, a private bus operator, QuickTransit, eliminated its Hapeville route..

Hotel shuttles are an overlooked, but well-utilized form of mass transit in the Hapeville area. Besides moving customers between the airport and hotels, they also carry employees along the route as well. Savvy employees use MARTA rail to reach the airport, from there, they are able to take advantage of their hotel's shuttle service for free. With many of the hotels using a timed schedule for their shuttles, employees can arrive at the airport at an appropriate time to transfer to the necessary shuttle. In many cases, this eliminates the need to wait for a MARTA bus transfer on Route 172. In addition, the hotels shuttles are more convenient and reliable than transferring at West End Station on Route 95 and riding a significant distance on a MARTA bus along Metropolitan Parkwaywhere there is a greater likelihood of traffic delays compared to the short distance that one must travel on a hotel shuttle. Finally, hotel shuttles provide door-to-door service, whereas buses stop at designated places, from which employees must walk the remainder of the way to their destination, which, in poor weather, is particularly undesirable.

The development of private bus transit in the area is new and began the Clayton Transit (C-TRAN) system discontinued area service in March 2010. Speedy Wiz Transport and QuickTransit are the two new operators in the area. Speedy Wiz is based in Kennesaw as a private shuttle service, but the company decided to try to experiment with bus service in Clayton County. It runs an infrequent service on Route 501, following the old C-TRAN Route 51, with 2.5-hour headways at each end of the linear route. It services an area connecting the cities of College Park, Forest Park, Lake City, Morrow, and Jonesboro. This system, as with QuickTransit, does not have marked stops and is not integrated in any way with MARTA. As a result, passengers do not receive free transfers for MARTA rail/buses; therefore, they must pay a second $2 fare on each journey if that journey requires a transfer. Moreover, although the driver would likely comply if a passenger requested to be dropped off in Hapeville, the service does not have any scheduled stops in the city at this time. The buses drive through the south side of the city alongside the airport. Nevertheless, if a significant demand resulted from Aerotropolis, Speedy Wiz would likely alter its route to capture some of this demand. Yet, its current ridership, with an average of 250 riders per bus per week, casts some doubt as to the long run operations of this service since it does not receive public subsidies.

In 2010, QuickTransit ran a similar service through Hapeville en route to Clayton County. It has since altered its route to the south side of the airport. It services an area connecting College Park with

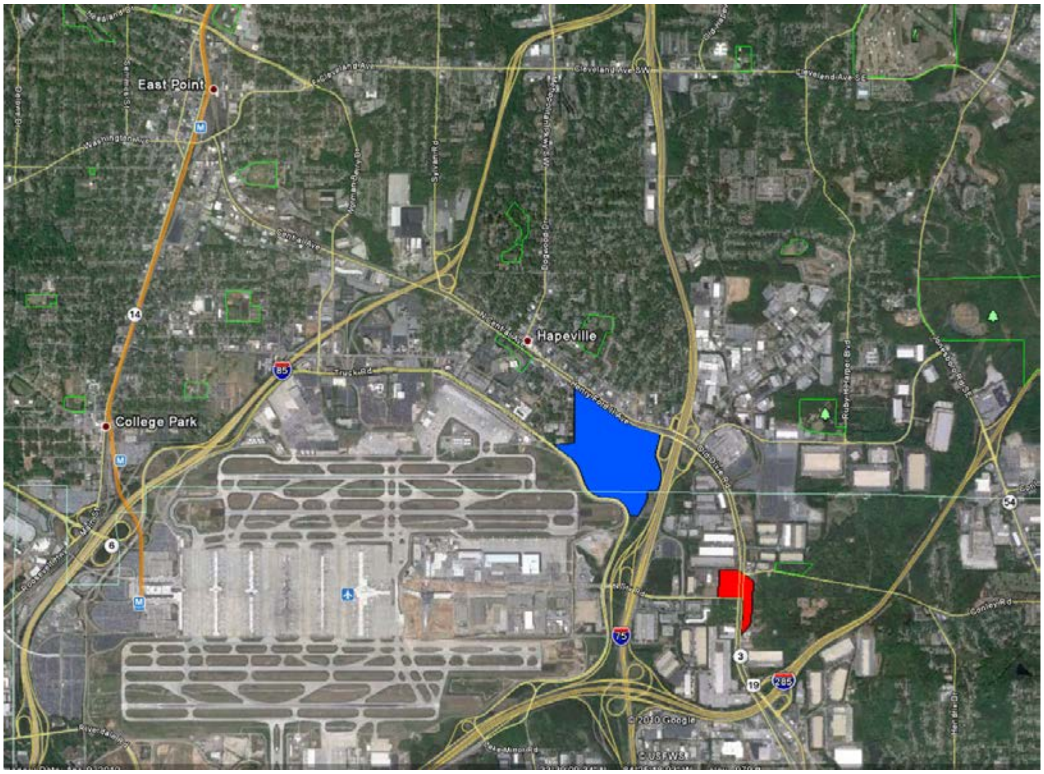
Riverdale and Morrow in Clayton County. The one-way fare for QuickTransit is $3.50, or $1.50 higher than for Speedy Wiz Transport .. In the scheme of mass transit, this is comparatively high for the region. However, a $25 unlimited ride weekly pass can bring down the average cost per ride to $2.50 based on one roundtrip for each weekday. Ridership on this system was significantly higher than Speedy Wiz Transport with short buses carrying between 25 and 30 people one-way during peak times. Ridership was somewhat light during the day, but still took on enough riders to make the system feasible. As mentioned, this service no longer reaches Hapeville, but its ridership shows that Clayton County has a need for transit service connections to MARTA and potentially to an employment center such as Aerotropolis.

In the November 2, 2010 general election, Clayton County citizens voted in favor of becoming a member of MARTA in a non-binding referendum. In this referendum, over 67 percent of citizens were in favor, a large enough margin that must lead to the consideration that the county may soon bring forward a binding referendum, which should lead to the extension of MARTA services to the county. If Jacoby would benefit from increased access to its Aerotropolis development if MARTA wee extended.

Current transportation plans for the area would bring regional rail to a site about one mile southeast of Aerotropolis, where planners have proposed the construction of the Southern Crescent Transportation Service Center (SCTSC). This center would be one of three stations for a proposed high-speed ground transportation train between Chattanooga and Atlanta connecting Downtown Chattanooga, Lovell Field Airport, Dalton, Cartersville, Town Center (Kennesaw), Cumberland/Galleria, and Downtown Atlanta with Clayton County. It could later expand to as far north as Nashville and as far south as Savannah. Moreover, if the state constructs a proposed commuter line between Macon/Lovejoy and Atlanta, this center, or Aerotropolis directly, would likely host one of the stops for this line. Both of these major rail plans would bring more passengers, many of which would likely be commuters, to the area around Aerotropolis.

The project team responsible for the development of HSGT between Atlanta and Chattanooga has set the majority of the route with the exception of the section within the Perimeter in Atlanta. Regardless of the final route/alignment selected, the team expects to include stops along the I-75 corridor at Downtown Chattanooga, Lovell Field Airport, Dalton, Cartersville, Town Center (Kennesaw), Cumberland/Galleria, Downtown Atlanta, and the future Southern Crescent Transportation Service Center (SCTSC) in Clayton County. Within the Perimeter, one of the two corridors proposed includes the use of an existing Norfolk Southern rail corridor that bisects the northwestern section of the city between I-20 and I-75. The second of the two corridors follows the I-75 corridor throughout Atlanta. Each of these two corridors includes two alignments, a median and non-median alignment, which references the location of the railroad with respect to I-75. Each route includes the same stations.

Clayton County has proposed to locate the SCTSC at the intersection of Aviation Boulevard and Old Dixie Highway. The map below shows the location of the SCTSC in relation to the Aerotropolis development. The two will not be adjacent to each other but will be approximately one mile apart when traveling along Old Dixie Highway/Henry Ford II Avenue.



Although the regional rail lines would connect to the projected multi-modal passenger terminal (MMPT) in Downtown Atlanta, where passengers could transfer to MARTA rail, the area near Aerotropolis could capture more riders and relieve potential congestion in Downtown with access to MARTA rail. Furthermore, this would be a more logical transfer point for people trying to reach the airport or another destination in south Atlanta. Lastly, the addition of MARTA rail could transform Aerotropolis into a true TOD.

The extension of MARTA rail to Hapeville/Aerotropolis could provide MARTA with similar benefits to those that the agency enjoys at Lindbergh City Center. With the purchase of land north of Aerotropolis, MARTA could capture the value of the land and lease it out to developers, providing a new source of income that would not be dependent on taxes and, thus, not subject to being split between operations and capital reserves. The additional station would provide a new point of attraction and generation for riders, potentially capturing and earning more choice riders, who would like to arrive at or depart from Hapeville/Aerotropolis. This increase in ridership would add more revenues for operations in the future. In addition, a public-private partnership with JDI could reduce the financial burden on MARTA for the spur, while increasing accessibility, traffic, and land values at Aerotropolis. This would be a mutually beneficial effort that could set precedent for future development in Atlanta.

A spur line would provide a public good as well, giving Hapeville, a jurisdiction that has paid into the MARTA system since its inception, its first MARTA rail line, which MARTA had proposed in its original plans. Moreover, the line would create an appropriate gateway into Clayton County, which, with its options limited to private-sector transit systems, would give the county's citizens an opportunity to utilize public transportation.

Appendix C: Applying the Aerotropolis Model to Metro Atlanta

With an average of 240,000 passengers per day, Hartsfield-Jackson Atlanta International Airport has won the title of the world's busiest airport for the 13th consecutive year in 2010 (Hartsfield-Jackson Atlanta International Airport, 2011). The number of passengers increased 1.51 percent from, 88.0 million in 2009 to 89.3 million in 2010, and international passengers increased by 3.47 percent over the same period. Moreover, as the nation's fourth largest concentration of Fortune 500 companies, Atlanta is the focal point of headquarter relocations and expansions, both nationally and internationally.

Applying the Aerotropolis Model in metropolitan Atlanta area presents a bigger and different challenge from other metropoli in that more emphasis should be laid on bringing out the existing economic development potential in this region and enhancing the airport's presence as a gateway to the rest of the world. Realizing the aerotropolis vision can be achieved in three ways: strengthening the airport's role as a national air cargo distribution center, developing Hapeville into an airport city and the leading economic growth engine for South Atlanta, and finally, transforming metro Atlanta into an international aerotropolis and multimodal transportation hub.

Atlanta Airport as an Air Cargo Distribution Center

The continuing liberalization, privatization and globalization of markets have rendered the aviation industry more important than ever. The aviation industry is assuming an increasing role in supporting the regional, national, and global economy through drawing foreign investments from international trade, and, introducing quality products and speedy service to places that have never been reachable before.

Apart from the interdependent relationship between air cargo and GDP as demonstrated by Kasarda and various other scholars, the aviation industry is also responsible for many other positive outcomes, including acceleration of global trade, integration of sourcing, manufacturing and distribution activities, and expansion of metropolitan cities.

Today, air cargo business is more concentrated in some parts of the world compared to passenger traffic. Eighty-five to ninety percent of the world‟s total air car
largest international airports. The 30 largest airports enjoy 70 percent of the total share (Senguttuvan, 2006). As the air cargo business becomes more competitive globally, the business forms in major metropolitan cities with international airports in presence are rapidly transforming and developing. For instance, Amsterdam's Schiphol Airport possesses one of the most liberalized customs in the world. A joint agreement between Schiphol Airport and Korea's Incheon International Airport has been signed recently in promotion of paperless air cargo transportation utilizing the Air Cargo Information System (Air Cargo World, 2011). With more initiatives undergoing to speed up the security inspection process for both air cargo and passengers, Schiphol Airport currently accounts for approximately 1.9% of the economic output in the country, and, has successfully attracted over 500 international companies to its surrounding area.

The Atlanta airport is the region's most significant employer. According to the 2009 Economic Impact Report released by the airport, over 58,000 jobs in Atlanta are directly related to airport activity, and business revenues generated by the aviation business directly were $32.5 billion. The airport is accountable for creating more than 434,000 jobs and $58.2 billion business revenues in the metro area, combining direct, indirect and induced impacts. Eighty percent of U.S. consumers, more than 200 million people, are within a range of either two hours' flight or one day's trucking from the Atlanta airport.

Table 1: A Summary of Atlanta Air Cargo by Origin and Destination

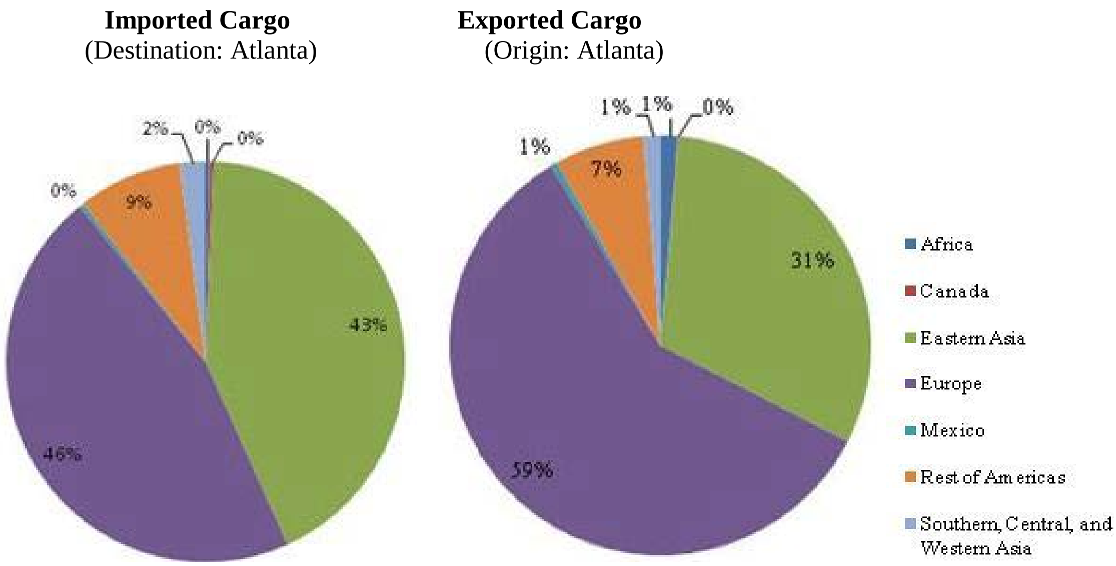
Origin	**Transshipment**	**Destination**	**Total Weight (000 tons)**	**Total Value ($ millions)**
Domestic Cargo				
Domestic*	N/A	Atlanta	21.04	$3,636.05
Atlanta	N/A	Domestic	15.99	$2,255.19
International Cargo				
International**	Domestic	Atlanta	272.68	$24,455.67
Atlanta	Domestic	International	173.62	$12,238.19
International	Atlanta	Domestic	0.33	$25.23
Domestic	Atlanta	International	4.62	$435.28

*Domestic regions other than Atlanta
**International regions
Source: Yang, Leigh, and Zhou, 2010

However, the ranking of the Atlanta airport by air cargo traffic has been steadily declining since 2002. The air cargo volume of Atlanta airport was 563,139 metric tons in 2009, when the airport fell behind the world's 30 busiest airports by cargo traffic. Freight transportation services only took up 7% of the airport's revenue in 2009, while the revenue coming from passenger service and airport administration reached 88% (Hartsfield-Jackson Atlanta International Airport, 2009).

An air cargo analysis utilizing the Commodity Flow Survey (2007) data shows that Atlanta is a cargo distribution and processing center primarily serving the Southeastern U.S. and Europe (Yang, Leigh, and Zhou, 2010). More than 90%, or about 450,000 tons, of the air cargo shipped or transshipped through Atlanta had an international origin or destination (Table 1: A Summary of Atlanta Air Cargo by Origin and Destination). There was significantly more cargo, both domestically and internationally, that is consumed in the Atlanta area than was produced and disbursed from Atlanta. Europe and Eastern Asia were the predominant origins and destinations of international air cargo, contributing to about 90% of the total value. Domestic cargo shipped to Atlanta majorly originated from Los Angeles and St. Louis, while the primary destinations of cargo shipped from Atlanta were Los Angeles and Boston. The major types of commodity shipped by air were machinery, electronics, precision instruments, pharmaceuticals and transportation equipment.

Figure 1: Imports and Exports with Atlanta as Origin or Final Destination



Source: Yang, Leigh, and Zhou, 2010

The analysis of air cargo data also indicates that air is the only mode of transportation throughout the entire itinerary of air cargo shipped through Atlanta, instead of being transshipped via railroad, ferry or trucking. Such a finding implies that though the Atlanta airport is a principal aeronautic portal of the southeast region, its connection with various other modes of transportation still needs to be strengthened. The 1,244 miles of interstate highways currently within the boundary of Georgia have created an unparalleled advantage for Atlanta to be a trucking transshipment center. It would be ideal for an air cargo warehousing and distribution center to be located in a close proximity from the airport. A direct connection between airport terminal and this industrial/warehousing complex by designated express corridors will substantially expedite the speed and efficiency of air cargo distribution.

Besides logistic infrastructure, the general economic environment may also affect the air cargo industry by exerting influence on aviation liberalization, custom reform, and the level of organizational corruption. According to the statistics provided by Kasarda and Green (2005), a positive correlation was observed between aviation liberalization and variables such as air freight, trade per capita, GDP per capita, and net foreign direct investment per capita. Estimation showed that for air cargo, an average of 20% transportation time and 25% cost were consumed in customs clearance process. The study further proved that aviation liberation, custom efficiency, and lower organizational corruption contribute to greater economic development of a region measured by GDP per capita and foreign direct investment.

One local example of aviation liberalization is the Foreign-Trade Zone (FTZ) #26, originating from Hartsfield-Jackson Atlanta International Airport. It encompasses several subzones of industrial and manufacturing sites throughout metropolitan Atlanta (Table 2: A List of the Subzones in Georgia Foreign-Trade Zone). FTZ #26 helps with enhancing the competitiveness of business in the global market through reduction in duties and processing fees and provision of quicker goods movement

Table 2: A List of Subzones in Georgia Foreign-Trade Zone

26A GM 26C Ford 26D Yamaha 26E Pratt & Whitney 26F Precision Components	26G Roper Corporation 26H Ricoh Electronics, Inc. 26I Inflation Systems, Inc 26J Eastman Kodak Company 26K Noramco, Inc.

Source: United States Department of Commerce, 2011

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