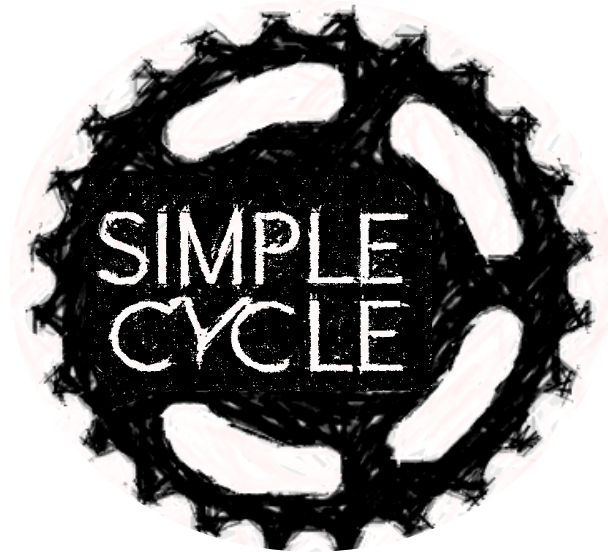


SimpleCycle: Electrifying bike shares



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SIMPLECYCLE

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The Eco-E Project fulfills a core requirement for the Master's of Environmental Science and Management (MESM) Program. The project is a three-quarter activity in which small teams of students conduct customer discovery research to develop a business model for a new environmental venture, in addition to focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Eco-E Project Final Report is authored by MESM students and has been reviewed and approved by:

ADVISOR

ADVISOR

DATE

Brief Description

In 2012, Americans drove over 2.7 trillion miles in private motor vehicles (cars). The dominance of cars in the U.S. transportation system, particularly in urban areas, contributes to several significant environmental and public health issues including transit-related inactivity, air pollution, and climate change. The focus of this Eco-Entrepreneurship project was to develop a business that takes urban cars off the road by helping individuals to bike more often. Our proposed business is to augment existing bike share systems in U.S. cities with a network of peripheral stations containing portable electrification units (EUs) that can be attached to individuals' personal bikes and bike share bikes, converting them into electric bikes. These EUs will also be made available at existing bike share stations, thus leveraging the current infrastructural network to extend the serviceable area of the bike share and increase connectivity. Our service will create value for both the managers and operators of bike shares by increasing overall system usage and revenues. By providing individuals with reliable access to electric power for bike trips, SimpleCycle lowers the current barriers to biking, giving people access to a cheaper, healthier, and more convenient form of transportation.

Table of Contents

Brief Description	i
Executive Summary	1
Environmental Problem.....	6
Dominance of Cars in the U.S. Transportation System	6
The Environmental Impacts of Urban Motor Vehicles	8
i. Transportation-Related Inactivity	9
ii. Urban Air Quality and Human Health	11
iii. Mobile Source Air Pollution and the Physical Environment	15
iv. Traffic Congestion	19
Increasing Urban Biking as a First-Best Policy Solution.....	20
i. Federal Policy Solutions	20
ii. Local Policy Solutions	22
Business Model Environment	24
The End of the Car Culture	24
Access Versus Ownership & the Sharing Economy	27
The Internet of Things	28
Market Opportunity & Industry Trends	28
Business Model Development	31
Initial Customer Problem Hypothesis	31
Customer Discovery Methods	34
Business Model 1: Bike-Enabled Ride Sharing (Individual)	41
Business Model 2: Bike-Enabled Ride Sharing (Employer)	43
Proposed Business Model.....	45
Overview of Organizational and Ownership Structure of Bike Shares	45
SimpleCycle: Electrifying Bike Shares	47
i. Business Model Concept.....	48
ii. Customer Segments and Value Propositions.....	49
iii. Key Partners, Activities, and Resources	57
iv. Revenue Streams and Cost Structure	59
v. Market Size	60
vi. Target Cities	62
vii. Financial Projections for Launch in New York City	64
Environmental Benefits	71
Introduction.....	71
How SimpleCycle Produces Benefits.....	71

i. Caveats.....	71
ii. Methods.....	72
Results	75
i. Greenhouse Gases	75
ii. PM _{2.5}	75
iii. Ozone	76
iv. Gasoline and Traffic Congestion	77
v. Health Benefit of Biking	77
Discussion	78
Next Steps.....	79
Works Cited	81
Appendices	87
Appendix 1: The Electrification Unit.....	87
Appendix 2: Financial Model Assumptions	89

Tables and Figures

Table 1: Average Daily American Travel Behavior	7
Table 2: Percent of Total Government Transportation Expenditures by Mode (Average 1995-2009).....	8
Figure 1: Environmental Impacts of Motor Vehicle Transportation	9
Table 3: Population-Weighted Contributions to Air Pollution by Sector	12
Figure 2: Major U.S. Cities, Air Pollution Emissions, and National Ambient Air Quality Standards Non-Attainment Zones	13
Table 4: Cost and Usage of Recent Bike Infrastructure Projects	23
Figure 3: Vehicle-Miles Traveled per Capita, Peaking in 2004	25
Figure 4: U.S. Retail Sales of Passenger Cars and Bikes	29
Figure 5: Annual Electric Bicycle Sales by Region with a Forecast Scenario	31
Table 5: Summary of Customer and Industry Research Interviews.....	32
Table 6: Summary of Survey Respondent Sources and Location	36
Table 7: Willingness to Pay for SimpleCycle Survey Results	37

Figure 6: Survey Results Regarding the Willingness to Share a Ride with Various Types of People	38
Figure 7: Business Model Diagram	48
Figure 8: General Commute Concerns.....	52
Figure 9: Survey Respondent Opinions of Bike Commuting	53
Figure 10: Respondent Reasoning for Car Commuting	54
Figure 11: Expected Annual Cost of a 12-Mile Round Trip Commute	55
Table 8: Ranking and Selected Characteristics for Target Cities	63
Table 9: SimpleCycle Customer Segments	65
Table 10: Daily Demand and Expected Annual Revenues from Service Contract.....	66
Table 11: Estimated Infrastructure and Maintenance Costs	68
Table 12: SimpleCycle’s Cumulative Profitability.....	68
Figure 12: Five-Year Financial Projection	69
Table 13: Emission Rates Used for Environmental Benefit Calculations.....	73
Table 14: Greenhouse Gas Benefit Calculations.....	75
Table 15: Benefit to New York City PM 2.5 Reduction Goals.....	76
Table 16: Gasoline Consumption and Cost Reductions.....	77

Executive Summary

Bike shares are public non-motorized transportation systems, designed to provide users point-to-point transportation for short trips (0.5 to 3 miles). Users pick up a bike share bicycle at any self-serve bike sharing station in the network and return it to any other bike sharing station (Toole Design Group 2012). The organizational structure of a bike share is comprised by two key entities. First, there is an implementation agency such as a municipal transportation authority, which oversees the design, and installation of the system, and sets the fees for use. Second there is a system operator, an entity who is contracted by the implementation agency to run the bike share. They are in charge of the daily operation of the bike share.

SimpleCycle is a package of physical infrastructure and services that augments existing bike shares, providing current bike share users and other urban cyclists with reliable access to electric power for bicycle trips. In short, SimpleCycle ‘electrifies’ existing bike shares. SimpleCycle produces environmental benefits by enabling urban travelers to use bikes instead of private motor vehicles (cars) for their transportation needs. From the business perspective, SimpleCycle creates value for cities with bike shares by increasing the usage of their existing system, and creates value for bike share operators by increasing their revenues.

The electrification of bike shares has the potential to ameliorate several significant environmental problems associated with private motor vehicles. In general, these problems stem from the current dominance of cars as a mode of transportation in the U.S. There are more than 800 cars per 1,000 U.S. residents, while in most developed countries this ratio is under 600 (ABW 2012). In total, Americans drove almost 3 trillion miles in 2012, enough to travel to the sun and back more than 16,000 times (Perks and Raborn 2012). The prevalence of cars has driven the evolution of urban transportation infrastructure that inhibits the use of active modes of transportation (e.g. walking, biking), contributing to physical inactivity. Only approximately half of Americans get enough physical activity, contributing to increased impacts of heart disease, diabetes, and stroke (Gotschi and Mills 2008; WHO 2002). The social cost of this physical inactivity is estimated at nearly \$76 billion per year (CDC 2007). SimpleCycle addresses this issue by making active transportation more practical, accessible, and convenient within urban environments.

In addition to physical inactivity urban motor vehicle emissions also negatively affect human health. Traffic-related air pollution, including ground-level O₃ and PM_{2.5}, exacerbate asthma, impair lung function, and raise total cardiovascular morbidity

and mortality (HEI 2010). In our analysis, we estimate the cost of these negative health effects to be on the order of \$90 billion per year (Caiazzo *et al.* 2013; Lee *et al.* 2009). Urban motor vehicle emissions also impact ecological systems at broad regional scales. The deposition of PM_{2.5}, NO_x, and O₃ contribute to reduced photosynthesis, acidification of soils and aquatic environments, eutrophication, and shifts in community structure (Lovett *et al.* 2009; Greaver *et al.* 2009; Grantz *et al.* 2003). While these external costs are difficult to quantify, we estimate their approximate total value at \$1.56 billion per year (Muller *et al.* 2011). Beyond local and regional issues, SimpleCycle helps mitigate the contribution of the U.S. transportation sector to anthropogenic climate change. Presently, this sector is the fastest growing greenhouse gas (GHG) emitter in the country, accounting for 28 percent of total U.S. GHG emissions (EPA 2011a). Compared globally, the amount of CO₂ released by the U.S. transportation system is greater than any other nation's entire economy, except for China, and private motor vehicles account for more than two-thirds of transportation-related emissions (Greene and Plotkin 2011; Unger *et al.*, 2010). By taking cars off the road, SimpleCycle mitigates the effects of motor-vehicle air pollution and contributes to building the social and political inertia for a transition to less fossil-fuel intensive transportation systems.

Furthermore, SimpleCycle helps mitigate traffic congestion. Traffic congestion has a magnifying effect on all the aforementioned environmental impacts, and is a huge problem in its own right, imposing an annual social cost of approximately \$121 billion (Eisele *et al.* 2012). From a policymaker's perspective, at both the national and local level, increasing urban biking is a comprehensive and cost-effective solution to addressing the environmental problems associated with the overabundance of private motor vehicles.

Several social and market trends suggest that our proposed business model is both timely and durable. First and foremost, bicycling and bike sharing are on the rise in the U.S. Nationwide, the percent of all commutes made by bicycle has increased by 10 percent since 2012, and the number of bike commuters in 17 of the largest U.S. cities has more than doubled since the year 2000 (ACS 2012; LAB 2013a). As for bike sharing, there are now close to 40 cities with active bike share programs within North America and the number of stations has doubled since 2012 (Brady 2013). Furthermore, this rise in urban biking is accompanied by the growth and expansion of the global and North American markets for electric bicycles (e-bicycles). According to a recent report, the global market for e-bicycles will grow annually at a rate of 7.5 percent between the years 2012 and 2018, with particularly high growth in North America (Navigant Research 2012).

In addition to biking more, Americans are also beginning to drive less. Between 2001 and 2009, the average annual number of per capita vehicle miles driven decreased by 23 percent (Frontier Group 2012). This reduction is likely related to a decrease in the social value attributed to car ownership, the increasing cost of car ownership, and the availability of internet-mediated technologies (Rosenthal 2013; Martin and Shaheen 2011; Frontier Group 2012). The shift in car usage is particularly evident among 16 to 39-year-olds (millennials), who are increasingly turning to the internet instead of their car to socialize, recreate, and network without physically relocating (Rosenthal 2013). Internet technologies are also making real-time transit data more accessible and public transportation options easier for both regular and infrequent users.

In coordination with millennials preferring access over ownership, the sharing economy has emerged. The sharing economy is based on maximizing ownership of a good by splitting its use amongst several people. By avoiding ownership of the assets used, people not only spend more wisely but their product variety and quality options expand significantly (Sundararajan 2013). Peer-to-peer sharing technologies such as Lyft, Uber, Sidecar and Spinlister are creating new, more attractive, and less costly mobility solutions. The sharing economy is also growing and it is estimated that total revenues between peer-to-peer and sharing companies could reach \$3.5 billion in 2014 (Geron 2013).

Additionally, the 'Internet of Things,' a situation in which communication can flow between people and objects as a result of internet connectivity, is spreading to the transportation sector and has breached the bicycle industry (Ashton 2009). Innovative technologies and software, such as a bike lock that can be activated using a mobile application and tracked over the internet, or electric wheels that can be controlled via smartphone are emerging to provide cyclists with increased control over and connectivity to their bikes (Campbell-Dollaghan 2012; Sticky Bottle 2013). The confluence of these trends support the viability of SimpleCycle, which seeks to expand bike sharing by offering shared access to electrifying units connected to a digital network via a smartphone application.

In order to 'electrify' an existing bike share system, our organization will purchase portable electrification units (herein EUs) that are capable of attaching to both bike share bikes and personal bikes, converting them into electric bikes. These EUs will be made available to urban cyclists both at existing bike share stations, and at newly constructed stations owned and operated by SimpleCycle. The stations constructed by SimpleCycle will contain EUs only, and will be located outside of the coverage area of the existing bike share. Thus, the new peripheral stations will provide urban cyclists beyond the coverage area of the existing bike share with access to electric

power for their personal bikes, but leverage the existing network as pick-up and drop-off locations for the EUs.

Our product is offered in the form of a service contract to the bike share operator and implementation agency. In return for increasing usage of the existing bike share system, SimpleCycle earns \$1 for each trip made using an electrification unit. Individual users gain access to the EUs at SimpleCycle or existing bike share stations either by paying a fee to augment their existing bike share membership, or a higher per-use service fee. In order to facilitate these transactions, SimpleCycle's mobile application will be integrated into the existing bike share payment system, but it will remain up to the implementing agency and bike share operator to decide how to raise fees for electrified bike share service. Whether via a membership or a one-off payment, individuals that register with our system will receive a digital RFID tag, which when scanned at a SimpleCycle existing bike share station, will give them access to an EU for a set period of time. The duration of this rental period will also be determined by the implementing agency and bike share operator.

We are confident that this business model will function in any city with a bike share because both city governments and third-party bike share operators stand to benefit from augmenting their bike share with SimpleCycle. Cities who implement SimpleCycle provide a larger percentage of their resident populations with access to the bike share system. Government or third-party bike share operators are provided with increased usage of their existing system. Most importantly, by providing individuals with reliable access to electric power for bike trips, SimpleCycle lowers the current barriers to biking, giving people access to a cheap, healthy, and convenient alternative to private motor vehicle transportation.

From a financial standpoint, the profit potential of SimpleCycle is high. We estimate the total available market for our service to be more than \$120 billion per year, the total serviceable market to be \$18.5 billion, and our target market to be \$85.1 million per year. In order to assess the financial viability of SimpleCycle, we constructed a discrete-time model to evaluate SimpleCycle's cumulative profitability over the five-year period following launch in our priority market, New York City. According to this model SimpleCycle will require approximately \$6 million in start-up capital, then becomes profitable after approximately 2.5 years of operation, earning more than \$12 million five years after launch. Despite persistent uncertainty about the estimation of demand, the return to fixed capital, and the cost and technological specifications of the built infrastructure, the model results are relatively stable. Consequently, we are confident in the asserted profitability of our business model.

Finally, as an extension of this financial model, we evaluated the environmental benefits that would be produced given the modeled operations in New York City. The results indicate that SimpleCycle can contribute to approximately 1 percent of the annual CO₂ reductions required to meet the city's 2050 GHG reduction goals, prevent the emission of 168 mt of O₃, save the city approximately \$10 million in premature deaths due to PM_{2.5} reductions, and reduce obesity-related health care costs by \$12.7 million. While based on inherently uncertain estimates, this analysis highlights that SimpleCycle not only produces environmental benefits, but that these benefits exceed the start-up costs and service contract fees required to finance our operations.

Environmental Problem

The objective of the Simple Cycle Eco-Entrepreneurship project is to mitigate the environmental impacts of urban transportation systems in the United States by reducing the number of cars on the road. To understand these impacts, we first provide an overview of transportation in the U.S., which establishes the dominant role cars play in the transportation ecosystem. We will then demonstrate how cars produce environmental impacts, and provide background information on the nature and severity of these impacts. Next, we will evaluate the efficacy and cost of current policy solutions to the problem of too many cars, across levels of government and implementation. In the last section of this overview, we present the quantitative and qualitative metrics that establish urban biking as a solution to this problem.

Dominance of Cars in the U.S. Transportation System

It is difficult to overstate the current predominance of cars, pickups, vans, and motorcycles (herein 'private motor vehicles') as a means of transportation in the United States. According to the U.S. Department of Transportation, there are approximately as many private motor vehicles (240 million) as there are licensed American drivers (BTS 2013; Santos *et al.* 2011). By contrast, as of the most recent inventory, there is only 1 transit bus for every 4,000 people, and 1 commuter train car for every 45,000 citizens (BTS 2013). Furthermore, the average age of vehicles in the U.S. fleet is increasing, even as Americans continue to buy between 5 and 10 million new private motor vehicles each year (BTS 2013). The result is that more and more households today own multiple vehicles. In fact, while the number of households that own a single vehicle has remained stable at about 40 million over the past 40 years, the percentage of households with three or more vehicles has increased from 5 to 23 percent, a more than ten-fold increase (Santos *et al.* 2011). In a broader context, in 2012, Americans, who constitute only 4.5 percent of the world population, owned more than 13 percent of all the private passenger vehicles in the world (BTS 2013). Additionally, there are more than 800 cars per 1,000 U.S. residents while in most developed countries this ratio is under 600 (ABW 2012).

Beyond the size of the U.S. vehicle fleet, the dominance of private motor vehicles can also be seen in the daily transportation patterns of Americans. In total, Americans drove almost 3 trillion miles in 2012, enough to travel to the sun and back more than 16,000 times (Perks and Raborn 2012). More than 90 percent of these miles were driven by private motor vehicles (BTS 2013). The fundamental drivers of this overwhelming reliance on cars are the preferences of individual travelers, and the transportation choices Americans make during their daily lives **Table 1** breaks down the types of trips the average American makes in a given day, and the

likelihood that those trips are made in a private motor vehicle versus an alternative form of transportation.

Table 1: Average Daily American Travel Behavior

Trip Purpose	Daily Trips per Person	% of Trips (Private Vehicle)	Avg. Vehicle Occupancy	% of Trips (Transit)	% of Trips (Walking)
To / From Work	0.59	91.4	1.13	3.7	3.0
Family / Personal Errands	1.61	87.8	1.78	1.4	9.1
School or Church	0.36	70.7	1.84	2.2	9.4
Social and Recreational	1.04	76.9	2.20	1.3	17.5
Other	0.18	71.0	-	5.9	12.6
Total	3.79	83.4	1.67	1.9	10.4

Source: (Santos *et al.* 2011)

As the table shows, Americans make approximately 4 total trips per day, and most of the time all of them are made in a private motor vehicle (Santos *et al.* 2011). Commute trips are particularly dominated by cars, with over 90 percent of commute trips made in a private vehicle. It is also worth noting that, across all types of trips, average vehicle occupancy is less than two. In other words, most of the time Americans are driving (which is most of the time they are traveling), they are driving alone. Again, commute trips have the lowest average vehicle occupancy with only 1.13 persons per vehicle.

Finally, the dominance of the car in the U.S. transportation system can be seen in the proportion of government dollars that are spent on maintaining and adding to the country’s nearly 4 million miles of highways versus spending on transit and active¹ transportation programs (BTS 2013). **Table 2** lists these proportions and shows that nearly 45 percent of federal transportation dollars and 70 percent of state and local transportation expenditures are on highway projects.

¹ Active transportation programs include walk and bike infrastructure and related programs.

Table 2: Percent of Total Government Transportation Expenditures by Mode (Average 1995-2009)

Program Type	State / Local	Federal
Highway	69.6%	44.7%
Transit	19.9%	13.6%
Active	0.01%	2.3%

Source: (BTS 2013)

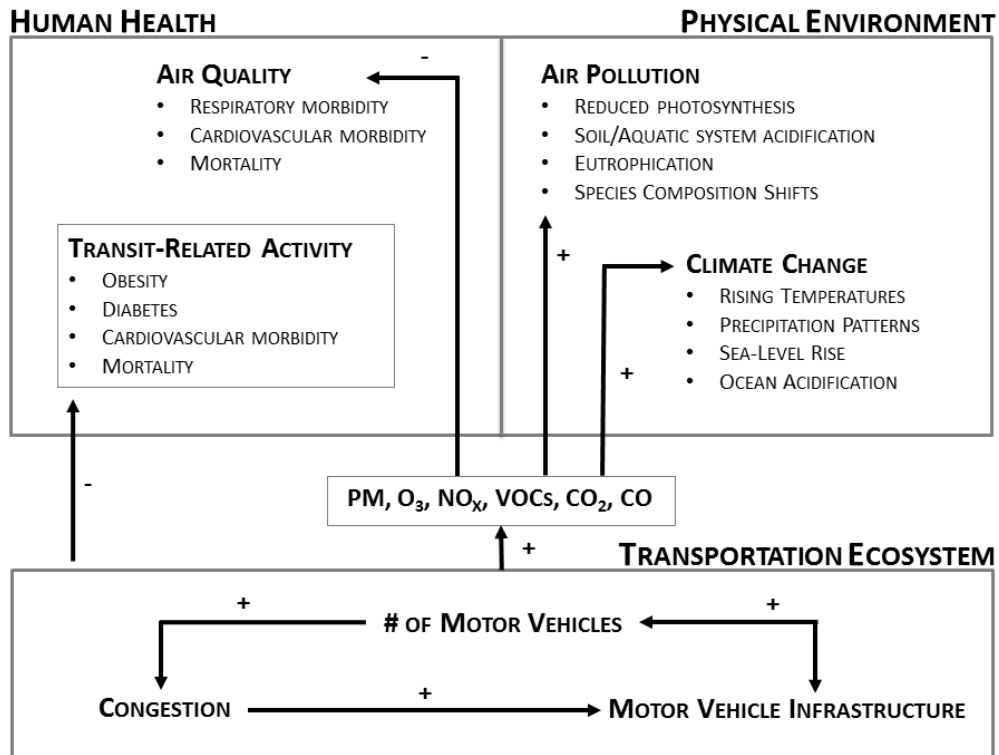
Note: Government expenditures on rail, water, and air transportation are not included in this table, and thus the columns do not sum to one.

In addition to direct spending, the federal government also engages in grant-making for transportation projects. Such grants account for the majority of funding that states end up administering to individual municipalities for the development and implementation of active transportation programs. However, overall, federal grants are also heavily focused on highway projects; more than 70 percent of federal grant money is spent on state and local highway programs while only 1.6 percent of federal transportation dollars are spent on bicycling and walking (BTS 2013; ABW 2012).

The Environmental Impacts of Urban Motor Vehicles

The behavior of individual drivers, the distribution of public spending, and the overall abundance of private motor vehicles, are all key indicators of the dominance of cars in the U.S. transportation ecosystem. But should this be considered an environmental problem? The answer is most certainly 'yes'. The overabundance of private motor vehicles in the U.S. transportation system negatively affects the environment in a myriad of ways, ranging from a reduction in air quality and negative health effects from atmospheric particulates emitted during fossil fuel combustion to the emission of greenhouse gases that alter the global climate. **Figure 1** provides a conceptual model of the processes through which cars produce environmental impacts.

Figure 1: Environmental Impacts of Motor Vehicle Transportation



The lower component of the figure illustrates the positive feedback cycle through which motor vehicles remain a dominant component of the transportation ecosystem. The more cars there are, the more principal and minor arterial roadways, and surface streets become congested. Congestion leads to investment in motor vehicle infrastructure (i.e. more highways). More miles of highways enable the transportation system to accommodate more cars, and in kind, an abundance of cars maintains the reliance of the transportation system on motor vehicle infrastructure. This positive feedback cycle has two direct effects, each with associated environmental issues. The first is the production of emissions that influence both human health and the physical environment through reducing air quality, and contributing to anthropogenic climate change. The second is the indirect effect the overabundance of cars has on human health via transportation-related inactivity.

i. Transportation-Related Inactivity

Transportation-related inactivity is defined as the use of motorized transport rather than walking, bicycling, or any other physically active mode of transportation. We consider transportation-related inactivity an environmental effect of the

overabundance of cars in the U.S. because it is an emergent effect of the positive feedback loop described above and pictured in **Figure 1**. In particular, because 270 million out of 314 million Americans live in urban areas² and urban drivers log 65.6 percent of all the vehicle-miles traveled in the U.S., we will focus our subsequent analysis of transportation-related inactivity on its manifestation in the urban context (BTS 2013; Puentes and Tomer 2008). Because the transportation ecosystem is so dominated by private vehicles and motor vehicle infrastructure, it is often impractical or inconvenient to travel from one place to another using another mode, and so people rely on private motor vehicles. For example, while U.S. cities have more than 10 miles of public roads per square mile, they average fewer than 1.8 miles of bicycle lanes and multi-use paths per square mile (BTS 2013; ABW 2012; Cox 2012). Leaving aside the fact that there are large stretches of public roadways, such as highways, where bikes are not permitted to travel, this statistic implies that, in order to bike in many U.S. cities, urban cyclists must travel in traffic with motorists. In many cases, this is either unsafe, or impractical for any extended trip. Thus, people are forced to rely on motor vehicles to safely and conveniently get where they need to go. This reliance begets further reliance, and the result is a dearth of physical activity, which is a serious issue in the United States. In 2007 less than half of all Americans met the Centers for Disease Control and Prevention's recommendation of at least 30 minutes of modest physical activity on most days (Gotschi and Mills 2008). This percentage, however, would be nearly 100 if all Americans were to shift to active commuting. For example, in 2009 the mean one-way commute time for individuals who lived and worked in the same principal city was 13 minutes for those who walked to work, and 19.4 minutes for those using means of transportation other than walking, driving, carpooling or public transit (mostly cyclists) (McKenzie and Rapino 2011). This implies that an urban car commuter who converts to walking or biking would get an additional 26 or 40 minutes of moderate physical activity during workdays, respectively. Should all physically inactive individuals adopt this behavior, nearly everyone would meet the CDC's daily recommendations.

While such a sea-change in commuting behavior is unlikely, this thought experiment highlights the key role transportation-related inactivity plays in the overall physical inactivity of the American public. As a corollary, transportation-related inactivity is then a key driver of the many staggering public health issues in the U.S. associated with physical inactivity. These effects include increased impacts of chronic diseases including heart disease, stroke, colon cancer, type 2 diabetes, breast cancer, and osteoporosis (WHO 2002). Furthermore, inactivity is one of the key contributors to the epidemic of obesity observed in the U.S. since the 1990s (Gotschi and Mills 2008). Across the United States, 64 percent of adults are overweight, 27 percent of

² Defined here as municipalities with a population greater than 250,000.

adults are obese and every year approximately 300,000 premature deaths are caused by being obese or overweight (CDC 2009; Allison *et al.* 1999). The annual medical costs of physical inactivity have been estimated at \$76 billion or close to 10 percent of all public medical expenses (CDC 2007; Anderson *et al.* 2005). More qualitatively, psychological health and mental well-being are facilitated by regular exercise, and thus inhibited by the dependence of Americans on cars to navigate their transportation environment.

ii. Urban Air Quality and Human Health

Having addressed the indirect health effects of a motor-vehicle-dominated transportation ecosystem, we now focus on the negative health impacts of motor vehicle emissions. Returning to **Figure 1**, we see that motor vehicle emissions can negatively affect human health by reducing local air quality. Motor vehicles emit large quantities of carbon dioxide (CO₂), carbon monoxide (CO), non-methane hydrocarbons — also known as volatile organic compounds (HCs or VOCs), nitrogen oxides (NO_x), particulate matter (PM_{2.5}), and mobile source air toxics, such as benzene, formaldehyde, acetaldehyde, and 1,3-butadiene (HEI 2010). In addition, NO_x and VOCs combine to form ozone (O₃) and contribute to nitrate and secondary organic aerosols, which are important components of PM_{2.5} (Grabow *et al.* 2012). Traffic-related air pollution, including ground-level O₃, PM_{2.5}, negatively affect human health by inducing oxidative stress, which results in inflammation and other harmful physiological responses, in both the respiratory and cardiovascular system (HEI 2010). A comprehensive 2010 study by the Health Effects Institute concludes there is sufficient evidence to infer a causal relationship between exposure to traffic-related air pollution and the exacerbation of asthma, the onset of childhood asthma, non-asthma respiratory symptoms, impaired lung function, total cardiovascular mortality, and cardiovascular morbidity (HEI 2010). Furthermore, multi-city studies, single-city studies, and several meta-analyses of these studies provide relatively strong epidemiological evidence for associations between short-term O₃ exposure and all-cause mortality (EPA 2006).

The emissions of these substances from motor vehicles are a significant component of total air pollutant emissions, and a significant source of urban air pollution (HEI 2010). For example, in 2012 on-road vehicles in the U.S. accounted for 38 percent of total CO emissions, 34 percent of total NO_x emissions, 13 percent of total VOC emissions, and 7 percent of total PM_{2.5} emissions (Caiazzo *et al.* 2013; BTS 2013). Additionally, as shown in **Table 3**, when population density is factored into the risk associated with air pollution emissions, road transportation becomes the single most impactful sector in terms of its contribution to O₃ and PM_{2.5} related health risk.

Table 3: Population-Weighted Contributions to Air Pollution by Sector

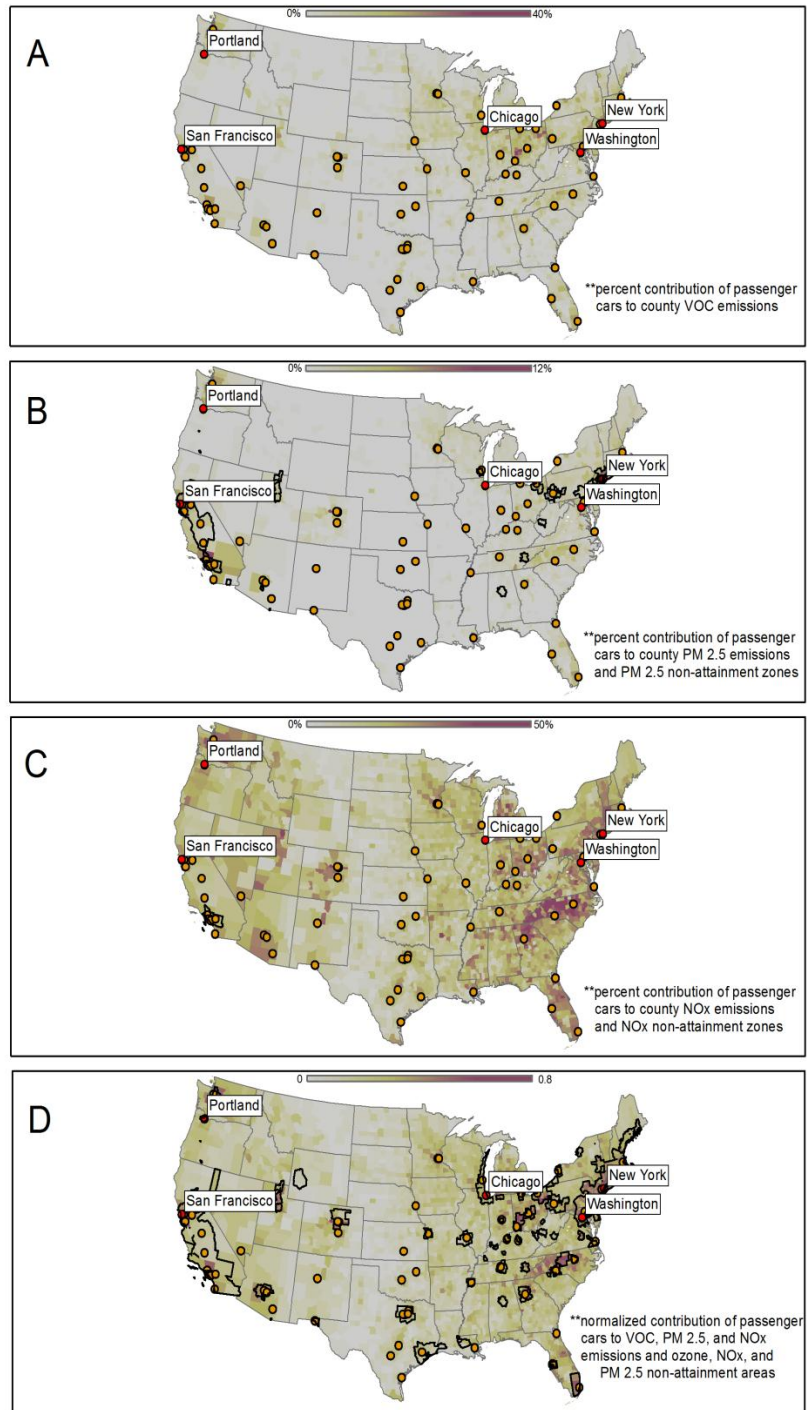
Sector	Total PM _{2.5} (µg/m ³)	O ₃ (ppb)
Electric Power Generation	2.27	2.15
Industry	1.78	2.06
Commercial/Residential	1.82	0.67
Road Transportation	2.3	6.9
Marine Transportation	0.36	0.39
Rail Transportation	0.2	0.53
Total from Combustion	8.73	12.7

Table 3: Population-weighted concentrations of PM_{2.5} and O₃ attributable to combustion emissions from the six sectors considered in this study. The PM_{2.5} concentrations are annually averaged while the O₃ concentration is evaluated as daily maximum averaged over the ozone season (April-September).

Source: Caiazzo *et al.* 2013; estimates based on 2005 emissions data.

In recognition of these adverse effects on human health the EPA currently regulates O₃, PM_{2.5}, CO, and NO_x, as “criteria pollutants” and implements and enforces rules and regulations to ensure that ambient concentrations of these pollutants do not exceed health-based National Ambient Air Quality Standards (NAAQS) (OAQPS 2012). While regulation has resulted in significant improvements in air quality over the past decade, the NAAQS for PM_{2.5} and O₃ are consistently exceeded (OAQPS 2012). Over 131 million people - 42 percent of the nation - still live where O₃ and PM_{2.5} concentrations are often dangerous to breathe. These people live in 191 counties, which are all in metropolitan areas (*State of the Air* 2013). Therefore, health problems associated with air pollution are almost exclusive to the urban environment. **Figure 2** further illustrates this strong correlation between federal air quality regulation non-compliance and proximity to major U.S. cities (including SimpleCycle’s target markets).

Figure 2: Major U.S. Cities, Air Pollution Emissions, and National Ambient Air Quality Standards Non-Attainment Zones



Data from: *U.S. EPA GIS Downloads 2013; NEI 2014*

Figure 2 demonstrates the formative role of urban private motor vehicles in the U.S. to overall emissions and air quality non-compliance. In panels A through C, the percent contribution to the total 2011 emissions of VOCs, PM_{2.5}, and NO_x that are attributable to ‘light-duty passenger vehicles,’ is visualized at the county level. The ‘light-duty passenger vehicles’ classification is based on monitoring standards used by the EPA. In this report, we assume that ‘light-duty passenger vehicles’ are analogous to private motor vehicles, as we have defined them. For the visualization in panel D, the percent contribution of each of the previous pollutants was normalized to 1 based on the maximum observed percent contribution, and then summed across pollutant categories. A value of 1 in panel D would indicate that cars account for the maximum observed percent contribution of VOCs, PM_{2.5}, and NO_x. The orange dots in each panel represent U.S. cities with a 2007 population of 250,000 or greater. Red dots indicate cities that are priority markets for SimpleCycle (see **Target Cities**). Finally black lines indicate the extent of NAAQS non-attainment zones for each of the represented pollutants. For panel D, the black lines indicate the extent of the union of PM_{2.5}, NO_x, and O₃ non-attainment zones.

Focusing even more closely on emissions from private motor vehicles, there is also growing evidence showing that the health risk due to vehicle emissions is increased for people who live or work near highways and busy urban thoroughfares (*State of the Air* 2013). According to these studies, the area most affected by traffic-related air pollution was roughly 0.2 mile to 0.3 mile (300 to 500 meters) from the highway (HEI 2010). Thus, since the number of people living “next to a busy road” may include 30 to 45 percent of the population, the health effects of urban motor vehicle air pollution remain a significant environmental concern (“Disparities in the Impact of Air Pollution” 2013).

As with transportation-related inactivity, the significance of air pollution related health impacts resulting from motor vehicle emissions can be seen in the high cost it imposes upon society. Caiazzo *et al.* (2013) produced and evaluated a comprehensive model of the health effects of air pollution based on 2005 U.S. emissions inventories, and concluded that, nationwide, road transportation accounts for approximately 53,000 PM_{2.5}-related and approximately 5,300 ozone-related early mortalities each year, the largest number of any sector considered in the study. For comparison, consider that in 2005 the number of fatalities related to car accidents in the U.S. was approximately 43,500 (Caiazzo *et al.* 2013). Using the authors’ estimate of a total of 0.70 million life years lost from both PM_{2.5} and ozone exposure per year, and an estimate of \$129,000 for each year of quality life, this implies that road transportation cost the nation more than \$90 billion dollars in 2005 (Lee *et al.* 2009). And while conditions have certainly improved in the past 9 years, regional and city-specific studies of air-pollution related mortality indicate that this social cost is still very substantial. For example, a 2008 study found that, in California’s South Coast and San Joaquin Valley air quality management districts, excess air pollution contributes to an annual loss of \$28 billion in health care costs, school absences, missed work and lost income potential from premature deaths

(Hall and Brajer 2008). Even more recently, a 2013 review of New York City's local air quality improvement plan estimated that unsafe PM_{2.5} concentrations still account for more than 2,000 premature deaths, 4,800 emergency department visits for asthma, and over 1,500 hospitalizations for respiratory and cardiovascular disease each year (Kheirbek *et al.* 2013). Using a median estimate of the value of a statistical life of \$7 million, this equates to a minimum annual cost to the city of more than \$14 billion dollars (EPA 2014b).

iii. Mobile Source Air Pollution and the Physical Environment

In addition to negatively affecting human health, motor vehicle emissions also negatively impact the quality of the physical environment. As illustrated in **Figure 1**, these effects can be grouped into two categories. First, there are the impacts that air pollutants incur upon natural systems at the local to regional levels. Second, there is the contribution of motor vehicle emissions to the anthropogenic alteration of the global climate system, and all its associated physical, biological, and ecological effects. We now consider the range and scope of impacts due to motor vehicle emissions in each of these two categories.

a. Regional Air Pollution Impacts

The effects of air pollution have been identified, with varying levels of certainty, in all ecosystem types in which they have been studied. In general, no ecosystem type found in the U.S. is free from the impacts of air pollution, and most are affected by multiple pollutants (Lovett *et al.* 2009). In this section, we focus our analysis on ecologically impactful air pollutants for which cars in urban areas are the major source. As mentioned in the previous section, private motor vehicles are the primary source of NO_x emissions in the U.S., are one of the greatest contributors to ground-level O₃ formation, and are a significant source of particulate emissions. All three of these have significant local and regional impacts on natural systems.

First, consider motor vehicle emissions of nitrogen-oxides. NO_x emissions can be transported long distances in the atmosphere before depositing on ecosystems hundreds of kilometers downwind of urban areas (EPA 2006). As shown in **Figure 2**, the regions with the highest contribution of total NO_x emissions from cars are the Northeast and Mid-Atlantic regions. Consequently, these are also the regions where NO_x related air pollution impacts are most significant (Greaver *et al.* 2012). The deposition of NO_x from vehicle emissions represents an exogenous input of nitrogen (N) to natural systems, and there is strong evidence for effects of N deposition in both terrestrial and aquatic systems (Lovett *et al.* 2009). Across ecosystem types, arguably the most significant impact of chronic N addition is acidification. Increasing acidity increases the mobility of aluminum and other heavy metals which are toxic to

fish at elevated levels, and can be toxic to plant roots (Lovett *et al.* 2009). In terrestrial systems, decreasing pH also alters plant, soil, and microbial interactions, and can lead to loss of soil fertility, reduced productivity, and even tree death. Additionally, the accumulation of N can also lead to shifts in species composition as N-loving species out-compete those better adapted to less fertile soils (Lovett *et al.* 2009). This affect may come at the expense of biodiversity. For example, a seminal study of N fertilization in a Minnesota grassland showed 40 percent reduction in species richness over 12 years (Wedin and Tilman 1996). In aquatic systems, N enrichment is a fundamental driver of eutrophication, in which excess algal growth and decomposition can lower oxygen concentrations, endangering fish and shellfish, among other organisms (Lovett *et al.* 2009). Atmospheric deposition is often the largest single source of N to aquatic ecosystems, and most estuaries and bays in the Northeast and Mid-Atlantic regions have some degree of eutrophication due to excess N loading, including some extreme cases such as the Chesapeake Bay (Lovett *et al.* 2009; Greaver *et al.* 2012). For the most part, the effects of atmospheric N pollution are chronic, not acute, and subtle but potentially serious. Acidification, eutrophication and changes in plant-species composition may not cause immediate extinctions, but the effects can propagate through a food web to affect many organisms in an ecosystem.

Also featured in **Figure 2** is the spatial distribution of the impact of motor vehicles on PM_{2.5} concentrations. The environmental impacts of particulate emissions are not well studied. Part of this is because PM_{2.5} is a pollutant defined by size (any particulate less than 2.5 microns in diameter) rather than by chemical composition. Consequently, there is great variability in the type and chemical nature of particulate matter that is classified as PM_{2.5}, making generalizations about its ecological impacts difficult to formulate. Caveats aside, there is evidence that PM_{2.5} has negative effects on plants. Leaves coated with dust may be abraded, or subjected to increased thermal stress due to radiative heating. Particulates may also interfere with plant tissues, reducing the amount of light they can photosynthesize (Grantz *et al.* 2003). Additionally, as with NO_x emissions, particulate matter deposited into soils and aquatic environments can alter biogeochemical processes, nutrient availability, and pH (Grantz *et al.* 2003).

Finally, ground-level O₃ is also a widespread regional threat to ecosystems, and tends to occur in particularly high concentrations downwind of major urban areas (Lovett *et al.* 2009; EPA 2006). As precursors of O₃, the distribution of VOCs and NO_x shown in **Figure 2** are also indicative of the spatial distribution of elevated O₃ concentrations caused by motor vehicles. Again, areas with higher contributions from private motor vehicles near urban areas correspond to regions of ozone non-attainment (the majority of the black-outlined area in **Figure 2(D)**). In terms of

biological effects, O₃ is known to reduce photosynthesis in most plants and cause foliar lesions in sensitive plants (Lovett *et al.* 2009). Ozone at the levels found in most of the United States often does not kill plants outright but slows their growth and may make them more susceptible to other fatal stresses such as insect or pathogen attack (EPA 2006). Ozone has little effect in the water, but may have effects on emergent aquatic plants or air-breathing animals that are part of aquatic ecosystems (Lovett *et al.* 2009). Furthermore, the effects of O₃ on animals other than humans have not been well studied, but given the existing toxicological literature, these effects are likely to be significant.

In assessing the scale and magnitude of these regional ecosystem impacts, it is most instructive to return to **Figure 2**. **Figure 2(C)** outlines the spatial distribution of NO_x impacts from motor vehicles, and the non-attainment zones in **2(D)** indicate where these impacts are most severe. In fact, the non-attainment zones featured in **2(D)** may underestimate the scope of the impact of motor vehicle emissions on ecosystems as the primary NAAQS standards are set to protect human health, but are often insufficient to protect ecosystems from air pollution (Lovett *et al.* 2009). Estimates of the total cost of motor vehicle air pollution are difficult to come by. However, a recent review of the external cost of air pollution by Muller *et al.* (2011) puts the total external cost of air pollution from the transportation sector at \$23.2 billion in year 2000 dollars. In this publication, the authors also find that approximately 95% of external costs from air pollution associated with electricity generation are due to impacts on human health (Muller *et al.* 2011). Assuming this ratio also holds for emissions from the transportation sector, we estimate the present value of the total annual costs of transportation-related air pollution *not related* to human health impacts (i.e., what we might consider impacts on natural systems) to be \$1.56 billion.

In summary, the effects of regional air pollution (NO_x, PM_{2.5}, and O₃) produced by motor vehicle emissions on natural systems are diverse and, in many cases, still poorly understood. However, where direct evidence is lacking, the science is suggestive of significant impacts on ecosystems. Additionally, it is important to note that the various pollutants we considered interact dynamically with one another, with other air pollutants, and with macro-scale changes in global atmospheric composition. While none of these were considered here explicitly, the effects of regional air pollutants from motor vehicles on ecosystems will depend on these interactions (Lovett *et al.* 2009).

b. Global Climate Change

Fossil fuel combustion in motor vehicles emits carbon dioxide and other heat-trapping pollutants from burning fuel, contributing significant amounts of greenhouse gases (GHGs) to the atmosphere. These gases warm the Earth's surface by absorbing energy and preventing the loss of heat to space. When sunlight hits Earth's surface, some of it is absorbed and then re-released back into the atmosphere as infrared radiation (heat). GHGs absorb some of this energy and radiate it in all directions, including back to Earth, contributing to the warming effect on Earth.

Recent climate changes are likely the result of human activities, such as burning fuel in automobiles that have contributed to the observed increase in the concentration of GHGs, particularly CO₂, in the atmosphere (IPCC 2007). Presently, the U.S. transportation sector is the fastest growing GHG emitting sector in the country, accounting for 28 percent of total U.S. GHG emissions (EPA 2011a). Compared globally, the amount of CO₂ released by the U.S. transportation system is greater than any other nation's entire economy, except for China (Greene and Plotkin 2011), and cars, SUVs, and pickup trucks combined account for more than two-thirds of those transportation-related emissions (Unger *et al.* 2010). Changes in climate resulting from rising GHG levels are predicted to have potentially serious effects on food supply, water resources, infrastructure, ecosystems, biological processes, and the survival of species. For example:

- Average global temperatures are expected to increase between 2°F and 11.5°F by 2100, which could increase the frequency and intensity of extreme heat events, particularly in areas that already experience heat waves (NRC 2010). Increasing temperatures may also induce changes in phenological patterns and cause biogeographical range shifts that could threaten the survival of climate sensitive species (Hannah 2011).
- Increases in GHGs are likely to influence patterns of precipitation, increasing precipitation in some regions and decreasing it in others (Metz and Coninck 2005), which could affect the availability of water resources, the intensity of floods, and the viability of traditional crops.
- The strength of winds and quantity of rain associated with tropical storms and hurricanes are predicted to increase as the ocean warms (U.S. GCRP 2009). This increased storm intensity could result in more damage from storms as time goes on.
- Global sea level is expected to rise at an elevated rate as sea ice and glaciers melt and ice sheets slide into the ocean (Nicholls 2007; Lenton *et al.* 2008).

As a result, global sea level may rise by as much as 2 feet by 2100, posing a serious threat to the security of coastal infrastructure (GCRP 2009).

- Ocean pH has increased 25 percent since pre-industrial times as a result of elevated atmospheric CO₂ and is projected to change even more by the end of the century (Myhre *et al.* 2013; U.S. GCRP 2009). By reducing the ability of calcifying organisms to make shells and skeletons, ocean acidification can lead to extinction, reduced abundance, or range shifts for species in the ocean (Hannah 2011).

In the larger program of this analysis, it is important here to note that we acknowledge that climate change is a global problem, and that it is unlikely that SimpleCycle's projected GHG mitigation impact will contribute directly to avoiding the predicted effects of climate change. However, we do believe that the environmental benefit of contributing to the solution is meaningful. Whether through creating social inertia to address climate change, or by freeing up funds that would otherwise have to be spent on other transportation initiatives, every molecule of CO₂ that SimpleCycle prevents from being emitted is a part of the larger solution.

iv. Traffic Congestion

An important factor, which exacerbates all the environmental impacts associated with an overabundance of urban private motor vehicles, is traffic congestion. As illustrated in **Figure 1**, traffic congestion is one of the key components of the positive feedback cycle, which sustains the dependence of the transportation ecosystem on private motor vehicles, and thus contributes to transportation-related inactivity. Traffic congestion increases the quantity of emissions from motor vehicles in two ways. First, congestion increases the time it takes for individuals to drive their commute, which increases the quantity of emissions required to make each trip. Increased travel time means that vehicles are operating for longer periods of time and producing a greater volume of emissions. Second, congestion slows down the average speed of traffic. Because engines typically operate more efficiently at higher speeds, this reduces the efficiency of fuel use over the course of a trip.

Congestion is a huge problem in the United States. In 2011, it caused urban Americans to spend an additional 5.5 billion hours in transit and purchase an extra 2.9 billion gallons of fuel, resulting in a cumulative social cost estimated at \$121 billion (Eisele *et al.* 2012). In this same year, the average urban commuter spent an extra 38 hours traveling and wasted 19 gallons of fuel at a cost of approximately \$818. They also produced an additional 380 pounds of CO₂ due to traffic congestion (Eisele *et al.* 2012). It is also worth noting that congestion is at its worst during the daily commute. While commutes only make up approximately 20 percent of all trips

they consistently represent the peak travel demand across transportation systems and thus the most highly congested times of day (Santos *et al.* 2011). Finally, not only has congestion in the U.S., by every measure increased substantially over the past 30 years, it is also predicted to continue to increase over the next decade (Eisele *et al.* 2012). According to a 2012 study by the Texas Transportation Institute, by 2020 the total delay caused by congestion is anticipated to rise from 5.5 to 8.4 billion hours, wasted fuel to rise from 2.9 to 4.5 billion gallons, amounting to a rise in overall social cost from \$121 billion to \$199 billion (Eisele *et al.* 2012).

Increasing Urban Biking as a First-Best Policy Solution

Due the pervasiveness and severity of the impacts described in the previous section, policymakers across levels of government have devised several mechanisms for addressing the impacts that result from an overabundance of motor vehicles in the transportation system. In this section, we provide an overview of these policy solutions, and argue that increasing urban biking is the most comprehensive and cost-effective option from a social welfare perspective. It should be noted that this section does not contain a full cost-benefit analysis of the discussed policy options. Instead, we present qualitative reasoning that supports our assessment of increasing urban biking as a first-best policy option for reducing the environmental impacts of private motor vehicles.

i. Federal Policy Solutions

As mentioned in the previous section, the main policy tool for addressing the environmental impacts of motor vehicle emissions at the federal level is the Clean Air Act (CAA). Originally passed in 1970, the CAA authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants. While mobile source regulation under the CAA has a rich and diverse history since 1970, major improvements to air quality have resulted from four main mechanisms: (i) tailpipe emissions standards for criteria pollutants, (ii) technology mandates for new vehicle production, (iii) monitoring standards for existing vehicles, and (iv) fuel composition standards, such as the Corporate Average Fuel Economy (CAFE) standards (EPA 2012). Given its long history and the extent of its implementation, it is perhaps unsurprising that the Clean Air Act has produced significant environmental benefits. In general, the consensus emerging from cost-benefit analyses of the CAA is that its benefits to public welfare have far exceeded the cost it has imposed on consumers and industry. For example, one cost benefit analysis of the CAA from 1990 to 2020 recently published by the EPA found that, benefits from the policy over this time period outweighed its costs by a factor ranging from 4:1 to 90:1 (OAR 2011). However, the direct costs of the regulations implemented under the authority of the

CAA are not to be overlooked. The aforementioned EPA publication also estimates that the direct compliance cost of the 1990 CAA Amendments was over \$53 billion (in 2006 dollars) in 2010, and that lifetime compliance costs will be near \$400 billion (in 2006 dollars) by 2020 (OAR 2011). Specifically, of these estimated lifetime compliance costs, approximately 60 percent result from the regulation of on-road vehicle technologies, emissions, and fuels (EPA CBA of CAA 2011).

In 2010, the CAA cost the nation approximately \$65 billion (in 2006 dollars), \$28 billion of which were borne by the manufacturers and users of on-road vehicles (OAR 2011). Furthermore, of the emissions reductions achieved through the implementation and enforcement of the CAA, the largest and most significant of these were made by electric power generators and industrial point sources. Emissions reductions from these sources have been the primary source of the Act's social benefits, while the contribution (so far) of reductions in mobile source emissions is rather small (Holladay 2011). Consequently, the regulatory cost borne by the transportation sector is high relative to other sectors, and the benefits produced by regulating mobile sources are relatively small – so the cost to benefit ratio of mobile source regulation under the CAA may be substantially lower than for the Act as a whole.

The point of this discussion is not to denigrate the achievements of the CAA, but rather to highlight its relative inefficiency when it comes to dealing with the environmental problems associated with motor vehicle pollution. Increasing rates of biking in urban populations nationwide, by contrast, is perhaps the most efficient way to reduce these impacts. This efficiency argument has three main components. First, from an emissions standpoint, most of the technological innovations motivated by the CAA offset *some but not all* emissions from motor vehicles. Replacing trips in motor vehicles with trips made on a bicycle offsets 100 percent of motor vehicle emissions associated with that trip. This fact makes increasing rates of urban bicycling especially effective as a policy tool for addressing the contribution of motor vehicles to anthropogenic climate change, because federal regulation of GHGs is either nascent or non-existent in most parts of the country. Rather than decreasing GHG emissions through the slow squeeze of technology mandates or tailpipe standards, increasing urban bike rates has the opportunity to take cars off the road, and abate substantial GHG emissions in rapid fashion.

Second, making cars cleaner does not address the health issues associated with transportation-related inactivity, which, as our previous analysis showed, constitute a high annual social cost. Biking, even with the assistance of an electric battery, contributes to better public health. Cycling counts as “moderate physical activity,” and bike commuting helps people build physical activity into routine parts of their

day (Ainsworth *et al.* 2000). Empirical evidence shows a positive correlation between rates of bike commuting and many public health metrics. For example, states with higher levels of bicycling also have a higher percentage of adults who get 30 minutes of exercise per day (ABW 2012; CDC 2009; ACS 2009). Similarly, there is an inverse relationship between bicycling rates and Body Mass Index (BMI), lipid levels, and blood pressure, and states with the highest bicycling rates have the lowest rates of diabetes (Pucher *et al.* 2010; Hu *et al.* 2004; CDC 2009; ACS 2009; Wen and Rissel 2008). Given these trends, the benefits of even a modest increase in biking could be substantial. A 2008 study estimates that if one of every ten adults started a regular biking program, the United States could save \$5.6 billion annually (ABW 2012). Also, recall that approximately 95 percent of the quantified social benefit produced from air pollution regulation is due to improved public health (CDC 2007; Anderson *et al.* 2005; OAR 2011). This indicates how significant health effects tend to be in traditional benefit-cost analyses. Thus, given that increasing biking improves public health both through increasing levels of physical activity and improving air quality, it is likely that the social benefit per dollar spent on progressive bike policies far exceeds that of traditional air quality regulation.

Finally, without engaging in rigorous quantifications, the cost of implementing bike programs in urban areas is substantially less than the regulatory burden of current federal air pollution regulation CAA. For example consider that the initial capital cost of Washington D.C.'s Capital Bikeshare system was approximately \$13 million in 2010, with annual operating costs of about \$2.5 million, while the anticipated regulatory cost of the CAA in 2020 is \$70 billion in 2010 dollars (Kaplan 2010; OAR 2011). Using these figures and a discount rate of 5 percent, the amount of money spent on air quality regulation in the year 2020 is enough to capitalize almost 2,500 bike shares and operate them for a period of 6 years from 2014 to 2020. While certainly back-of-the-envelope in nature, this calculation highlights the fact that the cost of increasing urban bike ridership relative to current federal air quality regulation is very low. In conjunction with the fact that replacing trips in cars with trips on bikes represents total, rather than partial, emissions abatement, and that increasing biking simultaneously mitigates the impact of air quality and physical inactivity on public health, the preceding calculation suggests that increasing urban bike ridership is a socially efficient policy option.

ii. Local Policy Solutions

At the other end of the spectrum, local and city governments should also regard increasing bike-ridership as a first-best policy solution to the problem of “too many cars”. The arguments in support of this claim are essentially the same as in the federal case. However, the repertoire of policy tools available to local or municipal governments differs greatly from that used by the federal government. Generalizing

these options broadly, we can consider three main types of local policy solutions to congestion, air quality, and environmental issues caused by an overabundance of motor vehicles: (i) expansion or extension of city highway systems, (ii) expansion of city public transit systems, and (iii) active transportation infrastructure projects (e.g. pedestrian/bicycle paths, and bike shares).

In lieu of performing full benefit-cost analyses of these different local policy options, **Table 4** compares the cost and usage of recent bike infrastructure projects (bike shares and bike networks) to ongoing public transportation projects in New York and Washington D.C., and to a major highway reconstruction and extension project currently taking place in Portland.

Table 4: Cost and Usage of Recent Bike Infrastructure Projects

	New York		Washington D.C.		Portland	
	Bike	Public Transit	Bike	Public Transit	Bike	Highway
Description	Citi Bike Share: 6,000 Bikes, 300 Stations	8.5 Mile Extension of 2nd Ave Subway	Capital Bikeshare: 2,500 Bikes, 300 Stations	23 Mile Extension of Dulles Metrorail (11 New Stations)	Reconstruction of 27.4 Mile Bike Path Network & Bike Outreach Program	Columbia River Crossing: 5 Mile Bridge, Interchange Reconstruction, Light Rail Extension
Cost	\$30-\$40M	\$13B	\$13-\$14M	\$6.2B	\$65M	\$3.5B
Usage	25,000-42,000 Trips Per Day	600,000 Riders Per Day	3,500-11,000 Trips per Day	34,800 Daily Riders	16,000 Daily Trips	178,500 Vehicles Per Day
\$ per Daily User	\$700-\$1,600	\$21,500	\$1,200-\$4,000	\$178,000	\$4,000	\$20,000

Sources: Alstadt *et al.* 2012; ABW 2012; Capital Bikeshare 2014; Daddio 2012; Donnelly 2009; Holeywell and Lippman 2012; NYC Bike Share 2014; Regional Plan NY-NJ-CT Association 2003

There are several key points to take away from this table. First, bike infrastructure projects are hundreds to thousands of times cheaper than either public transit or highway projects, which provides flexibility to local and municipal governments. Instead of betting the budget on one massive public transportation or highway project, city officials are better able to invest in biking incrementally and expand bicycle infrastructure based on observable metrics of success. These smaller projects also tend to be easier, faster, and more feasible to implement, and are subject to fewer delays. Second, the final row of **Table 4** shows the estimated cost of each project per daily user that project benefits or serves. While this metric is certainly inexact, and fails to account for any indirect benefits or costs associated with the different projects, it is a good proxy for the overall efficiency of each type of policy. As the figures in the table demonstrate, the cost per daily user of bike infrastructure projects is much lower than for public transportation or highway projects in each city, indicating bike-oriented policies may generate more welfare than these other types of projects. This assertion is supported by the cost benefit analysis literature of bicycle infrastructure projects, which generally find that every \$1 invested in bike

infrastructure projects yields approximately \$3 to \$5 in social benefits, and up to \$100 when the statistical value of lives is incorporated (ABW 2012). By comparison, a meta-analysis of more than 80 benefit-cost studies of public transportation systems in the U.S. finds that, on average, the social benefit of every \$1 invested in public transportation is only \$1.03 to \$1.71, with a group mean of \$1.34 (Harford 2006). Also of note is that less than 30 percent of the studied transit systems had benefit-cost ratios greater than 1 (Harford 2006). This may be due to the fact that many public transportation systems are designed to become solvent and produce social benefits only if they operate at a certain capacity.

In summary, we believe that increasing urban bike ridership is a more efficient policy solution for the issues posed by motor vehicles than traditional policy approaches at both the federal and local levels of government. Based on this belief, we are confident that our proposed business model represents a solution to the environmental problems associated with private motor vehicles, and that the adoption of our business plan will result in significant social benefits.

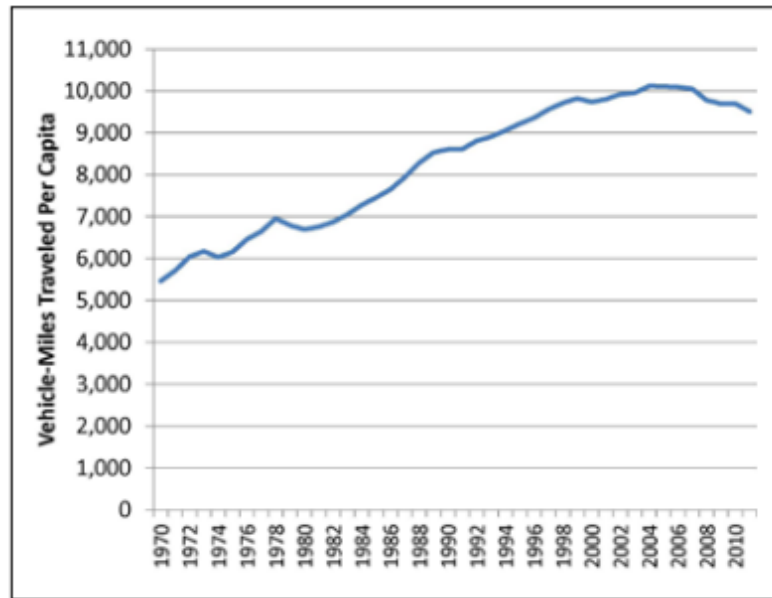
Business Model Environment

To demonstrate the timeliness of our business opportunity, in this section we discuss the business environment in which SimpleCycle will function. There are several social movements including the transition away from car culture and the increasing popularity of access versus ownership that support our business model. These movements paired with evolving concepts such as the sharing economy and the 'Internet of Things', have proved to validate our approach to solving a customer problem. We will also discuss trends occurring within the transportation industry that further suggest that our business proposition is a strong market opportunity and solves an important, existing problem.

The End of the Car Culture

Perhaps the most compelling social trend in support of SimpleCycle is that America is moving away from the car culture. People across the world, particularly in the United States, are driving fewer miles in private motor vehicles. Between 2001 and 2009, the average annual number of vehicle miles driven by people between the ages of 16 and 34 decreased from 10,300 miles to 7,900 miles per capita. This represents a decrease of 23 percent (Frontier Group 2012).

Figure 3: Vehicle-Miles Traveled per Capita, Peaking in 2004



Source: Frontier Group 2012

While it may seem as though this trend is strongly related to the 2008 recession, the recession only partially explains this decrease in driving. The reduction in driving began prior to the recession, and seems to be continuing despite the start of the country's economic recovery. This persistence indicates that the U.S. may be experiencing a cultural shift, likely a result of the widespread use of the internet, the renewal of center cities, smartphone use and the sharing economy. These factors lead researchers to believe that the people who ceased car commuting due to the recession may find little reason to resume the habit. Americans are moving to more urban areas where they can access additional transportation alternatives. Nearly two-thirds of people between the ages of 18 and 32 surveyed by the Urban Land Institute in 2011 indicated that living in communities that supported walking and contained social amenities such as grocery stores, restaurants and doctors was either essential or preferable. In support of this cultural shift local, state and federal policies are starting to align land-use and transportation policies to support smart growth and mixed communities (Frontier Group 2012). An example of policy support for the encouragement of suburbanization and private motor vehicle use is mortgage lending for the construction of roads. Policies like this are less likely to be implemented as driving rates diminish. Increases in road or bridge tolls further paired with the explosion of car and ride sharing programs nationally support these political and social movements.

The shift in car usage can be seen particularly in certain demographics such as among 16 to 39-year-olds, because people within this age range do not place the same level of priority on driving as they once did. This characterization within younger generations such as millennials is thought to be because they do not value cars and motor vehicle ownership as much as they value technology. In fact, research has shown that there is an inverse relationship between the percentage of young drivers and the availability of the internet. Trips taken in private motor vehicles reduce the amount of time the younger generation has to access the internet on one of their various electronic devices (Rosenthal 2013).

There are several additional explanations for the reduction in vehicles miles traveled. With respect to the financial demands of owning and operating a car, rising fuel costs have significantly increased the average annual cost of owning a car. The average annual cost of filling a vehicle's fuel tank in 2001 was \$1,100 (in 2011 dollars) however, the cost of filling the same tank in 2011 cost \$2,300 (in 2011 dollars). It is extremely unlikely that the cost of fuel will return to the low prices seen in the 1980s or 1990s, therefore high fuel prices will likely be a major factor in whether or not people choose to own a motor vehicle (Frontier Group 2012). Car sharing programs have also had an impact on the reduction in vehicle usage for a couple reasons. Car sharing allows people to reduce the portion of their income spent on transportation. It has been estimated that each car share vehicle added to the fleet removes between 9 and 13 vehicles from the road. This means that car sharing can substantially reduce the number of vehicles owned per household, allowing households to transition toward a carless lifestyle and thus devoting a much smaller percentage of income to the costs associated with driving and vehicle ownership (Martin and Shaheen 2011).

Advances in technology have contributed to the movement of the younger generations from vehicle ownership to transportation alternatives in several ways. First, communications technology has become a substitute for trips in personal vehicles, providing individuals with social networking and recreational possibilities. People no longer have to relocate to contact others with the use of the internet and communication/networking software. Improvements in technology have also made transportation alternatives more convenient. There are numerous websites and smartphone applications providing real-time transit data, making public transportation options easier for both regular and infrequent users. Technology has further expanded the ease of getting from one place to another without owning a car by allowing for the development of new transportation alternatives such as car sharing and bike sharing services. These types of transportation services have rooted themselves across North America. This new lifestyle based on mobility and constant peer-to-peer connectivity is more compatible and safe with modes of transportation

other than driving. This safety concern has been recently addressed by state laws prohibiting the use of cell phones while operating a motor vehicle (Frontier Group 2012).

There are two remaining factors, which have contributed to the reduction in personal vehicle use and ownership. The first factor is that driving tests have become more stringent in every state within the U.S., making it harder for young people to obtain driver's licenses and therefore lowering the use and ownership of private motor vehicles. The second factor is that people have shown a growing interest in reducing their impact on the environment, particularly by driving less. A survey by KRC Research and Zipcar found that 16 percent of people between the ages of 18 and 34 said they strongly agreed with the fact that they would like to protect the environment, and therefore drive less (Frontier Group 2012). While this trend is predominately found among younger people, it is at least a contributing factor to the overall reduction in vehicle miles traveled.

Access Versus Ownership & the Sharing Economy

In coordination with millennials preferring access versus ownership, the sharing economy has emerged. The sharing economy is based on maximizing ownership of a good by splitting its use amongst several people. Sharing or peer economy models such as Lyft, Airbnb, Sidecare and TaskRabbit, enable disaggregation of physical assets in space and time, and create digital platforms making these disaggregated components amenable to pricing, matching, and exchange. By avoiding ownership of the assets used, people not only spend more wisely but their product variety and quality options expand significantly (Sundararajan 2013). Technology has made this process possible and many sharing economy-based startups are using technology to reduce the transaction cost of renting/sharing things such as cars, bikes, rides and rooms with other people. Industry analysts argue however, that the social driver of the sharing economy is the mindset of sustainability as well as the idea of meeting new and interesting people. This indicates that while the economics of collaborative consumption may demonstrate that it makes more sense to rent a good you only use occasionally, factors such as sustainability, citizenship and social opportunities are equally important for startups like Zimride, Citibike, and Airbnb (Neyman 2013).

Forbes magazine has estimated total revenues between peer-to-peer and sharing companies could reach \$3.5 billion in 2014, and experience growth in excess of 25 percent. Should this estimate prove to be accurate, peer-to-peer sharing would no longer just act as an income boost in a stagnant wage market; it would be a disruptive economic force (Geron 2013). Websites that have existed for years now such as eBay and Facebook provide credibility for individuals and security checks,

while smartphone applications allow peers to complete transactions virtually anywhere at any time. These characteristics of the sharing economy allow people to transition from a world centered around ownership to a world focused on gaining access to various goods and services.

The Internet of Things

The emerging theory of the 'Internet of Things', a situation in which communication can flow between people and objects as a result of internet connectivity, is spreading to the transportation sector (Ashton 2009). It has been predicted that we are entering an era of smart mobility as a result of new and expanding technologies. As mentioned earlier, these technologies are creating new and more attractive mobility solutions including peer-to-peer car sharing. This development has proved particularly important when paired with the aforementioned trend of millennials demonstrating a lower desire for vehicle ownership.

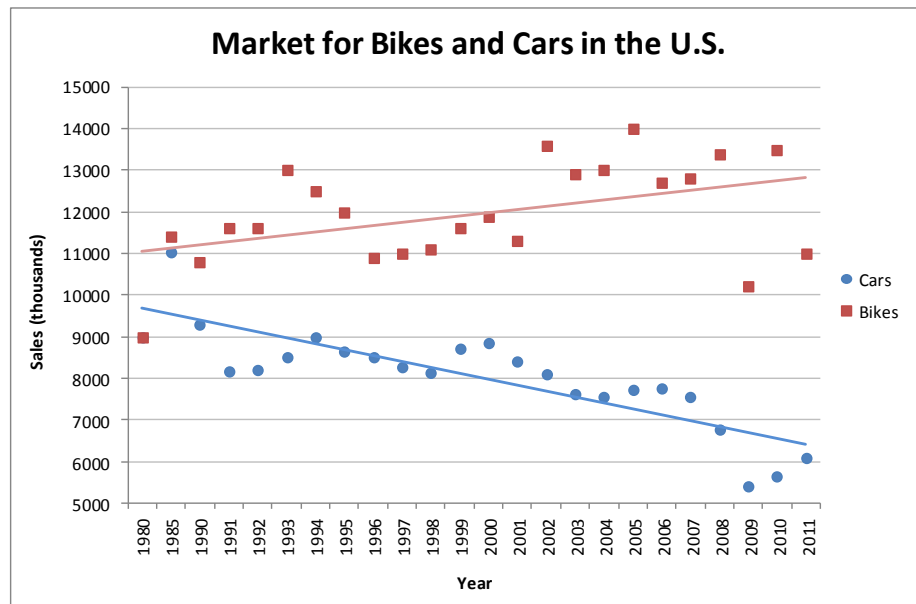
A more in depth look at some of these technologies shows that increased communication and data collection via GPS, cloud computing and mobile devices provides information on travel time, destination, traffic flow and vehicle occupancy. Numerous companies and applications have stemmed from such development, such as Waze. Waze, recently purchased by Google, is a smartphone app for traffic navigation that uses crowd sourcing to provide traffic conditions and suggest optimal routes for users. Crowd sourcing is one of many methods for engaging the 'Internet of Transportation'.

The 'Internet of Things/Transportation' has also breached the bicycle segment of the industry. There is a suite of internet-connected devices that have debuted over the past year such as Lock8. This is a Bluetooth-enabled locking device for bicycles, controlled by a smartphone app that notifies the user when someone is attempting to tamper with the locking device and allows users to build a network of locking bikes to share (Campbell-Dollaghan 2013). A second internet-connected device that deals more directly with the function of a bicycle is the Fly Kly. This is an electric wheel that is compatible with most bikes, and is capable of powering the bike up to 20 miles per hour holding a charge for up to 30 miles. The user's smartphone controls the speed at which this wheel moves the bike and the app sends the owner a notification if the bike is in motion in their absence (Sticky Bottle 2013). These are just two of the rapidly developing technologies supported by the 'Internet of Things' that are improving the way people travel, particularly for bicycling.

Market Opportunity & Industry Trends

The market opportunity for SimpleCycle rests primarily in the fact that bike commuting is on the rise nationwide. According to the American Community Survey, approximately 0.64 percent of all commutes were made by bicycle. This represents a nearly 10 percent increase from the previous year. Due to the fact that this increase is the largest year-on-year increase since 2007-2008, it is once again evident that people are choosing to use bicycles as a mode of transportation not only in response to the economic recession, but because the car culture is waning (League of American Bicyclists, 2013). In 2009, 16 to 34-year-olds as a group took 24 percent more bike trips compared to 2001. This segment of the population also walked and took public transit significantly more often in 2009 than they did in 2001 (Frontier Group 2012). The transition toward biking among certain demographics correlates with the sales trends for bikes versus cars in the U.S., as shown in **Figure 4**.

Figure 4: U.S. Retail Sales of Passenger Cars and Bikes



Data from: National Transportation Statistics 2013

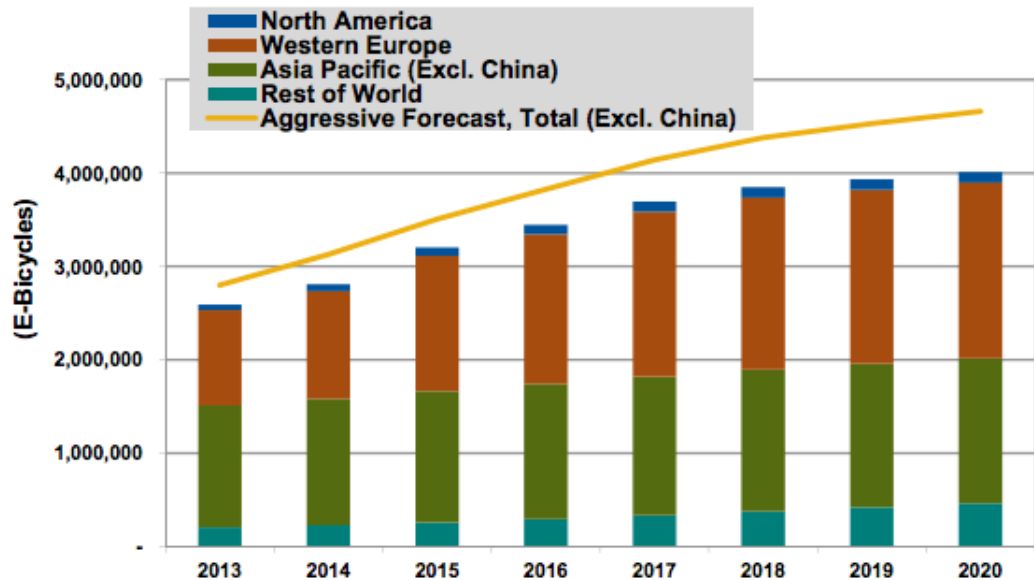
This growth in bicycling is also occurring alongside improvements to infrastructure as cities make it a priority to provide safe bicycling infrastructure. The number of protected bike lanes in the U.S. increased from 62 to 102 just in the last year (Schmitt 2013). These efforts are certainly promoting the rise in urban biking specifically. With the movement of young professionals toward cities and the ever increasing cost of living in those cities, people often live on the fringes of the urban center. Due to the fact that driving is costly and time-consuming and public transit is not reliably available or convenient, these so called urbanites have to turn to

bicycles as a dominate form of transportation. In the seventy largest U.S. cities, bike use among commuters has increased by 63 percent since 2001 (League of American Bicyclists 2013).

The rapid growth of bike sharing has further reduced the barriers to bicycling in urban areas. By 2011, there were an estimated 136 bike sharing programs within 165 cities globally, but as of 2013 experts believe there are nearly 700 cities worldwide offering bike shares (Shaheen and Guzman 2011; Brady 2013). There are now close to 40 cities with active bike share programs within North America and the number of stations has doubled since 2009 (Brady 2013). As these numbers indicate, bike shares have gained popularity quickly as people begin to implement bike commuting and bike trips into their daily routines.

In addition to bike shares, there are several emerging electric bike or e-bike startups making the market prospects for e-bikes in North America quite robust. Aside from the e-bike wheel mentioned previously, there are multiple other e-bike or e-wheel companies beginning to market and sell their products. One of these products is known as Riide, and was developed with the belief that 2014 would be the year for electric bikes. Riide is an electric bike built for the young urban commuter, and attempts to provide an e-bike that is less bulky than the majority of e-bikes currently on the market (Crook 2014). According to a recent report, the global market for e-bicycles will grow annually at a rate of 7.5 percent between the years 2012 and 2018. This could produce global sales of nearly 47 million units and \$11.9 billion in worldwide revenue in 2018 alone (Navigant Research 2012). As illustrated in **Figure 5**, annual e-bike sales have been rising across the globe and are expected to continue doing so.

Figure 5: Annual Electric Bicycle Sales by Region with a Forecast Scenario



Source: Navigant Research 2013

Note: China has been excluded because of its large market size.

While there is certainly no shortage of electric bicycle technology heading for the market, most of these new options come with a rather hefty price. These technological advances have a strong chance of enabling bike commuting to become even more pervasive across the U.S.; however the average commuter may not be willing to spend over \$800, the average cost of an electric bicycle (Galbraith 2012). Despite this price consideration several market forces including the increased usage of bicycles as a commute option are driving the market for e-bikes. Rapid urbanization has put stress on traffic systems pushing more people toward commute alternatives. The acceptability of e-bikes is also rapidly increasing as the number of market entrants rises and products mature. Finally, the increasing quality and affordability of battery options for these products and the rebounding economy particularly in North America are allowing electric bicycles to find success in the market place (Hurst and Gartner 2013).

Business Model Development

Initial Customer Problem Hypothesis

Beginning in the Fall of 2012 we came together with the intention of assessing the potential for using a web-based platform to simplify the commute experience and

increase access to pertinent social and spatial information for commuters and transportation planners. Specifically, we held two original goals:

- i. Develop spatial data collection infrastructure with urban planners to facilitate increased traveler access to web-based information about the availability of parking in order to reduce stress, traffic, and vehicle miles traveled.
- ii. Create a web-based platform to enable an information exchange between individual travelers about personal transportation resources (e.g. rides to specific destinations, parking availability) in order to incentivize peer-to-peer information gathering, and thus sharing of transportation resources.

Our business goals were tied directly to environmental and social issues as well as to the understanding that we would develop a profitable, triple bottom line business. Our environmental goals included:

- i. Reducing transportation emissions and facilitating the most efficient use of transportation resources.
- ii. Simplifying and increasing commuter access to relevant, sustainable transportation information.
- iii. Building a product that fosters the development of communities that are in support of sustainability with respect to transportation.

With these initially broad ideas we started the process of hypothesis validation/invalidation, began conducting customer interviews and initiated our first phase of customer discovery. Below is a table of our cumulative customer discovery. We actively interviewed numerous experts in the sustainable transportation field as well as potential customers of a service like SimpleCycle.

Table 5: Summary of Customer and Industry Research Interviews

Interviews	
Commuters	45
Industry Experts	18
Companies	9
Transportation Management Organizations	6
Survey Responses	1,899
Total	1,977

Millions of Americans face barriers associated with their daily commute. Multi-modal commuting can reduce some of these barriers such as the cost associated with parking and driving, and the abundance of private motor vehicles on the road, however there are also barriers to this method of commuting such as time and convenience. In the case of the public transit commuter, time and convenience are critical. There is a large customer pain revolving around the organization and optimization of multi-modal transport. It has proven difficult for many public transit commuters to coordinate between the multiple legs of their commute, which becomes increasingly difficult when commuters attempt to multi-modal commute with their bicycle. The distance between transportation hubs and a commuter's final destination is often referred to as "The Last Mile". This distance varies for each commuter, and having access to a bicycle for this portion of a commute has proved to be advantageous for a large portion of commuters. The advantage of incorporating a bicycle into the commute is ineffective however, when the other transportation mode does not allow for reliable and easy bicycle transport. The barrier of unreliable bicycle transport prevents travelers from using multimodal transportation with a bicycle more frequently. Many people who have experienced issues with bicycle commuting on the bus decide that it is not worth the hassle for them to continue trying to commute with a bicycle while using the bus.

The first iteration of SimpleCycle focused heavily on these public transit users who also bike commute. During the early stages of customer discovery we validated our initial customer problem, public bus and bike commuting simultaneously is unreliable. For example, the majority of city buses only provide two bicycle rack spaces per bus. When these racks are occupied, commuters with bicycles must either wait for another bus or bike the duration of their commute. Both of these options lack compatibility with the average commuter's schedule, and often make commuters give up on their attempt to optimize their commute by biking "The Last Mile". Additionally, distance commuters traveling between cities cannot make free transfers between the different transit agencies they must use in order to get to work. Having to pay full fare for multiple segments of a trip adds up to an expensive commute. These commuters also claimed that time is a major concern with public transportation; public routes tend to have multiple stops and take longer to get from point A to point B than using a personal motor vehicle.

Commuters who own bicycles and/or currently use bicycles during their commute have expressed strong opinions regarding the need for commute optimization and a safe, secure, reliable place to store their bicycle. The current transportation infrastructure does not offer an attractive solution to these commuters, but they would enthusiastically welcome a commute solution that allows them to incorporate the versatile functionality of their bicycle.

Discovering these customer pains allowed us to shift our project to focus more directly on understanding the pain points associated with bicycling and bike commuting. We specifically wanted to focus on utilitarian cycling, and what solutions we could develop to reduce customer pain and generate value. Some commuters have recently turned to ride sharing or carpooling options; however these solutions do not address the problem of incorporating bicycles into the commuting process. A portion of potential multi-modal bike commuters turns to driving their private motor vehicles for the entirety of their commute. The single passenger motor vehicle commute is a leading cause of traffic congestion, thus negatively impacting the environment. Most commuters we spoke with fell into one of the above-mentioned groups and expressed an overall lack in satisfaction with the commuting process.

Customer Discovery Methods

Our team gathered both primary and secondary customer research related to the customer problem. Most of this research was done through informational interviews via email, in-person meetings or telephone, with additional information gathered through market and industry research, interviewing industry experts and conducting a literature review.

We established a core customer problem hypothesis after conducting informational interviews (n = 30). These interviews took place on city buses, with fellow commuters traveling toward the UCSB campus and among peers. The hypothesis that bicycle commuters experience pain while attempting to incorporate a bicycle into their commute was validated with this initial customer research. The resulting business model hypothesis was that people would bike commute more often if they had reliable access to one-way trips in motor vehicles with their bike (i.e. bike-enabled ride share). This would be made possible by distributing portable bike racks to SimpleCycle drivers, allowing them to attach a bike to their car at any time.

An integral part of the customer discovery process was designing, conducting and analyzing a customer research survey. In addition to individual interviews, we designed and implemented a commuter survey to understand commute habits and strategies, as well as to determine the characteristics of commuters that would be most likely to use our service. The goal of our survey was to investigate the following questions:

- i. Why do people car commute rather than bike commute?
- ii. Why do people bike commute rather than car commute?
- iii. What is the willingness of employees to share their car commute with

another passenger, and what incentives (if any) need to be provided to make this a viable commute option?

To better discern the features of our product or service and to define the types of commuters our business should target, our survey focused on the following topics:

- i. Survey respondent willingness to participate as a driver, passenger, or both.
- ii. Characteristics and design of the business platform (e.g. between friends, coworkers, strangers).
- iii. Willingness to use a portable bike rack during a ride share.
- iv. Potential incentives to be provided to drivers (e.g. portable bike racks, cash, discounts).
- v. Survey respondent characteristics (gender, age, income, commute distance, commute mode, family size, work schedule, etc.).
- vi. Potential incentives to encourage non-bikers to use SimpleCycle.

The survey received 1,899 responses with over 900 responses from UCLA commuters and more than 500 responses from members of the UCSB Transportation Alternatives Program (TAP) and Traffic Solutions contacts. A summary of all survey respondents is given in **Table 6**. This large sample size helped answer many of our research questions. Survey results indicated that:

- i. Individuals are generally hesitant to have someone attach a bike rack to their car while sharing their car commute.
- ii. People are far more willing to share rides with people they know.
- iii. The willingness to pay for a bike-enabled ride sharing service is between \$1 and \$5 per ride (depending on commute distance), or the equivalent of the cost of a ride on public transit.

Table 6: Summary of Survey Respondent Sources and Location

Organization	Location	Responses
UCLA	Los Angeles	979
UCSB TAP	Santa Barbara	444
Irvine Spectrum Motion	Irvine	298
Traffic Solutions	Santa Barbara	99
Hacienda TMO	Pleasanton/Bay Area	43
SBBC	Santa Barbara	12
CEC	Santa Barbara	8
SimpleCycle Website	All	7
CSUMB	Monterey Bay	5
Patagonia	Ventura	2
REI (SB)	Santa Barbara	1
Mattel	El Segundo	1
Total		1,899

As a more in depth summary of our survey results we can divide our findings into a few sections, the first being drivers. The survey highlighted concerns that drivers have with commuting to and from work. We found that the time spent commuting, the environmental impacts of commuting and the cost of commuting are the main concerns of drivers. We also looked at drivers' willingness to ride share if paid and their willingness to give rides to bikers using a portable bike rack. A significant portion of drivers indicated that they are willing to give rides to bikers for the right price. This demonstrates that the supply of drivers will be sufficient to accommodate the demand from bikers, as bikers currently constitute a very small percentage of commuters. These findings indicate that our service would be appealing to drivers as well as bikers because they would reduce the cost of their commute, reduce their environmental impact by ride sharing and reduce the time spent commuting by gaining access to HOV lanes in certain locations.

Survey findings related to bicyclists revealed that SimpleCycle customers include those who would like to start bike commuting or bike commute more often, but are currently held back by the inconveniences of traditional biking. We looked at survey respondents who indicated that they bike at least occasionally in order to understand what they perceive to be barriers to bike commuting. We found that 66 percent of respondents were concerned about the time they spend commuting. 46 percent of people said that the distance of their commute prohibited them from

considering biking as a mode of transportation. 28 percent said that biking infringed upon their ability to look professional when they arrived at work, and 26 percent expressed a need to access one-way trips in private motor vehicles. In summary, to solve our customer’s problems our service must be designed to make bike commuting faster, easier and more convenient. The survey confirmed our hypothesized customer problems, and validated our hypothesis that one-way trips in cars are of value to bike commuters.

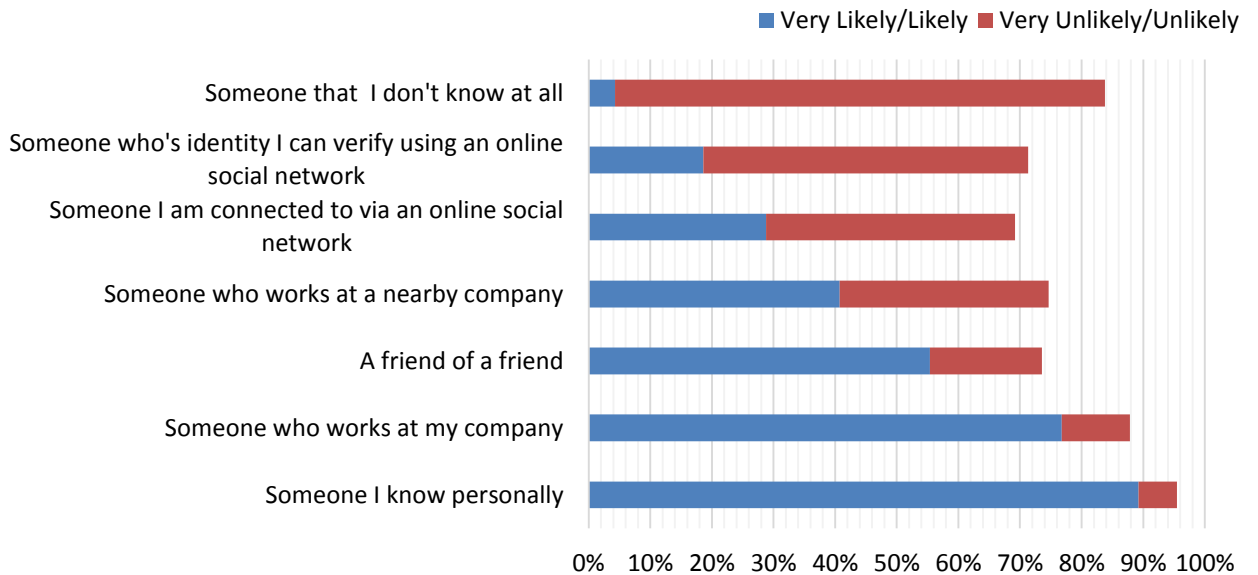
We also examined demographic characteristics and opinions about commuting in order to generate a customer profile. Characteristics of particular importance include a willingness to pay between \$2 and \$3.50 per ride for our service, and a desire to start bike commuting more often. A significant portion of potential customers also indicated that they may not currently bike commute, however they are looking for a way to do so, and are willing to try an alternative/seeking for a way to change their commute.

Table 7: Willingness to Pay for SimpleCycle Survey Results

Willingness to Pay for SimpleCycle	
Mean	\$3.50
Median	\$2.50
Maximum	\$300/Month (approximately \$15 per ride assuming 20 rides taken per week)

The figure below reflects the willingness of bikers to ride share with various people. As you can see, people are much more willing to ride share with people that they know personally or with a coworker. To us, this indicated that there is value in creating connections or referrals that help people find ride shares they are comfortable with.

Figure 6: Survey Results Regarding the Willingness to Share a Ride with Various Types of People



We closely analyzed the business models, customer profiles, and fees charged by existing public entities and businesses within the transportation industry to understand the environment in which our business will exist. We conducted interviews with companies such as Lyft and Wheelz, and compiled research on Uber, SideCar, and Zipcar. This gathering of information highlighted the fact that there is potential in dividing property rights and ownership to match more diverse traveler use-cases. People are becoming less attached to full private motor vehicle ownership than passed generations and having access to a car is often more important among many individuals than obtaining ownership. Customers benefit from one another in sharing-based models where the benefits of ownership can be spread between many individuals. We feel that the general trend of access over ownership can be carried into the utilitarian bicycling space and used to create new value for urban bicyclists.

John Pucher, a leading researcher on the subject of bicycles, gave a lecture that SimpleCycle attended. While discussing his research he validated our hypothesis that there is potential for increasing bicycle ridership in American cities, but the barriers to successful implementation include public policy issues and the need for cooperation between governmental agencies and private companies to shift policy in order to reduce the risk for new/alternative systems and encourage their development.

Public transportation is expensive and increased urban bicycling may have positive feedbacks to reducing peak load of public transit systems. Buses are most profitable when full yet when a route has more demand than capacity the transit agency will sometimes add a bus to the line in order to meet the extra demand. The cost of dispatching another bus to a line is greater than the fare revenue from the spillover customers and reduces or eliminates the profitability of the original bus that is at maximum capacity. We see transportation planning and management agencies within local governments as key partners with the ability to encourage a robust bicycling system for positive spillover effects in addition to the direct positive benefits of bicycling.

As previously mentioned, our initial customer discovery found that time, cost, and convenience are the factors of highest importance for most urban commuters when making transportation decisions. These factors are encouraging for multi-modal transport because of the possibility of reducing the cost of parking and driving, but currently the barriers of time and convenience prevent commuters from using multi-modal transport more frequently.

The current pains that come with incorporating a bike into the commute must be overcome by a solution that opens peoples' eyes to the following possibilities. If a bike can be easily used for "The Last Mile" of a commute, there would be a dramatic increase in the range of mobility on either end of the commute compared to walking. Distances that are considerably far to walk are a quick pedal away. "Last Mile" biking opens up a range of novel, optimized connections that bikes can accomplish.

Our initial solution for the researched customer problem was a reservation system and information network that would allow users to reserve bike space on public transportation, and give commuters bike optimized routes. These two products would provide commuters peace of mind in knowing they have confirmed access to infrastructure enabling them to multi-modal commute with a bicycle.

SimpleCycle aimed to reduce the risk of attempting a multi-modal commute with a bike by giving customers risk free access to limited bicycle infrastructure on public buses and trains. There are no comparable offerings that address the inability to reliably bring your bike along for the public transportation portion of your commute. Public transportation systems are optimized for walking and driving as "The Last Mile" mode of choice. There are no existing systems designed to optimize the incorporation of a bicycle into transportation flow. Current bicycle options are first come first serve, have inconvenient time restrictions and include sections that may be faster to complete via private motor vehicle.

Additionally, SimpleCycle would optimize routes to take advantage of the speed and mobility of bicycles in urban environments. Benefits such as the speed you can bike downhill, the ability to move faster than cars in dense urban areas and an increased range of mobility compared to walking can each be leveraged. The reach and speed with which you can connect transit to your first and last mile can be greatly increased.

Ultimately we pivoted from this model because of the logistical issues of managing reservations on such a high demand, public good. Having this option in current public transportation systems would inherently exclude users in certain demographics who rely on a free and open bike rack. The reservation system could have a negative impact on bike commuting by taking away bike rack resources that would have gone to people without access to an electronic device to make their reservation. Liability concerns and legal restrictions on public buses limit the quantity of bike racks that can be placed on a bus. Speaking with and researching several bus agencies, we found that 2 to 3 is the maximum number of bike racks allowed on a bus by the vast majority of bus agencies. Allowing storage of bikes inside the bus is also a hazard and not typically granted. Bus agencies would have to be a key partner in this model; however they are very restricted in the types of solutions they can physically offer.

Upon invalidating the bike rack reservation business model, we focused on developing a deeper understanding of the problems and pain that bike commuters face. Our goal was to understand bike commuting customer problems and derive a profitable solution. The first solution developed was bike-enabled ride sharing. We worked on various iterations of the bike-enabled ride sharing model. Specifically, two distinct variations and sets of customer problems were researched:

- i. Biker and driver pains associated with getting to and from work.
- ii. Employer pains related to managing commute regulations and issues.

Concern for safety is one of the major factors influencing the decision made by occasional bike commuters and potential bike commuters of whether or not to bike. One of our key assumptions in testing this hypothesis was that bike safety was affected by weather, darkness and traffic conditions.

The hypothesis that bike commuters experience pain while attempting to incorporate their bicycle into their commute was the starting assumption for this segment of our customer research. Realizing that public transportation might not be the best method for creating a multi-modal bike commute, we determined that

private motor vehicles could be an effective multi-modal platform for our problem solution. We determined that understanding the pain points for drivers was critical. The reasoning behind this was that solving problems experienced by drivers could be used as a method to encourage drivers to provide rides to bicyclists. Effort was directed at discovering explicit customer pains faced by drivers. Specifically, we investigated the hypothesis that there are a significant number of highly cost-sensitive individuals who drive to work, either regularly or occasionally, but bike recreationally or competitively and would be willing to give a ride to bike commuters.

The biggest pain for bikers is the inability to make round trips with a bike. Making one-way trips via bike both convenient and reliable would provide value to bicyclists. In the following sections the two resulting models are presented. The specifics of each model are highlighted and an explanation of how we were able to invalidate each model is provided.

Business Model 1: Bike-Enabled Ride Sharing (Individual)

The “Individual Model” is based on the basic relationship between drivers and bikers, relying on information sharing from both parties and portable-universal bike rack distribution through a supplier.

In this model, SimpleCycle is a smartphone application that links a network of participating drivers to bike commuters with portable, ‘universal’ bike-racks enabling people to commute by bicycle and share rides in cars as needed. By helping potential bike commuters coordinate carpools with drivers of private motor vehicles, SimpleCycle helps commuters save time and money, and avoid inconveniences. This service also improves air quality and reduces emissions from commuter vehicles. Bikers would subscribe to our service in order to reliably access one-way trips to or from work in a car, allowing them for example to bike commute and still run errands after work, or avoid being sweaty for that important meeting. Drivers would be paid for each ride given via a cashless transaction facilitated by our proprietary web platform, which would also coordinate pick-up locations, and optimize a route to a common destination. SimpleCycle would also offer value to drivers by allowing them to save time if they have access to a carpool lane along their commute. In this model, our business would profit from the difference between the revenues earned from bike subscribers and the cost of paying participating drivers.

The unique offering here is that SimpleCycle would combine the extra space in private motor vehicles with the bicyclists need for a reliable platform for multi-modal commuting. SimpleCycle would incentivize private motor vehicle commuters to pick up bicyclists by providing a free bike rack (with a prominent SimpleCycle

logo) for personal use in exchange for giving a predetermined number of rides to commuting bicyclists. There would be a range of bike racks available that fit various types of cars, carrying between 2 to 4 bicycles, and require a mandatory number of rides to be given that is proportional to the value of the rack. Once the mandatory number of rides has been met, drivers would be able to earn extra fare from passengers for additional rides given. From the bike racks, SimpleCycle would receive advertising space on personal vehicles and a guaranteed fleet of drivers incentivized to provide rides. As a result, drivers would enjoy a high quality bike rack for personal use, empty seats in private motor vehicles would be utilized, and multi-modal bicycle commuting would be enabled.

SimpleCycle would also handle the optimization of combining driver and cyclist commutes to create a solution for both by taking advantage of the bicycles urban speed in heavy traffic, downhill sections, and access to bike paths. SimpleCycle would create a superior method of navigating the urban environment that optimizes the combined power of dynamic ride sharing and bicycle mobility. This would allow for the option to incorporate the best sections of a commute for a bicycle and also create enjoyable or relaxing alternatives as a means to turn a commute into a stress relieving outdoor experience. Drivers would save on the monetary cost of commuting from bridge tolls, gas and other costs such as time by having access to carpool lanes. Bicyclists would be able to complete a multimodal commute that would not be possible in a timely and efficient manner by utilizing public transportation systems. Both cyclists and drivers would also have the opportunity to make new and meaningful connections.

This model offers value through an optimization, reservation, and information network that leverages dynamic ride sharing, reserve-able bicycle space, and bicycle optimized commute routes to give commuters ease in knowing that they have confirmed access to infrastructure that enables them to multi-modal commute with a bicycle. SimpleCycle users would no longer have to choose whether or not to bring their bicycle along for their commute. Incorporating their bicycle would no longer be an impediment, but rather a method for maximizing the efficiency of their commute.

At the same time many urban environments are conducive to bicycling, they also contain isolating features that can impede a bike commute. For example, when there are bridges that do not have bike access there is extreme difficulty in getting in and out of a city on a bicycle however, once you are in the city a bike may be the optimal transportation solution. In the San Francisco Bay area, you cannot get on the BART with a bicycle during peak hours, you cannot bike across most of the bay bridges, the Drivers Bridge toll is expensive and drivers cannot use the carpool lane if they are alone. This combination of pains is an example of a problem SimpleCycle

would be solving in this model.

The initial notion of how this service would work involved giving drivers bike racks as an incentive to pick up bikers. While this still may prove to be an important incentive, we realized that it might introduce some logistical issues (e.g. drivers may not want to drive around with a bike rack all the time, certain racks may not work for certain bikes, bikers may not feel there are enough available drivers). Thus, because we wanted to focus on offering a reliable way for bikers to access one-way trips, we thought it might be more viable to develop a solution in which the bike rack is actually the property of the biker. If we could find or develop a small enough, portable, bike rack that could fit onto any car, bikers would have much greater flexibility and drivers would be less constrained by always having a bike rack. A company by the name of SeaSucker currently manufactures a bike rack that fits many of these qualifying characteristics, and we investigated the potential of developing a portable, universal bike rack. It became evident however, that the bike racks had several limitations.

During this time, the legal landscape for SimpleCycle was rapidly evolving. Ride sharing companies have recently been deemed legal according to the California Public Utilities Commission. The “sharing economy” however, still presents some legal questions. One of the biggest questions was whether or not ride share drivers for companies such as Lyft and Uber are employees. We consider this market position to be very advantageous. The current legal climate has been informing us on our macro-environment and providing us with analogs for comparing and testing the liability and insurance component of our evolving business model.

Business Model 2: Bike-Enabled Ride Sharing (Employer)

The foundational proposition of the “Employer Model” is that employers have high commute management costs and are looking for solutions to reduce the number of private motor vehicle trips to and from their offices. This iteration was based on the foundational principle that people would bike commute more often if they had greater access to one-way trips in private motor vehicles that can accommodate bikes. We also built on our learnings that people are more likely to ride share with people they know more personally. We found that among our survey respondents, there was a higher willingness to ride share with people that knew each other or worked together. This indicated that increased participation would be possible if we were to enable co-workers to ride share with each other.

Our market research suggests that employers have pains associated with commute management issues and want to reduce the number of private motor vehicles arriving at business campuses. Many would-be bike commuters end up driving

because of the impracticality of biking one half of their commute and this causes increased congestion on corporate campuses. Additionally, providing parking for employees is expensive and employers can save money by reducing the amount of parking that they have to provide.

The concept of this iteration of our business model was to provide employers with a complete bicycle ride sharing system. A fleet of small, portable bike racks capable of being quickly attached to a range of vehicles would be provided for individuals to use when ride sharing with fellow employees. The ability to secure rides would be possible via a smartphone application, connecting bikers to a network of drivers within the company that are willing to carpool. This system would allow employees to take one-way trips in cars with their bikes. By facilitating 'bike-enabled ride sharing' SimpleCycle will allow customers to bike commute more often and reduce the costs associated with private motor vehicles to employers. The value proposition of this model includes reducing the parking demand for employers, helping employers improve employee retention, and increased compliance with regulations.

In speaking with managers of Transportation Management Associations/Organizations (TMAs/TMOs), we determined that employers, at least in California, are concerned with commute impact reduction, mainly as a way to reduce the need to increase parking capacity and meet regulatory mandates. However, the transportation management efforts of large employers tend to focus on creating a suite of options that facilitate commute impact mitigation (i.e. carpools, vanpools, increased transit use) rather than targeting efforts at increasing bike ridership specifically. Part of this is due to the fact that the tax breaks established to promote alternative commute strategies do not offer much to incentivize bike commuting (only up to \$20 of pre-tax fringe benefits per month per employee). The opportunity to offer these employers value by reducing their demand for parking through increasing the number of bike commuters is still significant, as it would allow employers to offer their employees the opportunity to 'cash out' their company-provided parking space under California's Parking Cash Out Law (AB 2109). Cashing out parking would allow employers to minimize the amount of parking they need to lease/purchase/build if they are increasing the size of their workforce, and to use existing parking space for other purposes to increase productivity. Thus, while a service that enables more people to bike commute by offering reliable access to one-way trips in cars would still be useful for these large firms, it would have to be integrated into a larger framework of transportation management strategies. If SimpleCycle were to move into this space and decided to target employers as our customers, we would have to design our product to work within existing multi-faceted transportation management strategies.

For our business model to work for employers it must also work for individuals. We found there was too much social inertia against ride sharing for our bike-enabled ride sharing model to be financially sound. Convenience is a very important part of commuting. A key aspect of convenience is the ability to plan one's commute independently. The necessity of relying on someone else for a shared ride hampered our previous model's appeal to potential customers because it didn't allow them to be independent in planning their commute.

Understanding this barrier to acceptance, SimpleCycle used all of our valuable customer discovery and industry research to rethink the best way to solve the customer problems that we continued to encounter. The revised customer problem hypothesis includes independence as a key ingredient. Our next solution was to provide commuters with reliable access to electric power for their bike and make bike commuting faster, easier, and more convenient.

Proposed Business Model

Overview of Organizational and Ownership Structure of Bike Shares

In order to understand SimpleCycle's business model, it is first necessary to define what a bike share is, and explain how bike shares are organized and financed. Bike sharing is a non-motorized transportation service, typically designed to provide users point-to-point transportation for short trips (0.5 to 3 miles). Users pick up a bike share bicycle at any self-serve bike sharing station in the network and return it to any other bike sharing station. Payment for bike share service varies widely, and users usually have the option to pay for a bike for only a few hours, a whole day, or purchase longer monthly or annual subscriptions (Toole Design Group 2012).

i. Organizational Structure

Bike shares are public systems involving two key entities. First, there is an implementation agency such as a municipal transportation authority (e.g. NYC Department of Transportation). The implementation agency is the ultimate authority in control of the system. They oversee the system design, contract third parties to operate the system, set the fees that individuals must pay, and monitor the level of service provided by the system.

Second there is a system operator. The system operator is a third party who is contracted by the implementation agency to run the bike share. They are in charge of the daily operation of the bike share including (i) maintenance of bikes and stations, (ii) customer service, (iii) payment processing, and (iv) marketing and brand

management. The operator can be another government agency, or an external for-profit or non-profit company (ITDP 2013).

ii. Ownership Structure

The financial structure of bike shares varies depending on (i) whether the system operator is a public entity, a private for-profit company, or a private non-profit entity, (ii) who owns the capital assets in the bike share, and (iii) the specifics of the contract negotiated between the system operator and the implementation agency.

a. Publicly Owned and Operated

In a publicly owned and operated bike share, the implementing agency owns all the capital assets and assumes all the financial risk. The benefit of this type of ownership structure is that public goals for the bike share are prioritized, and the system is more likely to provide equitable access to all city residents. Having only one entity in control of all aspects of the system also simplifies management. However, these systems have the potential to be run inefficiently, and they require more public resources than other ownership structures (ITDP 2013).

b. Publicly Owned and Privately Operated

In this type of bike share, the implementing agency owns all capital assets and contracts a private third party to provide the services. The contracts offered by the agency are typically 5-10 years, corresponding to the lifetime of the bikes and stations. Outsourcing the provision of services to a third party means the city assumes less of the financial risk associated with the bike share than in publicly owned and operated systems. However, properly incentivizing the operator to maintain the quality of the capital assets, and re-contracting with system operators can be problematic (ITDP 2013).

c. Privately Owned and Operated

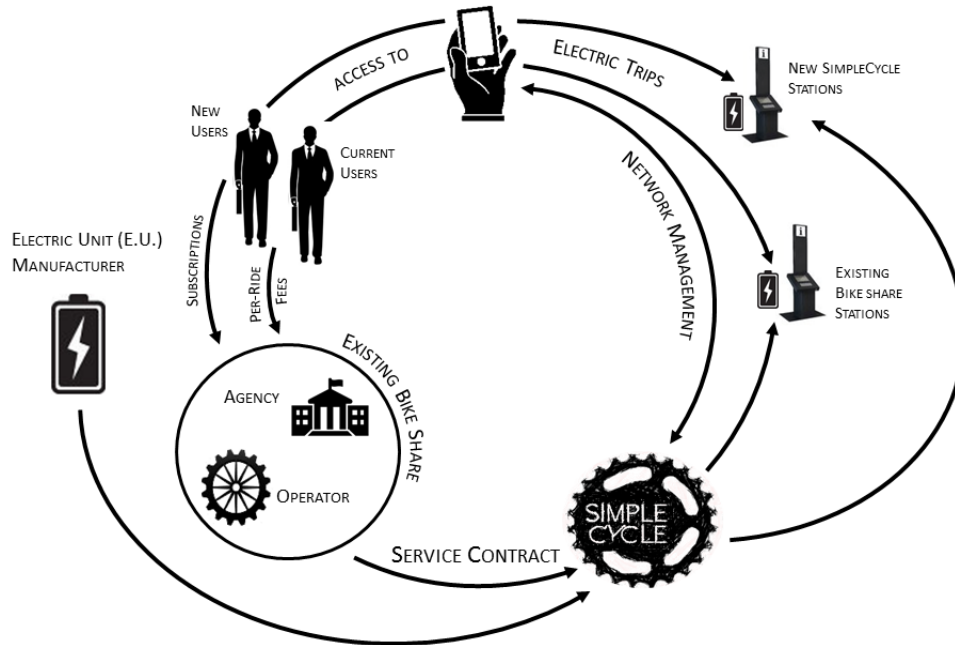
Under this arrangement, the implementing agency provides the space for the development of the bike share, and then contracts a private third party to construct and operate the system, subject to system-wide service and performance standards. The contracted third party owns all the capital assets. Revenue from the service fees is split between the system operator and implementing agency. These systems are typically the most efficiently run, and have the highest return on investment. However, issues can arise when private incentives (i.e. profit maximization) do not coincide with the public goals of the bike share (ITDP 2013).

Another important aspect of the financial structure of bike shares is advertising contracts. Depending on the intentions of the implementing agency, and the ownership structure of the system, the implementing agency or system operator may enter into an advertising contract with private for-profit companies. This is often done in privately owned and operated bike shares to provide the system operator with the revenue necessary to turn a profit. For example, in New York's Citi Bike system, the system operator, NYC Bikeshare, negotiated a five-year, \$41 million contract with Citibank for advertising rights on their bikes and stations and will also receive \$6.5 million over five years from MasterCard in return for being named the systems preferred payment provider (ITDP 2013). Finally, it should be noted that separate contractors may exist for all the different aspects of a bike share, including for the operations, hardware, IT and software, and marketing and public relations. Given this brief overview of the organizational and financial structure of bike shares, we now turn to describing how SimpleCycle's business model will operate, and produce profits.

SimpleCycle: Electrifying Bike Shares

In simplest terms, SimpleCycle is a package of physical infrastructure and services that affords system operators the chance to increase profitability, and implementing agencies the opportunity to augment and expand the level of service provided by the system as a whole. The fundamental proposition of our business model is that these dual objectives can be achieved by incorporating electric power into existing bike share systems. **Figure 7** provides a visual schematic of the main components of the business model.

Figure 7: Business Model Diagram



In this section, we will first outline the basic concept of our product/service. We will then describe and explain each of the key components of **Figure 7**, including (i) customer segments and value propositions (ii) key partners and key activities, and (iii) the revenue system and cost structure of the business. Next we will estimate the size market SimpleCycle could capture, ranging from what is theoretically possible to what is reasonable given the nature of our customers and the state of bike sharing in the U.S. Then we will identify target markets and discuss our proposed launch site. Finally, we will present financial projections for our business' operation in the first five years after launching.

i. Business Model Concept

In order to 'electrify' an existing bike share system, our organization will purchase portable electrification units (herein EUs) that are capable of attaching to both bike share bikes and personal bikes, converting them into electric bikes³. These electrification units will be made available to urban cyclists both at existing bike share stations, and at newly constructed stations owned and operated by SimpleCycle. The stations constructed by SimpleCycle will contain electrification units only, and will be constructed outside of the coverage area of the existing bike share. Thus, the new peripheral stations will provide urban cyclists beyond the

³ See Appendix 1 for a description of the electrification unit

coverage area of the existing bike share with access to electric power for their personal bikes, but leverage the existing network as pick-up and drop-off locations for the electrification units.

Our product is offered in the form of a service contract to the bike share operator and implementation agency. In return for increasing usage of the existing bike share system, SimpleCycle earns \$1 for each trip made using an electrification unit. The specific form of this contract is dependent upon the ownership structure of the bike share. For example, in New York City, which is a privately owned and operated bike share, a performance contract would be negotiated with the managing private company, NYC Bikeshare, and the development of public land and fee schedule would be negotiated with NYC DOT. The basic premise remains the same regardless of the ownership structure: sign a service contract guaranteeing increased usage, augment the existing system with electrifying units and new peripheral stations, and earn \$1 per electrified ride made in the system.

Individual users gain access to the EUs at SimpleCycle or existing bike share stations either by paying a fee to augment their existing bike share membership, or a higher per-use service fee. In order to facilitate these transactions SimpleCycle's mobile application will be integrated into the existing bike share payment system, but it will remain up to the implementing agency and bike share operator to decide how to raise fees for electrified bike share service. Whether it is via a membership or a one-off payment, individuals that register with our system will receive a digital RFID tag, which, when scanned at a SimpleCycle existing bike share station, will give them access to an EU for a set period of time. Again, the implementing agency and bike share operator will determine the duration of this rental period.

We are confident that this business model will function in any city with a bike share because both city governments and third-party bike share operators stand to benefit from augmenting their bike share with SimpleCycle. Cities who implement SimpleCycle provide a larger percentage of their resident populations with access to the bike share system (if only with a personal bike). Government or third-party bike share operators are provided with increased usage of their existing system. Most importantly, individuals are provided with a viable alternative to private motor-vehicle transportation.

ii. Customer Segments and Value Propositions

In most bike ownership structures, the implementing agency has full control over the decision to negotiate a performance contract with SimpleCycle. However, if the bike share is privately operated, this contract must also be negotiated with the bike share operator in order to ensure SimpleCycle is successfully implemented. Thus, we

consider the economic buyer for SimpleCycle as the combined institutional entity represented by the bike share operator and the implementing agency. This is our primary and most important customer segment. But why would an implementing agency or bike share operator want to purchase SimpleCycle? The answer is that the increased usage of the bike share produces benefits for both of these entities.

First, consider the implementing agency of a bike share. Such an agency is a public entity serving public interests, including congestion and air pollution mitigation, equitable access to public transportation, and, increasingly, GHG mitigation. All of these are addressed by increasing the overall usage of an existing bike share system. In addition, the extension and augmentation of an existing bike share system increases the regulatory purview of the implementing agency, and therefore also aligns with their political incentives. Furthermore, SimpleCycle offers these benefits without demanding any public funding. A service contract with SimpleCycle only requires that our business earn a \$1 surcharge on every electric ride provided by the bike share system. As detailed further on, this is almost certainly less than individuals' willingness to pay for access to electric power for their personal and/or bike share bikes. The implementing agency retains the total authority to set the levels of fees for electric rides provided this surcharge is covered.

The main reason for charging just \$1 per electrified ride when willingness to pay is likely higher is to ensure the buy-in and cooperation of the other half of the bike share partnership, the bike share operator. According to an analysis of U.S. systems, the fees for service or annual memberships set by the implementing agency's existing bike shares are not high enough to cover the costs of operating them (ITDP 2013). The size of this gap between stable revenues from users (called 'farebox revenues') and operating costs varies across existing bike share systems. For example, Capital Bikeshare in Washington D.C. achieves close to 90 percent farebox recovery, while the Bixi bike share in Toronto only recovers about 60 percent (ITDP 2013). The gap between system revenues and operating costs is usually accounted for in the service contract negotiated between an implementation agency and a bike share operator. In most privately operated bike share systems, the majority of profitability is derived from lucrative advertising contracts (ITDP 2013). Thus, considering private bike share operators as a customer, their problem is that fares for service are not high enough. In providing a service valued more highly by customers than the surcharge demanded for our service, SimpleCycle provides bike share operators with a means of achieving higher farebox revenues. Furthermore, because our business manages and pays for its own operations, this additional revenue is provided to bike share operators without increasing their own operational costs (minus some minimal costs of coordinating and integrating management and operations with our organization). The structure of the

SimpleCycle service contract also has the added benefit of aligning the existing bike share operator's incentives with those of our organization. Both entities receive more revenue the more electric rides are made on the system.

The preceding discussion of the value SimpleCycle creates for implementing agencies and bike share operators explains why our organization is ensured to be considered for a service contract. Our economic buyer will be interested. However, given the structure of the proposed service contract, the profitability of our enterprise is solely determined by how often individuals pay to access electric power for their personal bike or a bike share bike. Consequently, individual users are also a core customer segment in our business model. In projecting demand for our service, we considered two main categories of individual users: (i) current users of the existing system who will pay for access to electrified bike trips on bike share bikes and (ii) individuals who will pay for access to electric power for their personal bikes at the newly constructed peripheral stations. Each of these groups could be further subdivided based on a number of qualities, including socioeconomic or demographic traits, underlying motivations for desiring access to electric power for bike trips, or the types of trips they would make using SimpleCycle. An accurate and detailed estimation of demand for our service would attempt to account for variation across these and other qualities.

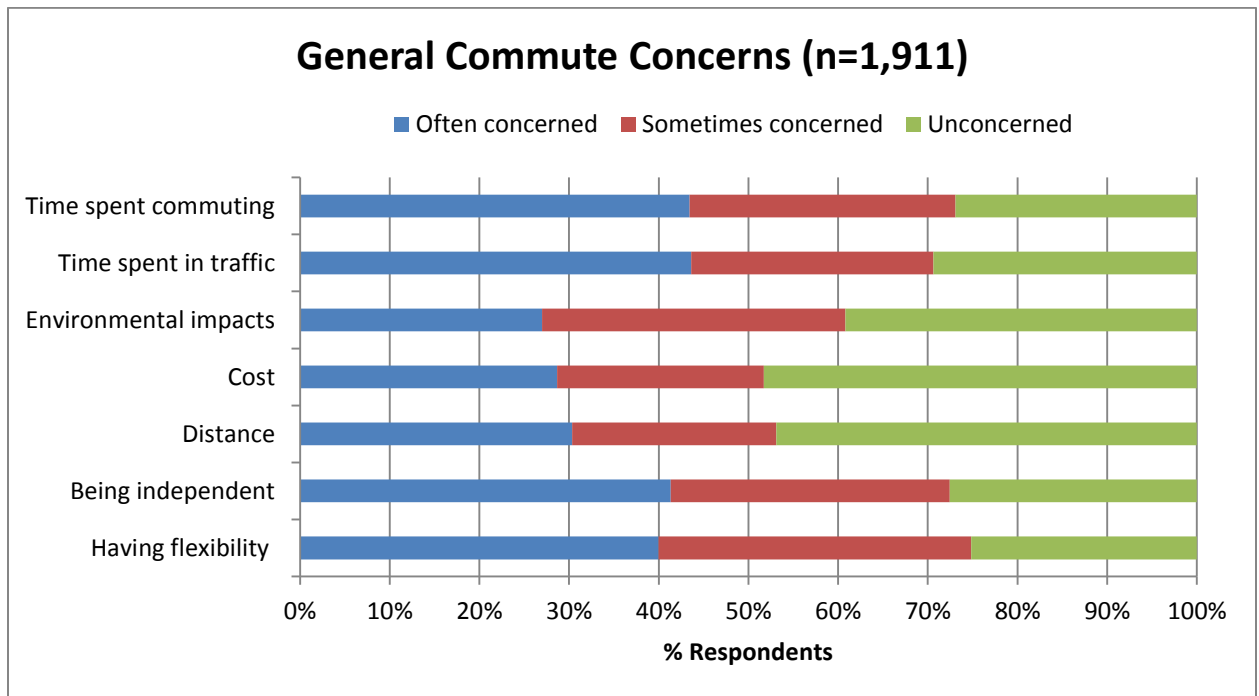
However, as described in the Business Model Development section of this report, much of our customer discovery research focused on bike commuters and individuals that would like to start bike commuting. As a result, the subsequent discussion of how SimpleCycle creates value for individual users is focused on current and would-be bike commuters. While this is an inherent limitation of the data we collected for this analysis, we believe that bike commuters, and individuals that would like to start bike commuting constitute a large proportion of the individual users who would pay for access to electric power for their personal bikes at peripheral stations. This assertion is partially supported by the fact that existing bike share usage data shows that the majority of users are annual subscribers, rather than one-off users (CitiBike System Data, Capital Bikeshare System Data). From this we can infer that bike share users are primarily people who derive repeated, rather than one-off utility from the service. Commuters certainly fit this description. Furthermore, we believe the customer problems faced by commuters are representative of individual concerns with intra-urban travel more generally. This caveat aside, we now present quantitative evidence for why SimpleCycle solves problems faced by urban commuters.

Our market research survey results indicate that nearly 33 percent of commuters would either like to begin bike commuting, or bike commute more often than they

currently do. Furthermore, a full 20 percent of survey respondents indicated that, if all commute options were possible, biking would be their most preferred way to commute. While these results lack broad generality as nearly all survey respondents lived in Southern California, we believe they are at least partially representative of the preferences of Americans as a whole. And yet, the highest rate of bike commuting in any city (Portland) is only 6.1 percent. Nationwide, it is less than 0.6 percent (LAB 2013a). This discrepancy between the stated willingness to bike and actual ridership indicates the presence of barriers (i.e. customer problems that prevent individual commuters from getting on their bikes). The results from our survey, as well as information from secondary research and in-person interviews shed light on the nature and source of these customer problems.

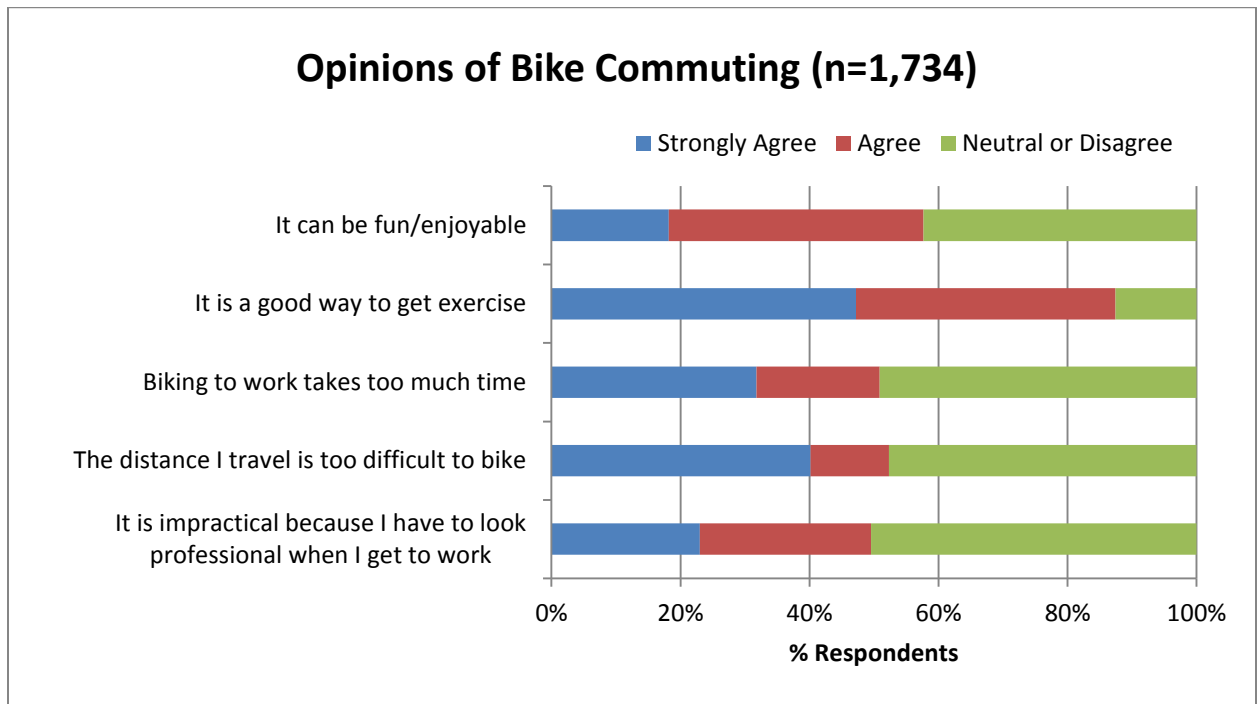
To begin with, we identified the three important general concerns individuals have about commuting. These concerns relate to the time individuals spend commuting, the financial and environmental cost of commuting, and the convenience or inconvenience of commuting. **Figure 8** shows the percentage of our survey respondents that were ‘sometimes’ or ‘often’ concerned with specific examples of each of these generic issues, as well as the percentage of respondents who were unconcerned.

Figure 8: General Commute Concerns



As **Figure 8** shows, more than 70 percent of commuters are concerned with the amount of time they spend commuting or stuck in traffic. A similar proportion of respondents were concerned with having flexibility in choosing when to arrive at or leave work, and commuting independently without planning or depending on others. Finally, more than 50 percent of commuters are concerned with the financial or environmental cost of their commute. These general commute concerns constitute a set of barriers that prevent many people from biking. Other questions posed in our survey elucidated more specifically how concerns of time, cost, and convenience manifest as barriers to bike commuting. For example, we asked individuals to rate how strongly they agreed with certain statements about bike commuting. The results from this question are shown in **Figure 9**.

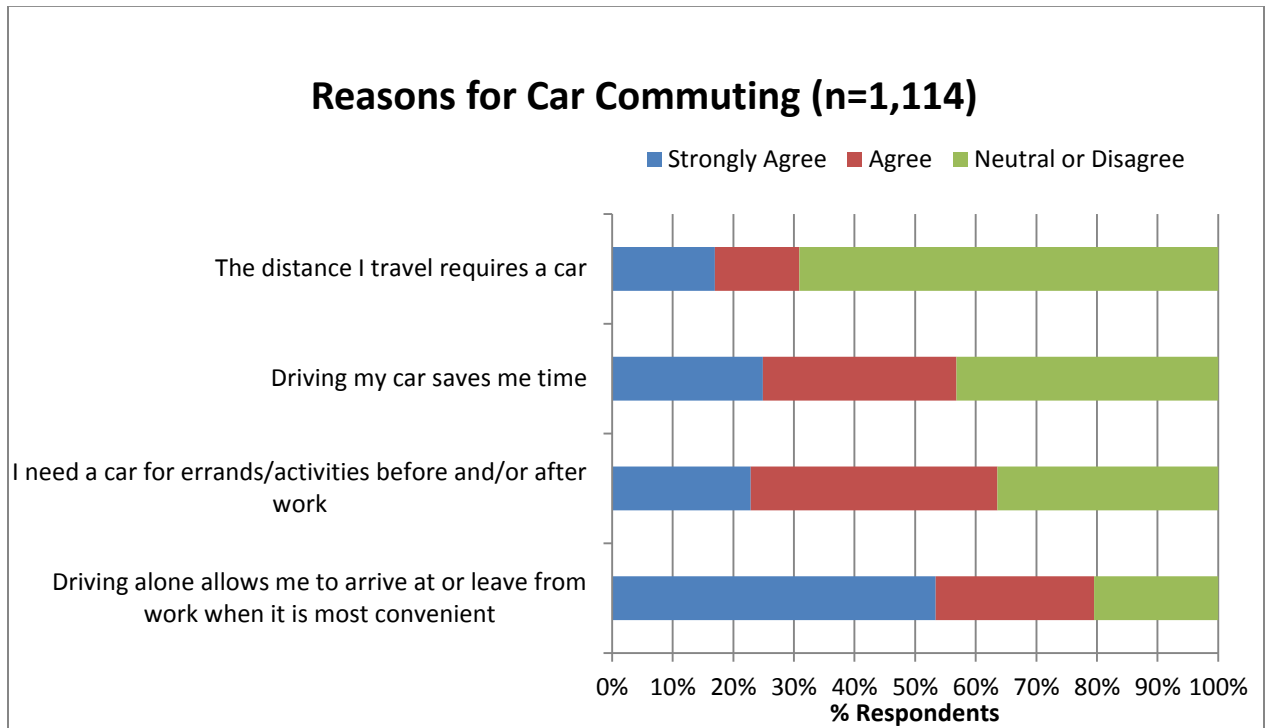
Figure 9: Survey Respondent Opinions of Bike Commuting



While a majority of respondents agreed that bike commuting could be enjoyable, and almost all felt it was a good way to get exercise, many were held back by concerns relating to time and convenience. For example, nearly 40 percent of respondents felt strongly that they lived too far away to bike to work. Additionally, 50 percent agreed that having to look professional at work infringed upon their willingness to bike commute. Both of these can be seen as an extension of a general concern over the lack of convenience respondents associated with bike commuting. Finally, more than half of respondents felt that biking to work would take too much

time. These same concerns are reflected in the reasons respondents cited for why they drove to work, which are displayed in **Figure 10**.

Figure 10: Respondent Reasoning for Car Commuting



As illustrated in this figure, nearly 80 percent of commuters drive because they highly value the flexibility to arrive/leave work when it is most convenient. Another 63 percent agreed or strongly agreed that they drove because they had to run errands before or after work. The high level of respondent support for the last two statements in **Figure 10** clearly demonstrates that people value the convenience afforded by private motor vehicles. In conjunction with the strong opinions about the inconveniences of bike commuting illustrated in **Figure 9**, this result suggests that more people would bike commute if it were more convenient. A similar conclusion can be drawn from respondents' concern about time. More than half of respondents said that bike commuting takes too long, and almost the exact same percentage indicated they car commute because it saves them time. Again, given the discrepancy between apparent willingness to bike commute and actual rates of bike commuting, this result suggests that more people would bike commute if it did not take as long.

In providing individuals with reliable access to electric power for their bikes, SimpleCycle addresses both of these customer problems. The electric motor allows

bikers to travel faster and with less difficulty than traditional biking, saving time and making it less challenging to look professional upon arriving at work. Furthermore, with the assistance of electric power, individuals who live significant distances from their workplace can bike commute without great difficulty. Finally, making biking more feasible also creates value for individual commuters by giving them access to a cheaper way to commute. **Figure 11** shows the expected annual cost of a 12-mile round trip commute using different modes of transportation.

Figure 11: Expected Annual Cost of a 12-Mile Round Trip Commute

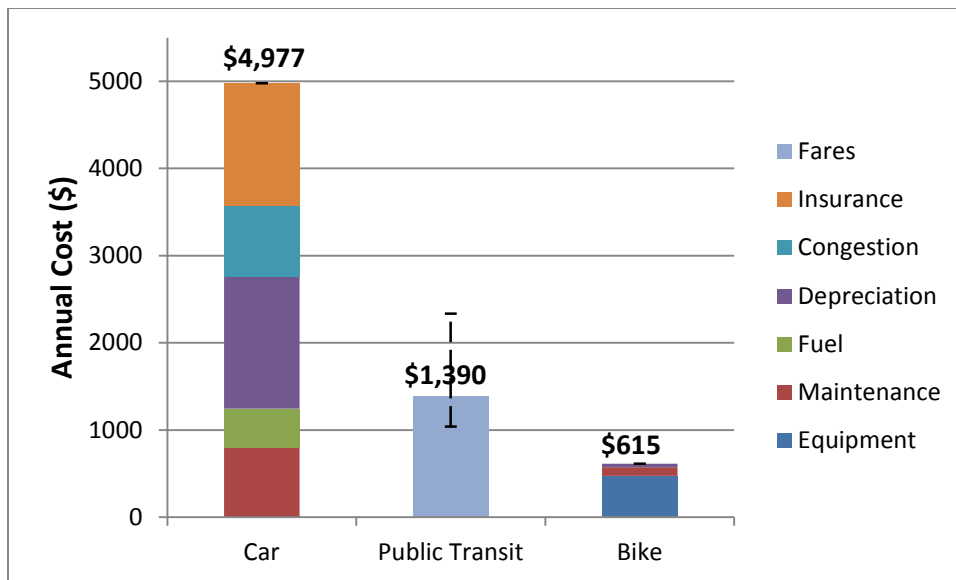


Figure 11: Estimate of the annual average cost of bike commuting is derived from (Roth 2011); the estimate of the annual average cost of car commuting is based on data from (Commute Solutions 2014), and an assumption of a 12-mile round trip commute. The estimate for the annual cost of commuting using public transportation is based on the median total public transit fare that would be required to service a 12-mile round trip commute in four of SimpleCycle’s target markets (New York, Washington D.C., San Francisco, and Portland). The error bars on the public transportation estimate indicate the variability in annual transit membership costs due to the fact that different levels of transit membership could feasibly service a hypothetical 12-mile commute.

As this figure demonstrates, individuals who shift from car to bike commuting could see cost savings on the order of \$4,000 per year. Even individuals who use public transportation could save between \$300 and \$750. We should also note that the price of bike commuting shown in **Figure 11** includes the purchase of a new bike for \$475. Thus, the average annual cost of bike commuting over any substantial time period will be even lower. Even a partial commitment to bike commuting will allow customers to save money. For commercial ride share and taxi commuters, every trip they replace with a bike commute saves them from paying a fixed service fee. For

car commuting, vanpools, and public transportation, the average cost of commuting increases the more trips an individual makes using each mode. For example, the maintenance costs of car commuting will increase the more one car commutes, or it might be necessary to get a more expensive public transportation membership if one uses the service frequently. To the extent that a partial shift to bike commuting lowers these average costs, such a shift represents individual cost savings. SimpleCycle lowers existing barriers to bike commuting relating to time and inconvenience, thus making a significantly cheaper commute option more accessible. Therefore, our service addresses all three of the most significant general commute concerns. Under the assumption that these concerns are common to all manner of intra-urban travel, the preceding evidence demonstrates that SimpleCycle will create value for both existing bike share users, as well as individuals with access to electric power for their personal bikes at the peripheral SimpleCycle stations.

In order to be able to extract a surcharge for each electric ride and not pass the cost onto the existing bike share operator or implementation agency, individual users must be willing to pay more than the current rate for bike share services. Our business model assumes we are able to extract a \$1 surcharge per electric ride. In order to validate this assumption, consider the average daily spending on transportation of a single adult earning the living wage in New York City, one of our target markets. Then compare this value to the daily price of an annual bike share membership. According to an MIT study, a single adult earning \$12.75 per hour in New York City is willing to spend \$8.73 per day on transportation (Glasmeier 2014). The current price of an annual Citi Bike membership is equivalent to only \$0.26 per day (NYC Bike Share 2014). Based on these estimates an individual earning the living wage would be willing to pay \$8.47 more per day on transportation than the daily cost of an annual bike share membership. This is more than eight times the value we are proposing to charge per electrified trip. Because SimpleCycle solves the previously described customer problems, this fact supports our claim that individuals' willingness to pay for electrified trips is more than \$1. Additionally, a study of Capital Bikeshare members shows that the main reason people use the bike share is as a method of commuting (LDA Consulting 2013). Capital Bikeshare members are similar to the customer segments we have identified for SimpleCycle. So consider a SimpleCycle customer who uses electric power on their commute twice per day. Assuming a membership cost is still on the order of \$0.26 per day, even if the individual paid an additional \$1 for each electrified trip, their total daily transportation spending would still be less than \$8.73 per day. Based on this result, a \$1 surcharge for electrified trips will not cause the price of bike share memberships to exceed individuals' willingness to pay. Additionally because SimpleCycle's \$1 per

ride surcharge is part of a service contract, the implementation agency retains the authority to raise prices in any way they choose.

iii. Key Partners, Activities, and Resources

a. Key Partners

Our business model will require participation and strong partnerships among several entities including electrification unit manufacturers, bike share operators and key employers. Each of these entities will receive benefits from partnering with SimpleCycle. These partnerships, why they are required in order to successfully operate the proposed business model, and why they are mutually beneficial are outlined below.

(i) Electrification Unit Manufacturer: First, the electrification units (EU) will be purchased from a third party supplier that specializes in manufacturing such units for bike share bikes. There are several emerging technologies that fit this description, the majority of which are currently seeking ways to promote their new products. These companies are eager to get their product in the hands of the general public as we found when we were considering the use of a universal bike rack. SimpleCycle would have a mutually beneficial relationship with its EU provider by establishing an early sales channel for a new product. Economies of scale allow us to secure a discount on individual EU price with bulk orders. We expect our order volumes to be large enough that we will collaborate with the suppliers to enhance existing EU design in order to expand their compatibility to more types of bikes. We plan to offer an enhanced and specific version of their EU for our system to maximize the value of our service to customers.

(ii) Bike Share Operator: Second, it is crucial for SimpleCycle to partner with bike share operators. Our business model requires locating the majority of the EUs at existing bike share stations. To do so, we will work with the parent bike share company to plan and execute the installation of our service/EUs at current bike share stations. Additionally, the payment system, and IT infrastructure of the existing bike share must be integrated with our new system. Painless integration with existing bike share systems requires successful cooperation with the bike share operator, and thus necessitates a deep understanding of how each existing bike share functions. Our system must work seamlessly with existing infrastructure and operations. Together SimpleCycle and existing bike shares can dramatically increase the customer experience, and expand the customer base for both partners.

(iii) Employers: SimpleCycle's third key partner is local employers. Sponsoring promotions with employers located in key areas in our extended service area will ensure that SimpleCycle is able to site its new peripheral stations in the most optimal locations. Alternatively, employers will have the option to request locations for such stations and can obtain advertising space at these stations. Partnering with employers will also help create demand by marketing our service to their employees. As previously described employers must address the commuting needs of their employees in order to increase retention rates including the provision of parking spaces and alternative transportation options. Interested employers could help fund peripheral stations in order to have a station constructed near their office location. In doing so, employers can receive discounted fees for their employees using SimpleCycle and can advertise their business at the station itself. By locating stations near employers, SimpleCycle should have access to a greater number of commuters that are willing and able to use the service. In turn, the number of employees needing a parking space would decrease and employee retention would increase as a result of having greater access to alternative commute options

b. Key Activities

SimpleCycle's business model relies on two main components or activities. First, there needs to be a physical network of existing bike share and peripheral stations containing EUs. Thus our business will engage in the installation of EUs at existing and peripheral stations in optimal locations throughout our target cities. The physical installation of the stations and EUs will precede the launch of the system to the users. The design of these physical stations consisting of a structure, which holds and dispenses EUs, will be done in a way that requires the least amount of land area per station. The location of peripheral stations, or those that are not part of existing bike share stations, will be selected based on the location that provides access to the greatest amount of people and with employer locations in mind.

The second component is our digital network management software and mobile application. This network management software will keep track of where each EU is at all times, providing us with insight on system performance, the location of EU demand hot spots, and where station maintenance is required. The software will also monitor the supply and demand of EUs at each station, and determine how to best allocate EUs within the system. The optimal allocation determined by this software will feed directly into the mobile application which will provide users with incentives, such as discounts or 'points' in a digital game built around SimpleCycle usage, to redistribute the EUs to their optimal locations. In this way we will minimize the costs associated with manually redistributing EUs within our system. The mobile application will also be integrated with the existing bike share payment system, allowing individuals to pay for subscriptions or one-off electrified trips using their

smartphones. Finally, the mobile application will provide users with information such as station location, supply of EUs at each station, and route suggestions to the nearest bike share or SimpleCycle station.

c. Key Resources

In addition to the physical capital required to build and operate our business, SimpleCycle's key resources include those required to ensure that we have access to key locations, and those that contribute to creating demand for our service. In this respect, partnerships and good relations with businesses is a very important resource. Partnerships with businesses enable the construction of EU stations in optimal locations. The promotion of our service to the employees of large firms is also a key marketing resource. Transportation Management Organizations (TMOs) and large commercial real estate firms may also be able to provide access to key locations for station construction, and may contribute to creating demand for our service. Our business can also gain sponsorship by NGOs that are involved in sustainable transportation campaigns. This sponsorship will be crucial in the marketing of our service to individuals who are highly likely to use a service like this.

Finally, SimpleCycle will require substantial information technology (IT) resources. The network of EUs will be organized by a back end system of proprietary network management software and hardware. The front-end side of the information technology will consist of the mobile application and station interfaces. In order to ensure a painless and convenient customer experience, it is key that our business procures and develops sufficient IT resources, including skilled software and mobile application developers, as well as data storage and computing capacity.

iv. Revenue Streams and Cost Structure

SimpleCycle has two distinct revenue streams, both negotiated as contracts with third-parties. First, and most importantly, there is the service contract negotiated with the implementing agency and bike share operator. The terms of this contract are flexible, but must specify that SimpleCycle will earn \$1 of revenue from each bike trip electrified by our service. Second, the exterior of the electrification units and stations will be sold as advertising space to willing third parties. The price and pay-period of the contract for these advertising rights will be negotiated case-by-case with interested parties.

Costs are divided into system construction costs, maintenance costs, labor costs, and other fixed costs. To deliver the value proposition to our customers, SimpleCycle will construct and install stations outside the range of the existing bike share system. In addition to building peripheral stations, electrification units must be purchased to

stock both the peripheral stations and existing bike share stations. SimpleCycle will also pay for the electricity to keep the electrification units charged and able to deliver electrified trips without running out of power. Once the system is up and running, SimpleCycle will have to hire employees to perform routine inspection and maintenance, including fixing or replacing missing or broken electrification units. Behind the scenes, there is also the cost associated with managing our service. Office space, computing resources, and a core administrative and management team are needed to keep the system running. Specific estimates of all of these costs are discussed in the *Financial Projections for Launch in New York City* section of this report.

v. Market Size

Given that SimpleCycle's revenues are generated from each bike trip electrified by our service, our estimates of market size are reported in the units of total annual trips. Under the assumption that we earn \$1 from each of these trips, these market size estimates are equivalent to their annual dollar value. To begin with, there are approximately 128.3 million commuters in America (Santos *et al.* 2011). Even assuming every city and town in the U.S. had a bike share, SimpleCycle can only conceivably be useful to individuals living within the serviceable area of the peripheral stations containing electrifying units. For simplicity we assume that the serviceable area is 15 miles from any urban or town center. 68 percent of Americans, 87.2 million individuals, commute less than 15 miles (StatisticBrain.com 2014). According to the National Household Transportation Survey, Americans make approximately 3.79 trips per day (Santos *et al.* 2011). Thus, U.S. commuters living within 15 miles of the workplace make 328.9 million trips per day, which equates to more than 120 billion trips per year. We can consider this value a theoretical maximum of our total available market size.

However, because SimpleCycle depends on the existence of an operating bike share system, our serviceable market is significantly smaller. Yet, the number of bike sharing systems in the U.S. is currently growing rapidly. For example, the number of bike share stations in the United States doubled in 2013, including the launch of two major systems in Chicago and New York (Malouff 2014). This makes estimating our total serviceable market difficult. On the other hand, it implies that the subsequent approximation will, if anything, be an underestimate. To try and pin down this moving target, we rely upon the fact that, while bike sharing is growing rapidly, it remains highly concentrated in large urban areas with dense populations. For example, of 1,925 bike share stations nationwide, more than half are in New York, Chicago, and Washington D.C. and more than 1,500 stations are located in just 8 cities (Malouff 2014). There are approximately 19.8 million commuters living within the greater metropolitan areas surrounding these cities. Again assuming that 68

percent live within 15 miles of the workplace, and that each individual makes 3.79 trips per day we estimate that there are 18.5 billion annual trips in our serviceable market.

To estimate our target market, we focus more closely on the different types of individuals that are likely to use our service. These can be grouped into three primary categories. First there are individuals who currently car commute but would use SimpleCycle as a means to start bike commuting. In an attempt to even more realistically represent SimpleCycle's theoretical serviceable area, we constrained our estimate of the size of this first customer segment to the total number of car commuters that live inside the borders of each of the 8 major bike share cities, rather than in the greater metropolitan area. Based on American Community Survey (ACS) data from 2012 there are approximately 2.4 million such commuters (ACS 2012). Next, our market research survey indicates that 19.5 percent of these individuals want to start bike commuting and that, of this derivative group, 65 percent already own a bike. To avoid the overreaching assumption that these individuals would replace *all* of their daily trips with bike trips, we instead claim that these customers use SimpleCycle only for commute trips 2 days per week (approximately 0.6 commute trips per day). Based on this assumption, we estimate that would-be bike commuters constitute a target market of 67.7 million annual electrified trips.

The second type of SimpleCycle customers are current bike commuters that would like to bike commute more often. Based on ACS data, there are 121,157 bike commuters living in the 8 major bike share cities (ACS 2012). We assume that all of these individuals would derive utility from having access to electric power for at least some of their daily bike trips. However, without any data to constrain the number of daily trips bike commuters would make using electric power, we simply estimate that it is approximately 10 percent of the total number of trips made by this customer segment. Under these assumptions, and again assuming each individual makes 3.79 trips per day, we estimate that current bike commuters constitute a target market of 16.7 million annual electrified trips.

Existing bike share users could also be SimpleCycle customers. Fortunately bike share operators usually collect data on the daily usage of their system. Using these publicly available data, as well as data from a 2012 report on bike sharing in the U.S. we estimate that 42,732 trips are made using bike share bikes in the 8 major bike share cities each day (NYC Bike Share 2014; Capital Bikeshare 2014; Divvy Bikes 2014; Bay Area Bikeshare 2014; Toole Design Group 2012). However, given that current trips made using bike shares are relatively short (0.5 to 3 miles) it seems unlikely that very many of the individuals making these trips would desire to pay for

electric power (Toole Design Group 2012). To account for this fact, we assume that only 5 percent of future trips made by existing bike share users would be made using an electrifying unit. Extrapolating over an entire year time, we calculate that existing bike share users constitute a target market of approximately 780,000 annual trips. It should also be noted that it is very likely that current car commuters and current bike commuters constitute a large proportion of current bike share usage, and so these trips may be double counted. However, given the relative insignificance of the target market for this customer segment relative to the previous two, we ignore this inconvenient fact for now. Finally, summing across the three different customer segments, we find a total target market of 85.1 million annual electrified trips. While it is evidently riddled with uncertainty, we believe this estimate of our target market size provides a useful ballpark estimate for assessing the near-term market potential of our proposed business model.

vi. Target Cities

There is considerably less uncertainty in our assessment of the most viable cities in which to launch our service. Cities where SimpleCycle will be most successful are those where there is extensive bike infrastructure, a strong bike culture, and a high level of awareness of bikers as users of the urban transportation system. In terms of the environmental benefits produced from our service, SimpleCycle will be the most effective when deployed in cities that are more congested, have more polluted air, and where public health could be most improved by increasing active transportation. In consideration of these criteria, we collected information on all U.S. cities with bike shares that have a resident population greater than 300,000, had more than 1,000 bike commuters in 2012, and experienced positive growth in bike commuting over the period from 2000 to 2012. For each of these cities, we assessed 15 quantitative metrics, a selection of which are shown in **Table 8** (the full list is articulated in the table description). To come up with a final suitability index for each city, we calculated the value of each quantitative metric as a proportion of the maximum for each category (or the complement of the maximum, in the case of risk of death for bikers, and physical activity). Finally, we summed these proportional rankings across categories. The results are shown in the table below.

Table 8: Ranking and Selected Characteristics for Target Cities

Rank	City	2012 Bike Commuters	Growth in Bike Commuting ('00'-'12')	Risk of Death Biking (fatalities/10000)	Bike Facilities* (mi/mi ²)
1	New York	37491	107%	3.51	2.4
2	Washington D.C.	13372	118%	0.55	3.4
3	Chicago	19503	214%	1.45	1.8
4	San Francisco	17028	90%	0.87	5.6
5	Portland	18784	249%	0.95	2.4
6	Philadelphia	13800	166%	1.31	4.2
7	Minneapolis-St. Paul	15909	140%	1.05	3.1
8	Seattle	15014	256%	1.14	2.8
9	Miami	1787	81%	6.37	1.1
10	Denver	9540	201%	1.54	2.7

Rank	City	Annual Delay Due to Congestion (hrs/commuter)	% Adults Physically Active**	Annual Transportation Expenditures (\$/consumer)	Air Quality Non-Attainment
1	New York	59	47.1%	8495	PM ₁₀ 3
2	Washington D.C.	67	49.5%	9563	O3
3	Chicago	51	50.3%	8840	PM ₁₀ 3
4	San Francisco	61	54.0%	9535	PM ₁₀ 3
5	Portland	44	53.2%	n/a	O3
6	Philadelphia	48	47.4%	8202	PM ₁₀ 3
7	Minneapolis-St. Paul	34	54.5%	8833	-
8	Seattle	48	52.0%	9380	O3
9	Miami	47	42.6%	8427	O3
10	Denver	45	55.8%	n/a	O3

Data from: LAB 2013a; Eisele *et al.* 2011; U.S. EPA GIS Downloads 2013

*Bike facilities refers to on street bike lanes, signed bike routes, and multi-use pedestrian and bike pathways

**Physically active refers to adults who get 30+ minutes of moderate physical activity five or more days per week, or those who get 20+ minutes of vigorous physical activity three or more days per week. A complete list of ranking criteria: (i) total number of commuters in city metropolitan area, (ii) 2012 bike mode share for commuting, (iii) number of bike commuters in 2012, (iv) growth in bike commuting from 2000-2012, (v) risk of bike death, (vi) density of bike facilities (vii) annual hours of delay due to congestion per commuter, (viii) percent of total lane miles in urban road system congested during peak hours (ix) excess CO₂ produced due to congestion, (x) annual total cost of congestion (xi) percent of adult population that is overweight, (xii) percent of adult population that is physically active, (xiii) annual per capita public spending on bike/ped programs, (xiv) annual total consumer expenditures on transportation, (xv) air quality non-attainment (ozone, particulate matter, or both).

The results shown in **Table 8** are consistent with qualitative information we have acquired through interviews and informal discussions. The most highly ranked cities also correspond to the locations of the largest and most viable markets for existing bike shares. Based on these qualitative correlations, we are confident in our use of this assessment tool to identify our target cities. The most highly ranked city is New York, and so we chose it as our initial launch site. New York’s high ranking is mainly due to its overall size, but is also a result of the fact that, for such a large city, New York has seen sustained growth in bike commuting, has excellent bike facilities, and is beset with both congestion and air quality issues. Consequently, we use city-level

data from New York in the in the following projections of SimpleCycle’s post-launch financial performance. It should be noted that while New York City is used to provide a specific context for our financial projections, we believe that any of the top five cities identified in our target cities analysis would provide a similar level of financial viability.

vii. Financial Projections for Launch in New York City

We constructed a discrete-time model to evaluate SimpleCycle’s cumulative profitability over the five-year period following launch in New York City. The choice of such a limited time horizon was done with the understanding that financial projections for start-ups are highly uncertain, and so longer-term projections are likely to be unrealistic. The general structure of the model is very simple. First we calculate total annual revenues and costs based on estimates of the line items described in the *Revenue Streams and Cost Structures* section of this report. We then calculate profit earned in each year as the difference between revenues and costs discounted at a rate of 15 percent. Cumulative profit is the running total of these discounted annual profits. In the following description of our model, we focus on the processes and key assumptions through which we generated our estimates of annual and cumulative profits. The parameters used to evaluate this model (such as the cost of stations, EUs, employee salaries, etc.) can be found in **Appendix 2**.

Beginning with revenue streams, our first task was to estimate the total potential demand for our service. In order to calculate the number of potential SimpleCycle customers in New York at the time of launch (assumed to be 2014), we used the same methodology described in the calculation of our total target market in the *Market Size* section of this report⁴. As noted in that section, these customers are either (i) current car commuters who convert to bike commuting and use SimpleCycle peripheral stations, a.k.a. ‘would-be bike commuters’, (ii) current bike commuters, or (iii) existing bike share users. The estimated number of (i) and (ii) as well as the average number of daily trips made on New York’s Citi Bike bike share system are listed in **Table 9**.

⁴ We used ACS data to estimate the number of car and bike commuters, and Citi Bike system data to assess the daily number of bike share trips.

Table 9: SimpleCycle Customer Segments

Segment	Total Potential Customers in 2014
Would-be bike commuters	108,500
Current bike commuters	32,700
Average daily Citi Bike trips	26,000

In projecting this total potential demand into the future, we assume that the total number of would-be bike commuters in New York remains fixed but that both the number of bike commuters and the number of trips made using bike shares to grow over the next five years. In order to evolve these values over time we assumed that bike commuting continues to grow at the average annual rate observed over the period from 2000 to 2012 (9 percent per year)⁵, and that bike share usage increases at 5 percent per year. To convert the potential demand from would-be bike commuters and current bike commuters into an annual number of trips, we made the conservative assumption that these customer segments would only pay for access to EUs for 4 one way commute trips per week, which equates to approximately 0.6 times per day.

Next, in order to quantify how much of this total potential demand is captured as revenue, we assume that 5 percent of the would-be bike commuters and 10 percent of current bike commuters begin using SimpleCycle in its first year of operation (year 1). We also assume an adoption rate of 5 percent within the existing bike share system (i.e. 5 percent of total annual trips made on the system are made using an EU). The predicted demand in terms of the number of would-be bike commuters, the number of current bike commuters, and the total number of daily electrified trips are shown in **Table 10**. The annual revenue that accrues to SimpleCycle from a \$1 surcharge on every electrified trip is shown in the last column. These values represent the service contract component of our business' revenue streams.

⁵ LAB 2013a

Table 10: Daily Demand and Expected Annual Revenues from Service Contract

Year	Would-Be Bikers	Electrified Trips per Day	Current Bikers	Electrified Trips per Day	Existing Bike Share Trips per Day	Electrified Trips per Day	Total Daily Electrified Trips	Service Contract Revenue*
0	0	0	0	0	0	0	0	\$0
1	5424	3255	3270	1962	27607	1380	6597	\$2,407,740
2	16273	9764	9231	5539	28987	1449	16752	\$6,114,324
3	27121	16273	15723	9434	30436	1522	27228	\$9,938,366
4	37969	22782	22793	13676	31958	1598	38056	\$13,890,270
5	48818	29291	30493	18296	33556	1678	49264	\$17,981,365

*Note the annual service contract revenue is calculated by multiplying the total daily electrified trips by 365.

Our other predicted revenue stream is from advertising. As mentioned in the overview of the financial structure of bike shares, the system operator of New York’s Citi Bike system will receive approximately \$48 million over the next five-years from Citibank and MasterCard in return for advertising rights (ITDP 2013). The SimpleCycle stations, and portable EUs will be far less visible than either bike share bicycles or stations. That said, SimpleCycle infrastructure will be located at existing bike share stations, which are heavily trafficked, and will be attached to bike share bikes, which are highly visible. Consequently, using Citi Bike as a case study, we estimate that advertising space on SimpleCycle infrastructure will be worth approximately \$2 million dollars per year for five-years. Both the service contract and advertising revenue streams are discounted at 15 percent in order to ascertain the net present value of future benefits.

Having estimated revenues, we now turn to costs. The main costs associated with our business model are those required to purchase and install the essential infrastructure (i.e. the EUs and peripheral stations). First, we modeled the amount of new infrastructure that would need to be constructed and purchased in each year based on the predicted demand for electrified trips from would-be and current bike commuters the following year. In this way, our infrastructure costs in a given year represent the expenditures required to build enough stations to meet the increased demand from new customers the following year. To quantify how much new infrastructure would need to be purchased and constructed, we assumed that each station will contain 20 EUs, and that each EU will service the daily trip demand of 7 customers. These assumptions are based on the average number of bikes at existing Citi Bike stations (18), and the average number of trips taken by each Citi Bike bicycle in a day (4.3) (NYC Bike Share 2014). Note that 7 customers demanding 0.6 electrified trips per day is equal to a demand of 4.2 trips per day.

Secondly, a large portion our total infrastructural expenditures are required upfront in order to equip the existing bike share stations with electrifying units. There are currently 330 stations in the Citi Bike network, and we assume each of these will be outfitted with 20 EUs in the year preceding the first year of operation (year 0 in

subsequent tables and figures). Importantly, the decision to equip all existing bike share stations with a full set of 20 EUs was made in order to ensure that would-be bike commuters and current bike commuters that make use of the new peripheral SimpleCycle stations would be able to leverage the convenience of the full existing bike share network.

Another important component of our projected annual costs are those required to maintain our system. In particular, as detailed in the *Cost Structures* section of this report, SimpleCycle will pay to (i) charge EUs when they are being stored at a SimpleCycle or existing bike share station, (ii) purchase new EUs to replace those that are damaged or lost, and (iii) hire employees to monitor system losses, replace EUs and conduct other forms of routine maintenance. Charging costs are estimated by assuming a flat electricity rate of \$0.23/kWh and that each EU is fully charged 1.5 times per day⁶ (BLS 2014). Replacement costs are calculated as the cost of replacing 5 percent of the total number of EUs in the system each year. Finally, the number of service employees is calculated by assuming that each SimpleCycle station will require weekly monitoring or service, and that a single employee can service eight stations per day (56 per week)⁷. Based on these assumptions, the projected cost of constructing new stations, purchasing EUs and electricity, and hiring staff are shown in **Table 11**. As with our revenue streams, these cost estimates are discounted annually at 15 percent.

⁶ Again, see Appendix 1 for a technical description of the proposed EU.

⁷ It is further assumed that SimpleCycle employs a core administrative and managerial staff of ten individuals.

Table 11: Estimated Infrastructure and Maintenance Costs

Electrifying Units	Year	EU's for New Stations	EU's to Replace System Losses	Total EU's*	Cost of EU Purchases	Cost of EU Charging
	0	702	365	7302	\$5,111,580	\$0
	1	1355	433	8657	\$824,798	\$379,189
	2	2103	538	10760	\$1,112,993	\$409,817
	3	2805	678	13565	\$1,291,058	\$449,264
	4	3607	859	17172	\$1,443,510	\$494,535
5	4368	1077	21540	\$1,520,082	\$539,411	
Stations	Year	New Stations	Cumulative Stations	Annual Construction Cost		
	0	35	35	\$175,564		
	1	68	103	\$294,571		
	2	105	173	\$397,497		
	3	140	245	\$461,092		
	4	180	321	\$515,539		
5	218	399	\$542,886			
Employees	Year	Number of Employees	Labor Costs			Total Annual Infrastructure and Maintenance Costs
	0	10	\$600,000			\$5,887,144
	1	18	\$925,029			\$2,423,586
	2	19	\$861,104			\$2,781,411
	3	20	\$799,862			\$3,001,276
	4	22	\$741,598			\$3,195,182
5	23	\$686,490			\$3,288,869	

*The total cumulative number of EU's in service also includes the 6,600 installed at the existing Citi Bike stations.

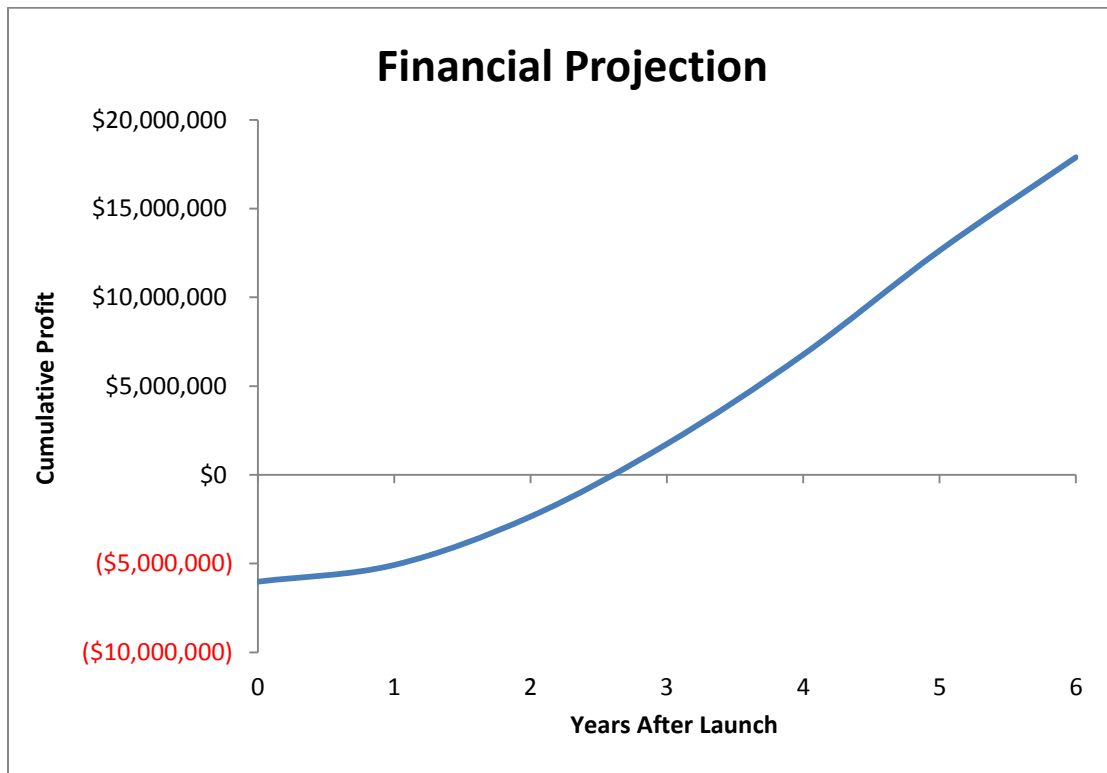
While the costs listed in **Table 11** constitute the majority of SimpleCycle's total start-up and operating costs, there are some less significant costs that were also incorporated into our model. The remaining components, which will not be presented here but are included in **Appendix 2** include the cost of developing our network management software and mobile application, as well as the cost of office space and IT infrastructure. Taking all of the aforementioned costs and revenues into account, the cumulative profitability of SimpleCycle over the five-year period following our launch in New York City is displayed in **Table 12**.

Table 12: SimpleCycle's Cumulative Profitability

Year	Costs	Revenues	Annual Profit	Cumulative Profit
0	\$6.02	\$0	-\$6.02	-\$6.02
1	\$2.80	\$3.74	\$0.94	-\$5.08
2	\$3.16	\$5.89	\$2.73	-\$2.36
3	\$3.40	\$7.49	\$4.09	\$1.74
4	\$3.61	\$8.65	\$5.03	\$6.77
5	\$3.73	\$9.59	\$5.86	\$12.63

*Note values in the table are in millions of dollars.

Figure 12: Five-Year Financial Projection



As **Figure 12** demonstrates, the proposed business model becomes profitable after approximately 2.5 years of operation, and earns more than \$12 million five years after beginning operations. Another important factor highlighted by **Figure 12** is that we will need around \$6 million dollars in capital funding to initiate operations in New York.

In summary, several insights concerning the advantages and uncertainties of our business model are brought to light by these financial projections. First, the results not only highlight that infrastructure demand is the most significant contributor to overall costs, but also that these costs are driven by the need to supply and maintain a large number of electrifying units. While this is an inherent property of our proposed business model, it is worth noting that technologies that could serve as electrifying units are currently evolving rapidly. Additionally, many bike shares now incorporate solar power into the design of payment terminals and it is feasible that solar may be an option for charging EUs in our system (Toole Design Group 2012). Consequently it is reasonable to expect that the costs associated with supplying the system with electrification units could be significantly reduced. Though none of

these alternatives were considered in this model, the overall trends support the durability of our business model concept.

Second, this financial analysis of our business model demonstrates the types of advantages SimpleCycle has over a traditional bike share system. For example, traditional bike shares often allocate significant resources (up to 30 percent of operating costs) to redistributing bikes throughout the system (ITDP 2013). Much of the time, redistribution is necessary because bike share bikes accumulate at the bottom of hills. This concern obviously does not translate to the redistribution of EUs, which convey the ability to bike up hills effortlessly. We can also disregard the costs of redistribution because our mobile application and network management software is explicitly designed to incentivize optimal distribution of EUs using real-time demand pricing and gameification. Finally, our business model is leaner than that of a traditional bike share in terms of initial capital costs. Our hardware is cheaper, and our system requires less customized software and IT infrastructure. For example, because existing bike share systems already have a payment and checkout software already installed, SimpleCycle could provide users with a seamless payment experience by integrating our offerings into the existing user interface.

In creating these financial projections, we also learned the parameters to which our model is most sensitive, and thus how uncertainty affects our predicted profitability. For example, because the number of times an EU is used per day determines the total number required by the system, the contribution of EUs to costs is highly sensitive to this parameter. Therefore, the better we can constrain the expected value of this variable, the better we can realistically predict our costs of capital. Secondly, while not a major driver of costs, cloud computing costs are currently a rough estimate. Depending on how transactions are actually managed within our network, computing capacity could vary significantly. Thus, further information concerning the data loads required to operate our service will also improve our financial projections. A final limiting constraint of our model is our lack of certainty regarding the number of electrified trips demanded by existing bike share users. In constructing our model, we experimented with several different adoption rates, ranging from 3 percent to 10 percent. For the final model run the 5 percent adoption rate was chosen to produce a conservative forecast. Yet without further customer discovery it remains unknown whether this assumption is an over or underestimate. Fortunately our model is not particularly sensitive to changes in this parameter, and so, all caveats aside, we are relatively confident in the presented analysis.

Environmental Benefits

Introduction

By promoting bicycle transportation and establishing a simple and reliable way for customers to consistently choose a bicycle as their mode of transportation, SimpleCycle will remove vehicles from roads. The reduction of vehicles on the road leads to less traffic and lower GHG emissions. The environmental benefit that SimpleCycle will provide can be measured by assuming that every bicycle trip using SimpleCycle is a reduction by one trip of an equivalent trip length in a private motor vehicle. In this section we explain the specific environmental benefits we have decided to calculate, the methods for calculating the environmental benefits, how SimpleCycle provides the environmental benefits, and the metrics that are used to evaluate the benefits.

How SimpleCycle Produces Benefits

By facilitating access to electric bicycles, SimpleCycle will allow customers to choose bike commuting in lieu of driving alone. The proceeding analysis shows that a reduction in the number of single passenger car commuters and an increase in the number of bike users results in significant benefits to the environment.

i. Caveats

The environmental impacts of motor vehicle transportation are diverse and complex, which often makes the benefits of sustainable transportation initiatives difficult to quantify. Below we will explain some of the variability that is not captured in our analysis, and explain the steps we have taken to reach quantifiable metrics to quantify each benefit.

Fossil fuel combusted in the engine of motor vehicles produces emissions that have direct and indirect adverse effects on human health and the functioning of biological and ecological systems. However, the quantity of emissions produced by motor vehicles is nonlinearly related to the amount of traffic congestion, and the weight of the individuals being transported. Thus estimates relating distance traveled in motor vehicles to pollution emissions are made with these complexities in mind. For our analysis we simplify and assume a linear relationship between vehicle miles traveled and emissions per mile.

Some pollutants remain local, whereas others are transported regionally, or even globally. Furthermore, both the direct and indirect effects of mobile source emissions are a function of a myriad of factors of the environment in which they

were emitted. Local and regional geomorphology, climate, weather, atmospheric chemistry, land-use and habitat configurations, determine how emissions translate into measurable negative environmental effects. The step of meticulously translating quantities of pollutants emitted into local pollution concentrations is not within the scope of this analysis as it would require complex modeling outside the scope of this project. Instead, when possible, total volume emitted and ambient concentrations are related with coarse conversions to generalize the relationship between emissions and local concentrations and to contextualize the magnitude of the emissions SimpleCycle reduces.

Demographic and social factors influence how much the use of and emissions from motor vehicle transportation contribute to issues of public health. Proximity to emissions, duration of contact, type of emissions exposure, and local and regional emissions around homes, all translate into the negative health effects associated with transportation emissions. Even within one city the concentrations of pollutants, particulate matter and ozone for example, can vary by orders of magnitude from block to block based on proximity to features such as congested roadways and large buildings burning heating oil in the winter months (NYC-DOH 2012).

The environmental impacts of motor vehicle transportation depend on how one chooses to define 'the environment'. In addition to considering the effects on non-human systems, we have also chosen to consider 'the human environment', including the health of individuals and the economic welfare of society. We examine the direct impacts of emissions and account for the proximal indirect effects, such as climate change and public health impacts.

ii. Methods

To contextualize our benefit calculations, we outlined the framework and constraints within which we calculate the environmental benefits of SimpleCycle. The simplification of the complexities mentioned in the *Caveats* section in combination with the proceeding constraints forms the environment within which the benefit calculations were made.

In this analysis of predicted environmental benefits stemming from SimpleCycle, we have decided to focus on the benefits SimpleCycle produces by reducing volatile organic compounds, NO_x, PM_{2.5}, O₃, CO₂, and gasoline consumption. The benefits from reducing these pollutants were chosen because they are metrics of the most relevant environmental problems, they are well represented in transportation literature, and because SimpleCycle's predicted contribution to addressing them is more easily and accurately quantifiable. In addition CO₂e, an equivalence factor that scales the pollution impact of GHGs to CO₂ based on warming potential and

concentration, is used to compare pollutant loads to reduction goals in our target market.

We gathered national averages of per mile emissions from private motor vehicles. These national averages are taken and multiplied by the vehicle miles reduced to calculate the volume of pollutants prevented from being released into the atmosphere. The following linear estimates of emission rates from private motor vehicles are used in the calculation of benefits resulting from SimpleCycle.

Table 33: Emission Rates Used for Environmental Benefit Calculations

Pollutant	Source of Estimate	Emission Rate	Yearly per Customer Reduction
VOC	OTAQ 2008	1.034 grams/mile	1,132 grams
NO _x	OTAQ 2008	0.693 grams/mile	759 grams
PM _{2.5}	OTAQ 2008	0.0044 grams/mile	5 grams
Ozone	McCubbin and Delucchi 1999	0.88 grams/mile	964 grams
CO ₂	OTAQ 2011	425 grams/mile	465,375 grams
Fuel	EIA 2009	0.05 gallons/mile	55 gallons
CO ₂ equivalent	EPA 2014a	0.42 kg/mile	460 kg

To calculate the total vehicle miles reduced, we determine the quantity and distance of motor vehicle trips replaced by trips on bicycles. Each time a person uses SimpleCycle, they replace 5 miles of driving with a bike ride. An average daily SimpleCycle usage of 0.6 times per day is used in the calculation. These values are based on our customer discovery process and are assumptions of expected usage frequency and distance traveled. We assume a standard distribution of daily rides per customer and distance per trip. Using these estimates we determine how many miles per year are traveled via bicycle with SimpleCycle.

Customers who convert from existing bike share use to electric bike share use are not included in calculating benefits. The environmental benefits are derived from customers who used to drive private motor vehicles and now bike commute instead. The value for total number of customers is derived from the projections of our peripheral customer base in the financial model. Total peripheral customer base at full market penetration was chosen to highlight the potential for benefits from SimpleCycle if fully adopted. For all of the calculations we assume that there are 174,000 customers avoiding 190,000,000 vehicle miles traveled annually.

Using the estimated avoided total vehicle miles travelled annually, we calculate the emissions those miles would have released using our estimate for single passenger car per mile emission values. The volume of emissions calculated from this equation is assumed to be the volume of emission that is prevented from being released because of SimpleCycle. The EPA's Pollution Prevention Program's Greenhouse Gas Calculator (EPA 2014a) was used to quantify the environmental benefits of reduced vehicle miles traveled due to SimpleCycle. The vehicle miles traveled calculator quantifies the emission rate of CO₂, CH₄, and N₂O per mile in terms of mt CO₂e.

To calculate health benefits we relate the reductions in ozone and particulate matter to public health statistics on the correlation between PM_{2.5} and O₃ to annual deaths and annual hospital admissions. Additionally, the effect of increased physical activity due to increased exercise was calculated by looking at a published negative correlation between bike commuting and rates of obesity.

It is important to clarify at the outset that this analysis will focus on the impacts of motor vehicle transportation and the potential benefits of SimpleCycle in New York City. New York City is the target city for the initial launch of SimpleCycle and quantifying environmental benefits are dependent on regional and local concentrations of pollutants. Instead of a national estimate, we have chosen to make our benefit calculation in the context of the emissions reduction goals of our target city. Additionally, our business model is designed to work for customers, within the context of the U.S. transportation ecosystem. Further consideration of how SimpleCycle could affect the environmental issues associated with transportation in other countries will not be considered.

To place in context the volume of pollutants that SimpleCycle prevents from entering the atmosphere, the current air pollution concentrations and reduction goals in our target market must be understood. New York City has pollution reduction goals and a timeframe laid out in New York City's sustainability plan (NYC 2011). Within this plan are several emissions-reducing initiatives that New York City is using to meet goals for cleaner air and a healthier population. SimpleCycle's environmental benefits in New York City can be shown to help New York City appreciably in meeting its sustainability goals in the coming years. For the health benefits derived from SimpleCycle, the current rate of occurrence of health problems are presented alongside calculated reductions to show the magnitude of the reduction from the baseline that are the result of our business model. Additionally health benefits derived from increased physical activity are shown to add sustainably to the total benefits of SimpleCycle to the people of New York.

Results

i. Greenhouse Gases

New York City is actively working to reduce GHG emissions. The policy goal in the city's official 2011 sustainability plan is to reduce greenhouse gas emissions to be 80 percent below 2005 levels (NYC 2011). For standardizing and simplifying the reductions goals, success is determined by meeting required reduction in metric tonnes (mt) of CO₂ equivalence (CO₂e). CO₂e values index the global warming potential of all GHGs to the global warming potential of CO₂. With this method, all GHG emissions can be combined into one value for comparison.

Using the estimated reduction in annual vehicle miles traveled as an input to the EPA's Greenhouse Gas Calculator (EPA 2014a), yearly GHG emission reductions were calculated. Taking the calculated value of emissions reductions, we estimated the percent contribution SimpleCycle will provide to annual reductions in CO₂ equivalence. Our contribution is a fraction of the transportation sector's aim to reach the 2050 city wide goal. The direct environmental benefit of SimpleCycle with respect to CO₂e, is our percent contribution to the transportation sector's mobile on-road source reduction goals.

Table 14: Greenhouse Gas Benefit Calculations

Customers Producing Benefits	Annual VMT Reduction	Yearly GHG Reduction (mt CO ₂ e)	Contribution to Annual On Road Mobile Source Reduction Goals
174,000	190,000,000	80,000	1.24%

To meet the city's reduction goals, 13 percent of the total GHG emission reductions should come from mobile on road emission sources. SimpleCycle reduces on road sources of GHG emissions, and can be a tool for New York City to provide approximately 1 percent of the required yearly GHG reductions from the transportation sector.

In addition to direct effects of CO₂, the EPA has released an estimate of \$40 per mt CO₂ as the social cost of carbon in the United States (EPA 2013). Based on our reductions, SimpleCycle will generate a saving of more than 3 million dollars to New York City.

ii. PM_{2.5}

Currently New York City fails to meet federal standards for PM_{2.5} (NYC 2011). New York City has chosen PM_{2.5} as the index pollutant for their pollutant reduction goals and broader goal of becoming the cleanest big city in America (NYC 2011). To meet the goal of becoming the cleanest big city in the United States, average PM_{2.5} levels must be reduced to 22 percent below 2005 levels (NYC 2011). PM_{2.5} is a regional pollutant and the concentration within New York City is only partially attributed to local sources. Time of year, weather conditions, industrial activities, and other variables cause the PM_{2.5} concentration to vary throughout the year. Bounding conditions were chosen to evaluate the impact of SimpleCycle on PM_{2.5} concentrations. Over half of the PM_{2.5} detected within New York City originates outside of the city and this non-local particulate matter has been detected to contain up to 70 percent of PM_{2.5} (NYC 2011). Of the local sources, the transportation sector is responsible for 11 percent of PM_{2.5} emissions and we assumed that reductions are set to be proportional across sectors to meet the citywide PM_{2.5} reduction goals.

Table 15: Benefit to New York City PM 2.5 Reduction Goals

	PM _{2.5} Reduction (ug/m ³)	Contribution to Transportation Sector Reduction Goals
50% PM _{2.5} is local	0.008	2.33%
30% PM _{2.5} is local	0.005	1.40%

Public health benefits can also be calculated from PM_{2.5} reductions. Using estimates from predicted health benefits due to reductions in PM_{2.5} concentrations (NYC-DOH 2010), we can calculate the number of premature deaths our system may prevent. Calculations show that SimpleCycle will produce the benefit of preventing 1 to 2 premature deaths, which can be valued between \$7 and \$14 million.

iii. Ozone

Currently New York City fails to meet federal standards for O₃ concentrations. Taking into account the formation of ozone discussed in the *Environmental Problems* section of the report, by reducing the quantity of mobile source emissions and consequently the concentrations of ground-level ozone, SimpleCycle will create significant human-health benefits.

Assuming ozone is a simple nonlinear function of NO_x and VOC emissions (McCubbin and Delucchi 1999) and given our projected reduction of vehicle miles travelled, we calculate that SimpleCycle will prevent the emission of 168 mt of O₃ each year.

iv. Gasoline and Traffic Congestion

By converting vehicle miles traveled into gallons of gasoline consumed, we are able to calculate the volume of gasoline that is prevented from being consumed and the cost savings that are associated with that reduction.

Table 16: Gasoline Consumption and Cost Reductions

Annual VMT Reduction	Annual Gasoline Reduction (gallons)	Expected Gasoline Price (\$/gal)	Total Dollars Saved on Gasoline
190,000,000	9,530,000	\$4.12	\$39,300,000

According to data used by the Texas Transportation Institute to assess nationwide congestion, for every 1,000 miles of driving avoided by public transportation, approximately 9 gallons of fuel and 0.08 tons of CO₂ were saved in 2005 (Eisele *et al.* 2012). With our calculated annual vehicle miles traveled reduction, 1.7 million gallons of gasoline can be conserved and 15,000 tons of CO₂ would not be emitted due to reductions in traffic congestion. As a note, these CO₂ reductions are separate from the CO₂e calculations in the preceding paragraphs.

v. Health Benefit of Biking

Obesity costs New York City more than \$4 billion annually (“Obesity” 2014; NYC 2012). Bicycling, on the other hand, contributes to better public health. Cycling is considered to be moderate physical activity, and bike commuting helps people build physical activity into routine parts of their day (Ainsworth *et al.* 2000). The incentives to exercise are different for work and urban transportation related exercise than around recreational exercise. Increased utilitarian exercise is part of the reason why states with higher levels of bicycling and walking have higher levels of physical activity (ABW 2012). There is a positive correlation between adults who get 30 minutes of exercise per day and the proportion of the population who bikes to work (ACS 2009; CDC 2009). Similarly, there is an inverse relationship between bicycling rates and BMI, lipid levels, and blood pressure (Hu *et al.* 2004; Wen and Rissel 2008) and states with the highest bicycling rates have the lowest rates of diabetes (ABW 2012; CDC 2009; Pucher *et al.* 2010;). Thus, by encouraging inactive people to bike commute, SimpleCycle stands to have dramatic public health benefits.

There are currently 32,695 bike commuters in New York City (LAB 2013a), which equates to 1% of total New York City commuters. Our estimate is that SimpleCycle can convert approximately 10,000 New York commuters annually from driving to bicycling. After five years SimpleCycle stands to increase the percentage of New York City bike commutes to 2% of all commutes.

The correlation between the percent of the population that is obese and the percent of trips to work made by bicycle or on foot is -0.58 (ACS 2009). Therefore, the increase in the percentage of bike commutes due to SimpleCycle can be anticipated to decrease the percentage of the New York City population that is obese by 0.58 percent.

In 2010 there were 6,585,990 residents over the age of 18 in New York City (ACS 2012). Assuming this includes all obese adults, 27 percent of these adults were obese (CDC 2009). Thus, a reduction in the percentage of the population that is obese of 0.58 percent, is equivalent to reducing the obese population by 10,000 individuals.

To calculate the benefits of SimpleCycle, we can assess the health care costs of obesity. In 2011 per capita national health care expenditures were \$8,187 and federal Medicare expenses were 15 percent higher, on average, for the obese (Gotschi and Mills 2008; CMS 2012). Therefore the annual reduction in health care costs associated with the increased physical fitness promoted by SimpleCycle can be calculated to be \$12.7 million.

Discussion

Pollution is heterogeneous throughout the city and many communities have much higher air pollution levels than the New York City average. Reducing the motorized commute traffic in these areas will have significantly higher benefits of pollution reduction. Of the environmental problems we analyzed, air pollution and traffic congestion are both local conditions that depend on local solutions. For example, minimizing traffic congestion in New York City has no impact on traffic congestion in Boston. In addition, there is a naturally occurring concentration of pollutants that are independent of the anthropogenic loads. These natural emissions are referred to as policy relevant background conditions, and are the expected ambient concentrations of the pollutants if there were no anthropogenic sources. This concentration load acts as a lower bound to frame pollutant loads and pollutant reductions.

By enabling electric bike rides, SimpleCycle will allow our customers to bike commute and ride share in lieu of driving alone. This analysis shows that a reduction

in the number of single-passenger car commuters and an increase in the number of bike commuters will result in significant benefits to the environment. Part of the benefit of Simple Cycle is that as a scalable solution to these environmental problems it is an option requiring less infrastructure or capital than bus, rail, and highway projects. Cities across the country with bike share programs could adopt SimpleCycle as an attractive alternative to private motor vehicle commutes.

Next Steps

As we move forward with the process of launching SimpleCycle, continuation of the customer discovery process is our top priority. In addition, since New York City has been chosen as the launch city, further development of a specific strategy for launching needs refinement. As we move forward, our strategy is to focus on improving our knowledge of the parameters in our model with the weakest validation and that the model output is most sensitive to. The financial model analysis brought to light the assumptions we make on revenues and costs that our business model is sensitive to. By focusing on tightening these estimates, with customer discovery research and additional market research, we can better plan for a successful launch of SimpleCycle.

As shown in the financial model, there is a lack of certainty regarding the number of electrified bike trips demanded by existing bike share users. Our potential profits are sensitive to the conversion rate of existing bike share customers to electrified rides, and further customer discovery to tighten this number is needed. The price charged per ride needs additional customer validation as well. Our initial willingness to pay research became less representative of the offering we were presenting customers as we shifted away from the ride sharing with a bicycle model. Although a rough validation of customers willingness to pay for electric bike rides was presented, by comparing the daily cost of electrified bike share to the daily transportation budget of someone earning the minimum livable wage, specific customer validation of this key metric is needed. Focused customer discovery in which we directly ask customers for their willingness to pay for electrified bike rides will both help to validate if customers are willing to pay more than one additional dollar per trip, and if so, how much more. A specific willingness to pay estimate for electric bike rides will allow us to determine how to best price the surcharge in our performance contract.

To launch in New York City, relationships with the New York City Department of Transportation, the implementation agency, and Alta Bike Share, the operator of the bike share, must be established. We must learn how to collaborate effectively with

the bike share operators and conduct a painless and seamless integration of the electrification system with the existing bike share system. From the customer's viewpoint, the bike share experience must not seem segmented between electric and nonelectric options. Smooth integration will be necessary for maximum customer adoption of our services. A working relationship needs to be established with the producer of the electrification units. The current electrification unit design we are planning on using is moving from the prototype and initial launch phases into full-scale production and there is a possibility that the EUs can be purchased for less than the estimated purchase price in our model. Further investigation into sourcing the EUs and establishing competitive bulk pricing on the units along with rigorous testing to make sure they can handle the daily load we are planning on placing upon them is required. These specific EUs have been designed for attaching quickly and easily to New York City bike share bikes, yet we are still uncertain as to how easily they will attach to customer's individual bikes and how receptive customers will be to attaching the EUs to their personal bicycles. By acquiring various types of EUs, and experimenting with attaching them to a variety of bikes, we will refine which electrification strategy is the most promising for our customers who want to electrify their existing bicycle.

One of the main problems that existing bike shares have is the operational costs associated with redistribution of bikes from crowded stations to under filled stations. Electrification of bikes removes some of the barriers that cause bikes to accumulate, for example, by making it effortless to get up a hill, and we want to capitalize on the ability to have customers to re-distribute bikes on their own. We are confident that with the appropriate incentives and operational strategy, we can convince our users to redistribute bicycles to where we need them by offering free rides, prizes, and turning the act of redistribution into a game and competition. We need to further determine what specific incentives will work to motivate customers to re-distribute bikes for us.

Overall, through the course of our research we have uncovered many customer problems related to urban bicycling that deserve solutions. In the broader context of the current landscape for bike-centric entrepreneurial ideas, trends are pointing towards exciting opportunities for those able to blend technological advances with creative methods of applying solutions to bike problems. Specifically, the current rapid rise in electrification of bicycles is producing smaller, more powerful, electric solutions that can take users farther on a single charge. The electric bike industry is young and as more consumers continue to realize the advantages of electric bicycles for urban trips, the market size will only increase. SimpleCycle looks forward to capitalizing on this exciting and expanding market and to convince people to leave the car behind and choose a bicycle for their next trip.

Works Cited

- Alliance for Biking & Walking (**ABW**). (2012). *Bicycling and Walking in the United States 2012 Benchmarking Report*. The Library of Congress, USA.
- Ainsworth, B.E., et al. (2000). "Compendium of Physical Activities: An Update of Activity Codes and MET Intensities". *Medical Science in Sports and Exercise*. **32**(9): S498-504.
- Allison D.B., et al. (1999). "Annual Deaths Attributable to Obesity in the United States". *Journal of the American Medical Association* **282**(16):1530-1538. doi:10.1001/jama.282.16.1530.
- Alstadt, B. et al. (2012). *CRC Economic Benefits Analysis: Final Report*. Economic Development Research Group. Boston, MA.
- Anderson, L.H., et al. (2005). "Health care charges associated with physical inactivity, overweight, and obesity". *Preventing Chronic Disease* **2**(4): A09.
- Ashton, K. (2009). *That 'Internet of Things' Thing*. RFID Journal. <http://www.rfidjournal.com/articles/view?4986>
- Bay Area Bike Share. (2014). "System Metrics". bayareabikeshare.com. <<https://bayareabikeshare.com/system-metrics>>. Retrieved: March 10, 2014.
- Bureau of Labor Statistics (**BLS**). (2014). *Average Energy Prices, New-York-Northern New Jersey-Long Island—January 2014*. U.S. Department of Labor, Bureau of Labor Statistics New York-New Jersey Information Office. New York City, NY. <<http://www.bls.gov/ro2/avgengny.pdf>>
- Brady, P. (2013). *Why 2014 Might Be the Biggest Year Yet for Bike Sharing*. <http://www.cntraveler.com/daily-traveler/2013/12/best-bike-share-cities-in-the-world>
- Bureau of Transportation Statistics (**BTS**). (2013). *National Transportation Statistics*. U.S. Department of Transportation, Research and Innovative Technology Administration, Washington D.C.<http://www.bts.gov/publications/national_transportation_statistics>.
- Caiazzo, F. et al. (2013). "Air Pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005". *Atmospheric Environment* **79**: 198-208.
- Campbell-Dollaghan, K. (2013). *The Internet of Bikes: This Smart Lock Lets You Track and Share Rides*. Gizmodo. <http://gizmodo.com/this-internet-connected-bike-lock-will-let-you-track-an-1453187103>
- Capital Bikeshare. (2014). "System Data". capitalbikeshare.com. <<http://capitalbikeshare.com/system-data>>. Retrieved: March 10, 2014.
- Centers for Disease Control and Prevention (**CDC**). (2009). *Behavioral Risk Factor Surveillance System (BRFSS): State Health Information*. CDC. Atlanta, GA.
- Centers for Disease Control and Prevention (**CDC**). (2007). *Overweight and Obesity: Economic Consequences*. CDC. Atlanta, GA.
- Centers for Medicare and Medicaid Services (**CMS**). (2012). *National Health Expenditure Tables: Aggregate and Per Capita Amounts, Annual Percent Change and Percent Distribution: Selected Calendar Years 1960-2011*. CMS Baltimore, MD.
- Commute Solutions. (2014). *The True Cost of Driving Online Calculator*. commutesolutions.org. Santa Cruz County Regional Transportation Commission. <<http://commutesolutions.org/external/calc.html>>. Retrieved March 3, 2014.
- Cox, W. "New US Urban Area Data Released". newgeography.com. <<http://www.newgeography.com/content/002747-new-us-urban-area-data-released>>

- Crook, J. (2014). *Riide Is An Electric Bike For Cool Kids*. Tech Crunch. http://techcrunch.com/2014/01/17/riide-is-an-electric-bike-for-cool-kids/?utm_campaign=fb&ncid=fb
- Daddio, David W. (2012). *Maximizing Bicycle Sharing: An Empirical Analysis of Capital Bikeshare Usage* (Master's thesis). Retrieved from: http://rethinkcollegepark.net/blog/wp-content/uploads/2006/07/DaddioMP_Final-Draft.pdf
- American Lung Association. (2013). "Disparities in the Impact of Air Pollution". stateoftheair.org. <<http://www.stateoftheair.org/2013/health-risks/health-risks-disparities.html>>
- Divvy Bikes. (2014). "Data Challenge". divvybikes.com. <<https://divvybikes.com/datachallenge>>. Retrieved: March 10, 2014.
- Donnelly, Lauren. (2009). "Dulles Corridor Metrorail Project: A Cost-Benefit Analysis". *Policy Perspectives* **16**: 57-74.
- Eisele, B., Lomax, T., and D. Schrank. (2012). *TTI's 2012 Urban Mobility Report Powered by INRIX Traffic Data*. Texas A&M Transportation Institute. U.S. DOT Southwest Region University Transportation Center. <<http://mobility.tamu.edu/ums/report/>>.
- Frontier Group and U.S. PIRG Education Fund. (2012). *Transportation and the New Generation: Why Young people are Driving Less and What it Means for Transportation Policy*. Frontier Group. Atlanta, GA. <http://www.uspirg.org/sites/pirg/files/reports/Transportation%20%26%20the%20New%20Generation%20vUS_0.pdf>
- Galbraith, K. (2012). *Batteries Add Power and Market Appeal to Bicycles*. New York Times. <http://www.nytimes.com/2012/06/28/business/energy-environment/batteries-add-power-and-market-appeal-to-bicycles.html>
- Glasmeier, A.K. (2014). "Living Wage Calculation for New York City, New York". *Poverty in America: Living Wage Calculator*. livingwage.mit.edu. <<http://livingwage.mit.edu/places/3608151000>>. Retrieved March 5, 2014.
- Geron, T. (2013). *Airbnb and the Unstoppable Rise of the Share Economy*. Forbes. <<http://www.forbes.com/sites/tomiogeron/2013/01/23/airbnb-and-the-unstoppable-rise-of-the-share-economy/>>
- Gotschi, T., and K. Mills, (2008). *Active Transportation for America: The Case for Increased Federal Investment in Bicycling and Walking, Rails-to-Trails Conservancy*, <http://www.railstotrails.org/atfa>.
- Grabow, M.L., et al. (2012). "Air Quality and Exercise-Related Health Benefits from Reduced Car Travel in the Midwestern United States". *Environmental Health Perspectives* **120**(1): 64-75.
- Grantz, D.A., Garners, J.H.B., and Johnson, D.W. "Ecological effects of particulate matter." *Environment International* **29**: 213-239.
- Greaver, T.L. et al. (2012). "Ecological effects of nitrogen and sulfur air pollution in the US: what do we know?" *Frontiers in Ecology and the Environment* **10**(7): 365-372.
- Greene, D., and Plotkin, S. (2011). *Reducing greenhouse gas emission from US transportation*. Pew Research Center on Global Climate Change, Arlington, VA.
- Hall, J.V. and V. Brajer. (2008). *The Benefits of Meeting Federal Clean Air Standards in the South Coast and San Joaquin Valley Air Basins*. Institute for Economic and Environmental Studies. California State University. Fullerton, CA.
- Hannah, L. (2011). *Climate Change Biology*. Academic Press, Elsevier, San Diego, CA.

- Harford, Jon D. (2006). "Congestion, pollution, and benefit-to-cost ratios of US public transit systems". *Transportation Research Part D* **11**: 45-58.
- Health Effects Institute (HEI) Panel on the Health Effects of Traffic-Related Air Pollution. (2010). *Special Report 17 - Traffic Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure and Health Effects*. Health Effects Institute. Boston, MA.
- Holeywell, R. and Lippman D. (2012). "The 5 Biggest U.S. Infrastructure Projects, Plus 5 at Risk". *Governing: Infrastructure & Environment*, April 2012.
<<http://www.governing.com/topics/transportation-infrastructure/gov-5-biggest-us-infrastructure-projects-plus-5-at-risk.html>>
- Holladay, J. Scott. (2011). *Valuing the Clean Air Act: How Do We Know How Much Clean Air is Worth?* Discussion Paper No 2011/1. Institute for Policy Integrity: New York University School of Law. New York, NY.
- Hu, G., et al. (2004). "Occupational, commuting, and leisure-time physical activity in relation to total and cardiovascular mortality among Finnish subjects with type 2 diabetes". *Circulation* **110**(6): 666-673.
- Hurst, D. and J. Gartner. (2013). *Electric Bicycles*. Navigant Research. Boulder, CO.
- Intergovernmental Panel on Climate Change (IPCC). (2007). *Summary for Policymakers*. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Institute for Transportation and Development Policy (ITDP). (2013). *The Bike-share Planning Guide*. Institute for Transportation and Development Policy. New York, NY.
<http://www.itdp.org/documents/ITDP_Bike_Share_Planning_Guide.pdf>
- Kaplan, Melanie D.G. (2010). "D.C. Unveils Country's Largest Bike Share Program". *SmartPlanet* Issue 13, November 2010. smartplanet.com. <<http://www.smartplanet.com/blog/pure-genius/dc-unveils-countrys-largest-bike-share-program/4940>>
- Kheirbek, I. et al. (2013). *New York City Trends in Air Pollution and Its Health Consequences*. New York City Departments of Health and Mental Hygiene, Environmental Protection and the Mayor's Office of Long-Term Planning and Sustainability. New York, NY.
- League of American Bicyclists (LAB). (2013). *Where We Ride: Analysis of bicycling in American Cities*. American Community Survey Data Report for 2012. The League of American Wheelman, Inc. Washington, DC.
- League of American Bicyclists (LAB). (2013). *ACS: Bike Commuting Continues to Rise*.
<http://www.bikeleague.org/content/acs-bike-commuting-continues-rise>
- Lee, C.P, Chertow, G.M. and Zenios S.A. (2009). "An empiric estimate of the value of life: updating the renal dialysis cost-effectiveness standard." *Value in Health* **12**(1): 80-87.
- Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S., & Schellnhuber, H. J. (2008). "Tipping elements in the Earth's climate system". *Proceedings of the National Academy of Sciences of the United States of America*, **105**(6): 1786-93.
- LDA Consulting (2013). *2013 Capital Bikeshare Member Survey Report*. LDA Consulting, Inc. Washington, D.C.

- Lovett, G.M. *et al.* (2009). "Effects of Air Pollution on Ecosystems and Biological Diversity in the Eastern United States". *The Year in Ecology and Conservation Biology, 2009. Annals of the New York Academy of Sciences* **1162**: 99-135.
- Malouff, D. (2014). "Here are America's largest bikesharing systems in 2013". [greatergreaterwashington.org. <http://greatergreaterwashington.org/post/21260/here-are-americas-largest-bikesharing-systems-in-2013/>](http://greatergreaterwashington.org/post/21260/here-are-americas-largest-bikesharing-systems-in-2013/). Retrieved March 8, 2014.
- Martin, E. and S. Shaheen. (2011). GHG emission impacts of carsharing in North America, *IEEE Transactions on Intelligent Transportation Systems*, 12(4), 1074-1086
- McCubbin, D.R. and M.A. Delucchi. (1999). "The Health Costs of Motor-Vehicle-Related Air Pollution". *Journal of Transport Economics and Policy*. **33**(3): 253-286.
- McKenzie, B., and Rapino, M. (2011). *Commuting in the United States: 2009*, American Community Survey Reports, ACS-15. U.S. Census Bureau, Washington, DC.
- Muller, N.Z., Mendelsohn, R., and Nordhaus, W. (2011) "Environmental Accounting for Pollution in the United States Economy." *American Economic Review* **101**: 1649-1675.
- Myhre, G., Shindell, D., Breon, F.M., Collins, W., Fuglestedt, J., & Huang, J. (2013). *Working Group I Contribution to the IPCC Fifth Assessment Report. Climate Change 2013: The Physical Science Basis*. Geneva.
- Navigant Research. (2012). *Annual Sales of Electric Bicycles Will Surpass 47 Million by 2018*. <http://www.navigantresearch.com/newsroom/annual-sales-of-electric-bicycles-will-surpass-47-million-by-2018-2>
- National Emissions Inventory (NEI) Data*. Office of Air Quality Planning and Standards (OAQPS), 2014. Available: <<http://www.epa.gov/ttnchie1/net/2011inventory.html>>. Retrieved: February 25, 2014.
- Neyman, J. (2013). *For Sharing Economy Start-Ups, a New, Social Currency*. Huffington Post. <http://www.huffingtonpost.com/julia-neyman/for-startups-a-new-subtle_b_3182072.html>
- Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden and C.D. Woodroffe. (2007). "Coastal systems and low-lying areas". *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge University Press, Cambridge, UK, 315-356.
- National Research Council (NRC). (2010). *Advancing the Science of Climate Change*. NRC, Washington, DC.
- The City of New York (NYC). (2011). *PlaNYC A Greener, Greater, New York*. New York City, NY
- The City of New York (NYC). (2012). Mayor Bloomberg, Public Advocate DeBlasio, Manhattan Borough President Stringer, Montefiore Hospital CEO Safyer, Deputy Mayor Gibbs and Health Commissioner Farley Highlight Health Impacts of Obesity. [Press Release]. Retrieved from http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2012a%2Fpr200-12.html&cc=unused1978&rc=1194&ndi=1
- NYC Bike Share, LLC. (2014). "Pricing". [citibikenyc.com. <https://citibikenyc.com/system-data>](https://citibikenyc.com/system-data). Retrieved: March 10, 2014.

- New York City Department of City Planning (**NYC-DCP**). (2009). *Bike-Share Opportunities in New York City*. New York, NY.
- New York City Department of Health and Mental Hygiene (**NYC-DOH**). (2010) *Air Pollution and the Health of New Yorkers: The Impact of Fine Particles and Ozone*. New York City, NY
- New York City Department of Health and Mental Hygiene (**NYC-DOH**). (2014). "Obesity" nyc.gov. <<http://www.nyc.gov/html/doh/html/living/obesity.shtml>>
- Office of Air and Radiation (**OAR**). (2011). *The Benefits and Costs of the Clean Air Act from 1990 to 2020*. Final Report. U.S. EPA, Washington D.C.
- Office of Transportation and Air Quality (**OTAQ**). (2008). *Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks*. Fact Sheet No: EPA420-F-08-024. U.S. EPA, Washington, DC.
- Office of Transportation and Air Quality (**OTAQ**). (2011). *Greenhouse Gas Emissions from a Typical Passenger Vehicle*. Fact Sheet No: EPA-420-F-11-041. U.S. EPA, Washington, DC.
- Perks, R. and Raborn, C. (2013). *Driving and Commuter Choice in America: Expanding Transportation Choices Can Reduce Congestion, Save Money and Cut Pollution*. Issue Paper 13-060A. Natural Resources Defense Council (NRDC), Washington, D.C.
<<http://www.nrdc.org/transportation/driving-commuter-choices.asp>>
- Pucher, J., et al. (2010). "Walking and Cycling to Health: A comparative Analysis of City, State and International Data". *American Journal of Public Health* **100** (10): 1986-1992.
- Puentes, R., and Tomer, A. (2008). *The Road...Less Traveled: An Analysis of Vehicle Miles Traveled Trends in the U.S.* Metropolitan Infrastructure Initiative Series No. 4. Brookings Metropolitan Policy Program. Brookings Institution, Washington, D.C.
<<http://www.brookings.edu/research/reports/2008/12/16-transportation-tomer-puentes>>
- Regional Plan NY-NJ-CT Association. (2003). *The Economic Benefits of the Second Avenue Subway*. New York, NY.
- Rosenthal, E. (2013). *The End of Car Culture*. New York Times.
<http://www.nytimes.com/2013/06/30/sunday-review/the-end-of-car-culture.html?_r=0>
- Roth, J.D. (2011). "The Costs and Savings of Bicycle Commuting". *Forbes: Personal Finance*. forbes.com <<http://www.forbes.com/sites/centurylink/2014/03/11/why-blackberrys-turnaround-may-be-too-late/>>. Retrieved March 3, 2014.
- Santos, A., et al. (2011). *Summary of Travel Trends: 2009 National Household Travel Survey*. Technical Report No. FHWA-PL-11-022. U.S. DOT, Federal Highway Administration (FHWA), Washington, D.C. <<http://nhts.ornl.gov/publications.shtml>>.
- Schmitt, A. (2013). *The Rise of the North American Protected Bike Lane*.
<http://momentummag.com/features/the-rise-of-the-north-american-protected-bike-lane/>
- Shaheen, S. and S. Guzman. (2011). *Worldwide Bikesharing*. Access: UC Transportation Center.
- American Lung Association (**ALA**). (2013). *State of the Air*. ALA. Washington, DC.
- StatisticBrain.com. (2014). "Commute Statistics". <<http://www.statisticbrain.com/commute-statistics/>>. Retrieved March 8, 2014.
- Sticky Bottle. (2013). *This Ground Breaking Invention Just May Be About to Revolutionise Commuter Cycling Forever*. <http://www.stickybottle.com/latest-news/this-ground-breaking-invention-just-may-be-about-to-revolutionise-commuter-cycling-forever/>
- Sundararajan, A. (2013). *From Zipcar to the Sharing Economy*. Harvard Business Review.
<http://blogs.hbr.org/2013/01/from-zipcar-to-the-sharing-eco/>

- Toole Design Group. (2012). *Bike Sharing in the United States: State of the Practice and Guide to Implementation*. Report prepared for the U.S. Department of Transportation Federal Highway Administration. Tool Design Group. Washington DC.
- Unger, N., Bond, T. C., Wang, J. S., Koch, D. M., Menon, S., Shindell, D. T., & Bauer, S. (2010). "Attribution of climate forcing to economic sectors". *Proceedings of the National Academy of Sciences of the United States of America*, **107**(8): 3382–7.
- U.S. Census Bureau. (2009). American Community Survey (ACS), 2009.
- U.S. Census Bureau. (2012). American Community Survey (ACS), 2012.
- U.S. Energy Information Administration (EIA). (2010). *Annual Energy Review 2009*, Table 2.8. DOE/EOA-0384(2009). U.S. EIA, Washington, DC
<<http://www.eia.gov/totalenergy/data/annual/archive/038409.pdf>>
- U.S. Environmental Protection Agency (EPA). (2006). *Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final)*. U.S. EPA, Washington, DC, EPA/600/R-05/004aF-cF, 2006.
- U.S. Environmental Protection Agency (EPA). (2011a). *Inventory of US greenhouse gas emissions and sinks: 1990-2009*. US EPA, Washington, DC.
- U.S. Environmental Protection Agency (EPA). (2012). "Milestones in Mobile Source Air Pollution Control and Regulations". epa.gov. <<http://www.epa.gov/otaq/consumer/milestones.htm>>
- U.S. Environmental Protection Agency (EPA). (2013). The Social Cost of Carbon. US EPA, Washington, DC. <<http://www.epa.gov/climatechange/EPAactivities/economics/scc.html>>
- U.S. Environmental Protection Agency (EPA). (2014). The P2 GHG Calculator. U.S. EPA, Washington, DC <www.epa.gov/p2/pubs/resources/GHGConversion.xls>
- U.S. EPA National Center for Environmental Economics (EPA). (2014). "Frequently Asked Questions on Mortality Risk Valuation". yosemite.epa.gov.
<<http://yosemite.epa.gov/EE%5Cepa%5Ceed.nsf/webpages/MortalityRiskValuation.html>>
- U.S. EPA Office of Air Quality Planning and Standards (OAQPS). (2012). *Our Nation's Air: Status and Trends Through 2010*. Technical Report No: EPA-454/R-12-001. U.S. EPA, Research Triangle Park, North Carolina.
- U.S. EPA GIS Downloads: Nonattainment Areas. Office of Air Quality Planning and Standards (OAQPS), 2013. Available: <http://www.epa.gov/oaqps001/greenbk/gis_download.html>. Retrieved: February 25, 2014.
- U.S. Global Change Research Program (GCRP). (2009). *Global Climate Change Impacts in the United States*. US GCRP Washington, DC.
<<http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>>
- Wedin, D.A. and Tilman, D. (1996). Influence of nitrogen loading and species composition on the carbon balance of grasslands. *Science* **274**: 1720–1723.
- Wen, L.M. and C. Rissel. (2008). "Inverse associations between cycling to work, public transport, and overweight and obesity: Findings from a population based study in Australia". *Preventative Medicine*. **46**(1): 29-32.
- World Health Organization (WHO). (2002). World Health Report: Reducing Risks Promoting Healthy Life. WHO. Geneva.

Appendices

Appendix 1: The Electrification Unit

There are multiple methods for electrifying a traditional bicycle. A front wheel friction drive system was chosen in the business model presented in this paper. Below are the technical specifications for such a system and two other possible methods for electrifying an existing bicycle, front and rear hub motors. All three options have pros and cons, are in early prototype or production phase, and advancing in capabilities. The table below compares the general technical specifications of existing products from these three bike electrification methods.

Electrification Method	Cost	Range (miles)	Charge Time (hr)	Weight (lbs)	Power (Watts)	Top Speed (mph)
Friction Drive	\$1,000	20	2	7	750	18
Front Hub	\$800	20	5	6	250	15
Rear Hub	\$800	31	4	13	350	20

i. Front Wheel Friction Drive

A friction drive motor propels a bicycle forward by engaging an electric motor with the rubber of the bicycle tire. The friction between the motor and the tire propels the bicycle forward. The unit that contains the electric motor also houses the batteries required to power the motor. This method has the advantage of being independent of the existing drive train of the bicycle and a single unit is compatible with various bicycles. The proof of concept version that was analyzed for this report is called the ShareRoller. The ShareRoller attaches to bike share bikes at the metal docking mount on the front of the upper fork on New York City bike share bikes (<https://www.kickstarter.com/projects/247419341/shareroller-first-portable-motor-for-share-bikes-a>).

ii. Front Hub Motor

A front hub motor houses both the motor and the battery of the electrification unit within the front hub of the bicycle. Standard bike spokes lace the electric hub to a standard bicycle rim and wheel. This method is independent of the existing bicycle drive train but wheel size, hub spacing, and break types must be compatible with the wheel in order to maintain compatibility between various bicycles. The proof of concept versions that was analyzed during business model development is called the Hill Topper (<http://www.electric-bike-kit.com>).

iii. Rear Hub Motor

A rear hub motor houses both the motor and the battery of the electrification unit within the rear hub of the bicycle. Standard bike spokes lace the electric hub to a standard bicycle rim and wheel. This method must be integrated with the existing drive train, hub spacing and breaking mechanism of the bicycle in order to maintain compatibility between various bicycles. The proof of concept versions that were analyzed during business model development are called the Copenhagen Wheel (<http://www.superpedestrian.com>) and the FlyKly (<http://www.flykly.com>).

Appendix 2: Financial Model Assumptions

i. Fixed Costs

Cost to construct a terminal	\$5000
Cost of an Electrification Unit	\$700
Electricity cost	\$0.23 (per kWh)

ii. Variable costs

Cloud computing	
Less than 10e6 annual trips	\$500 per month
Greater than 10e6 annual trips	\$1000 per month
App/software development	\$10,000
Employee annual salaries	
Wages	\$50,000
Benefits	\$10,000
Office space	
Less than 30 employees	\$10,000 per month
More than 30 employees	\$20,000 per month

iii. Revenue

Per ride surcharge	\$1
Annual advertising revenue	\$2,000,000

iv. Other Assumptions

Discount rate	15%
EU replacement rate	5%
Stations per employee per week	56
Administrative/management staff	10
EUs per station	20
Customers per EU	7:1
EU charges per day	1.5