Understanding and Changing the American Opinion of Human-Powered Commuter Vehicles

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Understanding the Field of Commuter Human-Powered Vehicles

For decades, the American commute has been dominated by combustion vehicles, most notably single-occupant automobiles. This era of dominance began in the middle of the 20th century, when the popularity of living far from work in newly constructed housing developments known as the suburbs surged (The Smithsonian Institute, 2017). Only 50 years prior, the invention of the modern bicycle had enabled people living in cities to travel the short distance to work (Herlihy, 2004). However, with the popularity surge of the suburbs and automobiles, the bicycle quickly became relegated to exercise or recreational equipment, and the distance of the commute to work stretched farther than the average person would be able to bike (The Smithsonian Institute, 2017).

Automobiles remain the most prevalent commuter vehicle in American cities, even for short commutes within the city (U.S. Census Bureau, 2011). Although use of automobiles is convenient, the environment is paying for this preference. Many environmental studies have pointed to the effect of short automobile commutes as not only a large contributor to climate change, but also as a part of the problem that can be solved (Stanford Transportation, 2019). In fact, a number of cities have begun to explore a return to human-powered vehicle usage as a way to help mitigate commuters' contribution to climate change, such as Charlottesville, Virginia, with their efforts to "Provide convenient and safe bicycle…connections…to promote the option of walking and biking" (Charlottesville Transportation, 2013). On one hand, this is a goal more easily set than accomplished; the technology can be developed, but adoption has remained low. Traditional human-powered vehicles such as bicycles are not seen as suitable for commutes primarily due to convenience and comfort concerns. On the other, this potentially leaves room for a commuter-centric human-powered vehicle to gain widespread acceptance and usage.

Understanding the American commute and how it has shaped opinions on human-powered vehicles is instrumental to understanding how human-powered vehicles can fit into the role of a commuter vehicle. As it also deals with product development in an environmental context, Geels' Multi-Level Perspective is instrumental in developing this understanding (Geels, 2011). In this paper, I argue that even though a human-powered vehicle specifically designed to function as a commuter vehicle could be implemented to help mitigate the contribution of short commutes to climate change is possible, the framing of such vehicles in American minds as recreational vehicles prevent widespread usage. Changing how a human-powered commuter vehicle is framed for consumers would be the key to the success of this new transportation system.

Harming the Climate by Commuting

For decades, the environment has been at the mercy of fossil fuel-driven energy demands, including providing heat and electricity for households, as well as fuel for commuter vehicles. The United States Environmental Protection Agency (EPA) estimates that over a quarter of American greenhouse contributions come from transportation alone, with most of that contribution coming from burning petroleum based fuels (US EPA, 2015). While efforts have been made to mitigate Americans' contributions to greenhouse gas emissions, such as more fuel-efficient vehicles and establishing regulations, combustion vehicles remain a rather significant issue. A breakdown of greenhouse gas emissions by economic sector, highlighting transportation as responsible for over a quarter of said emissions, can be seen below in Figure 1 (US EPA, 2015).

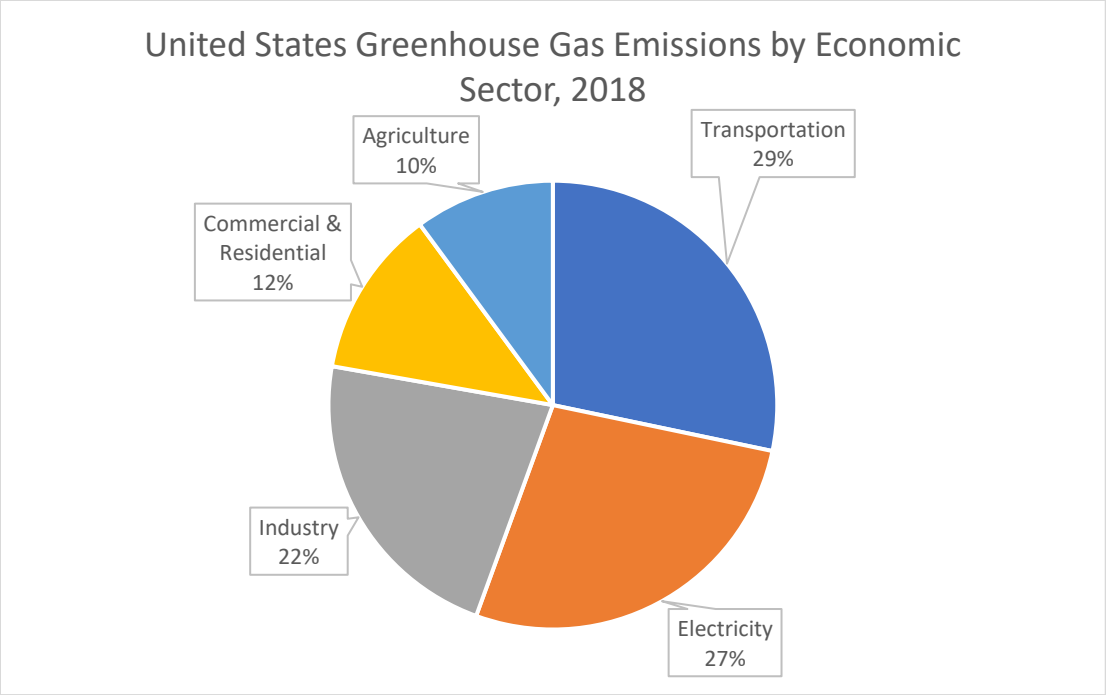

Figure 1. This chart represents the sources of greenhouse gas emissions by economic sector (US EPA, 2015).

Proposing an Alternate Commuter Vehicle: The State of the Art

Given the necessity and urgency of finding a way to reduce greenhouse gas emissions for the sake of the environment, alternative modes of transportation have become very attractive points of research. Chief among them are electric vehicles, but those shift the greenhouse gas emission balance towards electricity production rather than reduce emissions overall. Another promising domain is human-powered vehicles. Traditionally, this

Figure 2. A typical high-performance, racing human-powered vehicle (Human Powered RaceAmerica, 2015).

has meant bicycle commuting and not much else, but recent developments in human-powered vehicles designed for racing events have led to faster vehicles with more efficient drivetrain systems, such as the one in Figure 2 above. (The Mother Earth News Editors, 1981). Although these vehicles are capable of achieving speeds equal to or exceeding those of cars, they remain an unpopular mode of transportation for commuters, with less than one percent of commuters opting to travel using a human-powered vehicle, typically a bike (Florida, 2019). Data from the 2019 Florida study is summarized in Figure 3 below, which shows an overwhelming majority of commuters choosing to drive alone.

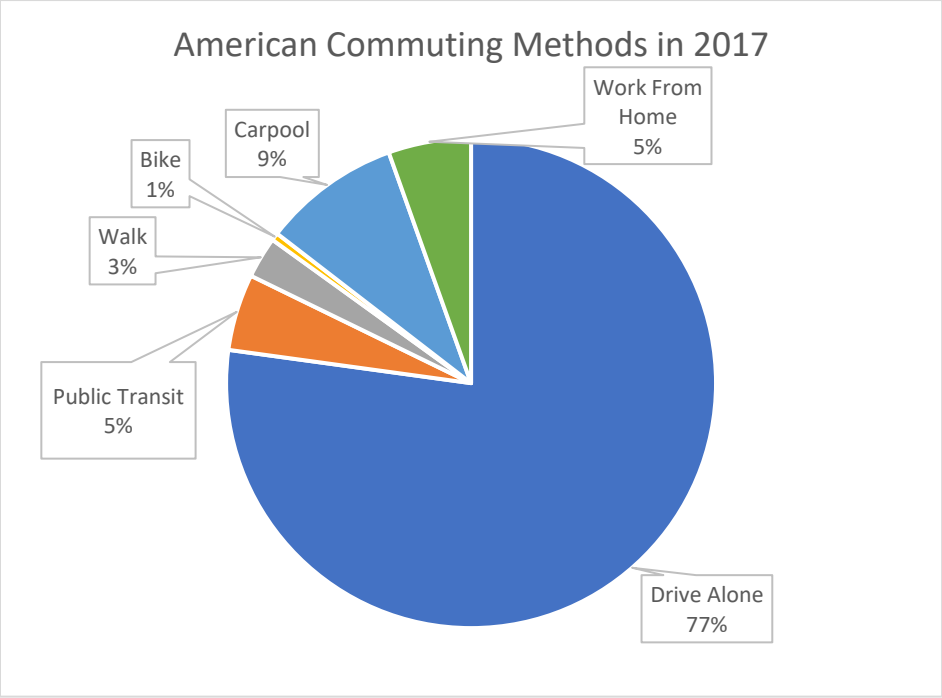

Figure 3. This chart shows the profile of American commuters (Florida 2019). “Driving Alone” represents over three quarters of American commuters.

The environmental benefit of human-powered vehicles over typical commuter vehicles such as cars extends beyond the elimination of fossil fuel usage. As they are typically smaller vehicles, manufacturing costs both in terms of materials needed and the fuel required to manufacture the vehicle are reduced. The greenhouse gas emissions of a human-powered vehicle

essentially become a one-time contribution during the manufacturing rather than a continuous contribution over the lifespan of the vehicle while it burns fuel. Even though the environmental benefits are relatively clear, the question of why there has been little adoption of human-powered vehicles as commuter vehicles still remains.

Establishing a Human-Powered Precedent

At least part of the explanation of American hesitation to commute on human-powered vehicles may lie in American opinions towards human-powered vehicles and bicycles in particular, as well as how those opinions have changed over time. Exploring the history of bicycle usage from its inception to the modern day helps to illustrate these changes. Bicycle historian David Herlihy dates the earliest ancestor of the bicycle, as seen in Figure 4, to 1817 in Germany, and was in fact developed as a means of travelling around cities without the need for a horse (2004). A multitude of other proto-bicycles were developed throughout the 19th century, all intended for travelling around cities, with the first truly recognizable modern bicycle arriving in the 1880's and 1890's (Herlihy, 2004). This new design, shown in Figure 5, was known as the "safety bicycle," and it was once again a vehicle intended to be used to travel around cities (Herlihy, 2004). Much of this early demand and

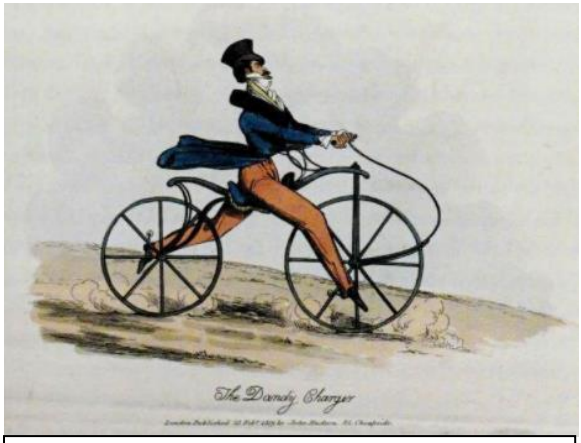

Figure 4. A picture of one of the first "proto-bicycles" (Herlihy, 2004).

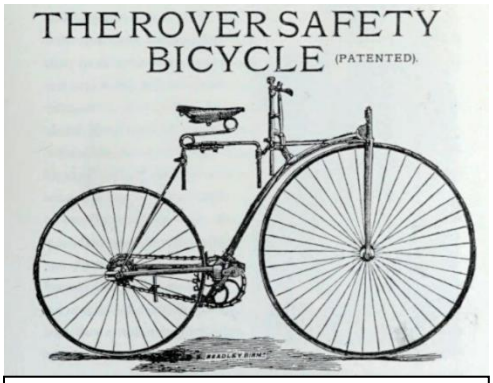

Figure 5. A picture of the first modern bicycle (Herlihy, 2004).

innovation took place in Europe, but the American market for bicycles was similarly strong (Herlihy, 2004).

Early in the 20th century, American cycling suffered a major decline, most likely due to the introduction of the automobile. As Americans quickly adopted the new vehicle, the bicycle was relegated to recreational or exercise purposes for a vast majority of users. The profile of American bicycle usage developed by the Breakaway Research Group in 2015 is shown in Figure 6.

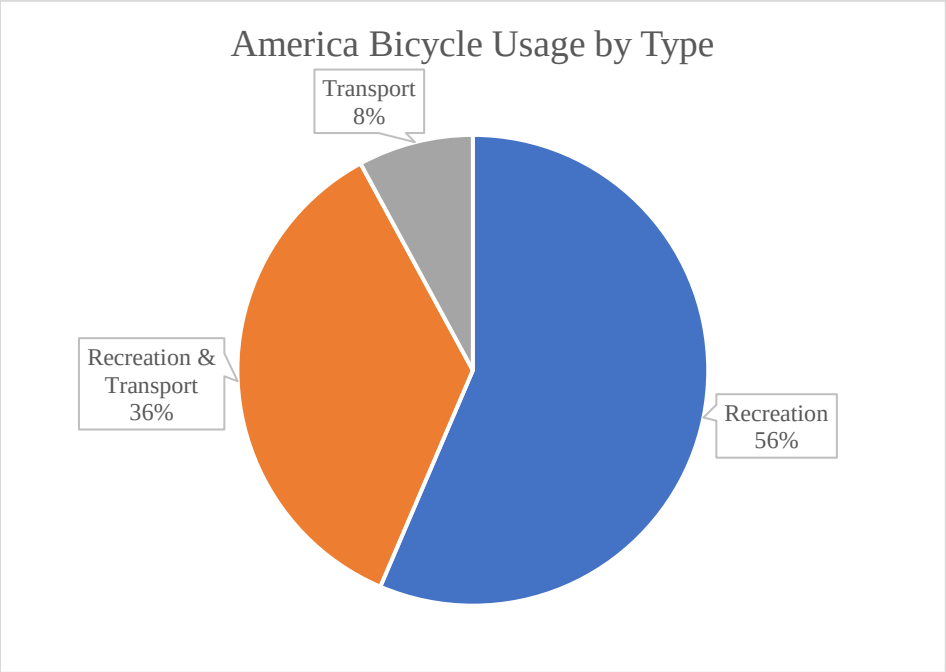

Figure 6. Chart showing results from a survey on American bicycle usage separated by type (Breakaway Research Group, 2015). Less than 10% of American cyclists use bicycles solely as commuter vehicles.

What remains unclear is why, despite the bicycle's early development and prevalence as a vehicle for travelling around cities, Americans seem unusually adverse to the idea of commuting on human-powered vehicles (Heinen et al., 2011). Going beyond the environmental benefits, bicycle commuters in Master's Degree of Urban Planning candidate Carolina Rodriguez's 2011 study claim commuting to work or travelling around town by human-powered

vehicle holds a number of emotional and physical health benefits. One man who routinely commutes on a human-powered vehicle reported significant weight loss, while another seemed to cycle purely for enjoyment (Rodriguez et al., 2011). Given such positive reactions and opinions from the few who do commute by human-powered vehicle, it is evident that some outside factor, such as roadway policies, suggestions from environmental scientists, or a lack of accessible technology, has prevented Americans from adopting a human-powered commute.

Developing an Understanding of Frank Geels' Multi-Level-Perspective

Analyzing the changes in American bicycle usage over the history of the bicycle may help to illuminate the development of some of the outside factors limiting adoption of a human-powered commute. These outside factors include active entities, such as policymakers, and passive entities, like the vehicles themselves and the policies put forth by the policymakers. Unfortunately for engineers attempting to increase American usage of human-powered vehicles as commuter vehicles, each of these components influences and is influenced by the rest. One attempt at sorting through systems as interconnected as this one comes in the form of Frank Geels' Multi-Level Perspective framework.

Geels' Multi-Level Perspective (MLP) framework provides a method by which systems centered around sustainability can be analyzed. This framework is especially useful when considering systems that have changed over time due to complex interactions between components. These systems are widely referred to by Geels (2011) as "socio-technical systems," a concept that illustrates the close connection between the human-centered parts of the system and the product- or technology-centered parts. Sociotechnical systems do not exist in a vacuum, however, and require the context of a "socio-technical landscape," a concept that Geels asserts "highlights not only the technical and material backdrop that sustains society, but also includes

demographic trends, political ideologies, societal values, and macro-economic patterns" (2011). Within a given socio-technical landscape, there exist several "socio-technical regimes," or distinct areas or components with distinct rules that govern their behavior (Geels, 2011). These include the socio-cultural, policy, science, technological, and user/market regimes (Geels, 2011). Geels (2011) also refers to "niches," which he defines as "protected spaces…where users have special demands and are willing to support emerging innovations;" these are the specific components that exist within a regime. The whole goal of the MLP framework is to relate the progression of a socio-technical system to what Geels calls "transitions;" these are overarching changes that affect every niche within a landscape. For instance, in the American commute system, an analysis making use of MLP might focus on the changing availability of technologies to American commuters and how that influences commute lengths and vice versa.

The Multi-Level Perspective framework also places emphasis on time-based development of a landscape. Figure 7 is included in the original description of the MLP framework as a way to depict how a landscape may go through transitions across time (Geels, 2011). Figure 7 consists of an initial state of the landscape, depicted as the pentagon on the left. Time progresses to the right of the figure. As time progresses, a helical arrow illustrates the circular influence each regime has on the rest of the regimes within the landscape. The many small arrows pointing in random directions seek to illustrate that there is no particular cycle in

which the regimes influence each other, but rather each regime influences and is influenced by the others continuously.

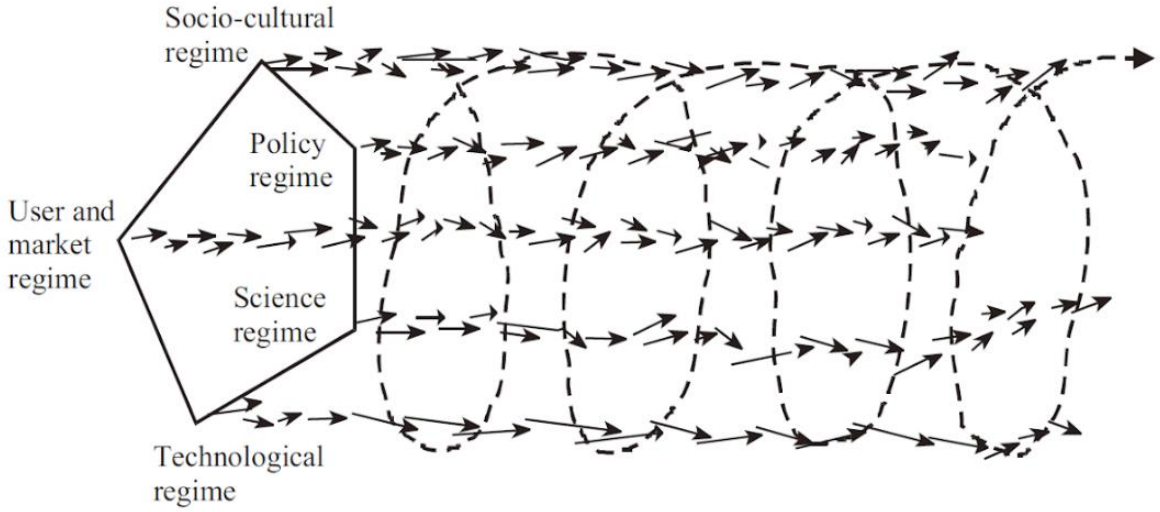

Figure 7. Graphic depicting the time-based development of a socio-technical landscape (Geels, 2011).

Why Geels' Multi-Level Perspective Applies to Human-Powered Commuter Vehicles

Geels developed the multi-level perspective framework specifically to describe landscapes centered around sustainability, and as the problem of increasing American usage of human-powered vehicles as commuter vehicles is very much an environmental problem, the MLP framework can be used to help understand this landscape. The following graphics seek to explain the development of the human-powered-vehicles-as-commuter-vehicles-landscape as it has undergone transitions throughout time. They were developed from research conducted on both the history of the bicycle and the American commute. The landscape at the invention of

human-powered vehicles is depicted in Figure 8. The development of this landscape begins with the invention of the bicycle in the early 19th century, when people began seeking a fast mode of transportation that did not require the constant care a horse did (Herlihy, 2004). The landscape then developed in the mid to late 19th century as people began to demand more safety features and efficient drivetrains to make the bicycles more effective as vehicles, and is shown in Figure 9 (Herlihy, 2004). Bicycle usage also became somewhat of a lifestyle, with young men taking very strongly to this mode of transportation (Herlihy, 2004). However, usage became somewhat limited with the introduction of traffic regulations—riders were limited in much the same way drivers are limited today.

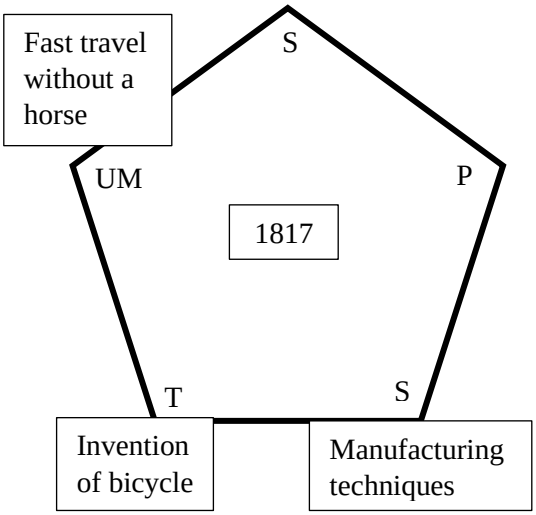

Figure 8. The landscape in 1817 (created by author).

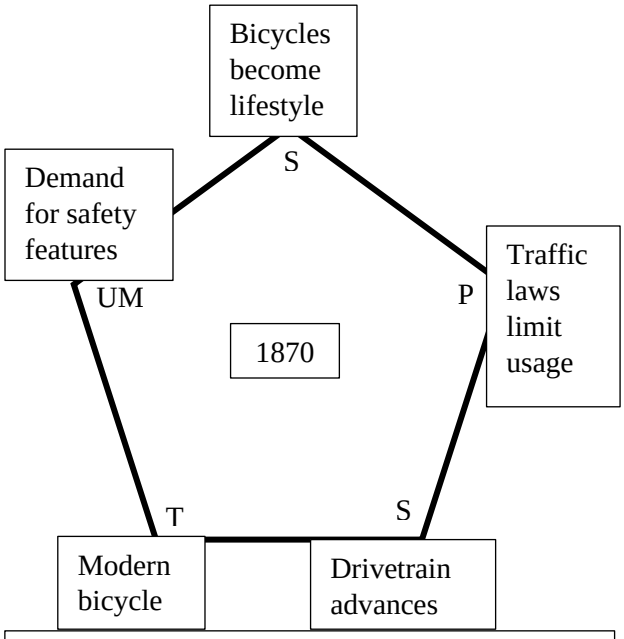

Figure 9. The landscape in 1870 (created by author).

The next major transition occurred in the middle of the 20th century with the departure of working Americans from the city to the suburbs. The landscape began to shift towards the state depicted in Figure 10. The longer commutes meant a more suitable mode of transportation gained favor: the automobile

and its combustion engine (The Smithsonian Institute, 2017). As the automobile became more and more popular due to lower prices and the necessity of use for long commutes, the bicycle became more popular among children than adults (Herlihy, 2004; The Smithsonian Institute, 2017). For a long time, the archetypal bicycle rider became a young boy riding with friends in his neighborhood rather than the working American man on his way to work (Herlihy, 2004). Human-powered vehicles were no longer serious commuter vehicles; they had been made into a toy.

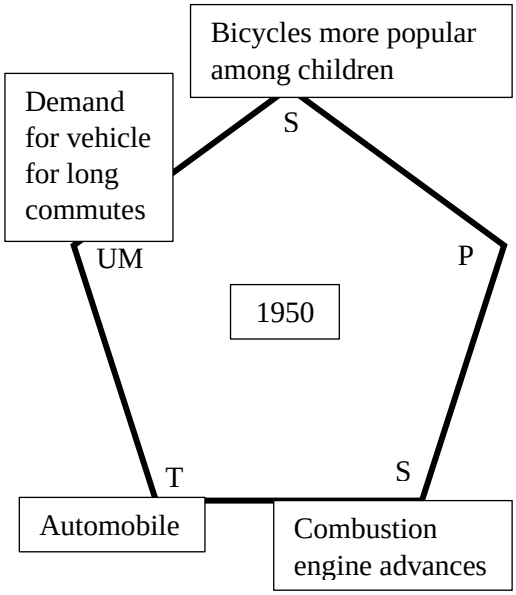

Figure 10. The landscape in 1950 (created by author).

The landscape remained as it stood in the 1950's for several decades. However, since the late 20th century, climate scientists have become increasingly worried by the contribution of commuter vehicles to greenhouse gas emissions and climate change. This has led to a renewed interest in human-powered vehicles as serious commuter vehicles. The current landscape is depicted in Figure 11.

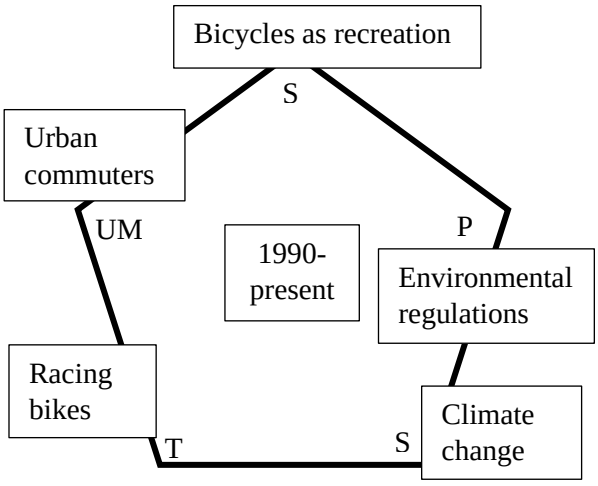

Figure 11. The modern landscape (created by author).

Bicycles have been firmly entrenched in American eyes as recreational equipment (Rodriguez et al., 2011). Climate scientists are recommending environmental regulations to policymakers, who

are then enacting environmental regulations. Human-powered vehicles, at least those used for racing events, are becoming more and more comparable to standard cars in terms of speed (The Mother Earth News Editors, 1981). Yet another transition is likely still needed before the landscape can reflect more widespread usage of human-powered vehicles and a change of American opinion.

Understanding the Implications of Opinions for Transportation Systems

Based on the research described in the previous two sections, it has become clear that Americans could eventually come to change their opinions on human-powered vehicles as commuter vehicles, but it would require a reframing of the vehicle as a commuter vehicle. In a way, this would mark an interesting return to the original purpose of human-powered vehicles. Perhaps the first step in beginning the transition to the next socio-technical landscape is to restructure American commuting patterns. Providing more of an opportunity for bicycle commuting by introducing new bike laws and lanes or incentivizing bicycle commuting could trigger a change in the the social-cultural and policy MLP regimes. These new opportunities could then incite a demand for human-powered vehicle manufacturers to create new commuter-specific vehicles, which would lead to a change in the technology MLP regime. De-emphasizing the automobile in urban settings may be difficult, so instead placing more emphasis on the suitability of human-powered vehicles for urban commutes may prove more successful.

Unfortunately, an urban commute is really the only option for a human-powered vehicle. The average suburban commute is much too far to be attractive or even possible for commuters using human-powered vehicles (U.S. Census Bureau, 2011). Even if speeds comparable to those of a car are d with little effort from the rider, daily half-hour bike rides from home in the suburbs to work in the city are likely not going to be appealing. However, due to the reduced automobile

traffic, a human-powered urban commute could ostensibly take less time than the same commute in an automobile. The increasing length of the American commute can be seen in Figure 12; the strong positive trend in the data suggests that commutes from the suburbs to work are only going to get longer and therefore more unsuitable for a human-powered commute.

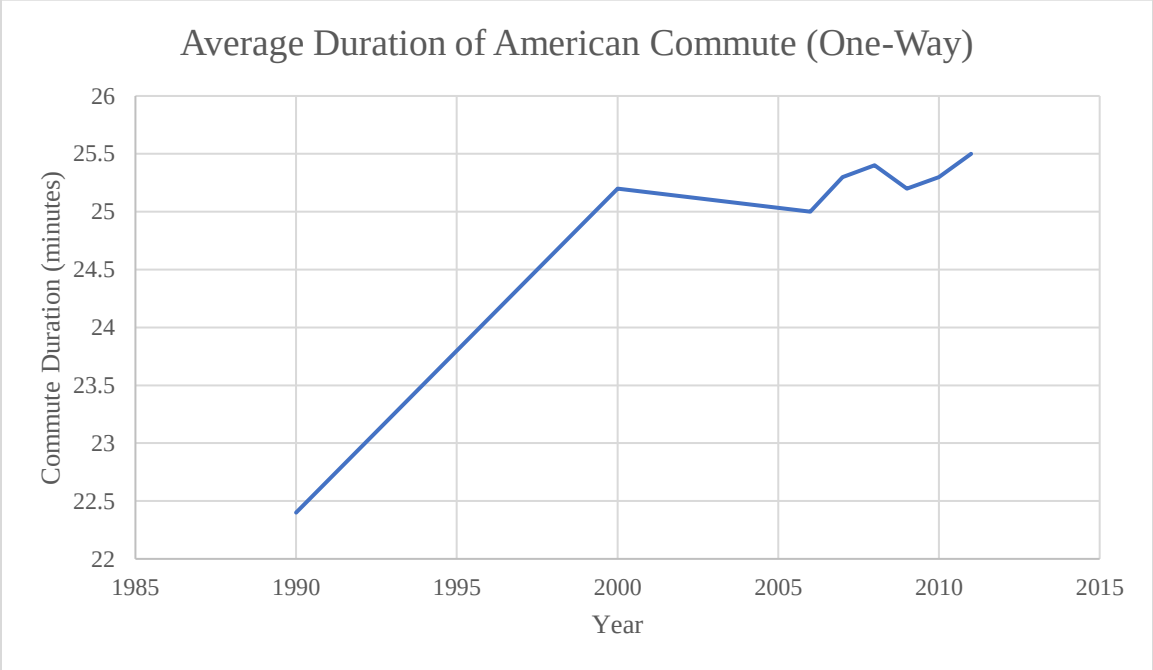

Figure 12. Plot depicting the average duration of Americans' commutes to or from work (U.S. Census Bureau, 2011).

The Limits of a Human-Powered Solution Within the Current Socio-technical Landscape

The technology of human-powered vehicles also is not where it needs to be for the vehicles to gain widespread usage as commuter vehicles. Using specially designed drivetrains and aerodynamic components, cutting-edge racing human-powered vehicles are in fact capable of reaching speeds comparable to that of an automobile (Pierre, 2020; The Mother Earth News Editors, 1981). However, many of these vehicles suffer from ergonomic shortcomings. The absolute highest-performing human-powered vehicles are typically entirely enclosed in an

aerodynamic shell that leaves little space for the rider or any cargo that may require transportation (Pierre, 2020).

In addition to the problems with the distance of the commute and the technology, human-powered vehicles have long been thought of as recreational or exercise equipment, despite originally being conceived as a mode of transportation. This is an important obstacle to overcome, because it seems that the Americans closely tie their opinions of vehicles to the vehicle's intended purpose (Heinen et al., 2011). When the early bicycle was first becoming popular as a commuter vehicle, it was because it had been presented as such. People who could afford them would eagerly take advantage of this new mode of transportation (Herlihy, 2004). A similar acceptance trend occurred with the popularization of the automobile, except this time it resulted in the role of the bicycle in American society changing. Since over half a century has passed since this transition, those opinions have become fairly entrenched.

Changing the Current Landscape

One potential way that human-powered vehicles could return to prominence as commuter vehicles is by leaving the archetypal bicycle as it stands as a recreational vehicle and introducing a new type of human-powered vehicle as the commuter variety. This sort of specialization has already occurred with automobiles; very rarely are vehicles created to be commuter vehicles used for anything other than that purpose. Creating a dedicated human-powered commuter vehicle could almost bypass the mental block Americans seem to have on using bicycles for their commutes (Alan M. Voorhees Transportation Center, 2011; Heinen et al., 2011). Outside of driving to an event, the typical commuter vehicle is not used for recreation, and the new, commute-centric vehicle could fill a similar niche. The main difficulty would then become

creating a vehicle that is sufficiently different from the bicycle so that it does not overlap with current vehicles.

The creation of a new vehicle could also provide a solution to some of the other concerns Americans have around using bicycles as commuter vehicles. Traffic safety is frequently brought up as a concern and limiting factor when people are asked about using a bicycle as a commuter vehicle, and reasonably so (Heinen et al., 2011). The typical bicycle leaves its rider rather exposed and susceptible to injury, whether it be from traffic collisions or simply falling off of the vehicle. Assuaging those concerns could be the entire goal of a newly designed human-powered commuter vehicle. A conceptual vehicle is shown in Figure 13. Commuters would most likely appreciate some measure of added safety as they travel to work in their new vehicle. A general lack of ability to transport cargo, such supplies needed on the job, is also cited as a concern for the feasibility of human-powered commuter vehicles (Heinen et al., 2011). Currently, most human-powered vehicle commuters solve this problem by wearing backpacks or jury-rigging crates to their bicycles (Rodriguez et al., 2011). This solution is not ideal, as it can create discomfort for the rider or throw the vehicle off balance, making commutes difficult. The design of a new human-powered vehicle could intentionally include ergonomic and functional features that could make the commute itself easier.

Figure 13. A potential commuter human-powered vehicle design in a commuter context (created by author).

Why Failing to Consider Opinions Leads to Failed Systems

Addressing opinions of new transportation modes meant to be widely adopted is crucial to the success of those new modes. Designers of previous systems, such as the Aramis personal rapid transit system in Paris, France, failed to take into account its users' opinions during the design process (Latour, 1996). The system was quickly abandoned due to users' perception of safety concerns. Aramis was composed of a collection of small train car-style vehicles that could physically connect and travel together in high-density areas and split off when the passenger needed to go in a different direction (Latour, 1996). The commuters intended to take advantage of this system felt very strongly that it was unsafe, and the system was essentially abandoned (Latour, 1996). Despite being technologically sound, Aramis failed due to an inability to consider user opinions. Restructuring the American commute around human-powered vehicles also runs the risk of failing due to commuter opinions. If American commuters continue to pinhole human-powered vehicles as recreational, a technologically sound system may fail, just as Aramis did.

Moving Toward a Potential Future Landscape

Human-powered vehicles are absolutely able to serve as commuter vehicles, but their capability remains limited by a few factors. The distance of the average American commute is well outside the average person's cycling ability. Especially when the commute starts in the suburbs and ends in the city, the length of the commute has only gotten longer both in terms of distance and time. Ergonomically, they are simply not as comfortable as automobiles, nor can they typically transport much other than the rider. A nicely molded, cushioned chair will almost always be preferred over a bicycle seat. Many bicycles are also designed to fit the role of recreation or exercise, and the ergonomic design considerations reflect this. Because there are

not many protective features around the rider on most bicycles, they are also often perceived as less safe. All of these factors combine to influence the American opinion on human-powered vehicles as commuter vehicles to be unsavory.

However, this opinion was not always the norm as it is now. The early bicycle was designed specifically as a commuter vehicle for short trips around cities. Bicycles filled that role until they were overtaken by automobiles, which were better equipped to deal with the longer commute from the suburbs into the city. Automobiles seemed to fix all of the problems that commuters had with using human-powered vehicles, but added one very important problem of their own: the environmental impact of burning fuel in combustion engines. As the number of automobiles on the road continues to rise, so do the levels of greenhouse gas emissions, leading to the nearly irreversible climate change the planet is experiencing.

Using human-powered vehicles as an option for short, urban commutes then becomes a question of attempting to save what is left of the environment. Even though human-powered vehicles offer a promising way to reduce greenhouse gas emissions from commutes, they still see little implementation in America. In order to gain more widespread usage, the deep-set opinions of human-powered vehicles held by Americans need to change. Perhaps the easiest way to start this change is with a new generation of human-powered vehicles that have been designed to specifically serve as commuter vehicles. At the most fundamental level, however, it is crucial to understand how the success of a system designed for transportation relies so heavily on the travelers' opinions of that system.

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