USING AUTONOMOUS ELECTRIC VEHICLES TO PROMOTE SUSTAINABILITY

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By

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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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DESIGN OF EFFICIENT LASER CUTTER AND PROMOTING SUSTAINABILITY USING AUTONOMOUS ELECTRIC VEHICLES

Climate change and production of carbon emissions has reached an alarming level in the past decade, with many nations declaring the issue a global emergency. Consequently, there has been a significant increase in media coverage and communication surrounding the topic of the current climate crisis. Despite this growing awareness and social discourse, few solutions to address climate change have been introduced. For instance, research has been done on the Spanish press, radio, and television media to analyze how climate change is discussed in the media and "in 8.8% of the stories covered by the press and 38.4% of television coverage" a potential solution has never been mentioned (Alonso et al., 2021, p. 117). One area of note that has a significant negative impact on carbon emissions production is the field of transportation. Unsurprisingly, the transportation industry, is responsible for 24% of global carbon emissions and this number is likely to continue to grow (Anable et al., 2022, p. 11). While a universal, agreeable solution to sustainability is difficult to achieve, tackling the field of transportation is the necessary first step.

The STS paper aims to combat climate change in transportation by means of implementing autonomous electric vehicles. Autonomous technology is defined as technology that can operate independently from humans and is growing in frequency each day. Many major corporations have reached a point in which autonomy is essential in their continued relevancy. According to Dr. G. V. V. Ravikumar, an associate vice president at Infosys consulting company, "if organizations are really serious about staying at the top, embracing autonomous technologies … is extremely critical (Ravikumar, n.d., para. 14). By using the Social Construction of Technology (SCOT) framework introduced by Trevor Pine and Wiebe Bijker, the impact of autonomous vehicles on environmental and social sustainability is investigated

(Bijker & Pinch, 1984). Allowing different social groups and societies that will be directly affected by the presence, or lack thereof, of this technology to possibly shape the direction of the technology in the future gives them a sense of agency in the matter.

The loosely coupled technical research seeks to promote sustainability in the field of solid waste by means of designing an affordable, highly efficient laser cutter. Solid waste management has become "one of the most urgent and complex socio-economic and environmental challenges of our time," and has seen a significant increase due to "population growth, lifestyle, [and] technological change" (Borthakur et al., 2021, p. 3). In the field of engineering, solid waste is often generated through means of three-dimensional printing and other methods. A particular way to reduce this generation of waste is by means of using a laser cutter. "Several educators have suggested the use of laser cutters in technology education manufacturing courses" as these devices yield less waste due to the precision and specificity of the technology (Flowers & Xu, 2011, p. 20). Existing laser cutter products on the market were surveyed and using this data, the design parameters for the technical project were chosen. The main goal of the project is to maintain high precision and accuracy without sacrificing affordability in order to present a more sustainable option to the market that is not readily available. The project is conducted under the supervision of technical advisor Sarah Sun and alongside team members Borah Choe, Christopher Dauber, and Dong Wook Kim.

Both the technical research and the STS research attempt to promote sustainable efforts, albeit through different avenues. This paper aims to provide a detailed explanation of the STS research and the environmental and societal impact said implementation can provide, whether this be positive or negative. Exploring the impact autonomous vehicles can have on

environmental sustainability could provide a solution to combatting climate change in future years.

THE IMPACT OF AUTONOMOUS ELECTRIC VEHICLES ON ACHIEVING SUSTAINABILITY

CURRENT GLOBAL CILMATE STATE

The production of carbon emissions and its effect on climate change has become a global issue of dire importance in the twenty-first century. Figure 1 highlights the severity of the issue as the average global temperature has increased significantly in just the past twenty years alone.

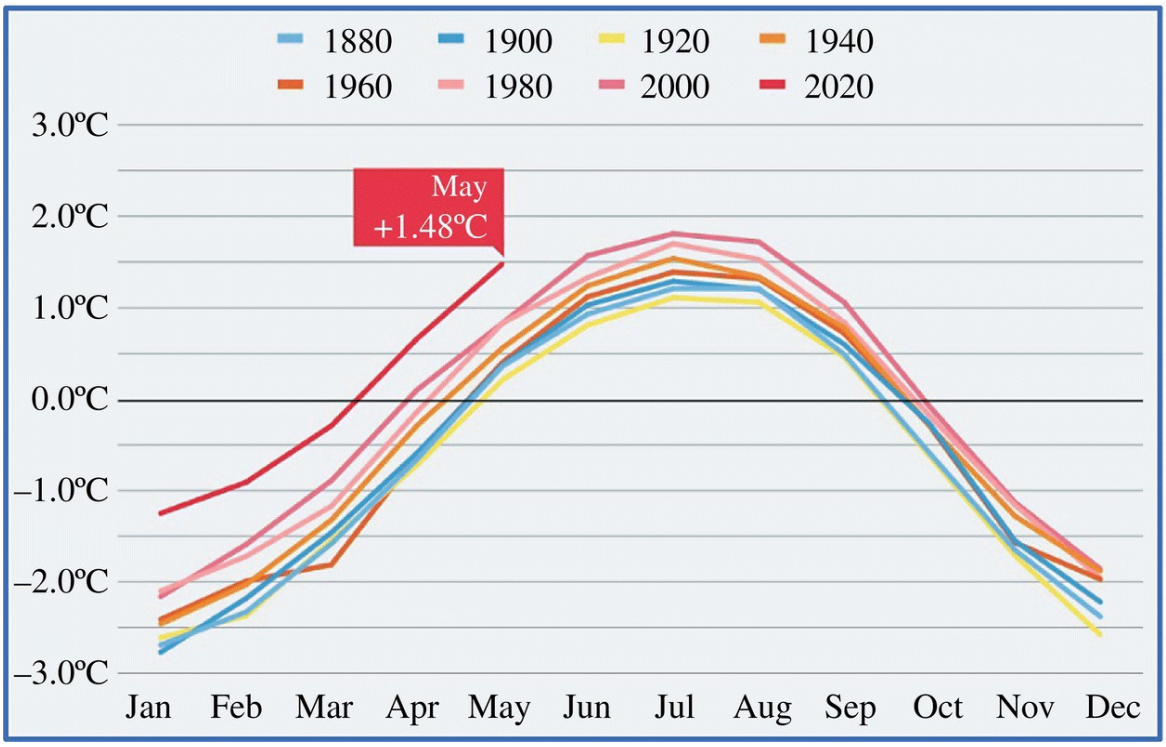

Figure 1: Annual temperature graph. Monthly divergence from average temperature calculated for selected years (Baweja et al., 2021, p. 8)

As previously mentioned, the transportation industry is largely responsible for the pure volume of carbon emission produced globally. The transportation industry is uniquely positioned to enact meaningful change because of the sheer size and impact of the field, thus allowing sustainable practices on a large scale and causing a significant impact that small scale practices such as

cycling simply cannot. This STS research paper specifically observes how autonomous transportation can employ sustainable practices and provide a potential solution to combat climate change on a large level.

REACHING CARBON NEUTRALITY IN THE FIELD OF TRANSPORTATION

While not true for all companies, numerous transportation and delivery companies are making a concerted effort to reduce their carbon footprint. One of the latest major corporations to take action was FedEx as highlighted by an article for *The Washington Post*. In order to reach their goal of carbon neutrality by 2040, FedEx took the following actions:

> The company pledged an initial investment of $2 billion to start electrifying its massive fleet of more than 180,000 vehicles and $100 million for a new Yale Center for Natural Carbon Capture (Butler & Mufson, 2021, p. A18).

While an important step in the right direction, these efforts must be mirrored across the entire automation industry to observe significant change. As the article states, "even if FedEx delivers on its promise of net carbon neutrality, it will remove less than 0.3 percent of U.S. greenhouse gas emissions" (Butler & Mufson, 2021, p. A18). Many other companies feel a similar sense of frustration as there is an immediate need to reduce carbon emissions throughout these companies; however, the technology required to achieve this goal of sustainability can only be researched and manufactured in a deliberate manner. This idea of electrifying the automation industry is paramount to reaching carbon neutrality.

Many urban cities, particularly those in Europe have adopted cycling and walking to combat automobile fuel emissions; however, this solution is not ideal for a multitude of reasons. While a shift away from cars is undoubtedly beneficial to the environment, the change is difficult to implement. A study done in Warsaw, Poland shows that cycling on a city-wide scale is tough to enforce, emphasizing "strict urban policy measures such as changes to infrastructure, services,

prices, or engineering are not, by themselves, sufficient to influence the mindset of decision-makers and potential users regarding modes of transport" (Adamczyk et al., 2022, p. 2). Given the modern age of business and transportation, cycling is simply not maintainable because it is not an efficient use of time and only short distances can be traveled.

IMPLEMENTING ELECTRIC VEHICLES

Introducing autonomous fleets of electric vehicles would greatly reduce overall carbon emissions from the current state of fuel combustion vehicles. Many suggest that an autonomous fleet of electric vehicles would provide a direct, path to overcome the automobile industry's wasteful energy consumption and carbon emissions (Martin, 2020, p. 29). While the process would undoubtedly be difficult to perfect, a systematic public transportation fleet of autonomous vehicles could reduce personal vehicle travel and carbon emissions through optimizing transportation routes all the while ensuring an efficient mode of travel for all people. If full autonomous fleets were to be achieved, general vehicle density would be reduced exponentially as self-driving taxis or buses would become the social norm. Electrification of vehicles is a monumental step toward environmental sustainability as electric vehicles have a significantly smaller carbon footprint than gasoline cars, but taking this another step further and reaching full autonomy would lead to a massive decrease in production of greenhouse gases. While this complete shift in transportation can dramatically reduce the transportation industry's carbon footprint, it can also encourage the research and manufacturing of completely carbon-neutral technology in other similar fields.

Thomas Porter, a researcher at the Big Data Analytics Research Unit in Dublin, Ireland, conducted several surveys and experiments finding that autonomous vehicles increase efficiency without human error; as shown in Figure 2 on page six, surveys reveal that there was an eighty

percent relevance in reduction of traffic accident-related costs and a sixty-two percent relevance in decreased fuel consumption of autonomous vehicles.

Table 8 Autonomous vehicle benefits to the mobility ecosystem (%, relevance)

Traffic safety improvements	82
Reduction of traffic accident-related costs	80
Increased mobility for elderly, disabled	77
Expanding car- and ride-share programs	75
Traffic network efficiencies	73
Decline in vehicle ownership and vehicles per family	67
Decreased fuel consumption	62

Sources: EY; my survey among 4,100 individuals conducted January 2020.

Figure 2: Autonomous vehicles table. Survey of autonomous vehicle benefits to the mobility ecosystem (%, relevance) (Porter, 2020, p. 34)

Not only does the data show a significant decrease in fuel consumption but also a decline in vehicle ownership which ultimately leads to a reduction in carbon emissions. Furthermore, there is a substantial improvement in traffic safety and mobility for elderly or disabled communities. The benefits of autonomous vehicles are present on a social level as well as an environmental one.

Complications Regarding Autonomous Electric Vehicles

Naturally, the process of electrifying autonomous fleets of vehicles is very complicated, with traffic engineers determining the specific conditions needed for free flow transportation with little to no accidents (Meyboom, 2019, p. 160). Extensive research and testing is required to ensure the safety of all people involved before this technology can be implemented on a large level. Attaining universal trust in autonomy is one of the major complications regarding the implementation of these vehicles. Despite its growing popularity, there is an argument that autonomous machines will inevitably be used “to replace human workers” (Ozturkcan & Merdin-Uygur, 2021, p. 1). There is a persistent fear among society that increase of autonomy in

the workspace can lead to economic detriment. Although people may believe that manufacturing jobs will be lost to automation in the years to come, this technology can make workers' jobs safer and easier while simultaneously promoting environmental and social sustainability. In an article from the *Journal of Environmental Psychology*, Cowen et al. argued that automation "technology touted as a solution may divert effort from individual action to mitigate environmental impact" (Cowen et al., 2015, p. 139). Diverting all time and scientific resources to studying these autonomous vehicles could hinder the research and exploration of other sustainable efforts. Therefore, it is important to introduce this technology in a gradual manner to allow opportunities for additional sustainable practices as well.

Another potential barrier that would make implementing electrical autonomous vehicles difficult is the political polarization that has occurred in the past decade. Issues and policies regarding sustainability efforts and climate change are more difficult to navigate than ever in today's political climate. In a fascinating article by Örjan Bodin, a researcher of environmental governance at the Stockholm University Resilience Center in Sweden, details the recent increase in politicization of environmental and sustainability concerns in the past few years. He argues that "sustainability research can do better at balancing the concerns of the left and the right" sides of the political spectrum (Bodin, 2021, p. 2152). Bodin seeks to encourage a more open and formal debate regarding environmental policies such as climate change or else significant progress cannot be made. A universal solution is difficult to achieve but Bodin proposes two possible solutions:

> [1] various forms of government interventions and regulations
> [2] economic incentives and market mechanisms (Bodin, 2021, p. 2152).

Discourse considering environmental issues, while frustrating, is imperative as long as extreme polarization and political gridlock does not occur. Complete objectivity is impossible when discussing any important issues, let alone sustainability, as everyone possesses personal biases. Attempting to eliminate these biases completely is not the solution- instead society should focus on actively listening and understanding opposite thinking beliefs and how a mutual agreement rooted in factual science can be formed.

SOCIETAL BENEFITS OF IMPLEMENTING AUTNOMOUS VEHICLES

In addition to environmental sustainability, autonomy can also lead to a dramatic increase in social sustainability such as fair labor practices, social equity, and satisfactory health and safety conditions. This could help persuade skeptics of the technology as the benefits are greater than just environmental improvement. For example, "reducing automobile dependency and encouraging people to walk" could lead to more social encounters in the city, thus improving social relationships and community engagement (Cugurullo, 2021, p. 82). Autonomous vehicles can also provide mobility and transportation for elderly and disabled communities. Furthermore, a social divide would be less apparent between different classes of wealth as autonomous bus transportation could be affordable for all parties. Eileen Crist, William J. Ripple, and Christopher Wolf, three journalists for the scientific journal collection *SpringerLink*, propose six transformative steps for mitigating climate change:

[1] energy- replacing fossil fuels
[2] short-lived pollutants- reducing methane, black carbon (soot), and hydrofluorocarbons
[3] nature- protecting and restoring Earth's ecosystems for sequestering carbon
[4] food- eating mostly plant-based foods, improving cropping practices, and curbing food waste
[5] economy- shifting from unlimited GDP growth to ecological economics and sustainable monetary practices
[6] human population- curbing population growth in the context of social justice (Crist et al., 2021, p. 1753)

The article highlights that climate change mitigation can be realized while still placing an emphasis on population policies that could promote social justice and gender equity. As seen in Figure 3 on page nine, social justice and population issues are rarely discussed when dealing with climate change policy. Implementation of autonomous technology such as transportation vehicles could serve as a gateway between environmental sustainability and social sustainability issues that are often undervalued when concerning climate policies.

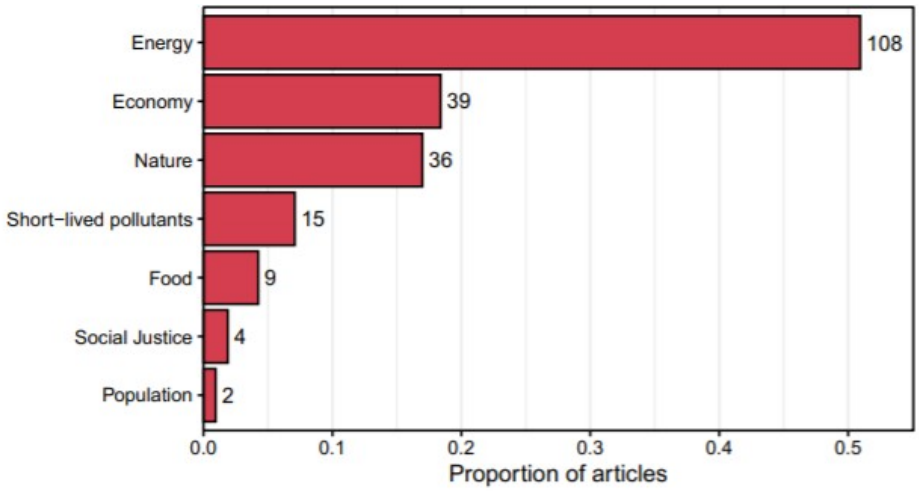

Figure 3: Climate change articles graph. Proportion of the 212 Nature and Science climate change policy articles dealing with each topic (Crist et al., 2021, p. 1754)

Autonomous fleets of electric vehicles could simultaneously combat climate change and serve as a means of transportation for underprivileged communities that do not always have access to reliable, affordable transportation.

The Social Construction of Technology (SCOT) framework introduced by Trevor Pinch and Wiebe Bijker is used to investigate the impact of autonomous technology on environmental and social sustainability (Bijker & Pinch, 1984). As seen in Figure 4 on page ten, the center party, in this case the engineer, communicates and exchanges information with the other relevant social groups affected by the specific autonomous technology, in this case electric vehicles. Therefore, different social groups and societies can express their interests, as well as their

concerns, about the technology and advocate for policies and legislation that will reflect their ideas. Consumers and normal individuals can have a direct say and impact on autonomous technology. Therefore, their assessments and desires can be well reflected in the eventual product of the vehicles created by engineers.

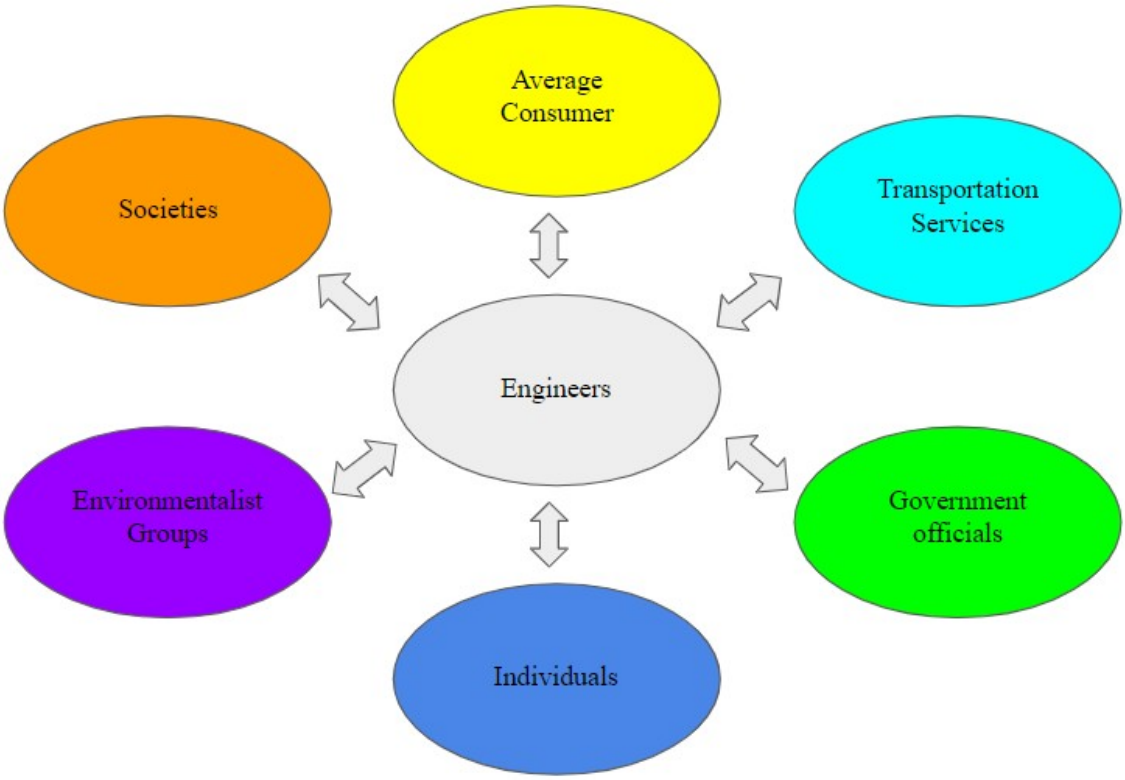

Figure 4: Sustainable autonomous technology SCOT model. The engineers facilitate information among various social groups to shape future technology (Lloyd, 2021)

For example, if the public generally is skeptical of safety issues concerning autonomous vehicles, this information can be relayed to government officials and eventually engineers. Consequently, adjustments can be made accordingly such as implementing electric vehicles with low degrees of autonomy and gradually building to a high level of autonomy.

FUTURE IMPLICATIONS OF AUTNOMOUS VEHICLES

Since the process of implementing autonomy on a large scale is a long and strenuous one, small goals can be met in the meantime. Before reaching any degree of autonomy, transferring to complete electrification in the automobile industry would greatly reduce carbon emissions. David Zipper, a Visiting Fellow at the Harvard Kennedy School's Taubman Center for State and Local Government, argues against the swift implementation of vehicles, claiming this technology may not be as safe and beneficial as we assume; however, he highlights a valuable notion that the average person could partake in simple tasks such as "promoting transit and cycling instead of driving" while this technology is being perfected (Zipper, 2022, para. 20). While simple tasks such as these do not provide a large-scale, universal solution to combat climate change, minor sustainable practices can be performed while the autonomous electric vehicles continue to be researched. Given the proper time and resources, autonomous electric vehicles can mark a monumental step towards achieving carbon neutrality and promoting a sustainable lifestyle.

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