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The Trucking Industry needs to catch up: A proposed solution to advance the trucking industry towards clean energy (STAS - Solar-Powered Trailer Amplification System).

PART A: RATIONAL

In recent years the automotive industry has been shifting to electric vehicles, a more environmentally friendly practice; why not the trucking industry? The trucking industry is a part of the transportation industry, responsible for 27% of the world's carbon emissions and 26% of the emissions produced by the transportation industry. In the United States, more than 4 million semi-trucks are on the road daily. The trucking industry is a vital part of the United States economy, commonly relied on throughout the country. Being the backbone of the American economy, the trucking industry is responsible for transporting 70% of all freight in the United States. Select a random product such as raw materials, manufactured goods, or food; chances are at some point in time that produce spent time on a truck being transported.

Why is this important? Currently, there is a significant emphasis in the consumer sector of the automotive industry to transition away from the internal combustion engine and shifting towards electric vehicles. While efforts are being made to do the same for the commercial trucking industry, not as much progress is being seen. For instance, in the United States, over 2 million electric vehicles have been sold to date, with that number only increasing yearly. When compared to electric trucks, that number is roughly only 45,000. With the trucking industry responsible for producing 26% of carbon emissions in the transportation industry, there are growing concerns and pressures to convert to electric. However, that is easier said than done. Electric semi-trucks are starting to roll out onto the market, such as the Volvo VNR electric, and others are being developed, such as the Tesla semi-truck, in the near future. However, when it comes to electric semi-trucks, taking into account the necessity for a more extended range and accomplishing this while pulling 80,000 pounds behind the truck can take time, effort and is challenging.

Thus, STAS (Solar-Powered Trailer Amplification System) was developed to help minimize this problem of range and battery longevity. By creating these so-called "smart trailers," which contain automatic sun-tilting solar panels to obtain maximum efficiency, they help increase the mileage range of the electric semi-trucks of the future. One step at a time, with the added range, helps more efficiently run specific trucking routes, which previously would not be able to be done without having to stop to recharge. Pairing this technology with the electric

semi-trucks of the future helps provide an important advance in mileage to the trucking industry and its effort to become carbon neutral.

PART B: RESEARCH QUESTION(S), HYPOTHESIS(ES), ENGINEERING GOAL(S), EXPECTED OUTCOMES

A. RESEARCH QUESTIONS

1. What can be done to advance the trucking industry to green energy?
2. What difference does adding solar panels to the roof of a trailer make?
3. Is it worth adding solar panels to the top of a trailer?
4. How can this benefit the trucking industry?
5. Can this be integrated into everyday practice?

B. HYPOTHESIS

With society looking for cleaner energy sources and shying away from energy sources that release high carbon emissions to the environment, an emphasis has been placed on electric cars, but why not trucks? This question spurred the creation of this research project in hopes of steering the trucking industry toward that direction of clean energy by taking a one-step-at-a-time approach to solving a complex problem. STAS (Solar-Powered Trailer Amplification System) creates a more efficient way to go about trucking with not much extra work being required. Thus creating a simple, cost-effective solution to improve the range of current electric semi-trucks so that the range is no longer a significant con when shifting to electric.

C. ENGINEERING GOALS

STAS aims to analyze the significance of using already existing trailers and maximizing their utility by using the allotted roof real estate to harness the power of the sun, using it to benefit the trucking industry. Additionally, to look at how a small aspect can make a difference in advancing the industry forward. The project utilizes readily available technology to create a simple solution of increasing the range just enough so it can create a major impact in the field. Having an extra 25 miles is the difference between having to stop and recharge for 30 minutes versus being able to complete the journey in one trip. The example route used for this research was Toronto to Port Newark. Over time, the time adds up, and this time saving can seriously affect a trucking company. Being able to drive an electric semi-truck to complete a long-distance route without stopping is a significant accomplishment. Using STAS in coordination with the drowsy driving law so that electric semi-trucks can operate for as long as it is deemed legal for the driver to drive.

STAS lines the roof of a trailer with solar panels attached to a rotating augmentation system which is manipulated by a servo. The servo can tilt the panels by utilizing a linkage

running through a support beam on the trailer which can manipulate the panel on a z-axis. The whole point behind the manipulation of the solar panels is to ensure that they are always facing the sun, ensuring maximum efficiency from the solar panels at all times. In the prototype, the panels that are 3 inches by 2.5 inches will be used to line the roof of a model trailer used for the concept prototype “smart trailer.” Since the whole purpose of the panels rotating is for maximum power optimization, the usage of photoresistors and the values they generate makes the sun dictate the orientation of the panels. The panels will move towards the optimal angle to extract the most energy from the sun.

D. EXPECTED OUTCOMES

After the completion of the project, the expected outcomes include a step in the right direction to advance the trucking industry toward a greener future. It can be found that there are alternative routes to getting a product from point A to point B using a truck, that little by little, the industry can begin to rely on electric semi-trucks. Using solar technology can increase the mileage of electric semi-trucks with minimal work having to be done. An increase in that, solar “smart trailers” paired with an electric semi-truck can run during the day as efficiently as a diesel truck.

PART C: DESCRIPTION OF PROCEDURES, RISK AND SAFETY, DATA ANALYSIS

A. PROCEDURES

1. Research information about standard trailer specifications in the United States along with a specific solar panel on the market.
2. Perform calculations to determine the maximum amount of output the solar panel can produce on the trailer.
3. Research information about an electric semi-truck being developed/on the market.
4. Use all the information gathered so far to see how effectively adding solar panels can affect the range of the truck.
5. With the information gathered, design a schematic using TinkerCAD circuits. This schematic consists of an Arduino Uno, two photoresistors, one micro servo, two resistors, and the allotted wiring necessary.
6. Develop a code that uses the photoresistors to manipulate the micro servo by turning it in a direction based on the amount of sunlight gathered.
7. Test this schematic to ensure that it properly works with the code.
8. Create a CAD model and renders using Autodesk Fusion 360 and Inventor, which is used as a basis for the diorama. The cad should include a 1:1 scale trailer and a mechanism to secure and manipulate the solar panel array.
9. CAD the parts that are required to be 3D printed using Autodesk Fusion 360.

10. Use Autodesk CFD to gather air resistance calculations based on the new trailer design and analyze how that may affect mileage. This data is also used to perform more analyses.
11. Use Cura to scale the solar panel securing mechanism cad and 3d print the components.
12. Assemble the diorama.
    a. Using a model trailer, secure the 3d printed components to the roof.
    b. Drill an access hole through the truck to thread the linkage used to attach the panels to the servo.
    c. Attach the solar panels to the 3d printed components.
    d. Replicate the Tinkercad schematic in real life and attach it to the front of the model trailer
    e. Attach the servo to the bottom of the trailer and link it to the panels.
    f. Add the battery inside the trailer.
    g. Connect to power and test.

B. RISK AND SAFETY

All of the procedures and stages of research were conducted in a laboratory with proper safety precautions to avoid any risk or injury. This includes wearing the appropriate safety protection when using tools. Additionally, laboratory equipment was safely handled under adequate supervision from the adult sponsor. The adult sponsor executed the proper teaching and instruction prior to the use of any tools.

C. DATA ANALYSIS

To analyze STAS' effectiveness, calculations are performed to ensure theoretical possibilities of success. Additionally, physical testing is done to ensure that the prototype consistently works and can produce results for its scale. This physical testing is created by beta testing, having the researcher use a flashlight to simulate the sun and holding that flashlight up to the photoresistors to analyze how the circuit reacts. Along with voltage and battery level readings to confirm that the circuit is functioning up to its intended purpose. A combination of calculations and physical testing can ensure the effectiveness of the small-scale prototype of the Solar Powered Trailer Amplification System, as calculations can back the physical testing.

D. PART LIST

a. Applications:
    - Autodesk Fusion 360 2023
    - Autodesk Inventor Professional 2023

- Autodesk CFD 2023
- TinkerCAD
- Arduino IDE
- Cura Ultimaker

b. Electronics
   - **1:** Arduino Uno
   - **7:** Solar Panels (3in by 2in)
   - **2:** Photoresistors
   - **1:** micro servo
   - **2:** 10k Ω resistors
   - **1:** Battery
   - Inverter
   - Wiring

c. Diorama
   - Model Trailer
   - 3D Printed Components
     - Linkage
     - Solar Panel Mount
     - Pivot Axis Shaft
   - Hand Drill
   - Paper
   - Polycarbonate
   - Glue
   - Tape
   - Paint

PART D: BIBLIOGRAPHY

"Semi." Tesla, https://www.tesla.com/semi.

EPA, Environmental Protection Agency, https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions.

"Series 6 Family." *Family | First Solar*, https://www.firstsolar.com/en/Products/Series-6.

Paulos, Rohan. "53' Trailer Dimensions: Length, Width, Weight & Height!" *Truck & Car | RVs Reviews By Auto Renting Tutors*, Truck & Car | RVs Reviews By Auto Renting Tutors, 28 Sept. 2022, https://www.miramarspeedcircuit.com/dimensions-of-53ft-trailer/.

William Anderson Director, and Marta Leardi-Anderson Executive Director. “Keep on Trucking: Trucks Must Keep Moving across Canada-U.S. Border amid Coronavirus.” *The Conversation*, 20 July 2022, https://theconversation.com/keep-on-trucking-trucks-must-keep-moving-across-canada-u-s-border-amid-coronavirus-134223#:~:text=On%20an%20average%20day%2C%20about%2030%2C000%20trucks%20roll,both%20countries%20would%20cease%2C%20idling%20thousands%20of%20workers.

“What You Need to Know about Semi Trailer Construction.” *Boxwheel Trailer Leasing*, 12 Mar. 2020, https://boxwheel.com/what-you-need-to-know-about-semi-trailer-construction/#:~:text=Now%20the%20most%20common%20trailers%20on%20the%20road%2C,These%20semi%20trailers%20have%20many%20positive%20characteristics%2C%20including%3A.