# Valencia Team

IEEE Orlando Section

Application For Funding

**Project Addressing Climate Change:**

# *Solar Powered Ventilation with Controlled Airflow for Parked Cars*


**Daniel Eisenbraun** [IEEE # 98706125]

**Ian Matheson** [IEEE # 98579639]

Supervisor:

**Dr. Masood Ejaz** [IEEE # 92131157]

**Department of Electrical & Computer Engineering Technology (ECET)**

**Division of Engineering, Computer Programming, & Technology**

**Valencia College**


2022 - 2023


Contact: Daniel Eisenbraun & Ian Matheson

deisenbraun@mail.valenciacollege.edu

imatheson@valenciacollege.edu

## Introduction:

Cars parked in direct sunlight are subject to a greenhouse effect. Solar radiation passes through the windows of the car and becomes trapped, heating the cabin air up to 45 °F hotter than the exterior air in just an hour [1]. *Table 1* shows how interior air temperature rises over the course of an hour for various outside air temperatures. This effect generates several issues. For one, the capacity of the car's AC must be large enough to deal with the excessive thermal load [2]. Cabin elements such as seats, dashboard, and vehicle electronics are subject to damage. The high temperatures also create an unsafe environment for humans and pets.

*Table 1 - Estimated Vehicle Interior Air Temperature v. Elapsed Time* [1].

**Estimated Vehicle Interior Air Temperature v. Elapsed Time**

| Elapsed Time | Outside Air Temperature (F) | | | | | | | | | % of 1-hr Rise 43° Rise |
|---|---|---|---|---|---|---|---|---|---|---|
| | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | |
| 0 minutes | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | |
| 10 minutes | 89 | 94 | 99 | 104 | 109 | 114 | 119 | 124 | 129 | 44% |
| 20 minutes | 99 | 104 | 109 | 114 | 119 | 124 | 129 | 134 | 139 | 67% |
| 30 minutes | 104 | 109 | 114 | 119 | 124 | 129 | 134 | 139 | 144 | 79% |
| 40 minutes | 108 | 113 | 118 | 123 | 128 | 133 | 138 | 143 | 148 | 88% |
| 50 minutes | 111 | 116 | 121 | 126 | 131 | 136 | 141 | 146 | 151 | 95% |
| 60 minutes | 113 | 118 | 123 | 128 | 133 | 138 | 143 | 148 | 153 | 100% |
| > 1 hour | 115 | 120 | 125 | 130 | 135 | 140 | 145 | 150 | 155 | |

Estimated

## Project Description:

The main objective of the Solar Powered Ventilation system is to remove trapped heat from a parked vehicle such that the air temperature in the vehicle is as close to the ambient air temperature outside the vehicle as possible. To accomplish this goal, the system will require a power module, cooling module, and control module.

### Power Module

This module will consist of a roof mounted solar PV array, the car battery, and PWM charge controller. The latter is required to charge the lead-acid battery of the car and protects against over-charging, over-discharge, over-current, and inverse current. The battery will then power the control and cooling modules. Activation and deactivation of the system will be done manually with a switch. Automatic deactivation will occur in two scenarios:

1. The battery voltage falls to 12.0 V, at which point the PWM controller will disconnect the load until the battery is charged to 12.6V.
2. Any of the windows is too high for the fans. Further detail is provided in control module.

### Cooling Module

The cooling module consists of centrifugal DC blowers, mounting hardware, nozzles for directing airflow from the intake centrifugal fans, and vent visors which will be used to mount the centrifugal fans to the sides of the car windows while parked. A CAD rendering of the proposed vent-fan assembly is given in *figure 1*.

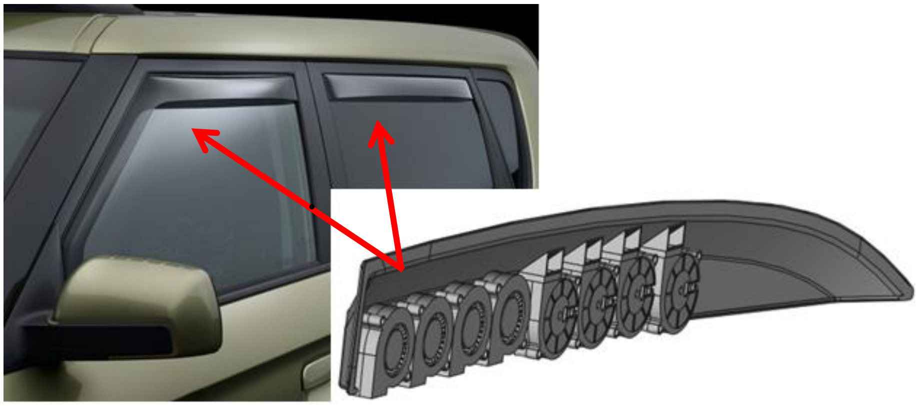

*Figure 1 – Model of vent visor fan assembly and installation area.*

**Control Module**

The control module consists of a single Raspberry Pi Pico MCU, programmed to control the fans through optocoupled relays. It will schedule and process measurements from IR proximity sensors, temperature sensors, and battery voltage sensor. Window position will be monitored with a proximity sensor in each vent visor. If any of the windows are raised too high for the fans, the MCU will force all fans off. The external temperature at each window will be monitored through a thermistor circuit, also mounted in each vent visor. Any measured temperature differential between windows will cause the MCU to control the direction of airflow such that air is taken in from the coolest windows and exhausted from the hottest windows. If there is no temperature differential, a default airflow direction has been specified on our website. Finally, a voltage divider with current limiting resistors will provide the battery level to the MCU, which will then adjust the number of active fans proportional to battery voltage.

**Uses and Limitations**

This device does *not* provide active cooling and is thus limited in its capacity to cool the vehicle to, at the lowest, the outside ambient air temperature. Therefore, all testing will be done in reference to a second vehicle without the device.

## Expected Outcomes:

The fuel consumption of a car can be increased by up to 20% due to AC usage. Over 10 years, the fuel burned by the AC can produce up to 4,600 kg of $CO_2$ over 10,000 km per year [3]. The AC's efficiency is especially diminished when the car first starts up after being parked in sunlight for extended periods, as it must work harder to remove the trapped heat from the car. By reducing the initial load on the car AC, the solar powered ventilator has the potential to save fuel and reduce $CO_2$ emissions. Trapped heat also damages the vehicle's interior, causing the dashboard, leather seats, steering wheel, and more to dry out and crack [4]. Electronics in the vehicle are also subject to wear and eventual failure [5]. These damages serve to shorten the vehicle's lifespan and call for excessive repairs.

As the climate continues to warm, hot vehicle interiors become even more dangerous. Approximately 38 children die from heat stroke each year in the U.S. [6]. The same can be said for hundreds of pets each year [7]. Not even the driveway is a safe place to keep a hot vehicle when left unlocked, as any children that can get access to the vehicle are at risk of heat stroke. Heat stroke can occur when body temperatures rise to 104 °F [8], and a parked car can reach 104 °F in just 30 minutes with outside temperatures of 70 °F according to *Table 1*. The Solar Powered Ventilator aims to help vehicle owners adapt to the rising climate by reducing internal vehicle temperatures. Though ventilation may not eliminate the possibility of injury or death, it may reduce the frequency of such occurrences.

## Expected Budget:

This project requires a large quantity of small DC fans. These will constitute a significant portion of the budget, though further investigation has allowed us to cut the costs of the fans nearly in half. The 100 W solar panel contributes another significant portion. The vent visors, charge controller, MCU, sensors, relays, various electronic components, wiring, and hardware make up the rest of the component budget. Necessary testing materials have also been added to the budget for consideration. The full proposed budget is broken down in *Table 2*.

*Table 2 – Proposed Budget*

| Item | Unit Price | Qty. | Vendor | Subtotal |
|---|---|---|---|---|
| **Project Components** | | | | |
| Kia Soul Sport Visors OEM U8220 2k000 | $28.95 | 1 | eBay | $28.95 |
| 100W Solar Panel | $79.99 | 1 | Solar Savings World | $79.99 |
| Brushless 12V DC Blower (4-Pack) | $7.99 | 11 | Amazon | $87.89 |
| Thermistor (5-Pack) | $8.43 | 1 | Amazon | $8.43 |
| Raspberry Pi Pico H - Pico with Headers Soldered | $5.00 | 1 | AdaFruit | $5.00 |
| 3.3V Relay Power Switch Module | $15.99 | 2 | Amazon | $31.98 |
| Current Sensor | $9.99 | 1 | Amazon | $9.99 |
| SPDT Switch | $0.82 | 1 | Digi-Key | $0.82 |
| PWM Charge Controller for Lead Acid Battery | $12.98 | 1 | Amazon | $12.98 |
| EDECOA Battery Cables 3 AWG | $34.99 | 1 | Amazon | $34.99 |
| Electronic Components [Resistors, Capacitors, Diodes, LEDs, IR LED, ICs] (Assorted) | $7.00 | 1 | Supplied by Group | $7.00 |
| 18 Gauge Wire | $7.00 | 1 | Supplied by Group | $7.00 |
| Screws and Nuts | $5.00 | 1 | Supplied by Group | $5.00 |
| Total Cost of Components | | | | $320.02 |
| **Testing Materials** | | | | |
| Shade Tent | $79.99 | 1 | Amazon | $79.99 |
| Temperature Sensors (4PC, Internal) | $13.99 | 2 | Amazon | $27.98 |
| Temperature Sensors (2PC, External) | $10.49 | 2 | Amazon | $20.98 |
| IR Temperature Gun (Surface) | $27.37 | 1 | Amazon | $27.37 |
| Total Cost of Testing Materials | | | | $156.32 |
| Contingency | | | | $50.00 |
| **Grand Total** | | | | **$526.34** |

# References:


[1] J. Null, "Vehicle Heating Dynamics," *Department of Meteorology and Climate Science, San Jose State University*, 2018. https://www.noheatstroke.org/vehicle_heating.htm (accessed Oct. 27, 2022).

[2] J. Rugh and R. Farrington, "Vehicle Ancillary Load Reduction Project Close-Out Report: An Overview of the Task and a Compilation of the Research Results," 2008. [Online]. Available: http://www.osti.gov/bridge

[3] "Vehicle air conditioning." https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/choosing-right-vehicle/tips-buying-fuel-efficient-vehicle/factors-affect-fuel-efficiency/vehicle-air-conditioning/21030 (accessed Oct. 29, 2022).

[4] A. Hess, "How To Protect Your Car From Heat Damage," *Insuramatch LLC*, Jul. 10, 2017. https://www.insuramatch.com/blog/how-protect-your-car-heat-damage (accessed Oct. 29, 2022).

[5] "Hot, hot, hot!," *Electrical and Computer Engineering, College of Engineering, Carnegie Mellon University*, 2021. https://www.ece.cmu.edu/news-and-events/story/2021/06/hot-electronics.html (accessed Oct. 29, 2022).

[6] J. Null, "Heatstroke Deaths of Children in Vehicles," *Department of Meteorology and Climate Science, San Jose State University*, 2022. https://www.noheatstroke.org/index.htm (accessed Oct. 29, 2022).

[7] "Pets in vehicles," *American Veterinary Medical Association*. https://www.avma.org/resources-tools/pet-owners/petcare/pets-vehicles (accessed Oct. 29, 2022).

[8] Mayo Clinic Staff, "Heatstroke - Symptoms and causes," *Mayo Foundation for Medical Education and Research (MFMER)*. https://www.mayoclinic.org/diseases-conditions/heat-stroke/symptoms-causes/syc-20353581 (accessed Oct. 29, 2022).