Delphi Solar Powered Fan and Heater Design
Client-Driven Project
Penn State of Mind

EDSGN 100
Penn State College of Engineering
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I. Executive summary

The main objective for this Delphi consumer-driven project was to innovate a product that would decrease the environmental impact of cars while still preserving a car’s initial levels of safety and vehicle-to-vehicle connectivity. With a specific focus on internal automobile temperature regulation, our team went through an extensive concept generation process researching existing temperature controls and brainstorming how each product or idea could be improved and adapted to a car. Every generated potential concept was listed on a concept generation matrix and evaluated which allowed us to finally able to narrow down our project to a solar powered fan and heater. The winning concept would roughly have three main components, a fan and a heating system, both connected to one solar panel and the idea behind this product was to create a means for drivers to have more control over the internal temperatures of their cars while the car is not in use. Our design, which will be described in more detail below, is a simple and effective method that can be implemented on all vehicles thus lowering the level of environmental harm cars inflict upon the environment.

II. Introduction

Currently in the automobile industry, cars rely heavily on AC/heating systems to regulate their internal temperature. This process is very energy draining as car temperatures change drastically due to the temperature of the external environment when the car is not in use. In attempt to maintain a more stable and regulated temperature, drivers sometimes will choose to roll down or up their windows when the car is not in use though this is still not a very efficient and effective method of temperature control. When in their cars, drivers typically depend heavily on their heating and AC units. Although these are effective methods of temperature control, they are not efficient or environmentally friendly as heat will be lost/gained when the car is not in use meaning that the heater or AC will have to be turned on again when people finish running errands and come back to their cars.

In order to address this problem, the purpose of our project was to implement a solar fan and heating system into a vehicle that would serve as a way for drivers to regulate their vehicle’s internal temperature while the car is temporarily not in use. The idea for this product came mostly from the Kulcar® solar fan product which was developed by the Taiwanese engineering company Sonray Technology, Inc. The aim of this product is not to replace the AC and heating units in cars (as that would require much more solar power) but rather to provide people with an effective yet environmentally friendly means to maintain their car’s warm or cool temperature in the winter or summer when they are not in their car while running errands. This product can also be turned on before a driver needs their car as a way to lower or raise their vehicle’s internal temperature to a more comfortable level before the AC or heating unit takes over during driving, similar to how people preheat their cars in the winter. During times of milder weather such as the fall and spring, the AC/heating may not even need to be used as no drastic change in temperature is needed.

Ideally, this product will prevent people from having to raise or lower their car temperature from the stifling heat of summer or freezing cold of winter of the external environment. Moreover, during the summer, car temperatures will actually exceed the temperature of the outside environment therefore, the solar fan will help lower temperatures so the internal environment is not unbearable when driver’s return to their vehicle.

By using this product, drivers will not only make the environment of their car more comfortable but this solar fan and heater will also increase their car’s efficiency as the more regulated, maintained
internal temperature means that a vehicle will not have to allocate as much power and energy on the AC/heating units.

Even though the solar fan must be attached to a window to allow air flow, this product will not compromise the safety of cars as the fan is compact enough not to obstruct the driver’s view when driving and the solar heater can be placed virtually anywhere inside the car. The solar powered fan/heater will also have no effect on a vehicle’s connectivity as it is not linked to any external information providing systems.

III. Research

Using your car’s air conditioning takes power away from the engine, reducing fuel efficiency. In fact, AC use can reduce fuel efficiency by 25% or more \(^6\). The concept of trying to increase fuel efficiency by reducing air conditioning use is not a recently generated idea. A common misconception is that driving with your windows down will increase fuel efficiency due to the lack of using air conditioning. However, driving with your windows down will actually reduce your car's fuel efficiency due to the large amount of drag created by the open windows \(^7\). The poor aerodynamics of the car counteracts the savings in heat reduction. Products have hit the market to try and tackle this problem. Most are fans that are positioned on at the top of a slightly opened window and blow the hot air out of the car. Small inefficient fans can cost as little as ten dollars while more expensive ones can cost up to $130 \(^8\).

Electric car heaters are available for purchase as well but it should be noted that the use of your heater while driving does not affect a car’s mpg \(^9\). People usually lose gas due to heating when they try and preheat their car in the winter. A cheaper electric car heater can cost as low as $20 and a more expensive one can cost over $100 \(^10\).

IV. Customer Needs

<table>
<thead>
<tr>
<th>Statement</th>
<th>Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>I don’t want to purchase a new car for the new feature</td>
<td>Inexpensive, it will pay off quickly</td>
</tr>
<tr>
<td>The new technology should not be using up my car battery</td>
<td>Use solar panels as the main source of energy, the car battery will serve as a energy energy</td>
</tr>
<tr>
<td>Added technology should not decrease my mileage</td>
<td>Product will be lightweight</td>
</tr>
<tr>
<td>Should not deter from the aesthetics of the car</td>
<td>minimal adjustments to visual appeal/ added features should be modern</td>
</tr>
<tr>
<td>New feature should be easy to learn and use</td>
<td>simple design, minimal effort put forth by driver</td>
</tr>
<tr>
<td>New feature should be reliable</td>
<td>The product will have a strong product integrity</td>
</tr>
</tbody>
</table>
Fan and heater will not have any negative effects on the car. Solar panels will be well insulated. The solar panels will not affect the windows.

Fan and heater actually make a difference in heat regulation. Fan will help reduce temperature and heater will help to preheat car.

It will have a positive effect on the environment. The fan/heater will help with decreasing the amount of pollution produced.

V. Target Specifications

<table>
<thead>
<tr>
<th>Need</th>
<th>Acceptable</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Reduction from Fan</td>
<td>up to 68°F more</td>
<td>up to 75°F more</td>
</tr>
<tr>
<td>Gas Consumption Saved by Fan over 3 months</td>
<td>up to 20 gallons</td>
<td>up to 40 gallons</td>
</tr>
<tr>
<td>Health Benefits</td>
<td>a solar fan helps to reduce volatile chemical build up because it refreshes the interior air</td>
<td></td>
</tr>
<tr>
<td>Environmental Benefits</td>
<td>cold engine can produce 50-100 times more greenhouse gas emissions which the car preheater will help to reduce</td>
<td></td>
</tr>
<tr>
<td>Car Benefits</td>
<td>helping to warm the engine will deliver better fuel economy, improve oil flow, and reduce wear of engine which will increase the life</td>
<td></td>
</tr>
<tr>
<td>Amount of Air that Goes through Fan</td>
<td>45 cfm</td>
<td>55 cfm</td>
</tr>
<tr>
<td>Voltage Output by Solar Panel</td>
<td>120V</td>
<td>135V</td>
</tr>
<tr>
<td>Voltage needed for Heater</td>
<td>120V</td>
<td>120V</td>
</tr>
<tr>
<td>Volts needed for Fan</td>
<td>9V</td>
<td>9V</td>
</tr>
<tr>
<td>Needs to be Lightweight</td>
<td>Kulcar-0.5lb</td>
<td>Heater- 2lb</td>
</tr>
</tbody>
</table>
VI. Concept Generation & Concept Selection

As seen in the concept generation table below, as a group, we were able to research and generate five distinct potential solutions to regulate car temperature. Varying weights for each criteria allowed us to differentiate and numerically rate each solution’s effectiveness. Temperature regulation effectiveness and seasonal use (the ability to use our product year-round) were given the most weighting as temperature control was the main objective of our project and seasonal use is important as consumers would be less willing to buy a product if they are only able to use it in the winter (heating system) or only in the summer (cooling system). With a maximum of 5 total point for each category, we were then able to rate each solution. Subcategory ratings and total ratings can be found in the decision matrix below:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Cost</th>
<th>Temp. Reg. Effectiveness</th>
<th>Easiness of Use</th>
<th>Seasonal Use</th>
<th>Aesthetics</th>
<th>Sun Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>20%</td>
<td>30%</td>
<td>10%</td>
<td>30%</td>
<td>10%</td>
<td>100%</td>
</tr>
<tr>
<td>Rating</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Weighted Score</td>
<td>0</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Rating</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>2.1</td>
</tr>
<tr>
<td>Weighted Score</td>
<td>0</td>
<td>1.8</td>
<td>1.6</td>
<td>1.3</td>
<td>1.3</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Our Solar Heater/Fan concept has the highest rating of all five concepts with a sizable one point lead over the concepts of solar fan and solar heater on their own. The combined concept allows for a higher rating in seasonal use which was our number one highest weighted criteria along with temperature regulation effectiveness. Although the solar heater and fan combination would the second most costly design, drivers will be able to use it in the summer and winter season and possibly during the spring and fall. The product will also pay for itself in the long run with respect to energy savings (calculations addressed in later section) so it will ultimately be an investment buy.

VII. Preliminary concepts

Originally we came up with the idea of solar powered controllable tints to keep cars cooler in the summer, but our idea was not cost efficient, and did not help keep the car warm in the winter. The tints cost about $2,000 per car, which we thought was a bit unrealistic for consumers as it would not pay off for itself in a car’s lifetime. Because of this cost inefficiency we reevaluated during concept generation and decided against the tints. We considered other ideas including solar shades and in car fan/heater options. We wanted our idea to be green and cost efficient, so we decided to include solar power to our device. During concept selection we found the fan/heater to be most effective and cost efficient, so we combined it with the solar power for the most cost efficient/green device.

VIII. Final description
The solar powered fan/heater can be mounted anywhere in a car with the wiring to the external solar panel. The device, powered by energy captured from the sun, circulates air in a parked car to keep the car warmer in the winter and cooler in the summer. The electricity from the solar panel powers the heater and the fan. When powered, the fan circulates cool or warm the air inside the car. If the car is parked for a decent amount of time, the driver will see the car get hot or cold over time depending on the weather. With this system installed, it will keep the car warmer/cooler, meaning the driver will use less air condition/heat. Overall, the system will help the consumer save gas by moderating the cars temperature under hot/cold weather. The fan will be made out of black plastic and metal, and will receive power through wires connected to the charge controller. The solar panel will be mounted on top of the car, maximizing energy gain from the sun. The captured energy from the sun is sent to the charge controller, where the voltage is regulated and the proper amount of power is sent to the fan/heater system.

IX. Systems diagram

X. Scenarios

**Summer:** You walk out to your car, which has been sitting in a parking lot for a few hours while you take care of errands. When you get to your car, you realize that your car is very hot because it has been sitting in the summer sun. You get in the car, turn on the solar fan, and begin to drive away. The solar fan will blow the hot air out of the car and maintain the cool temperature without using AC. The absence of AC will allow the engine to run more efficiently, providing more miles per gallon.

**Winter:** You walk out to your car in the morning about 10 minutes before you actually have to leave to start your daily activities. You switch on the solar heater and by the time you get to your car to drive away, your car is warm and you did not have to waste any gas.

XI. Total cost analysis:
   a. **Individual Component**
• Kulcar: Retail Cost is $129 but can be found on sale and other websites for around $89. We would only be needing the fan and not the solar panel which would be around $30\textsuperscript{4}.

• Heater: Retail Cost can be anywhere from $75.35 to $88.19  
  Costs: $75.35\textsuperscript{1}, $79.99\textsuperscript{2}, $88.19\textsuperscript{3}  
  AVERAGE PRICE=$81.18 (Our hope would be to get the cost down to around $60)

• Solar Panel: $37.75\textsuperscript{4}

• Total Cost of Devices around $130

• Implementation Cost: $0

• Connectivity Protocol and Cost- $0 (The product is not connected to any of the internal parts of the car so there is no connectivity cost)

b. Comparable Systems

• A comparable fan to the Kulcar design is the Ideaworks solar auto fan which can range anywhere from $10-20\textsuperscript{5}. The fan however does not work very well and reviews from customers show that the fan only worked for a few used or not at all. Reviews for the Kulcar show that it worked very well and helped to cool down the car. Most customers recommend this product and were willing to pay more than other cheaper solar powered car fans because the effects were much greater.

• A comparable heater to Kats’s car heater is significantly higher in cost. The other car preheater is found to be around $250\textsuperscript{6}. This car preheater has good reviews but is almost 3 times the cost and much bigger. It goes on the dashboard and takes up a lot of room. If we used this design we would have to get a bigger solar panel and the overall cost would be so high customers would not want it.

c. Cost Benefit Analysis

Assumptions
For our cost-benefit analysis, we will make the assumption that gas will cost $3 per gallon, an average car efficiency is 25 mi/gal, and that a driver will drive an average of 40 miles a day. Using these numbers, it is calculated that it will cost drivers $0.12 of gas per mile.

Summer
According to our research, the use of AC while driving will reduce a driver’s fuel efficiency by 25% \textsuperscript{7}. This would correspond to a 18.75 mi/gal efficiency using our initial 25 mi/gal average car efficiency without the running of AC. If a driver were to use their AC everyday in the summer, which we will generally assume to be ¼ of the year, or about 92 days, the following calculations show the cost of driving with AC on in the summer:

\[
\frac{40 \text{ mi}}{1} \times \frac{1 \text{ gal}}{18.75 \text{ mi}} = 2.13 \text{ gal} \times \frac{$3.00}{1 \text{ gal}} = $6.40 \text{ per day} \times 92 \text{ summer days} = $588.80 \text{ without solar fan}
\]

Compared to driving with the use of the solar fan everyday:

\[
\frac{40 \text{ mi}}{1} \times \frac{1 \text{ gal}}{25 \text{ mi}} = 1.60 \text{ gal} \times \frac{$3.00}{1 \text{ gal}} = $4.80 \text{ per day} \times 92 \text{ summer days} = $441.60 \text{ with solar fan}
\]
Therefore, the use of the solar fan during the summer will save us approximately $588.80-$441.60 or a total of $147.20. It is important here to note that this is the savings calculated by assuming use only during the summer. There will inevitably be times during the summer in which the weather will be cool enough not to use the fan but there will also be times during the fall and spring in which higher temperatures will allow the use of the solar fan.

**Winter**

According to research, leaving the process of leaving a car idle is equal to 1 mi of gas every 2 minutes\(^{13}\). During the wintertime, many people choose to preheat their car to allow for more comfortable internal temperatures when driving. Assuming that this preheating process takes about 10 minutes, the following calculations can be made to determine the cost of a driver preheating their car everyday in the winter, which is assumed to be ¼ of a year or about 92 days:

\[
\frac{10 \text{ mins}}{1} \times \frac{1 \text{ mi}}{2 \text{ mins}} = 5 \text{ mi} \times \$0.12 = \$0.60 \times 92 \text{ winter days} = \$55.20 \text{ without solar heater}
\]

**Total Savings**

In total the use of our product will save $147.20 + $55.20 = \$202.40 per year. Since the life cycle of the product must be at least 10 years, this means our product will total \$2,024 for a 10 year use.

d. **Payback Time**

Given that one summer use (92 days) will save $147.20, it will take less than 92 days for the product to pay for itself as the product is estimated to cost $130.

**XII. Life Cycle Analysis**

The environmental impact from, cradle to grave, will be absolutely nothing until the product has finished its life cycle. The product uses energy provided by the solar panel and produces no emissions. After the product has completed has been used in its entirety, there will be some environmental effect because not all of the components of the fan can be recycled, but most will. 90% of the solar panel can be recycled along with the environment friendly plastic casing around the fan and the fans’ blades\(^{11}\). Unfortunately most of the heater will not be able to be recycled but all of the wiring throughout the product will be\(^{12}\).

Because many people in America use their car multiple time a year, this product will go through numerous cycles. In fact, if a person had to travel 4 times a day and used this product every trip for the summer and winter months (92 days each) for ten years, the product would go through 7,360 cycles. The most likely failure to occur during its time period is a loose wiring connection. This issue could be resolved by removing a portion of the casing, and replacing the bad connection.

Temperature regulation in a car will always be desired, therefore this product will not become obsolete in a short period of time. The greatest threats to its relevancy are competing products, or if car manufacturers develop a more efficient air conditioning unit.
XIII. Conclusion

Overall this project gave us the opportunity to look at how to help regulate the internal temperature of the car and help reduce negative effects on the environment. We were thinking about how many people turn their cars on minutes before they go to get in their car to either heat up or cool down their car before they get in. We figured this would waste gas and have other negative effects. Our idea was to have a solar powered heater and fan to help regulate the temperature. We can run these while driving to so that you are not wasting gas on this. Our original idea was to use solar powered controllable tints but we found that they would have little effect on actually cooling down or heating up the car. The cost would not be worth the little effect it would have. We decided on the solar powered fan/heater which can be mounted anywhere and will have external wiring.

We found that the total cost of the product will most likely be around $130. If we were to use the product for ten years we would save over $2,000 in gas but it would pay for itself in one summer season or two winter seasons. It is significantly cheaper than other products in the market and it is solar powered. The fan that was created by the Kulcar company helps to reduce chemical build up in the interior air of the car. This helps to give you clean air to breathe while you are in your car driving. The car preheater also has many benefits besides saving you money. For one it can help to reduce greenhouse gas emissions because it helps to warm up your engine. When the engine is not warmed up it can produce 50-100 times for greenhouse gases than if it were warmed up. The warm engine will also help to improve oil flow which can reduce the wear and tear of the engine which will increase the life of it. Lastly, the warm engine will deliver a better fuel economy. The best part of our product is that none of this will be coming from your gas, the energy will be harnessed from the sun.

We were able to learn many great things from this project. We were really able to learn more about the design process through this project. We came up with many different concepts for our temperature regulation idea. We did a lot of research and realize that it was not a good idea in that it was not cost-efficient or it wouldn’t really have any positive effects. We were able to see how prototyping and collaborating on different ideas really worked. We all learned a lot about temperature regulation and its impacts on cars. After exploring many different ideas on this regulation we were able to come up with a final idea and learn more about solar power and how to use it to run a car fan and preheater. Overall we were able to learn more about the design process to come up with a prototype of a solar powered heater and fan that helped improve the greenness of the car without deterring from the connectivity or safety of the car.

XIV. Appendices

The CAD models below depict possible prototype components.
Cooling effects of Kulcar®

65°C to produce harmful gases

http://kulcarnow.myshopify.com/pages/the-kulcar-solution
XV. References: