The Pennsylvania State University
University Park Campus

Delphi Automotive Systems:
Safe - Green - Connected

EDSGN 100
Section 00#

Innovation for the Real World

Design Team #2
W.A.M.S. Engineering
Fall 2014

Submitted to:
Professor Berezniak

College of Engineering
School of Engineering Design,
Technology and Professional Programs
Penn State University

8 Dec 2014

Ultimate goal is to help make zero fatalities, zero injuries, and zero accidents a reality

Passionate about creating a world with zero emissions

Technology to allow seamless connectivity in the vehicle – it’s what consumers want, and we can make it a reality
ACKNOWLEDGMENTS

Penn State University

- Dean, College of Engineering
  Amr S. El Nashai, FREng
- Department Head, SEDTAPP
  Dr. Sven Bilén PE
- Course Instructor
  Professor Jack Berezniak PE
- Laboratory Assistants
  Morgan Gardner, Industrial Engineering Student
  Tirth Patel, Industrial Engineering Student
  Heather Dawe, Nuclear Engineering Student

Delphi

- CEO
  Rodney O’Neal
- COO
  Kevin Clark
- President, Delphi Electrical/Electronic Architecture (E/EA)
  Majdi Abulaban
- President, Powertrain Systems.
  Liam Butterworth
# TABLE OF CONTENTS

**SECTION 1.** EXECUTIVE SUMMARY

**SECTION 2.** INTRODUCTION
- 2.1 PROJECT OBJECTIVES
- 2.2 PROJECT BACKGROUND
- 2.3 SPONSOR BACKGROUND
- 2.4 PROJECT CATEGORIES
- 2.5 PROBLEM STATEMENT

**SECTION 3.** METHODOLOGY
- 3.1 PROPOSED DEVICE DESCRIPTION
- 3.2 RATIONALE FOR SELECTION
- 3.3 CUSTOMER NEEDS
- 3.4 OBJECTIVES AND GOALS
- 3.5 CONCEPT OF OPERATION
- 3.6 SYSTEM CONTROLS
- 3.7 SYSTEM MODEL
- 3.8 DAY-IN-THE-LIFE
- 3.9 LIFE CYCLE ASSESSMENT (LCA)
- 3.10 ECONOMIC ASSESSMENT
- 3.11 PRODUCT DEVELOPMENT AND MARKETING

**SECTION 4.** SUMMARY

**SECTION 5.** REFERENCES
SECTION 1  EXECUTIVE SUMMARY

We at WAMS Engineering propose a product to increase fuel efficiency in the typical vehicle. Our model incorporates a cross flow fans which will be located right behind the decorative grill of the car. These fans will generate energy from wind to be stored in a lithium battery. The energy stored in the battery will be used to help power the car and increase fuel efficiency. The price of incorporation of this product remains low since it only requires basic parts. This product is ideal for hybrid cars to increase the range and reduce the frequency of charging the battery. We intend to have our product increase efficiency of any vehicle it is incorporated on. Our system can be incorporated into any production vehicle, and can even be modified to be installed as an aftermarket device.
SECTION 2 INTRODUCTION

2.1 PROJECT OBJECTIVES.

Identify technologies and opportunities to make cars and trucks safer, greener, and more connected.

2.2 PROJECT BACKGROUND.

Every day someone is talking about cars of the future. This means cars that will park themselves, drive themselves, talk to us, think for themselves, avoid accidents, etc. What does this mean in terms of the technologies, societal acceptance, and the policies and supporting systems needed to enable these safer, greener, more connected cars and trucks? There are computers buried under the skin of the car, making them safer, greener, and more connected. The engineering community must constantly push the envelope of what is possible to truly make the best car.

2.3 SPONSOR BACKGROUND.

Delphi Automotive is a global automotive components design and manufacturing company—it is one of the world’s largest automotive parts manufacturers and provides electrical and electronic, powertrain, safety, and thermal technology solutions to the global automotive and commercial vehicle markets. Delphi operates 126 manufacturing facilities and 15 technical centers across 32 countries, utilizing a regional service model that enables it to serve its global customers. It has approximately 161,000 employees worldwide, with around 5,000+ located in the United States. Delphi operates through four segments: Delphi delivers innovation for the real world with technologies that make cars and trucks safer, more environmentally friendly, smarter, better connected, and more affordable than ever before. Delphi focuses in Electronic Architecture, Powertrain Systems, Electronics and Safety, and Thermal Systems.

2.4 PROJECT CATEGORIES.

Safe: Our ultimate goal is to help make zero fatalities, zero injuries, and zero accidents a reality. Protecting the driver and passenger is of upmost importance. Airbags are an example of a reactive safety feature after a crash occurs. Safety features now being designed into cars are more proactive to avoid the crash all together. Sensors are used to detect dangerous situations, and can alert the driver or even take over control of the car to avoid the situation. The use of smart phones while driving is also a major safety concern.

Green: We’re passionate about creating a world with zero emissions. Protecting the environment is also very important to the vehicles of the future. Hybrid and electric vehicles are becoming more popular as an alternative to traditional cars. There are also other alternative fuels being explored. However, by simply reducing the weight of a vehicle or having products that make engines run smarter or more efficient can dramatically improve fuel economy.
Connected: We have the technology to allow seamless connectivity in the vehicle—it’s what consumers want, and we can make it a reality. The vehicle of the future should be optimally connected to maximize the driver’s and passengers’ experience while minimizing the driver’s distraction. Connecting the vehicle itself and all its sensors to the outside world should not be overlooked. The vehicle of the future will have 100s of sensors collecting data which may be very beneficial to others.

2.5 PROBLEM STATEMENT.
We decided to choose the category of Green because we feel that the most pressing issue of our cars today are poor fuel efficiency, large carbon emissions, and lack of systems in cars that truly benefit the consumer while making the car greener. Our system focuses on expanding the drive time of hybrid cars on their batteries, or increasing the fuel efficiency of a gasoline engine by utilizing the wind generated by driving. Currently hybrid cars are limited because the range of their electric power is limited because there are few on board systems to charge while the car is moving without using the gasoline engine as a generator. For those who still choose to not drive a car with an electric power system, our system of capturing the wind as electrical power can increase efficiency by reducing the needed for large alternators. We have created a cross flow fan system that can create electricity while only negligibly affecting drag.
SECTION 3  METHODOLOGY

3.1 PROPOSED DEVICE.

Under the category of making a greener vehicle, with fewer emissions, this is essentially a small wind turbine for a vehicle. Instead of using the standard wind turbine blade, it utilizes a cross flow fan blade to act as the wind turbine. This design relies on very few components and only two moving parts. This system includes:

1. A cross flow fan
2. The fan housing
3. A small flexible coupler
4. A high efficient small generator or motor
5. An external battery pack
6. Computer monitoring
7. An alternator clutch

Only the fan and the generator are additional moving parts, thus create a system with fewer parts that are likely to fail.

The system is simple. It utilizes the air moving past the car to spin a small highly efficient generator or motor used as a generator. This is done by ducting the moving air across the blades of the cross flow fan, thus spinning the fan. Cars are inherently aerodynamically inefficient; this system will not greatly affect the overall drag, but will use the air, a currently wasted resource, to produce extra electrical power. This system can be integrated into any body surface or vent that is exposed to external moving air, such as the front grill or rear diffusor. The power generated can be used to augment any electrical system in a vehicle or can be stored within its own external battery pack. The system is simple to install and can be added to any production vehicle, or installed in the factory.

3.2 RATIONALE FOR SELECTION.

Many reasons prompted the selection of the power-producing turbine as a perspective invention. The fact that motor vehicles are very drag-prone objects brings up the discussion of wind, which is known to be harnessed for power in wind farms. Why not do the same on a car, which creates its own wind? Another point of focus was the efficiency of an alternator. An alternator decreases energy usage from the engine of a motor vehicle, making it more efficient. This would especially be true in hybrid/electric systems, making substantial increases in efficiency. However, the point that most customers will find most appealing is the low cost to purchase and simplicity to install. After much collaboration on the topic, this turbine system was determined to be the best product to produce.
3.3 CUSTOMER NEEDS.

- Most fuel efficient vehicle possible
- Cheapest vehicle
- Most reliable
- Provide a simple solution to increase reliability
- A product that doesn’t directly affect drivability in case of failure

Our Product increases the efficiency of hybrid cars and reduces energy costs. Customers of any type would benefit from this product. Although the product may be most ideal for hybrid vehicles, the design can be implemented on any vehicle. The customers that would be seeking this product are looking for a well-rounded. Customers need durable products that need little to no maintenance. The product needs to be cheap so that the price of the entire car is not raised by too much. Customers are always looking for a fuel efficient vehicle, so the product needs to increase fuel efficiency. Many customers are wary about adding technology to cars, so a product needs to be able to not affect the drivability of the car in the case of the part failing. A product must provide a simple solution to increase reliability.

3.4 OBJECTIVES AND GOALS.

- Create a product to increase efficiency of vehicle
- Implemented on all hybrid cars by the year 2020
- Make a durable product that requires low maintenance
- Create a cheap but affective piece of technology

The main goal of the proposed product is to increase fuel efficiency of a vehicle. As discussed above, many customers search for cars that have the best fuel efficiency. So the product satisfies the needs of its customers. A secondary goal is to keep the part relatively cheap in order to not raise the price of the vehicle while still maintaining a durable product requiring low maintenance. The final goal for the production of the product would be to have it be implemented on all hybrid cars by the year 2020.
3.5 CONCEPT OF OPERATION.

The basic concept of this devise would be as such. A fan would be attached to the front and/or the back grating of the car, where air flows through as the car moves. The aforementioned air current would spin the fans and thus generate power with a motor, much like a wind turbine. This would generate a substantial amount of electric energy simply by driving the car around, and would generate increased power at higher speeds, such as on the highway. This electric power could be stored in fuel cells much like the ones already in use by modern day electric cars. The stored power could then be used as a substitute for electrical systems already present in the vehicle, and thus would reduce the need of an alternator and would extend the life of the hybrid. Using the Wind Power equation and Betz Law, (assuming an average speed of 20m/s) the overall Power gained from this system:

\[
P = 0.5 (\text{Air Density}) (\text{Swept Area of the Turbine Blades}) (\text{Wind Speed})^3
\]

\[
P = 0.5 \left( 1.2 \frac{kg}{m^3} \right) (0.00387 m^2)(20 m/s)^3
\]

\[
P = 18.576 \text{ watts}
\]

\[
P_{avg} = 0.59 \times P
\]

\[
P_{avg} = 10.960 \text{ watts}
\]

![Power Output of a Single 6x1 in Cross Flow Fan Area](image)
3.6 **SYSTEM CONTROLS.**

As the system would be both activated and sustained by the car’s motion, the system would be entirely automated. There is the issue of power consumption, and so to monitor this there will be an automated or active feedback loop to measure the amount of power stored and created, and when it may be necessary to disable the system. Additionally, after a certain amount of power is created, it will be possible to run the card completely off the electrical power, especially over long distances. A computer program will decide when it is most efficient to disengage the clutch and use the stored electrical power.

3.7 **SYSTEM MODEL.**

The Fan shown in 6 inches in length and 2 inches in diameter
1:16 Scale of a 6in long Cross Flow
3.8 DAY-IN-THE-LIFE.
The typical use of this product would be on the highway for a hybrid car. The car would store the electric power generated from the turbine as it drives on the highway. When the car stops or slows down, the motor will be given the excess energy generated in order to accelerate the car back up to speed. This process will reserve fuel in the car.

3.9 LIFE CYCLE ASSESSMENT (LCA).
In accordance with the simplistic design, one aspect of the design process was made a crucial point of development: each part must already exist. Because of a lack of developmental cost (as well as other unforeseen expenses), the overall price of the turbine system will stay affordable to the customer. This system is designed to be extremely low maintenance, with easy to replace parts. This may not be necessary; however, as the life span is estimated to be similar to that of a typical motor.

The only drawback that has been encountered this far is the battery pack. As with every battery, precautions must be taken when creating and disposing of batteries. However, this is no more complex than creation/disposal of an ordinary twelve-volt car battery.

3.10 ECONOMIC ASSESSMENT.
This economic analysis is based on an AACE class five. This includes:

- A 0 to 2% Level of project definition
- Concept Screening end usage.
- The methodology relies on parametric models, judgment, and analogy.
- Accuracy Range -50% to +100%.
- Preparation effort 1.

All of the pieces are readily available and inexpensive. The fan can be taken from current tower fans, which can be mass ordered for less than a dollar a piece from manufacturers in china. Remote controlled aircraft motors can be used as the generator, or small efficient purpose built generators may be used. The housing and coupler will be made by injection molding, which carries a high up front cost but then after the molds are created the price per unit drops significantly. Due to the lack of parts, the system can be easily integrated into the production line and easily installed. The most expensive part would be a lithium polymer battery, which retail around 30 dollars per 5000maH.
Startup Cost: $100,000.00

This number was calculated by assuming the following:

1. The engineering time needed to complete the prototype is estimated to be roughly 100 to 200 hours to design the housing and the control system at 250 dollars per hour.
2. A $50,000.00 has been set aside for the initial set up for injection molding and retooling.

After the initial cost, the cost per unit will drop to between $10 to $20 dollars.

This is because after the initial set up all of the parts are cheap and readily available and simple to install. It is no more complicated than a tower fan that retails for $20, the only extra cost will be the using a different alternator and extra battery.

3.11 PRODUCT DEVELOPMENT AND MARKETING.

In order to produce an effective product, it is important to first produce a suitable testing platform to correct mistakes and perfect the design and application of our product. For this, we have determined to engage in a Solidworks model with wind tunnel simulation testing. After recording feedback and correcting mistakes, a working prototype of the turbine will be physically tested to ensure similar results as the corrected Solidworks model. The final step in product development is to produce and implement the product in vehicles across the world.

As for marketing, an approach that targets the eco-friendliness of the product would attract potential customers. This would be an advertisement that tugs on the heartstrings of the customer, perhaps inducing feelings of guilt for their own wastefulness. The advertisement would also demonstrate fuel efficiency that this product adds in any given vehicle.
SECTION 4

SUMMARY

The concept design of using a cross flow generator system provides an avenue to produce extra electrical power for a vehicle. This design can either be used to supplement the alternator power or supply a continual amount of electrical power, not dependent directly on a fossil fuel, which could increase the range of hybrid and electrical vehicles while operating on purely their electric motors. This system relies on the air passing over the car as it drives, which currently not a resource is used by vehicles other than for cooling properties. The gasoline engine in a hybrid vehicle will have to accelerate this system and force it through the air. This, however, is not detrimental to the fuel mileage because the system will not weigh more than an additional passenger, and will not increase the drag coefficient of the vehicle by a significant amount because the decorative panels at the front of vehicles already cause large amounts of drag. This system could cause hybrid vehicles to catch greater momentum in the market, as well as possibly allow a greater amount of electronic gadgetry to be placed into the vehicle.

A major strength of this design is its adaptability to any body style of any vehicle. The cross flow fan can be lengthened or shortened as needed to fit into many different openings. Multiple cross flow fans can be incorporated into a single vehicle to produce larger amounts of power. The units are small and thus easily incorporated into a variety of designs. The system has very few parts, and all of the parts have a life expectancy equal to that of the vehicle itself.

The main drawback or weakness of this design is the amount power it can produce. Based on the wind power equation, the power output is similar to velocity cubed. This means that in the city, or at other low speed driving the system will not produce much power. However, the power developed at higher speeds, as seen in section 3.5, is exponentially greater. This system is then effective for individuals that drive on the highway, which is a large percentage of the society; however, the system could store power on the highway in an addition battery for use later in the city.

This design was developed with ease of production and integration in mind. The concept relies on very few parts, and many of the parts are already available. This means that it would not adversely affect productivity in the factory. Few parts mean that it is fast and easy to install. The large availability of the parts means that the automobile manufacturer does not need any special tooling or expensive manufacturing processes. The concept also carries a low up front cost, as well as a low production cost, and therefore will not increase the cost of production vehicles by any significant amount.

This design could also be used for applications other than power production. In theory it could be used to modify the air flow around a vehicle, modifying how it cuts through the air, or could be used to duct air to specific components on the vehicle, such as for brake cooling at low speeds. This would be done by reversing the flow of power. Instead of gaining energy from the fans, power could be sent to the fans. Depending on how the fans were positioned and ducted, the system could be used to increase cooling performance of the vehicle, or to act as an active aerodynamic system.
SECTION 5 REFERENCES

