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Applied Thermoelectric Solutions (ATS)

Final Business Proposal

May 6, 2009

Group Members:

Chris Richardson
Tommy On
Matt Kengott
Dan Heller
Alex Heller
Mike Crepinsek
Kevin Conant
Business Description & Vision:

Applied Thermoelectric Solutions (ATS) is a Nevada based company created to utilize thermoelectric devices in advancing and aiding automotive power systems in the effort to reduce oil dependencies and harmful emissions.

Amidst economic and global crisis, the need for renewable energy is an ever growing concern. It is estimated that the world’s remaining oil supply will run dry in 40 years, according to experts from RFE/RL website. To combat this issue, research into renewable energy is becoming more prevalent. Currently there are several alternative fuel methods being researched for use in mass transit. As of now, gasoline/electric hybrid technology is being utilized to bridge the gap between current and future “green” technologies. Ultimately, society needs to become less fossil fuel dependent and more energy efficient. Also, with the nation in a current economic decline, the desire for luxury or extravagant items is less desirable. Considering the ramifications of global warming on the environment and the current economic crisis, “green” technology will become a high growth industry. Our product is designed to take advantage of the current economic crisis and launch “green” technology to the next level.

ATS will manufacture and market a patented mount and existing thermoelectric technology in an assembly, created to provide alternative energy to hybrid and electric automotives. The assembly converts frictional heating from vehicle brake pads to electrical energy. This conversion from mechanical energy to electrical energy can be used for a portion of the power input into a vehicle battery, thus improving hybrid and electrical automotive consumers’ gas mileage.

ATS is a new S Corporation getting ready to enter the market. Started by seven senior Mechanical Engineering students from the University of Nevada-Reno, ATS offers fresh and innovative ideas to acquire an advantage in a competitive market. Currently, ATS has created and tested a working prototype of the thermoelectric assembly. All engineering analysis has been conducted using analysis software, provided by the University of Nevada-Reno. The University of Nevada-Reno has granted ATS $350 dollars in the development of the prototype. ATS is in the process of obtaining a patent for the thermoelectric assembly. The patent will provide protection of the assembly and manufactured brake mount.

Company Ownership:
Upon funding for ATS, the ownership as follows:

Partnership (seven partners listed below) – 60%
- Kevin Conant
- Mike Crepinsek
- Alex Heller
- Dan Heller
- Matthew Kengott
- Tommy On
- Chris Richardson

Future Investors (up to) - 40%
**Start-up Summary:**
The total cost required for ATS to start-up and operate for three months will be $299,000. This total includes $99,000 for start-up expense, $10,000 for inventory start-up, and $190,000 for cash on hand. The amount of cash on hand will be used to pay for ATS operation until the business becomes self sustaining. The company will be self sustaining when the goal amount of sales is reached. In order to reach the start-up cost, ATS will utilize small business loans, Owner assets, and multiple investors. ATS is expected to begin production approximately three months after funding is received. See figure 1 for the portion of funding expected by owners, investors, and loans.

![Start Up Expenses Break Down](image)

**Fig. 1:** Total expenses for ATS including startup expenses over $10,000.
Fig. 2: Pie chart showing percentage of company ownership.
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**Market Definition:**

California has the largest concentration of hybrid vehicles in the nation and a “green” environment focus. The company will target Northern California as the initial market since it has the largest concentration of hybrid vehicles in the state. This concentration of vehicles will allow a sales team to easily penetrate a market of automotive shops for the installation of these kits. Basing ATS near Northern California will allow the customers to keep shipping and handling costs low. Another reason to launch in Northern California is because the average income per household in this area is about $80,000, with 42% of the owners of hybrids making over $100,000 per year according to Scarborough Research. With this income it is safe to say that the customers will be able to purchase the product and have it installed, without encountering financial hardship. This will allow ATS to grow in customers at a much faster rate than normal companies in the first five years since there is a growing “green” theme along with a solid financial standing of the future customers.

After the initial launch in Northern California has begun, the company can begin to expand to shops in Southern California and surrounding areas. The sales team will be able to offer certain promotions along with the surety of the product working. This will increase the demand for the kits along with an increase in product recognition. The company will see drastic increases in sales with promotions, which will cover the cost of the sales team.

Once the regional growth has been achieved, the sales team should be increased in staff in order to expand to shops throughout the country. This expansion could include Toyota or other hybrid manufacturers which would lead to a substantial increase in product demand. Brake companies could be targeted in order to integrate the kits into the brake pads, allowing the customers to save money on the systems.

**Target Customer**

The target customer for the initial launch of the product will be Northern California drivers of hybrid vehicles, with an initial focus on the Toyota Prius. Once the product becomes established in the market and demand for the product has started to increase, the sales team will target automotive shops that are certified to work on any hybrid and electric vehicles. The initial focus of the sales team will be to sell the kit directly to automotive shops. The shop will then be able to sell, service, and install the kits on hybrid and electric vehicles as an additional service to their existing customers. The targeting of automotive shops as a distributor of this product to customer has several key benefits for the shops including:

- The ability to bypass the initial costs of attempting to affect single consumers with advertising during the expansion phase.
- Automotive shops can order the kits in bulk, slightly reducing costs and allowing an inventory to be kept for convenience to the consumer.
- The shop will be able to have the kit in stock for their current hybrid customers, saving time and money for the vehicle owner. This takes the form of impulse buying which is a very effective means of selling products.
- Once a customer is established, this will lead to higher probability of future work on the customer’s automobile and provide a cheaper means of advertising for the shops.
While the sales of the product directly to automotive shops will be the primary method for sales, the consumer will also be able to buy the kits directly through the website or phone order.

**Market Research**

ATS members have had many surveys filled out by hybrid owners and prospective hybrid owners. These surveys and results will be referenced with a copy the results in Appendix A. These surveys include results that will validate claims of what hybrid owners would be willing to pay for this product. ATS has had a total of 48 surveys answered by hybrid owners and people interested in purchasing a hybrid in the future. These 48 surveys were answered by friends of ATS members along with random surveys. Of the 48 surveys, 13 were from hybrid owners and 35 were from prospective hybrid owners. These surveys have been compiled to determine a fair market price for this product along with helping ATS to determine future marketing possibilities.

From these surveys it is safe to say that there is a demand for this product. The average hybrid owner would be willing to spend $1100 on this product while the prospective hybrid owner would pay $860. Both of these values show that the product is within a reasonable price that people will be willing to pay. While the average age and income was higher for the hybrid owner than the prospective owner, the survey shows that gas mileage concern is very high for every person surveyed. The results also show that hybrid owners are more concerned for the environment than the prospective owners. Both of these statistics will play a crucial role in determining how to market and sell this product.

Due to some possible influences on the consumer’s time schedule for kit installation, a question was asked if the hybrid owner could go without their car in order to get the part installed. From this question, ATS found that 76% of hybrid owners would be able to get this product installed. The next question for hybrid owners was whether the person would rather have the kit already installed on their car; 100% of people said that they would rather have the part come on the car. This plays a role for determining how to market this idea to automotive companies like Toyota.

Other statistical results for prospective hybrid owners include:

1. 83% said they would purchase this product for a hybrid.
2. 94% said they would prefer to buy the product already installed.
3. 29% said they would buy a hybrid for gas mileage and to help the environment.

Other statistical results for hybrid owners include:

1. The average age was higher than prospective owners.
2. The average income was higher than prospective owners.
3. The average price willing to pay for the kit was higher than prospective owners.
4. 100% said that the reason they purchased the car was for gas mileage or environment.
5. 100% said they would purchase our product for an average of $1070.

There are some errors in these surveys that can be filtered out. Some people did not answer some of the questions, leading to an omitted response that would not contribute to statistics. Some people included values that were very large; ATS would double check with the person to make sure there was no error in recording. The hybrid owners totaled to 100% that would purchase this
product, however the value that some people recorded was lower than the product price, this leads to 85% of hybrid owners willing to purchase this product at the $325 selling price.

**Sales Potential**

According to the research done by *Consumer Reports* in 2006, the average amount of money spent on aftermarket parts for cars is approximately $720 for the life of the vehicle. *Consumer Reports* recently stated that they have not yet found an upgrade to a car that result in an increase to gas mileage. There are ways to increase gas mileage of a car including turbochargers, superchargers, exhausts, computer chips, and many more. These upgrades are possible to do and can increase gas mileage and performance when done right. These car modifications are costly when compared to this product since the cost of an exhaust system can be larger than $500. Turbo and superchargers will cost the consumer well over $1000 to buy and install properly. These upgrades are possible to many cars, however when it comes to hybrid cars, engine space is limited with the many electronics and engine. With a combination of the research from *Consumer Reports*, there is a demand for aftermarket parts on every automobile, regardless of the type of car. This leads to the question about how much the consumer is willing to spend on this product, which is an aftermarket kit.

Sales of the Toyota hybrids topped 600,000 cars last year according to *AutoBlog.com*; it is a reasonable assumption that this number will increase as the fossil fuel crisis increases and fuel prices continue to rise. In recent years fuel prices have come close to reaching over $5 per gallon, increasing the demand for fuel efficient hybrid vehicles. With simple calculations, the kit is expected to save a consumer an average of $120 per year with fuel costs at $4 per gallon. This allows the consumer to pay off their investment within three years if the consumer drives an average of 12,000 miles per year. A copy of the calculations done for this fuel saving analysis is in Appendix B. Figure 3 shows the hybrid sales in the U.S. since 2004.
Initial forecasts should include a 0.1% market penetration for the first year. Toyota sold over 600,000 hybrid cars, like the Prius, as of 2008 according to information taken from www.hybridcars.com. With possible car accidents lowering this number, market potential for the product will include a total of 400,000 hybrids. This means that ATS can expect to sell about 400 kits in the first year. After this kit has entered the marketplace, assuming good results, the market sales are expected to increase exponentially within the first five years. This relates to a 1% total market share after five years. If the company kits perform as expected, there will be an increase in demand to 3000 kits during the fifth year. This market share is forecasted to increase as the pressure to reduce dependency on fossil fuel continues to increase. Second year sales are projected at 900 kits with a 0.15% market share. Third year sales projection is 0.2% of the growing hybrid sales, with the assumption that total hybrid sales are constantly increasing, the product demand will increase to 1600 kits. Fourth year sales projection is reasonably projected to be 0.25% of the growing hybrid sales, assume 1,000,000 hybrids sold, leading to a demand of 2500 kits. The fifth year projection can be assumed to be 0.3% or greater, assume 1,000,000 hybrids sold since it is difficult to forecast the demand for hybrids with technology constantly changing, leading to a demand of 3,000 kits. This sales forecast model is non-linear model. The above information is shown in figure 3 along with the non-linear sales forecast for ATS product sales in figure 4. The exploded view of the forecasted product sales is shown in figure 5.
The breakeven analysis for this company includes an increase in employees and overhead for every year of business. The values used during the calculations for the breakeven point were taken from the direct labor wages in table 2 below, combined with the yearly operation costs in appendix D. Knowing these values along with the number of units forecasted to sell allow us to
determine the breakeven in units. Calculations show the breakeven point to be 59 months after business startup. This breakeven time in months correlates to sales of 8,278 kits. After the breakeven sales are reached, the company will have a profit of $39,800. After two year and four months the company will be making a monthly profit and become a self sustaining company.

**Products and Services:**

ATS will be selling a kit to individuals and automotive shops that will be used on hybrid cars to increase gas mileage. Currently, the Toyota Prius uses regenerative braking to recharge the batteries to increase the miles per gallon that a car can achieve. The kit from ATS will be used as an addition to the hybrid system to further increase miles per gallon. This will be done by harvesting the unused heat energy created from the brake pads and converting this heat into electricity. The kit designed by ATS was created for this purpose. This kit will help to benefit the customer by improving their gas mileage and as a result save money that would be spent on gasoline. By doing this, ATS is also helping to curb the dependency for fossil fuels, while creating a product that is environmentally friendly.

When there is a temperature difference between two different metals that are connected, a voltage is produced. This is known as the Seebeck effect. The Seebeck effect was discovered in 1821 by J. T. Seebeck. The Seebeck concept is used as the main design of thermoelectric devices. To utilize this concept, the thermoelectric device will have a hot and cold side; each side is made from different materials. When a temperature difference is applied to the corresponding sides, a current is then produced. This occurs because of the different energy levels that exist in the two different materials. As the materials heat up, a large imbalance of energy occurs. The electrons in the hotter material will then flow to the cooler region. If the conductors form a loop a continuous current will develop. A voltage then can be acquired. This concept is used today in thermocouples to measure temperatures by knowing a specific voltage. The governing equation to determine the voltage output of a thermoelectric is

$$ V = \int_{T_1}^{T_2} (S_B(T) - S_A(T))dT $$  \hspace{1cm} (1)

where $V$ is the voltage created, $S_B$ and $S_A$ are the Seebeck coefficients, which are a function of temperature and materials used, and $T_1$ and $T_2$ are temperature. Then if a current is measured, the power supplied by the thermoelectric can be found to be

$$ \dot{Q}_p = V \cdot I $$  \hspace{1cm} (2)

where $I$ is the current. Figure 6 shows a diagram of a basic thermoelectric circuit.
In a culture that is beginning to rely on “green” technology, thermoelectrics are one of the many renewable energy resources that exist today. Since thermoelectrics require a temperature difference between the hot and cold side to create a current, they are being considered more and more for use on waste heat applications. Waste heat is heat produced by machines and processes that is not used for any purpose. This is something encountered in industry and in day-to-day living. One example of something that creates a lot of waste heat is the automobile. This is seen by the heat given off by the car’s engine and exhaust system. One other interest of special concern where cars produce waste heat is their brake system. This is the area of concern which will be covered for this product.

The average car’s brake pads and calipers can reach temperatures of 480º Fahrenheit and higher, under normal operating conditions according to Twiflex. The measured temperature of the brakes for the ATS tested car was 300º Fahrenheit after normal city driving. This temperature can add up to a large amount of waste heat that is generated during braking, which leads to the purpose of this product. ATS is creating a mechanical system to mount a thermoelectric to the braking system of a car. For the purposes of the company, the efficiency of the mounting system will be measured. By knowing the system efficiency, changes made to the mount can be determined to be positive or negative based on an increase or decrease in measured efficiency. To determine the efficiency of the product, a measure of the waste heat by the brakes will be performed, which will then be followed by determining how much energy the thermoelectric will be able generate and put back into the system.

The product is designed to be a direct add-on to the Toyota Prius. This will limit the market to the owners of this specific car. An analysis of the brake pads and system will have to be done to ensure that the kits can be mounted on the different year models of the Prius. Once the kit is tested and able to be mounted on any model of Prius on the market, there will be constant tests and quality control experiments taking place. Recent Prius models come equipped with slotted brakes which serve to reduce the temperature and increase brake pad life on the system. Studies show that there is a temperature difference of 8% with slotted rotors compared to the economic rotors, taken from AA1car.com. This temperature difference will make the system less effective with the thermoelectric, but will still be able to generate energy leading to better gas mileage. The kit will have to be checked and constantly maintained throughout production since it will be
installed on a brake system. This has a large liability if bad parts are made and failure occurs which can lead to critical failure of the automobile under normal driving conditions. The product will be marketed through shops and websites, creating an inexpensive form of advertising relative to other forms. The competitive advantages, outlined below, will allow for a high demand after initial market penetration since there are many forms of upgrades and alterations to ensure fit on different hybrid models. The product will be able to undergo many upgrades in performance and reliability with a research and development team. This team will be employed by the company in order to broaden the market for this product to other hybrid vehicles.

The product itself will be subject to rather harsh environments including snow, road salt, rocks, high heat, water, and extreme cold. There are a couple features with the thermoelectric that make it able to handle some of these conditions. The thermoelectric being used is waterproof and designed to be able to operate within the average temperatures during driving. Things including rocks and road salt could be a hazard to the thermoelectric. If the thermoelectric is covered in road salt then there would be less heat transfer for the system and lead to a lower increase in gas mileage. The position that the product is mounted plays a role in the limitation of this hazard and will be designed during the product development. Rocks can damage the thermoelectric easily and leads ATS to having to design a small shield made of steel wire resembling a small thin fence. This cover will have to be small and thin enough to allow air to pass over the thermoelectric. This will reduce the risk of damage to the thermoelectric by rocks and debris.

**How it works**

The kit includes two brake mount pads, four thermoelectric sensors, and thermoelectric glue. This product will need to be installed by a certified technician, who is allowed to perform work on hybrid cars. The product is installed by attaching the brake mount pads to the inside brake pads on each of the front tire disc brake systems. Once installed, the thermoelectric device will be installed on the free end of the mounts. Thermoelectric glue will be applied to improve the heat transfer of the system between the different interfaces including the thermoelectric and mount, and between the mount and brake pad. After the system is installed, the thermoelectric will need to be properly connected to the battery charging system of the hybrid vehicle, this will have to be done by a certified technician to avoid any possible hazards.

Once the kit is properly installed, it is ready to be used. Unlike the Prius regenerative braking system, no effort is needed from the consumer for this product to work other than driving their car normally. The system will begin to work automatically once the consumer starts driving and the brake pads heat up. The heat from the brake pads will be transferred through the brake mount pads to the thermoelectric device, heating the side in contact with mount. The side of the thermoelectric not in contact with the mount will be cooled by the air rushing by it as the vehicle is in motion. By driving the vehicle, the system is producing a hot and cold side to the thermoelectric. Using this temperature difference, the thermoelectric can produce electricity. This electricity will be used to help recharge the batteries that are used to power the electric motor on the hybrid leading to an increase in fuel efficiency.

**Experimentation**

To test and optimize our system before testing begins, an experiment will be created. This experiment will contain a heater, aluminum brake mount, thermoelectric, blower, thermocouples,
and insulation. The heater will represent the brake pad heat source, which will generate heat from friction as brakes are applied. A thermocouple will be used to monitor and help keep the temperature between the heater and the mount at a designated value. This value will be established from several measurements of brake pad temperatures. Insulation will then be wrapped around the mount to keep heat flow in one direction towards the thermoelectric which is attached on the other side of the mount. As a heat is being provided to one side of the thermoelectric, a cold source will be placed on the other side of the thermoelectric at a much cooler temperature. Thermocouples will be placed on both sides of the thermoelectric to help with data collection on temperatures. The blower is used to simulate the vehicle in motion. An illustration representing this experiment is show below in Figure 7.

Fig. 7: Basic design for the automotive mount and testing.

Several benefits will come from creating this experiment for testing. First, the concept of the design will be able to be proved. Then if problems arise, they can be addressed as they come up and the system can be changed to fix each problem. Another benefit of creating this experiment is that it will be much easier to make the changes, if needed, to the system compared to adjusting it if it was already attached to the vehicle brake system. Next, the power gained from the system
based on different wind speeds can be determined to see if additional systems may be needed to improve cooling. Lastly, by knowing the power input from the heater, and knowing the power output from the thermoelectric, it will be possible to determine the efficiency of the system. The results of one experiment are located in appendix C.

An experiment was conducted using a 375 degree Fahrenheit heat source. From this experiment, the temperatures at thermocouples 1, 2, 3, and 4 were measured. These were monitored to determine when steady state of the system occurred. The temperature difference across the thermoelectric was determined by knowing T4 and using a known cold source of 32 degrees Fahrenheit. Last, the voltage and current coming from the thermoelectric was measured to determine the power output, Qout. Figure 1 in Appendix C shows the rising temperatures in the thermoelectric and power generated as the system approaches steady state. Figure 2 in Appendix C shows how the power correlates to the temperature difference across the thermoelectric. With the current design, only a power output of 0.3 Watts was produced. By knowing the properties of the material and based on the design, the heat supplied to the thermoelectric, Qin, was calculated using the equation

$$Q_{in} = \frac{k \cdot Acs \cdot (T2 - T3)}{L} \quad (3)$$

where k is the thermal conductivity of the material, Acs is the cross sectional area through which heat is transferred, T2 and T3 are the temperatures measured at the thermocouples 2 and 3, and L is the distance between the two thermocouples. By knowing Qout and Qin, the efficiency of the system was calculated by using

$$\eta = \frac{Q_{out}}{Q_{in}} \quad (4)$$

The efficiency of the current system is 4.2%. The thermoelectric has an efficiency of 10%. The system can be improved further to help bring more heat to the thermoelectric.

From conducting these experiments and evaluating the efficiency of the system, this gives ATS an important design procedure. This procedure is known as spiraling development. ATS will be designing for one specific hybrid car at a time, not necessarily limited to the Prius. For each different mount model that ATS develops, its efficiency will be measured. With this efficiency, ATS will make changes to the mount, then measure the efficiency again. Repeating this process until achieving the desired product is known as spiraling development. Once the maximum efficiency possible is achieved, the product will be ready to put out to market. This development plan will be applied to each and every product ATS develops to ensure the best possible product for the consumer. ATS will work constantly to design and produce mounts for various hybrid vehicles that are already in the market, and future vehicle models. The expected time it will take for each model is one month of design and testing. Once a mount is designed and finished for a certain vehicle, ATS can expand the product line and increase the market potential for the company. The market potential will increase when ATS has the availability to sell a product to more customers; there are different hybrid car models and manufacturers that can be expanded to.
Facilities
ATS used an assortment of resources to develop the product. In the initial stages of development, the Engineering Computer Center located on the UNR campus was used for analytical analysis. SolidWorks was used to model the product then ANSYS software was utilized to estimate the heat flow through the aluminum mount. All manufacturing drawings were comprised in AutoCAD software. Once all drawings were created, the drawings were sent to Ken Die Supplies, a machine company located in Carson City Nevada, to have the mount fabricated. Ken Die Supplies used a wire electric discharge machine (EDM) to cut the mount to the desired shape. Simple bending dies were used to bend the mount to its final form. In future production, an EDM machine will not be used. Instead, a die punch will be used for the final product, to lower cost of production. Once the prototype was manufactured, insulation was added along with thermocouples in order to be able to measure temperatures at various points. All testing was done using a heat gun, laser thermometer, thermocouples, and a multi-meter, and a standard stove. These facilities will be used for future development until a building is selected to rent for ATS.

Product Attributes
The new product by ATS has many benefits that will provide a competitive position in the market. The most important benefit is that the product requires minimal maintenance from the consumer, and requires no additional work for the product to work. Once installed, the system works on its own as the customer begins driving the vehicle. As soon as the brakes heat up, a charge will be created by the thermoelectric. Unlike the regenerative braking system currently in the Toyota Prius, this product will work while the car is in motion and does not require additional input from the driver. The system currently installed in the Prius requires the driver to anticipate braking, while this product gives the driver the ability to save energy from normal driving. This system will give the thermoelectric the ability to provide electricity to the battery system while driving normally.

A second advantage of this product is its ability to operate with no additional aid other than the heat created from braking. It does not require power or any other external force of energy outside of the heat from the brake pads. Again, no effort is needed from the customer other than normal driving. This is a positive affect for the consumer and the environment, while saving money and time at the gas pump.

Lastly, there is an important advantage this system has over other products in development. Other products are currently being researched to create electricity from the heat of the engine and exhaust. While this is a worthwhile effort at the present moment, these products will be made obsolete as fully electric cars come out into the market, which is likely happen in the near future since fully electric cars have been developed. One company has already designed and developed a fully electric car called the Roadster, by Tesla Motors, seen at teslamotors.com. With a fully electric car, there will not be a heat source from the engine nor an exhaust system, to generate the electricity to charge the battery. Braking systems will continue to be used in electric cars in order to stop the vehicle, and as a result, there is still heat created from the brake pads to harvest into electricity, ensuring that the ATS system will still function.
Competitive Advantage
This product has a large advantage over other products on the market; it capitalizes on the fact that drivers have to use the brakes. The brakes lose frictional energy through heat transfer that occurs on every car, hybrid or not. The company R&D team will design this system to fit on any hybrid or electric car’s brake system. With this available, there will be a market that increases from the Prius to all cars that have a second battery to serve as an energy storage device. The ability to mount this kit to several vehicles is to be displayed on the website, along with some general information about expected results.

The best competitive advantage is that this is “green” technology, referring to the fact that it is helping the environment by saving fuel. This technology and kit will allow companies and people to show their love for the environment by not producing as much emissions, and saving money while helping.

This system will put out enough power through normal driving that it could be a substantial part of the battery charging system. Currently the Prius design requires the user to pull a lever which engages the braking system to generate power which charges the electric motor battery. The thermoelectric system will provide a constant power supply as soon as the operator uses the brakes on the car. This power supply is used to charge the electric motor battery without the need for premeditative actions. While the electric motor in the Prius provides 50kW of power, the battery that powers this motor will be gaining more energy since there are two sources of power generation. The additional energy generated from this process will lead to an increase in gas mileage. Once tested, this system can be implemented on a car to help further decrease fuel consumption by combining with the previous technology installed on an automobile. Prius, for example, uses a kinetic braking system that allows the wheels to supply power to a battery during braking. This system is rather unique since you have to remember to pull a lever, when you slow down or stop. This means that the system will not increase the power in a battery if the driver does not control his vehicle properly. Things like emergency braking could waste energy during normal driving conditions without driver attention. The ATS system will not require the driver to do anything extra while braking since it will allow the vehicle to still generate power while driving and using the normal brakes.

Marketing and Sales Strategy:

Promotional Strategy
In order for ATS to promote the product being offered, ATS will have to look at individual customers automotive shops as two separate forms of promotion. The target market for this product includes both individual customers and automotive shops in Northern California. There is a substantial amount of research to be done for Northern California and surrounding areas in which to target and execute this sales strategy. Once research has determined the amount of money that an average person has, along with their cars owned, the company can make a decision about what automotive shops to target.

Automotive shop selection will be done by the president of ATS and will carry out promotional strategy. With the shops selected and targeted, the company should then begin to promote the product. The company can promote this product by offering price cuts for bulk orders to the
select shops. This will allow the dealer to get a discount based on the amount of parts that will be purchased. The next step would be to promote a discount on the sales price for early payment, if the parts were purchased on credit from the automotive shop. This discount will help influence the shop to advertise the kits. Whether the shop advertises in a magazine or a window, this advertisement will help generate demand as time passes. The promotion rate for bulk purchases will be 1% off of price for ten kits, 5% off sales price for orders of 11 or more. For credit purchases, ATS will offer a 3% sales price discount if the balance is paid in full within 30 days or full sale price due within 90 days. This promotional pricing will lead to a large amount of sales towards the fourth and fifth years of business, but with the forecasted sales for the first three years, this will be a reasonably small advertising cost. This cost for bulk sales discounts are factored into the advertising budget.

When it comes to an automotive shop selling a product that they purchase from a manufacturer, the shop is expected to sell the part with an average 50% markup on cost according to Auto Compare. This means that when a shop buys this product for $325, the customers will be looking at total cost of $488. When this value is analyzed from the survey data collected, there is a total of 47% of the hybrid owners would purchase this product. This substantially reduces the amount of future customers since the price in which the product is offered is higher than what 53% said they would spend on this product. This leads ATS to the conclusion that there is still a market potential for this product after a shop has the product and increases the price.

Market penetration pricing will not be offered with these kits since there is no other direct competition on the market for this system, according to Consumer Reports. The promotion to websites will be a 1% return on sales for successful leads. This leads to a maximum profit reduction due to promotional expenses for the first year of $26. While this number is not very large, the website owners should look at this promotion as an investment with possible returns of over $5460 for five years. These values assume that the investing website owner will turn 20% of the total sales of ATS.

Potential customer promotions will include a discounted installation rate at certain auto shops. This service rate discount can be exchanged for the referral from ATS to the shop. This works with the fact that a customer will most likely return to the shop which processed the installation of a part. This ability to refer a customer and keep them returning creates future business possibilities for the automotive shops. The ability for a company to recommend service at an automotive shop is a tool which can be invaluable to many shops.

Advertising Plan
The company will operate out of a warehouse, which will not require a store location. While there are cost benefits to using warehouse space, this will not support direct advertising in the form of a store location, in-person sales staff, or signage. For this reason alternative sources of advertising will be used to allow the company to increase the consumer awareness and sales demand for the product. The company will initially utilize several marketing tactics as part of the start-up plan. These methods will include:

- Automotive trade shows and conventions
- Sales calls to specialty auto parts stores and repair shops
- Company website and the ability to collaborate with other company’s websites
ATS will start with a website that gives detailed descriptions of our product and the kit we are selling. Once the website is available, it will have to be constantly maintained to show product development along with any industry developments. This will allow the company to grow globally without a sales team and with minimal advertising. The current sale price is subject to change as the cost of the setup is decreased by the amount of products sold.

The opportunity exists to collaborate with other companies and to use their existing websites to reach our target customer. These websites should be automotive style and “green” energy websites that share a common interest in hybrid vehicles. In exchange for recognition of the company product, the company can offer a small payment to the website owner that leads to sales of our product. A contract can be negotiated which gives the website owner a 1% return on the total sale of kits. This is a small number; however, as the website promotes the product the owner will start to receive substantial amounts of money. If the kit sells at $325, the owner shall receive $3.25. When multiplied by the number of leads a well visited website can create, this $3.25 can increase to $325 with 100 leads. This is reasonable to assume that these numbers of 100 sales will be able to occur well after the first year of business. With this known, the website owners will have to look at this option as an investment over five years, creating an income in the ranging on advertisements for simply carrying an article about the product that this company offers. The cost of the website advertisements are factored into the advertising budget.

The ability of ATS to gain endorsements from environmental agencies is another form of advertising through agency endorsements. ATS can offer these agencies a donation for each kit sold through a referral. This donation will be 1% of the total sales which can demonstrate the support of ATS for the environment. The ability for the environmental websites to advertise for ATS will bring a large amount of website and sales traffic for ATS. The environmental agencies already have a support from the customers that are targeted by ATS. This is a major bonus for both the agency support and ATS company support. This cost for referrals is factored into the advertising budget.

While in the first two years of business, the advertisement costs for website referrals and automotive shop discounts will be low since the forecasted sales are low; creating a maximum advertising cost of $845 for the first two years assuming 20% referral rate. As the company matures this cost for referrals is expected to increase. The beginning stages of business allow an advertising cost to be focused on website design and all other forms of non referral advertising.

**Distribution Channels**

The primary form of distribution for this kit will be through direct sales to consumers and certified shops. The kits will be sold via salesmen to the certified automotive shops. The kits will be sold through website sales and phone contact only for consumer sales. The sales will be focused in Northern California for automotive shops since it the most condensed area within the U.S. which contains hybrid vehicles.

The website sales will be able to work with the consumer directly through email contact and phone. The company will work with the consumer to suggest automotive shops that are certified to install the kits. With the suggestion of automotive shops, the company can create a contract to
receive a percentage of sales from the referred customer. This form of advertisement will enhance the quality of the system if the shop does a good job, creating future customers and a reliability towards a shop that can service the system if needed. The selection of shops to reference should be considered carefully in order to ensure a quality job.

Brand Recognition
Brand recognition will be a big influence on the sales of this kit. Co-branding will be the most effective form of advertising for the product. The Prius is known throughout the country as the reliable hybrid that gets an expected 50mpg. With the addition of the new technology, there is the potential to relate this kit to the increase in gas mileage in the Prius. If the company was able to sell these products to Toyota for direct manufacturing and installation, consumers will then be able to recognize the product as a sign of quality within a quality manufacturer. This will allow expansion of sales of the product to other automotive companies that manufacture hybrid vehicles. With the increase in recognition for ATS, the company will be able to research other applications to the thermoelectric models and produce products that can further increase the gas mileage of hybrid cars. A reasonable value to expect from the kit is an increase of six miles per gallon. This calculation was made by assuming a power output efficiency of the thermoelectric to be 70 percent of the maximum rated power output.

Pricing
The pricing of this product is rather hard to determine and includes many factors that can easily affect the selling price. Some major factors that may affect pricing include;

- liability insurance
- quantity discounts
- overhead costs
- advertising costs
- product life expectancy

Pricing Model
Unit cost analysis will be the pricing model used for the product. This will allow the company to make decisions based on the cost per unit, or kit in this case. The kit includes two manufactured mounts, four thermoelectric sensors, thermoelectric glue, and assembly. The base price for the kit will be $325. This unit price is reasonable based on the assumption that the consumer will be able to save enough gas over five years in order to pay off the investment. The five year estimate varies based on the amount of miles the consumer puts on the car every year and the possible increase in gas mileage of more than six miles per gallon. The cost of the kit to be manufactured and assembled for a total of two wheels will be $165, making the percent markup on price at 200%. There will be shipping and handling fees that will be added to each kit depending on the general area the kit will be shipped. This value should not vary due to the weight of the kit since they will be manufactured and assembled the same. Once different kits are offered for different vehicles there may be a slight increase or decrease in the shipping cost based on weight. The estimated cost for shipping will be $50.
Liability Insurance
There is a potential liability with this kit since it will be used on a hybrid brake system. If the part failed and caused an injury or death, there will be a lawsuit to follow. For this reason there will have to be a substantial liability insurance policy for the failure of the product in order to protect the investors of the company. The cost for an insurance policy is factored into the company yearly budget, in appendix D. The liability can be lowered by recommending certain certified shops for installation, ensuring the use of only high quality thermoelectric sensors, and the application of a disclaimer which will highly recommend certified installation. It will be a requirement that any company that is used as a source of thermoelectric sensors have liability insurance in place to mitigate any potential risk for ATS due to faulty workmanship on the sensors.

There is one more way in which ATS will lower the liability of this product, which includes the quality control of the mount. There will be a Brinell hardness test that will be done on a select amount of parts. This test is a way to determine the hardness of a material in order to limit weak parts that can fail during driving. The Brinell test machine is incorporated in the startup budget and will help lower the risk of part failure due to weak or faulty parts. The basic visual quality control check will be done for every part by the assembly technician to check for excessive cracks in the material. This check will be done during the assembly of the thermoelectric to the mount.

Quantity Discounts
A price reduction will be offered from the original $325 if a shop or distributor is willing to buy the kits in bulk. The company can offer the kits for a reduced rate for a quantity of more than 5 kits. This reduced rate comes with the ability for the company to decrease the setup costs for each order. The reduced rate will help encourage shops to increase the quantity of kits on hand for installation. The costs of the kits can be reduced by 5%. In addition, automotive shops can be encouraged to purchase larger quantities by offering credit terms to the qualified shops. These credit terms can’t be offered until ATS has enough equity and profit to support the loss of cash flow that will result. The shop will have a grace period of 90 days to pay back the debt owed from the credit before late fees are charged. This will have the risks that come with issuing credit to companies but this risk can be minimized by an analysis of the previous credit history of the company. If the company is unable to pay for the kits and unable to sell the kits, ATS will take back any unused kits and reduce the amount owed by that company. During this transaction the company will have to pay for shipping and handling to return the parts back to ATS.

Overhead Costs and Facility
The overhead costs include building, general utilities, engineer salaries, sales people salaries, worker’s comprehension insurance, manufacturing technicians, machine cost, tooling cost, maintenance, metal recycling, website design and maintenance, and much more. Detailed cost breakdown is included in Appendix D. This company will have a start up cost that, when analyzed on a per kit basis, will eventually reduce per unit as more units are manufactured. This average cost per month for operation is $20,000 for the first year and increases to $25,000 in year five. This means that the company will have to sell 125 kits per month to cover operating expenses for the first year, while selling the kits at $325. This breakeven amount will not be
achieved since the forecasted market sales for that year are only 400 kits. However, breakeven units per month will be able to be reached during the third year and after.

The facility being used for manufacturing and assembly of the product will be a 2,500 square foot warehouse located in Reno, Nevada. This building will allow ample space required for the storage of products, along with assembly and manufacturing equipment. This building will have to be expanded as the demand for the product increases after year five. The average cost for rental of a warehouse $0.67 per square foot of space. This leads to a total rent cost $1,250 per month.

**Advertising Costs**
Advertising costs will vary based on the how far the company is in the profit stages. The advertising costs at startup will include website design and maintenance along with California based advertising. There are many tools that can be used for a cheap form of advertising, webpage links are a way to do this. This placement of links and articles on frequently visited websites will create a liability and a debt owed to the website owners when referrals have purchased the kits offered by ATS. This will help minimize the cost to ATS while creating product sales.

As the company matures and begins to make a larger profit, other forms of advertising can be used. ATS will pursue advertising using a sales team that will take the product to automotive shops and dealers. This will cost a substantial amount of money, and will lead to a substantial increase in the demand of the product offered. An alternative to the sales team is to advertise to Toyota, and other major car companies, directly. The goal of this form of advertisement is to create a contract through the Toyota dealer that will allow the company to fill large orders of kits. This technology could possibly be bought by Toyota to allow a large profit for the company to sell the technology to Toyota directly. Since there are other car companies currently manufacturing hybrid cars including Ford and Honda, the sales can target these companies to sell the product directly. With this there is a sales pitch that can be used since these companies currently do not have a car with as high of gas mileage as Toyota has according to fueleconomy.gov. This advertising strategy for these companies would be to use the product made by ATS to increase gas mileage to be able to compete at a higher level with Toyota in gas savings.

These forms of advertising are factored into the operating and yearly costs for ATS. Refer to appendix D for the breakdown of costs per year.

**Product Life Expectancy**
With the thermoelectric and mount being exposed to a driving environment, there is a possibility that the life of the product can be lower than expected. The harsh environment can have rocks, road salt, water, snow and much more affect the efficiency of the product and the life expectancy. While these risks are mitigated during the product experimentation and design, they can still cause damage to the product. The life expectancy for the product with no outside influence will be designed to be five years. After five years of driving the product will need to be replaced with a new mount and thermoelectric. Based on the pricing of $325, and average fuel
savings calculated in appendix B, the product pays for itself within three years and allows two years of consumer profit.

**Literature and Patent Search**

There are 298 United States patents that deal with thermoelectrics. Of those 298, three patents indirectly relate to our proposed design.

- Patents 5,598,405 (Bell, 7/29/2003), 7,111,465 (Bell, 9/26/2006), and 7,273,981 (Bell, 9/25/2007) all deal with thermoelectric power generation utilizing the Seebeck effect. They claim to produce thermoelectric power by converting thermal energy into electrical energy via a temperature gradient. Our proposed design utilizes a thermoelectric sensor to transform thermal energy dissipated from the brake pads into electrical energy that could be used to power a hybrid vehicle.

- Patents 7,100,369 (Yamaguchi, 9/5/2006), 7,178,332 (Sasaki, 2/20/2007), and 7,430,875 (Sasaki, 10/7/2008) directly relate to our proposed design. These three patents encompass an exhaust heat recovery system. The thermal energy from the exhaust gases of a vehicle could be converted into electrical energy using thermoelectric devices.

The primary difference between our proposed design and these six patents is the use of the wasted thermal energy dissipated from the brake pads to power a hybrid vehicle. The patents that directly relate to our proposed design use the exhaust gas from the engine and convert that thermal energy into electrical energy. Yamaguchi claims to use the engine coolant as the low temperature heat source and Sasaki uses ambient temperature. Yamaguchi's proposed system is complicated and not realistic towards mass production. He proposed bypass pipes branched from the exhaust pipe through a plurality of branch pipes. Each branch pipe has an electric valve which opens and closes the pipe. The branch pipes opening and closing controls the temperature entering the thermoelectric device. Sasaki uses a heat pump to transfer the thermal energy to the thermoelectric device. Our proposed design adds two brackets to the vehicle and can be easily mass produced. Two thermoelectric sensors will be applied to each bracket which will transform the thermal energy dissipated from the brake pads into electrical energy that will be used to power a hybrid vehicle.

“Two-/Three-Dimensional Hybrid Model of the Themomechanical behavior of disc brakes” by Dufrenoy deals with the problems in analyzing the surface temperature in friction breaking systems. The journal article explains the difficulties in analyzing the thermal dissipation and surface degradations such as wear, phase transformation, and cracks. The difficulties in analyzing surface temperature include complex interactions between the thermal, mechanical and tribological behavior and the response of the disc and brake pads (conduction and distortions). Dufrenoy talks about how he analyzes the surface temperature using ANSYS. Our proposed design will include a heat transfer analysis of brake pads for a 1997 Jeep Wrangler utilizing ANSYS. Dufrenoy article explained the difficulties and his solution for analyzing the surface temperature in disc brakes.
**Organization and Management:**

**Management Team:** The following members of ATS have participated in numerous group projects pertaining to the mechanical engineering field along with all of the required classes for an undergraduate degree in mechanical engineering.

**Kevin Conant:** University of Nevada, Reno undergraduate student. Kevin is a mechanical engineer expecting to graduate in spring of 2009. Kevin will be the economic and financial advisor for the company. Kevin has relevant experience with CPAs and has basic knowledge in accounting. Kevin will aide in research and development of the product.

**Mike Crepinsek:** University of Nevada, Reno undergraduate student. Mike is a mechanical engineer expecting to graduate in spring of 2009 and anticipating on becoming a graduate student at UNR. Mike is currently working for the Reclamation Bureau performing in depth analysis on structures. Mike is also a research assistant to Dr. Park at UNR who specializes in heat transfer and renewable energy. Mike is the main heat transfer analyzer for ATS, also helping with product development and experimentation.

**Alex Heller:** University of Nevada, Reno undergraduate student. Alex is a mechanical engineer expecting to graduate in fall of 2009. Alex helps in research and development of the product along with legal investigation. Alex is currently interning for Charles River, a research company, as a lab research assistant whose attention to detail is very helpful for literature investigations.

**Dan Heller:** University of Nevada, Reno undergraduate student. Dan is a mechanical engineer expecting to graduate in spring of 2009. Dan helps in research and development of the product along with a literature search of current technologies.

**Matthew Kengott:** Vice President of ATS; University of Nevada, Reno undergraduate student. Matt is a mechanical engineer expecting to graduate in fall of 2009. Matt has worked at multiple engineering firms including Hamilton Company and EETechnologies Inc. Matt has designed multiple projects using 3D CAD and AutoCAD software. While interning at these companies Matt performed many experiments and tests on products and is an essential person for the experimentation of the ATS product. Matt’s father owns a sheet metal company in Carson City NV and is able to help out with business administration of ATS. Matt also help lead the research and development team.

**Tommy On:** University of Nevada, Reno undergraduate student. Tommy is a mechanical engineer expecting to graduate in spring of 2009. Tommy helps in research and development of the product. Tommy has experience modeling thermal profiles with COMsol during an internship with NASA. Tommy is the main SolidWorks and ANSYS analyst for heat transfer and product development.

**Chris Richardson:** President of ATS. University of Nevada, Reno undergraduate student. Chris is a mechanical engineer expecting to graduate in fall of 2009. Chris is currently in the U.S. Navy’s officer candidate program for Nuclear Engineering. Chris has interned at a variety of engineering companies including a machine shop as a supervisor to operations, and a marine construction
company as a project engineering intern. Chris has been a team leader for a variety of projects during his time at UNR and demonstrates the required traits to keep the team on track and professional; projects including ME 451 Space Truss, ME 351 Car Jack Modeling, along with numerous small projects throughout his four years at UNR. Chris has taken extensive business classes for his minor that allows him to contribute to marketing and operation of ATS. Chris helps in research and development of the product along with keeping track of team goals and deadlines.

All non-owner management positions still need to be filled.

**Company Organization:**

ATS will be based out of Reno, Nevada. It is within driving distance of northern California, the location targeted to be the companies cliental. Reno is also located near the company’s various suppliers, and the city contains a large workforce looking for jobs. ATS will be declared as an S corporation to help alleviate lawsuits from the owners and the company’s investors. The company will start off manufacturing during the week; Monday through Friday 7:00 A.M. to 3:30 P.M.. ATS will have a total of three employees, in the beginning, ranging in skill level and salary.

The following are the positions needed to operate the company for a year. The company will be producing roughly 400 units.

1 **President/Manager:** Manages office, performs payroll, human resources, sales, business and marketing, manages shipping and receiving, performs quality control, and increases production efficiency and janitorial work.

1 **Quality Control:** Purchasing, engineering analysis on products, performs quality control, increase production efficiency, and design product to ensure customer satisfaction.

1 **Standard Employee:** Performs various jobs though out the company including: shipping and receiving, assembly, taking inventory, assisting machinist, and answering phone calls.

ATS will assemble and distribute the product. Machining of the mount will be outsourced to a capable machine shop in the local area. The die punch for the stamping of the mount will be provided by ATS. The die is estimated to cost $20,000 as quoted by Ken Die Supplies. The die will produce huge cost savings, as more parts are made. The outsourcing to a machine shop greatly reduces the amount of personnel on staff. The staff reduction will lead to the biggest cost savings. It is estimated that ATS will break even after four years and seven months.
Table 2: Personnel table for the next five years.

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Financial Management:
Refer to Appendix D for the financial management of ATS on a per month basis for the first five years of business.
Appendix B
Appendix C
### Table 1: Experimental Results

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![Temperature and Power over Time](image-url)

Figure 1: Thermocouple Temperatures and Thermoelectric Power Generation
Figure 2: Power generation compared to temperature difference across thermoelectric
Appendix D
References:

**Oil References:**

**Hybrid Sales Numbers:**


**Profile Hybrid Drivers:**


**Gas Saving Devices:**


**Aftermarket Car Part Sales Numbers:**

**Breakeven Analysis:**

**Brake references:**


**Thermoelectric:**


**Electric Car Manufacturers:**