IPRO 356: PLUG-IN HYBRID ELECTRIC VEHICLE

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1.0 Executive Summary

The mission of Isopomoto is to analyze the business opportunities for Plug-in Hybrid Electric Vehicles (PHEV) for the Grainger Power Electronics Lab and All Cell Technologies. Superior fuel economy, lower long-term cost, and environmental considerations have played a role in the gradual, but steady trend from internal combustion vehicles to alternative power sourced vehicles. The plug-in hybrid electric kit offered by Isopomoto reduce emissions and dependence on gas, and is the next step towards a fully electric car that has zero emissions and zero dependence on gas.

Isopomoto was established in August 2006, but its members have been involved in hybrid vehicle research for five years. It is currently staffed by a Chief Executive Officer, Vice President of Operations, Chief Financial Officer, Chief Technical Officer, and six additional employees. The current executive staffing is expected to be adequate to meet identified market demand and potential for the next two years. Isopomoto is affiliated with the Grainger Power Electronics Center at the Illinois Institute of Technology.

The gas savings that Isopomoto's kits offer is tremendous. For example, a Toyota Prius hybrid coupled with Isopomoto's plug-in hybrid electric kit potentially achieves 123 miles per gallon (mpg). Applications for the use of plug-in hybrid electric kits include direct consumers and average car owners, commercial or private fleets, and licensing the technology to auto manufacturers. To reach direct consumers, an alliance with a dealership such as Chris Schneider's Honda Motorwerks is being considered. Concurrently, the Grainger Power Electronics Center is working on retrofitting the Ford Escape hybrid for a private fleet.

Using a Lithium Ion (Li-ion) battery, the cost per kit is $13,500. This will be the standard price during the company's initiation and developmental phase. This introduction price is necessary in order to offset the company's start-up costs. Once the company is in the operational phase, the target price per kit will be $12,000.

2.0 Business Plan

2.1 Company Mission and Background

Mission

Isopomoto was founded in August 2006 through the inter-professional project program at the Illinois Institute of Technology. The company name is a testament to the diverse background of our members and is derived from the Yoruba words for hybrid ('isopo') and car ('moto'). Isopomoto's vision is to complete the final stage in the commercialization of Plug-In Hybrid Vehicle retrofit technology. We aim to market our PHEV kit to private and public fleet owners, conventional hybrid owners, distributors, as well as car manufacturers with a particular emphasis on Chicago clients.

Background

It is projected that automobile ownership and use will significantly increase over the next few decades. Along with this comes the obligatory increased consumption of fuel. However, it is believed that oil production will reach its peak by 2025 and the increase will not be able to meet the demands of world use. Prices will skyrocket and tensions will heighten in the Middle East. It is thus imperative to find a way to reduce petroleum-based fuel use without compromising the automotive industry markets. One solution is to create more electric vehicles (MEVs). With sales of hybrids jumping 81% in 2005, the electric-combustion hybrid technology has already proven itself both in terms of usability and marketability.

There are several crucial advantages to PHEVs. Although the retail price of a PHEV is slightly higher than first-generation (conventional) hybrid vehicles, the operational cost is substantially lower. Fuel costs for conventional vehicles currently stand at 6 cents per mile; while for plug-ins the cost is only 3 cents (this includes the cost of electricity to charge the battery).[1] Moreover, the government will provide tax credits for alternatively fueled vehicles.[2] Because of reduced emissions, PHEV is environmentally friendly and is known as a 'gas-optional hybrid' because it does not

[1] *IAGS, Institute for the analysis of global security*
[2] *Energy Policy Act of 2005 (EPACT)*

need to use gasoline for typical commuter distances. This reduces emissions to zero! Government studies have found that PHEVs reduce greenhouse gases by 46 to 61 percent.[3] A study by the Electric Power Research Institute found that consumers prefer plug-ins because they offer the best of both worlds: the reliability of a traditional hybrid and the efficiency and performance of an electric car. With the benefits of reduced emissions, improved city driving performance, and higher fuel efficiency, these vehicles are more attractive than ever before despite their higher retail price.

Isopomoto's focus is on PHEVs but it has been involved in hybrid research for over 5 years. The PHEV is a hybrid car with an additional battery which has the ability to be recharged anywhere an electrical outlet exists. PHEVs run on this added battery in what is known as an all-electric mode until the battery is completely discharged whereupon it reverts back to conventional combustion. During this time, which can range anywhere from 20-100 miles depending on battery size, zero fuel is consumed.

The firm's preliminary research has determined that the PHEV concept can be a very successful and profitable alternative to conventionally powered automobiles and may well have the potential to capture the market from traditional hybrid manufacturers. The initial designs for Isopomoto's system has been completed and thoroughly tested for consistent results. The parallel research being conducted on batteries, engines, braking systems and so on allows Isopomoto to produce PHEVs entirely in-house.

2.2 Problem and Opportunity

The Problem

The importance of PHEVs has been entrenched by three primary socio-economic factors: oil prices, finite resources, and environmental pollution.

A. Oil Prices

The cost of oil has been rising steadily since the start of the century. The cost of a barrel of crude oil supplied by OPEC rose from around $22 a barrel in January 2001 to $57 a barrel in January 2006. This is an increase of almost 160% in 5 years! What is

[3] *Electric Power Research Institute*

worse is that this increase is continuing at an alarming rate. If current trends continue, Americans will end up paying $2.6 billion a day for oil by 2007.

There are many reasons for this continued increase in price:

i. *Increased demand due to accelerated growth in global economies*. This growth is largely due to developments in the U.S., India, and China. OPEC and other oil producing nations have not been able to meet the demand because they are already producing at their full capacity. Combined, China and India both account for a third of the world's population and in the next two decades, China's oil consumption is projected to grow at a rate of 7.5% per year and India's 5.5%. It will be strategically imperative for these countries to secure their access to oil.

ii. *The volatile situation in oil producing regions*. The Middle East and Nigeria, two of the oil-rich regions have been faced with countless internal and external conflicts making the region highly unstable. These factors highlight the U.S.'s growing vulnerability to oil price shocks, supply disruptions, as well as the balance of trade and international political issues.

iii. *Higher fixed costs incurred by oil companies.* With the demand for oil increasing daily, more resources are being allocated to securing oil both in and outside these volatile regions. These endeavors result in oil companies incurring large fixed costs which are thereafter passed on to consumers.

B. Finite Resources

The price of oil is not the only reason for the sudden interest in more efficient and alternative energy sources. Oil is a limited commodity. World crude oil reserves are estimated at approximately one trillion barrels. In 2004 alone, oil producers like OPEC produced about 76 million barrels per day totaling 27.7 billion barrels for the year.[4]

As world economic growth continues on an upward trend, crude oil demand will also rise. The 5.1 percent increase in demand in 2004 cumulated in an increase of over 2.5 million barrels a day. In 2005 it was an added increase of 1.68 millions barrels a day. Based on a forecast of these growths, oil demand is expected to reach a high of 90.6 million barrels per day in 2010 and 1 billion barrels per day by 2020[5]. We are using oil

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[4] Wirasingha, Sanjaka, Thesis, Page 6. ref [11]

[5] According to the OWEN reference case figure

faster than we can find it and it is vital that we look for alternate sources of energy. Hybrid Electric Vehicles (HEVs) are just a first step, but an important one, as efficient use of oil would give us a few more years of oil consumption- years that must be used wisely.

C. Environmental Pollution

Global warming and the depletion of the ozone layer are two of the many catastrophic situations that have made us look into less destructive ways of going about our daily lives. Usage of non-renewable energy has caused more environmental damage than any other human activity in the recent past and emissions from vehicles have been identified as a primary reason for environmental pollution. Vehicles are the largest source of smog forming pollutants in cities. It must be noted that many respiratory illnesses have already been directly related to vehicle emissions in many cities. The last twenty years or so has seen a tremendous effort to minimize this pollution, which is a result of the internal combustion engine (ICE) - one of the greatest but most inefficient creations of our time. Renewable energy causes fewer emissions, reduces chemical, radioactive and thermal pollution, and stands out as a viable source of clean and limitless energy.

Recent advances in diesel combustion technologies, better afterburners and catalytic oxidizers, and use of alternative fuels such as compressed natural gas (CNG) have resulted in overall reduction in emission of toxic gases. While this is a step in the right direction, the emissions from vehicles that have undergone these improvements are still too high. This has paved the way for new interest in HEVs which under the right conditions promise close to zero emissions.

The Opportunity

There is no doubt that the consumption of oil at this alarming rate will be detrimental to our survival. As a result, various types of electric-drive and other clean-fuel vehicles continue to be of interest as a means to control motor vehicle pollution and to curb petroleum use both in the U.S. and in many other countries. Since travel behavior is difficult to change, many analysts believe that modifying vehicle technology is the best means to offset the environmental impacts of continued increases in vehicle miles traveled (VMT) in areas where automobile use is dominant.

HEVs are a viable alternative to conventional ICE-based vehicles for the automobile industry. Recent efforts in HEV research are directed toward developing energy efficient and cost-effective propulsion systems. The Electric machine in the HEV propulsion system minimizes vehicle emissions and improves overall system efficiency while the Internal Combustion Engine provides extended range capability.

The addition of an externally rechargeable high capacity battery can potentially reduce fuel consumption to zero for short trips and substantially reduce emissions for longer trips. Even though municipal electricity comes from coal, natural gas, or nuclear power, environmental impact is still decreased due to the high efficiency of the supplying plants. The PHEV can provide the increased fuel savings, reduction of emissions, and high performance of an electric vehicle, as well as the distance capability and reliability of a standard HEV.

2.3 Isopomoto's Solution

2.3.1 The product: Plug-in Hybrid Electric Vehicle Kit

The PHEV kit is essentially a supplement to the battery pack of a conventional HEV (see figure 1). The kit contains an AC/DC converter, which charges the added battery pack using electricity from a household outlet. The capacity of the battery pack would vary depending on the requirements of each vehicle. Nickel-metal-hydride (NiMH) and lithium-ion (Li-ion) batteries are widely used. It is important to note that Li-ion batteries are significantly more expensive than NiMH batteries. The kit also includes a DC/DC converter to provide stable voltage and current to the battery pack of a HEV.

Figure 1: A Plug-in Hybrid Kit

2.3.2 Solving the problem

Isopomoto's product addresses the problems of increasing oil prices and pollution by cutting down the fuel consumption and reducing emissions. Assuming average driving patterns (see table 1), a plug-in with an electric-only range of 20 miles could be expected to reduce fuel consumption by about one-third as compared to a current hybrid. A plug-in with a 60 mile range could cut gasoline consumption by about two-thirds, though battery cost would be nearly three times that of the 20 mile plug-in.

Table 1: Electric-Only Range and Gasoline Savings for an Average Driver[6]

Electric-Only Range (miles)	Gasoline Savings Assuming All-Electric within Range	Gasoline Savings Assuming 50% Electric over 2X Range
10	21%	19%
20	37%	30%
30	50%	36%
40	60%	40%
50	67%	42%
60	72%	44%

With regard to greenhouse gas emissions, the advantage of plug-ins over conventional hybrids is greater in areas where electricity is generated with low-carbon fuels, and much more modest elsewhere. In California, where electricity is comparatively low-carbon, a plug-in with a 40 mile range could cut carbon dioxide (CO_2) emissions by one-third. Using the typical U.S power generation source mix, the CO_2 reduction of the plug-in relative to a hybrid would be about 15%. In most locations, achieving a major CO_2 advantage from plug-ins will require greatly reducing power sector carbon emissions.[7]

From a public health perspective, the benefits of plug-ins are, again, highly dependent on electricity generation source. Charging on the grid today, a plug-in would emit 5% to 40% less oxides of nitrogen (NO_X) than a hybrid, depending on geographic location. Sulfur oxide (SO_X) emissions associated with a plug-in would be much higher

[6] Source: ACEEE based on 2001 NHTSA data, as tabulated by ORNL (2006)
[7] Source: American Council for Energy-Efficiency Economy

than for a hybrid, except in areas with the cleanest generation mixes. Table 2 shows the estimated CO_2, NO_X, and SO_X emissions associated with a plug-in running for one year (12,000 miles) entirely on grid electricity generated in California, as well as using a theoretical average fuel mix for the U.S as a whole.

Table 2: Annual Emissions for a Plug-in Running 100% Electricity in 2005

Region	CO2 (lbs)	NOX (lbs)	SOX (lbs)
U.S	4,241	6.3	17.4
California	2,172	2.3	1.8
East Central Asia	6,154	10.6	33.9

2.3.3 Limitations

While Isopomoto is optimistic about the commercial viability of our product and its ability to solve the problems cited, the PHEV does have some limitations.

i. *Battery cost.* Battery expense is a major hurdle to the commercialization of plug-ins with extensive electric-only range. The cost of a plug-in battery exceeds $10,000 today but could drop to a few thousand dollars in the long term. Such a cost reduction will be achievable largely through economies of scale in the case of nickel-metal hydride batteries, though issues of performance, size and weight remain. Smaller, lighter, lithium-ion batteries are considered more promising for plug-ins, but these batteries will still require major advances in durability and cost before they are ready for this application.

ii. *Battery size and weight.* The size and weight of the batteries are a constraint of PHEV mass production. For example, if a NiMH battery is chosen, this will add more than 250 pounds to the weight of the vehicle and take up roughly 4 cubic feet of space.[8] This is approximately 25% of typical cargo space, and it could lessen appeal to customers. Furthermore, the increased weight will adversely affect both fuel economy and performance. The use of Li-ion batteries could ease weight and cargo space challenges, assuming the above-mentioned issues can be solved.

[8] American Council for an Energy-Efficiency Economy

2.3.4 Simulation Tool – Advanced Vehicle Simulator (ADVISOR)

The simulation of three drive cycles was executed: US EPA Federal Test Procedure (FTP), the Urban Dynamometer Driving Schedule (UDDS), and a highway drive cycle. FTP and UDDS are widely used as typical city drive cycles. The simulation results are tabulated in tables 3 and 4 for city and highway driving respectively.

Table 3: Simulation Results of City Drive Cycle

	Conventional Escape	HEV Escape	PHEV Escape
City (mpg)	23	36	76.3

Table 4: Simulation Results of Highway Drive Cycle

	Conventional Escape	HEV Escape	PHEV Escape
Highway (mpg)	26	31	58.8

2.3.5 Technical Costs

The break-down of these internal and external expenses are discussed below. A summarized table is also provided at the end (see table 5). The internal costs include the battery, AC/DC converter, DC/DC converter, and assembly labor.

Table 5: Summary of Technical Costs

Technical Costs	
Internal Costs ($)	
Battery (NiMH / Li-ion)	5,000 / 10,000
Power Electronics System (AC/DC Converter)	500
Power Electronics System (DC/DC Converter)	300
Assembly Labor	250 (25/hr * 10hrs)
Insulation / Packaging	500
Miscellaneous Components	200

2.3.6 Battery (Li-ion and NIMH)

There are two assumptions associated with battery selection. First, the PHEV Escape achieves an efficiency of 4.0 miles per kWh when operating in electric-only mode. Second, the PHEV Escape is a 20-mile electric range vehicle. With these assumptions, there are two options for battery selection: NiMH and Li-ion. The specifications of NiMH and Li-ion are as follows (see tables 6 and 7).

Table 6: Specifications of NiMH battery

Nominal Voltage	245 V
Maximum Voltage	265 V
Minimum Voltage	136 V
Maximum Discharge Current	150 A
Current Capacity	24 Ah
Energy Stored	6 kWh

Table 7: Specifications of Li-ion battery

Nominal Voltage	245 V
Maximum Voltage	286 V
Minimum Voltage	204 V
Maximum Discharge Current	50 A
Current Capacity	22.5 Ah
Energy Stored	6 kWh

2.3.7 AC/DC Converter

Supplying stable voltage and current to charge the batteries in the plug-in hybrid kit is essential. Therefore, we must use an optimal AC/DC converter for the plug-in hybrid kit. The cost of the AD/DC converter is $500. The specification of AC/DC converter is shown in Table 8.

Table 8: Specifications of AC/DC converter

AC Input Voltage	85 – 264V AC
DC Output Voltage	120 – 373V DC

2.3.8 DC/DC Converter

Since constant current and voltage needs to be supplied to the batteries in a HEV, the role of the DC/DC converter is very important. The cost of a DC/DC converter that can boost up minimum voltage of batteries in the plug-in hybrid kit to the maximum voltage of batteries in a HEV is approximately $300.

2.3.9 Assembly Labor

Unlike conventional vehicles, the PHEV Escape requires more advanced technology, and, therefore, skilled workers at the assembly line. Wages for the workers will be $25 per hour, and they will work 10 hours a day.

2.3.10 PHEV Model

A regular combustion (RC) engine model car was purchased with the intention to convert it to hybrid and then retrofit it with Plug-In technology. In order to achieve this, the combustion engine was taken apart and an electrical motor (EM) (electrical motor + control switch + battery) was added in such a way that car would run on either RC or EM mode. Activating the RC motor, let the DC motor charge the hybrid battery. Then next step was to add a battery in parallel to the hybrid battery using a DC to DC converter which could be charged externally. This model will be used as a marketing and education tool for our customers.

2.4 Industry Review

The primary purpose of this section is to understand the major trends and technologies affecting the automobile industry, its top players and how Isopomoto fits into the industry. With this in mind, a SWOT analysis for the firm is given below (table 9).

Table 9: SWOT analysis for Isopomoto

Organizational (Internal)	Environmental (External)
1. Strengths	1. Opportunities
Technological prowess	High gasoline prices
Productive and committed team	Increased environmental awareness
	Current emphasis on fuel economy
2. Weaknesses	2. Threats
No capital	Alternative fuels
No established customer base	Discovery of new gas reserves

2.4.1 Major trends affecting the auto industry

The Big Three's Dominance of the U.S. Auto Market Is Compromised

Throughout most of automotive history, the Big Three (General Motors, Ford and DaimlerChrysler) have dominated the U.S. market. However, during the past decade, they have slowly lost that luxury (see figure 2). American carmaker's share of the U.S. market fell from about 73.5% in 1995 to about 58% in 2005. In 2006, the percentages shifted even further with the US companies holding just 53% of the market, while Asian automakers took 41.4%.

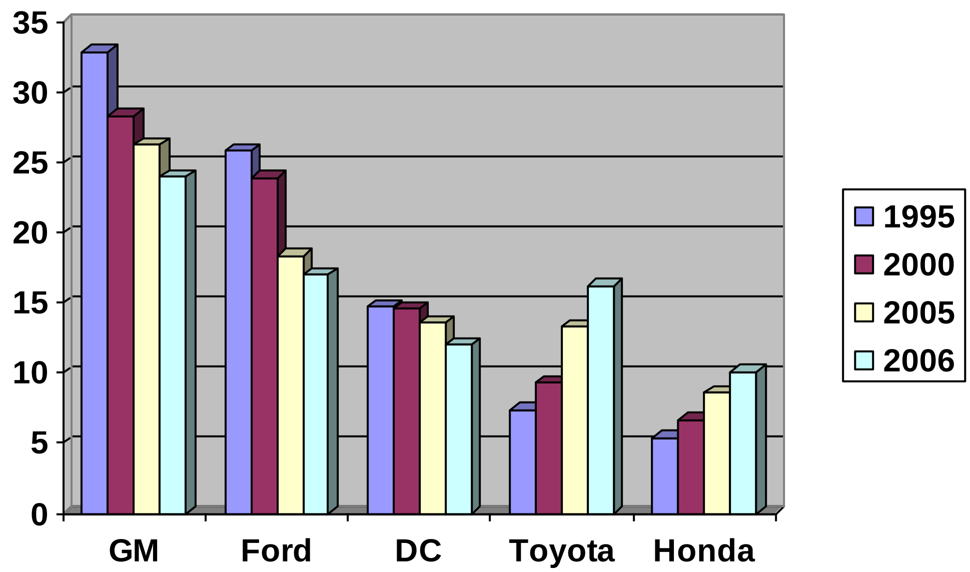

Figure 2: The decline in % market share of U.S. companies from 1995 – 2006[9]

This gradual shift is largely due to a general perception among a substantial number of American consumers that foreign products are superior in design and quality. Despite heavy discounting and incentives from American carmakers, consumers still seek the fuel economy often associated with Asian models. In July 2006, Toyota surpassed Ford in unit sales while Honda surpassed the Chrysler Group (the US arm of DaimlerChrysler) to rank fourth in unit sales (refer to table 10).

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[9] Plunkett Research, Ltd.

Table 10: U.S. Market Share of Cars and Light Trucks, July 2006[9]

General Motors	26%
Toyota	16.2%
Ford	15.9%
Honda	10.1%
Chrysler Group	10%

Fuel Efficiency Becomes a Key Selling Element

Prices at the pump averaged around $1.93 per gallon across the U.S. in the summer of 2004. By the summer of 2006, self-serve gas was typically selling at $2.95 per gallon (see figure 3). Analysts project prices to remain at more than $2.50 per gallon.

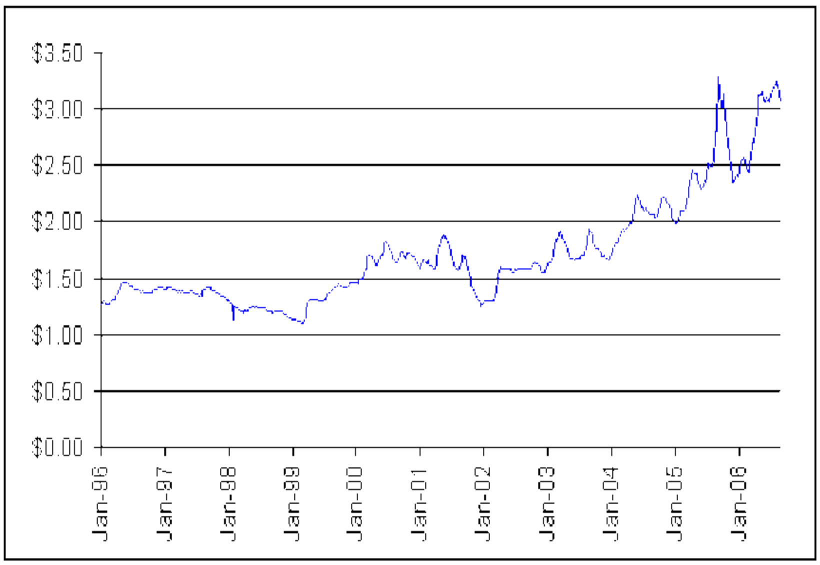


Figure 3: U.S. Average Retail Premium Gas Prices, Jan 1996-Aug 2006[9]

The skyrocketing price of gasoline has many drivers reconsidering the vehicles they are willing to drive. Minivans, pickups, and SUVs are quickly losing share to smaller and more fuel-efficient vehicles. In spite of high gasoline prices, the sales of the larger vehicles remained steady right up to 2005. However, in 2006 there was a sharp decline in sales, while the sales of the smaller vehicles continued to rise (table 11).

Table 11: US sales of Automobiles and Light Trucks (in Thousands), 2003-2006[9]

Year	Automobiles	Minivans, SUVs and pickups
2003	7614.5	9025.3
2004	7504.5	9360.0
2005	7667.2	9820.9
2006	8000.0	8500.0

The Environmental Protection Agency (EPA) rates the hybrid models produced by Honda and Toyota as the most fuel-efficient. According to J.D. Power and Associates, 13 hybrid models were on U.S. car lots in 2006 and sales will account for 1.51% of total vehicle sales. It is projected that by 2012, hybrid vehicles would account for 4.1% of the market for 18.3 million vehicles.

Currently each manufacturer is required to achieve an average of 27.5mpg on each passenger car they build and 20.7mpg on pickups, minivans and SUVs.[10] However, the government proposed new rules in August 2005 and added further standards in early 2006 that would institute sweeping changes to fuel efficiency standards. California standards have a decided impact on manufacturers since the state accounts for 10% of all new auto sales in the U.S. California is now requiring new cars and light trucks to emit 30% less carbon monoxide, 20% fewer toxic pollutants than current federal standards. Auto industry spokespeople claim that such changes are not feasible and if they were, would cost upwards of $4360 per vehicle.

Alternative Fuels Gain Popularity among Automobile Customers

The steady rise in the price of gasoline has renewed the average consumer's interest in alternative fuels such as ethanol, natural gas, hydrogen, and bio-diesel, including electric vehicles, whether fully electric or a gas-electric hybrid.

The interest in ethanol has primarily been fueled by the high prices of gasoline. However, with ethanol prices on the incline (figure 4); the interest is expected to be short-lived. Natural gas is quite popular because it is a highly developed technology, economically feasible, and environmentally friendly. However, the bulkiness of the kits

[10] Corporate Average Fuel Economy Standards

and safety issues associated with temperature keep natural gas from gaining popularity across the U.S.

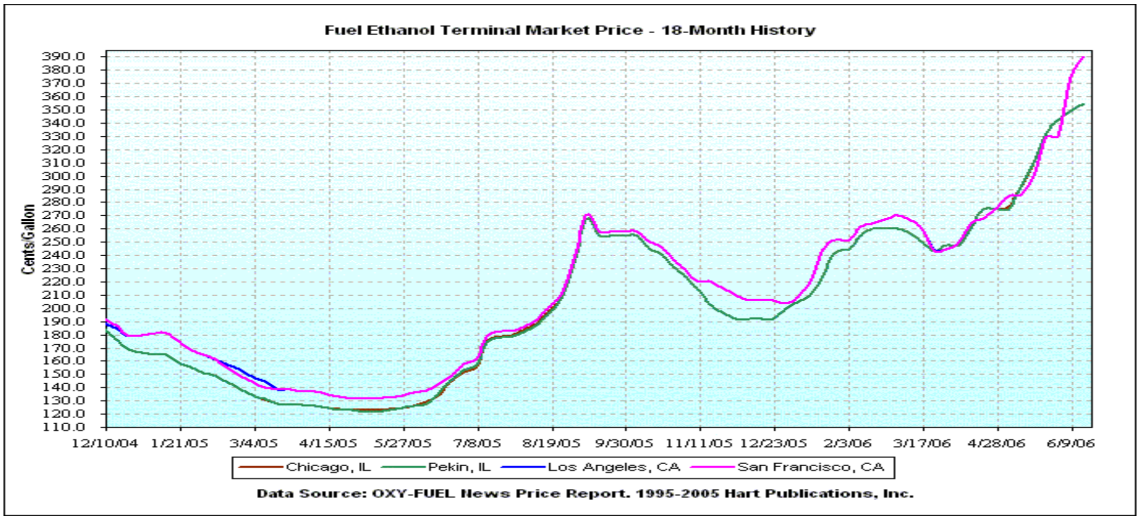


Figure 4: Ethanol Market Price – Dec 2004 to June 2006[11]

Hydrogen-based fuel cells are clean and efficient energy sources, but remain grossly expensive due to limited production and the industry's low technology base. Bio-fuels continue to be popular in spite of limited resources and the cost of technologies involved.

Table 12: The cost of conventional and alternative fuels, June and February, 2006[12]

Fuel	Average Price, June 2006	Average Price, Feb 2006	Difference	Units
Gasoline (Regular)	$2.84	$2.23	$0.61	per gallon
Diesel	$2.98	$2.56	$0.42	per gallon
CNG	$1.90	$1.99	($0.09)	per GGE
Ethanol (E85)	$2.43	$1.98	$0.45	per gallon
Propane	$2.08	$1.98	$0.10	per gallon
Bio-diesel (B20)	$2.92	$2.64	$0.28	per gallon
Bio-diesel (B2 –B5)	$2.97	$2.46	$0.51	per gallon
Bio-diesel (B99-B100)	$3.76	$3.23	$0.53	per gallon

[11] http://www.energy.ca.gov/gasoline/graphs/ethanol_18-month.gif
[12] U.S. Department of Energy, Alternative Fuel Price Report, June 2006

While table 12 above shows the overall nationwide average prices for conventional and alternative fuels on a per gallon basis, table 13, shows the same on an energy-equivalent basis.

Table 13: The cost of conventional and alternative fuels on an energy-equivalent basis, June 2006[12]

Fuel	Average Price, (gasoline gallon equivalents)	Average Price, (diesel gallon equivalents)	Average Price ($ per 10^6 BTU)
Gasoline (Regular)	$2.84	---	$24.58
Diesel	---	$2.98	$23.13
CNG	$1.90	$2.12	$16.50
Ethanol (E85)	$3.43	$3.83	$29.74
Propane	$2.88	$3.21	$24.95
Bio-diesel (B20)	$2.67	$2.97	$23.10
Bio-diesel (B2 –B5)	$2.67	$2.97	$23.10
Bio-diesel (B99-B100)	$3.71	$4.13	$32.10

It is seen that the prices for alternative fuels in terms of energy-equivalent are higher than their cost per gallon because of their lower energy content per gallon. However, consumer interest increases as the price differential per gallon increases, even if that differential does not translate to savings on an energy-equivalent basis.

Outsourcing of Component Manufacturing / Sharing of Parts and Designs

The return on the billions of dollars invested by the Big Three in acquiring foreign carmakers may be found in the increasing amounts saved by the outsourcing of design and engineering to overseas offices along with the sharing of component designs across a wide range of models. A growing manufacturing trend is for American carmakers to gather design work and components from foreign plants and manufacture or assemble vehicles domestically. Achieving the "American look", which may include significant changes in bodywork and interiors, is of major importance to car sales in the U.S. Attempts to market the same car, identical in every detail, across global markets have resulted in dismal failures.

With an understanding of these trends, a PEST analysis (refer tables 14, 15, 16 and 17) for the firm has been done. This guides Isopomoto in identifying its most likely barriers to market entry.

2.4.2 A Political, Economic, Social, and Technological Analysis for Isopomoto

Table 14: Political Analysis

Factors	Impact on Isopomoto
1. Political stability	Will ensure a smooth entry
2. Federal safety regulations (high voltage)	Might delay acceptance and profits
3. Intellectual property protection	Will necessitate patenting our technology
4. Tax – rates, rebates and incentives	Will be another plus for our customers
5. Wage legislation – minimum wage and overtime	Might reduce initial profits
6. Mandatory employee benefits	May reduce initial profits
8. Product labeling requirements	Will increase product cost

Table 15: Economic Analysis

Factors	Impact on Isopomoto
1. Infrastructure quality	Will build customer confidence and ensure product quality
2. Workforce skill level	Will affect product quality and wages
3. Labor costs	Will be significant as we will be labor Intensive
4. Inflation rate	Will have an adverse effect if the inflation rate is too high
5. Unemployment rate	Will have a negative impact on sales
6. Economic growth	Will aid our growth
7. Illinois's transition to a competitive market structure for electricity from January 2007	Will reduce economic appeal in Illinois

Table 16: Social Analysis

Factors	Impact on Isopomoto
1. Demographics	Will help to identify potential customers
2. Environmental Consciousness	Will definitely help our sales and growth

Table 17: Technological Analysis

Factors	Impact on Isopomoto
1. Development of alternate fuels	May reduce sales

2.4.3 Barriers to Entry

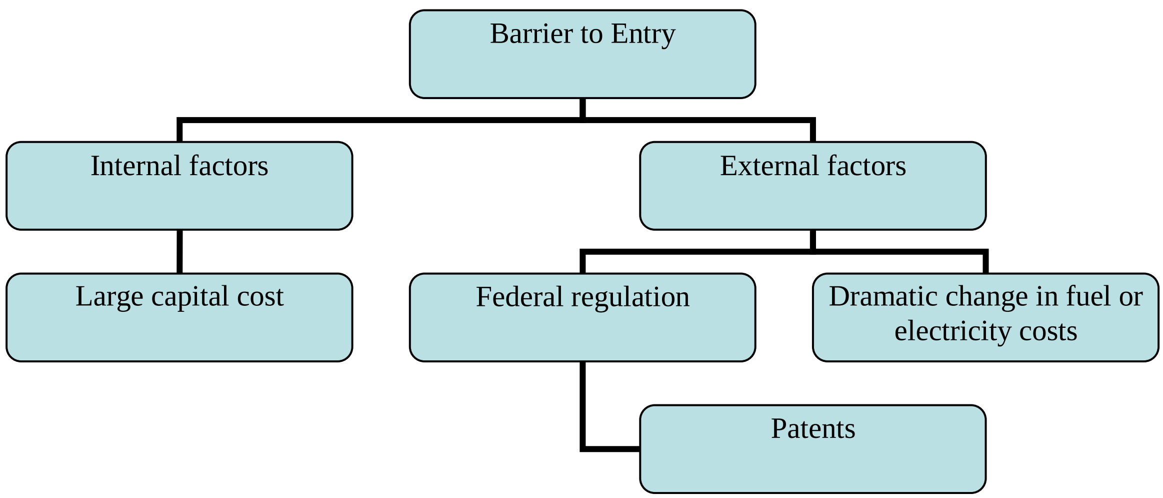


Figure 5: Most likely Barriers to Market Entry

As a startup company, there are certain entry barriers to confront. Erring on the side of caution, the following list of possible barriers and suggested solutions to overcome or circumvent them have been compiled (figure 5).

A. High Capital Investment

Our novel retrofit approach to PHEVs require special training for our employees who are to become experts to the working and designing aspects of the technology. Our employees are also expected to diagnose problems and assist future customers in the vehicle conversion process. The costs associated with the operation of the company, both fixed and variable, include rental space, utility, raw material and shipping, wages, legal and other expenses. Therefore, our company needs to secure a substantial portion of the startup cost through a combination of public and private funds, both in grants and loans, along with investment.

B. Federal Regulations

Another great concern deals with regulations and standards from the federal and state government. For a start-up company, quality standards may be hard to obtain initially. Therefore, to avoid any possible legal issues, our lawyers are to review all pertinent legal codes to make sure our company complies fully with all levels of regulations. The enforcement is delegated to our quality control team, who are in charge of ensuring our products meet the set standards. Isopomoto's reputation relies on product quality and must be taken very seriously.

C. Patents

Isopomoto must ensure that it does not infringe on existing patents. To protect the company from competition and allow for sustainable developments, we will patent our technology. Having patents will help to maintain our unique approach and distinguish ourselves from the competition.

D. Dramatic Change in Fuel or Electricity Prices

If fossil fuel prices were to drop dramatically while electricity prices hike up, the plug-in hybrid approach will be challenged. However, due to the limited resource of fossil fuels, this is unlikely to happen. Even in the scenario that new oil deposit fields are discovered, the price of electricity is expected to drop alongside with fossil fuels, since the latter are typically the primary source for electricity generation. It is therefore, expected that the drop in electricity price will compensate for the drop in fossil fuel price. In this case, PHEVs would still remain competitive in terms of fuel economy and emissions reduction.

2.5 Customer Analysis

The demand for plug-in hybrids in particular is growing every day, with non-profit organizations such as California Cars Initiative (Cal Cars) taking a step forward. Companies like Toyota, DaimlerChrysler and Ford have already displayed their interest in this technology. The plug-in kit manufactured by Isopomoto can be retrofitted easily into HEVs, thus making it convenient for the customers to incorporate this efficient technology into existing vehicles. So far, three potential customers have been identified.

I. Direct Consumer (Individuals) – Hybrid car owners can directly get the plug-in kit retrofitted into their vehicle. The advantages of marketing to this customer include greater long term profits, as well as control of quality and marketing. The disadvantages include high business and financial risk, higher operational cost and reduced short-term profits. Marketing to the direct consumer also does not guarantee steady sales by which a financial model could be based.

II. Direct Customer (Public and Private Fleets) – Examples include the Chicago Transit Authority. This market is highly desirable because it promises a steady and predictable supply of hybrids for conversion. The mass customization will help Isopomoto standardize its retro-fit process.

III. Indirect Customer
   i. Licensing the technology to major car manufacturers — No exclusive contracts will be allowed. The disadvantages of going this route include high business risk because success is linked to the ability of licensee to procure a steady market base, restriction on distribution options and restricted market access. On the other hand, advantages include immediate brand acceptance and relative ease of entry into international markets.
   ii. Partnering with a global Auto Company — Setting up a retrofit operation just outside the production unit where the finished HEVs could be converted into PHEVs. This type of marketing is advantageous because it offers immediate brand awareness and greater long term profits. The

disadvantages include reduced resources for research and development and restricted distribution options and market access.

2.5.1 Case Studies

Early market introduction of plug-in hybrid technology has the best chance of success in the commercial delivery fleet market where operating costs are critical to the profitability of the firm. PHEVs represent the future for the utility industry fleet. With this view in mind, we plan to do a case study on two customers.

I. Chicago Transit Authority (CTA)

The CTA is the second largest public transportation system in the United States. CTA's two thousand and thirty three busses covered almost seventy five million miles and consumed twenty four million gallons of fuel at a cost of forty three million dollars in just one year (2005).

Impact of Fuel Cost

The CTA's operating performance for the year 2005 was negatively impacted by the spiraling cost of fuel for revenue operations. The increase in fuel prices generated $9.1 million of additional cost to CTA's operating expenses. On average, for every $0.10 increase in fuel prices, CTA's annual fuel cost increases by $2.4 million.

Plug-in Hybrid CTA Bus

Converting the present CTA buses in plug-in hybrid electric buses will undoubtedly alleviate the problem of rising fuel cost. The retrofit approach proposed for hybridization will guarantee a fuel efficiency improvement of thirty percent and would only cost the CTA around twelve thousand dollars per conversion.

Table 18: Case Study, Cost Savings for CTA

Parameters	2005 - Conventional	2007 - Conventional	2007 - Hybrid	2007 – Plug-in Hybrid	
Mileage	37000 mi	37000 mi	37000 mi	37000 mi (22400 gas + 14600 electric)	
Fuel efficiency	3.13 mpg	3.13 mpg	4.9 mpg	10.4 mpg	4mi/ kWh
Fuel usage	11,805 gal	11,805 gal	7,551 gal	4571.4 gal	3650 kWh
Unit fuel cost	$2.13/gal	$2.41/gal	$2.41/gal	$2.41/gal	$0.0838/kWh
Total fuel cost	$25,144	$28,450	$18,198	$8,574	$11,323 ($11017 gas+ $305 electricity)

Table 18 discusses the cost benefit to CTA by converting their buses to PHEVs. The total cost of conversion per bus is Fifty One thousand dollars ($51,000). Each bus will save the CTA over $17,000 the first year and adding up to a total savings of $120,000 over a lifetime of 12 years. The cost recovery period is 36 months per bus. The cost of fuel for 2007 was calculated using data from the last five years.

II. Ford Escape - City of Chicago

ComEd, one of the largest US electric utilities with approximately 5.2 million customers and more than $15 billion in annual reserves is joining the Illinois Institute of Technology (IIT) in developing Plug-in Ford Escape Hybrids. All Cell Technologies and the Grainger Power Electronics Lab are leading this effort and are in the process of developing a PHEV kit for a Ford Escape owned by the city of Chicago.

Ford Escape Plug-in Hybrid

Table 19: Case Study, Cost Savings for Ford Escape

Parameters	2007 – City Conventional	2007 – City Hybrid	2007 – City Plug-in Hybrid	2007 – Hwy Conventional	2007 – Hwy Hybrid	2007 – Hwy Plug-in Hybrid
Mileage	12000 mi	12000 mi	12000 mi	12000 mi	12000 mi	12000 mi
Fuel efficiency	23 mpg	36 mpg	76.3 mpg	26 mpg	31 mpg	58.8 mpg
Fuel usage	521.7 gal	333.3 gal	157 gal	461.5 gal	387 gal	204 gal
Unit fuel cost	$2.31/gal	$2.31/gal	$2.31/gal	$2.31/gal	$2.31/gal	$2.31/gal
Total fuel cost	$1205	$770	$362	$1066	$894	$471

According to the case study done on the Ford Escape, the mileage given by the SUV on the city roads and the highways differs slightly. Keeping this dissimilarity in mind, two separate sets of data were prepared for city and highway respectively (refer to table 19). The table discusses the cost benefits of converting from conventional to PHEVs for the Ford Escape. There will be a total fuel cost savings of $797 if the Ford Escape SUV is driven in the city. On the other hand, the same vehicle gives a saving of $595 on the highway. The fact that the fuel saving for each year will increase with the increasing fuel cost was accounted for in this calculation.

2.5.2 Market Survey

Isopomoto also conducted a survey involving 120 participants on September 23, 2006, in downtown Chicago to gain a better understanding of the average consumer. Each participant was asked various questions regarding HEVs as well as PHEVs. Here are some of the statistics gathered from their responses:

80.8% have heard of HEVs
48.3% have heard of PHEVs

72.5% would pay $2000 more for an HEV over a conventional vehicle
44.2% would pay $3000 more for a PHEV over a conventional vehicle

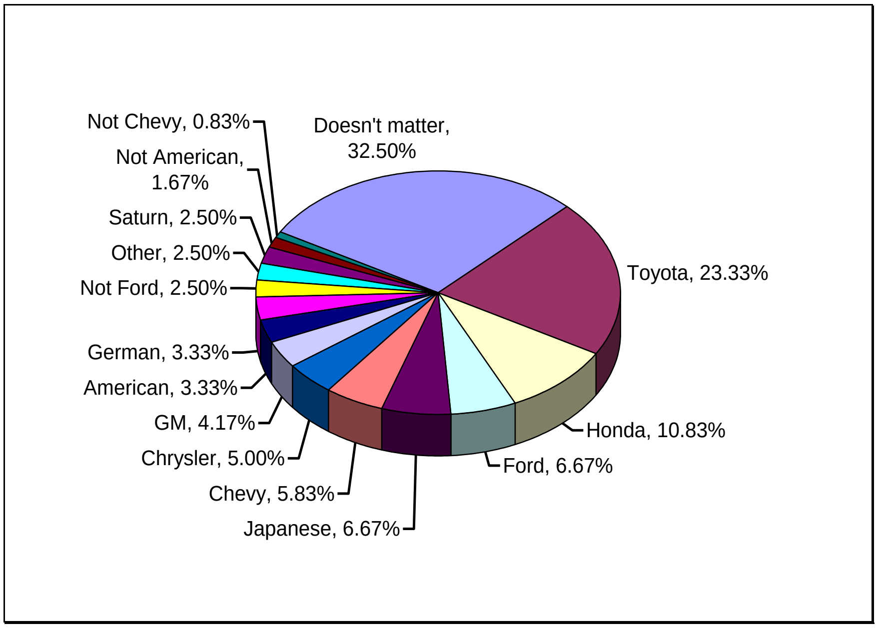


Figure 6: Manufacturer preferences

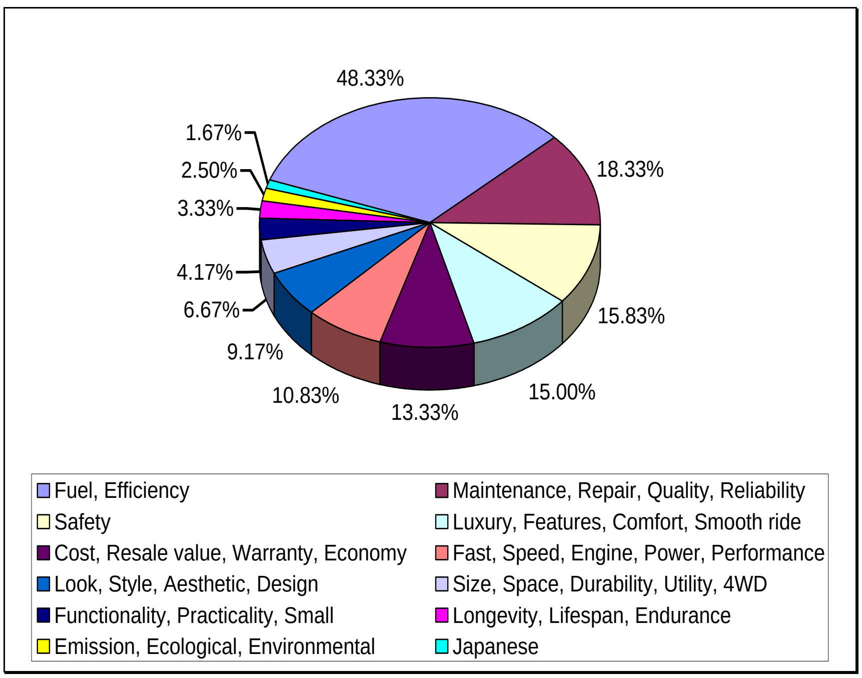


Figure 7: Most sought after qualities

32.5% say the manufacturer of the vehicle doesn’t matter (see figure 6)

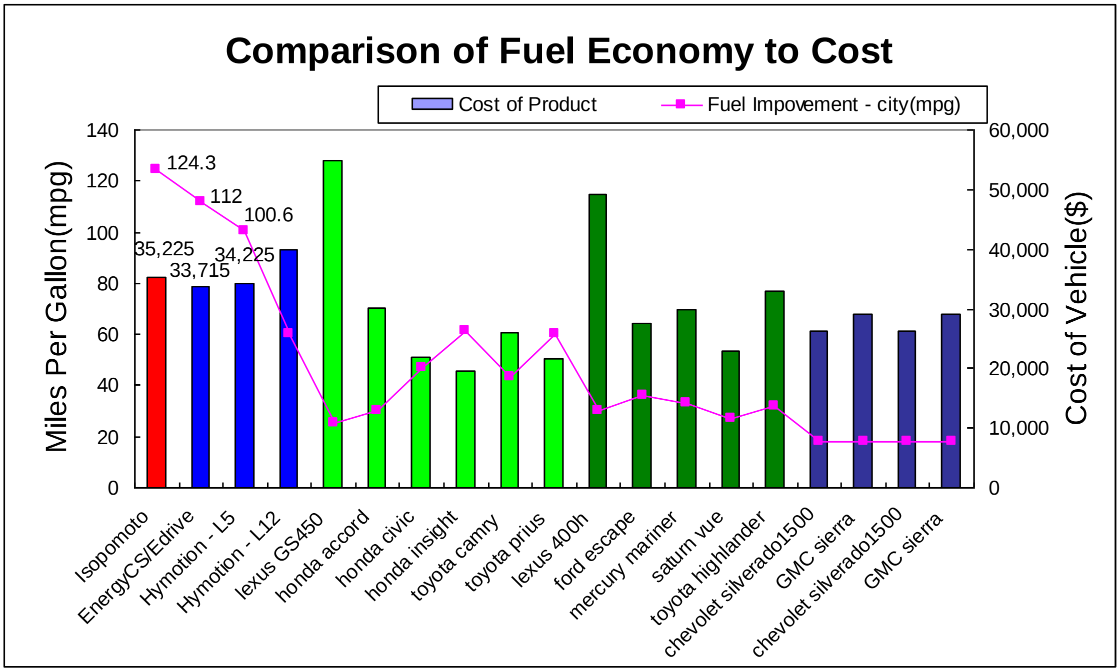
23.3% say they would most likely buy from Toyota (see figure 6)

48.3% listed fuel economy and efficiency as important (see figure 7)

18.3% listed reliability as important (see figure 7)

2.6 Competitor Analysis

As with any start-up firm, Isopomoto faces competition. Through an initial analysis, we have identified seven competitors. These are identified individually, below, and cost and efficiency data are summarized in figure 8.



: Plug-in hybrid

: Hybrid

: Hybrid – SUV

: Hybrid - truck

Figure 8: Isopomoto versus Competitors on Product Cost and Fuel Economy

2.6.1 EnergyCS and EDrive Systems, LLC.

The PHEV Toyota Prius was engineered and developed at EnergyCS with support from EDrive Systems, LLC and Valence Technologies. EDrive plans to begin selling its conversions in the summer of 2006, and is targeting a price range of $10,000 to $12,000; on top of the price of the Toyota Prius which is $21,725 (MSRP). This puts the final price tag well into the range of conventional luxury cars.

The Prius specifications are as follows: [13]

1) 9kWh Saphion™ battery system replaces the standard 1.3kWh NiMH pack
2) Up to 35 miles electric vehicle range at urban speeds below 33mph
3) Testing indicates that the batteries would last over 5 years in an EDrive equipped Prius, with 10 or more years being possible

A full charge could take 9kWh of electricity from the wall socket, but on days when the car is driven less than 50 miles, the electricity needed to re-charge will be less. If the battery were totally depleted, it would take 9 hours to charge the battery.

2.6.2 Hymotion

Hymotion is a multinational company, founded in 2005, headquartered in Toronto, Canada. Hymotion's kit contains a battery management system that monitors the voltage of each cell in the pack along with the temperature of the battery modules. The L5 for the Prius takes approximately 5.5 hours to charge on 120V or 4 hours on 240V. The L12 for the Escape takes approximately 12 hours on 120V or 6 hours on 240V.

The performance of each battery and their key features are given in Appendix A. Presently, the firm manufactures PHEV kits exclusively for government and fleet use. However, the firm plans to ship PHEV kits for consumer use in October 2006. The target price for the L5 Prius kit is currently US $9500 with installation. A two year warranty is included.

2.6.3 PML

PML are designers and manufacturers of electric motors, joysticks and drive systems. They are in the spotlight for designing a car that runs only on a battery and a bank of ultra capacitors. The car, dubbed the Mini QED, has will run for four hours of combined urban/suburban driving, powered only by a battery and bank of ultra capacitors. For longer journeys at higher speeds, a small conventional internal combustion engine is used to re-charge the battery. In this hybrid mode, fuel economies of up to 80mpg can be achieved.

[13] www.energycs.com

Specifications:

1) Motors: 4 x 750Nm 1800rpm high efficiency
2) Drive electronics: 4 x 480Amp 450V Hi-Pa drive™ 24 phase sine wave inverter IGBT water cooled CAN bus communications
3) Battery: 300V nominal 70 amp-hour lithium polymer 700A peak
4) Ultra Capacitor specification: 350V 11 Farad 700A limited[14] (see Appendix B)

Other Key Features:

1) It is adaptable to other vehicle chassis
2) It eliminates the need for gearing and mechanical drive train
3) It creates more space inside the car

2.6.4 Team Fate – UC Davis Hybrid Electric Vehicle Group

UC Davis is one of the seventeen teams who will re-engineer a Chevrolet Equinox SUV to minimize energy consumption, emissions, and greenhouse gases while maintaining or exceeding the vehicle's utility and performance (see Appendices C, D and E).

Continuously Variable Transmission (CVT) power train system

1) Charge-sustaining HEV (CSHEV) system uses gasoline to charge the batteries which means the energy efficiency is poorer than if the batteries are charged by the electric grid.
2) The engine produces too much power most of the time unless the engine is about one-fourth the size. Thus to construct a Charge-depletion HEV (CDHEV) power train, the engine needs to be about a quarter of the displacement of a conventional engine with about ¼ the power.
3) The running cost of CDHEV vehicles is between 1/3 to perhaps as low as 1/8 the cost of pure gasoline or diesel cars because of the cost of electricity and the incentives.

[14] (http://news.hspn.com/articles/570/1/PML-Builds-640hp-Electric-MINI/Page1.html)

2.6.5 HEVT – The Hybrid Electric Vehicle Team of Virginia Tech

The Hybrid Electric Vehicle Team (HEVT) of Virginia Tech is a group of students that research, design and build working hybrid vehicles. HEVT has competed in many similar competitions each year Challenge in 1996, 1997, 1998, and 1999, earning two first place awards and two second place awards.

Specifications:

1) Engines: The team considered using reformulated gasoline, compressed hydrogen gas, ethanol (E85), and biodiesel fuel. The team decided to use E85, which is composed of 85% ethanol and 15% gasoline.
2) Electric Motors: The first motor replaces the alternator and starter to give the engine stop and start capabilities. The other is a larger, more powerful motor, used as a traction drive for the rear wheels.
3) Energy Storage: Cobasys NiHMax288-60, a nickel hydride battery pack, designed specifically for hybrid SUVs.

2.6.6 AC Propulsion – EV car

This conversion will be based on the Scion XA and XB—the new sport compact vehicles built by Toyota. A base model and a premium model with a larger battery will be developed. The base model will outperform the Toyota RAV4 EV and is expected to sell for about the same price. First production is planned in 2005 (refer to Appendix F).

Product: AC-150 Gen-2 EV Power System

Specifications:

1) Output (at motor shaft): 150 kW @ 7,000 - 8,000 rpm, 220 Nm at 0-5000 rpm
2) Efficiency (battery-to-shaft): 91% peak efficiency, 86% at road load
3) Charger: Unity PF, GFI compatible 200 to 20,000 Watt, bi-directional reductive™
4) Package: Motor, inverter, charger, power supply 80 kg total including motor and cooling system
5) Voltage: 336–360 V nominal 240 V min, 450 V max
6) Current: 580A dc max (drive)-200A dc max (regeneration)

7) Torque: 220 Nm max, 0-5,000 rpm (drive) 115 Nm max (regeneration)
8) Power: 150 kW max, 7,000-8,000 rpm50 kW continuous at 8,000 rpm

2.6.7 Electrovaya

Situated in Toronto, Canada, Electrovaya's co-founders Sankar Das Gupta and Jim Jacobs began battery technologies research in 1983.

Maya 100 – Features and Specifications (refer to Appendix G for additional information) It is powered by the award-winning lithium ion SuperPolymer® battery.

Specifications:

1) Range of 230 miles or 360 kilometers
2) Proprietary lithium battery – five times the energy density of lead acid batteries at less than one-third of the weight
3) Unique battery design allows for hill climbing, and cold weather operation
4) Top speed (regulated) of 140kmph or 80mph
5) The pure battery ZEV features very low maintenance costs and operating costs at less than a cent per kilometer

2.7 Sourcing and Staffing

2.7.1 Staff

Workers are needed to assemble and install kits and, therefore, will need to be trained to install the technology. Since this is a highly specialized task, a training crew is required. The majority of the training will occur at plant start-up. Standardized training procedures are planned as operation continues. This standardized training will then be administered to any new hires. Even though it is in the company's interest to cut costs, workers will not be exploited, and will be paid competitive salaries.

A product support and troubleshooting branch is required. This will ensure product quality and allow for streamlined problem solving capabilities within Isopomoto. In order to maintain a good reputation and fulfill the company's goal of premium customer service, a convenient and easy-to-use support center will be created.

A marketing team is integral to acquiring business from the end user. This will increase awareness and sales as well as boost the company image. The executive branch is already in place and consists of the Illinois Institute of Technology (IIT) students who spearheaded Isopomoto.

As Isopomoto expands, extensive use of staff will be necessary to handle the logistics. Lawyers will be needed to deal with patents and other legal issues. Accountants are required to manage the finances. Technical advisors and a research team should be in place to keep Isopomoto competitive. A human resources manager who will oversee all training, compensation, and personal needs of employees will also be hired.

A quality control team will ensure that the finished product meets quality standards and will also manage questions and complaints from buyers.

2.7.2 Facilities

A central office is the key to the success of Isopomoto. This is the location where Isopomoto will conduct all its business. This will include amenities such as a reception area, offices for executive and staff, and eventually a showroom. This would ideally be in an urban area, such as downtown Chicago. The only drawback to this is that floor space in the city is more expensive than it is in the suburbs or further south. However, downtown, or possibly the North Side would be more attractive locations for a business front.

A warehouse to store supplies and parts and a shop for assembly and installation are both necessary in order to function. This warehouse needs to be big enough to store batteries, kits, and other electronic equipment. Since the intention is to market this product to large fleets, the warehouse also has to be big enough to house equipment for potentially thousands of units. The warehouse and shop floor should either be in the same place or merely close to each other. The location of the warehouse and shop floor will be based on cost — this land should be purchased for as little as possible — and not at the end-user location.

2.7.3 Sourcing and Service

The largest and most plentiful item in the warehouse will be batteries. Many very large, high quality batteries will be stored there. Since the cost for facilities to produce these batteries would be very high, the decision has been made to purchase these batteries rather than in-house production.

There will be different sourcing needs for different customers (i.e. large fleets and end users). Fleets are the easiest to plan for because the company typically coordinates with a chief engineer in charge of managing the fleets. Once project finalization occurs, Isopomoto will then retrofit identical vehicles on a large scale. More choices must be made available to end users since each individual has their own unique needs. However, they might not want to deal with the hassles of taking their car out to the shop, or even of being without a vehicle. This opens up several doors. One obvious path is having a vehicle delivery or pickup, where arrangements are made with the customer some way to get their vehicle from them, whether it is picked up from their house, or they leave it at the central office. Isopomoto is also considering rental car arrangements, or rush install, available at a premium to the customer.

Once Isopomoto is a thriving company with a steady customer base and cash flow, upgrading the manufacturing facilities could be a consideration. Currently, the plan is to use skilled technical workers to take care of the work. However, as the company advances, automation in the factory could be a serious consideration.

2.8 Financial overview

2.8.1 Funding requirements

The maintenance, operating, and start-up costs need to be considered. Start up costs (refer to table 18) will include property, facility installations (internet/phone lines), office equipment and furniture, initial training of staff, research and development, licensing and permits, and business registration.

Included in the maintenance and operating costs are employee wages and benefits, parts for the conversion kits, advertising, shipping for the kits, lawyer fees, accounting fees, insurance, research and development, training as needed, office equipment maintenance, office supplies, and facility costs.

Revenue will come from product sales, forms of fundraising such as grants and loans from partners, investors, venture capital firms, and small business loans.

Table 18: Breakdown of start up costs

Description	Amount (USD)
Facility	3200/month
Office equipment	19000
Office furniture	6000
Initial training	4000
Legal	200
Research and development	IIT Affiliation
Total	$33000

2.9 Partnerships and Alliances

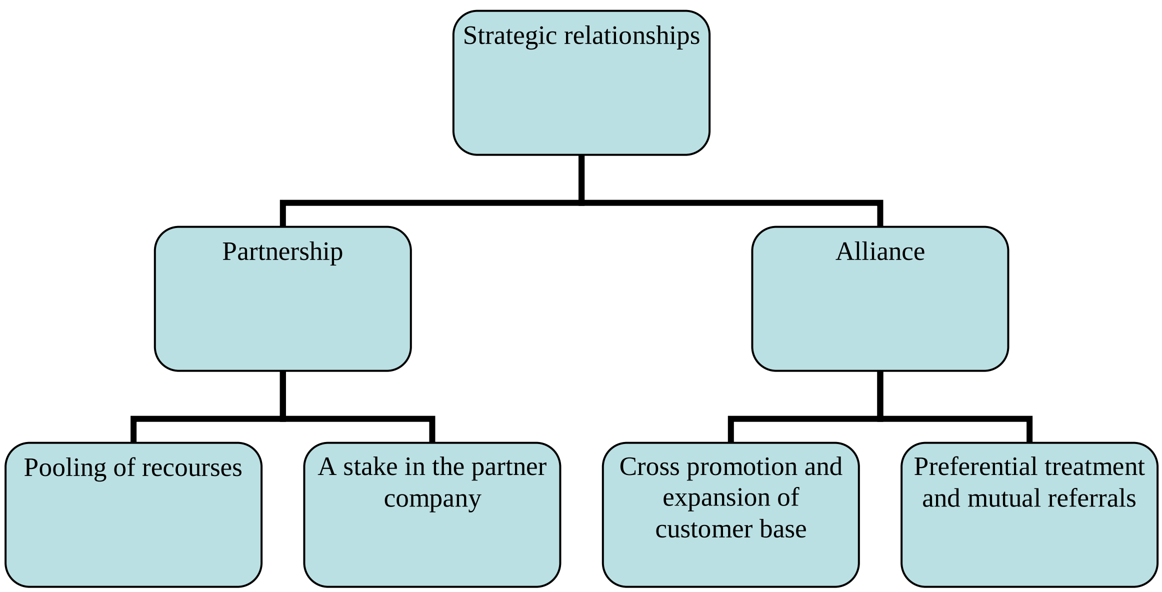


Figure 9: Isopomoto's Strategic Relationships

Mutually beneficial strategic relationships are always welcome. Through mutual cooperation, expansion of business contacts and a broader customer base are readily achieved. As shown in figure 9, Isopomoto is looking at two types of relationships – partnerships and alliances.

Partnerships mark the closest collaborations between the involving parties. Pooling of resources, in aspects ranging from capital, financial, logistical and technological are to be expected. Representatives from either party will be informed and consulted in the operation and decisions at its partner company.

Alliances offer an excellent channel of cross-promotion. We are interested in establishing alliances with all interested groups in hybrid technology and environmental protection. Preferential treatment will be given to customers from alliance companies. The referral of business among alliance members serves both to satisfy the needs of the customers and to bring business to allied companies.

Currently, Isopomoto has established a partnership with IIT, which has supplied the technological expertise vital to the development of the PHEV kits. Moreover, there is close contact between the company and Honda Motorwerks, a dealership that focus exclusively on hybrid vehicles.

Isopomoto believes that there is a great potential for both partnership and alliances, and strategic relationships in all areas and modes of cooperation. Any party with similar concern for environment and support for hybrid technology is welcome to join forces and promote the common agenda.

2.10 Risk Analysis and Management

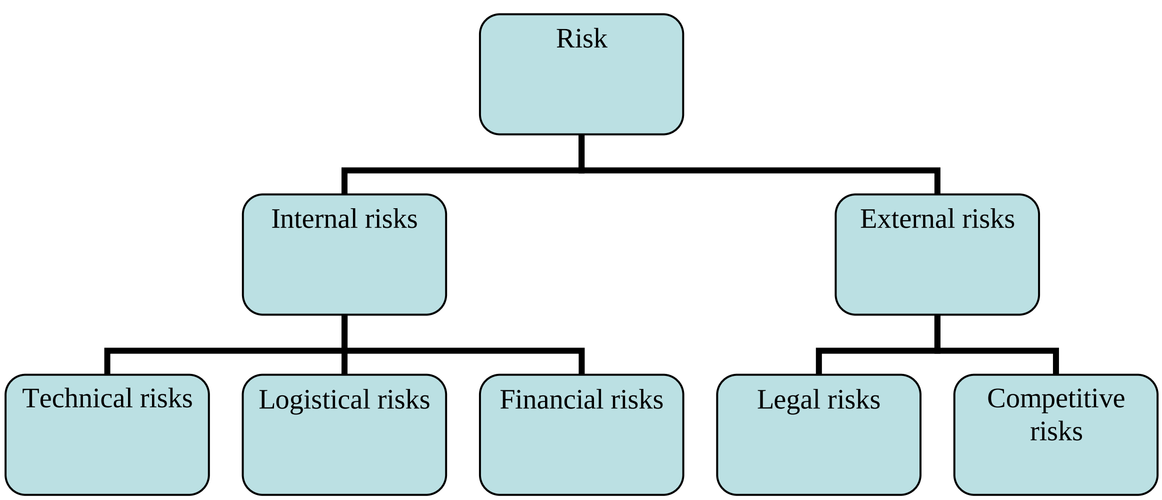


Figure 10: Risk Analysis

The risks associated with the daily operation and sustainability of Isopomoto encompass many aspects (see figure 10). Internal as well as external factors may influence the future path of the company. Therefore, this analysis serves as a pre-emptive measure for assessing the risks, exploring the possibilities of occurrence, and offering certain counter-measures to address specific issues where appropriate.

In broader terms, risks can be classified into financial, legal, technical, competitive, and logistical risks. Financial risks include low cash flow (as a result of not hitting the sales quota and of incurring high costs), economical recession, inflation, and loss of investment due to lack of interest from investors. In the case of sale imbalance, adjustment of the productivity can be made to accommodate the low demand while diverting the human and financial assets to sales and marketing. Using simple economic supply and demand concepts, the company will re-evaluate the retail value of its products and services, possibly lowering the premium to allow the market to adjust during this period of time and settle into an equilibrium position where sale and production will be stabilized. Figure 11 demonstrates how to strike the right balance between demand, supply, production and sales.

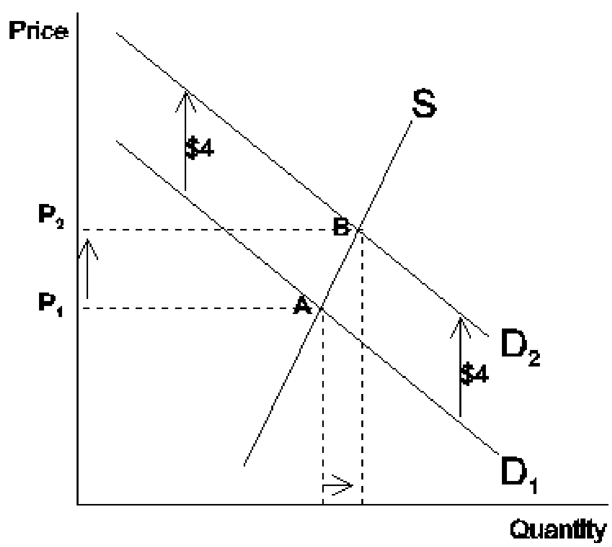


Figure 11: Hitting the right balance between demand, supply, production and sales[15]

According to the National Bureau of Economic Accounts, the national economy of the U.S. has been steady for the past twenty years as measured by the Gross Domestic Product (see figure 12). Therefore, there is no foreseeable significant impact on Isopomoto's finances from the national economical environment.

[15] Source: http://www.econ.rochester.edu/eco108/ch6/q6_11.gif

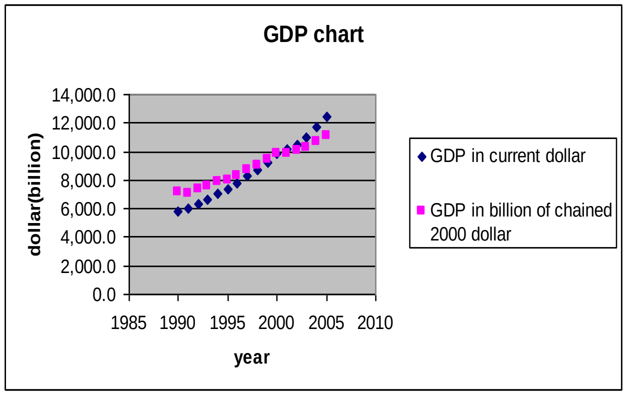


Figure 12: GDP Chart of the US[16]

To minimize the impact of certain investor withdrawals, the company's financing will be multi-sourced. Investors will be sought from vast backgrounds over the public and private sectors, such as the national science foundation (NSF), non-profit organizations, venture capitalists, educational institution grants, and a combination of other loans, and investments. In doing this, we are essentially preparing a financial cushion to ensure the longevity of the company in the unlikely and unfortunate incidence of investor loss.

The legal issues will be resolved by the firm's legal department. They will be in charge of reviewing pertinent patents and federal and state laws to make sure that the firm complies with all levels of regulations and operates within the boundaries of legality.

Most customer-related technical issues can be avoided by having adequate quality control. Safety is of top priority and has been integrated into the design and operation of our product. Technical issues can be harder to tackle. One of the problems that might arise is when the pace of technological development cannot match the demand from the market. The only feasible solution is to increase the budget for research and development, and work with human resources to recruit skillful scientists. Expectations are that increased sales will pay for these additional costs.

Competitive risks stem from the nature of a free market economy. Apart from the competition mentioned above, we anticipate competition from other energy sectors. The fuel cell technology is still in the development stage, and mass marketing is not expected until 2030. Finally, logistical risks are to be resolved by human resources.

[16] Source: http://www.bea.gov/bea/dn/home/gdp.htm

2.11 Accomplishments and Path Forward

Many major milestones were accomplished during the first semester of Isopomoto's existence. The company's primary responsibility, the completion of a business plan outlining the prospects of PHEV technology, was finished within the projected timeframe. Additional projects undertaken were also highly successful: a company sponsored survey was conducted with 120 participants; all team members received extensive training in ADVISOR; a relationship was developed with Honda Motorwerks; and the beginnings of a PHEV model car were witnessed.

Future undertakings by Isopomoto will involve solidification of partnerships with Grainger Power Electronics Center, IIT, and Honda Motorwerks. This will ensure future funding and access to the technology on which our PHEVs depend. It is also Isopomoto's goal to put the final touches on the PHEV remote control model to increase efficiency and coordination of power supplies. A more complete financial evaluation including materials, sourcing, and staffing numbers is projected to be completed within the next two months.

In the long run, Isopomoto expects to be the leader of all PHEV manufacturers in terms of technical innovation, customer service, and cost. To this end, the company will focus on growing its R&D department and focus on increasing fuel economy, fuel efficiency, system responsiveness, as well as decreasing weight and material usage. It is the intention of Isopomoto to be the premiere supplier of Plug-In Hybrid Electric Vehicles and the vision and tenacity of the team members will ensure that this occurs.

3.0 Appendices

3.1 Appendix A[17]

L5 Lithium Power specification

Battery Type	Lithium Polymer
Energy	5kWh
Charge temperature range	-10 deg C to 35 deg C
Operation temperature range	-20 deg C to 45 deg C
Charge Voltage	120V/240V (15A circuit)
Charge Time	5.5hrs/4.0hrs
Weight	72.5Kg

L12 Lithium Power specification

Battery Type	Lithium Polymer
Energy	12kWh
Charge temperature range	-10 deg C to 35 deg C
Operation temperature range	-20 deg C to 45 deg C
Charge Voltage	120V/240V (15A circuit)
Charge Time	5.5hrs/4.0hrs
Weight	147.5Kg

[17] http://www.hymotion.com/pdf/Specs_PHEV_L5.pdf, Specs_PHEV_L12.pdf

Comparison of L5 and L12 Batteries on Performance and Key Features

L5	L12
Performance - 50Km range on Battery only - Zero fuel consumption in city driving below 55km/h -100mpg city/hwy combined driving Key features - Integrates into vehicle without removing factory battery - Once PHEV battery is depleted, vehicle resumes normal operating normal using factory battery - While PHEV battery is in use, the stock battery fuel gage indicates the status of the PHEV battery - Inertial cut off switch - Manual electrical interlock for service/installation - Battery temperature control and monitoring -Interlock to prevent vehicle movement while plugged in -Reinforced impact resistant construction	Performance - 80Km range on Battery only - Zero fuel consumption in city driving below 55km/h -100mpg city/hwy combined driving Key features - Integrates into vehicle without removing factory battery - Once PHEV battery is depleted, vehicle resumes normal operating normal using factory battery - While PHEV battery is in use, the stock battery fuel gage indicates the status of the PHEV battery - Inertial cut off switch - Manual electrical interlock for service/installation - Battery temperature control and monitoring -Interlock to prevent vehicle movement while plugged in -Reinforced impact resistant construction

3.2 Appendix B

Ultra Capacitor: 350V 11 Farad 700A limited

Item	Original target specification
Emission	Zero
Autonomy	1500 km
Top speed	200 kmph minimum
Acceleration	0-100 kmph in 6 secs
Braking	No mechanical brakes
Fuel	Zero carbon
BHP	250 BHP minimum
	Current specification
Emission	Zero for 4 hours
Autonomy	1500 km
Top speed	200 kmph minimum
Acceleration	0-100 kmph in 6 secs
Braking	No mechanical brakes
Fuel	Carbon neutral option
BHP	640 BHP

3.3 Appendix C

Team Fate's Past Vehicles

	Engine	Electric Motor Continuous/Peak	Battery Pack	Transmission	DOH
Coulomb	35.8kW 600cc spark ignition gasoline engine	50/75kW	18.6kWh 320V	Continuously Variable Transmission	0.68
Sequoia	93.2kW 1.9L spark ignition gasoline engine	50/75kW rear 50/75kW front	29kWh 90AmpHr 320V	6 speed manual	Rear Power train 0.467 Total 0.62

3.4 Appendix D

Efficiency (Coulomb Result)[18]

	Engine Turn-On Speed(mph)	Gasoline Used(liter)	Electricity Used(kWh)	Gasoline Equivalent (liter/100km)
EV-Mode FUDS	N/A	0	1.74	4.43
HEV-Mode HWY	65	0.195	0.51	3.75
Stock Vehicle Hwy	_	_	_	8.1
Stock Vehicle City	_	_	_	11.7

[18] http://www.teamfate.net/techpapers/EVS18%20PlugIn%20Full%20Perf.pdf)

3.5 Appendix E

Sequoia Result[19]

Fuel Economy	City		Highway	
All Electric	228DC Wh/km		250 Wh/km	
Hybrid Electric Mode	7.53 equivalent liter/100km		7.53 equivalent liter/100km	
Stock Vehicle	16.8 liter/100km		14.7 liter/100km	
Range				
EV	103km		95km	
HEV	571km		657km	
Green House Gas Impact	GHGI(CO2 equivalent)		Reduction from Stock Vehicle	Green House Gas Impact
NPTS/California	180g/km		65%	NPTS/California
NPTS/California Long-Term	154.7g/km		70%	NPTS/California Long-Term
Tailpipe Emissions Rating	Mode		Rating	
	EV		California ZEV	
	HEV		California ULEV	
	Combined		California SULEV	
Acceleration			Sequoia	Sub-urban
	0-96km/hour		8.9s	8.8s
	Standing quarter mile		17.7s	17.3s
	Average Grade	Charge Sustainable Speed	Top Speed	
Trailer Towing	0%	105 kmph	129+ kmph	

[19] http://www.teamfate.net/techpapers/EVS18%20PlugIn%20Full%20Perf.pdf)

All numbers are for towing a 3175 kg trailer. Numbers are comparable to stock vehicle	2% 7.2%	96.6 kmph 56.3 kmph	129+ kmph 96.6+ kmph

3.6 Appendix F

Preliminary AC Propulsion EV Specifications[20]

	Base	Premium
AC Induction Motor	75kW	130kW
Vehicle Weight	2570lb	2850lb
Range	80-110mi	150-210mi
Acceleration 0-60	<9sec	<7sec
Top Speed	82mph	90hph
Battery Type	Li Ion	
Battery capacity	20kWh	35kWh
Charging	Plug-in-anywhere Fast charge in 2 hrs V2G capable	
Features	A/C, full power	

[20] http://www.acpropulsion.com/ACP_PDFs/ACP_FAQ_Cars.pdf

3.7 Appendix G

Details of Isopomoto's Competitors

Competitor	Technical Approach	Business Stage	Product Cost, $	Current Clients	Projected clients
EnergyCS/ Edrive	PHEV	targeting the beginning of 2007 for first consumer deliveries	10000 - 12000	Clean-Tech LLC UK company Amberjac Projects Ltd Toyota	Clean-Tech LLC UK company Amberjac Projects Ltd Ford, Honda, Lexus
Hymotion	PHEV	working to ship PHEV kits for consumer use around October '06	L5 Prius kit priced at 9500 - 12500	Toyota Ford	Toyota Ford
PML	PHEV	Developing	-	-	Fleets and individual consumers
UC Davis-Team Fate	PHEV	Research	-	-	GM
PSUHEV	PHEV	Research	-	-	GM
HEVT	fuel-cell ethanol/battery powered engine	Research	-	-	-
AC propulsion	Plug-in EV	on sale	-	-	-
Electrovaya	Plug-in EV	on sale	-	Fleets/direct consumers	Fleets/direct consumers

Product Performance Characteristics of Isopomoto's Competitors

	Fuel Improvement	Emission Improvement	Control Strategy (Logic)	Type	Size	Voltage	Dimensions
EnergyCS /Edrive	130 miles per imperial gallon, 1 Imperial gallon = 4.4 liters; 1 US gallon = 3.8 Liters	zero emission in city driving below 55km/h	BMU (Battery Management Unit) system	Li-ion	9kWh	-	-
Hymotion	100mpg	zero emission in city driving below 55km/h	Active cell balancing, temperature and voltage monitoring CAN bus communications	Li-ion	L5 : 5kWh L12 : 12kWh	L5 : 120/240V L12 : 120/240V (charge)	L5 : 838*415*261 L12 : 1028*380*366
PML	80mpg Fuel Zero carbon	Emissions Zero - for 4 hours combined	Battery Management system	Lithium Polymer Ultra Capacitor		Li-Po : 300V UC : 350V	-
UC Davis-Team Fate	Ford Escape :	zero emission	CVT	metal hydrid	Coulomb:18.6k	320V	-

	city - 36.2mpg 38.7mpg	in city driving		e battery	Wh Sequoia : 29kWh		
PSUHEV	2002 Ford Escape : hwy - 25rpm	Urea Injection System NOx Reductio n Catalyst	CVT	Li-poly battery	37kWh	180V	-
HEVT	expects to reduce gas usage by 80%	-	-	Lithiu m-ion	30kWh	-	-
AC propulsion	Powered by only electricity	Zero emission	"vehicle to grid," (V2G) system	Li Ion	Base : 20kWh Premium : 35kWh	348V	-
Electrovaya	less than 20% comparabl e ICE vehicle with minimal maintenan ce cost	Zero emission	-	Li-ion poly-mer	45kWh	110 / 220V charge	-

3.8 Appendix H

Isopomoto is currently headed by the Chief Executive Officer, Jason Fuglestad, ably assisted by the Vice President of Business Operations, Dolapo Popoola. The financial aspects of the firm are managed by a Business team headed by the Chief Financial Officer, Sujit Thomas. The research, development and technical aspects are managed by a Technical team, headed by the Chief Technical Officer, Julie Patti.

Executive Profiles

Jason M Fuglestad — Chief Executive Officer was born in Rapid City, South Dakota on the 20th of October, 1982, before his family moved to Illinois in 1983. He graduated high school at Round Lake Senior High School in Round Lake, Illinois where he was involved in the Academic Team, Math Team, National Honor Society, Student Communication Council, and soccer team. He attended the College of Lake County while working full time until January, 2005. After earning 73 credits toward an Electrical Engineering degree, he transferred to the Illinois Institute of Technology to complete his studies. He will obtain a Bachelor's in Science Degree in Electrical Engineering in May of 2007.

Over the summer of 2006, Mr. Fuglestad worked as an intern for InvenTek Corporation where he was involved in building protection circuitry for a Rolled-Ribbon Li-Ion battery developed by the same company. Currently, he is involved in an intercollegiate competition called the Formula Hybrid Competition where he is the team leader for the Energy Storage team.

In 2006, Mr. Fuglestad became the CEO of Isopomoto, a project startup company at IIT. His desire to be involved in this project comes from his interest in automobiles and alternative energy sources.

Dolapo Popoola — Vice President of Business Operations was born in Lagos, Nigeria. She attended high school in Nigeria and Zimbabwe before traveling across the Atlantic to pursue a bachelor's degree in Chemical Engineering at the Illinois Institute of Technology in Chicago, Illinois.

Bound to complete her bachelor's degree in a few weeks' time, her plan is to concentrate on being an entrepreneur. During her time at IIT, she has been part of the Ed Kaplan Entrepreneurial Program and has had the opportunity to study venture capitalists and several successful entrepreneurs. She has had lots of practice creating and editing business plans and has worked with three start-up companies already. She is very interested in sustainable energy projects and devoted 3 months of her summer to creating a plan to retrofit at least 20 Chicago Public Schools' to support solar energy.

Ms. Popoola is responsible for ensuring that effective operations and infrastructure are in place to support the staff of Isopomoto. She also pushes Isopomoto to achieve its strategic goals and is well positioned in an evolving and competitive environment. Dolapo believes in the future of Isopomoto. The technical team and staff at Isopomoto have clearly proven themselves trustworthy and Ms. Popoola is committed to structuring operations to reflect this and its world class technology.

Sujit Thomas – Chief Financial Officer was born in West Bengal, India. He has traveled halfway across the globe for his education. He finished his high school in Dubai, followed by his Bachelor's Degree in India. He is currently pursuing his Master's Degree in Mechanical Engineering at the Illinois Institute of Technology, Chicago, Illinois.

His inquisitive nature exposed him to the field of hybrid electric vehicles. Finding the concept interesting and eager to be part of the next generation of hybrids, he joined Isopomoto as Chief Financial Officer in August, 2006. He shares the optimism of the entire company and is looking forward to helping the team grow. However, Mr. Thomas is also keenly aware of the entry barriers a start-up firm like Isopomoto will face in the technologically advanced and competitive automobile industry.

Recognizing the need to have an overall view of the automobile industry and the limited resources at hand, Mr. Thomas contacted market research companies to conduct a survey of the automobile industry. He finally struck it with Plunkett Research Ltd., and proceeded to identify the major trends impacting the industry as well as key players and new entrants.

His efforts have given Isopomoto insights into its product development program as well as a wealth of information to identify potential customers and develop marketing strategies. Besides keeping himself continuously updated on the industry, Mr. Thomas also drafted a preliminary business plan for the company. He remains in constant touch with the VP of Business Operations and the Chief Executive Officer to ensure a smooth entry for the company with a steady growth in its future years.

Julie Patti — Chief Technical Officer is a junior mechanical engineering major from the western suburbs. She joined Isopomoto as Chief Technical Officer last August and has since led a presentation on the state of the oil industry, developed the company mission, analyzed the problems and opportunities associated with the automotive industry. She is in the process of compiling and editing the final draft of the company's business plan.

She transferred to the Illinois Institute of Technology (IIT) last fall from College of Dosage (COD). Several years ago, she graduated from DePaul University with a Bachelor of Music in vocal performance and has been financing her second bachelor's degree by teaching voice, piano, and guitar lessons, as well as singing at weddings. While attending COD, she took several classes in automotive technology and decided that she was destined to become a mechanical engineer. Ms. Patti was first introduced to sustainable concepts in engineering through the book *Cradle to Cradle: Remaking the Way We Make Things* and decided to devote her life to environmental sustainability in the form of renewable energy.

The past two years have presented her with many opportunities to explore energy usage and its effect on the environment. An active member of the Chicago Center for Green Technology, she has attended many conferences and seminars to keep abreast of the ever-changing sustainable energy technology industry. Ms. Patti is extremely excited to be a part of such a promising start-up company as Isopomoto and is looking forward to watching it grow.

Jae Suk Lee — Technical Team was born in South Korea on January 26th 1981. He is in charge of researching company solution and simulating vehicles with Advanced Vehicle Simulator (ADVISOR). He came from South Korea as an exchange student, and decided to transfer to Illinois Institute of Technology (IIT) after the exchange student program and stay in the United States to continue studying Hybrid Electric Vehicle (HEV) technology.

Currently, he is also a motor/inverter team leader of the Formula Hybrid Competition Team of IIT led by Dr. Ali Emadi. In the team, he is in charge of making a motor to run with an inverter controller for the Formula hybrid vehicle, and leading four other sub-team members who are not familiar with motor drives. In spring 2006, he designed and simulated a hybrid electric Chicago Transit Authority (CTA) bus with ADVISOR for the Inter-professional project (IPRO). In addition, he designed a power supply for a laptop computer and a motor drive for a HEV with PSIM as parts of *Power Electronics*, and *Power Motor Drive* classes.

Through a Plug-in Hybrid Kit project at Isopomoto, he is seeking to contribute towards solving the gas crisis and developing environmentally friendly vehicles with experience from projects and knowledge from lectures.

Hassan Ali — Technical Team was born in Rawalpindi, Pakistan on 8th March 1982. He attended High school in Pakistan at Grammar High school for boys. He did his first associate in economics from Pakistan at Pakistan Air Force College for boys. He received his associate in Electrical Engineering from Chicago at Wilbur Wright College. As a member of Isopomoto, he has researched the problem and opportunity of plug-in hybrids developed a Plug-in Hybrid RC model. He came to U.S. in 2001. After college he transferred to Illinois Institute of Technology.

In 2006, he became a member of the research team working on developing a formula hybrid car under project manager Sanjaka G Wirasingha led by Dr. Ali Emadi. He is a member of the team working on control switch for formula hybrid car. He also has a keen interest in car modeling and designing which began his interest in HEVs. After his Bachelors in Electrical Engineering he plans to study automotive design. In addition, he also worked as an assistant in Pakistan Ltd bank in Pakistan as an intern during his associate in economics.

Through a Plug-in Hybrid Kit project at Isopomoto, he aims to cut down the usage and the U.S. dependency on foreign oil which is acting as a barrier to a better economy and a healthier atmosphere.

Yin Zhao — Business Team is a junior year undergraduate student in chemical engineering and chemistry at Illinois Institute of Technology. He grew up in China, and attended the prestigious Elementary and Middle schools attached to Tsinghua University. Immigrated to the United States at the age of fourteen, Yin Zhao enrolled in five different high schools and obtained his high school diploma at D.W. Daniel High School in Central, South Carolina.

Being environmentally conscious and technology driven, Mr. Zhao has always been interested in an alternative solution to the current energy supply of fossil fuels. He currently pursues a minor in energy, environment, and economics (E3). Yin Zhao also enjoys analytical thinking and computation. He has engaged in several research efforts in theoretical modeling and won several awards, both locally and nationally, for his performance in mathematics and chemistry Olympiad competitions.

For the current project, Mr. Zhao have been in the supporting role of collecting pertinent information, conducting survey, and coordinating communication among the business team members. Yin Zhao is in charge of the analysis and report on barrier to entry, risk and management, and partnership and alliances sections of the business plan.

Seung-Hun Baek — Business Team is a senior student majoring in electrical engineering at Illinois Institute of Technology. As a member of Isopomoto, he created the industry review, competitor analysis, and physical modeling. He was born in South Korea and attended Ajou University until spring of 2005. He financed this by teaching mathematics for high school students as a personal tutor. In the middle of his college career he served in the Korean Army for 2 years. He worked for the office of public information and was in charge of monitoring and reporting to the press. After retiring as a sergeant in 2004 he performed a design project, which was building a ‘line tracer’ with a microprocessor called AVR and did a presentation in his last semester in Korea.

He realized the need to study abroad and transferred to Illinois Institute of Technology in the fall of 2005. He is taking more advanced courses for graduate students in power and control and plans to work on building testers for hybrid cars with research assistants in the laboratory. He is currently working on the design of power supplies with Pspice in the class, ECE411.

Seung-Hun Baek has been on the Dean's List every semester at IIT and belongs to *'Eta Kappa Nu honor society'*. He believes in the practicality and possibilities of the hybrid car, so he took his first step toward his goals by becoming member of the business team, 'Isopomoto'.

Mary Cyriac — Business Team was born in India on Aug 22, 1986. Being an Army kid, she traveled all over India, studying in 8 different schools. She graduated from National Public School, Bangalore in May 2004 and left the country to pursue her Bachelors degree in Electrical Engineering at the Illinois Institute of Technology.

In May 2006, Mary got an opportunity to get some real-world, hands-on experience in the field of Electrical Engineering by joining the Formula Hybrid Competition team at IIT. She is a part of the Energy Storage sub-team where she is concentrating on Ultra-capacitors and Li-ion Batteries. Ms. Cyriac is also the Webmaster for the Society of Women Engineers at IIT, through which she has been able to support other women in the field of Engineering.

Mary's interest in Hybrid Vehicles also led her to join the Business team at Isopomoto. Being a part of the company, she has been able to develop her business skills and it has also helped her look at things from a whole new perspective. She successfully drafted the Project Plan for the Company. She is currently involved in doing a Case Study on CTA Buses and Ford Escape Hybrids. She is also a part of the Sales and Marketing branch of the Company. Through her efforts, Mary wants to help Isopomoto establish itself as one of the top companies in this field by creating a successful solution to enhance the fuel efficiency of hybrid vehicles.

Matthew David Anderson — Business Team was born in Munster, Indiana on August 4, 1986. He grew up in Dolton Illinois, however, where he still resides. He graduated from Marian Catholic High School in 2004, where he spent considerable time in the band there. He was also in the National Honors Society and the National Junior Classical League. In his senior year of high school, he decided on majoring in computer engineering at the Illinois Institute of Technology.

In August, 2006, Mr. Anderson became a member of the business team in Isopomoto. What drew him to join this company was his interest in technology. He has always had an interest in technology, especially in computers. Being a business team member for Isopomoto has given him a new insight into how businesses are run. Also, his skills with computers are helpful to the success of the website.

In Isopomoto, Mr. Anderson was responsible for the compilation, revision and submission of the project plan. He is also in charge of the website, with creative assistance from Mary Cyriac and Jason Fuglestad, the CEO of Isopomoto.