Plug-in Hybrid Electric Vehicle (PHEV)

Hybrid vehicles ?

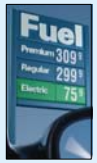
- Increasing oil Prices
- Finite Fuel resources
- Environmental Pollution

Advantages

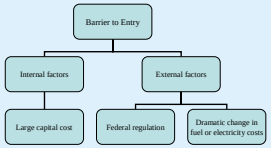
- High mileage
- Return on investment is fast
- More Efficient
- Overall profit is higher
- Lesser emission

Why plug-in hybrids?

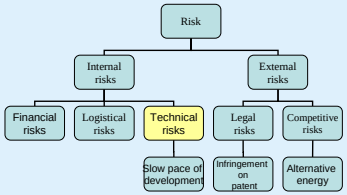
- Decreases Greenhouse gas emissions (CO_2)
- Support from local & state legislature
- Reduces gasoline consumption by two-thirds
- Highly dependent on electricity generation source thus reducing NOx and SOx gases



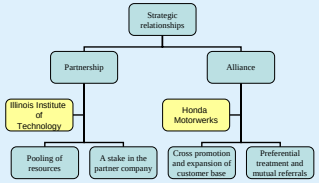
Barriers To Entry



Risks Involved



Partnership and Alliance



Case Study #1: Chicago Transit Authority

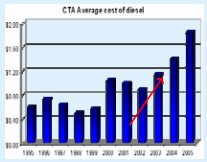
Second largest public transportation system in the U.S., over 1.6 million customers daily

Bus Operation Facts

- 1 million rides provided on an average weekday
- Approximately 205,000 miles traveled each day
- 150 bus routes with a total of 11,924 bus stops

CTA Diesel Cost

- Increase in fuel price generated an additional operating cost of $9.1 mil.
- Since '03, fuel increased $0.79/gal resulting in $18.5 million in added expense. Rider ship growth fell short by 8.8 mil. trips



The Fleet in 2005

Number of buses	2033
Distance covered	74.8 mil. miles
Fuel consumption	24 mil. gallons
Cost of fuel	43 mil. dollars

Per Bus	2005	2007 - conventional	2007 - hybrid	2007 - PHEV
Mileage	37,000 mi	37,000 mi	37,000 mi	37,000 mi (22,400 gas + 14,600 elec.
Fuel efficiency	3.13 mpg	3.13 mpg	4.9 mpg	4.9 mpg + 4mi/kwh
Fuel	11,805 gal	11,805 gal	7,551 gal	4572 gal + 3650 kwh
Cost of diesel	$2.13/gal	$2.41/gal	$2.41/gal	2.41/gal + 0.084/ kwh
Tot_fuel cost	$25,144	$28,450	$18,198	$11,323 ($11,017 gas + $305 electric)

$10,252 $6,895 $17,000

Case Study #2: Ford Escape

Illinois Institute of Technology (IIT) (Plug-In Hybrid Electric Vehicle Project) + ComEd (5.2 million Customers) = Plug-in Ford Escape Hybrids (62 hybrid vehicles at present 114 hybrid vehicles by the end of 2007)

	2007 – conventional (City)	2007 - Hybrid (City)	2007- PHEV (City)	2007 – conventional (Highway)	2007 - Hybrid (Highway)	2007- PHEV (Highway)
Mileage	12,000 mi	12,000 mi	12,000 mi	12,000 mi	12,000 mi	12,000 mi
Fuel efficiency	23 mpg	36 mpg	76.3 mpg	26 mpg	31 mpg	58.8 mpg
Fuel consumption	521.7 gal	333.3 gal	157 gal	461.5 gal	387 gal	204 gal
Cost of gasoline	$2.31/gal	$2.31/gal	$2.31/gal	$2.31/gal	$2.31/gal	$2.31/gal
Tot_fuel cost	$1,205	$770	$362	$1,066	$894	$471

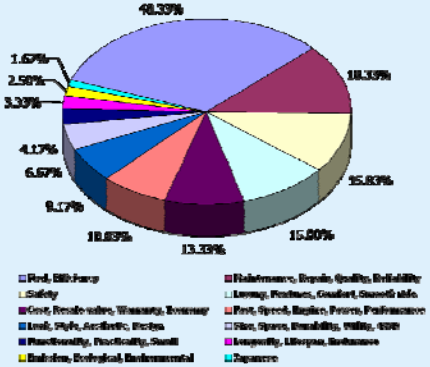
$435 savings $435 savings $797 savings

$172 savings $423 savings $595 savings

Survey Results

120 people were surveyed at Chicago's Millennium Park:

- 48.3% listed fuel efficiency as most important
- 73% would pay $2,000 extra for a HEV
- 44% would pay $3,000 extra for a PHEV



Customer

Three Main Types of Customers have been identified :

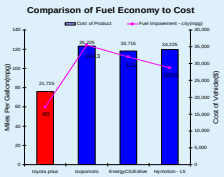
1. Direct Consumer
2. Direct Customer (Private and State owned Fleets)
3. Indirect Customer
   - i. Partnership with a Global Auto company
   - ii. Licensing to major auto manufacturers

Competition

Existing Competitors

1. EnergyCS, LLC. – California-based
2. Hymotion, LLC. – Canada-based
3. DaimlerChrysler-Benz & EPRI
4. Amberjac Projects – UK-based
5. Maranello 4-cycle SCE – Italy-based

Company	Price (US $)	Fuel Efficiency (city mpg)
Isopomoto	12,000 Goal:10,000	124.3 (Prius) 76.3 (Escape)
EnergyCS	Goal: 12,000	112 (Prius)
Hymotion	12,500 Goal: 9,500	100 (Prius) 60 (Escape)

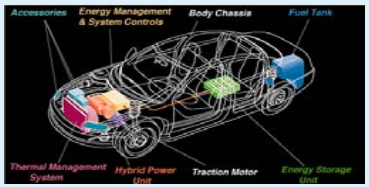


Plug-in Hybrid Electric Vehicle Technology

Introduction

The dominant trend in the automotive industry leans towards the increased use of electrical power to drive automobile systems. A practical solution for the auto industry to achieve higher fuel economy, lower emissions, and increased performance is through Hybrid Electric Vehicles (HEVs), which uses a combination of Internal Combustion Engine and electric motors to achieve those objectives.

What is an HEV ?



Source: Department of Energy

--ICE:

A internal combustion engine scaled up or down depending on the configuration of the HEV

--Motor:

An electric motor provides propulsion to the wheels or can generate power for the batteries

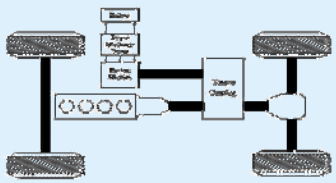
--Batteries:

A set of batteries provides electric power for both the electric motor and any other electric loads of the vehicle

Hybrid Topologies

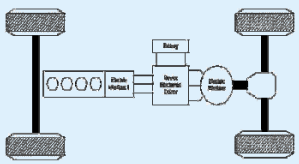
Parallel Configuration

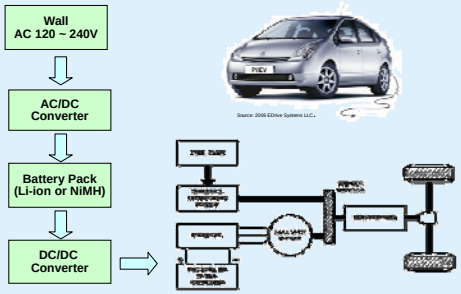
- Electric motor mechanically connected to ICE
- Increased Fuel Efficiency & Performance



Series Configuration

- ICE powers electric generator
- Electric Generator charges batteries
- Batteries and generator power electric motor
- Increased Fuel Efficiency & Performance





Plug-in Hybrid vehicles ?

- Also referred to as Gas-optional HEV's, it gives the driver the flexibility of driving in an all electric mode
- All electric = zero emissions
- The ICE is highly inefficient at low speeds consuming more fuel.
- The ICE does not burn the fuel completely at inefficient performances thus releasing more carbon (emissions)

Source: Spectrum, IEEE

- All of the advantages of the HEV with added electricity use
- Power your house with your car
- Use no gas on short trips with zero emissions

Component cost

Component	Description	Cost per kit
Battery (Li-ion)	245V, 24Ah, 6kWh	$10,000
Power Electronics 1: (AC/DC Converter)	Input: 85 – 264 V AC Output: 2 – 48 V DC	$500
Power Electronics 2: (DC/DC Converter)	Input: 12 V DC Output: 350 V DC	$300
Assembly Labor	$25/hr * 20	$500
Insulation / Packaging		$500
Miscellaneous		$200
Total		$ 12,000

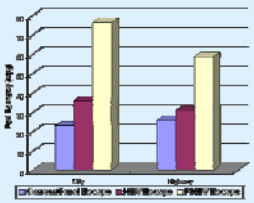
Source: 2006 EDrive Systems LLC.

Advanced Technology:
- Externally charged battery

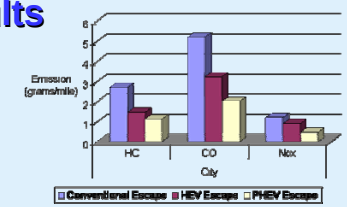
Wide Application:
- Retro-fit Approach
- Can convert any existing hybrid vehicle

Value
- Reduces oil consumption and emissions

Simulation results



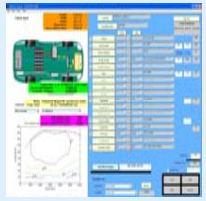
Compared to a hybrid vehicle the PHEV has over twice the fuel efficiency and almost half the emissions



Advisor

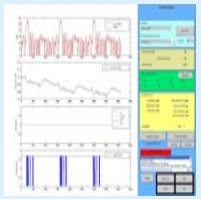
- Advanced Vehicle Simulator Developed by the National Renewable Energy Laboratory
- ADVISOR is a set of model, data, and script text files for use with Matlab and Simulink.
- Predicts the performance of a vehicle
- Analysis of conventional, electric, hybrid and fuel-cell vehicles

Simulation Parameters



- Design a vehicle and choose an engine
- Pick a transmission
- Determine an optimal electric motor & battery
- Decide a control strategy of a vehicle
- Select a drive cycle
- Change a number of cycles
- Set an initial condition of a vehicle

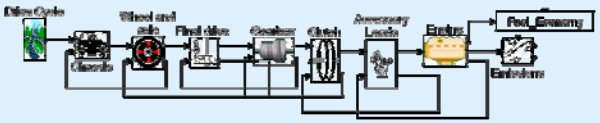
Simulation Results



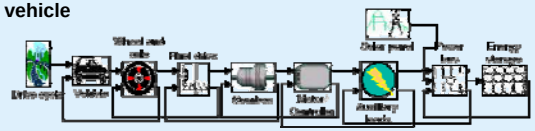
- ADVISOR predicts:
- Fuel efficiency
- Battery State of Charge
- Emission
- Overall system efficiency

Optimization Methodology

Each component is studied and optimized separately using the methodology outlined in the chart below.



- Block diagram of the components of the conventional vehicle



- Block diagram of the components of a hybrid electric vehicle

IPRO 356 Fall 2006

ISOPOMOTO

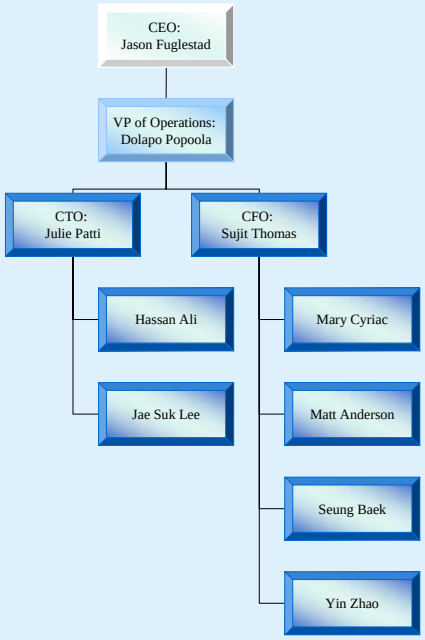
Mission Statement

To analyze the business opportunities for Plug-In Hybrid Electric Vehicles (PHEV) for the Grainger Power Electronics Lab and AllCell Technologies

History of Isopomoto

Isopomoto was founded in 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 Yoruban for hybrid (isopo) car (moto). This was created by one of our founders who spent her formative years in Nigeria.

Company Structure



The Team

Accomplishments

- **Developed a Business Plan for Isopomoto as a Start-up company manufacturing Plug-in Hybrid Conversion Kits:**
- **Case Studies: Built on case studies of the Chicago Transit Authority and the City of Chicago as potential customers for mass conversion of their fleets.**
- **Cash Flow Analysis: Quantified our costs and estimated our revenues to prepare a cash flow analysis.**
- **Performance Tests: Performed trial simulations and tests on several types of batteries to determine which conditions provide the highest efficiency.**
- **Survey: On September 23, 2006, the IPRO team conducted a survey of 120 participants in Chicago's Millennium Park.**
- **Industry: Conducted an in-depth review of the automotive industry, identified our competition and compared products**

What sets us apart from the competition is our technology. Our retrofit approach allows us to apply it to any HEV for a low cost providing better results.