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
- Lower emission

Why plug-in hybrids?
- Decreases greenhouse gas emissions (CO2)
- Support from local & state legislature
- Reduces gasoline consumption by two-thirds
- Highly dependent on electricity generation source thus reducing NOx and SOx gases

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

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

Increase in fuel price
- Fuel increased $0.79/gal resulting in $18.5 million in added expense.
- Rider ship growth fell short by 8.8 mil. trips

Increase in fuel price generated an additional operating cost of $9.1 million.

The Fleet in 2005
- Number of buses: 2033
- Distance covered: 74.8 million miles
- Rider ship growth: fell short by 8.8 million trips
- Fuel consumption: 24 million gallons
- Cost of fuel: 43 million dollars

Why plug-in hybrids?
- Reduces gasoline consumption by two-thirds
- Reduces Greenhouse gas emissions (CO2)
- Overall profit is higher
- Generated an additional operating cost of $9.1 million

Case Study #2: Ford Escape
Ford Escape
- High mileage
- More efficient
- Lower emissions
- Decreases green house gas emissions (CO2)

Infringement
- Illinois Institute of Technology (IIT)
- EnergyCS, LLC. – California-based
- Hymotion, LLC. – Canada-based
- DaimlerChrysler-Benz & EPRI
- Maranello 4-cycle SCE – Italy-based

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

Comparison of Fuel Economy to Cost

Company | Price (US$) | Fuel Efficiency (city mpg)
---------|------------|-------------------------
Isopomoto | 12,000 | 124.3 (Prius)
Hymotion  | 12,500 | 100 (Prius)
EnergyCS  | 12,000 | 76.3 (Escape)

2007 - conventional
2007 - hybrid
2007 - PHEV

Mileage
- Chicago Diesel Cost
- Mileage 12,000 mi
- Fuel efficiency 3 mpg
- Fuel consumption 33.3 gal
- Cost of gasoline $0.23/gal
- Tot_fuel cost $1,205

2007 - conventional
2007 - hybrid
2007 - PHEV

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- Fuel efficiency 3 mpg
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ComEd
- (5.2 million Customers)

Plug-in Ford Escape Hybrids
- (62 hybrid vehicles at present)
- 114 hybrid vehicles by the end of 2007

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- Fuel Efficiency
- Mileage 12,000 mi
- Fuel efficiency 3 mpg
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Partnership and Alliance
- Strategic
- Competitive
- Financial
- Technological
- Customer
- Risk

Barriers To Entry
- Internal factors
- External factors
- Large capital cost
- Infringement
- Cost of diesel
- Financial

Cost of Vehicle ($)
- Fuel Efficiency
- Mileage 12,000 mi
- Fuel efficiency 3 mpg
- Fuel consumption 33.3 gal
- Cost of gasoline $0.23/gal
- Tot_fuel cost $1,205

Risk involved
- Technical
- Logistical
- Physical
- Legal
- Financial

Risks involved
- Internal factors
- External factors
- Risk
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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?

--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)

Component cost

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

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:

- Externally charged battery
- Retro-fit Approach
- Can convert any existing hybrid vehicle
- 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

Advanced Technology:
- Externally charged battery
**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 Yoruba for hybrid (isopo) car (moto). It was created by one of our founders who spent her formative years in Nigeria.

**Company Structure**

**Accomplishments**

- Developed a Business Plan for Isopomoto as a Start-up company manufacturing Plug-in Hybrid Conversion Kits
- Performance Tests: Performed trial simulations and tests on several types of batteries to determine which conditions provide the highest efficiency.
- Industry: Conducted an in-depth review of the automotive industry, identified our competition and compared products
- Survey: On September 23, 2006, the IPRO team conducted a survey of 120 participants in Chicago's Millennium Park.
- Case Studies: Built on the 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.

**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.**