# Zinc Fuel Car

IPRO 313
FALL 2010

# Problem


- Internal combustion engines
  - Emission pollution
  - Dependence on oil

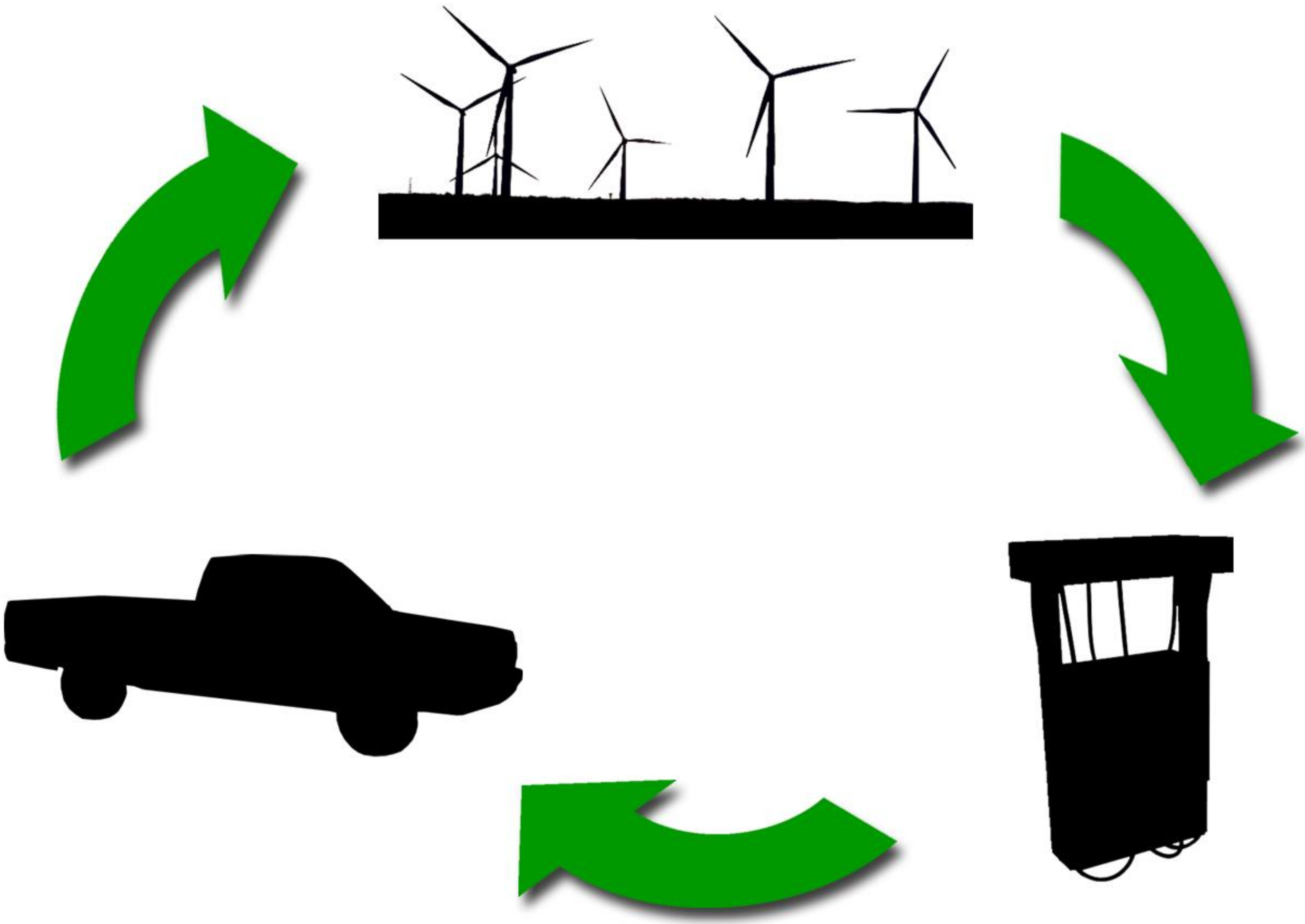
- Alternatives

| Biofuels | Hydrogen Fuel Cell | Plug-in Hybrid | Electric |
|---|---|---|---|
| - Emissions<br>- Land needed to produce | - Expensive<br>- Dangerous<br>- Made from natural gas | - Emissions<br>- Oil dependence | - Expensive<br>- Limited range |

# Answer


- Zinc Fuel
  - Zero emissions
  - Safe
  - Renewable
  - Easy transition for users
  - Abundantly available
  - Cheap

# Renewable Energy



# Who will benefit?

- Zinc manufacturing and processing companies
  - Wider use of zinc will increase profits
- Sustainability organizations
  - Help advance their cause
- And most of all: consumers!
  - Cheaper fuel
  - Little change to current driving and refueling habits

# Mission


- Develop a working car that runs on zinc fuel
- Help to advance sustainable technology
- Work cooperatively with people of different majors and skill sets

# History of Zinc Fuel

- Original technology was invented and patented by John Cooper (Lawrence Livermore National Laboratories)  in 1996
- Built a prototype
  - Wasn't meant to be refuelable
  - Was never mass produced
- Zinc Air Inc recently acquired the patent

# History of the IPRO

- Decided what technology to use
- Received grant from Exelon
- 2 trucks donated to work with, from Argonne
- Listed parts needed for truck compatibility
- Built and tested first battery prototype

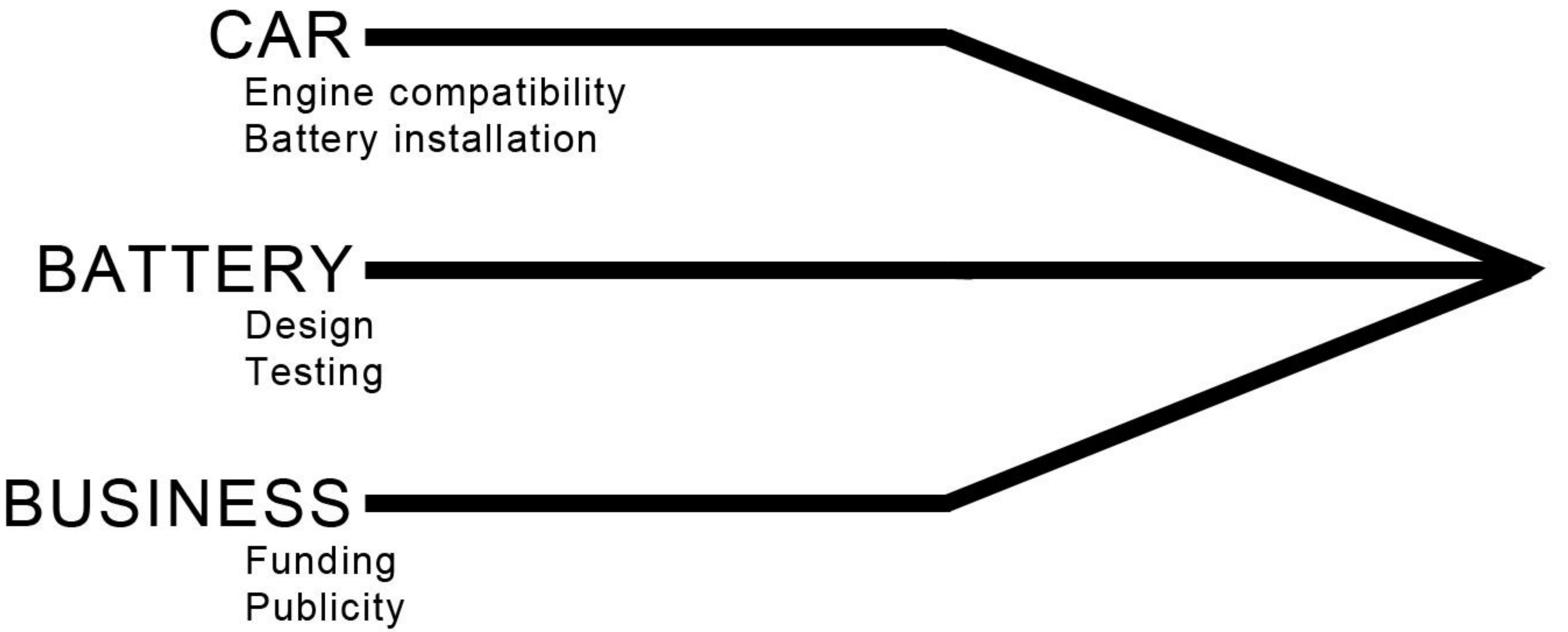

# Term Objectives

- Analyze test results from first prototype
- Design, build, and test second prototype
- Disassemble truck
- Install components needed for compatibility
- Determine what other parts are needed
- Continue to search for funding
- Improve outside interest in the project

# Team Organization

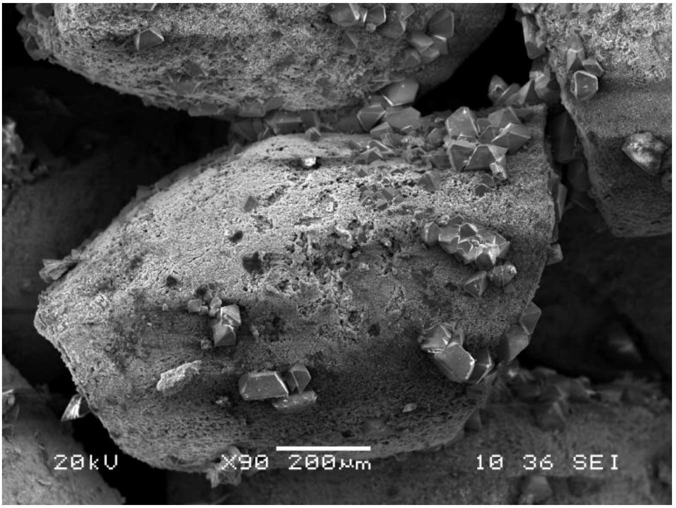
- 3 teams of 4-5 people
- Developed semester timeline
- Weekly meetings
  - Progress report
  - Decision making
  - Plans for the upcoming week

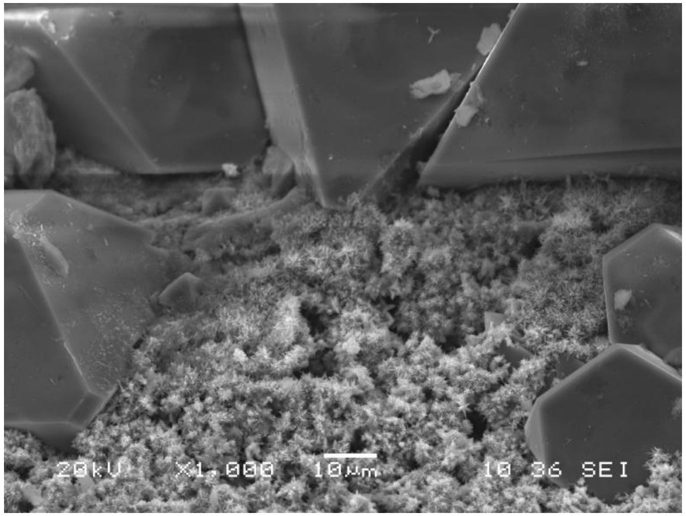
# Team Organization

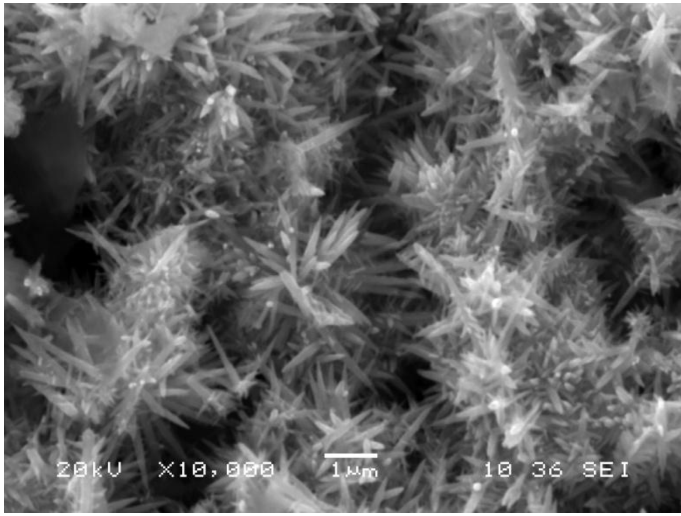


# Battery Team

- Analysis of the first prototype

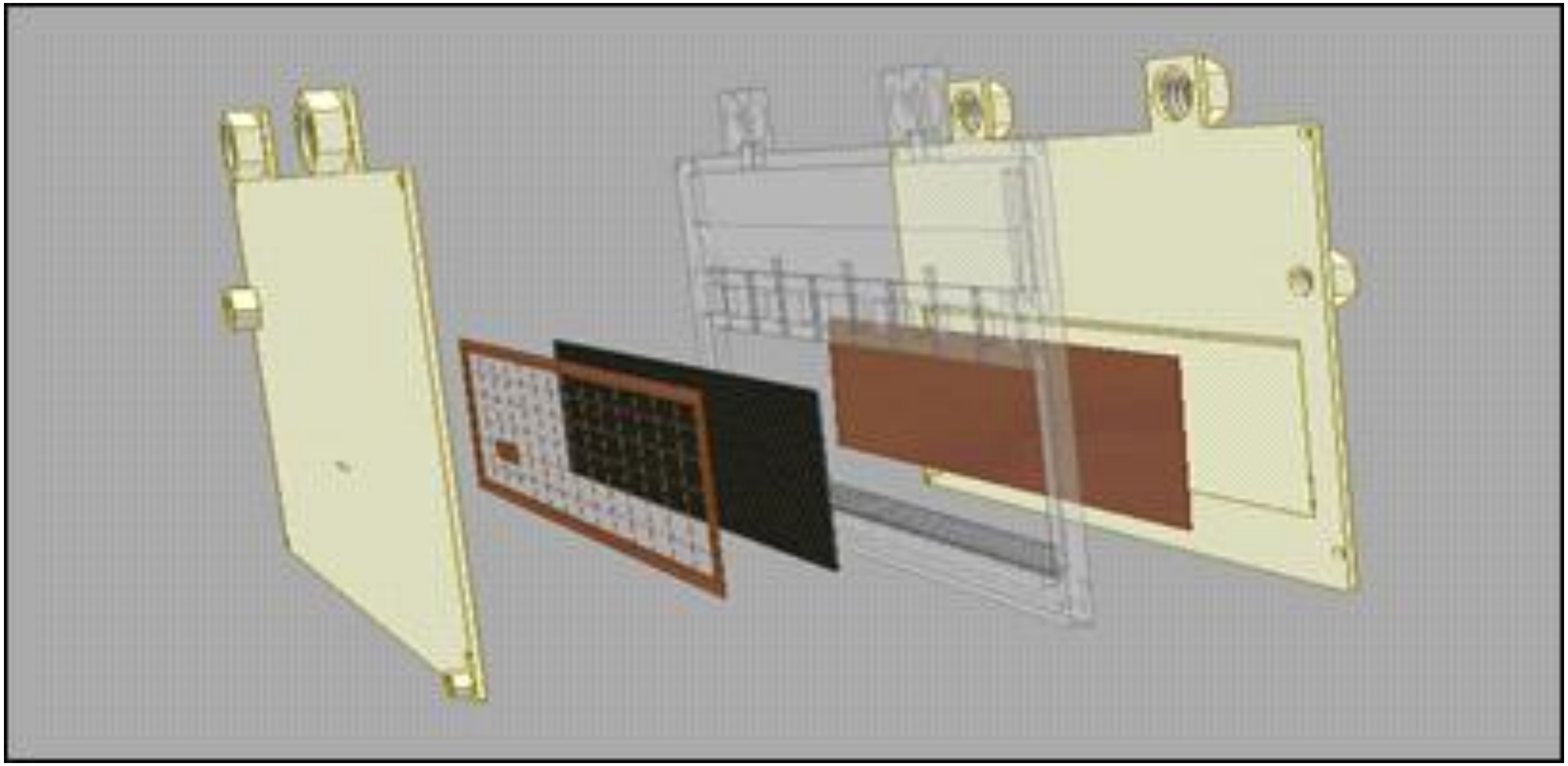


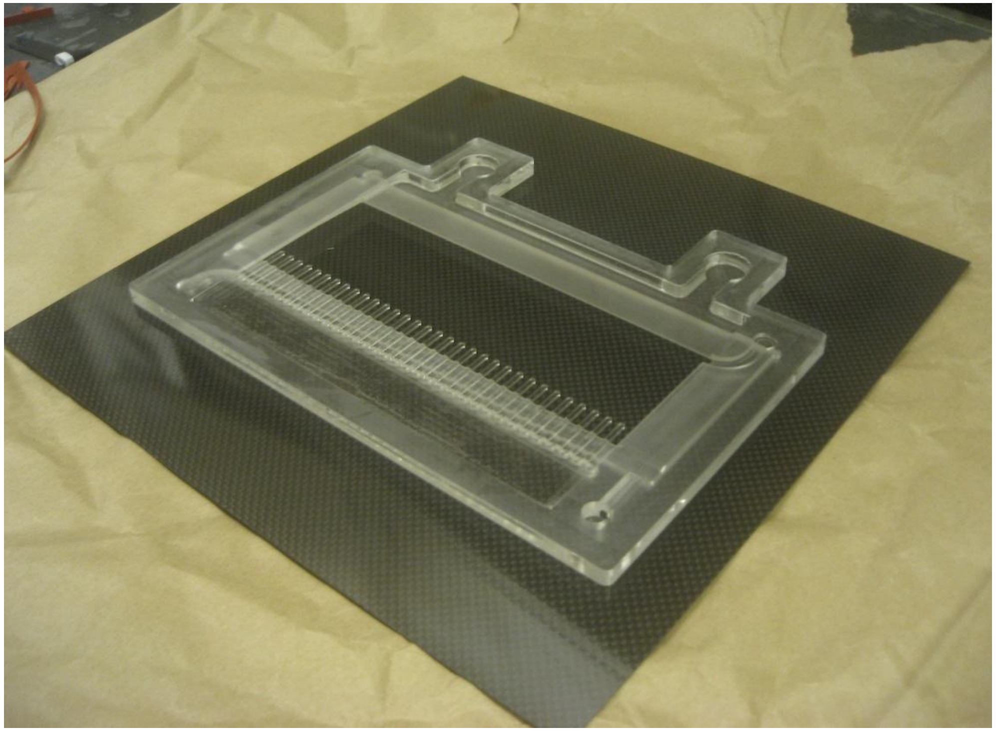
# Battery Team

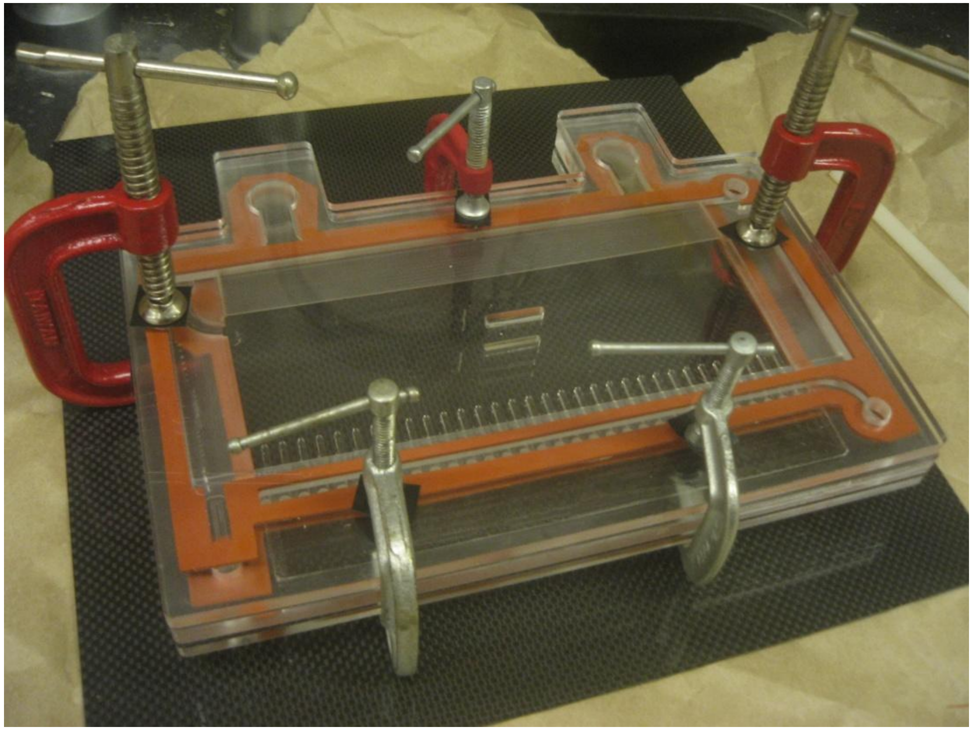
- Design of the second prototype



# Battery Team

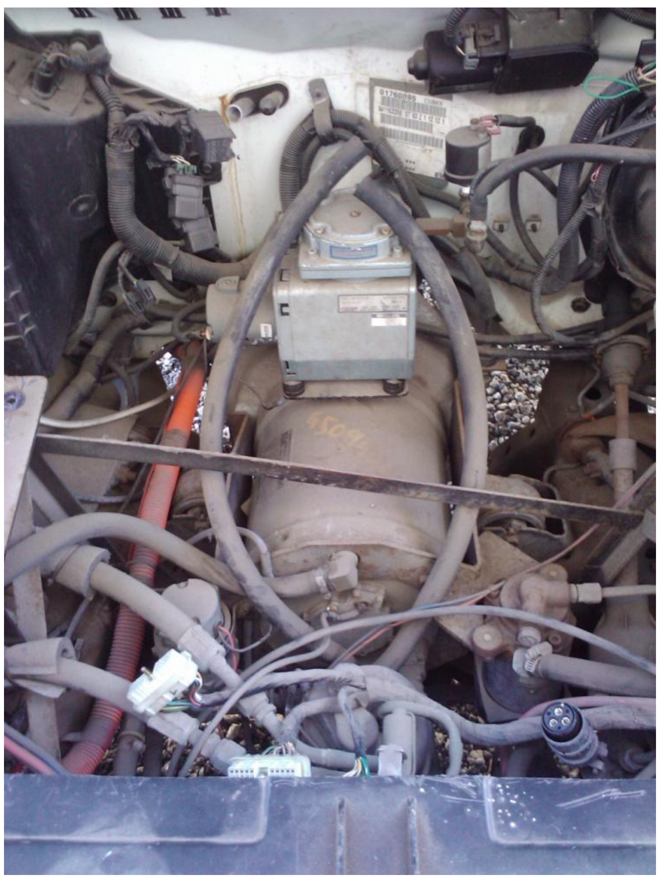
- Construction of the second prototype





# Car Team

- Disassembly of the truck



# Car Team

- Reassembly of motor and transmission

# Car Team

- Research and analysis for secondary battery

### PbA- Lead acid

- Oldest and proven
- Low Energy density-:20 -35 Watt-hr/kg.
- Suited for range rather than power.
- ~2V output per cell

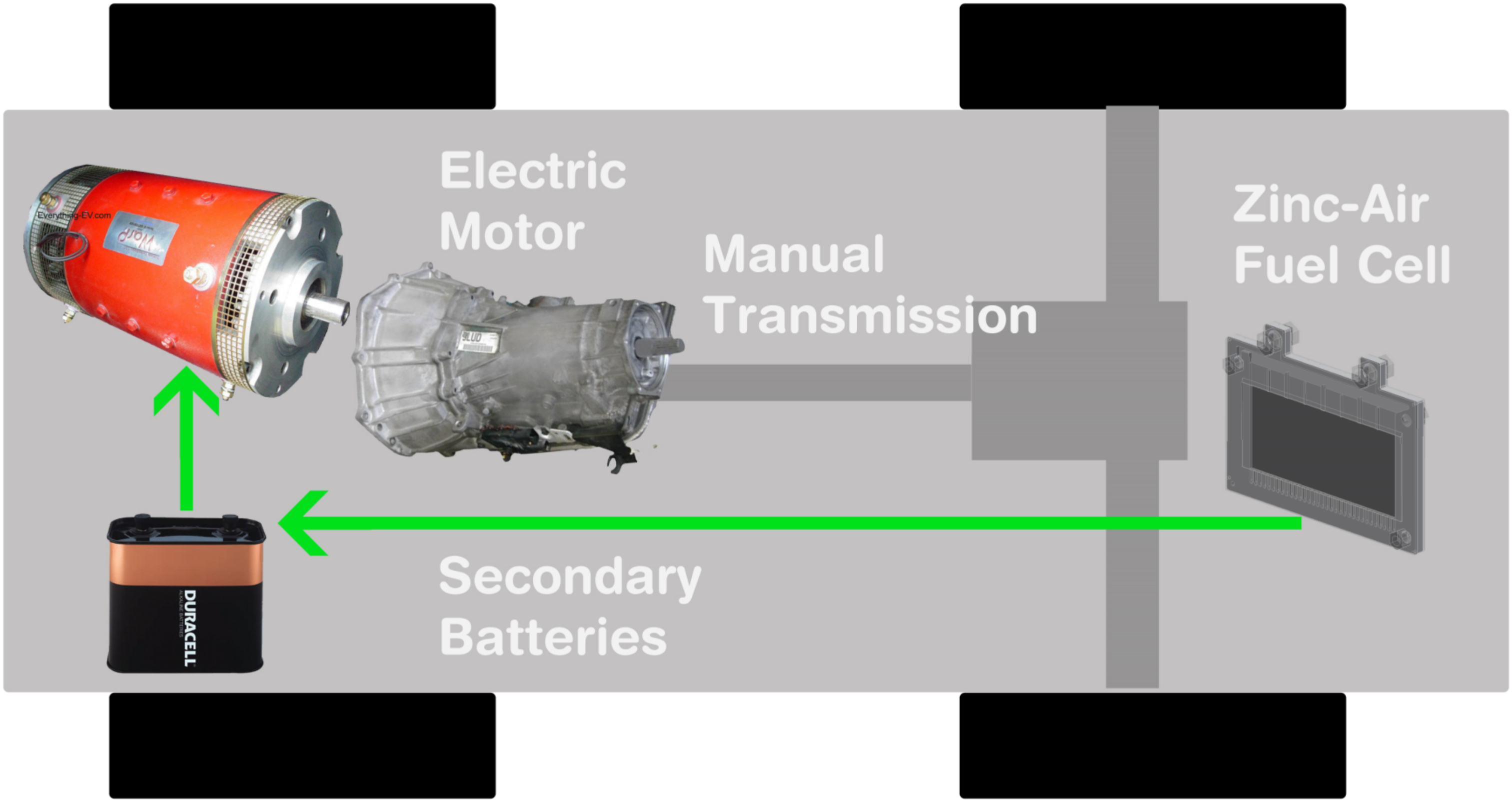
### NiMH- Nickel Metal hydride

- Energy density of 50-60 Watt-hr/kg.
- ~1.2 V per cell.
- Technology patented by Chevron.
- Few sources, ex used Toyota Prius batteries.
- Maximum current draw is limited.

### Li-ion Lithium ion

- Latest technology, in study.
- Best energy density 100-110 Watt-hr/Kg, hence the lightest.
- Eco-friendly.
- Ranges 3-4V per cell.
- Best option

# Car Team


Electric Motor
Manual Transmission
Zinc-Air Fuel Cell
Secondary Batteries
DURACELL

# Business Team

- Created Facebook page to spark interest


- Submitted a grant proposal to the WISER Institute

WISER

[ WANGER INSTITUTE FOR SUSTAINABLE ENERGY RESEARCH ]

# Cost Analysis


Table 3.11. Cost Comparison Between a Civic, a Prius, and a ZAFC EV Using Solar Derived Electricity

| Vehicle | MSRP | Rebate | Federal tax credit | City MPG | Hwy MPG | Avg MPG | Fuel consumption per year | | Annual fuel cost | Annual maintenance cost | Cost over entire ownership | Savings over entire ownership |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2004 Chevrolet S-10 | $24,660 | $0 | $0 | 17.0 | 23.0 | 20.0 | 435 | gal | $1,521.74 | $0.00 | $44,905.69 | $0.00 |
| 2008 Honda Civic | $17,760 | $0 | $0 | 25.0 | 36.0 | 30.5 | 278 | gal | $972.22 | $0.00 | $31,016.63 | $13,889.06 |
| 2008 Toyota Prius | $22,875 | $0 | $0 | 48.0 | 45.0 | 46.5 | 222 | gal | $777.78 | $0.00 | $34,871.71 | $10,033.98 |
| ZAFC Powered S-10 | $32,967 | $0 | $7,500 | 87.0 | 62.8 | 74.9 | 3966.7 | kg | $991.67 | $218.84 | $42,511.75 | $2,393.93 |
| ZAFC Powered Civic | $26,067 | $0 | $7,500 | 87.0 | 62.8 | 74.9 | 3966.7 | kg | $991.67 | $218.84 | $34,504.02 | $10,401.66 |

Table 3.12. Cost Comparison Between a Civic, a Prius, and a ZAFC EV Using Coal Derived Electricity

| Vehicle | MSRP | Rebate | Federal tax credit | City MPG | Hwy MPG | Avg MPG | Fuel consumption per year | | Annual fuel cost | Annual maintenance cost | Cost over entire ownership | Savings over entire ownership |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2004 Chevrolet S-10 | $24,660 | $0 | $0 | 17.0 | 23.0 | 20.0 | 435 | gal | $1,521.74 | $0.00 | $44,905.69 | $0.00 |
| 2008 Honda Civic | $17,760 | $0 | $0 | 25.0 | 36.0 | 30.5 | 278 | gal | $972.22 | $0.00 | $31,016.63 | $13,889.06 |
| 2008 Toyota Prius | $22,875 | $0 | $0 | 48.0 | 45.0 | 46.5 | 222 | gal | $777.78 | $0.00 | $34,871.71 | $10,033.98 |
| ZAFC Powered S-10 | $32,967 | $0 | $7,500 | 87.0 | 62.8 | 74.9 | 3966.7 | kg | $396.67 | $218.84 | $36,143.64 | $8,762.05 |
| ZAFC Powered Civic | $26,067 | $0 | $7,500 | 87.0 | 62.8 | 74.9 | 3966.7 | kg | $396.67 | $218.84 | $28,135.90 | $16,769.78 |

# Cost Analysis


- Assumptions
  - Zinc shipped between stations and reprocessing plants. Assumed 25 mile distance each way
  - Shipment of zinc costs $400 for 40,000 lb based on interviews
  - Cost of electricity from coal power plant 5 cents per kWh, cost of electricity from solar power plant 25 cents per kWh
  - Gasoline price assumed to be $3.50
  - Interest rate for time value of money 1.5%

# Challenges


- Securing the space and equipment needed to work on the truck
- Effectively building on previous semesters work without negating progress
- Learning curve of the technology
- Window of opportunity
  - Develop system before hybrid vehicles become the “norm”

# Ethics


- Long term effects
  - Taking away jobs from the oil industry
  - Refinement of zinc ore releases toxins
    - Most zinc is from Canada and Alaska

# Conclusions


- Need more funding to continue
- Zinc oxide and precipitation are affecting the battery performance, needs to be resolved
  - Recommend a higher flow rate of electrolyte, more concentrated solution, and second chamber in car to separate oxide from cell
- Second battery needs to be selected
  - Most expensive component, decision is crucial

# Next Steps

- Continue testing and designing single cell battery
- Design and build full-scale battery to test in modified truck, solve issues with available space in the truck
- Continue seeking sponsorship and publicity, build a website to promote the project
- Devise commercialization strategy for implementation of our system